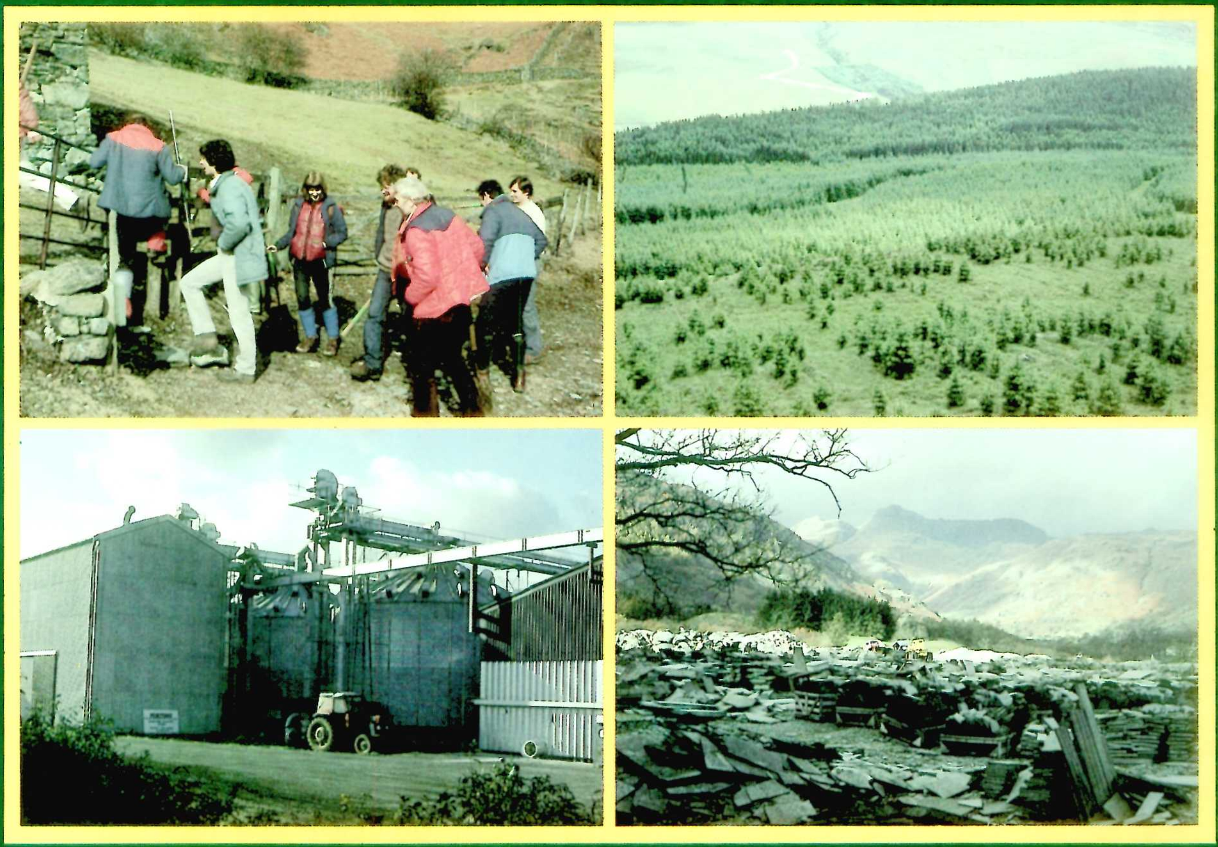
RURAL INFORMATION FOR FORWARD PLANNING



INSTITUTE of TERRESTRIAL ECOLOGY
NATURAL ENVIRONMENT RESEARCH COUNCIL

Natural Environment Research Council

Rural information for forward planning

ITE symposium no.21

R G H Bunce & C J Barr
Merlewood Research Station
GRANGE-OVER-SANDS
Cumbria

INSTITUTE OF TERRESTRIAL ECOLOGY

Printed in Great Britain by
Reminder Press

Published in 1988 by
Institute of Terrestrial Ecology
Merlewood Research Station
GRANGE-OVER-SANDS
Cumbria
LA11 6JU

BRITISH LIBRARY CATALOGUING-IN-PUBLICATION DATA
Rural information for forward planning
ITE symposium, ISSN 0263-8614; no. 21)
1. Regional planning — Great Britain — information services
I. Bunce, R G H II. Barr, C J
III. Institute of Terrestrial Ecology. IV. Series
026'.711'0941 HT 395.G7
ISBN 1 870393 05 8

COVER PHOTOGRAPHS
Some examples of topics involved in rural planning

1. Conservation working party, Langdale, Cumbria (top left)
   Recreational pressures are still increasing in many upland areas and much work is required to restore damage. The group is proceeding to a cliff to repair a path damaged by rock climbers
2. Afforestation of open moorland, Dumfries and Galloway Region (top right)
   Although forestry is outside planning regulations, planting on open hillsides is a controversial issue that is, however, covered by consultation procedures
3. Intervention warehouse, Huntingdonshire (bottom left)
   Agricultural surpluses are at the centre of the discussion about the role of agriculture in the countryside and are likely to have a major influence, both directly and indirectly, in forward planning
4. Slate quarry and the Langdale Pikes, Cumbria (bottom right)
   The maintenance of the countryside in a National Park reflects a delicate balance between traditional activities, such as quarrying, and the semi-natural landscapes of the fells

(Photographs 1, 3 & 4 R G H Bunce; 2 R L Storeton-West

The *Institute of Terrestrial Ecology (ITE)* was established in 1973, from the former Nature Conservancy's research stations and staff, joined later by the Institute of Tree Biology and the Culture Centre of Algae and Protozoa. ITE contributes to, and draws upon, the collective knowledge of the 14 sister institutes which make up the *Natural Environment Research Council*, spanning all the environmental sciences.

The Institute studies the factors determining the structure, composition and processes of land and freshwater systems, and of individual plant and animal species. It is developing a sounder scientific basis for predicting and modelling environmental trends arising from natural or man-made change. The results of this research are available to those responsible for the protection, management and wise use of our natural resources.

One quarter of ITE's work is research commissioned by customers, such as the Department of Environment, the European Economic Community, the Nature Conservancy Council and the Overseas Development Administration. The remainder is fundamental research supported by NERC.

ITE's expertise is widely used by international organizations in overseas projects and programmes of research.

Drs R G H Bunce and C J Barr
Institute of Terrestrial Ecology
Merlewood Research Station
GRANGE-OVER-SANDS
Cumbria
LA11 6JU
044 84 (Grange-over-Sands) 2264

Contents

Page

Preface 5

KEYNOTE PAPERS

The planner's view 6
(H H Jones, Powys County Council, Llandrindod Wells)

Problems of the supplier 10
(M E Taylor, Countryside Commission, Cheltenham)

An independent view 14
(J T Coppock, Department of Geography, University of Edinburgh, Edinburgh)

The approach adopted by Highland Regional Council 21
(C J Claridge, Highland Regional Council, Inverness)

Future trends in information systems for rural planning 29
(P A Burrough, Department of Physical Geography, University of Utrecht, Utrecht, The Netherlands)

POSTER PAPERS

Integration and evaluation of rural policy in a period of rapid change 33
(M Bell, Institute of Terrestrial Ecology, Merlewood Research Station, Grange-over-Sands)

The use of the MAP2 program in landscape planning and research 40
(A van den Berg, De Dorschkamp, Wageningen, The Netherlands)

Woodlands in the Welsh landscape: an analysis based on remotely sensed satellite data and digital terrain information 48
(P A Bradbury*, R H Haines-Young*, P M Mather* and C W Smart†
*Department of Geography, University of Nottingham, Nottingham
†Planning Services, Welsh Office, Cardiff)

The Culm Measures project: a study of how woodlands might augment farm incomes in an area of difficult lowland in south-west England 56
(O H Brandon, Dartington Institute, Totnes)

The National Countryside Monitoring Scheme 66
(J Budd, Nature Conservancy Council, Peterborough)

Statistical and spatial analysis of land resource data 77
(P A Burrough and J van Keulen, Department of Physical Geography, University of Utrecht, Utrecht, The Netherlands)

Classification models and water resource planning 82
(K R Bull, Institute of Terrestrial Ecology, Monks Wood Experimental Station, Huntingdon)

A land resource information system at the 1:25 000 scale 85
(D A Davidson* and G E Jones†
*Department of Environmental Science, University of Stirling, Stirling
†Department of Geography, University of Strathclyde, Strathclyde)

Relational data bases and digital mapping — a flexible approach to information management and display 92
(R G Healey, B A Morris, A J Alexander, D J Bartlett and T C Waugh, Department of Geography, University of Edinburgh, Edinburgh)

Measuring the areas of rural land use parcels 99
(R P Kirby, Department of Geography, University of Edinburgh, Edinburgh)

A technique for assessing wildlife in an arable landscape 105
(R A S Storey and R Tinklin, School of Science, Humberside College of Higher Education, Hull)

WORKSHOP REPORTS

Methods for the identification of priorities in rural planning 108
(M Bell, Institute of Terrestrial Ecology, Merlewood Research Station, Grange-over-Sands)

Perception and interpretation of information for rural planning 109
(C P Mitchell, Department of Forestry, University of Aberdeen, Aberdeen)

Data needs for rural planning 110
(R H Haines-Young, Department of Geography, University of Nottingham, Nottingham)

Final discussion 112
(D K Lindley, Institute of Terrestrial Ecology, Merlewood Research Station, Grange-over-Sands)

Appendix I: List of participants 114

Preface

Increasing pressure on the countryside is one of the major areas of planning concern. In his recent review of the planning system, Andrew Thorburn, Past President of the Royal Town Planning Institute, argued strongly that local authorities bore the responsibility for controlling and co-ordinating rural development, because (i) they have statutory authority under the Town and Country Planning Act, and (ii) they are not governed by the vested interest of individual agencies. In his suggestions for enhancing that role, he proposed that 'authorities should be obliged to seek views from representatives of rural interests and advice from scientific and practical experts'.

It seems clear from the Government response to the Countryside Commission 'uplands debate' that a system of incremental adjustment is seen as the way forward. Major policy shifts are not promised, but local authorities will receive further notification of proposed land use change under the Wildlife and Countryside Act. To react to such notifications, planners need access to information from different disciplines.

Equally, as agencies responsible for the major land issues, ie forestry, agriculture, conservation and construction, compete for the available land, the integration of rural resources becomes an even more critical issue. Furthermore, the available planning methods need to be examined — a need emphasized by the lack of central planning control over major aspects of rural development. Limited control is exercised by the different agencies, but there is no overview of the impacts of the various policies. At a regional scale, other interest groups, such as the National Trust, exercise constraints which also need appraisal.

The conference was called because it seemed timely to discuss collaboration between planners and information suppliers, such as that built up between the Highland Regional Council (HRC) and the Institute of Terrestrial Ecology (ITE). With emphasis on cost-effectiveness and integration, the conference provided a forum for the discussion of various approaches to the problems of collaboration, and demonstrated the range of information available.

Whilst it has taken some time to prepare these papers for publication, the contents are still very topical. Our thanks are due to Mrs P A Ward who has been of great assistance in the editing process and has seen the volume through its final stages.

R G H Bunce and C J Barr
May 1986

KEYNOTE PAPERS

The planner's view

H H JONES
Powys County Council, Llandrindod Wells

Before considering what type of information planners might require for forward planning in relation to rural areas, it is necessary to look first at the context in which rural planners are operating. There are 3 matters to be considered:

1. the attitude of Government towards forward planning;
2. the legislative framework for rural planning;
3. current developments in agricultural and forestry policy.

In relation to the first matter, what the Government appears to be saying at the moment is that it does not want too much planning because without it the free market will operate more effectively, and society would benefit as a result. This attitude was reflected in the original *Green Belt Circular* which, to many people, suggested that the Government, under pressure from the developers, was about to loosen up its Green Belt policy. However, that Circular was rapidly withdrawn in the face of strong opposition, mostly from Tory MPs in the shire counties which would have been most affected by such a change.

However, the attitude towards planning has been raised again in the recent Government White Paper *Lifting the burden*. This document tells us that the development plan process is slow and cumbersome, and that county structure plans contain too much detail.

The attitude of the Government is that the twin priorities of generating jobs and providing land for housing have not been reflected fully or quickly enough in structure plans and the decisions of local planning authorities. The burden of planning must be lifted. The implication behind such statements is that less, rather than more, information will be required in the planning process. These statements, combined with the continuing downward pressure on public finance, mean that any information for forward planning must be firmly directed towards solving real problems.

The second point to understand is that planning legislation has very little to do with rural planning. Development plans tend to be restricted to land use matters which are subject to planning control and influence. Planners have argued strongly that this view is totally unhelpful in trying to solve rural planning problems. The 2 main rural land uses, agriculture and forestry, are largely free of planning control, and the influence that planning authorities can exert on these areas of activity is minimal. It cannot be denied, however, that the impact of agriculture and forestry on the economy and appearance of the countryside and its wildlife is of great significance and is particularly relevant to the planning of rural communities.

There are some who think that the time has come for a considered rural land use strategy, whereas others take the view that co-ordination of rural policy would solve the problem and lead to integrated solutions for rural land use. Although there has been a great deal of talk about the need for co-ordination on rural policy, there are few signs yet of this being achieved. Practical experience suggests that co-ordination can only be successful if incentives are provided or some penalty imposed if it is not achieved. Of course, when planning legislation was being framed, farmers were seen quite rightly as guardians of the countryside, but in the past 40 years that view has changed. Government policy has been aimed at increasing agricultural production and many incentives have been offered to achieve it. The result is that farmers have now come to be regarded by many people, including politicians, as destroyers of the countryside, rather than its guardians.

That leads to the third point in the consideration of information for forward planning, the changes in the policy areas of agriculture and forestry. In relation to agriculture, there is the new Commission of the European Communities (CEC) Agricultural Structures Directive and the recent consultative paper of the Ministry of Agriculture, Fisheries and Food (MAFF) on the new Farm Capital Grants System. One of the ideas advanced by the UK Government was that of Environmentally Sensitive Areas (ESAs), which were, in the words of MAFF, areas of national importance, which, in practice, many people believed would mean Sites of Special Scientific Interest (SSSIs) in National Parks and Areas of Outstanding Natural Beauty. However, the alternative view is that there are areas of regional significance which would benefit from this designation. The purpose of designation is to assist farmers to introduce or maintain agricultural practices which are compatible with the requirements of protecting the countryside. The scheme will not, at present, receive funding from the CEC and that is, no doubt, the reason why the UK Government is being cautious about its application.

There is a proposal to introduce enabling legislation in the 1985–86 session of parliament, which will provide a significant change in agricultural finance and has obvious implications for rural land use planning.

There are other matters within the CEC Directive which have a bearing on conservation, and the Association of County Councils has been pressing for prior notification of Agricultural Grant Schemes to county planning authorities, who would then be able to exercise some control over potentially damaging operations. This system already operates successfully in National Parks.

There are also policies for woodlands on farms which are of interest. In relation to woodlands, however, the main change is likely to be in the introduction of the Forestry Commission's new broadleaved policy which, for the first time, recognizes the value of existing broadleaved woodland and the need to secure effective management to take account of conservation, as well as commercial, interests. Policies on afforestation, however, show little change. There continues to be a high degree of interest in Forestry Grant Schemes by private investors, which seem likely to continue and may even increase in scale if hill and upland farming runs into difficulty. The recent Nature Conservancy Council (NCC) publication on *Forestry and conservation* sets out the problems and shows a way forward. All of these changes point to the need for sound information which will assist in land use decisions.

That is the background against which the information required for forward planning needs to be considered. The comments below are drawn on experience in 3 areas: the Powys woodlands survey, the mid-Wales uplands survey, and experience in the Nature Conservancy Council's Advisory Committee for Wales.

There is undoubtedly a need for a rural land use strategy in this country,not involving a grand monolithic plan but rather a flexible strategy which would try and effect some balance between agriculture, forestry, conservation and the socio-economic development of rural communities. Considerable amounts of public money are currently being invested in agriculture and forestry, and there is increasing concern about the effects of such activities on conservation in a broad sense. There is, as yet, no clear policy framework within which conflicts might be resolved, and attempts to provide such a framework, eg the Lofthouse report on the Llanbrynmair area of mid-Wales, commissioned by the NCC, have not met with success.

It seems, therefore, that there is a strong case for a rural land use strategy which would provide a framework for the considered use of community resources.

The policy at present appears to be increasingly to afford protection to certain limited areas of countryside, such as National Parks and SSSIs, leaving the rest of the countryside to take care of itself. Examples of such a trend are seen in the recent introduction of Special Landscape Orders to cover the whole of National Parks, and in the arrangements introduced for prior notification of Agricultural Grant Schemes which applies within National Parks and SSSIs only. Such policies emphasize, however, that, there is an urgent need to give greater attention to the management of the wider countryside. County planning authorities have an opportunity to develop strategies and to implement them in management arrangements through their structure plans, and also by carrying out work directly, often using Manpower Services Commission Schemes.

To be effective, planning authorities need sound, concise and understandable information. The information will come from a variety of sources and at the end of the day will, in its interpretation, be subject to value judgements, some of which will be politically influenced.

The *Nature conservation review* demonstrated how it was possible to develop a rationale for identifying important sites of nature conservation interest, but experience, again in the Berwyn Mountains of Wales, showed that early work which concentrated on botanical interest needed to be broadened to take account of ornithological factors. When that was done, the areas appropriate for designation as SSSIs expanded enormously.

The 1957 notification of Moel Sych in the Berwyns covered 3662 hectares, while the 1983 designation of the Berwyns was for 15 301 hectares, over 4 times as large an area. Even then, NCC was criticized by the Royal Society for the Protection of Birds (RSPB) for not having designated a sufficiently large area. The farmers and landowners, on the other hand, strongly opposed such a large designation.

The main conclusion to be drawn from such conflicts is that sound information, which will stand up to vigorous scrutiny, must form the basis of such designations. Value judgements were also shown to influence the final form of designation. At that level of operation, where the designation of SSSIs involves an established legal framework, the research needs to be very thorough.

In other areas, the situation may be different. In the case of Llanbrynmair Moors, which was another interesting exercise in mid-Wales, what was being sought was a strategy which would reconcile farming, forestry and nature conservation interests.

Landscape conservation, however, was not a consideration. The exercise aimed to identify which land was reasonably capable of agricultural improvement, which was suitable for growing trees, and which needed to be conserved. The areas overlapped, and judgements were required about the relative value of the various interests.

Although there appeared to be real scope for developing an integrated land use pattern, with farming and forestry, in particular, operating in an integrated way, this result was not achieved. What did happen was that the landlord sold off the farms to the tenants who, in turn, sold off land to a forestry group in order to finance agricultural improvements, some of which were on land which would have been better growing trees. So, information is not sufficient; there must also be the political will to see that action follows. Such a framework is not yet available, but the proposals for Environmentally Sensitive Areas offer a potential solution.

It seems to be sensible, despite all the obvious difficulties, to identify which areas can and should be reasonably developed or conserved for various purposes, even though, at the end of the day, individual landowners may decide to do something quite different. Where public money is involved, however, this could be directed towards achieving integrated rural land use policies. It has been interesting to see, from the mid-Wales uplands survey which looked at land use changes over the post-war period, that the same areas of land may have undergone a series of reclamations for agriculture and reversions to rough pasture. It is thus more than likely that grant aid has been given to the same area on more than one occasion. The question is, therefore, raised about whether the best use is being made of resources, and is a further indication of the lack of information about the need for reclamation in relation to a particular farm unit and the costs of maintaining reclaimed areas in the future. These decisions must then be set out within the context of the needs of conservation.

The one information area that has so far defied objective assessment is that of landscape appraisal. There have been numerous attempts at such assessments, but none have proved completely successful. Beauty is still, it seems, in the eye of the beholder. Nevertheless, any countryside strategy must take account of landscape and attempt to place a value on it.

Another area where we need information if we are to make reasonable judgements about land use is in relation to the rural economy at a local level. For example, the investigation by Dyfed County Council into the effects of milk quotas has shown how such decisions can have wide-ranging and long-term effects on a local economy. At another level, the recent moves to stimulate farmers' interest in the conservation of small woodlands will probably depend, for their success, as much on information about commercial management and marketing as on data about landscape and wildlife.

The uses to which the information currently being gathered is likely to be put need constant surveillance. Otherwise, there is a danger, well known to all planners but not always recognized, of making data collecting an end in itself. The Powys woodlands survey is an example, where so many data were collected that there was a risk of not being able to 'see the wood for the trees'. The fact that the purpose of such information gathering is to aid management decisions about woodlands must always be borne in mind.

The second danger to be guarded against is an overemphasis on one element, often related to the particular interest of the investigator. In Wales, it seemed at one time that the conservation of wetlands was receiving too much attention to the exclusion of other important sites, eg woodlands. The danger is that overemphasis on one area of data collection and analysis can distort policy-making, and does not therefore make the best use of resources.

There must be a reasonable balance in data collection and analysis — between accuracy, completeness of coverage, the value of data and the cost of collecting and analysing that data. It must also be borne in mind that decisions will rarely wait for the completion of data collection to the standards sometimes perceived by researchers. Speed is often as important as completeness. Traditionally, planners have operated on the basis of survey — analysis — plan, and such a procedure should form the basis of rural planning. That process may need refinements and additions, but it is still basically sound. Taken in the context of structure plan preparation, national and regional policy needs to be taken into consideration. It is in this area that rural planning is lacking direction, and better guidance is needed on agriculture, forestry and conservation policy, in particular. More information is also required to assist mineral extraction, tourism, and recreation planning when taken in conjunction with rural socio-economic factors.

At a more local level of planning, information is required at 2 levels, one of which will provide a basis for safeguarding important conservation sites, and needs careful surveillance. At the other level, information is needed to guide broad land use policies. For example, in the Powys structure plan there are Nature Conservation Zones, where it is intended to introduce management arrangements to integrate conservation, farming and forestry interests. The plan is not very effective, of course, because the appropriate mechanisms to make such a policy work are lacking. However, it is used in examining proposals for Forestry Grant Schemes, and the new proposals for Environmentally Sensitive Areas could also provide an improved mechanism for management. The information for designating Conservation Zones was provided by NCC after a rapid consideration of conservation requirements, derived largely from existing records. This work has been refined and extended subsequently, and we now have new SSSIs in a number of Zones.

The rapid approach, without exhaustive investigation, met the planning needs at the time quite adequately, and has much to commend it.

The Powys woodlands survey, carried out under a Manpower Services Commission Scheme in close collaboration with the Countryside Commission, NCC and local naturalist groups, has been used as an advocacy document in relation to the Forestry Commission's *Broadleaved policy review* and will be used in conjunction with the Welsh Wildwoods Campaign. Survey and analysis show an important but deteriorating resource. The objective of data collection and analysis is to introduce woodland management schemes and agreements to protect the best woodland sites. The information gathering, therefore, is a clear aim that can be monitored effectively.

In addition to the process of survey — analysis — plan, therefore, monitoring and review are also required, and the gathering of information which will assist in making the right management decisions. Again, referring to woodlands, management regimes need to be devised which can be implemented by the farmer and in which he will be interested, albeit with assistance in the form of grants where necessary.

Turning back to SSSIs, the designation of an area of wetland is of limited use, without appropriate advice on the management of the catchment area for that wetland. Appropriate information is, therefore, required as the basis for management plans, particularly where multiple uses are involved.

In conclusion, there is an urgent need for meaningful forward planning in rural areas, although the attitude of Government is not helpful. The development plan system provides an appropriate framework and, in the absence of any central initiative, local planning authorities need to give urgent attention to devising appropriate rural policies. Such policies cannot be meaningfully devised without adequate information and analysis. Local authorities and others are able to implement policy to some degree, and they require information on which to base management decisions. There is, then, a need for continuous monitoring and review, in order that the effects of decisions may be understood and that the same mistakes are not repeated.

The need to have a purpose in collecting data must constantly be borne in mind. All too often, data collection is not properly directed with clear objectives, and accuracy sometimes has to be traded off against time and cost. The 'quick and dirty' approach is often the one to adopt, allowing for later refinement. Furthermore, before embarking on a new venture, it is essential to assess existing knowledge about the subject.

The position is complex and difficult to manage, but, if there are no attempts to introduce better relationships in rural policy-making, then there is the danger of doing irreversible harm, not only to the countryside and its wildlife, but also to the rural communities.

Problems of the supplier

M E TAYLOR
Countryside Commission, Cheltenham

1 Introduction

The purpose of this paper is to introduce issues facing the supplier of information for rural development planning. As it is widely known, the Countryside Commission is neither solely a supplier of information in the purest sense nor solely an end user. Its role is largely that of the middle man, the disseminator and collator of other people's data sets. The Countryside Commission has to consider both the supply and subsequent use of data, and is, therefore, concerned with both aspects at different times. However, on consideration, most people also service the needs of other users, as well as being users themselves; for example, a computer analyst will provide programming advice, as well as use data for his own purposes.

2 Problems of supply

Over the years the Countryside Commission has attempted, on several occasions, to establish reliable data sets for a variety of purposes. In a number of cases, these experiences were not altogether happy ones, and they do identify some of the problems facing both the supplier and the user of rural planning information.

As a provider of information, the Commission is often in the position of collating data collected from a variety of different sources. Similar problems are encountered in the development of collated data sets, whether a single source is providing data in a continual flow over a period of time, or whether the data are from a multitude of sources.

In the early years of its development, the first and most obvious problem which the Commission experienced was the difficulty in obtaining reliable observations as the basis of the data set. The second problem related to motivation of the suppliers of the information.

An example of the first type of problem is the Countryside Commission's attempts in the late 1960s — early 1970s to carry out a project looking at the changes in the English landscape, *The changing countryside* project. The principle behind the method was that a number of trained observers would be commissioned to carry out surveys on sample kilometre squares throughout England and Wales. In order to overcome some of the difficulties encountered in previous exercises of this type, it was decided that all the supervisors of the observers should undergo fairly intensive training. These supervisors would then be responsible for training the individual groups of observers. The participants were mainly senior teachers, usually working on environmental studies at GCE 'O' or 'A' level, and the actual observers were mostly 'A' level students who would be involved as part of one of their 'A' level studies, usually geography. After a considerable amount of effort and time, the Commission abandoned the enterprise for the simple reason that studies showed that neither the supervisors nor the observers could make consistent and reliable observations. These problems extended to what might have been considered to be apparently easily recognizable features in the landscape, such as hedgerows and other field boundaries, watercourses, and trees or groups of trees. Once it came to looking at more complex assemblies or where more judgement was required, such as vegetation types, these problems became even more pronounced. There were also significant problems in upland areas with the identification of sample areas on the ground. It was with considerable reluctance that, after several attempts to overcome these problems, the Commission decided that it was virtually impossible to actually put together a data set which would serve any useful purpose, if it were based on the observations of a number of independent people, no matter how well they had been prepared.

