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ENVIRONMENTAL ISSUES IN THE 1980s: RURAL LAND USE

by

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ENVIRONMENTAL ISSUES IN THE 1980s

RURAL LAND USE

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INTRODUCTION

1 The aim of this paper is to identify some of the priority research areas in the field of rural land use, and particularly those which would benefit from collaboration between the life sciences (represented by the Natural Environment Research Council (NERC) and social sciences (represented by the Social Science Research Council (SSRC).

2 The approach is from the life sciences end of the spectrum, recognizing that whilst there is a great deal of in-house research of a technical nature, there is increasing interaction between the two sciences as nature, landscape and environment conservation interests become stronger, and as demands on the land resource increase and change. The social and economic requirements of the population have to be balanced against the short and long term production capacity of the land.

3 Within the United Kingdom the small land area relative to the population predisposes us to a conflict of land use interests. These interests or demands exert competing pressures on land use through, for example, increasing demand for home grown forest products, increased efficiency of agriculture from a reduced area, reduced demand for water, potential increased demand for sources of renewable energy. Pressures for change in rural land use are influenced by and influence social and economic characteristics of the population. Some of these competing pressures are satisfactorily resolved through existing markets; others require policies for the pursuit of wider objectives.

4 The aims of the World Conservation Strategy (WCS) are:

i) to maintain essential ecological processes and life-support systems,

ii) to preserve genetic diversity,

iii) to ensure the sustainable utilization of species and ecosystems.

When applied to the land resource of the United Kingdom they may be inconsistent with iv), to 'yield the greatest sustainable benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations' (International Union for Conservation and Natural Resources 1980). The challenge in research is to quantify the policy benefits and identify ways in which an optimum combination of benefits can be achieved within the constraints on the pursuit of these objectives. The constraints relate to the availability of public funds, the limits of resource supply and of the private objectives of resource owners.

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GENERAL RESEARCH NEEDS

5 Before discussing some of the particular research questions related to rural land use, there are four general features which should be included in the developing research programme.

Combination and interaction of uses

6 Because of the structure of Government organizations and our history of land use, our understanding and management has become compartmentalized. Research within each compartment, eg forestry, agriculture or nature conservation, is well developed, but there is a lack of understanding of how land uses may be allocated or integrated for mutual benefit. This, despite the fact that much of our land, especially the uplands, is under multiple use. There is also evidence that within a land holding, planned allocation of land, for example to farming and forestry, can increase material and economic production. More integrated, multiple-cropping systems may also be beneficial on certain land types. Whether with allocation or integration, 'there are remarkably few facts relating to the interaction of the (land use) systems, as production functions or even as case studies' (Mutch & Hutchinson 1980). Thus a primary research need is:

- to examine the potential of land for varying combinations of uses and degrees of integration, with the associated economic and social consequences and constraints.

Scale and context

7 There is a recurrent demand for local case studies which provide information at a realistic management level but usually lack the capacity for more general application. Conversely, in the collection of national information, the structure of the data is lost, thus preventing examination of regional or local variations. The value of research information is increased where there is a structured framework allowing replicated local studies to be selected from defined strata and quantitatively placed in regional and national context. Particular problems arise when sampling crosses administrative boundaries and the development of a European perspective is inhibited by incompatible baseline information.

Short and long term research

8 Research during the next decade needs to focus on the questions that will arise in the late 1990s. There is a considerable amount of *ad hoc* research designed to answer the questions of the day, but research, like many industrial and social developments, has a long lead-time. Thus an important component of the research programme should be speculative and strategic.

Research for decision-making

9 There is a tendency, at least in the life sciences, to concentrate research effort onto description of the present state, an analysis of how it has changed and on monitoring of change. Whilst the need for 'facts' and

baseline information is real, the important questions are concerned with the future - analysis of how land uses are likely to change, what is the potential for change, how can we control and what is the optimal balance that we wish to achieve? (Figure 1). Such questions tend to be treated as mere speculation, but prediction and exploring options (optimizing) demand the same rigour as other aspects of the science; various techniques are available but are little used by researchers, planners or land use managers. The development, application and testing methods for forecasting, option assessment and appraisal on decision-making is one research need; ensuring their application is another phase of the resource allocation activity which, ultimately, is for decision-makers to undertake.

RESEARCH TOPICS IN RURAL LAND USE

10 It is conventional to consider land uses individually. However, there is considerable multiple land use and interaction, with combined effects on the rural community, and this is where a research thrust is required. As the questions associated with land use in the uplands and lowlands are distinct, the two land types are considered separately.