The second type of problem facing the supplier is the motivation of the providers of the raw material. An example was the attempts of the Commission in the late 1970s to act as the collator and disseminator of basic information on National Parks in England and Wales, following a recommendation in the Sandford report concerning the role of National Parks and, in particular, the role of the Commission in supporting their development. The basic premise seemed reasonable enough, that somewhere within the country there should be an authoritative and reliable set of data concerning both social, economic, conservation and recreational attributes of 10 National Parks. This task did not seem to be a difficult one, given that all of the National Park officers are extremely well motivated and concerned with the development of their own Parks, as well as the national concept. However, again, we experienced problems in defining exactly what data should be made available and how they should be collected. One of the difficulties experienced was that people seemed only prepared to provide help with the collection of data which they personally could use or needed. The difficulty with the 10 National Parks is that they each have their own particular priorities and problems, with the balance of interest varying from one to the other. As a result, the data which would normally be assembled by each Park were extremely variable when viewed from one Park to another. Over the 3 years in which we attempted the exercise, the results suggested that it was really not providing reliable and consistent data at a national level. Even such fairly simple things as the number of visitors to visitor centres produced problems because of the different methodologies used for estimating or counting. The Commission was faced with the choice of producing a national data set which was known to be faulty, or alternatively producing no data at all, and the latter option was chosen.

However, the Commission is now looking at ways in which a national data set can be provided which relies entirely on data normally and regularly produced as part of the day-to-day business of the Parks, rather than by the approach in the late 1970s when Parks were requested to collect data specifically for the national data set. Whilst this problem may be identified as being one of motivation/commitment, it should not be seen in any way as a criticism of the way our National Park staff co-operated on this project. It merely reflects the reality that the quality of data seems to be directly proportional to the potential usefulness of the data to the observer.

3 Problems of use

Turning to the other side of the Commission's role in this exercise, that of the user of information, the problems are to some extent the obverse of the ones identified above.

Invariably the use to which the data are put is not the one for which they were originally collected. This situation produces problems of interpretation and, in many cases, raises doubts about real utility of the information. Another problem facing the user of any data set is to understand the errors and confidence which the supplier of the data can place on the information provided.

In scientific work generally, it is normal to express observations and results within defined statistical confidence limits, and it is therefore surprising that in countryside conservation and rural planning the notion of confidence limits appears to be the exception rather than the rule. This situation can cause particular difficulties in examining trends, which is often the only way in which to make judgements about whether particular policies are appropriate or not, or about what, in reality, they are achieving. It is important, therefore, to be sure that, when data on change are being examined, it is known whether or not the errors inherent in those data are so great as to invalidate or undermine any conclusions reached.

A third problem, which is linked to some extent to those above, can occur when data have been collected with vague or imprecise definitions. Such data lead to discussions as to whether or not the trends shown are significant in policy terms. Time and effort will also be spent arguing about whether the trends actually are as they appear, or whether they are merely the function of shifts of emphasis in definition or interpretation. To some extent, this uncertainty is also reflected in the Commission's experience with *The changing countryside* project.

Fourthly, perhaps the most fundamental problem for the user of information is actually determining what is available and where it can be found in an appropriate format.

An example of the first of these problems is given by the experience the Commission gained in producing its discussion documents on the uplands. The first of these documents was an attempt to produce a summary of what had happened in upland England and Wales over the last 10–20 years, in terms of social, economic and conservation interests. It was decided that one of the issues that should definitely be examined was shift in population of the areas. This aspect was seen to be particularly important because of a common assumption that there was a continued drain on the rural population towards urban centres, and that this drain would be magnified within the uplands of England and Wales. An obvious starting point was the national census carried out by the Office of Population Censuses and Surveys (OPCS). The Commission had carried out a fairly detailed summary of the demographic characteristics of the National Parks based on the 1969 census. It seemed reasonable, therefore, in 1980–81 to use the data from the 1979 census for updating. However, some problems were encountered because the census had not been constructed to recognize the boundaries of National Parks, so that OPCS had to interpret the boundaries in terms of innumeration districts. Whilst it was realized that this interpretation was bound to produce some problems, it was surprising that some peculiar errors were thrown up, at least on the first attempt. In one National Park, for instance, the OPCS data overestimated the population by 13%, while in another National Park the population was underestimated by 14%. These differences are obviously significant when set against the sort of trends involved in the study. The explanation for such differences was the way in which the enumeration districts had to be assigned across the Park boundaries, as these did not necessarily correspond to the boundaries of the districts themselves. After a certain amount of adjustment and discussion with the National Park officers, it proved possible to reconcile these differences. However, as a user of the information supplied by the census office, the Commission could have reached completely the wrong conclusions about what had been happening within the National Parks.

This experience also highlighted yet another problem identified above, ie one of definition. There was a change in the definition of the resident population between 1970 and 1980. To the unwary, this change could lead to quite the wrong interpretation of what had been happening to the population of any given area over this time period.

Another and perhaps more dramatic example of the effects of different interpretations and definitions can be found in the parish returns made by farmers to the Ministry of Agriculture, Fisheries and Food. Anyone who uses these data to look at what has happened to farm-based woodlands over the last 10—15 years would be rather surprised to find a major discontinuity in the trend curve during the early 1970s. Relying solely on the published data without having a magnifying glass to read the very small print, this discontinuity would appear to be attributable to a major increase in the amount of woodland which farmers had created on their holdings. In reality, it is due to a complete change in the way that farm woodland was defined. Prior to 1973, farm woodland as recorded on the census had to be woodland which had a use on the farm. Post-1973, the definition was changed to include all woodland that was actually located on the farm. Clearly, the effect of this change would be to remove any inhibitions farmers might have from recording unproductive woodland as part of their farm enterprise.

An example of the fourth problem facing the user of information is again drawn from the experience of the Commission in the uplands. It is a widely held view that information required for many purposes must be available somewhere, if only access could be obtained. No matter how well briefed or well informed, a person is unlikely to be aware of all data sets held in various Government, academic and research institutes throughout the country. This fact was brought home to the Commission quite forcibly during the preparation of the discussion document *What future for the uplands*. The Commission was well aware that it was important to give proper recognition to the archaeological and cultural heritage which can still be found in the uplands of England and Wales. The problem was to give some sort of quantitative dimension to its value. The obvious source of information seemed to be the Directorate of Ancient Monuments within the Department of the Environment. Unfortunately, within the timescale of the document, the Department was not able to provide the information required. To the embarrassment of the Commission, it was subsequently established that the Royal Commission on Ancient Monuments had a data set stored on computers in the basement of the building that had been used for our discussions with the Ancient Monuments Directorate. The Director of the Royal Commission was then able to point out that at fairly short notice the Commission could have access to all the information needed to ensure adequate representation of the archaeological interests in both the discussion paper and the final policy paper. Whilst, clearly, the Commission was at fault in not knowing of the data set, it was surprising to find that few other people were aware of the scope and the scale of the data held on the Royal Commission's computers. The Commission has no doubt also embarked on other studies and research appraisals which have merely duplicated work which had been carried out previously, but for which no documentation was available.

4 Conclusions

The most fundamental problem facing the consumer of planning information is a knowledge of where it can be found. The other problems identified are, to some extent, only real if you actually know that the data exist in the first place. Any organization which wishes to become a supplier of data for rural planning could make an extremely valuable first step in producing a comprehensive listing of the data currently available. It would be even more valuable if that listing could identify as far as possible the reliability of the data, possibly expressed in conventional statistical terms, but, if not, as some sort of qualitative judgement, together with a brief summary of the type of information which can be extracted. It would be beyond our wildest dreams of even greater use if it could also include a summary or statement on the limitations on their use. It is very wasteful of time to obtain reports which purport to provide information of a particular nature, which, when they arrive, are clearly nothing whatsoever to do with the title. If the report title is misleading, and is not supported by the information contained within, then it is counter-productive to the author in the annoyance caused. The titles of many papers or bibliographies suffer from this 'headlines syndrome'.

The problems of the supplier and the consumer of planning information are very similar. The former will only be motivated to provide the data required by the latter, if it knows precisely what is wanted. The latter is only likely to tell the supplier what is measured, if it is realized that the data exist. The conference was intended to provide an opportunity for the 2 interests to communicate, with ITE primarily adopting the role of supplier. However, it must be recognized that often the supplier is only going to be able to provide the information if the user co-operates in the collection of the data in the first instance. There will be few occasions in forward rural planning areas where the primary source of the information is not the local planning authorities themselves. Experience with the National Parks planning problems suggests that, unless there is a clear commitment on the part of the users to recognize the problems facing the suppliers, there will never be data bases which are adequate or appropriate for the tasks to which they are applied. In conclusion, the cost of acquiring the data set must never be greater than its value in the planning process. This factor may make it inevitable that much planning is done without adequate data, but it will still be necessary to identify those areas where data sets can be established, with reasonable reliability, continuity and cost.

An independent view

J T COPPOCK
Department of Geography, University of Edinburgh, Edinburgh

1 Introduction

The objective set for the paper was to give an independent view on rural information for forward planning, but the content is inevitably a personal view. However, the views expressed are certainly independent, in that the author has not been employed by any agency that either collects information or is involved in any aspects of forward planning. Nonetheless, it is inevitably shaped by the experience gained over some 35 years, particularly in respect of the collection of data on rural land use. Over the last 20 years, beginning with membership of the Land-use Data Subcommittee of the Natural Resources Advisory Committee, the experience built up has been increasingly policy-orientated, eg as chairman of the Nature Conservancy's Land Use Panel from 1967 to 1971, and as specialist advisor to the Select Committee on Scottish Affairs in its inquiry into land resource use in Scotland in 1971–72. Subsequent experience was gained as a member of the Scottish Joint Committee on Information Systems for Planning throughout its existence in the 1970s and the Ordnance Survey Review Committee in 1978–79. These experiences are significant because they indicate that my 'independent view' is likely to be biased by concern with rural land use, rather than with the whole range of rural information, and with national rather than local issues. Nevertheless, I believe that what I have to say applies, in greater or lesser degree, to all information for planning.

The subjects fall broadly under 5 heads, each of which requires much more space than is available in the present context. First, the need for information is examined before considering some existing sources and ways in which the supply of information could be improved, either by adapting existing machinery for its collection or commissioning new surveys. Experience in other countries is then examined briefly, before focusing on handling information in the context of geographical information systems.

2 The need for information

The most important question in considering information for forward planning, and which has proved to be the one most difficult to answer satisfactorily, is establishing the exact purpose for which the information is required. Answering it implies a subordinate question about how the information will be used to meet that need, once it has been acquired. Both these questions tend to be neglected, yet they are fundamental. Only when a clear answer has been given about why the information is needed, is it possible to determine how far existing sources can meet that need and, if new information is required, how that should be obtained.

The question of need then requires extensive discussion, although it is, in any case, one for planners and policy-makers to answer. In practice, it is often replaced by other questions, particularly 'What information is available' and 'What can the user do with the information when he obtains it'. It is recognized that the relationship between the need for information and its supply is an iterative one. Planners' needs are shaped by their experience, and they are likely to ask for the information they know about; at the same time, new techniques are enlarging the range of questions that can be asked and altering the feasibility of answering them. In some instances, technology runs ahead of applications and those responsible for its development may have little regard to (or awareness of) how the resulting information will be used. There is, for example, little doubt that, in terms of its ability to satisfy planners' needs, remote sensing from satellites has been oversold by enthusiastic proponents. Nevertheless, what can be asked and answered does change over time in response to changes in both planners' perceptions and technological developments.

As part of their answers to questions on need, planners must also ask and answer 3 related questions.

i. How important is currency (ie that the information is up-to-date)?

ii. How comprehensive a coverage is required — must the whole area be covered or will a sample suffice?

iii. How accurate must the information be?

Of course, the answers to each of these questions will have implications for costs, and there are obvious trade-offs between them. What those trade-offs are and what the 'best buy' will be can be determined only by answers to the question of need and by an evaluation of how that information can be supplied.

Three other questions also require answers. The first relates to the importance attached to information about change, for it is generally easier to establish the situation at any one time than to measure rates of change or to compare situations at 2 points in time. The second concerns the need to compare one category of information with another, although answers in a planning context are presumably self-evident. Last, there is the question of whether discrete data are required and, if not, what level of aggregation — local, regional or national — will satisfy users' needs. The answers to each of these questions will similarly have implications for the cost of collecting, storing and using information, although technological changes in micro-electronics are likely to shift the balance between these stages by reducing the real cost of storing and manipulating data.

A case has long been made for the collection of certain categories of information independently of specific needs, because they are likely to be a common element of most, if not all, requirements for information for planning. The maps of the Ordnance Survey were described by the Ordnance Survey Review Committee as part of the essential infrastructure of the modern state, and similar arguments have been presented in respect of soils, climate, hydrology, mineral resources and population. Indeed, until the 1980s, Governments have been progressively extending the range of such basic information which now uses much aerial photography and all satellite imagery. This approach poses 2 problems, viz the criteria by which Governments determine what should be collected, and the answers they give to the questions posed earlier, for the collection of data is expensive and the resources that can be devoted to this task finite. For example, the Ordnance Survey cannot maintain its maps fully up-to-date without much greater resources than it currently commands, and the Soil Surveys have had to divert resources to producing national and regional maps in advance of the completion of their detailed maps for the whole country.

3 Characteristics of existing sources

The next topic to be covered is often neglected — that of determining the characteristics of existing sources of information. If what is required already exists, it is clearly sensible to use it, and, even if such sources are not wholly satisfactory, it may nevertheless be necessary to employ them as surrogates, provided their limitations are not too severe and are outweighed by the high cost of collecting new data to the required specification. To make that decision, it is necessary to know how these data were collected, what they mean, what reliance can be placed upon them, and (depending on the locational precision users require) how accurately they can be located. If information is required on change, it will likewise be important to know how comparable the data are over time and, in particular, how consistent definitions and interpretations of the different categories have been, also whether information is available for the same areal units.

Unfortunately, many of the existing sources that might be used for forward planning in rural areas are poorly documented, have never been properly evaluated for this purpose, and are often little understood. It is true that the Social Science Research Council (as it then was) and the Royal Statistical Society published a series of handbooks on British statistical sources, mainly in the 1970s, but such books soon become dated. Several official descriptions of statistical sources exist, but these too are out of date. Neither have internal evaluations of data by collecting agencies (if they exist) been published; indeed, in view of frequent internal changes of staff, it is doubtful whether many of the staff of such agencies have any accurate knowledge of the data that have been collected and how comparable they are over time. These deficiencies are particularly important where (as is usually the case) the purposes for which planners require the information are very different from those for which it was collected; indeed, the data may have deficiencies for planning purposes of which even those responsible for their collection are unaware.

The annual agricultural census conducted in England by the census branch of the Ministry of Agriculture, Fisheries and Food (MAFF) illustrates some of these problems. The census is conducted by means of a postal questionnaire to all known occupiers of agricultural holdings above a certain size. The results are checked against those for the previous year and are subject to plausibility tests; discrepancies lead to inquiries, but these will only be indirect as there is no longer any capability for investigating them in the field. For largely historical reasons, the returns for individual holdings are consolidated into parish summaries, although holdings rarely fall exactly into parishes, and there are varying levels of discrepancy between the parish and the land to which the summary refers. This discordance is likely to have increased as holdings have grown larger, but in no systematic way. The actual location of the land to which the summaries refer is, however, of little importance to MAFF, and they are compiled primarily as an administrative step in the preparation of county, regional and national totals. The summaries are not published and, to maintain confidentiality, parishes with few holdings must sometimes be amalgamated with others, although such amalgamations do not necessarily take place between adjacent parishes and may even be between parishes at opposite ends of a county.

These characteristics are important only if it is intended to use the summaries to establish the characteristics of farming throughout a county, when they may lead to anomalies that would be difficult to explain. They are more important when attempts are made to examine agricultural changes over time, because the areas on the ground represented by the summaries for each parish are unlikely to be identical at different dates; there may also be difficulties posed by changes in the coverage of the census and in the definitions used. As a result, such comparisons must be made with caution, and only in rather broad terms. Thus, unless users understand these limitations, highly misleading conclusions may be drawn, especially in investigations of a county or smaller area.

This example highlights 2 aspects of the use of data collected by others, especially census-type data. First, they are generally collected with no regard for their possible use by other public bodies; indeed, the recent Rayner review of Governmental statistical sources was concerned only with their value to the agency that collected them and took no account of any wider use. Second, the use of data may be constrained by considerations of confidentiality and by the methods of collection and aggregation used. It may also be limited by copyright, a constraint which is likely to become more severe as the Government seeks to maximize the revenue derived from data collected by official agencies. The task of evaluating other possible uses would be much easier if all sources of data were properly documented, and if the data themselves were labelled in ways that indicated their positional accuracy, their reliability and their currency.

These remarks apply most strongly to the data which are collected by public agencies primarily or exclusively for their own purposes, such as the annual agricultural censuses and the periodic censuses of woodlands. Nevertheless, similar documentation is required for those data collected for general use, such as the topographic maps of the Ordnance Survey, the thematic data collected by such agencies as the Soil Survey of Great Britain and the British Geological Survey, and the greater variety of data collected by the Office of Population Censuses and Surveys. For example, it is not self-evident to a user on what basis isolines on a climatic map have been drawn or what exactly woodland recorded on an Ordnance Survey map shows; in fact, information on a climatic map for elevations above 400 m is largely informed guess work, and staff of the Ordnance Survey will record as woodland land from which trees have been cleared but which they have reasons to believe will be replanted. Aerial photography and remotely sensed imagery from satellites similarly need adequate documentation, although they present users with very different problems from those presented by data collected by questionnaire or field survey.

Although the emphasis in this section has been placed on the limitations of such data (partly because this aspect has often been neglected), it is also fair to say that their potential use in planning has never been fully exploited. The collection of good data is generally expensive and, provided existing sources are treated with care and understanding, they can often be used at relatively low cost, whether as surrogates for data that might have been collected if resources allowed, or as sources of data in their own right.

4 Improving the situation

There are 2 ways in which the availability of data could be improved: by modifying or adapting existing sources, or by obtaining data by commissioning original surveys, whether by observation/inquiry on the ground or indirectly by commissioning aerial photography. Two examples of the former are presented, before making a more general appraisal of the latter.

4.1 Adapting existing machinery

With one recent exception, this approach is potential rather than actual. Its justification is that a mechanism for collecting data is already in place and could be adapted at lower cost to meet other needs than undertaking surveys. The chief obstacles to such an approach are the sectoral structure of departments in both local and central Government, which tend to react in a protective way to attempts by others to use 'their data' (ignoring the fact that all such data have been collected with public funds, and presumably should serve the public interest), and that the Government is obsessed with saving manpower rather than with promoting more efficient use of resources. Those who are responsible for the machinery by which data are collected may neither understand nor be interested in the needs of others, and Government agencies cannot generally employ more staff to meet the needs of others for data, even if payments for doing so would more than cover any additional cost.

The one example where additional data have been collected in this way is the scheme introduced in January 1985 whereby information on land use change is collected throughout Great Britain by the Ordnance Survey. As part of the normal procedures for revision of its maps, under which its surveyors attempt to identify all changes which need to be recorded, it will also collect similar information on 22 categories of change (mainly relating to the urban and near-urban environment) on behalf of the Department of the Environment and the Scottish Development Department who will meet the additional costs. How successful this approach will be remains to be seen. The surveyors are skilled in recording and measuring accurately in the field; but they are being asked to record information which they are not specifically trained to collect, including some categories which, by their very nature, are difficult to identify in a consistent way. I have no doubt that the data will be collected efficiently, but I do have reservations, from what little I have seen of the process, about what the data so collected will actually mean.

Another example, relating to proposals that were not accepted, is again provided by the agricultural census. The chief weaknesses of this census for rural planning are 3-fold. First, the census is least helpful on those aspects of rural land use that are of greatest interest to planners, in particular the transfer of land from agricultural to urban use and the improvement of rough land. Second, there is the problem, already noted, of the uncertainty about the location of all the data on land use and livestock recorded in the census, arising from the way in which the census is compiled and the additional procedures needed to maintain the confidentiality of the individual returns. Third, there is the additional complication that the summaries refer to areas that vary greatly in size and heterogeneity.

While the question of confidentiality remains an intractable one, the census could undoubtedly be made more useful to others (and also to MAFF itself) by modifying the way in which the data for individual holdings are assembled and by improving the locational referencing of such data. A proposal was made by the author more than 25 years ago that the centroid on the steading of each holding should be given a reference on the National Grid, a procedure that could easily be undertaken by the Ministry's advisory staff in the course of their visits to farms. Such referencing would enable the holding data to be aggregated in different ways to minimize the weaknesses noted earlier; but the suggestion was rejected on grounds of cost, and because it was not required for the Ministry's purposes. More recently, a group of geographers from the Rural Study Group of the Institute of British Geographers has submitted comprehensive proposals with the same objective; but these too are unacceptable, being seen neither as necessary for Ministry purposes nor cost-effective.

The scope for such modifications to a wide variety of official procedures for collecting data is very large, but the structure of departments in both central and local Government makes it difficult to secure the collection of data in ways that serve the interests of a number of departments or other bodies. The usefulness of the data collected for general purposes could also be improved by making those data available in forms that facilitate that use, notably by converting them into digital form to some common standard, an issue which will also be discussed in the context of geographical information systems.

4.2 The collection of data to meet planners' needs

If no suitable data exist and modifications to existing procedures for collection are unacceptable, then the only remaining solution is to undertake or commission surveys to provide what is required. This is the approach normally adopted, whether on a country-wide or a local basis. Several national surveys are either under way or being contemplated, and some are discussed more fully elsewhere in this symposium volume. In 1977, the Institute of Terrestrial Ecology itself undertook a sample survey to provide, by field observation, estimates of a wide range of land uses, and repeated that work in 1984 so that changes could be measured. Its approach has been adapted to provide estimates of land use and land use changes in the Highland Region in Scotland. The Nature Conservancy Council is conducting a survey of changes in habitats since the Second World War, using existing aerial photography, and likewise covering many similar categories of land use. Third, Hunting Surveys are conducting a similar survey of changes in the rural landscape, for the Department of the Environment and the Countryside Commission, using aerial photography and ground survey, together with some experimental satellite imagery. Commissioned surveys are potentially very costly, but that cost can be greatly reduced by sampling (as can the cost of existing procedures for collecting data), and all these surveys are based on samples. Sampling can also make more effective use of limited resources of skilled manpower. Such an approach is satisfactory where information is required only for large areas, eg the whole country or its constituent regions, and where the phenomena being surveyed are not highly variable or localized. Where data for small areas are required, the size of samples must be increased accordingly and the economies of sampling correspondingly reduced. On the other hand, sampling may limit the wider use of the resulting information, especially where data from different sources or for different periods must be compared, as with the censuses of woodland conducted by the Forestry Commission in 1965 and 1979. Further work is required on sampling strategies for collecting spatially distributed data in which there is a high degree of autocorrelation.

Four main approaches are possible to the collection of data, the choice of which will depend in part on what is required and the resources available: indirect inquiry, primarily through postal questionnaires; observation and/or inquiry 'in the field'; aerial photography; and some combination of these approaches. Each has strengths and weaknesses, the importance of which depends on what is being collected and for what purpose. Nothing further is considered here on indirect inquiry, other than to note that response rates are characteristically low and the quality of answers depends on the ability of respondents to understand the questions and to supply the answers (as well as on their willingness to do so). Directly administered questionnaires are also not considered, except to note that, while they too are expensive, response rates are much higher and ambiguities and uncertainties can be removed by interviewers (perhaps at some cost in bias).

In the hands of skilled and experienced staff, field observation is probably the most reliable way of securing information and has the additional merit that it provides an opportunity (at some cost) of seeking clarification of the significance/meaning of what is being recorded. Its appropriateness does depend on the information being sought, and some kinds of data can be collected only by field observation. Such surveys are, however, time-consuming and expensive, especially if they depend on skilled staff, as they must if reliable and consistent interpretations are to be made. Field surveys also permit no second thoughts without a return visit, and often require access to private land, a consideration that poses problems even for those official bodies that have statutory rights of access. Some information, too, cannot easily be recorded accurately from a ground view, eg the boundaries of different classes of rough vegetation.

The advantages and disadvantages of aerial photography are, to a large extent, the converse of those pertaining to field survey. Aerial photography provides a wider perspective than a ground survey, no time is wasted in travel, there are no problems of access (except in relation to ground truth) and a permanent record exists which can be consulted again at a later date or used for resampling. Photographs can also provide some information in response to other questions that were not envisaged at the time of the photography (though establishing ground truth may not then be possible). On the other hand, taking good photographs depends on suitable weather conditions, all information is derived at second-hand by interpretation of what is recorded on film, and there are many categories of information which cannot be identified from photographs with any certainty and others which cannot be identified at all, eg activities within buildings. Commissioned aerial photography is also costly, although the archival value of the photographs should be included when evaluating the cost. It also seems likely that the economies of taking sample photography are limited, and it may cost little more to obtain complete cover and to interpret a sample of the resulting photographs.

The aim of a hybrid approach is to maximize the advantages and to minimize the disadvantages of the method chosen. Thus, what can reliably and consistently be interpreted from aerial photography is obtained in this way and is complemented by sample surveys on the ground to provide estimates of what cannot. Such an approach has obvious attractions when information is sought on various aspects of rural land.

In this paper, discussion has been avoided of remote sensing from satellites, which I identified earlier as a category of information collected by others in anticipation of need, in part because of shortage of time and space, but also because of its low resolution in relation to the complexity of the British countryside, the still experimental nature of much interpretation, and the fact that it is generally inaccessible to most planners, requiring the use of expensive equipment and scarce skills. It may have some current applications, eg in relation to some categories of land cover, and clearly its potential value will increase as resolution improves, especially in relation to the uplands, for which there is generally a paucity of information on any consistent basis from other sources.

5 Experience in other countries

In examining the supply of information for rural planning, it is important to take note of what is being done in other developed countries, both in North America, where countries of continental extent have been innovative in applying new approaches, and in Europe, where the problems in countries such as the Netherlands more closely resemble our own. It is not possible, in this paper, to do other than note the point and cite some examples, such as the use of high-level colour aerial photography in the United States to develop country-wide records of land use/land cover, the preparation of 5 separate coverages of land capability maps of settled Canada as part of the Canada Land Inventory, and the use of conventional aerial photography in France for recording the agricultural census and in Canada for monitoring urban growth. There are certainly lessons to be learnt in terms both of what to do and what not to do.

6 Handling data

It is also important to consider not only how information can be obtained, but how that information will be handled and how the results will be used in planning. The Committee of Inquiry into the Handling of Geographic Information must likewise consider how information must be collected. In many ways, we are in a transitional stage in which the advantages of using computer-based systems are increasingly perceived, but where necessary skills and equipment may be lacking and little information is in digital form, especially the historical data required for measuring trends and establishing change. Even where data are digital, they are often not compatible, and planning staffs have varying levels of sympathy for, and understanding of, current progress. Different agencies are moving at different rates to develop digital systems for the collection, storage and display of the information they collect or for which they are responsible, and this is often being done with considerations other than planning in mind and with a narrow perception of their own problems and little regard for those of others.

These problems, together with experience in other countries, lead naturally to a consideration of geographical information systems, ie the development of computer-based systems for handling spatially referenced data of diverse kinds. Although there is increasing reference to integrated geographical information systems, chiefly in the context of remote sensing and digital mapping, the term seems tautological in that the underlying concept of a geographic information system is the ability to relate and integrate data of different kinds.

British experience of such an approach to rural planning appears to be limited, although many local authorities have been developing computer-based information systems of varying degrees of sophistication over the past decade. It is unfortunate in this respect that the lead originally given by the Department of Environment through the publication of its report *A general information system for planning* (GISP) has not continued, and that so many different systems should have been devised. There has been no comprehensive evaluation of the use of such systems for rural planning, and, because planning itself has a strong urban orientation, it is probably equally true of general information systems for planning. The only well-known comprehensive system is the experiment sponsored by the Standing Committee on Rural Land Use in the Dunfermline and Kirkcaldy Districts of Fife, known as the Rural Land Use Information System (RLUIS). In this experiment, those agencies with responsibilities in rural Scotland, and represented on the Standing Committee, pooled their data, which were either in digital form or converted to that form for this experiment,and posed questions for which they wanted answers. Unfortunately, the project was terminated with the abolition of its sponsoring body, although the data still exist and offer considerable scope for further research and development. In the Department of Geography at Edinburgh University, we have a much more limited data base for the whole of Scotland, the Tourism and Recreation Information Package (TRIP) which, despite its name, also contains information on topography, land use and population. It was commissioned by, and designed to meet the needs of, a number of public agencies, but these have made very different use of it, partly because of differences in understanding and levels of interest.

As with remote sensing, there has been some tendency for geographical information systems to be driven by technology rather than to respond to expressed needs. Although it is obviously necessary to develop efficient ways of storing and handling diverse data, it is equally important to pay attention to the characteristics and limitations of the data that are being stored. Such systems have also tended to be driven by cartographic considerations, in part because much of the initial impact has come from developments in automated cartography and from the problems of comparing maps at different scales and on different projections. Cartographic representation is, of course, important in rural planning where answers are often required in map form; but there is increasing realization that digital information derived from maps should be held in ways in which they can be treated as spatially referenced data, to be related to data derived from other sources, and not simply by reference to their suitability for cartographic output.

In this respect, also, it is useful to examine the experience of other countries, particularly in North America. The Canada Geographic Information System (CGIS) is one of the oldest and largest of such systems; it has a strong rural emphasis and contains a variety of data from different sources, including the 5 categories of rural land capability prepared for the Canada Land Inventory. The system does not appear to have lived up to the expectations of its designers, partly because land is a provincial and not a federal responsibility, but also because it was long in the hands of technicians who tended to wait for users to come along. There is now sufficient experience of systems elsewhere to show that considerable effort must be devoted to marketing and to demonstrating to those who are not technically qualified that such systems can help to solve their problems. A much stronger effort is now being made to sell the CGIS to potential users.

Apart from the technical problems of handling and storing data, the main needs, if effective use is to be made of the opportunities for rural planning presented by geographical information systems, appear to be the following.

1. Establishing common standards and recognizing data as a corporate resource, so that such data can be readily transferred between users.

2. Establishing a common digital framework so that thematic data of various kinds can be linked. The obvious mechanism for doing so is through the Ordnance Survey's programme of digitizing its maps, although OS is convinced that there is insufficient demand for a medium-scale digital data base and the timescale envisaged for the large-scale maps is far too long.

3. Establishing pilot projects in rural areas (of which the RLUIS project is one example), which can demonstrate to potential users how their needs can be met in cost-effective terms.

4. Converting into digital form those data not already so held, including a selection of historical data, so that trends can be established and the scale of change measured.

5. Evaluating and documenting all data sets, with reference not only to their value as data, but also in respect of the ease and precision with which the data can be located, so that users fully understand their strengths and weaknesses.

6. Providing training of more skilled staff, and 'hands-on' experience for others.

7 Conclusion

The present age is one of change, in which technology is developing at a much faster rate than attitudes, the understanding of needs and the availability of essential data. In these circumstances, there is a danger that each organization will act in isolation, a point highlighted by the existence of the separate initiatives noted earlier to establish the scale of changes in different categories of land cover in rural areas. Although each has somewhat different objectives, there is considerable overlap between them, and it seems reasonable to suppose that there is scope for integration of effort. Similarly, a number of agencies, including the Ordnance Survey, the Institute of Hydrology and the Forestry Commission, are digitizing topographic maps, to different standards and for different purposes. There is surely a case for a more collaborative attitude towards data on the part of those who collect them, and a recognition that it is in the public interest that such data, largely collected with public funds, should be widely used.

Although the coming generation will, no doubt, find it much easier to accept and adopt new approaches to handling data, there remains the concern that the application of sophisticated techniques to poorly understood and documented data may still be 'garbage in, garbage out'. To avoid that situation, a primary need is to establish the characteristics of the data and to understand how they can best be used to serve the needs of rural planners.

The approach adopted by Highland Regional Council

C J CLARIDGE
Highland Regional Council, Inverness

1 Introduction

The purpose of this paper is to describe the recent experience of a large rural regional planning authority in attempting to handle, in a systematic way, considerable quantities of data that are essential to the proper planning of the rural environment. The paper briefly describes the nature of the Highland Region and the range of rural planning issues it faces; the type and availability of data that are of interest; the information systems which have been adopted by the Highland Regional Council (HRC) Planning Department; and the use of these systems.

The Highland Region extends to 25 000 km^2. It has the largest area of any local authority in Europe and is larger than Wales. It extends 240 km north—south, from the sea cliffs of Caithness and Sutherland to the high mountains of the Cairngorms, and 230 km east—west, from the productive arable farms of Nairn to the scattered crofting townships of Skye. The Region has a population of around 200 000, of which less than one-third live in towns of more than 5000 people, whilst one-third live in and around communities of less than 200 people. During the 1970s, the Region's population grew by more than 14%, largely as a result of oil-related development in the Moray Firth area. However, in the remoter areas, depopulation has continued since the 19th century.

The Regional Council is responsible for all aspects of statutory planning, including the preparation of structure and local plans and the handling of all planning applications. There are a wide range of land use issues facing the Region, many of them arising from potentially competing interests in the use and/or safeguarding of land. The extent of some of these interests is illustrated in Figure 1.

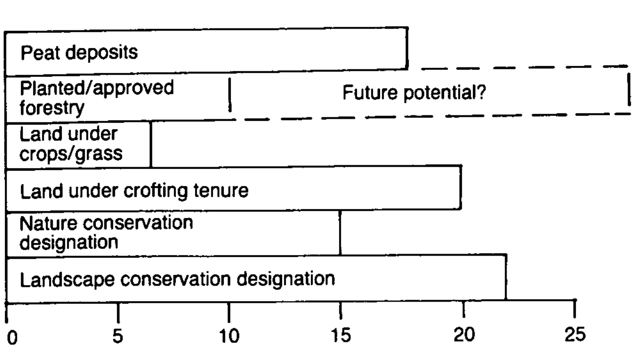


Figure 1. Significant rural land uses and designations in Highland Region

It is evident from the above figures that there is an overlap between some of the various interests, and therefore potential for conflict. In some cases, the Council is directly responsible for determining decisions on land use change, eg the extraction of peat for fuel or horticultural use on a commercial scale. However, in the majority of cases, the Council's role is purely advisory, eg in relation to nature conservation designations, or forestry, with primary responsibility for decisions resting with central Government departments or agencies. Despite its limited role, the Council considers it important that a co-ordinated approach is adopted in relation to evaluating land use change, in order that decisions can be taken in the best interests of the community.

The Regional Council has just commenced its first comprehensive review of its structure plan and has identified a number of rural land use issues which need further consideration, before either formulating policies or seeking action from Government or other agencies. These issues include the following.

Agriculture

1. What is the most appropriate type(s), scale and distribution of agriculture within the Region, taking into account the likely availability of resources, the need to sustain rural communities in the Region, and the increase in competition from agricultural areas elsewhere?
2. Is there a need, and what scope is there, for increased diversification or specialization in agriculture within the Region?
3. What policies should be pursued in safeguarding agricultural land?

Forestry

4. Should the Regional Council, in view of its wide land use planning interests, try to reach agreement with landowners and bodies also involved in land use to identify the location and type of forestry which should be encouraged within the Region as part of an overall strategy?
5. Should changes in land use to forestry be made the subject of some statutory control? If so, who should exercise that control?
6. Should the Government be asked to review

the financial basis for encouraging private forestry to enable local landowners and farmers to participate more effectively?

Conservation

7. Is there a need for a more integrated approach to conservation and other rural land uses and, if so, how best might this be achieved?
8. How best can conservation be achieved at the same time as maintaining a flourishing rural economy (and *vice versa*)?
9. The Council is to pursue some sort of 'Park' status within the Region — what type of park would be most appropriate and what parts of the Region might be considered for designation?
10. Is there a need to reconcile the extensive designation of nature conservation sites within the Region with the need to develop the Region's resources?
11. Is there scope for deriving more benefits, within the Region, from nature conservation designations, by giving more priority to the educational and interpretative aspects of such designations?

These issues are included because they have implications for data collection and retrieval, and the way in which rural land use information systems need to be constructed if they are to be used effectively by both planners and policy-makers. Experience elsewhere has shown that the value of an information system is often in inverse proportion to its degree of sophistication.

2 Nature and availability of data

The data relating to rural land use that the Council considers it important to capture, store and analyse reflect the desire to resolve, or at least contribute to, the resolution of the issues outlined above. These data, which have been collected for each of the 28 000 one km Ordnance Survey (OS) grid squares in the Region, are listed below. (A few items have been collected mainly for the purposes of the land classification system outlined later in the paper.)

CLIMATE (from climatic and Macaulay Institute maps)

Average number of days of snowfall per year; average minimum January temperature; average daily hours of sunshine for July; climatic guidelines for the assessment of land capability; assessment of climatic conditions based on exposure.

GEOLOGY (from geological maps)

Solid geology; drift geology.

LATITUDE/LONGITUDE

Distance to west coast; distance to south coast.

TOPOGRAPHY AND HUMAN ARTEFACTS (from 1:50 000 OS maps)

i. Areas of:	sea, intertidal, land between 0–76 m, 77–198 m, 199–488 m and 489–1344 m, woodland, urban areas, loch (freshwater), land cliff, sea cliff.
ii. Length of:	Slope line (highest to lowest point), main road (A class), metalled road 4 m wide, fenced minor road, unfenced minor road, single-line stream, double-line stream, coastline.
iii. Variables:	A class road nearer (than any other metalled road), distance to other metalled road (if A class road not nearer), maximum elevation, minimum elevation, height of hill behind, distance to hill behind, aspect (degrees from north).
iv. Frequency of:	settlements, streams, woods, lochs.
v. Presence of:	footpath, island (not freshwater), flat rock (coastal), shingle/sand/mud.

LAND CAPABILITY (from Macaulay Institute maps)

For agriculture.

NATURE CONSERVATION (from Nature Conservancy Council (NCC) records)

Sites of Special Scientific Interest (location and habitat).

OTHER DATA

Red deer numbers; population; land in crofting tenure.

3 Development and use of information systems

Since 1981, the HRC Planning Department has been working jointly with the Institute of Terrestrial Ecology (ITE) to develop a rural land use information system based on one km OS grid squares, which is run on the Department's Superbrain Microcomputer. Prior to its association with ITE, the Planning Department had no microcomputer facilities; rural land use information was largely limited to map data, and therefore difficult to manipulate other than by relatively crude sieve-mapping techniques.

As a result of the joint approach by ITE and HRC, a system has been evolved which combines the predictive capability of the stratified sample frame of the ITE land classification system (Bunce *et al.* 1981) with a stand-alone data base for every one km OS grid square in the Region. The data base was originally limited to data necessary to assign ITE land classes to each grid square. It has subsequently been extended to include other data, eg nature conservation designations, land capability for agriculture, red deer distribution, etc.

The use of one km grid squares enables sufficiently fine-grained assessments to be made for strategic planning purposes. The use of a finer grid would not be practicable or cost-effective within such a large region. For example, a 100 m x 100 m grid would involve a 100 times increase in data capture and storage resources. In many cases, source data cannot be found at a sufficient level of accuracy to justify such a degree of resolution. The data items can be used singly or in combination, and results produced in tabular or map form. The mapping technique has been developed within the Planning Department using a simple dot-matrix printer (HRC 1984). All the computer programs for the input, storage and analysis of data have been developed in-house, and are consequently simple to adapt to meet new requirements. The importance of end user control over information, computing facilities and methodology cannot be overestimated. The result is that the Council can tailor the system to meet its own, often changing, needs.

An example of the results of combining different data items is shown in Figure 2. The map shows accessible peat deposits and was produced by identifying one km grid squares with the following characteristics (which can be modified as desired):

i. presence of peat in the square;

ii. within 5 km of a metalled road;

iii. overall gradient of less than 10 degrees;

iv. minimum altitude below 300 metres.

The system has been fully operational since the end of 1984 (HRC 1985a); prior to that date, it operated on one in every 4 grid squares. The land classification system and data base have been used for the construction of a forestry model and a sample survey of amenity woodland.

The forestry model attempts to assess the land use and economic consequences of further afforestation in the Region. Forestry currently occupies 10.8% of the Region's land surface, and the Forestry Commission has assessed its potential at 27%. Consequently, modelling the dynamics of forestry is extremely relevant to current strategic planning problems.

The appraisal of forestry potential has been approached in 2 parts. The first part involves assessing technical suitability for forestry (eg altitude, exposure, etc) and identifying possible land use constraints (eg agricultural quality, nature conservation interest, red deer, etc) for every single grid square in the Region, ie using the data base. The second part involves assigning monetary values to appropriate forestry enterprises and agricultural operations, based on an assessment of a sample of 8 squares in each of 23 land classes, ie using the ITE land classification system. The monetary values can be altered easily.

The 2 parts are integrated and allow the allocation of additional forestry (after considering constraints, etc) to be made for individual grid squares; for example, no allocation will be made where the square is already occupied by woodland. This 2-part approach is a particularly significant refinement of the ITE land classification system, which hitherto had allocated additional forestry to each square in a specific land class using an average value per land class.

Some examples of the stages of the forestry model are shown in Figures 3—5. Figure 3 shows the existing woodland as given by the data base, Figure 4 shows the land theoretically suitable for forestry by excluding sea, intertidal areas, woodland, urban, loch, cliff and land which is too high or exposed for planting, while Figure 5 reduces this theoretically suitable land one stage further by removing squares with Macaulay Land Capability for Agriculture Classes 2—5. It is relatively simple to alter the threshold values for any of the constraints used and, if appropriate, different values can be assigned to each one km square.

The Council's amenity woodland survey undertaken in 1984 illustrates the value of the ITE land classification system in providing a means of producing comprehensive results relatively cheaply and quickly. The survey methodology and results have been documented (HRC 1985b), and therefore only a brief outline is included in this paper.

The amenity woodland survey was based on a stratified random sample of 8 squares in each land class (184 squares in all). Of this sample, 101 squares were known from a 1981—82 land use survey to contain trees and these squares were surveyed in the field for the amenity woodland survey. This approach had a number of advantages over other sampling possibilities. First, the woodland information could be directly related to other land use information within the square. Second, by remaining within the framework of the land classification system, results could be extrapolated and applied to the Highland Region as a whole. Third, because some land classes have more woods and different woodland types than others, the samples covered the full range — from isolated trees to com-

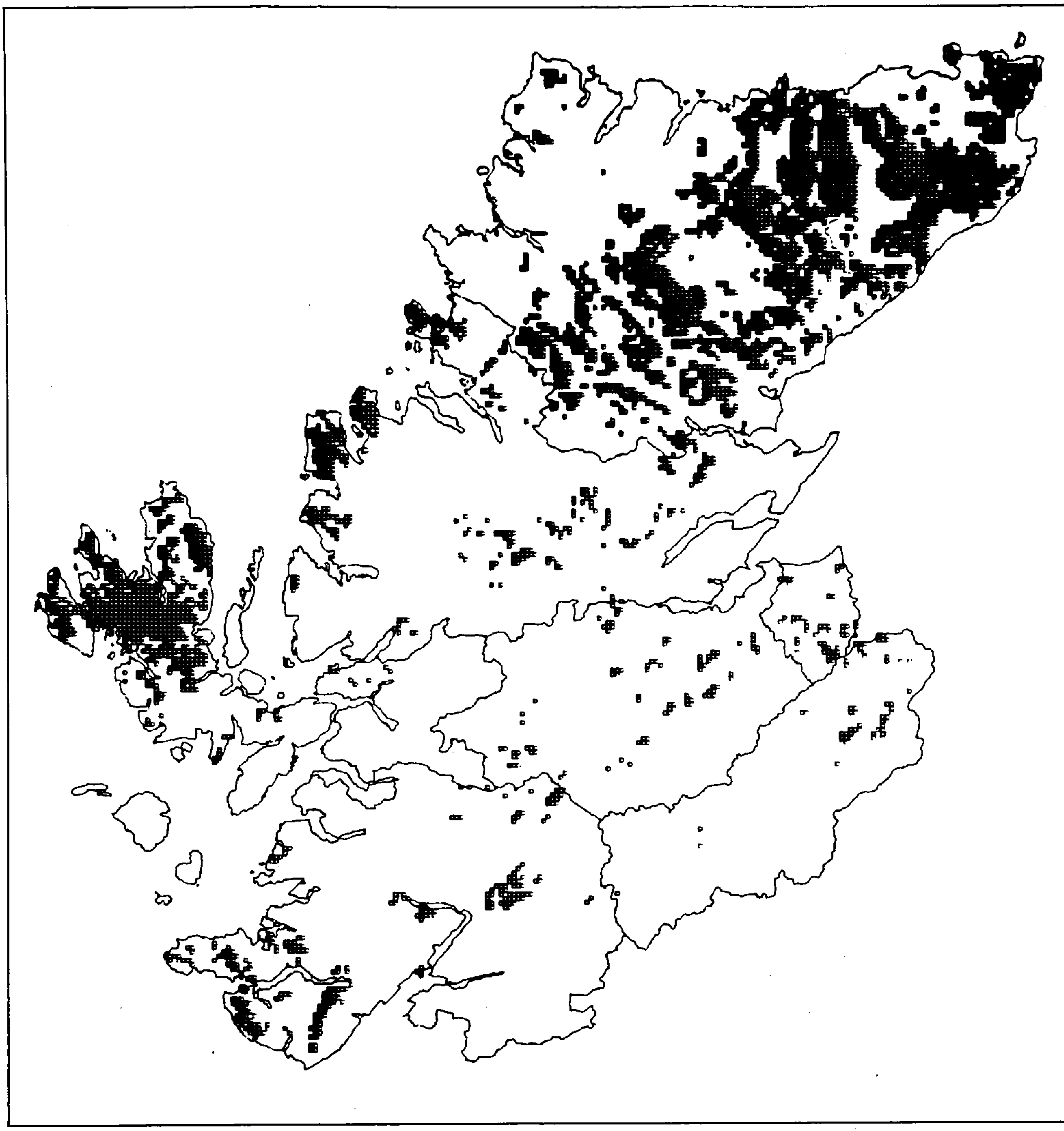


Figure 2. Distribution of accessible peat deposits in the one km x one km squares of Highland Region

mercial plantations. Finally, it was possible to ensure the existence of woodlands within the sample squares.

As an example of the results from this survey, Table 1 shows the major species within the main woodland types.

4 Conclusions

The systems that we have developed, and are continuing to develop, enable us to undertake the following tasks.

i. Provide an inventory of basic regional statistics
An integrated assessment of the overall resources of the Region is required, particularly with regard to features that are not recorded systematically by other agencies, eg amenity woodland.

ii. Indicate the broad regional distribution of resources
Knowledge of the distribution and definition of resources throughout the Region is a necessity for planning, and, although some features are already well documented, data for others are not always readily available. For example, the land use, topography and other features within

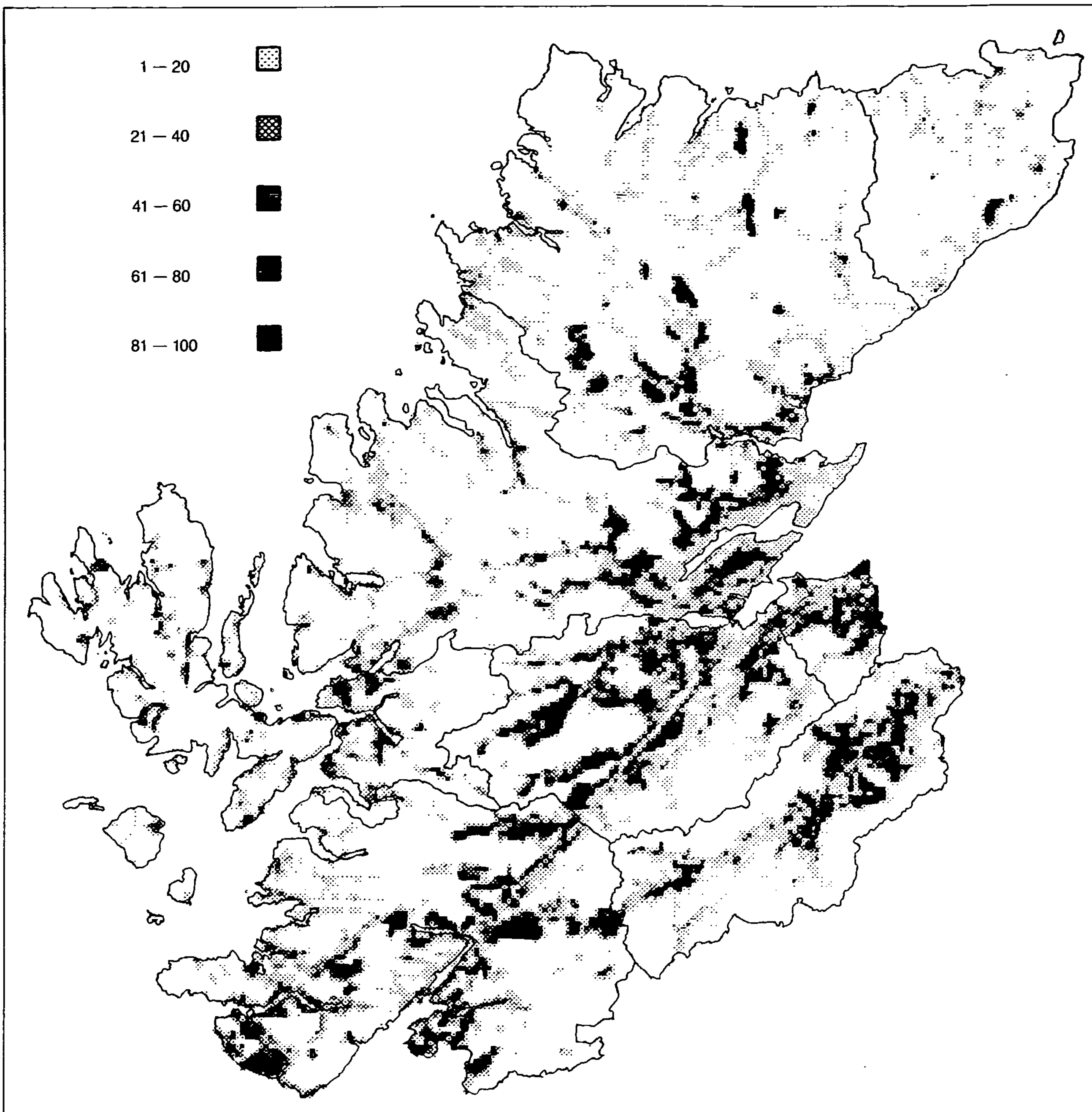


Figure 3. Distribution of existing woodland in the one km x one km squares of Highland Region

National Nature Reserves/Sites of Special Scientific Interest and National Scenic Areas have never been quantified, although such designations may have implications for land use change.

iii. Monitor land use changes
Many changes in the landscape pattern tend to be incremental both in time and space, but they can often result in a cumulative effect which has substantial implications for other land uses and/or settlement patterns. Previously, the expense of monitoring has meant that information on change has not been available, although the identification of trends in land use is essential to forward planning.

iv. Assess land use potential
The Council is particularly concerned to retain population in rural areas and therefore to identify future employment opportunities. Apart from assessing the physical suitability of land for different activities, eg increased forestry, improvement of marginal agricultural land or the development of peat resources, the socio-economic and environmental consequences of such action require to be quantified.

v. Test policy options
All land in the Region is used to a greater or lesser extent, and it is important to be able to assess the implications for existing land use and settlement patterns of any proposals that

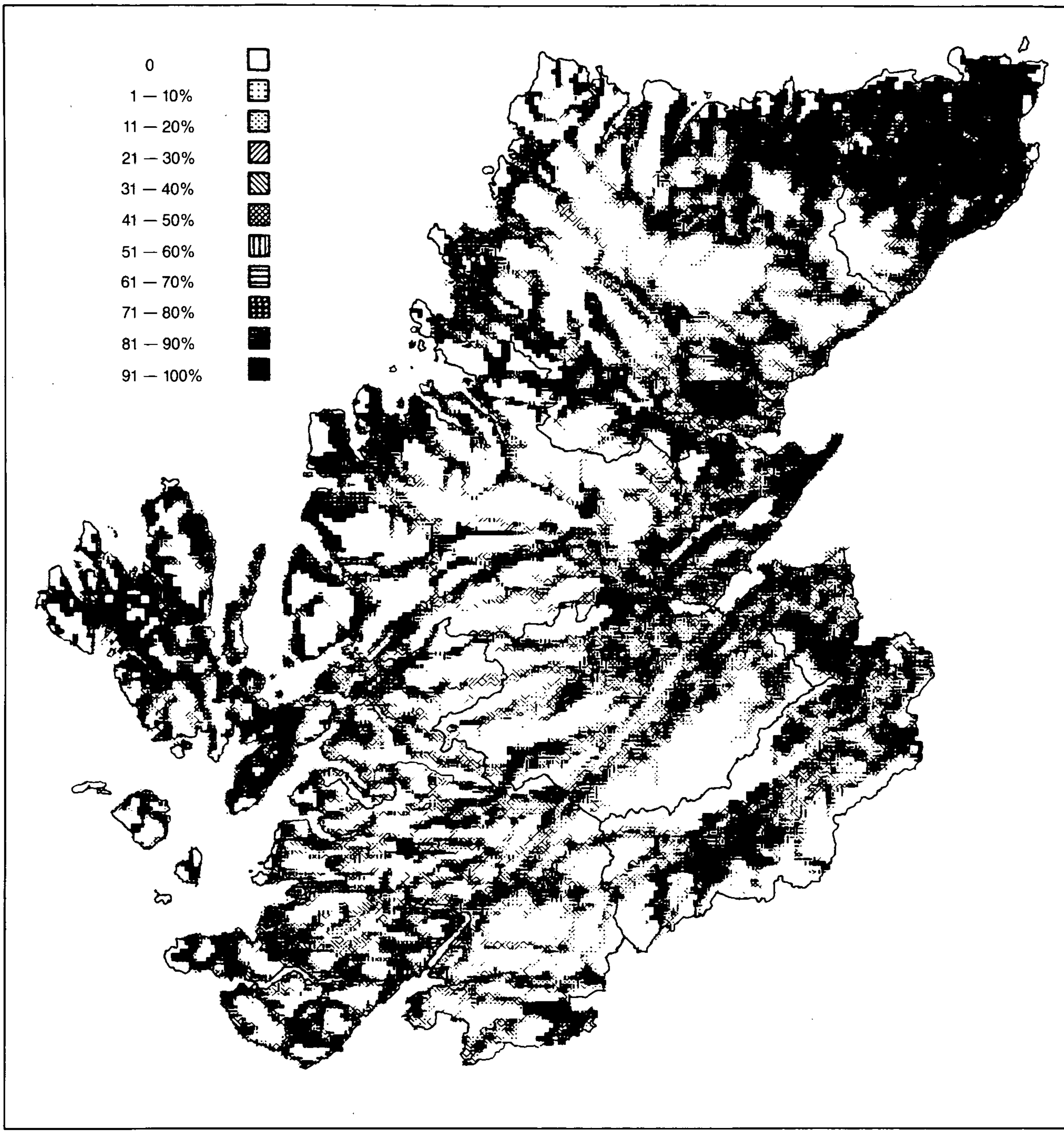


Figure 4. Distribution of the land potentially available for forestry, without regard to agricultural constraints

may modify them. Thus, for example, the impacts of strategies to change agricultural production or to increase afforestation need to be assessed for the Region as a whole, without the time and expense involved in carrying out major survey work for each new proposal.