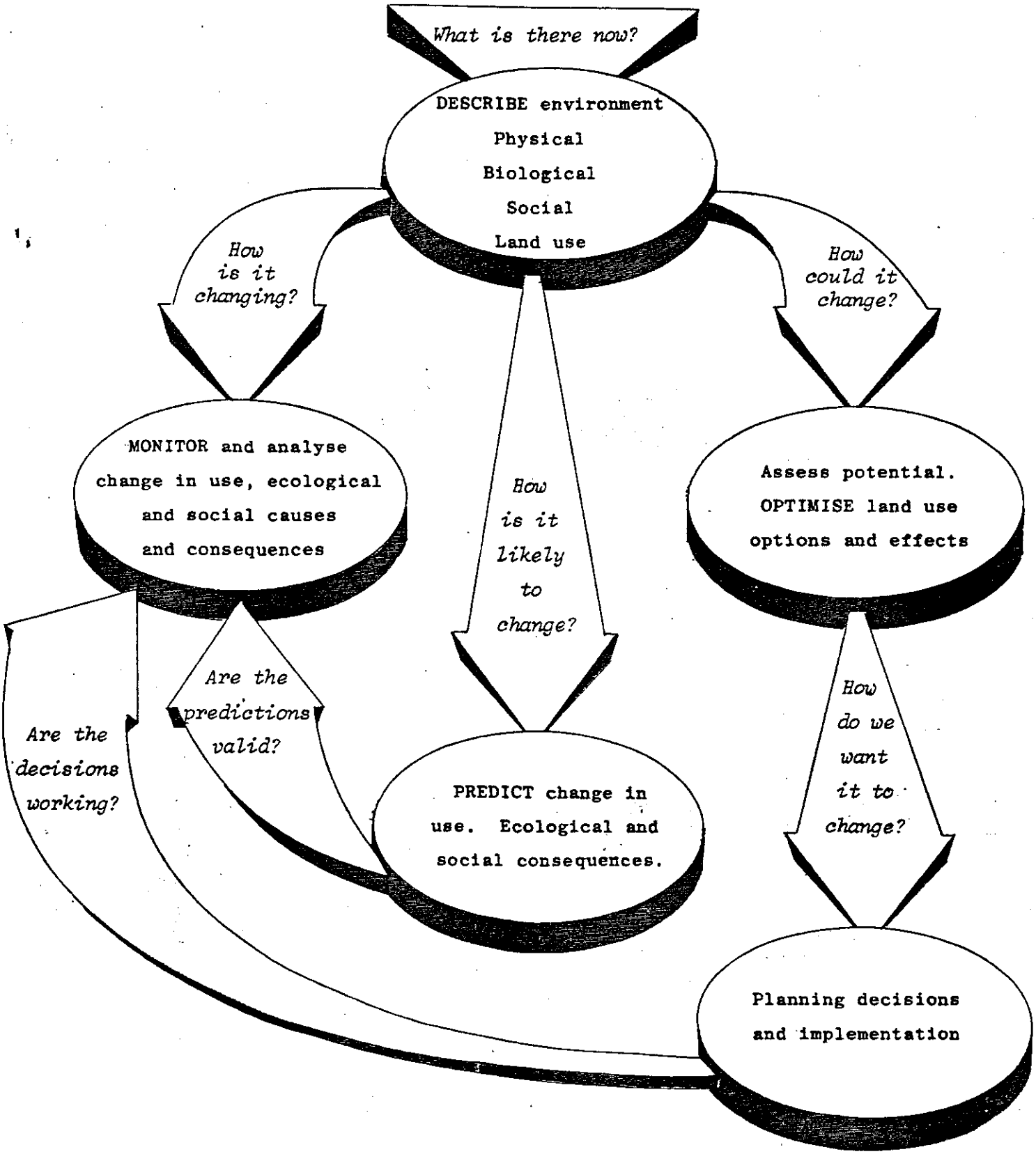
UPLANDS

11 The Countryside Commission debate 'What future for the Uplands?' (1983) identified the central issues:

> 'The various studies of changes in both the landscape and the socio-economic well-being of the uplands re-affirm that a means must be found to achieve better co-ordination of government policies. Only in this way will it be possible to reconcile and achieve three policy objectives for which there is already a wide concensus of public support:
>
> Social - to maintain the population levels in the uplands and reasonable provision of services;
> Economic - to provide opportunities for suitable economic development which take account of the special needs of the uplands;
> Environmental - to safeguard areas of particular national scenic, recreational and wildlife importance.
>
> All the departments and agencies, whether in Whitehall or Brussels, whose policies have an impact on the uplands, should reconsider these policies against the three objectives above. The aim should be to ensure that purely sectional objectives are not in conflict with overall policy or other objectives.'

12 Unfortunately sectional objectives are in conflict and the three objectives are probably themselves incompatible - unless acceptable levels of social, economic and environmental states are defined and agreed. Research is required to provide further information to clarify the issues and options as a basis for policy decisions, the research objectives being:

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



- to provide quantitative predictions of likely future changes in population structure and economics, land use pattern, landscape and nature conservation expecially in areas where policy conflict is likely to be maximal, eg National Parks and National Scenic Areas;

- to establish a monitoring programme designed to evaluate and improve predictions;

- to assess the extent to which policies do in fact conflict, ie what is the trade-off between policies promoting competing activities such as agriculture and forestry;

- to determine the extent to which changes in land use can be induced by differing types of control, eg tax incentives, subsidies, planning restrictions.

Two examples of one approach to such objectives, using linear programming to explore land allocation options and conflicting policies, are given in Appendix I. It should be emphasized that these are examples and a wider range of methods are available; it is the approach which is relevant here.

13 Forestry is expanding and is likely to continue to expand. The research requirements in forestry have been discussed at a recent workshop including forestry, conservation, hydrology, university and research interests. The topics identified are given in Appendix II and include main aspects of interaction of forestry with other land uses. Many of the topics have social and economic implications but aspects which are not covered and which interface with social sciences are:

- to determine the effect of afforestation on the social and economic structure of different rural communities and on other land uses; and to identify the characteristics of rural communities which would receive most benefit from future afforestation.

See also Appendix III for recommendations for research, including socio-economic research, from the Centre for Agricultural Strategy (1980); Strategy for the UK forest industry.

14 Agriculture within the uplands has been the subject of many reports, recommendations and pleas, especially in relation to rural depopulation and social deprivation. Analysis of the extent to which various policies and incentives have succeeded in sustaining marginal agriculture, and the conditions which have been conducive to success, may be a profitable research subject.

15 Agricultural improvement of moorland has produced heated debate in such areas as Exmoor. Whilst such issues are important locally, they are of small significance to the conservation of upland moors on a national scale. The moorland fringe represents a zone of fluctuating land use (Parry, Bruce & Harkness 1981). In 12 upland parishes in England and Wales, 2.6% of the original moorland has been improved for agriculture whilst 5.0% has reverted from agriculture. Although improvement has increased in recent years the total loss of moorland, from all uses, by the year 2000 will be about 10% given continuation of recent trends (Figure 2). Loss to forestry will be greater in Scotland but there the area of moorland is much greater. There are climatic and edaphic, as well as economic factors, which will limit agricultural improvement, but a study of Exmoor (Miller,

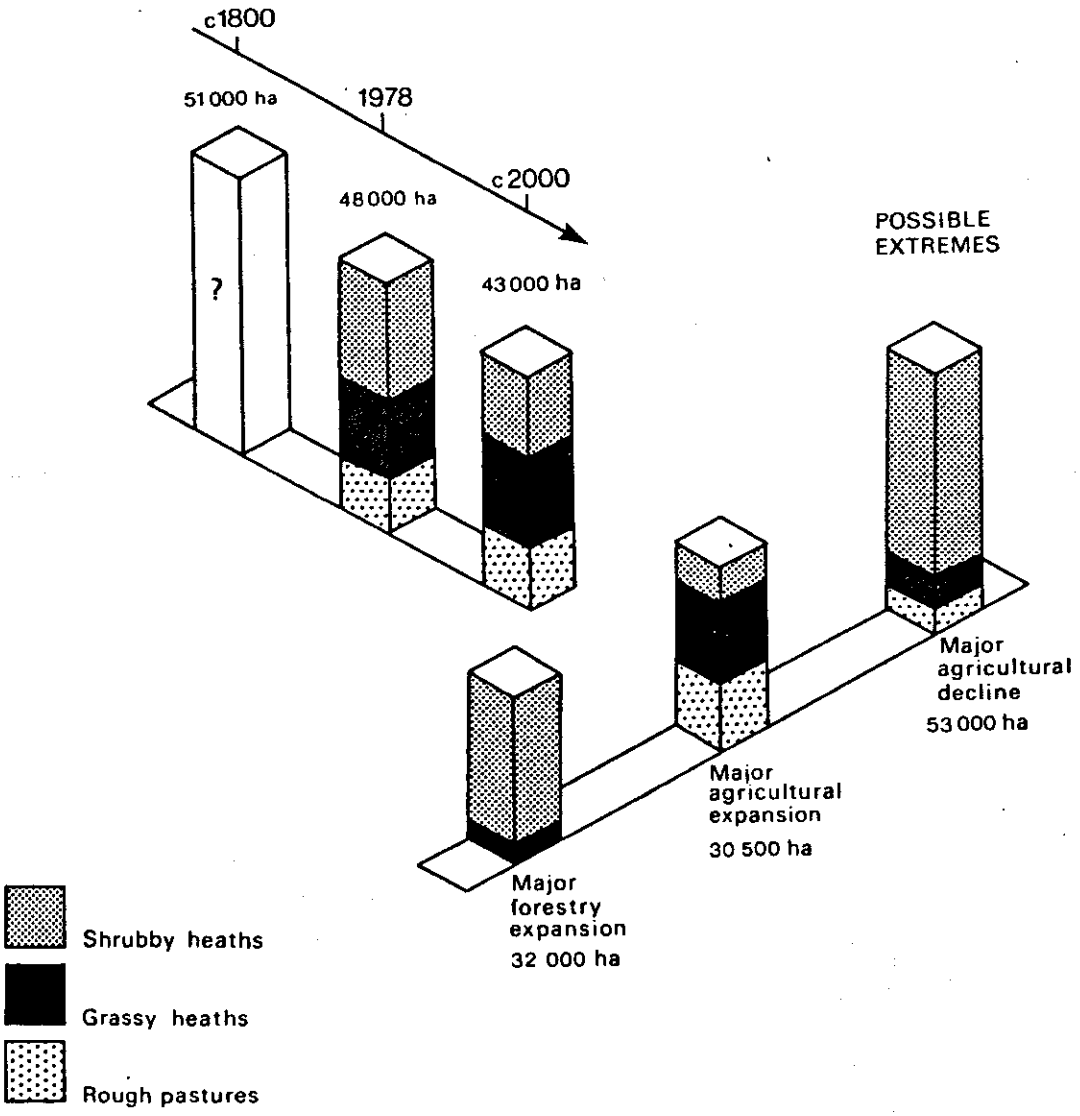


Figure **2** **The predicted area and vegetation composition of moorland in 12 upland areas given various trends in land use.**
The most likely trend is a continuation of the recent pattern of change in the study areas up to the year 2000. The effects of a major expansion of agriculture or forestry, and major decline of agriculture, are shown as possible extremes. The major change represents the degree of land use change which has occurred in some areas in the past, but which is envisaged as applying to all areas simultaneously.

(From Ball et al. 1982)

Miles & Heal, in press) indicates that vegetation management within the moorland is as important to survival of scenically important heather moor as agricultural improvement.

16 One aspect which deserves specific attention is the potential economic benefit which can result from planned integration of agriculture and forestry on hill and upland farms. The Centre for Agricultural Strategy (1980) indicated that increased agricultural production can occur despite land loss to afforestation. Case studies have indicated that with planned land re-allocation to forestry, increases in agricultural output may occur but suggest that decreases are also possible (Stewart 1978; Mutch & Hutchinson 1980). However, the Hill Farming Organisation have developed a planning model which examines the critical factor of the spatial arrangement of land allocation within a holding. Based on a classification of the physical characteristics and production potential of the land, the model explores the possible patterns of afforestation which would provide the best economic return for a holding, minimizing road and fence costs while maintaining the continuity of the agricultural unit. A wide range of economic return was produced with different degrees of integration under different site conditions (Maxwell, Sibbald & Eadie 1979). Whilst the basic idea is not new, the potential benefits, variations in relation to farm type and structure, the policy and social constraints to implementation, all still need to be examined through field and theoretical research.

17 Energy from renewable resources in the uplands represents a land use, the development of which may be of benefit to rural communities as well as contributing to the national energy balance. The subject in general is currently intensively researched from various angles nationally and in Europe (eg Palz, Chartier & Hall 1981; Strub, Chartier & Schlesser 1983; Carruthers & Jones 1983), but in the uplands two aspects have the potential for application and, whilst the energy technology and feasibility is being explored, social aspects need to be considered more fully (Carruthers & Jones 1983):

i) The use of thinnings and forest residues for energy from a modified form of conventional forestry is a plausible option (Mitchell et al. 1983). Five million tonnes could be produced for energy from the existing 0.9 M ha of upland forest, with an additional 5-18 M t from an expansion of 0.9-2.8 M ha, the range dependent on constraints by other land uses.

ii) Cropping of semi-natural vegetation, particularly bracken, could provide a significant source of solid fuel or gas for local rural communities. There are about 300 000 ha of bracken in Britain, part of this can be cropped with modern farm machinery on land which is currently under-used (Callaghan, Scott & Lawson 1982). Preliminary economic assessments indicate that such energy cropping is marginally non-viable, but changing energy supplies and costs, together with social considerations, could tip the balance, as indicated in the wider context of the European Community (Heidrich & Schafer 1984).

18 Land tenure is a key factor controlling land use in the uplands, superimposed on which are designations such as National Parks, National Scenic Areas, Areas of Outstanding Natural Beauty, SSSIs, etc. Whilst constraints on land use are perceived by many people, either positively or negatively, there is little objective data which define the extent to which such designations have actually modified land use in the desired manner and have inhibited development such as agriculture.

19 A particular feature of the uplands is the common land and croftings which cover some 2.5 M ha. Such areas receive minimal management and are considered to be important reservoirs of wildlife and recreation. Institutional changes could enhance productivity but will interact with conservation and recreation. Here the range of options and the interactions between land uses can be explored in advance of policy decisions.

20 Amongst competitors for land use, recreation has received some attention from researchers but many questions remain to be resolved. The impact of farming practices on the 'amenity value' of agricultural land, the degree of competition for different forms of recreational experience and the best method of valuing such public goods in appraisal situations are examples.

21 There may be important interactions between the social structure of rural areas and the human environment they offer. For example, several questions remain to be answered on rural housing which, itself, is but one component of the motivation set determining the pattern of settlement. Related to this is the problem of rural deprivation which has, so far, received limited attention.

LOWLANDS

22 In the lowlands the majority of land is under single use. However, this is more apparent than real, for although agriculture dominates, that use influences nature conservation, landscape and amenity uses and water quality. Issues and conflicts tend to be more intense in the lowlands, for various reasons and the conclusion of the Centre for Agricultural Strategy (1976) remains true: 'The information on land area, land use, change in use, land capability ownership and tenure is fragmentary and, in general, inadequate for land allocation and planning purposes and for predicting the consequences of any proposed fiscal legislation on agricultural production. A national land inventory is needed.' In particular trends in change in use, and the consequences of these changes to other uses, lack information. The Centre for Agricultural Strategy (1976) emphasize the national scale, but at the regional level where planning is put into practice, information is extremely variable.