The way forward, therefore, lies in marrying the ITE land classification system with a 100% data base using one km grid squares. The grid squares have particular advantages when considering an area as large as the Highland Region, *viz* data are relatively cheap and easy to acquire; the degree of resolution is particularly useful for strategic planning purposes; the data can be easily computerized; the boundaries of the squares are easily defined and understood by a wide range of other users/data suppliers. The system is also capable of adjustment to accommodate digital data and remote sensing data.

5 Acknowledgements

I would like to acknowledge the concerted efforts of my Planning Department colleagues, Mac Baldwin, Neil Black, Bob Cameron and Brian Mackenzie, in establishing the land classification system.

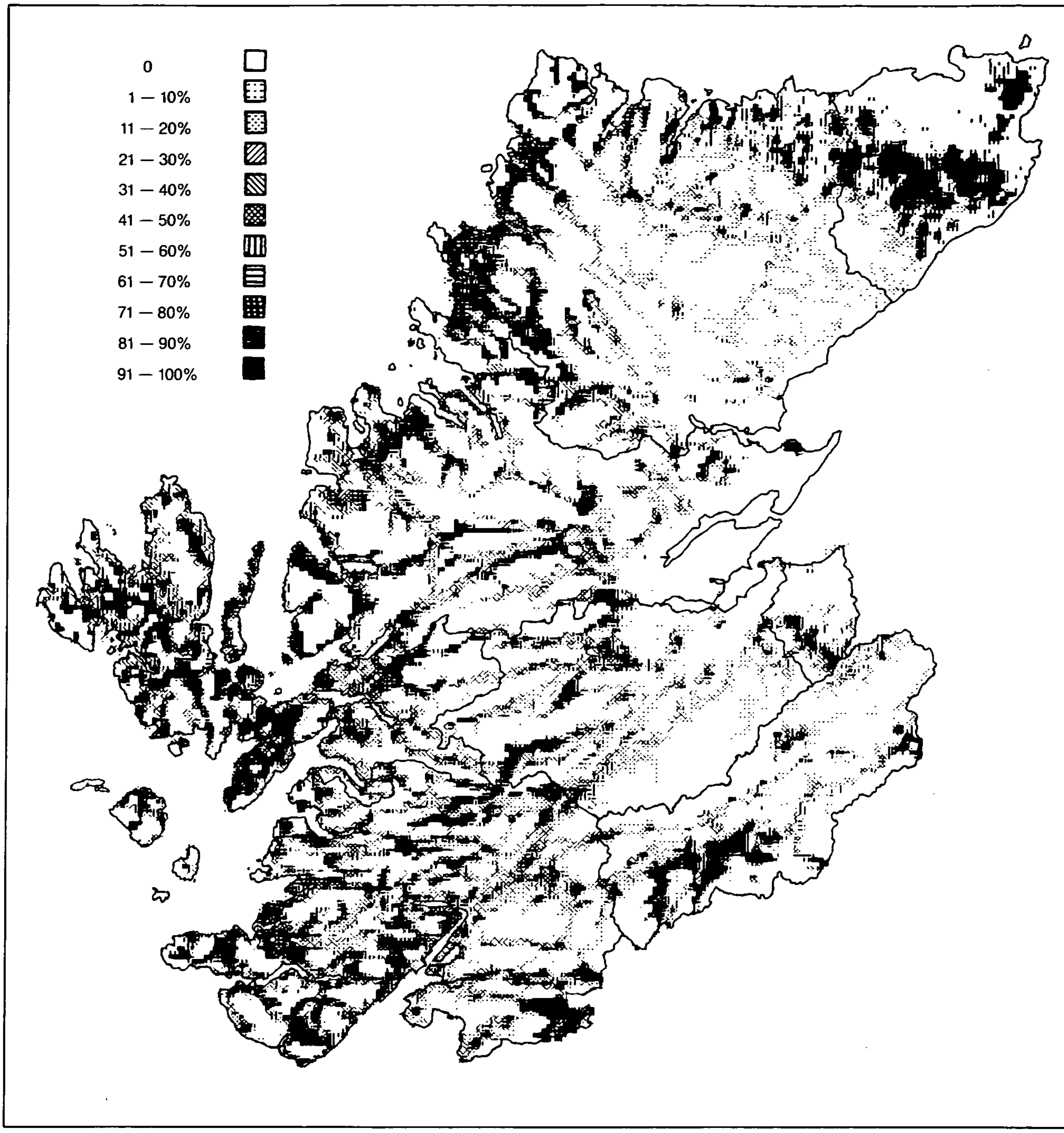


Figure 5. Distribution of the land potentially available for forestry, after removal of land that is likely to remain in agriculture

6 References

Bunce, R. G. H., Barr, C. J. & Whittaker, H. A. 1981. *Land classes of Great Britain: preliminary descriptions for users of the Merlewood method of land classification.* (Merlewood research and development paper no. 86.) Grange-over-Sands: Institute of Terrestrial Ecology.

Highland Regional Council. 1984. *Map production using a micro-computer.* (Information Paper no. 3.) Inverness: HRC Planning Department.

Highland Regional Council. 1985a. *HRC/ITE land classification system.* (Information Paper no. 5.) Inverness: HRC Planning Department.

Highland Regional Council. 1985b. *Amenity woodland survey technical report no. 1.* (Information Paper no. 7.) Inverness: HRC Planning Department.

Table 1. Woodland types: major species

Woodland type	Major species (%)
Coniferous plantings	Lodgepole pine (36.7), Sitka spruce (29.0), Scots pine (25.5)
Semi-natural broadleaved woods	Birch (78.6), goat willow (5.6), oak (5.4)
Scattered trees	Birch (54.1), Scots pine (20.2), rowan (12.2)
Semi-natural mixed woods	Birch (41.6), Scots pine (33.9), juniper (10.5)
Riverside trees	Birch (44.1), alder (20.0), rowan (10.7), Scots pine (5.9)
Broadleaved woods underplanted with conifers	Mixed broadleaves and conifers (69.2), birch (9.6), rowan (7.6), Scots pine (6.6)
Roadside trees	Mixed broadleaves and conifers (21.7), beech (17.9), hawthorn (14.9), birch (8.6), European larch (8.2)
Mixed plantings	Beech (36.6), Scots pine (29.4), birch (8.0), Douglas fir (6.2), rowan (5.5), western hemlock (5.1)
Multi-stemmed stands	Hazel (76.9), mixed broadleaves (9.6)
Policy woodlands	Mixed broadleaves and conifers (59.1), birch (8.6), Scots pine (5.7), Douglas fir (5.7), willow (5.5), alder (5.2), horse chestnut (5.2)
Hedgerows	Hawthorn (65.9), beech (11.9)
Shelterbelts	Scots pine (67.7), European larch (22.9), Douglas fir (8.9)
Semi-natural copses	Birch (52.2), goat willow (23.6), Scots pine (11.2), beech (7.5)
Railwayside trees	Birch (33.4), ash (19.5), beech (18.9), goat willow (14.1), rowan (14.1)
Semi-natural clumps	Birch (51.5), goat willow (16.0), Scots pine (10.5), rowan (6.8), alder (5.4)
Broadleaved plantings	Norway maple (43.8), rowan (21.9), cherry (21.9)
Isolated trees	Scots pine (26.9), birch (25.0), rowan (13.5), ash (9.6), European larch (6.7), alder (5.8)

Future trends in information systems for rural planning

P A BURROUGH
Department of Physical Geography, University of Utrecht, Utrecht, The Netherlands

1 Introduction

Successful information systems for forward planning in rural areas are the result of a complex blend of personal skills, good organization, suitable data and appropriate tools. The tools include computer hardware and software, but it must be stressed at the outset that the possession of impressive technical capabilities has little point, unless they are placed in the right context.

Rural information systems imply that the organization (Government authority or private consultant) has a clear and well-formulated idea of the following:

i. the kind and scale of the projects for which the rural information system is to be used;

ii. the sources of suitable data for the information system;

iii. the processing tools necessary to handle these data;

iv. the conceptual tools necessary to formulate strategies, analyse data and synthesize disparate material into logical and consistent plans;

v. an overall managerial and organizational context in which the information system can operate as an integral component. This context includes such diverse aspects as skilled staff, planning committees and legal and Governmental channels necessary for the total, effective, operation of any rural information system.

2 Rural information systems

Rural information systems imply systems that operate to consider the planning problems of large areas in moderate detail. The exact details and scale may vary with the country and the landscape in question (there is a vast difference between the Sahel regions of countries in west Africa on the one hand, and the highly detailed Dutch land consolidation schemes on the other), but essentially we are not dealing with the cadastral or registration problems of urban areas, but rather with the problems of human interaction with landscape and landscape processes. To overstate our case, we are probably more interested in the use that is made of land, and the consequences of that use, than we are of recording the exact boundaries of the land parcels for tax purposes. We are, therefore, more likely to want to include in the rural information system details about the separate aspects of the landscape — geology, landform, soil, water, vegetation, land use, settlement, agricultural and forestry practices — and landscape processes — erosion, eutrophication, salinization, seismic activity, groundwater flows, fluvial and littoral activity, and so on — and how they all interact under human usage, than to set up a register of detailed ownership or the accurate location of essential services (gas, water, or electricity lines).

If we look back for a period of some 40—50 years at the kinds of question that have been asked by rural planners, we see that there are a number of general lines that can be followed to obtain some idea about how things may develop in the future. These lines are summarized in Table 1. Although the time-scales may vary enormously for different countries, we note that, in general, there has been a progression from purely qualitative description to quantitative analysis. There have also been movements in which the landscape has been approached holistically (the integrated or landscape ecology approach) or from the point of view of the separate geographical and geological disciplines. In the latter, there have been strong trends towards quantification, and towards measuring single variables rather than proceeding via 'regional' generalizations.

Table 1. The development of landscape studies

		TIME AND TECHNICAL DEVELOPMENT
Inventory	Qualitative	
	'What is there in area X?'	
Exploitation	'What can be done in area X?'	
	'What are the limitations or the constraints on doing Y in X?'	
	'Where are there suitable areas for activity W?'	
	'What are the impacts/consequences of activity W in area X?'	
Interaction	Quantitative	
	'What will be the probable impacts/consequences of activities W1, W2, P. . . . in X?'	
	'Which scenario leads to optimum use of resources?'	

We can identify 3 phases of geographical data handling, which I shall call **inventory, exploitation** and **interaction.** In the first, or inventory, phase, the accent was on simply finding out what resources were available. This emphasis was not only true in many developing countries (cf Brunt 1967), but also in North America and Australia (eg Burrough 1978), and to a lesser extent in Europe. The second phase found us asking how the areas that had been surveyed could be used or exploited; could certain types of land use be successfully practised in given areas? How much land of a given type was available? How should evaluation methods proceed for the optimum use of land (eg Beek 1978; Brinkman & Smyth 1973)? All too soon, the results of the misuse or overexploitation were manifest so that rural information systems became necessary aids for environmental impact analyses. These studies were performed initially to find out why certain developments had produced unwelcome effects; later, they were used in an attempt to predict what the results of a given development project might be on the landscape in question. A concurrent development was the incorporation of economic analyses into the operation of land evaluation (Beek 1978).

We are still very much in the second phase and the first part of the third phase of the developments outlined above. The effects of technological change, population growth and mobility have placed new demands on landscapes the world over. In the 1970s, when environmental studies were very fashionable, there were very serious developments towards setting up procedures so that the possible consequences of development could be assessed before political decisions were made. Unfortunately, the planners and environmentalists of the day lacked the necessary data and tools to handle the complex problems with which they were confronted. Today, some 15 years later, we have powerful tools for environmental analysis that can greatly assist in all the 3 phases just enumerated. It is paradoxical that these new tools are themselves the product of the societies that have also been responsible for many of the problems facing the rural planner (cf Weisenbaum 1976).

Initially, data collection for rural planning was qualitative and descriptive. Ground survey was the only means of obtaining the data required, which meant that surveys were slow, uneven in coverage and quality, and probably somewhat biased. Survey of certain aspects of the landscape (landform, land use, geology, soil) was greatly assisted and considerably improved by the development of aerial surveys and aerial photography, though studies of vegetation, animal movements, air and water quality and many other important attributes still required detailed measurement in the field. The science of remote sensing has extended the rates at which data about large areas can be collected and analysed for certain classes of landscape attributes, such as water, land use and vegetation cover.

One consequence of the earlier methods of data collection was that surveys of landscape resources could not easily be repeated. Consequently, it was difficult to observe landscape change taking place. This difficulty encouraged the view that landscapes were mainly static, largely unchangeable phenomena in which slow, gradual change was the rule. The use of multi-temporal aerial photography and satellite imagery, and the growing realization that change can occur not only gradually but with catastrophic speed have led to new requirements for data and data handling. These data requirements have also led to new ways in which data are processed before reaching the rural planner (Table 2).

Table 2. Data collection and processing in rural planning studies

Data collection	Data processing	
Pencils and paper 'eye-ball' assessments	Qualitative classification, integration and mapping followed by re-interpretation for specific uses	TIME AND TECHNICAL DEVELOPMENT
Aerial photography		
Remote sensing and quantitative sampling	Quantitative analysis of single or multivariate data sets for specific purposes precedes classification. Use of geographical information systems to store and process data as required	
	Increase of interactive systems and mathematical modelling in planning studies	

For many field sciences, the original sampling procedure was to go to the field and record a few points or sample areas in great detail. Because the data were so complex, even small numbers of points resulted in vast amounts of data. So, the data had to be classified before they could be used to categorize the areas that were mapped from aerial photography or geomorphological landscape analyses. Landscapes were divided into regions, soil mapping units or other thematic classes. The only information that could be retrieved and used for planning was that which could be extracted from the classification. Much expensively gathered information was lost.

Today, it is no longer necessary to classify in order to make large volumes of data digestible. Both quantitative and qualitative data can easily be recorded in digital form during the field study. These data can be classified and condensed if required, but they can also be used separately or in combination in order to examine specific problems. If desired, cheap, efficient techniques can be used to map each variable separately (cf Burrough & van Keulen 1988; Burrough & de Veer 1984) before the spatial data need to be classified.

The necessary techniques for spatial data analysis are to be found in the computer tools that are known as geographical information systems. Besides being able to make use of data coming from field studies and existing maps, geographical information systems allow the integration and analyses of data from many different sources, including remote sensing scanners. Because the landscape data are recorded in elementary form, the rural data base can be used as a digital test bed for exploring the consequences of given planning decisions, or simply as a tool to examine the ways in which trends may be leading to landscape change (Burrough 1986; Steinitz 1979; Steinitz & Brown 1981; Teicholz & Berry 1983). By setting up plausible scenarios, a planner can explore the possible consequences of a whole range of development options before any commitments are made. These kinds of study are becoming increasingly common, but it should be pointed out that they can only be carried out sensibly within organizations that have taken the necessary steps to incorporate modern rural information systems into their normal work procedures.

There have also been major developments in the use of mathematical methods for the statistical analysis of field data and for building quantitative models of landscape processes. In particular, in the geological sciences, in ecology and in soil science, statistical techniques have been much used for spatial analyses and quantitative mapping (eg Agterberg 1982; Nielsen & Bouma 1985; Ripley 1981; Verly 1984). Mathematical models are now used routinely for analysing and predicting weather changes, groundwater movements, air pollution, or the spread of insects and disease, and similar dynamic problems. In the Netherlands, the Centre for World Food Studies has pioneered the application of the linear programming methods of systems analysis developed at the International Institute for Applied Systems Analysis in Laxenburg, Austria, to planning agricultural production in developing countries. The use of these methods, while requiring specialist skills, has resulted in better and more appropriate information being supplied to the planner than was ever possible before the computer age. Geo-mathematical methods now form important parts of many geographical information systems used for rural planning.

A particularly attractive feature of working with geographical information systems for landscape planning is the ease with which the shape of the landscape itself can be used, in the form of a digital elevation model (DEM), together with other thematic or quantitative data. Not only can many important attributes of the landscapes, such as the gradient and aspect of slopes, inter-site visibility, and the catchment areas be derived automatically (eg Evans 1980), but it is also possible to 'fly around' the landscape models in order to obtain a realistic impression of how visible changes might occur (eg Burrough 1986; Ross & Evans 1984) or to model the visible and structural consequences of new roads and bridges (Purdie 1984). The landform can be modelled cheaply and quantitatively in 3 dimensions: in particular, there has been a considerable amount of work done to make 3-dimensional methods of landscape analysis work on easily usable and cheap microcomputers. These facilities are becoming increasingly appreciated by landscape architects who 'can now use computers as tools without having to make them (their) vocation' (Kelly 1985).

3 The future

The future trends in information systems for rural planning will most probably be a direct continuation of the new developments that have been made in the last few years. We may expect the following.

1. Rural planning will be more analytical: there will be increasing demands for 'what if', and quantitative analyses before development plans are finalized.

2. New data may be needed to supply the users of these 'what if' analyses. Data will be more quantitative, and less generalized. They will be fed into mathematical models of landscape processes, rather than be intuitively generalized using 'eyeball' techniques.

3. Computer tools will continue to become easier to use, smaller, more powerful and relatively cheaper.

4. Spatial data for rural planning will need to have a better spatial resolution than at present in order to be able to model many types of change or feature accurately. Geographical information systems will incorporate both 'vector' (ie point, line, polygon data) and 'raster' (ie grid cell) data.

5. The planners and planning organizations that

do not avail themselves of the new technologies will be superseded by those who do. As techniques become cheaper and easier to use, however, computer methods will become less arcane, so existing staff should have fewer difficulties in adapting to the new tools, provided they can accept the philosophy of the methodologies being used.

6. For some time, there will continue to be a shortage of skilled and experienced personnel available for the technical aspects of operating and running modern rural information systems. Consequently, both on-the-job training and training of new recruits in universities and technical colleges will be necessary.

4 References

Agterberg, F. P. 1982. Recent developments in Geomathematics. *GeoProcessing,* **2**, 1-32.

Beek, K. J. 1978. *Land evaluation for agricultural development.* Wageningen: PUDOC for International Institute for Land Reclamation and Improvement.

Brinkman, R. & Smyth, A. J. 1973. Land evaluation for rural purposes. (Publication no. 17.) Wageningen: PUDOC for International Institute for Land Reclamation and Improvement.

Brunt, M. 1967. The methods employed by the Directorate of Overseas Surveys in the assessment of land resources. In: *Actes 2nd Symp. Int. de Photo Interpretation, Paris, 1966.*

Burrough, P. A. 1978. Overseas methods of land evaluation. In: *A national study of soil conservation.* Canberra: Department of Environment, Housing and Community Development.

Burrough, P. A. 1986. *Principles of geographical information systems for land resources assessment.* Oxford: Oxford University Press.

Burrough, P. A. & van Keulen, J. 1988. Statistical and spatial analysis of land resource data. In: *Rural information for forward planning,* edited by R. G. H. Bunce & C. J. Barr, ?-?. (ITE symposium no. 21.) Grange-over-Sands: Institute of Terrestrial Ecology.

Burrough, P. A. & de Veer, A. A. 1984. Automated production of landscape maps for physical planning in The Netherlands. *Landscape Planning,* **11**, 205-226.

Evans, I. S. 1980. An integrated system of terrain analysis and slope mapping. *Z. Geomorph., Suppl. Bd,* **36**, 274-295.

Kelly, K., ed. 1985. *Computers in landscape architecture. I. Introduction to microcomputers.* (Technical Information Series no. 8.) American Society of Landscape Architecture.

Nielsen, D. R. & Bouma, J., eds. 1985. *Soil spatial variability.* (Proc. Workshop International Soil Science Society and the Soil Science Society of America, Las Vegas, 1984.) Wageningen: PUDOC.

Purdie, C. 1984. Accuracy in computer-aided visual impact analysis. In: *Computer aided landscape design: principles and practice,* edited by B. M. Evans, 76-83. Glasgow: Landscape Institute, Scotland.

Ripley, B. 1981. *Spatial analysis.* Chichester: Wiley.

Ross, R. & Evans, B. M. 1984. The development of visual resources management and computer-aided design in the United States Forest Service. In: *Computer aided landscape design: principles and practice,* edited by B. M. Evans, 85-105. Glasgow: Landscape Institute, Scotland.

Steinitz, C. 1979. Simulating alternative policies for implementing the Massachusetts Scenic and Recreational Rivers Act: The North River Demonstration Project. *Landscape Planning,* **6**, 51-89.

Steinitz, C. & Brown, H. 1981. A computer modelling approach to managing urban expansion. *Geo-processing,* **1**, 341-375.

Teicholz, E. & Berry, B. J. 1983. *Computer graphics in environmental decision making.* Oxford: Pergamon.

Verly, G., ed. 1984. *Geostatistics for natural resources characterization.* Dordrecht: Reidel.

Weisenbaum, J. 1976. *Computer power and human reason.* San Francisco: Freeman.

POSTER PAPERS

Integration and evaluation of rural policy in a period of rapid change

M BELL
Institute of Terrestrial Ecology, Merlewood Research Station, Grange-over-Sands

1 Environment and society

The question of how far the place where one lives affects social position, values and thought is one of the great recurrent debates. 'Environmental determinism', as it has come to be called, has a long history. From Montesquieu's argument that climate lay behind national character, through Renan's assertion of the role of the desert in forming the monotheic character of Islam and Christianity, through to Mumford's vision of the city, attempts have been made to tie physical form to social life (Allison 1975; Mumford 1973; Renan 1869; Montesquieu 1978). Sometimes it is explicit, more often it is implicit, as in the well-known assertions by Alice Coleman that certain types of urban form lead to crime and other anti-social behaviour. This view tends to take Newman's concept of defensible space into far more arguable areas (Newman 1973). Sometimes, as in the case of Braudel (1975), that most elegant and synoptic of historians, the interplay of environment and society becomes the epistemological method itself. In his explanation of taking 'the Mediterranean' as a focus for historical study, he argued: 'Geography in this context is no longer an end in itself but a means to an end. It helps us to rediscover the slow unfolding of structural realities, to see things in the perspective of the very long term'.

Thus, when a student of society is told it is possible to relate socio-economic factors to a leading method of classifying Britain's land by the use of primarily ecological, topographical and climatic data, he is bound to be interested. This paper, then, describes work to be undertaken at the Merlewood Research Station of the Institute of Terrestrial Ecology (ITE) to examine the possibilities of using the same sampling framework for land use change and related social factors. The Merlewood land classes (MLCs) are known to be effective in national sampling, eg of data on upland vegetational change; in simple terms, the question arising is whether one could cross-relate that change to, say, the incidence of low-income tenant farmers, if that were required. As a preliminary experiment, it seems particularly suitable to examine applicability for 3 factors. One category, of which those designing the system may not be aware, is the Rural Development Area (RDA); the other categories of land use designation which have since been added are Less Favoured Areas and National Parks. This paper outlines some of the thinking behind the approach, and describes work being undertaken as part of a joint Economic and Social Science Research Council/Natural Environment Research Council Fellowship established at Merlewood.

2 Social science information, and decision-making: the case of Rural Development Areas

2.1 Policy background

Some readers may be less familiar with RDAs than others because, *inter alia:*

i. this paper is aimed at a mixed audience, including natural scientists who have no professional connection with local Government or rural development;

ii. the RDAs are a policy tool of the Development Commission, whose remit does not extend beyond England;

iii. even some of the participants from local Government may come from areas which were never likely to receive RDA status, and thus have no reason to be involved in the selection process;

iv. there appears to be no single widely available publication describing the process of RDA selection. (Readers who have been closely involved in selection may wish to move on in the paper. Alternatively, they may find that their view of the process varies somewhat from that gleaned from primarily official sources.)

The Government agency involved is the Development Commission (DC). It was established in 1909 by that reforming Liberal Government pressured by the social interventionism of the new Labour Party, and having lost its Cobdenesque, free enterprise, 'laissez-faire' ideology to the Conservatives (Dangerfield 1970; Pelling 1966). Thus, the DC was born in a steamy political atmosphere and has had to continue to justify its position to different Governments. In ecological terms, at least, survival is a success, and, by way of coincidental celebration of its 75th birthday, the DC moved to grant-in-aid status.

The shift from direct responsibility to the Department of Environment was one element of a general Governmental review of the DC's functions. In regard to priorities, the review held that the DC should select its own areas, whereas previously the Environment Secretary had reserved the final decision on bids under the DC's system of Special Investment Areas (SIAs).

Responsibility for designation was not utterly untrammelled. It will be remembered that the present administration has pursued a policy of focusing aid on the most needy areas. In the out-turn, RDAs ended up covering an area 95% of that of the SIAs, with some 90% of the population of the predecessor designation. Despite the aggregate reduction, the RDAs subsume part of 28 counties, whereas the SIAs were in only 19.

2.2 Extending the land class system

RDAs look likely to present an admirable and important extension of the land class system's applicability to social issues because of the following.

i. Although the DC has no formal remit for agriculture *per se,* elements of the Rural Development Programmes (RDPs) drawn up for the RDAs may well focus on forestry and farm diversification (DC 1985; Bell 1985). Thus, such a designation is necessarily an important component of the general project on policy-induced change.

ii. As will be discussed further below, RDAs were sieved out through a series of socio-economic indicators of deprivation. This concept has generated a considerable literature (Shaw 1979; McLaughlin 1981), and McLaughlin has recently reported to Department of Environment on further work. Thus, RDAs should fit some rational pattern of designation based on prespecified criteria. In being non-random then, that would presuppose that any fit with the land class system should be other than mere chance.

iii. The process illustrates well 2 elements, quite normal in public administration, which will be of note to those used to more precise sciences. First, the data availability for social indication is imperfect, and has particular difficulties marrying up with the idea of what is 'rural', especially in a time of changing settlement patterns (Cloke 1983). Second, conceptions of what the DC themselves call the sensible and pragmatic determined the final decisions on boundaries (DC 1984).

2.3 The mechanics of designation

The Government's 6 criteria for RDAs were as follows.

i. Unemployment is above average for Great Britain, account being taken of changes in recent years.

ii. There is an inadequate or unsatisfactory range of employment opportunities.

iii. Population decline or sparsity of population is having an adverse effect.

iv. There is a net outward migration of people of working age.

v. The age structure of the population is biased towards elderly people.

vi. Access to services and facilities is poor.

For selection purposes, it will not be necessary for all the criteria to be satisfied, but it is envisaged that most Rural Development Areas will meet the first criterion and one or more of the remainder. However, they may also be selected where a combination of any of the criteria indicates a concentration of problems.

The Commission immediately recognized that boundaries for action and grant assistance would benefit from following administrative boundaries, where possible. A glance at many of the excellent research papers for the Royal Commission on Local Government (Redcliffe-Maud 1969) illustrates the complexity of taking administrative boundaries as surrogates for other social factors. So, understandable administrative imperatives may not conform to other criteria.

As alluded to above, it was decided that 'RDAs should be no more extensive than the SIAs' (DC 1984), and thus an element of comparison between needy areas was imported. It is particularly relevant for using RDAs as a test that the DC undertook its own independent initial search. SIAs — like many similar instruments — had been founded on bids from local authorities.

In its search, the DC utilized 2 rules: minimum size for the areas as a whole, and exclusion of the 'urban area' as beyond its preview. The general guidelines on minimum size were as follows.

— RDAs will be of such an extent, with a sufficient range of social and economic problems, as to justify the implementation of a comprehensive action plan over a period of at least 5—10 years.

— They will not be smaller than an average-sized rural district, or 25—30 parishes, although they might straddle existing county boundaries.

— They will be of such size that, bearing in mind local travel-to-work patterns, job opportunities are unlikely to be significantly affected by changes and developments outside the proposed area.

— They will be of such extent, with such a total population and such a range of social and economic problems, that one or 2 significant events, eg the setting up of a single large factory, the building of a small housing estate at a single location, or the introduction of a more effective public transport service, would probably not solve the problems experienced.

— They will be areas capable of supporting a programme designed to bring into use a significant amount of industrial or business floor space — say 8000 square feet per year over a period of 5—10 years — by both public and private sectors, including conversion of redundant buildings; this capability will mean, amongst other things, that each area will contain a number of settlements likely to be capable of yielding the necessary sites over the period in question.

The taxonomy and functional relations between towns of particular sizes and their hinterlands have been one of the bases of human geography from Von Thunen onward (Chisholm 1979). The DC took their stance on a population of 10 000, and, whilst recognizing that this 'cannot be a hard and fast rule, because the functions in relation to rural areas performed by towns of similar size can be quite different', it was nonetheless 'thought right to apply the 10 000 limit fairly strictly' (DC 1984). This requirement to balance rules and flexibility is a recurrent social policy problem (Forder 1975).

After some 30 local meetings, the boundaries were finalized — and intended to remain guidance on policy for 5—10 years. The Commission drew out a number of general features.

— Compared with the SIAs, there is a slight reduction in coverage in the northern and south-western counties and an increase in priority area coverage in Midland counties, particularly those on the Welsh Marches and the east coast.

— For the first time, the Commission has designated priority areas in metropolitan counties (West Yorkshire and South Yorkshire) and the home counties (Kent). This action reflects the fact that administrative boundaries do not necessarily represent the divide between urban and rural areas and that, even in the relatively prosperous south-east, there are rural areas of severe deprivation.

— There is a general movement away from larger towns and cities, resulting in a 'halo' effect around the more major settlements. This movement, in part,reflects the stricter application of the town size population limit, but also the Commission's view that its resources should, in general, be concentrated on remoter areas less influenced by the fortunes of larger urban centres.

It is for special committees in these areas to draw up RDPs covering their needs and requirements in a time of rural change.

3 Other potential applications of the land classification system within the Fellowship

At its inception, the Fellowship favoured primarily upland work. RDAs often coincide with uplands, but do not necessarily follow such boundaries; and other categories of area for study have been pursued. These other categories both utilize and refine the method as a sampling frame, and permit survey results to be generalized to the 'wider population', ie to convert sample figures into GB, England, Wales or regional statistics as required.

After RDAs, the 2 aspects considered suitable for work within the Common Agricultural Policy (CAP) framework are:

— selection of areas for extended Less Favoured Areas status

— designated National Parks.

Additionally, a farm visiting programme will be undertaken in the hills and uplands. Economic profiles can be developed to compare with regional farm management survey (FMS) data of similar types. The comparable data for alternative enterprises or levels of output can then be used as one input to the modelling of the farm's predicted *economic* reaction to putative EEC change.

From the survey farms, it will be possible to extrapolate back to the wider population, taking note of special (or even unique) social factors, and of the results from earlier work on farmers' actual reactions to changes which have occurred. This information will include standard work on the relationship between size and performance (Britton & Hill 1975), or tenure and performance (Gasson & Hill 1984). A starting point will be work already undertaken, primarily by Richard Tranter at the Centre for Agricultural Strategy (CAS).

4 Work by Tranter on the land availability study

The method has been taken forward in the agricultural field by Tranter, in 2 major contributions.

i. Analysis of likely agricultural use of the different land classes leading to a series of gross margin costings.

ii. Utilization of field records to identify specific occupiers of land for their use in a postal questionnaire for the British Library. This study permitted checks to be carried out to assess the stratification of the sample *vis-à-vis* farm size, tenure and related agricultural criteria.

4.1 Approach to the farm costings in the land availability study (LAS)

The LAS was a collaborative effort between ITE, Dartington Institute, CAS, Aberdeen University and the Forestry Commission (Westonbirt Arboretum). The study was commissioned by the Energy Technology Support Unit, who also collaborated in it.

The principal aim was to identify land in the British Isles which might be available for the production of timber as an energy crop. One of the ultimate outputs was a model allowing an assessment of how much land might convert into forestry on various cost assumptions. It was also important to know in what areas such conversion might occur.

Tranter set out to obtain the best fit of farm system to the appropriate MLC squares in order to assess the physical and the financial performance of agriculture on the various land use/types recorded on the 256 ITE km^2 sample squares. Such levels of performance would then be compared with values arising from the assessments of potential wood energy plantations on the same parcels of land. Where these latter values exceeded those assessed for agriculture, it was taken that those areas were 'available for wood energy plantations' on financial constraints grounds. In colloquial terms, forestry would 'win' as a potential land use over agriculture.

Tranter used a gross margin (GM) approach to the question of comparing performance, a decision which would win the approval of most agricultural economists. The use of this approach is increasing, and it has been employed by leading consultants at a number of major public inquiries, such as those into Stansted Airport and the A1–M1 Link Road. Its advantages include the following:

- the fact that, for most short-term alterations in cropping or practice, it is not possible for a farm enterprise to alter its fixed costs;
- the concept is understood and employed by many farmers;
- it can, with commonsense and judicious consideration, be applied to performance from specific parcels of land. These data are derived from the gross margins given in MAFF's standard guide.

A number of different values had to be combined in the LAS, and prices, yields, inputs and outputs were therefore tied to 1977–78 levels. A significant element of the Fellowship will be to update these figures.

The most accepted, nationally available, source of GM data is Nix's (Wye College) annual *Farm management pocketbook,* which bravely predicts for the year ahead. FMS data provide an historic record of actual performance in the year selected as a base, and are available by region from the appropriate universities. These annual records will be one of the prime data sources for the farm modelling aspects of the Fellowship, as they were for Tranter (1985). The major step forward will be that the Fellowship permits the opportunity to visit farms in certain classes and areas to ascertain how closely the model accords with reality.

Tranter himself described his efforts (and some assumptions) in this field as 'heroic'; indeed, they were, in the best sense. He utilized data such as rainfall, related soil moisture deficit, soil type and herbage/crop response, which, for each class, was a major exercise in itself. No attempt was made to allow for management factors, as the data did not permit it.

As well as including management elements, in due course the Fellowship will utilize and extend the data from ITE's survey in another way. The tabulated field records show features such as hedges and ponds which are considered as environmental *desiderata*. It is therefore proposed to identify the types of land, and types of farm, where the most significant environmental gains and losses might take place.

Tranter's exercise drew on a wide body of existing knowledge to predict likely yield ranges for particular crops potentially grown in different ITE classes. He sought a 'financial measure for the performance of agriculture for, say, a particular piece of *Lolium perenne* in a valley in upland Wales, rather than a generalised performance measure for whole farms in that part of the country'. An example will illustrate his approach. From the potential range of grassland enterprises, 4 distinct models were utilized:

- specialist dairying
- livestock rearing
- hill sheep
- lowland fat lamb

The model for hill sheep, for example, was based on work by Lazenby and Doyle (1981). Their results per animal were converted into stocking densities on land of different qualities, and it was found that the different land classes with grassland could be reasonably consolidated into 4 'herbage groups', subsuming a range of different levels of forage yield in terms of tonnes of dry matter ha^{-1}. The eventual gross margins to set against forestry options showed a considerable range (as one would expect). For hill sheep, the range was from £76 ha^{-1} down to no effective profit at all.

5 The inclusion of non-economic data in the model

One of the principal steps in the LAS work was to try and incorporate factors beyond a straight economic comparison. It was realized that a number of constraints would work against the establishment of forestry on land where it was theoretically economic so to do. The constraints considered were:

Areas of Outstanding Natural Beauty
Ancient Monuments (and other archaeological)
Capital transfer tax
Exemption agreement
Common land and crofters' rights
Country parks
Forest parks
Heritage coasts
National Nature Reserves
National Parks
National Scenic Areas
National Trust (and ornamental gardens)
Plans (regional, structure, local)
Private nature reserves
Sites of Special Scientific Interest
Water gathering problems

A careful judgement (based on close reading of relevant policy documents) was needed to assess which of these constraints were likely to preclude energy forestry.

The application of particular constraints in the final LAS study was undertaken systematically, with levels of 'scoring' for constraints which — it was considered — would exclude forestry.

Again, this work will help to provide a useful basis for the Fellowship study, which will equally have to take into account policy aspects on potential land use changes — policies which have often altered themselves, eg in the increased support for farm/forestry integration (Forestry Research Co-ordination Committee 1984, 1985). The Fellowship will allow a check 'on the ground' regarding some designations which may influence tree planting.

The LAS recognized that constraints beyond extant land use policies, as well as institutional factors, would necessarily intrude into any large-scale change. The position of tenant farmers, for example, was altered by the recent Agricultural Holdings Act, permitting them to plant trees without the landlord's consent, although it appears that the trees become the property of the landlord. The notional figures for tenanted land (some 40% of farmland) need treating with care, in any case, as many family tenancies are established for taxation and inheritance reasons. Nonetheless, a large area of Britain is subject to farming institutions or tenure systems which are likely to react to land use change in a different way from owner-occupiers.

6 Who farms the land?

In surveying any sample population, a balance must be struck between using the same populations — thus assisting comparability — and bothering people too often.

The farmers and land occupiers in the ITE sample squares have been visited by field surveyors seeking permission to enter for 2 rounds of survey (1977–78 and 1984). To date, they have only once been deliberately used, because they farm within the squares, and this gives a sample framework. Obviously, they may have been used coincidentally by other research workers.

During collection of field data in 1984, ITE was able to collect details of owners and/or occupiers of the land. For a British Library project looking at how farmers gathered, structured and managed information in taking decisions, Tranter requested access to these data to use the farmers as his sample. This project was seen as a useful extension of the system, and will certainly prove helpful when the Fellowship moves into a field work phase, not least because the field-recorded details were not always complete or accurate. Thus, Tranter had to check names and addresses against telephone directories.

Tranter's work (Jones *et al.* 1988) work also refined some of the recording which was unclear regarding agricultural use. For example, records of rye-grass *(Lolium perenne)* leys might prove to be golf courses or reservoir fringes. In the end, from 144 squares (in England and Wales), only some 120 ha from 14 400 ha could not be ascribed to a likely owner or farmer. A total of 509 addresses were mailed and a response of 36% was obtained. There were some differences in completion rates from different land classes, but, on the whole, the pattern was consistent.

The overall conformity of the 21 534 ha farmed by respondents was close to official figures on tenure (62.5% owned, 37.5% rented) and provided a range of farm enterprises. The comparison on farmer age, education and family size was also close to what national data exist on these factors, as were the data on rent levels and off-farm incomes.

7 Current progress

The proportions of different land classes falling within the RDAs have been mapped and compared with national proportions. It is thus possible to utilize, first, the 1977–78 data, and the 1984 data as they become available, to see if farming and land use patterns (including change) are different in RDAs from elsewhere. Combined with modelling exercises and field work (including farm interviewing), it is hoped to move toward a position which will

Table 1. Overlap between LFAs and RDAs

Area falling within	England & Wales(kha)*	MAFF figure	Percentage of England/Wales*
RDA only	2 736		18.0
RDA & original LFA	1 363.5		8.9
RDA & extended LFA	373.5		2.4
All RDA	4 473		29.1
Original LFA	1 431		9.3
Original LFA & RDA	1 363.5		8.9
All original LFA	2 794.5	2 443	18.2
Extended LFA only	675		4.4
Extended LFA & RDA	373.5		2.4
All extended LFA	1 048.5	803	6.8
All LFA	3 843		25.0
All LFA/RDA overlap	1 737		11.3
Outside of both	8 797.5		57.2
Total land area	15 376.5	15 120.6†	

* Derived from Merlewood sampling frame
†Whitaker's Almanack (including water surface)

allow policy integration and evaluation on an established and robust data base.

The use of sample squares for estimation has produced the figures for RDA and LFA given in Table 1.

The principal use of this enhanced sampling frame, and modelling base, has been in a study supported by the Department of Environment/Development Commission. This work, on the countryside implications of CAP changes, was able to calculate some predicted areas of land use change in an era of CAP decline, and to differentiate between land in/out of LFAs or RDAs. The identification of subregions already disfavoured, and which were also likely to be harmed disproportionately by the decline in support for agriculture, makes it possible to begin 'targeting' places likely to be in need of especial assistance in the medium term. It may even throw a little further light on the question of relations between land and the society upon it. It is doubtful, however, whether we will be able to express it as elegantly as Jacquetta Hawkes (1953) did in her classic and elegaic work, but it may be a little more quantitative.

'In the extreme south-west the Doulting quarries gave the material for Wells Cathedral and for Glastonbury, but Gloucestershire is the region where these limestones have done most to create an entire countryside. Men and sheep and the limestone hills have together made the Cotswold realm, with its small unchanging towns and church-proud villages, its hamlets and country houses, surely one of the most lovely stretches of rural urbanity in the world.'

8 References

Allison, L. R. P. 1975. *Environmental planning: a political & philosophical analysis.* London: Allen & Unwin.

Bell, M. 1985. *Farm diversification in the EEC. (Report of the Rural Life Conference.)* London: National Council for Voluntary Organisations.

Braudel, F. 1975. *The Mediterranean and the Mediterranean world in the age of Phillip II.* London: Fontana.

Britton, D. K. & Hill, B. 1975. *Size and efficiency in farming.* Farnborough: Saxon House.

Chisholm, M. 1979. *Rural settlement and land use.* London: Hutchinson.

Cloke, P. 1983. *An introduction to rural settlement planning.* London: Methuen.

Dangerfield, G. 1970. *The strange death of liberal England.* London: Paladin.

Development Commission. 1984. *The designation of Rural Development Areas.* London: The Commission.

Development Commission. 1985. *Further advice on rural development programmes.* London: The Commission.

Forder, A. 1975. *Concepts in social administration.* London: Routledge.

Forestry Research Co-ordination Committee. 1984. *Report of the Review Group on the Integration of Farming and Forestry in the Lowlands.* Farnham: Forestry Commission.

Forestry Research Co-ordination Committee. 1985. (Information Note no. 7.) Farnham: Forestry Commission.

Gasson, R. & Hill, B. 1984. *Farm tenure and performance.* London: Wye College, School of Rural Economics.

Hawkes, J. 1953. *A land.* London: Readers Union.

Jones, G. E., Rolls, M. J. & Tranter, R. B. 1988. *Information management in agriculture.* (A report to the British Library.)Reading: Agricultural Extension and Rural Development Centre, University of Reading. In press.

Lazenby, A. & Doyle, C. J. 1981. Grassland in the British economy — some problems, possibilities and speculations. In: *Grassland in the British economy,* edited by J. L. Jollans, 14-50. (CAS Paper no. 10.) Reading: Centre for Agricultural Strategy.

McLaughlin, B. 1981. Rural deprivation. *The Planner,* **6**, 31-33.

Montesquieu, C. L. De. 1978. *Spirit of the laws (selections).* California: The University Press.

Mumford, L. 1973. *The city in history.* Rickmansworth: Penguin.

Newman, O. 1973. *Defensible space: crime prevention through urban design.* London: Macmillan.

Nix, J. 1984. *Farm management pocketbook.* 15th ed. Ashford, Kent: Wye College.

Pelling, H. 1966. *The origins of the Labour Party.* Oxford: Oxford University Press.

Redcliffe-Maud, J. M. 1969. *Local government in England. Report of the Royal Commission.* (Cmnd 4040.) London: HMSO.

Renan, E. 1869. Histoire des Origines du Christianisme. In: *Collected works,* edited by Psichari, 1947-61. Paris.

Shaw, J. M. 1979. *Rural deprivation and planning.* Norwich: Geo Books.

Tranter, R. B. 1985. An assessment of the financial performance of agriculture on the 256 ITE one km sample squares. In: *Growing wood for energy in Great Britain,* a synthesis compiled by Dartington Amenity Research Trust, technical annexe 2, 1-142. Dartington: Dartington Amenity Research Trust

The use of the MAP2 program in landscape planning and research

A VAN DEN BERG
De Dorschkamp, Wageningen, The Netherlands

1 Introduction

For several years, various institutes in the Netherlands and several departments in the Agricultural University in Wageningen have been using the MAP program, an extended package for analysing, transforming and displaying raster data. This program was initially developed at Harvard (Tomlin 1977) and later refined at Yale University (Tomlin 1983).

The original MAP program was primarily intended to be a teaching tool. Its application had many drawbacks, especially in larger projects. Also, the user-friendliness of the program left much to be desired. For these reasons, the landscape division of De Dorschkamp has modified the program, in consultation with other MAP users. This modified program is called MAP2 (van den Berg 1985; van den Berg *et al.* 1984).

The aim of this paper is to show the possibilities, advantages and disadvantages of using MAP2, based on first experiences in 4 Dorschkamp research projects. Technical details about how to use MAP2 are not discussed. To illustrate MAP2's potential as broadly as possible, its use in different fields of landscape research (landscape ecology, landscape planning and visual aspects of the landscape) will be described. Before illustrating the role of MAP2 in a particular project, the background to the project will be briefly described. The paper concludes with a discussion of the value of this computerized method of landscape analysis.

2 Using MAP to identify ecologically auspicious sites

2.1 Context of research

The concept of an 'ecologically auspicious' site is important in research on the possibilities and effects of adapted agriculture (ie forms of agriculture that are also adjusted to the needs of nature and landscape management). If natural qualities of the environment are to be saved, or, even better, to be given a better chance, forms of management that have a positive effect on nature and the landscape and yet also fit in with the management of existing agricultural holdings must be developed.

The research needed to develop such management forms is focused on the relations between agriculture, the natural environment and the landscape. In the last 20 or 30 years, the practice of spreading manure on the fields has increased, and over large areas of the Netherlands the water table has fallen. As a result, the present ecological qualities in agricultural areas are undergoing dramatic changes. For this reason, it is not useful to develop management strategies that only focus on these present qualities.

It is in this respect that the ecologically auspicious sites are important: they are a useful concept for the development of forms of management, because, in addition to considering the current ecological qualities, they also take a long-term view and consider potential qualities.

2.2 Results of MAP2 application

Using the MAP2 computer program, some of the qualities that lead to ecologically auspicious sites are derived, localized, and related to each other. The accent is thereby placed on the potential qualities of the abiotic environment.

We have applied this procedure to a predominantly agricultural area of about 700 ha: the Hackfort Estate, which is in the north-east of the Achterhoek (part of the province of Gelderland). The following data have been recorded in raster format in a MAP data base (raster size 20 m x 20 m):

- *River basins* A distinction is made between upper courses and lower courses. In general, upper courses are more ecologically auspicious than lower courses (they are less nutrient-rich and easier to manage because they are not so prone to outside influence).
- *Areas of seepage* Regional seepage occurs at several places in Hackfort. The seepage water is rich in iron and lime, and therefore in these areas the phosphorus is better regulated (the calcium and the iron fix the free phosphorus).
- *Groundwater* Gradual gradients in areas with higher water tables are considered to be ecologically auspicious.
- *Presence of lime in the soil, within 1.20 m of the ground surface* As mentioned above, lime has an important regulatory function. It plays an important role in the transformation of the humus and the fixation of free phosphorus.
- *Soil* Soils are distinguished according to fertility and elevation (the actual elevation is not recorded). On the lower, originally more fertile, soils, more manure can be tolerated from an

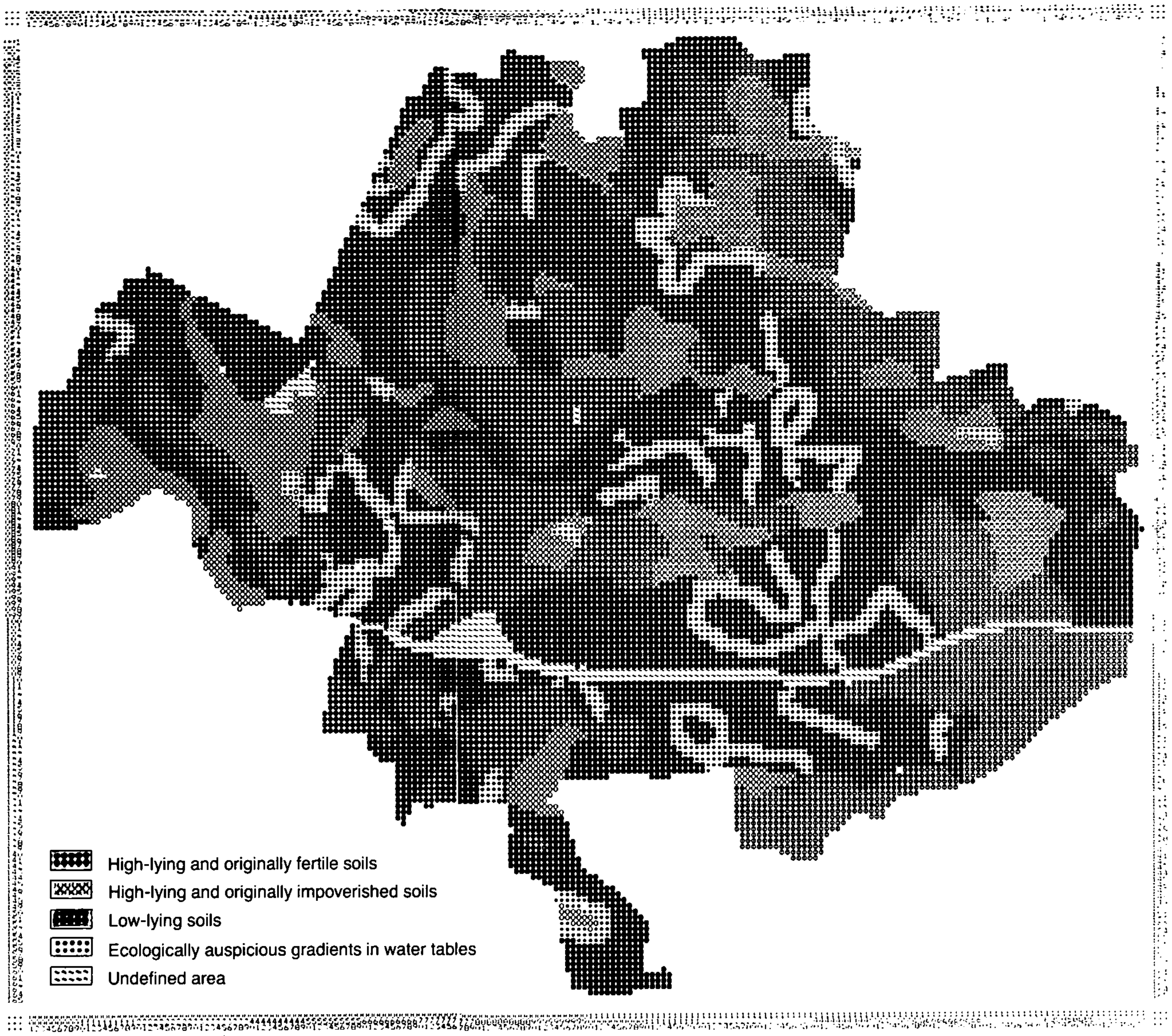


Figure 1. Map showing high-lying and originally fertile soils, high-lying and originally impoverished soils, low-lying soils and ecologically auspicious gradients in water tables

ecological point of view than on the higher, more impoverished, soils.

— *Forests and linear boundary plantings* Ecologically auspicious sites are also determined by the present quality of forests and linear plantings.

To ascertain the potential qualities of the abiotic environment in Hackfort, the following gradients were derived, localized and mapped, using the MAP2 program (Figure 1):

— ecologically auspicious gradients in soil features (high-lying to low-lying, fertile to impoverished);

— ecologically auspicious gradients in the water tables.

A site with the above gradients, plus lime-rich seepage, is ecologically very auspicious.

In addition to inventories of the vegetation and avifauna, the following derived maps provide a good picture of the current ecological qualities in the Hackfort Estate.