23 The land budget predictions of Edwards and Wibberley (1971) and the Centre for Agricultural Strategy (1976) focus attention on some of the key questions of land allocation. Although the focus may be on agriculture, they incorporate other uses, and provide the base for developing a more integrated view of our land resource with the capacity for examining interactions and exploring regional variations, linking with methods discussed earlier (paragraph 12, and Appendix I). The study by CAS (1976) has been seriously questioned by Wise and Fells (1978) and the policy implications they draw have been attacked by Whitby and Thomson (1979).

24 A variety of specific issues arise in the lowlands associated with particular trends in management for agriculture and forestry and their effect on other uses. Such issues require research to quantify the extent of management changes and their consequences, eg:

- the removal and management of hedgerows with effects on wildlife and and soil conservation;
- the management of straw and stubble by burning and its effect on adjacent field boundaries and soil conservation;
- the effects of increased land drainage on habitat and species loss and on management of remaining wetlands;
- the effect of modified pesticide use and management practices on wildlife and game;
- the effect of continued increase in fertilizer use (with reduced crop response) on ground and surface water and on soil stability;
- the loss of habitat and reduction in species populations of conservation interest, and of landscape features, through conversion of deciduous to coniferous forest.

25 Whether these issues are to be resolved by taxes or subsidies, by modifying the 'market' (as with management agreements) or by administrative fiat (as with planning controls) is a basic question to be resolved with each problem. Potential remedies may be evaluated on the basis of financial or economic cost but the very difficult problem of evaluating, or even measuring the benefits, remains.

26 The main research requirement is in identifying the potential problems before they become issues, in exploring and defining alternative management practices which are then used to divert the problem and find positive solutions. Examples of this approach are indicated in the forestry research priorities (Appendixes II and III) in which, for example, increased research on species mixtures is advocated, or in the Conservation and Development Programme for the UK (1983) in which the potential of organic farming is emphasized or in the development of seed mixtures to provide a conservation management tool to maintain herb-rich meadows (Wells 1982).

27 One of the main research areas requiring strategic research is obviously that of energy conservation. Whilst considerable emphasis is placed on technical means of improving efficiency of use of existing, largely non-renewable, resources, the development of renewable energy sources links the life and social sciences. Assessment of potential energy from various forms of biomass (Table 1) indicates a 10% contribution to the UK primary energy consumption but with considerable significance to rural economies and to nature and landscape conservation. The main research needs have been identified by Carruthers and Jones (1983) and are given in Appendix IV.

Table 1.
Estimates of potential annual UK energy output of various means of decreasing the amount of 'unused' biomass energy (Carruthers & Jones 1983)

Resource	Energy output (PJ)	
Industrial and commercial refuse	220.00[1]	
Domestic and trade refuse	210.00[1]	
Oil and tyres	25.00[1]	
Sewage sludge	20.00[1]	
Process wastes	6.00[1]	
Total urban wastes		481.00
Dry crop residues	147.90[2]	
Wet crop residues	14.87[2]	
Animal wastes	50.92[2]	
Horticultural wastes	0.91[2]	
Wood residues	21.64[3]	
Early thinnings	6.00[4]	
Total agricultural wastes		242.24
Total wastes and byproducts		723.24
Rural natural vegetation	58.68[5]	
Farm woodland	15.27[6]	
Urban vegetation	16.50[5]	
Aquatic and marine vegetation	4.29[7]	
Total unharvested vegetation		94.74
Total		817.98
% 1981 UK primary energy consumption[8]		9.77
System changes – dual purpose oilseed rape		93.20
% 1981 UK primary energy consumption[8]		1.11

1 Estimated total production requiring disposal 1976/1977
2 Estimated available production 1976
3 1977
4 1980
5 1975–1979
6 1979
7 Source year not specified
8 8 369 PJ