— *Soils plus forests and linear plantings* In comparison with normal Dutch conditions, the Hackfort area shows a great variety of associations between forests, linear plantings and soils.

— *Forests and other linear plantings plus the water table* Three categories of forests can be distinguished: wet forest, dependent on a high water table; dry forest, dependent on a perched water table; and an intermediate category.

— *Forests plus other linear plantings, and ecologically auspicious gradients in the water table* As expected, the forests with the ecologically most valuable vegetation lie on these gradients.

To identify the ecologically auspicious sites in the Hackford Estate, the above-mentioned actual and potential qualities are considered per river basin. Also taken into account are the size of the river basin and the possibility of altering the groundwater level. This procedure is not performed by the computer, but relies on the MAP computerized geographical information system.

This resulting information provides valuable starting points for the development of alternative forms of management that take account of the problems of applying manure to the small-scale landscape of the Achterhoek (small fields bounded by linear plantings).

3 Drawing up a development scenario for the Markerwaard

3.1 Research context

In late 1984, the Flevoland Tourist Office (VVV) took the initiative of organizing a competition to find the best plan for providing amenities for the Markerwaard (at present, still part of the Ijsselmeer). Entrants were asked to create a spatial design with matched development scenario for the plan area, following a programme of requirements. The development scenario was to be expressed in maps showing the situation 5, 10 and 30 years from the beginning of occupation of the area. The first stage was developed with the help of the MAP2 program. Here, the emphasis was on the reclamation of the area.

3.2 Application of MAP2

The starting point was the beginning of occupation, indicating:

- the area to be reclaimed;
- the area as yet unsuitable for reclamation because of its unfavourable soil condition or because it is very low-lying (to be reclaimed later);
- dumping site for dredged mud (to be reclaimed later);
- raised-up area intended for the development of future nature reserve (not to be reclaimed).

The MAP2 computer program was used to indicate how the reclamation should proceed in the first 5

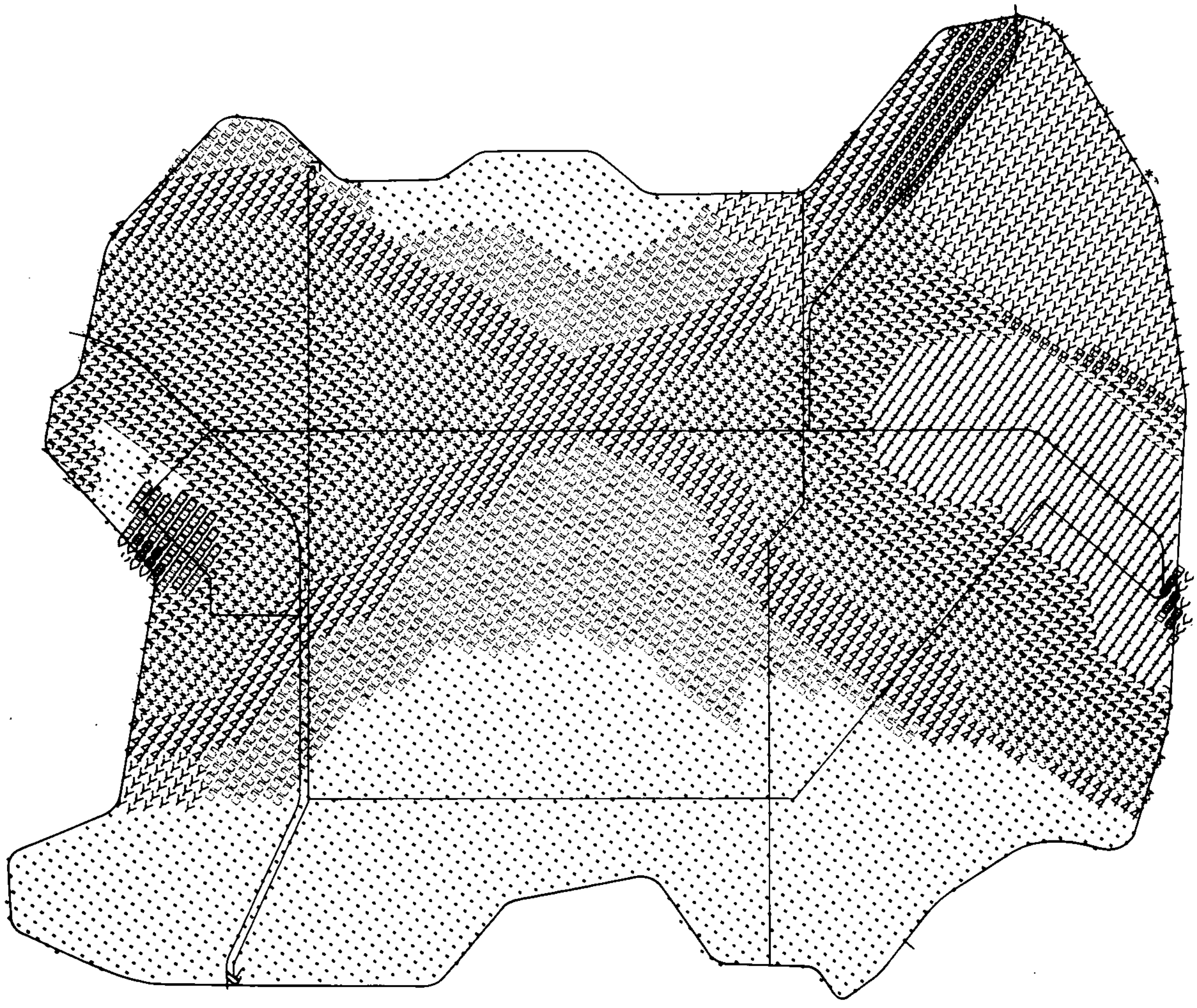


Figure 2. Sequence of reclamation for the first 5 years

1 = reclaimed area in the first year
2 = reclaimed area in the second year
3 = reclaimed area in the third year
4 = reclaimed area in the fourth year
5 = reclaimed area in the fifth year

years, bearing in mind the following:

- the reclamation will start from 2 nuclei of development;
- thereafter, development will proceed from year to year along the chosen linkage between the 2 nuclei; this is the occupation axis from which the area is to be reclaimed;
- the reclamation of the north-eastern nucleus will begin a year earlier, because here the physical conditions are more favourable.

Using data on the soil's suitability for reclamation, the MAP2 program sought out areas most suitable for reclamation that lie within a particular radius. (The area to be reclaimed annually was stipulated.) The following conditions, in order of decreasing importance, determine the sequence in which the area within the given radius will be reclaimed:

i. the area to be reclaimed must be contiguous with the 2 nuclei of development;

ii. the areas most suitable for reclamation are reclaimed first;

iii. the areas nearest existing reclaimed areas must be reclaimed.

Figure 2 shows the resulting sequence of reclamation in the area for the first 5 years.

4 Landscape analysis: the Boxtel case study

4.1 Research context

In recent years, the group of practising Dutch landscape architects has pressed increasingly for the exploration of the possibilities of using computers in landscape research and planning. In response, the Dorschkamp Institute and Kuiper Compagnons (a civil engineering consultant bureau) have jointly begun a case study of the ways in which commissions for landscape analysis at a local level could be computerized (van den Berg *et al.* 1984). The area chosen for this study was the rural area around Boxtel, a small town in the province of North Brabant, and areas for future spatial developments — mainly of urban spread — were identified by a computerized landscape analysis.

4.2 Application of MAP2

In this study, the landscape was postulated to be the result of actions and interactions between biotic, abiotic and anthropogenic factors. These actions and interactions were studied from ecological, visual and cultural/historical points of view. The concept was translated into a framework (see Figure 3), in which gradients in, and relations between, derived characteristics of biotic, abiotic and anthropogenic patterns were analysed using the MAP2 program, to reveal their interaction. The resulting information indicated those areas that are important from the ecological point of view, contribute regional quintessence, and are under threat from building schemes. Finally, locations that are most suitable for housing were identified.

The above-mentioned framework showed the different stages in data processing, which was essential because MAP2 has to be used in a logical, stepwise progression. Within each stage, data were processed in groups according to constructed 'command trees', showing which commands are executed on which data and in which sequence. This method of analytical landscape analysis shows clearly the significance of the final conclusions and how they are influenced by certain criteria.

5 Visual aspects of the Farma barrage study

5.1 Research context

To supply the area of Maremma Grossetana — a fertile coastal plain around the town of Grosseto (Italy) — plans have been developed for constructing barrages in the Merse and Farma rivers.

For the Farma drainage basin, this implies the construction of a barrage, a storage lake, an access route to the barrage, a derivation canal and underground pipelines, and it was feared that this area of outstanding natural beauty would suffer from the implementation of these plans. Therefore, the Regione Toscane commissioned the Dorschkamp Institute and the Laboratory of Physical Geography and Soil Science (University of Amsterdam) to carry out a landscape impact study.

The study included describing and evaluating the landscape and predicting the likely effects. Both ecological and visual aspects of the landscape were taken into account. The MAP2 program was used for analysing the visual aspects of the landscape and predicting the effects of the planned activities on these aspects.

5.2 Application of MAP2

The direct visual influence of the planned constructions is limited to a small area (4 km x 6.5 km), and data on altitude, land use, housing, roads and planting were derived for this area from orthophoto maps and converted to 50 m x 50 m grid cells. Also, alternative sites for the planned works were put into the grid system. The range of the disturbance zones round these alternative sites varies, as a consequence of the construction of roads, storage lake, barrage and derivation canal. Furthermore, the area of the storage can vary between 5 ha and 40 ha, depending on hydrological aspects and the water management regime.

5.3 Analysis of the visual aspects of the landscape (scenery)

Visibilities were computed from selected viewpoints, using a simple gridded digital terrain model, and average heights of plantations were added to the data on altitude. Figure 4 shows the scenery visible from the roads in the area.

Route analysis was simulated by classifying viewpoints on roads according to the size and shape of the outlook and the frequency of land use types within these outlooks.

Two kinds of relationships were analysed: those between data located in the same place (vertical relations), eg the relation between land use and altitude; and those between differently located data (horizontal relations), eg the relation between land use and distance to housing.

5.4 Evaluation

The evaluation was based on a number of hypotheses, some of which can be expressed cartographically, especially those concerned with diversity, naturalness and orientation. Diversity and natural-

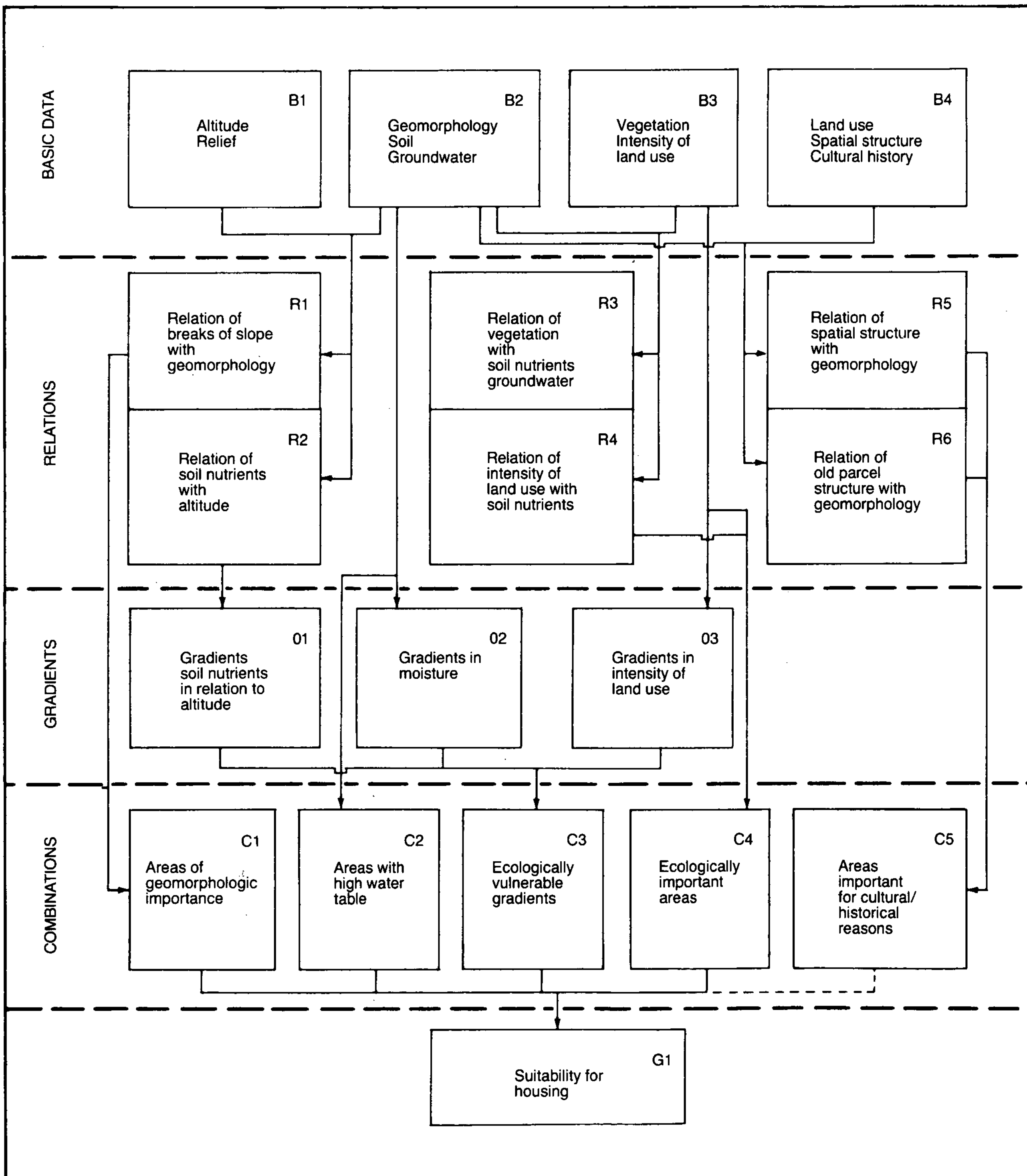
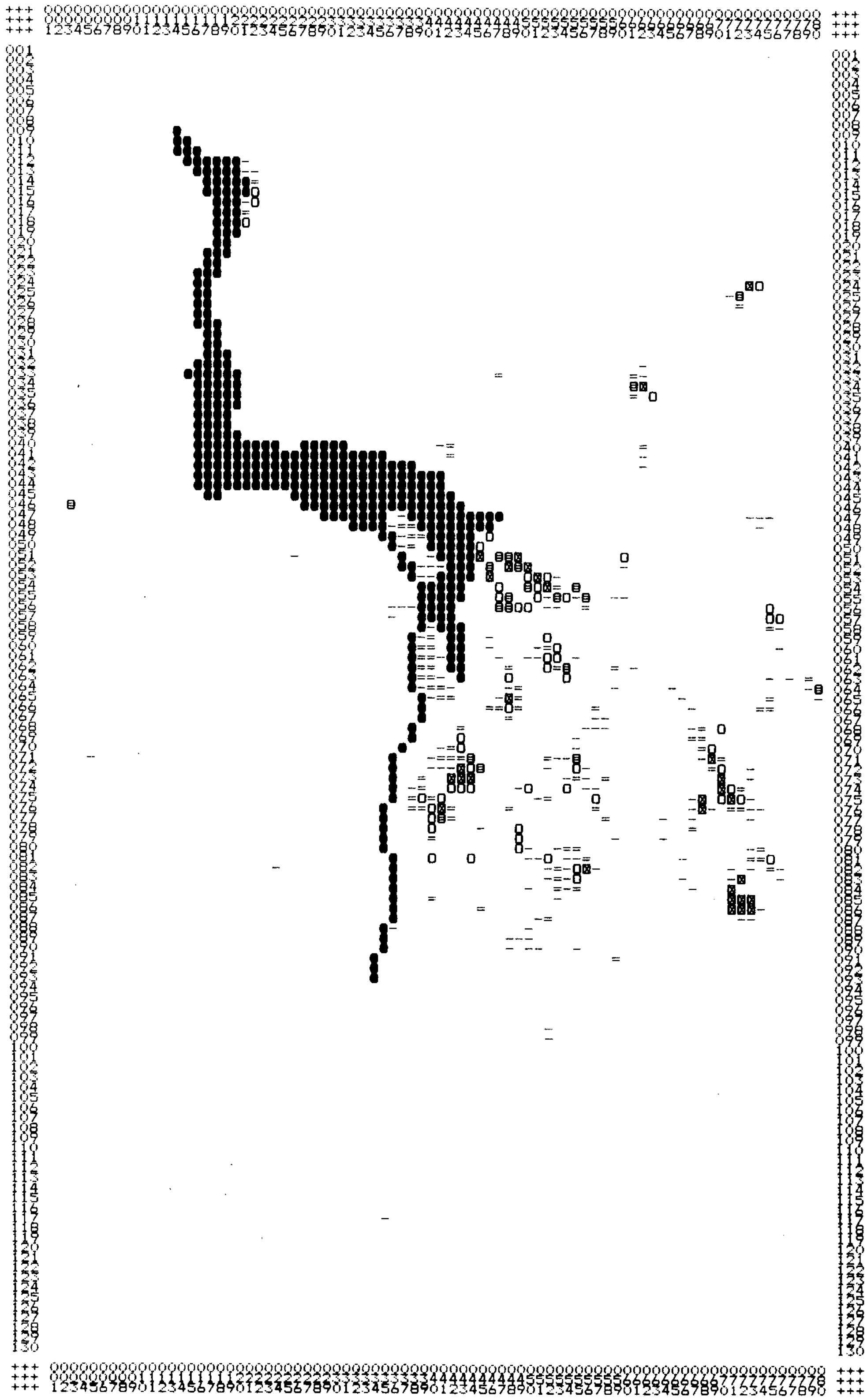


Figure 3. Framework of the Boxtel case study

						COVERAGE
		0	o x vis. from 7	3959	CELLS	38.1%
-	----	1	1-10 x vis fr 7	4129	CELLS	39.7%
=	====	2	11-20 x vis fr 7	910	CELLS	8.7%
O	OOOO	3	21-30 x vis fr 7	464	CELLS	4.5%
OOO	OOOO	4	31-40 x vis fr 7	341	CELLS	3.3%
OXLM	■■■■	5	41-51 x vis fr 7	257	CELLS	2.5%
*	****	6	no viewp on road	242	CELLS	2.3%
****	****	7	viewp on road	98	CELLS	0.9%

Figure 4. Scenery visible from the roads



					COVERAGE
-	----	1	1-5 GRIDS VISIB.	144 CELLS	1.4%
=	====	2	6-10 GRIDS VIS.	91 CELLS	0.9%
OO	OOOO	3	11-15 GRIDS VIS.	58 CELLS	0.6%
OOO=	8888	4	16-20 GRIDS VIS.	20 CELLS	0.2%
OXLM	⊠⊠⊠⊠	5	21-44 GRIDS VIS.	30 CELLS	0.3%
OO#+	●●●●	6	DISTURBANCE	373 CELLS	3.6%

Figure 5. Sites from which the planned activities will be visible

ness can be assessed from land use data, and orientation by computing the areas from which important orientation points (landmarks or high summits) are visible.

5.5 Prediction

By locating the planned activities and the disturbances they cause in this grid system, the visually most vulnerable sites can be computed and mapped. Figure 5 shows the sites from which the planned activities will be visible. The changes in scenery were partly evaluated with the MAP2 program: changes in diversity, naturalness and orientation were computed or assessed by comparing the maps showing diversity, naturalness and orientation with the map showing the visually vulnerable sites.

6 Discussion

In general, a computerized approach to landscape analysis forces one to adopt an analytical way of thinking. The larger and more complex the research problem, the more difficult it is to construct such a logical, stepwise approach. Yet this approach facilitates a better understanding of the methods and results of landscape analysis by others (eg the persons who commissioned the study), and the influence of particular criteria on the final results can easily be traced.

The ability to produce different alternatives based on different criteria is the most important advantage of using computers in landscape analysis. However, a consequence is that the amount of output can increase enormously, and there is a danger that the main emphasis of the analysis will be lost. Information must be selected carefully and proper records must be kept of all data produced.

Sometimes, problems arise with the interpretation of results: the output does not always match expectations based on a general insight into landscape relations. The output may be a true representation of reality,but it is also the product of survey errors, omissions in basic material, and inaccuracies resulting from grid conversion or incorrect data processing. The ideal grid cell size depends on the nature of the data: for linear formatted data, eg on vegetation or cultural/historical characteristics, a small grid is most suitable, but the amount of data increases exponentially with decreasing grid cell size. The final choice depends on the storage and processing capacity available, the difference in accuracy of available basic material, and the scale of the research object (local, regional or national).

The cartographic possibilities for displaying raster data are poor, and relations with topography are not readily apparent, although the readability of maps can be improved by using transparent topographic overlays.

The most frequent complaint concerns the process of data gathering. Although the use of digitizers has advantages over manual methods, the input procedure is still soul-destroying and time-consuming. There is an urgent need to standardize the gathering of basic geographical data, in order to facilitate the exchange of digital data.

In summary, the computerized approach to landscape analysis has both advantages and disadvantages. It is expected that the most negative points will be solved in future by continuing improvements in hardware and software, by research methodology and research needs being better attuned to such developments, and by the increasing availability of standardized digital geographical data.

7 References

Berg, A. van den, Lith, J. van & Roos, J. 1984. MAP: a set of computer programs that provide for input, output and transformation of cartographic data. In: *Methodology in landscape ecological research and planning,* vol. 3, 101-113. (Proceedings 1st IALE seminar.)Roskilde: Roskilde University Centre.

Berg, A. van den. 1985. *MAP2 manual.* Wageningen: Rijksinstituut voor Onderzoek in de Bos- en Landschapsbouw "De Dorschkamp".

Berg, A. van den, Bijlholt, A., Germeraad, P. W., Lith, J. van & Roos, J. 1984. *Landschapsanalyse Boxtel.* Wageningen: Rijksinstituut voor Onderzoek in de Bos- en Landschapsbouw "De Dorschkamp", Bureau voor ruimtelijke ordening en Architectuur BV, Rotterdam.

Tomlin, C. D. 1977. *The cartographic modeling package.* New Haven: School of Forestry and Environmental Studies, Yale University. (Unpublished.)

Tomlin, C. D. 1983. *Digital cartographic modeling techniques in environmental planning.* New Haven: Yale University.

Woodlands in the Welsh landscape: an analysis based on remotely sensed satellite data and digital terrain information

P A BRADBURY*, R H HAINES-YOUNG*, P M MATHER* and C W SMART†
Department of Geography, University of Nottingham, Nottingham
†Planning Services, Welsh Office, Cardiff

1 Introduction

An analysis of the form and character of woodlands is of fundamental importance for any who seek to understand the diversity of patterns present in the Welsh landscape. In the case of broadleaved woodlands, for example, it has been argued that, despite the small total area occupied by such woodlands, and despite the small size of the individual plots, their contribution to the overall character of the Welsh landscape is disproportionately large. The same may be said for the stands of conifer which have come to dominate many tracts of land in the Principality. An analysis of the evolution of the contemporary Welsh landscape would be incomplete without an account of the patterns of planting and its impact on the rural scene.

Despite the significance of woodlands for the Welsh landscape, a systematic treatment of their contribution has yet to be made. Although many basic data on woodlands are becoming available (Forestry Commission 1983, 1985), few studies have been able to consider woodlands as part of an integrated landscape mosaic. Thus, accounts of the role of woodlands in the landscape are largely anecdotal. After noting the importance of woodlands in the Welsh landscape, for example, it has been suggested that their landscape interest often springs from their diversity and the way in which they punctuate the pastoral scene. In the lowlands, it is suggested that broadleaved woodlands have aesthetic value where they occupy rocky knolls or small hills surrounded by pastures. As linear features along watercourses, field boundaries and roads, they also significantly enhance landscape quality. In contrast, monotonous coniferous blocks are often criticized for their detrimental impact on the quality of the landscape (eg Crowe 1978). Crowe further identifies guidelines for the design of plantations with improved visual qualities by the planting of a variety of tree species, the avoidance of geometrical boundaries and harmonizing with topographic features.

Criticism of earlier qualitative ideas about the landscape importance of woodlands must not be taken as implying that these ideas are without value, for they offer an important starting point for any further analysis. The task of providing a more rigorous and systematic treatment of the landscape importance of woodland is a difficult one, and any purchase we may gain on the problem is significant. The difficulty of the task is 2-fold. On the one hand, there is the lack of any accepted yardstick of landscape quality; on the other hand, basic data on the composition and character of the landscape mosaic are difficult to assemble over sufficiently wide areas for regional patterns to be identified.

The present study focuses on the problem of characterizing woodlands in the landscape mosaic, in order to build up a set of techniques and concepts which can be applied to a wider range of landscape components. It is considered that, if an advance can be made with such problems, then a fresh view of the issues of landscape quality might eventually be achieved.

The following questions have provided the basis for the study.

- How accurately can woodland character (composition, size, location and form) be recognized using remotely sensed data?
- How can these data be used to describe the role and status of woodlands in the landscape mosaic?
- Can changes in woodland area be related to particular landscape units?

2 Study area

The study area, 20 km by 40 km, covers much of the county of West Glamorgan (Figure 1). It extends from the headwaters of the Neath River at an altitude of 481 m OD, down to low-lying agricultural areas adjoining the Bristol Channel. The area is well wooded, with large coniferous plantations dominating the uplands both in terms of area and visual impact. The most common species in the study area are Sitka (*Picea sitchensis*) and Norway spruce (*Picea abies*), Japanese larch (*Larix kaempferi*), Scots pine (*Pinus sylvestris*) and lodgepole pine (*Pinus contorta*). Woodland in the lowland areas is generally restricted to the poorer soils and steeper slopes and includes many natural or semi-natural sites having oak (*Quercus petraea*), ash (*Fraxinus excelsior*) or beech (*Fagus sylvatica*).