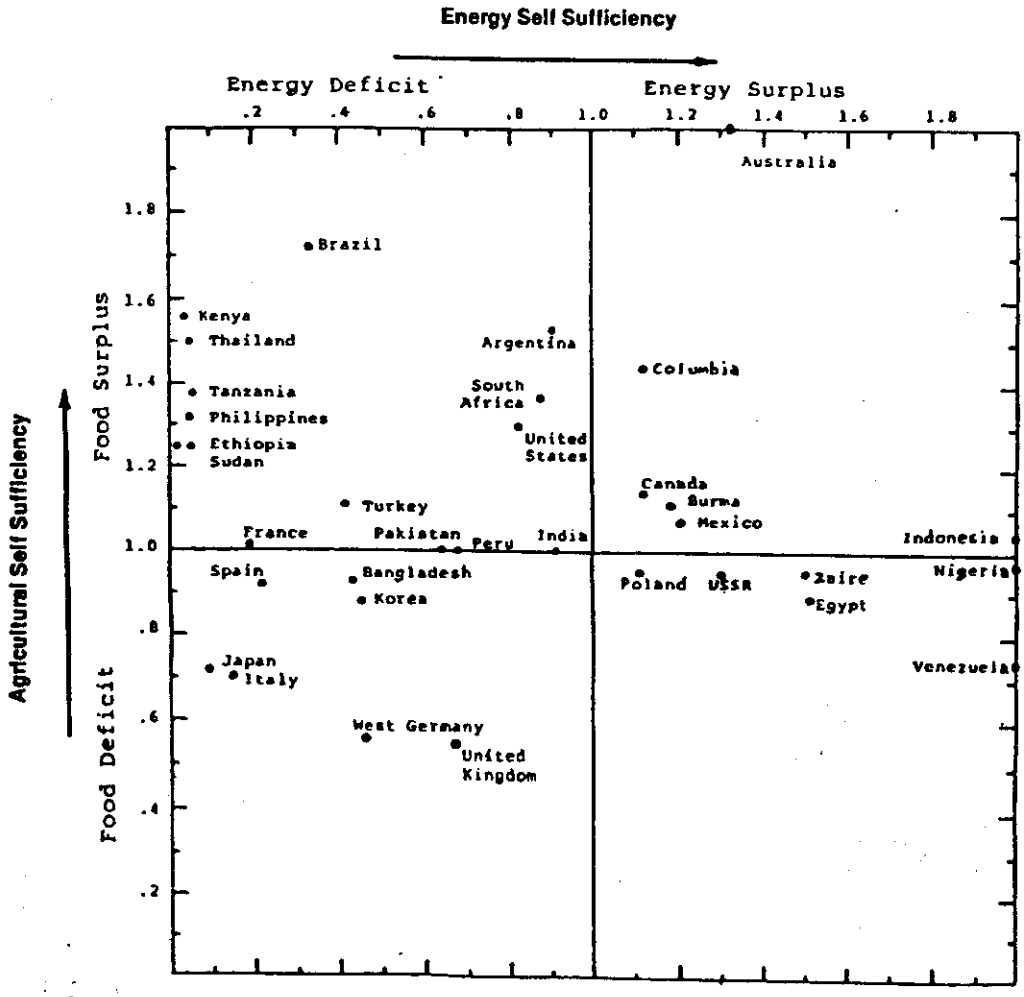
CONCLUSIONS

28 There are undoubtedly many detailed research questions which are relevant to the present discussion - such questions as: what is the change in bird species composition when moorland is afforested? or what are the best methods of assessing landscape value? or how many jobs are generated by forestry versus farming? These are mainly questions of detail, reflecting sectional interests, and have not been developed in this paper. The area in which inter-disciplinary research is required associated with the national land resource is in the integration of land uses, integration (including allocation) designed to minimize conflict between interests and to provide an optimum balance of uses. Such research must identify main policies, the compatibility of these policies and their interaction with other land uses. To do this, the strategic research must use the products of detailed research, but that detailed research should be generated within a broader framework which is currently lacking. This inter-disciplinary approach to research does not depend on the presence of a single national agency responsible for planning or on controls on rural land use planning at a regional level - these are separate issues.

29 The changing rural land use in Britain and its inter-relationships with social and economic needs cannot be separated from similar questions in other countries and from the general pattern of supply and demand of renewable resources. Policies of the European Community are an obvious example. Figure 3 indicates the UK position (in the early 1970s), relative to other countries, in the degree of self-sufficiency for agricultural products and energy. Our position regarding forest products would show an even lower degree of self-sufficiency - a deficit of about 90%. Thus the allocation of land to different uses within a country needs to be designed to complement those of other countries to provide an optimum balance for the Community as a whole. The questions of political solutions to such a challenge should not be confused with the analysis of land resource options.

30 Finally, returning to a more domestic note, the need for a co-ordinated baseline of national information on land resources from which to explore changes in land use and ecology has been identified as a priority area by the Institute of Terrestrial Ecology within NERC (Appendix V). The next step in the process of national resource allocation must be to develop methods by which such inventories can be converted to a usable state for decision-makers. Whether this will best be done by identifying a unit of 'conservation' or whether by attaching monetary values to particular environmental phenomena remains to be seen.

Figure 3. The degree of self-sufficiency in food and energy in various countries (from Rask 1979)



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AN APPROACH TO EXPLORING LAND USE OPTIONS AND CONFLICTING POLICIES

EXPLORING OPTIONS FOR LAND ALLOCATION

Pressures on a limited land resource come from a variety of uses. The demand for products changes with time as does the production potential through technical development. Thus the pattern of use is changing and with it the opportunity to influence the distribution of use, whether by direct planning or by persuasion. In the uplands of Britain the expansion of forestry and of the general characteristics of the planning process (Centre for Agricultural Strategy 1980). The 'conflict' may be resolved by market forces and political pressures, but assuming some level of cooperation between the agencies involved, ie moving from sectoral to integrated planning, there are various techniques which can assist integration of information.

The analysis of land allocation options in Cumbria by Bishop (1978) shows a sequence of processes which is of general application: classify and survey land - assess land use potential - define constraints and objectives - optimize land allocation - repeat with revised variables.

The initial land classification described the physical attributes of climate, geology and physiography which largely determine land uses in an area which ranges from fertile lowlands to severe montane conditions. The land classification (Bunce, Barr & Whittaker 1981) derived from existing maps, was used to survey the county and define the area and distribution of each of the 16 land classes in the 6800 km^2 of the county, using 1 km^2 cells as the basic land unit.

The dominant land use is agriculture with a combination of dairy plus a small area of arable land in the lowlands, and beef and sheep rearing on the marginal land and uplands. About 6% of the county is currently under coniferous or deciduous forest and the area is expanding. Superimposed on these direct land uses, nearly half of the county is designated for nature and landscape conservation and recreation, including the Lake District National Park.

A matrix was developed defining the production potential of each agricultural and forestry use for each land class. Production potential was assessed from a combination of observed and theoretical values, the latter based on the known physical conditions of the land classes. Agricultural and forestry production was quantified in terms of meat, wool, milk or timber output per ha. For comparison, the less tangible uses of nature conservation and recreation were given numerical values using, as far as possible, measurable criteria such as species diversity and carrying capacity. The values were estimated for both land class and land use, thus allowing a range of combinations to be produced. Additonally, the labour input required for levels of land use was defined, allowing analysis of the effect of land allocation on employment in the county.

Certain constraints to the allocation of land to a particular use may be identified. For example, in Cumbria expansion of forestry within the National Parks and onto Common Land is restricted thus limiting the 'availability' of a proportion of the area of certain land classes. At the time of the study part of the county was proposed for designation as an Area of Outstanding Natural Beauty and the possible effect of this constraint on forest development was also examined.

Within these constraints the objectives to be achieved in any land allocation were to maximize output of individual products, eg wood,while maintaining at least the current levels of output of other products, the current conservation and recreational 'value' and employment levels.

Up to this stage Bishop's study did not differ markedly from many planning exercises in the type of information collected, although his emphasis was clearly quantitative and systematically related to the initial land classes. However in the final stage, to examine the optimum distribution of land uses to achieve particular objectives, he used linear programming rather than the more generally used methods of overlay and sieving. Linear programming of the computerized data simply allows a more detailed examination of the complex set of combinations of land use than is possible by conventional methods.

The detailed results of Bishop's study are not relevant here but they indicated, for example, that within the current constraints of designated land, output of timber could be achieved by afforestation mainly in marginal land classes. To compensate for the loss of agricultural production from the marginal land some

redistribution of use on the remaining land is necessary to maintain the agricultural output. Thus it is important to recongize that a variety of patterns of use can achieve similar levels of output, the linear programming model being designed to identify the optimum pattern for particular objectives.

There are many problems involved in such an exercise, not least in the comparison for material and aesthetic uses, the accuracy of the production values, the sensitivity of the model to changes in variables and the difficulty in testing the validity of the projections. However, these are the same problems that apply to most planning situations and methods. They may be phrased in a different language but the model is basically following the same steps which are traditionally taken in the mind of the planner. The model however makes the assumptions explicitly and allows the planner, or more likely the group of planners, to explore the complexities of the situation, integrating the data which he has painstakingly collected and examining its strengths and weaknesses. This approach is an aid to the critical thinking of the planners, just the same as the soils map or the estimates of land capability.

EXAMINING THE COMPATABILITY OF LAND USE POLICIES

Whether considering policies dictated by Government Departments or proposed by local pressure groups, it is often necessary to consider how the competing interests can be accommodated within a land unit. An example of this type is provided by a development of Bishop's model applied to the Sedbergh District, a small part of Cumbria, by Smith and Budd (1982).