There is a wide range of non-woodland cover elements in the study area. Open moorland is common in the exposed uplands, particularly where drainage is poor. Bracken (*Pteridium aquilinum*) is also common on the steeper slopes of the uplands and on poorer soils of the lowlands. Along the

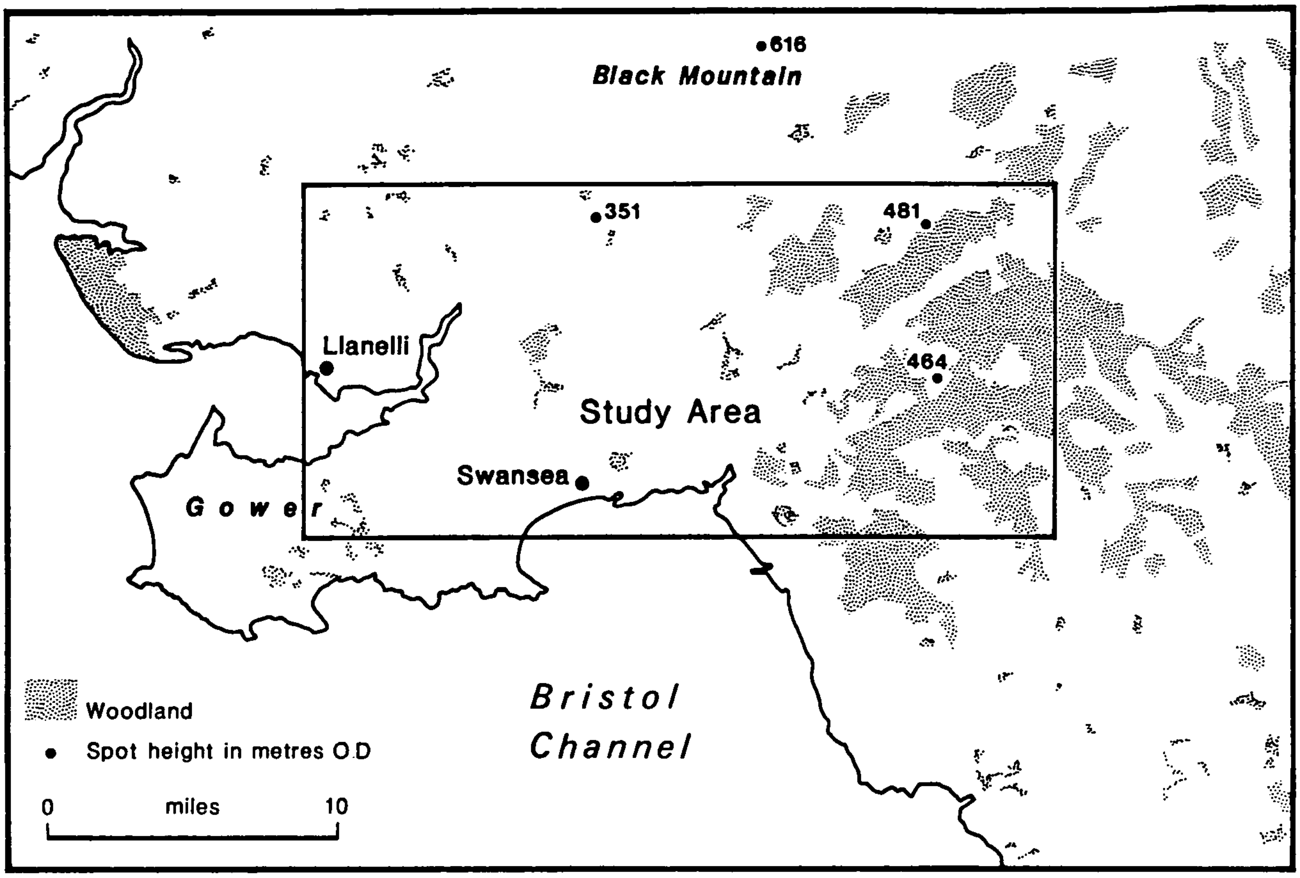


Figure 1. Location map

coastal areas, saltwater and freshwater marshes occur, often adjoining mudflats. Agriculture in the area is essentially pastoral. Non-vegetated areas include outcrops of bare limestone rock and large opencast coal sites in the uplands, the latter forming great scars on the landscape. In the lowlands, there are also the major urban, suburban and industrial areas of Swansea and Llanelli.

3 Analytical methods

Three basic steps are involved in the analysis of landscape using remotely sensed data

— the production of land cover classifications from remotely sensed imagery;

— the integration of the classified imagery with digital topographic data;

— the resampling of the land cover and topographic data using a grid system in order to classify woodland and more general landscape characteristics.

Land cover classifications have been prepared using geometrically corrected Landsat Multi-spectral Scanner (MSS) and Thematic Mapper (TM) imagery. Within the study area, the location of a range of characteristic cover types was identified by field work carried out in 1984 and 1985 or, in the case of coniferous woodlands, from 1:10 560 Forestry Commission stock maps. This information was used as 'training' data to provide the computer with spectral statistics for each cover type. A variety of classification techniques was used to classify the Landsat imagery, including the centroid, and maximum likelihood algorithms (Swain & Davis 1978; Moik 1980).

Following the classification of individual land cover elements, patterns in the landscape mosaic were assessed by superimposing a contiguous grid of cells on to the imagery. Information can then be extracted for each cell relating to the density of each cover type, the way in which they are associated and the spatial patterns present. These data were then combined with digital elevation data for a more complete classification of woodland character and landscape context.

In order to examine whether a relationship exists between woodland change and landscape type, information was gathered from the New Popular and Seventh Series Ordnance Survey (OS) maps at 1:63 630 and 1:50 000 Landranger series. This information enabled the woodland density in each OS grid square to be mapped for 1924, 1964 and 1980, so that past geographical patterns could be compared with those derived from the remotely sensed imagery.

Table 1. Classification accuracy based on confusion analysis (%) using MSS and TM imagery, Path 204 Row 24

	Centroid			Maximum likelihood		
	July MSS	April MSS	July TM	July MSS	April MSS	July TM
Cover class						
1. Pine	59	88	80	44	46	76
2. Spruce	20	12	52	36	34	76
3. Larch	17	34	37	20	43	42
Coniferous (1-3)	78	92	94	81	87	92
4. Broadleaved	29	15	56	17	12	82
Woodland (1-4)	75	84	93	72	80	96
5. Scrub	21	9	10	12	12	32
6. Felled wood	*	*	88	*	*	88
7. Bracken	57	8	53	42	17	57
8. Heather	2	6	35	22	24	55
9. Grass moor	35	46	45	38	48	43
Moorland (5-9)	61	46	74	62	64	81
10. Pasture	*	*	14	*	*	73
11. Cereals	*	*	14	*	*	64
Agriculture (10-11)	33	93	54	52	85	77
12. Bare rock	46	36	1	46	28	99
13. Urban	78	79	76	81	74	69
14. Mudflats	10	20	15	48	72	72
15. Marsh	1	23	5	27	34	47
16. Open water	94	97	98	85	94	98
Overall accuracy	36	38	41	43	46	62

*Not included due to insufficient pixels

4 Results

Table 1 shows the accuracy values obtained in the land cover classification. It is clear from these results that substantially better classification accuracies are obtained using the maximum likelihood classifier with TM data.

Although these preliminary investigations indicate that the maximum likelihood classifier is the most suitable as the basis for this study, a routine for the classification of a full TM subscene is not yet available on the Nottingham Image Processing System.† Thus, current work has been based on the use of the centroid method. Despite the inferior performance of this classifier, acceptable levels of classification accuracy can be obtained by amalgamating the cover types into broader groupings. Woodlands as a whole can be distinguished with an accuracy of 93%; rough grazing, urban and open water are classified with accuracies of 74%, 76% and 98% respectively. The poorest classification was obtained for the agriculture classes (54%).

Once the initial cover classification had been made, the classified imagery was geometrically

†Such software is now available.

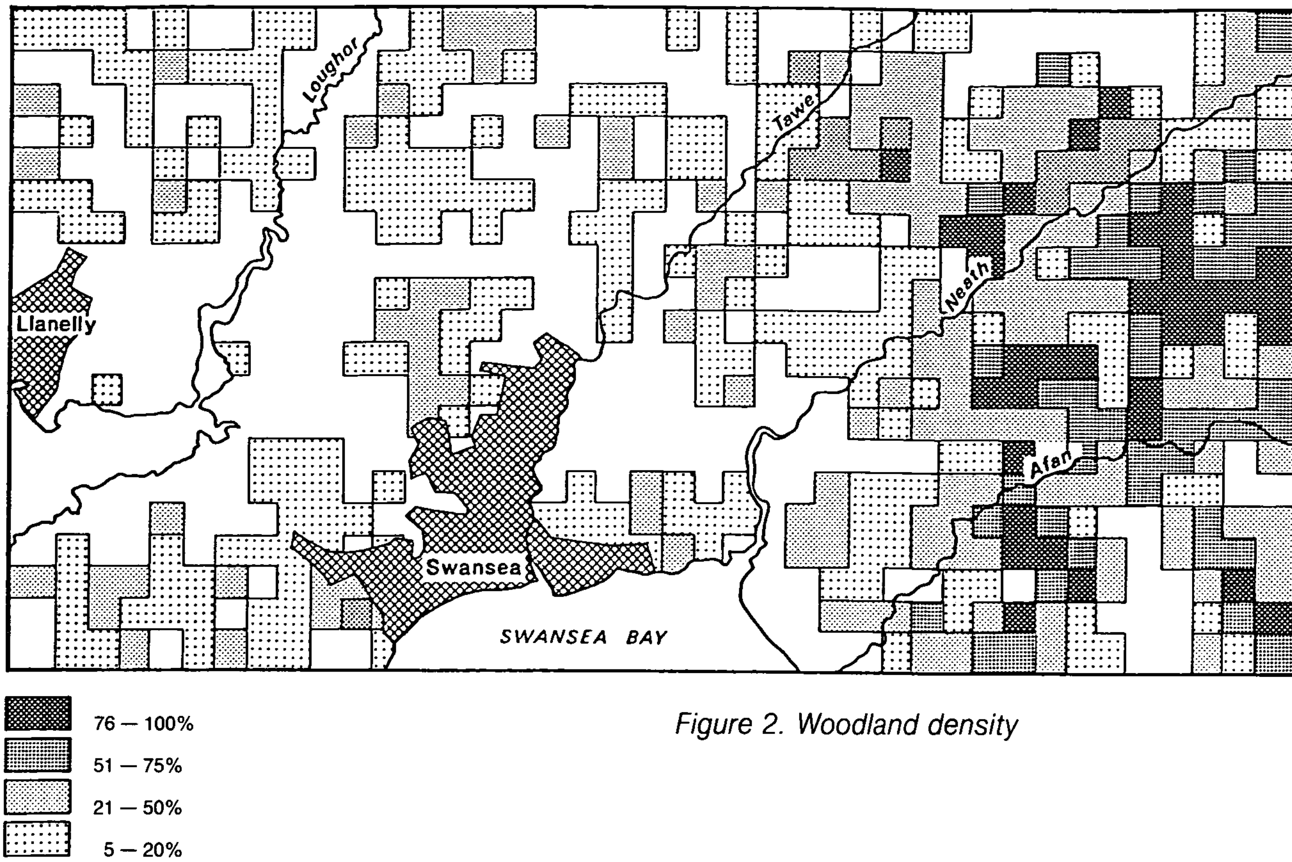


Figure 2. Woodland density

corrected and registered to the OS National Grid and the digital elevation data set. Information about the land cover mosaic and its physical characteristics can then be extracted for each 1 km x 1 km cell. As an example of the kind of data produced, Figure 2 shows woodland density in each one km grid square. Comparison with Figure 1 indicates that there is a good overall correspondence in the geographical patterns produced.

5 Discussion

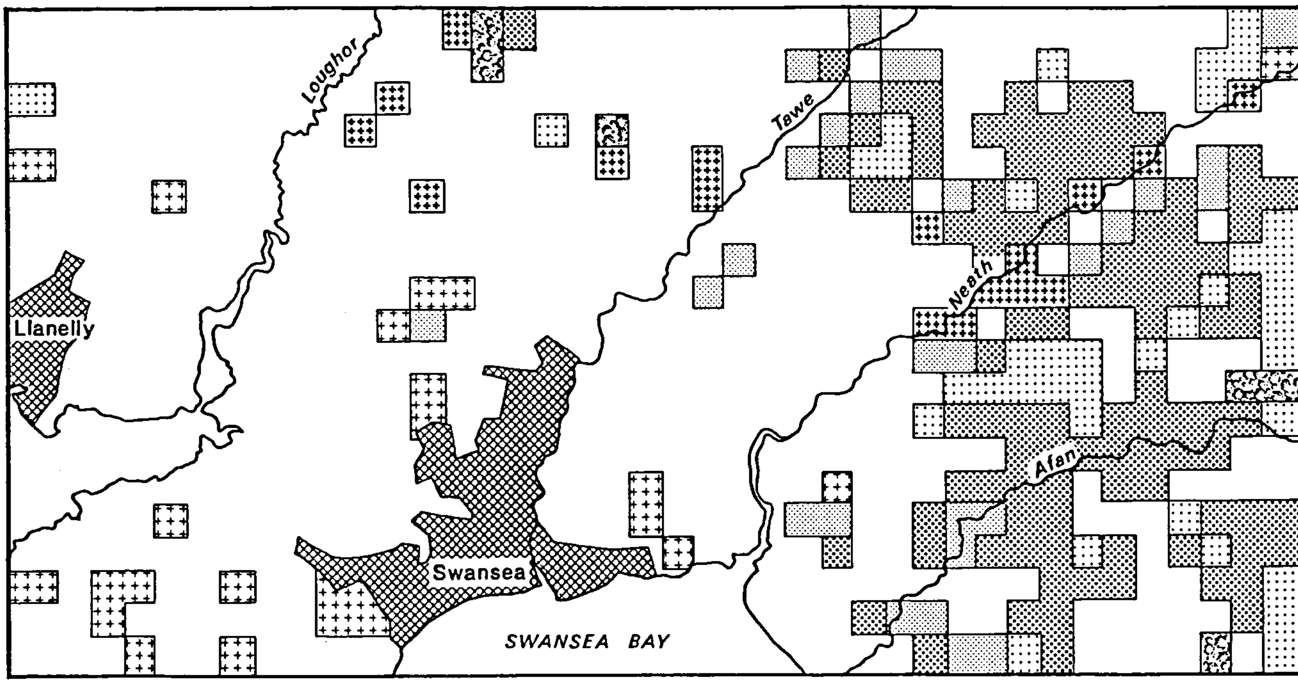
5.1 Woodland character

The character of woodlands in terms of types and terrain context is shown in Figure 3. Four variables were used in the analysis: broadleaved and coniferous woodland density, mean altitude and mean slope. Each grid square in which woodland was the dominant cover element was allocated to one of 8 classes, depending on whether it was predominantly broadleaved or conifer, upland or lowland (200 m was used as the cut-off), and whether the general terrain was sloping or flat (less than 10% slopes). The resulting classification identifies upland coniferous woodland in the east of the study area on both steep slopes and on flat or gently sloping land. Adjoining such woodland are lower altitude coniferous woods, most of which are on steep slopes. The western parts of the study area consist mainly of broadleaved woodland on gentle slopes. In the vicinity of Pontardawe and along the Neath valley are areas classified as steeply sloping broadleaved woodland, the majority of which are classified as lowland (below 200 m).

An assessment of the fragmentation in texture of woodlands was based upon the measurement of the number of woodland boundaries in each grid square. These data were combined with that for woodland density to give a measure of the number of woodland edges per unit area of woodland (see Figure 4). This classification indicates that the coniferous woodland in the east of the study area is predominantly 'blocky', whereas in the west of the study area both coniferous and broadleaved woodland is fragmented.

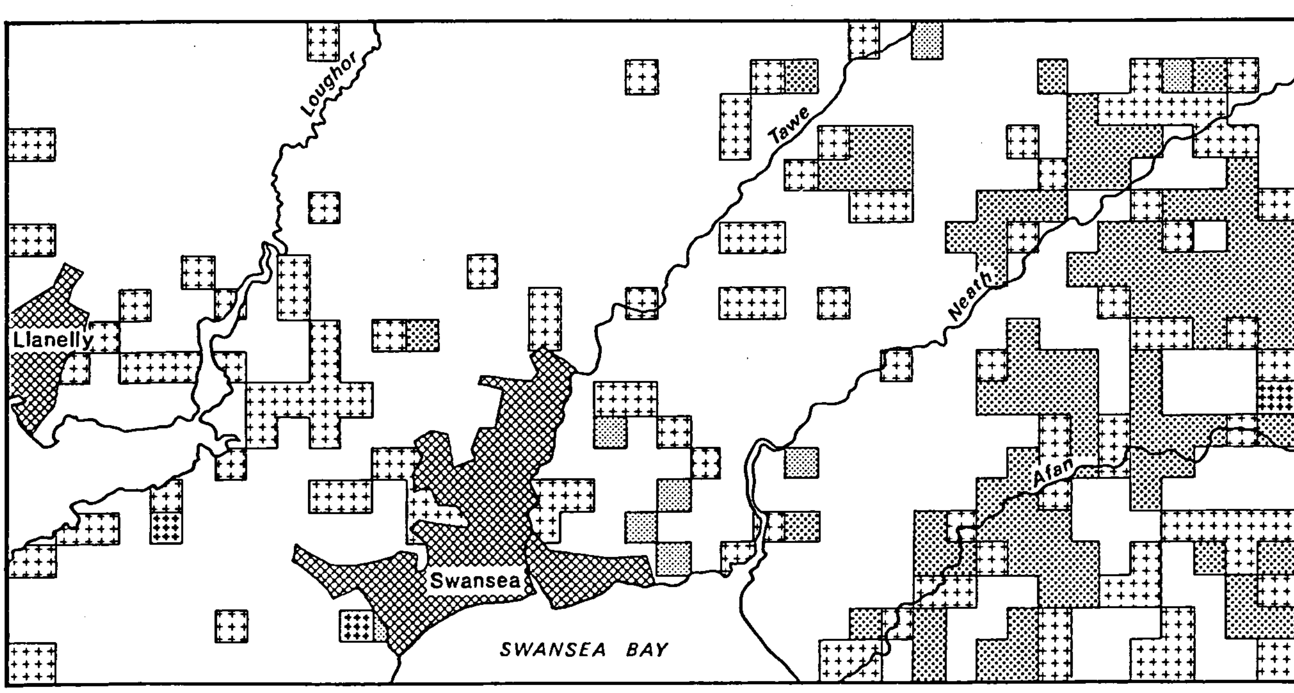
A preliminary analysis of the context of woodland within the landscape was carried out by measuring the type of land cover with which woodland is normally found in association. Details of the density of improved agricultural land, rough grazing and urban or industrial land were taken from the classified image in the same manner as for woodland. Those grid cells in which woodland was present were then allocated to one of 4 classes: woodland dominant, woodland/rough grazing mix, woodland/agriculture mix, and woodland/urban mix (see Figure 5).

The dense areas of woodland in the east are classified as blanket woodland, where woodland is the dominant land cover type. On the periphery of these areas is land where woodland abuts rough grazings. In the lower-lying parts of the west, woodland occurs on agricultural land. Normally such woodlands occur in small blocks or sinuous



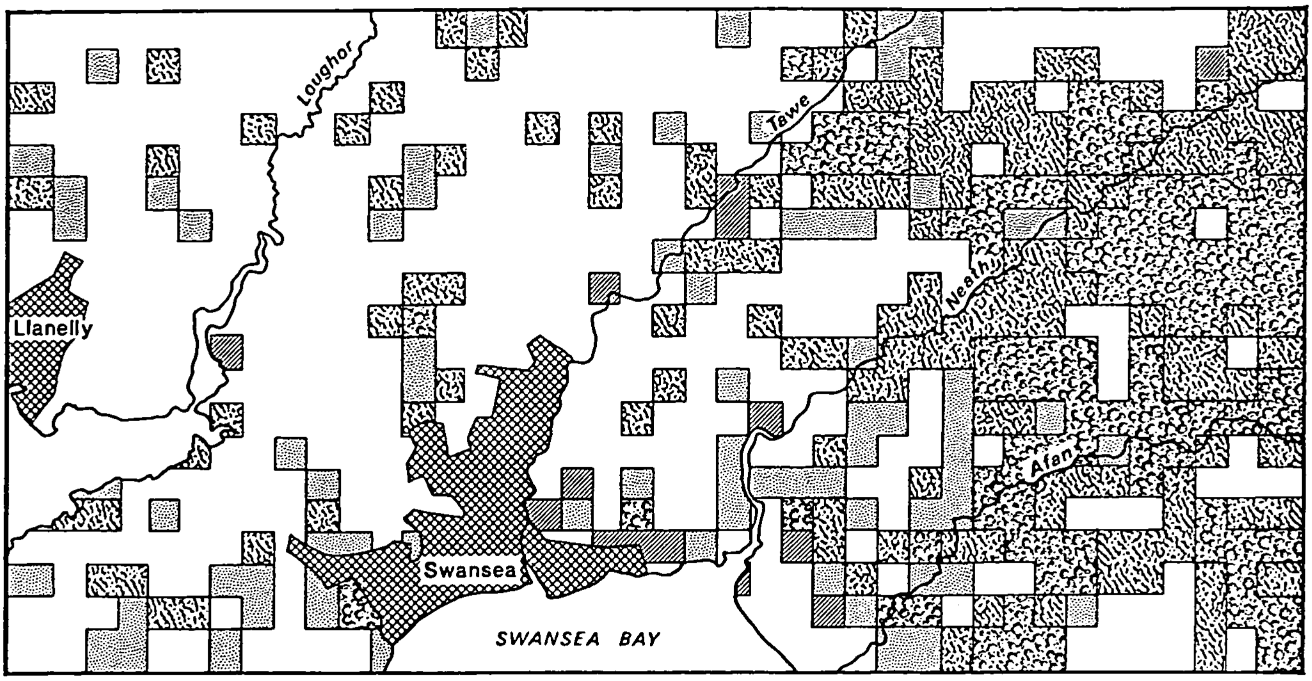
Upland plateau conifer
Steeply sloping conifer
Lowland conifer
Upland broadleaf
Lowland steeply sloping broadleaf
Lowland gently sloping broadleaf

Figure 3. Woodland composition



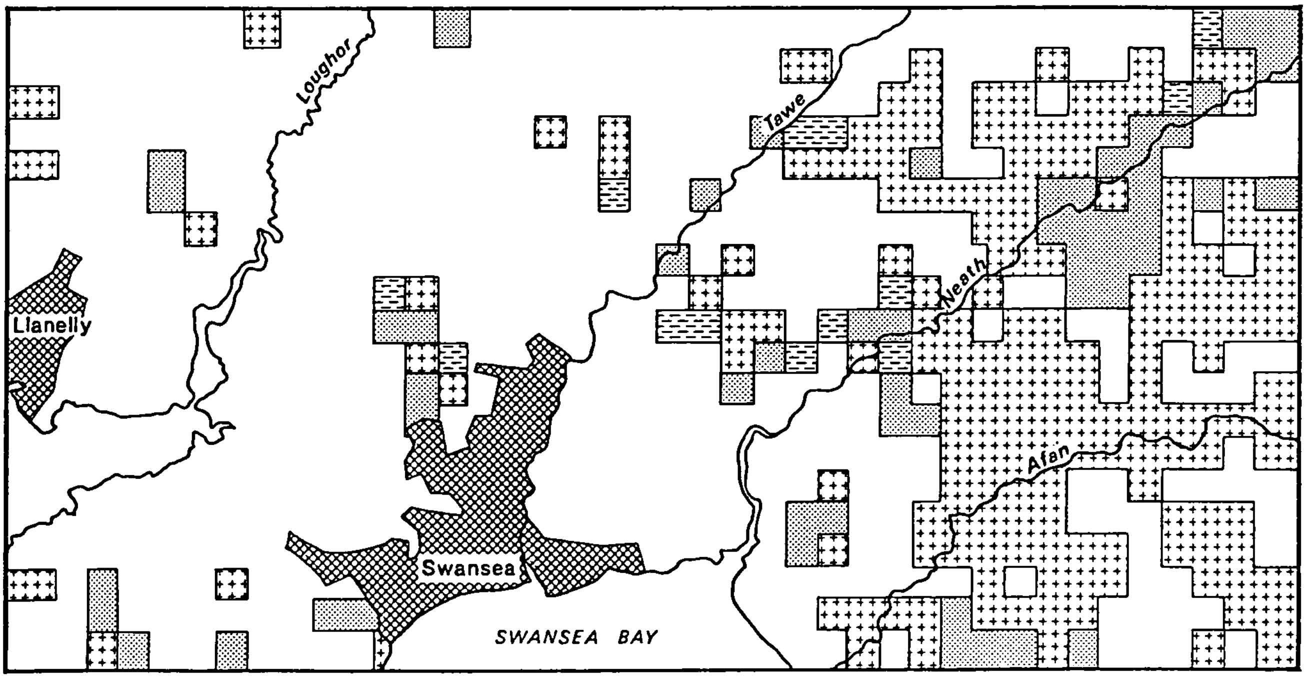
Blocky conifer
Fragmented conifer
Blocky broadleaf
Fragmented broadleaf

Figure 4. Woodland fragmentation



Blanket woodland
Woodland/Moorland association
Woodland/Agriculture association
Woodland/Urban association

Figure 5. Woodland context



Loss
Gain
Little change

Figure 6. Woodland change 1920-64

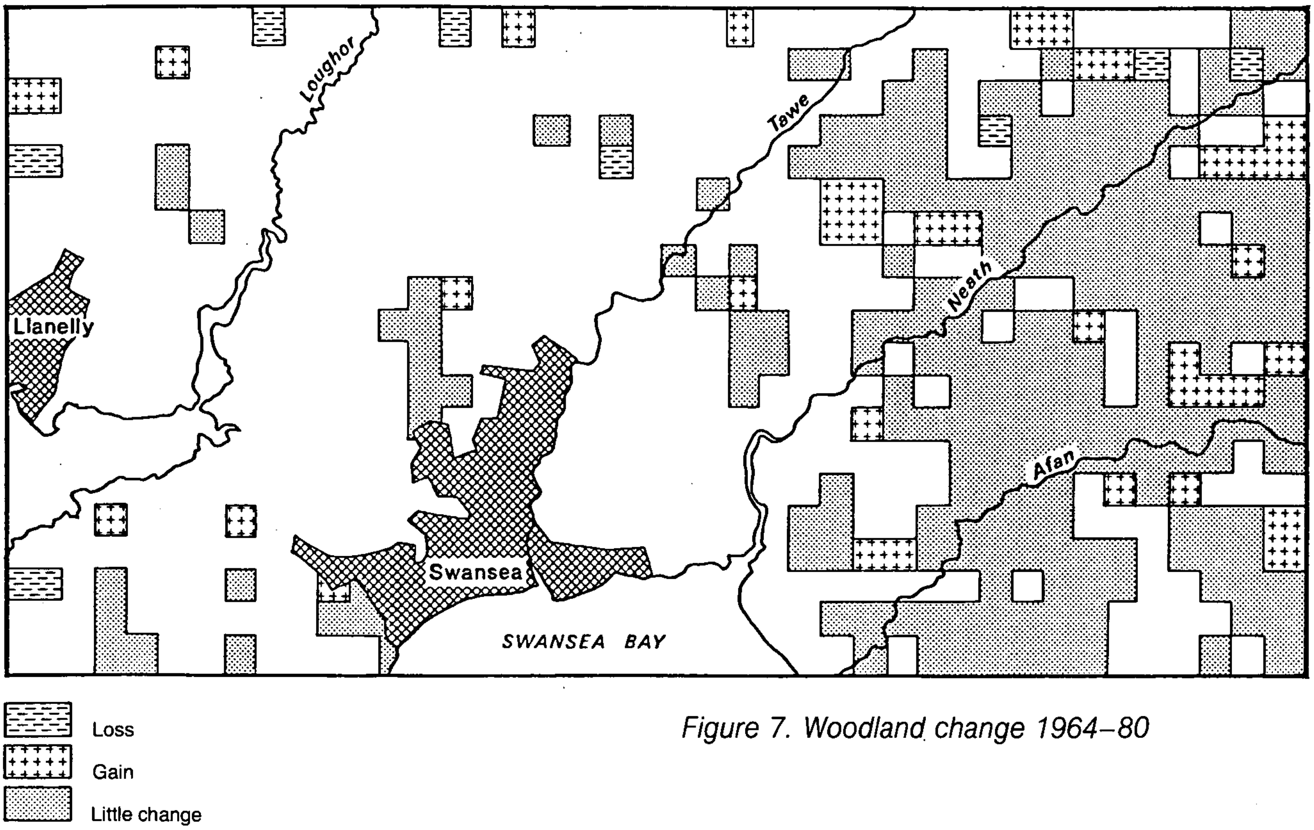


Figure 7. Woodland change 1964–80

shapes, and tend to give the landscape an enclosed effect which can improve the visual quality of monotonous agricultural areas. Elsewhere in the lowlands, those areas were woodlands occur in a predominantly urbanized setting are shown.