Within the Sedbergh District the main elements of the policies of the agricultural, forestry and conservation organizations were identified as protection of the broadleaved woodlands, good quality agricultural land, Common Land and sites of conservation interest and restriction of coniferous afforestation to the poorer agricultural land. To translate the various policies into a general strategy for the area, representatives from the interested organizations participated in identifying the acceptability of land uses in specified land classes.

From local information the productivity of the land classes was defined and in combination with the identified policy aims, was incorporated into a linear programming model for the district. Economic values were placed on material inputs and outputs to provide a common criterion for comparison of agriculture and forestry. In the absence of an acceptable economic assessment of the conservation value of particular areas, those areas were excluded from the optimization sequences.

The model was used to identify the distribution of land uses which was compatible with the various policies and Figure 1 maps the land use pattern which would maximize expansion of afforestation while protecting land identified in the policies of other users. Afforestation is projected mainly on the upper slopes and the pattern of uses largely corrobates general opinion on the preferred solution. The critical assessment therefore provides quantitative support for the policies and collaboration in the assessment helps to provide a better understanding of the interactions between uses. The financial expression of the data also allows the possible effect of changes in economic value to be examined, indicating areas where a decision on land allocation is least likely to be affected by external factors.

COMMUNICATION AND IMPLEMENTATION

An important feature of the Sedbergh study was the participation of the policy organizations in the definition of the information included in the model, in identifying options to be examined and interpreting the results. In many ways these organizations or individuals are the planners and decision makers or have the capacity to promote land allocation. The model provided a common focal point through which they could interact, expressing their views in a precise, quantitative form, the consequences of which could then be examined. Such an approach has been a characteristic of the planning methods developed by Holling and co-workers in Canada and seen in the involvement of local land owners in the planning of the recreational development of the alpine village of Obergurgl (Holling 1978).

Problems of implementation, through the absence of an overall authority or the presence of a number of land owners, are largely outside the scope of the use of quantitative models. Such problems exist with any planning situation but

the use of financial incentives and advice are well tried solutions. However the approach of modelling can help in examining the level of incentive that can tip the economic balance from one land use to another. At this point we return to the early stages of the planning processes, that of monitoring to detect the rate of change resulting from the implementation of decisions.

CONCLUSIONS

The examples given above have been drawn from a very limited set of studies. It is easy to argue over detail, but the intention of this Appendix is to emphasize the need for, and the value of, the distinct stage of examining options for land use allocation. The use of various forms of models encourages the definition of policies, exploration of a range of options and the interactions between land use. Although such models are far from perfect, their flexibility allows ideas and information to be explicitly incorporated into them. They represent technical aids which reduce subjectivity at a stage which is traditionally left to debate, and increase the use of the comprehensive data which are usually collected in the early stages of the planning process.

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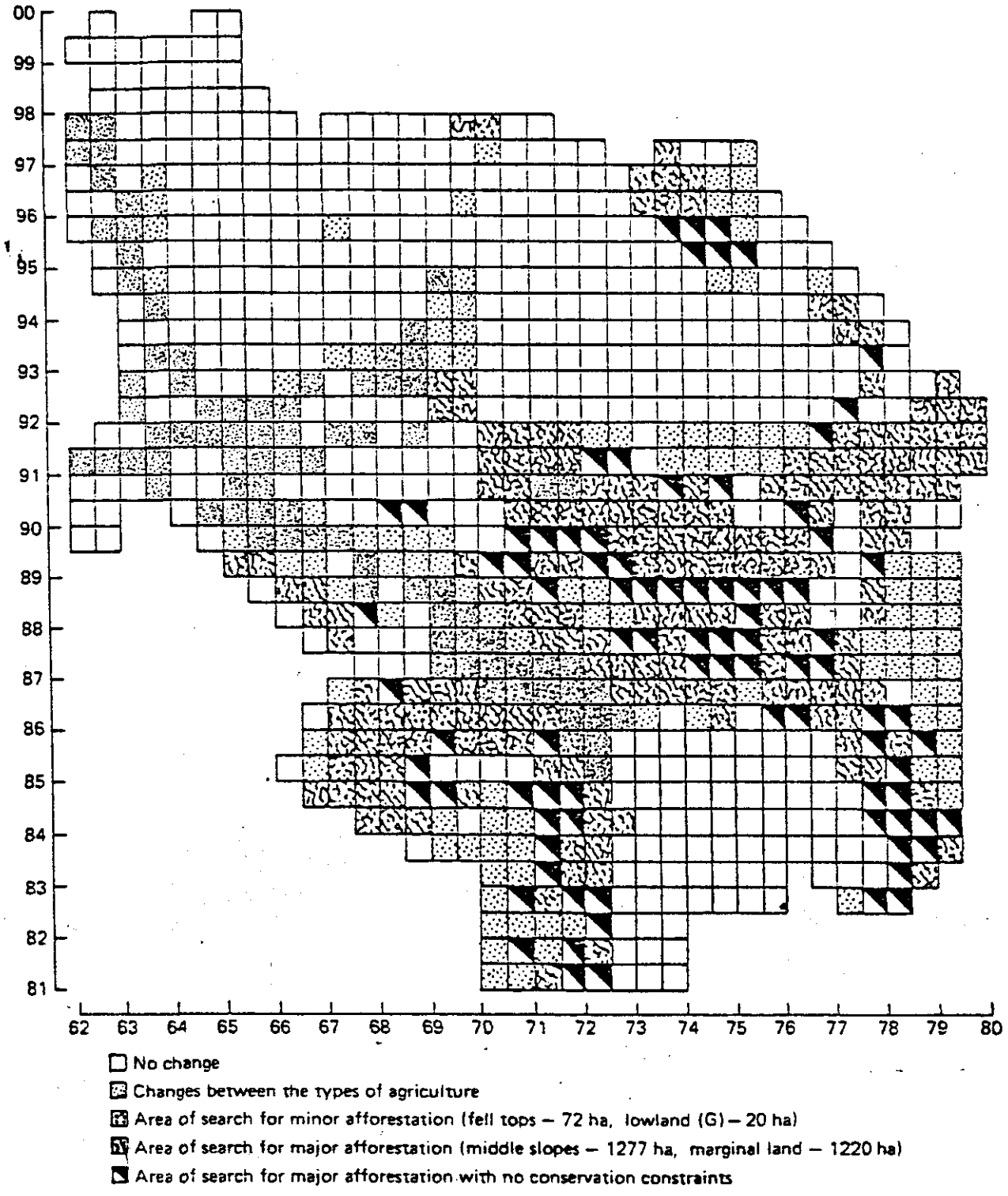

Appendix Figure 1. POTENTIAL LAND ALLOCATION IN THE SEDBERGH DISTRICT OF CUMBRIA

An example of the land use pattern which could allow increase in forestry, with minimum disruption of land use policies defined by other agencies. (From Smith & Budd 1982)

RESEARCH NEEDS IN FORESTRY

Topics identified as in need of further research by a workshop sponsored by the University of London Interdisciplinary Committee for the Environment and the Natural Environment Research Council, March 1982.

The workshop identified 36 topics (grouped under nine headings) as needing further research. These topics were not ranked in order of priority for the following reasons:

i) all require attention and it is not possible to forecast the implications that research on these topics could have for forestry;

ii) the workshop particularly emphasised the importance of interdisciplinary approaches which could involve topics listed under more than one heading - effective collaboration between different disciplines can produce results of greater long-term value than in-depth studies of various problems, however excellent these may be in their own right;

iii) forest structure is continually changing - the workshop recognised the need therefore for sequential and comprehensive series of observations, whether they be concerned with root growth, nutrient cycling or the developmental changes from sapling to mature tree;

iv) the proper division of effort between basic and applied research, though not discussed at the workshop, is clearly a matter of considerable importance for those concerned with the funding and direction of research.

1 LAND USE

The key question is - 'how can we achieve an optimum balance between increased forest production and other land uses?' To answer this we need to:

- investigate the direct and indirect effects of forestry on agriculture

- develop critical methods for assessing conservation and amenity benefits, and for evaluating the net effects of other interacting land use options.

2 SOILS

UK foresters have been 'creating' forest soils since the Napoleonic Wars, a process which has increasingly led to expansion onto otherwise intractable soils (such as peat bogs and upland heaths) involving heavy inputs of energy. We need to:

- study the effects of site preparation on soil characteristics and tree stability

- further determine the factors affecting root distribution

- evaluate the cycling of nutrients, with special attention to functional processes - the interactions of these processes with the carbon cycle need further study

- investigate those aspects of the management of stands which may maximise both the efficiency of use of soil nutrients and the returns from fertilisers.

3 HYDROLOGY

Hitherto research has concentrated on the question 'do forests use more water than does grass?'. The crucial question now is 'how do forests affect seasonal run-off and hence reservoir yield, river flows and so on?' We should:

- extend the detailed studies carried out on Plynlimon to afforested catchments of different ages in different climates and soils, with particular reference to the probability of flash flooding

- study the effects of afforestation and of felling on water quality (involving the determination of ion balances), potability and stream biota

- investigate the surface resistances and transpiration of a range of tree species and provenances.

4 PATHOGENS

The most frequent cause of disease is a disturbance of the balance between host and pathogen, often arising from the conscious import of exotic tree species or the inadvertent introduction of exotic (or more virulent) pathogens. We should undertake:

- anticipatory research, involving the selective study of potential pathogens of trees grown in Britain, both native and introduced

- studies of variation in the virulence of pathogens and in host resistance

- consideration of the problems associated with clonal forestry (for example, the desirable degree of diversity).

5 INSECT PESTS

Whilst species colonising introduced trees in Britain should be recorded and their native habitats should be identified, such information is likely to be of limited value for the prediction of outbreaks of damaging pests. Efforts should be concentrated on:

- investigations of host/site/pest interaction

- factors affecting the dispersion of insects

- methods of applying control agents (insecticides, viruses, pheromones, or others)

- monitoring the effects of such control agents on non-target species

- the identification and isolation of viruses with appropriate pathogenicities and specificities, in particular for the control of:

  larch sawfly (Cephalcia lariciphila)
  pine looper (Bupalus pinarius)
  pine shoot moth (Rhyacionia bouliana)

6 PHYSIOLOGY

The main contribution of physiology to forestry is in providing a better understanding of the factors, both internal and external, which affect and control the growth and reproduction of trees. Useful information is likely to come from research carried out on a wider range of species than those of particular interest to commerical forestry. Topics needing further work are:

- the identification of inherent factors determining yield in both quantity and quality, including tolerance of nutrient deficiencies and upland conditions

- the physiology and structure of roots, with particular emphasis on windthrow and nutrient uptake (including the role of mycorrhizas)

- studies relating the size, form and wood properties of mature trees with their early growth, to provide a basis for the recognition in young trees of characteristics important later on - this information would be particularly valuable for Sitka spruce

- investigations of the physiology of flowering (with information needed on Sitka spruce, beech and oak), juvenility and ageing, and vegetative propagation, including tissue culture

- the determination of the factors controlling seed viability, productivity and germination.

7 GENETICS

Although foresters have attempted for many years to improve the quality of their breeding stock, there is much basic research required on:

- the effects of selection on a wider range of species than at present studied, using both provenance trials and laboratory testing

- the amount and significance of inherited variation in both coniferous and broadleaved species

- changes in progeny and clone characteristics and performance with both age and stand development, also an examination of the potential for exploiting genotype-site interactions

- the inheritance of wood properties

- research into seed orchard management

8 MANAGEMENT OF BROADLEAVED WOODLANDS

The primary aim of research is to determine the influence of management on timber production, nature conservation, and other benefits. We need to:

- define the extent and nature of broadleaved woodland in Britain, and classify it with reference to timber production, wildlife conservation, landscape, amenity and other uses

- investigate silvicultural and management techniques (especially weed control), with the aim of decreasing costs while maintaining or improving tree yield and quality

- develop methods for the production of fast growing, high quality planting stock, in particular by investigating provenance differences and clonal propagation

- investigate the wood properties and potential uses of broadleaved trees.

9 WILDLIFE AND CONSERVATION

Vertebrates (especially red deer) may be simultaneously pests, resources for food, and a valuable amenity. There is a fine balance between control and conservation. We need to:

- identify and evaluate the effects on the natural fauna and flora mosaics of planted and unplanted blocks of different shapes and sizes

- study the role of deciduous islands in providing wildlife habitats in coniferous woods, and determine the effects of areas grown beyond their normal rotational age

- quantify the effects of forests and fauna and flora in their vicinity

- investigate the biology and behaviour of squirrels (both red and grey) and all deer species in relation to their effects on the development of natural and man-made woodlands.'

RESEARCH RECOMMENDATIONS FROM CENTRE FOR AGRICULTURAL STRATEGY, REPORT 6, 1980: STRATEGY FOR THE UK FOREST INDUSTRY

'Increasing the level of self-sufficiency in timber involves:

i) improving the output from each forest to a level that can be sustained without risk of higher costs in the future;

ii) improving the efficiency of utilisation of the wood from each tree or ha of land.

To achieve these objectives, research must continue on a wide range of topics.

WOOD PRODUCTION

i) Research is needed into: the ecological basis of production; site selection and treatment; interactions between sites and species or provenances; alternative methods to give sustained production at a site without risk of soil deterioration (including cultivation, drainage, fertiliser use at planting and during the life of the plantation).

ii) Research continues to be necessary on harvesting methods and basic forestry engineering. Safeguards and long-term monitoring are needed to reduce the risk of site deterioration. Efficient production and utilisation of wood starts at the stage of harvesting, and the greater the volume harvested the greater the risk of site deterioration, especially on the poorer soils normally used for forestry.

iii) To provide hardy species which give good volume and quality production for specific site conditions, research is needed on tree physiology, species selection and tree breeding. Most species and breeding research in the UK is currently concerned with conifers, though investment per unit of value produced is less than for agricultural crops. Research into broadleaved species lags even further behind; more work is needed on breeding, silviculture and production of nursery stock.

iv) Research must continue: silvicultural systems (alternatives to plantation forestry); improved means of propagation and establishment; work to suit species to sites; the feasible extent of integration of farming and forestry; modifications of silvicultural systems to cater for the needs of amenity and wildlife.

v) A continuing programme of protection research is essential where intensive timber production is practised. This includes: entomology and pathology; effects of application of chemicals; biological control of diseases and pests.

In attempting to raise productivity rapidly at a time when energy costs were still relatively low, the Forestry Commission concentrated on high input forestry. Difficult establishment conditions or pests have been dealt with using low labour, high capital input methods. Such solutions may no longer be feasible.

Moreover, the use of cropping systems which are radically different from natural systems may have side effects still unknown. The possibility that the inherent value of land may be eroded requires urgent study; so that techniques may be developed which give sustained production without damaging the soil or the environment.

WOOD UTILISATION

Members of the Home Grown Timber Advisory Committee (HGTAC) include: the Forestry Commission (FC), industrial interests and the forest products laboratory of the Building Research Establishment. Some research at the laboratory of the Building Research Establishment is sponsored by the FC and industry directly. An institutional framework for research exists, but it appears that at present resources are thinly spread, resulting in a piecemeal approach to the major problems of the industry, such as: timber properties and utilisation, preservation and finishes, products and product development and marketing (Building Research Establishment 1979). Work is needed in the following fields:

i) timber drying and preservation: extending the life and determining the best use of home-grown and imported timber (new processes are needed which can be adopted by small sawmills and timber yards);

ii) marketing British timber: grading techniques and machinery; revision of specifications as necessary, and suiting timber produced to a wide range of applications;

iii) improving design methods to save timber whilst retaining strength and safety; further research on glues and resins for bonding solid wood and panels components;

iv) reducing sawmilling wastes and residues to a minimum, for example by the development of techniques to cut wood smoothly, also by making full use of residues (including degraded waste) for secondary products. More work on recycling forest products is also needed.

FORESTRY-RELATED FUNDAMENTAL RESEARCH

To allow the forest industry to anticipate and provide for possible future developments, more basic research is needed on:

i) the effects of forests and other vegetation types on terrestrial hydrology, to make possible a rational approach to the problems of competitive land use;

ii) the physiology of trees and the interaction of physiology and climate;

iii) animal behaviour and demography and the survival of plant species in changing environments, so as to forecast likely effects of further afforestation on wildlife conservation;

iv) the effects of forests on soils: the likelihood and nature of deterioration in site quality need to be identified;

v) the ecological systems underlying all forms of forest life, from trees to their pests;

v) the assessment of forestry research - should projects be measured in terms of their cost-effectiveness, their efficiency with respect to energy input, or by other criteria?

SOCIO-ECONOMIC RESEARCH

Increased afforestation and timber production affect other fields giving rise to the following questions:

i) What are the implications of forestry for regional development?

a) What are the needs of rural communities? Should capital or labour intensive methods be preferred? How should labour be organised to overcome fluctuating labour demand at any forest site?

b) How will the introduction of forestry or integrated forestry and farming affect the infrastructure of the rural economy, employment and tourism?

c) What is the optimum structure of the UK wood processing industry and how can it be achieved? Where should mills be located?

d) What needs are there for extended training and education facilities for forestry and wood processing? How can safety standards be improved?

ii) What are the long-term implications of afforestation of leased or tenanted land?

iii) How important are forests as a recreational resource: should they be developed and if so, how? What else can be done to conserve wildlife in the countryside?

iv) What sort of product should be produced for future needs (what proportion of hardwood and softwood, sawlogs and smallwood?

v) How well can prices be forecast? Is the present system of incentives and taxation adequate to promote the desired level of private sector planting?

The interactions of forestry with other uses of the land require detailed analysis so that the costs and benefits of afforestation may be accurately quantified and evaluated. Also, the economics of alternative silvicultural systems, including integrated farming and forestry, require further investigation.'

MAJOR AREAS FOR RESEARCH DEVELOPMENT IN BIOFUEL PRODUCTION IN UK

RECOMMENDED BY CARRUTHERS AND JONES (1983)

i) ECONOMICS

a) Detailed economic studies of particular biofuel production opportunities, such as wood energy plantations in the uplands.

b) Exploration of markets for specific technologies (eg on farm or regional anaerobic digesters, gasification plants) as determined by feedstock availability and energy demand.

ii) POLICY

a) An assessment of the relative strategic value of food, fuel and timber production at a national level.

b) Studies of the social and economic implications of the development of biofuel production at the local, regional and national level.

iii) FEEDSTOCK PRODUCTION

a) Full-scale demonstration of the most promising systems (eg wood energy plantations, bracken management).

b) Further research on existing and novel fuel crop species to improve yields and ease of management.

c) Development of harvesting machinery for fuel crops and residues.

d) Development and demonstration of agroforestry systems and the integration of biofuel production with crop and animal production, and recreation.

e) Research on integrated systems of production, energy use and recycling of wastes and nutrients.

iv) FEEDSTOCK CONVERSION

a) Pilot plant demonstration of technologies such as thermal processing to produce methanol and substitute natural gas.

b) Further development of other technologies, such as anaerobic digestion, to produce cheap, reliable and simple systems for use on the farm.

v) FUEL UTILISATION

a) In the short term - development and demonstration of the use of biofuels as substitutes for, or additives to, conventional fuels, and their use in conventional engines, boilers and furnaces.

b) In the longer term - development of engines specifically designed for biofuels and of multifuel engines.

INSTITUTE OF TERRESTRIAL ECOLOGY PROGRAMME 13:

LAND RESOURCES AND LAND USES

The primary objective of the Programme is:

> ' To produce analyses of the environmental characteristics of the land resources of Britain, and of how these resources are now used. These analyses will summarise why the present land use pattern has developed. They should enable predictions of the changes in land use that may occur over the next 20 years, and the ecological implications of such changes, given either the continuation of present trends, or alternative policies. '

Such ecological assessments are required at regional, national and international levels. They are needed to inform and support planning policies and decisions, as components of a wide range of research projects, and more generally as sources of data. Every effort must be made to achieve compatibility between data from different levels of study. This is essential to ensure effective cross reference between data at regional and national scales within Britain, and should assist comparative evaluations of Britain in the European context.

Liaison with others will be necessary. Opportunities for co-operative work with central executive departments and agencies, regional authorities, Universities and other academic institutions, and with other Research Councils will be sought and welcomed.