Despite the simplicity of the analyses presented above, data such as those provided by Figures 2–5 allow us to characterize the place of woodlands in the landscape. They are typical of the kind of data necessary for the management of rural resources. The potential of remote sensing systems is that, perhaps for the first time, problems of acquiring the data necessary for landscape assessment no longer seem intractable. Indeed, the technology allows us to focus on the problem of how landscape resources can be assessed.

Using such data, we may develop concepts such as typicalness, naturalness, diversity, and rarity to describe the patterns that can be detected in the landscape mosaic. In this way, the location, size and character of different landscape types can be mapped, and the pattern of their geographical relationships assessed. Thus, if we refer to Figure 5, we can see those areas where, for example, woodland is a dominant element in an agricultural landscape. We can identify the extent of such patterns, how rare they are, and how they relate to other landscape units. Perhaps more importantly, we can identify those areas where woodland is a minor element in the landscape, and where landscape quality might be improved by planting.

Criteria such as those suggested above (size, typicalness, diversity, etc) are identical to those used for the evaluation of sites as potential nature reserves (see Ratcliffe 1977). The evaluation of nature reserves for conservation is confounded with the same kind of value judgements as in landscape resource management. Despite such problems, some consensus has been achieved in the field of nature conservation using these criteria. With the more easily accessible data on landscape provided by remote sensing systems, it is possible that similar concepts may be successfully applied here.

5.2 Woodland change

In an attempt to build up a picture of the pattern of woodland change,woodland densities were measured on the archive OS maps for 1920, 1965 and 1980. Such data can be displayed in a similar format to that of Figure 2. A comparison of such data allows the geographical patterns of woodland change to be detected and mapped (see Figures 6 & 7). Figure 6 shows that, between 1920 and 1964, there was a widespread increase in the woodland area in the east of the study area. Between 1964 and 1980 (see Figure 7), new woodland appeared on the periphery of these areas and on the islands of remaining moorland within these established woodlands.

Comparing these maps with Figures 4 and 5, it can be shown that in the earlier time period the planting of conifers in lowland areas (ie below 200 m) represented only 9% of total coniferous afforestation. Between 1964 and 1980, planting on lowlands increased to 25% of total afforestation. With regard to deforestation, in the earlier period woodland loss occurred in predominantly agricultural areas. This trend appears to be continuing, recent losses being concentrated in those lowland areas with an agricultural/woodland mix or where woodland is dominant.

The importance of such analysis of landscape change is 2-fold. First, it allows the identification of sensitive landscape types. Such analysis will have application beyond the study of woodland areas. The protection of sensitive environments is currently achieved through planning controls or by grant aid. However, the designation of such areas is usually arbitrary; for example, although the Commission of European Communities (CEC) is currently discussing the designation of Environmentally Sensitive Areas in which grant aid is to be given to farmers to safeguard the landscape, there is little objectivity in the delimitation of such areas. If the analysis of change presented here for woodlands can be extended to a more complete range of landscape components, then a more rigorous framework for decision-making might be established.

Second, information on the dynamic aspect of the landscape mosaic may be of value as a potential input to models of landscape change. One such model relating to woodlands has been suggested, with 2 groups of factors influencing the management of woodland and patterns of change: 'natural' factors, including soil quality, rainfall and risks such as fire; and 'societal' factors, including tax concessions and grants on woodland, planning controls, and changes in market prices for forest and woodland products. Using such data as those presented here, the models might be refined and tested to enable the prediction of woodland change under different policy scenarios.

6 Conclusions

The current generation of satellite remote sensing systems has a number of limitations for those interested in the study of landscape. The ability to recognize certain land cover types may, for example, be limited, and some features (eg hedgerows, walls, isolated trees) may not be detectable at all. In addition, multiple land uses may be difficult to detect. Nevertheless, given the major difficulties associated with the use of traditional data sources, the use of remotely sensed data in conjunction with ground surveys can provide a valuable insight for the study of landscape. Such data allow the location, size and character of landscape units to be mapped over large areas on a uniform and consistent basis.

The use of remotely sensed data in the study of landscape patterns is still at an early stage, and much additional work needs to be undertaken. The analysis of woodlands presented here has been used merely as a means for the identification of the major issues. On the one hand, we need to develop more accurate and more detailed classifications of the basic land cover elements; on the other hand, we need to develop algorithms to help recognize the subtleties of pattern present in the land cover mosaic. If such advances can be made, however, then with the integration of such data with the more traditional sources of information available to the rural planner, we can begin to assess and describe the character of landscape over a much wider range of criteria than has currently been possible.

7 References

Crowe, S. 1978. *The landscape of forests and woods.* (Forestry Commission Booklet no. 44.) London: HMSO.

Forestry Commission. 1983. *Census of woodland and trees 1979-82. Wales.* London: HMSO.

Forestry Commission. 1985. *Census of woodlands and trees 1979-82. Counties of Mid, South and West Glamorgan.* London: HMSO.

Moik, J. G. 1980. *Digital processing for remotely sensed imagery.* NASA SP 431. Greenbelt, Md: Goddard Spaceflight Center.

Ratcliffe, D. A. 1977. *A nature conservation review.* Vol. 1. Cambridge: Cambridge University Press.

Swain, P. H. & Davis, S. 1978. *Remote sensing—the quantitative approach.* New York: McGraw-Hill.

Watkins, C. 1985. Sources for the assessment of British woodland change in the twentieth century. *Appl. Geogr.* **5,** 151-166.

The Culm Measures project: a study of how woodlands might augment farm incomes in an area of difficult lowland in south-west England

O H BRANDON
Dartington Institute, Totnes

1 Introduction and background

The Culm Measures of north Devon and Cornwall are a carboniferous series of rocks tending to give rise to heavy clay soils which cope poorly with the relatively high rainfall of the region. Although not high in altitude (240 m), the area is often open and exposed to winds from the west and north. These winds, together with a number of other factors, combine to put farming under particular pressure, recently exacerbated by the imposition of dairy quotas.

Forestry manifests itself as a combination of relatively large tracts of conifer plantations in state or private ownership, together with generally unmanaged, smaller areas of broadleaved woodland on farms. Though the risk of windthrow in the area can be significant and locally severe, conifer plantations, particularly of Douglas fir (*Pseudotsuga mensiezii*) have shown themselves capable of high yields of good-quality timber.

In the light of this apparently high technical potential for forestry, coupled with difficult agricultural conditions, a study was initiated to establish the extent to which forestry might contribute to farm incomes in the future. Both afforestation of marginal agricultural land and management of existing woodlands have been considered within this study.

2 Approach

2.1 Classification and survey

The land classification technique developed by the Institute of Terrestrial Ecology has been used to produce a unique classification of the 3100 km^2 of the Culm Measures. The use of, primarily, topographic and climatic attributes of one km grid squares identified 11 land classes (Figure 1) characteristic of the coastal areas to the west, river valleys and

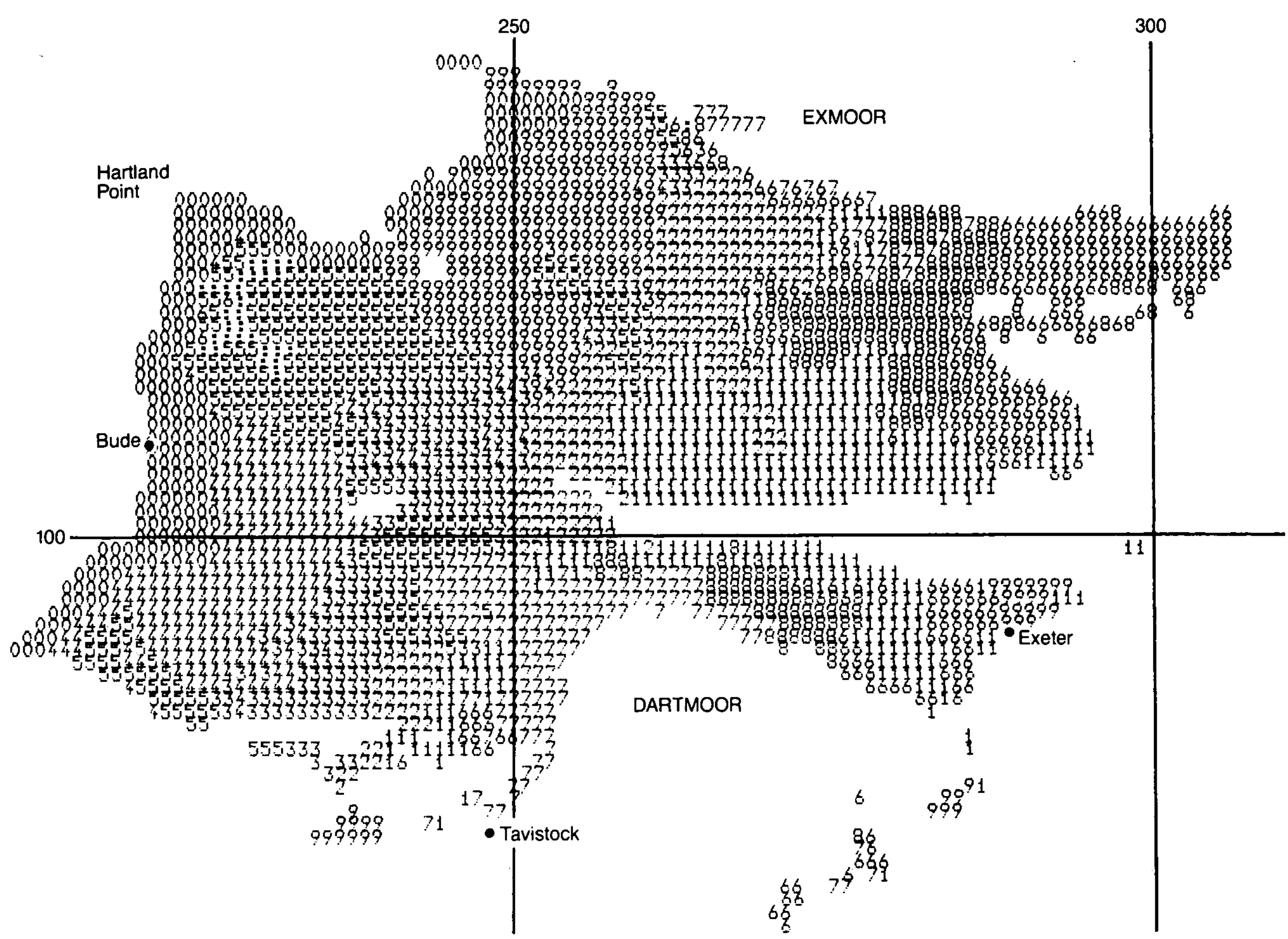


Figure 1. Distribution of land classes on the Culm Measures

estuaries, high-rainfall areas adjacent to Dartmoor and Exmoor, etc. These classes were used as strata within which sample one km grid squares were randomly selected for field survey.

The object of the survey was 3-fold:

- to assess present and potential agricultural value;
- to ascertain the characteristics of the areas of woodland present;
- to investigate the attitudes of farmers to the management of their woods and the afforestation of their land.

The surveyors mapped land cover (vegetation), topography and soils, and commented on the degree to which agricultural productivity might be improved through drainage. Blocks of woodland greater than 0.1 ha were surveyed. Blocks were subdivided into compartments where appropriate, and plot measurements and management data collected. This information subsequently enabled the woodlands to be classified according to their stocking characteristics, and the costs of management pitched according to the features commonly identified during the survey.

2.2 Economic models of land use

The field survey provided information necessary for an assessment of the financial performance of agriculture. This information was supplemented with data from several other sources, notably a compilation of Farm Management Survey data from 40 sample farms on the Culm Measures and the parish data relevant to the parishes within which the sample squares fell. Figure 2 illustrates an outline of the way in which the different data sources were integrated in order to estimate the financial performance of grazing land. This approach was applied to each unique parcel on each sample square so as to produce a base against which the financial performance of forestry might be compared.

The afforestation land use model required an assessment of species suitability, yield, establishment costs and crop value. These assessments were based on the best available data. For species and yield, the Forestry Commission's subcompartment records for all state-owned woods on the Culm Measures were examined to determine relations with site characteristics. Although these data provided over 1000 instances on which to base an assessment, no authoritative relation could be established. Only the most general correlation between species/yield, land class and simple soil type divisions (brown soils and gleys) could be identified.

Table 1 shows the relation used when ascribing a species and yield to a particular site on each site of the sample one km grid squares. Establishment costs were based on both private (Commonwealth Forestry Institute survey) and state sources, and ascribed according to site conditions identified during the survey of the Culm. Thus, costs were a function of soil type, vegetation cover and topography. The spacing, thinning regime and rotation age considered suitable were a function of an assessment of windthrow hazard of each area in the sample squares. The Culm exhibits the full range of

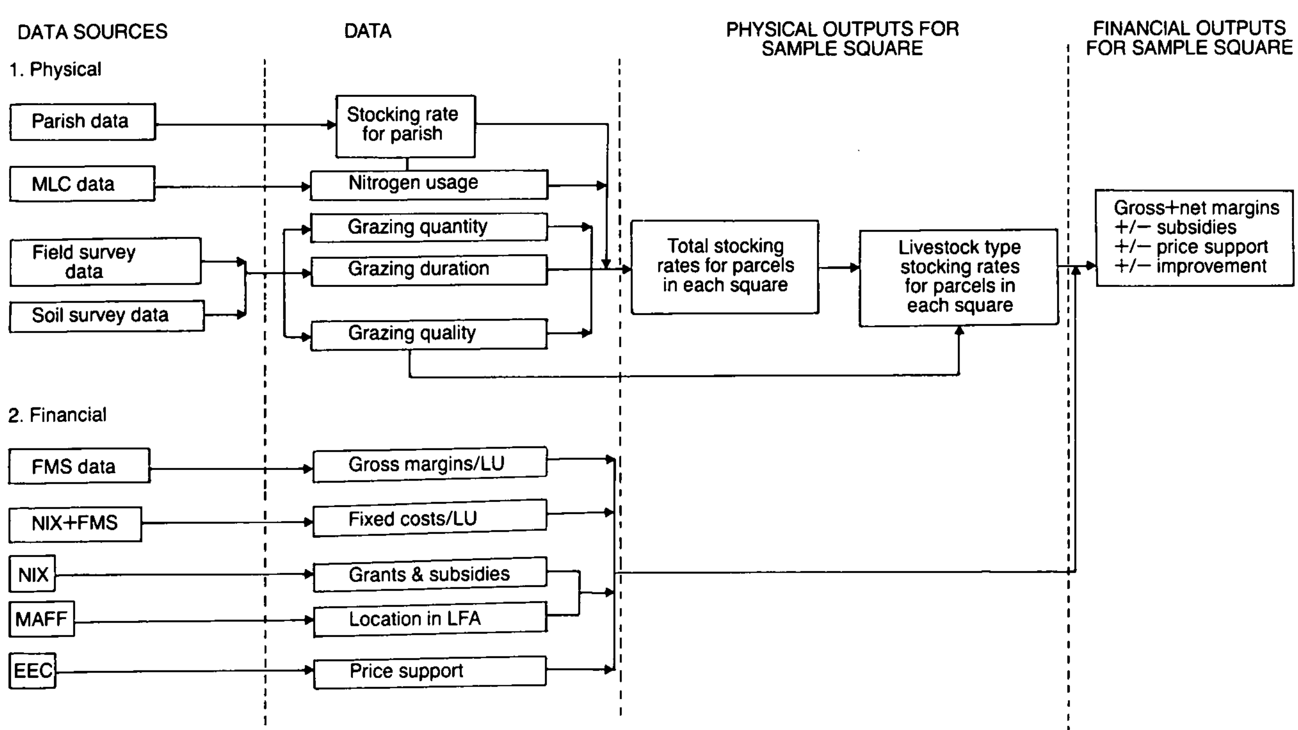


Figure 2. Agricultural land use valuation

Table 1. Species yield classes by soil type and land class on the Culm

Spp/ soil	Land class 1 (B G)	2 (B G)	3 (B G)	4 (B G)	5 (B G)	6 (B G)	7 (B G)	8 (B G)	9 (B G)	10 (B G)	11 (B G)
Sitka spruce	16	18	16	16	16 14	16	16 14	16	16 14	16	14
Norway spruce	16	18 16	12	14	12	18 16	12	16	12	12	12
Lodgepole pine	10	10	10	12	10	8	10	8	10	10	10
Douglas fir	16	18 14	—	—	—	16	18 12	14	14 12	14 12	—
Japanese larch	14 12	12 14	16 14	10	12 10	12 14	12 10	12	14	8 10	10

B=brown soils; G=gleyed soils

windthrow classes, and so the afforestation models reflect this range, including wide-spaced, no-thin regimes on the exposed, surface water gley sites, as well as more closely spaced, thinned models for the sheltered land to the east and on the freely drained slopes of the river valleys. Figure 3 illustrates an outline of the integration of relevant data sources in estimating the physical and financial yield of forestry.

The financial models of both agriculture and forestry may be considered with varying levels of grant aid or fiscal support included. Thus, the agricultural models may be used to determine the differences in financial performance of agriculture with and without the inclusion of the grants and subsidies for both improvement and income maintenance. This aspect is particularly relevant given the recent designation of about 25% of the Culm Measures as an agriculturally Less Favoured Area under the terms of the CEC Directive 268/75. For forestry, both planting grants and the fiscal benefit of opting for Schedule D assessment may be incorporated into the economic models.

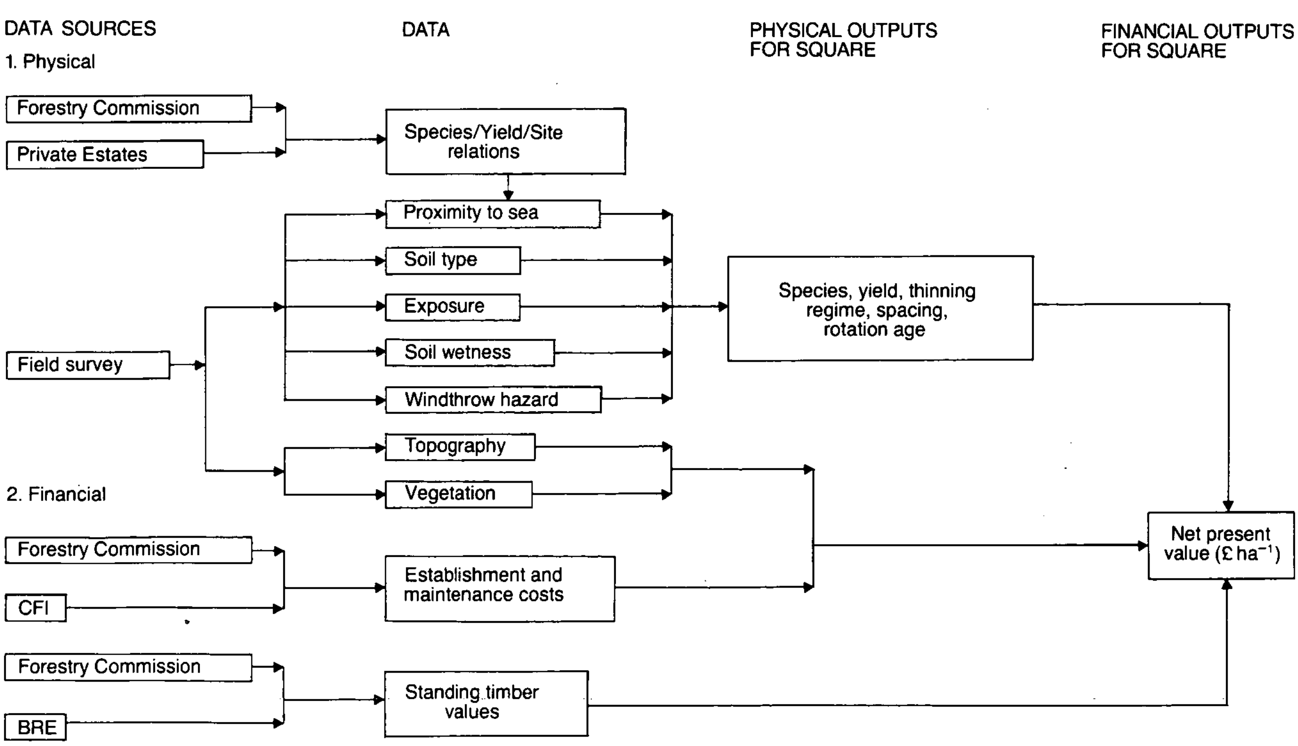
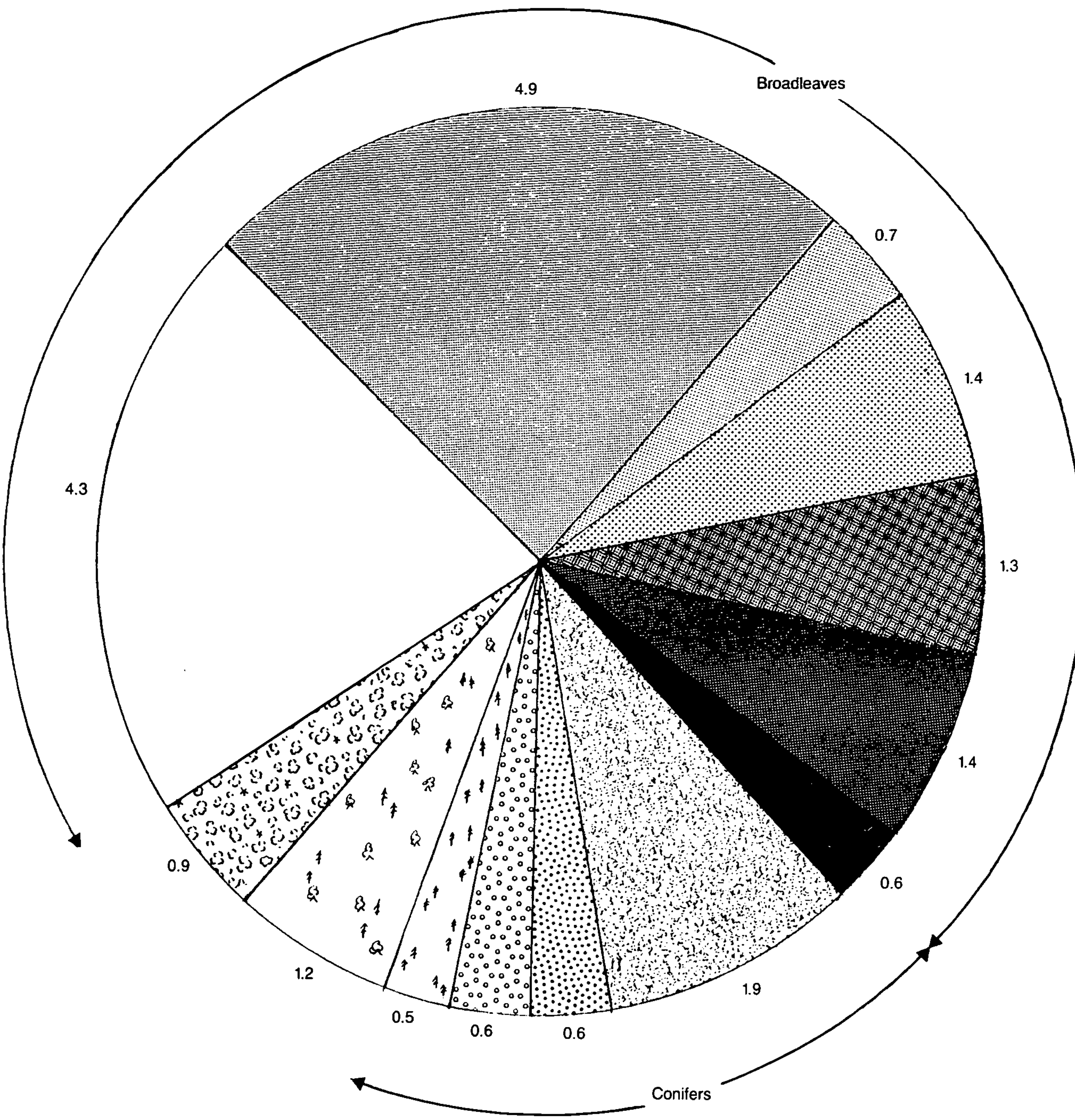


Figure 3. Procedure for potential forestry land use valuation



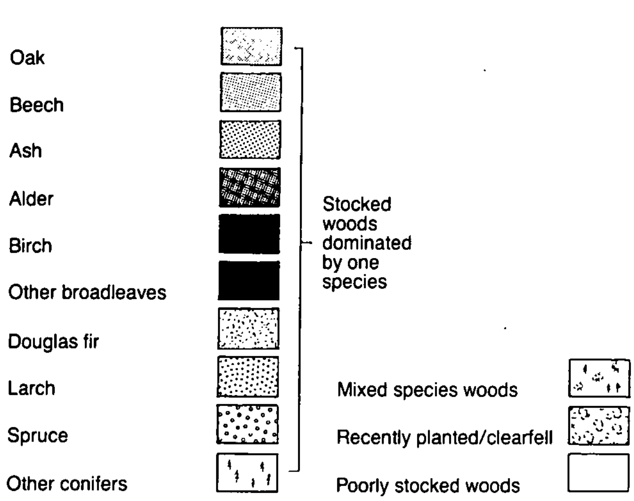
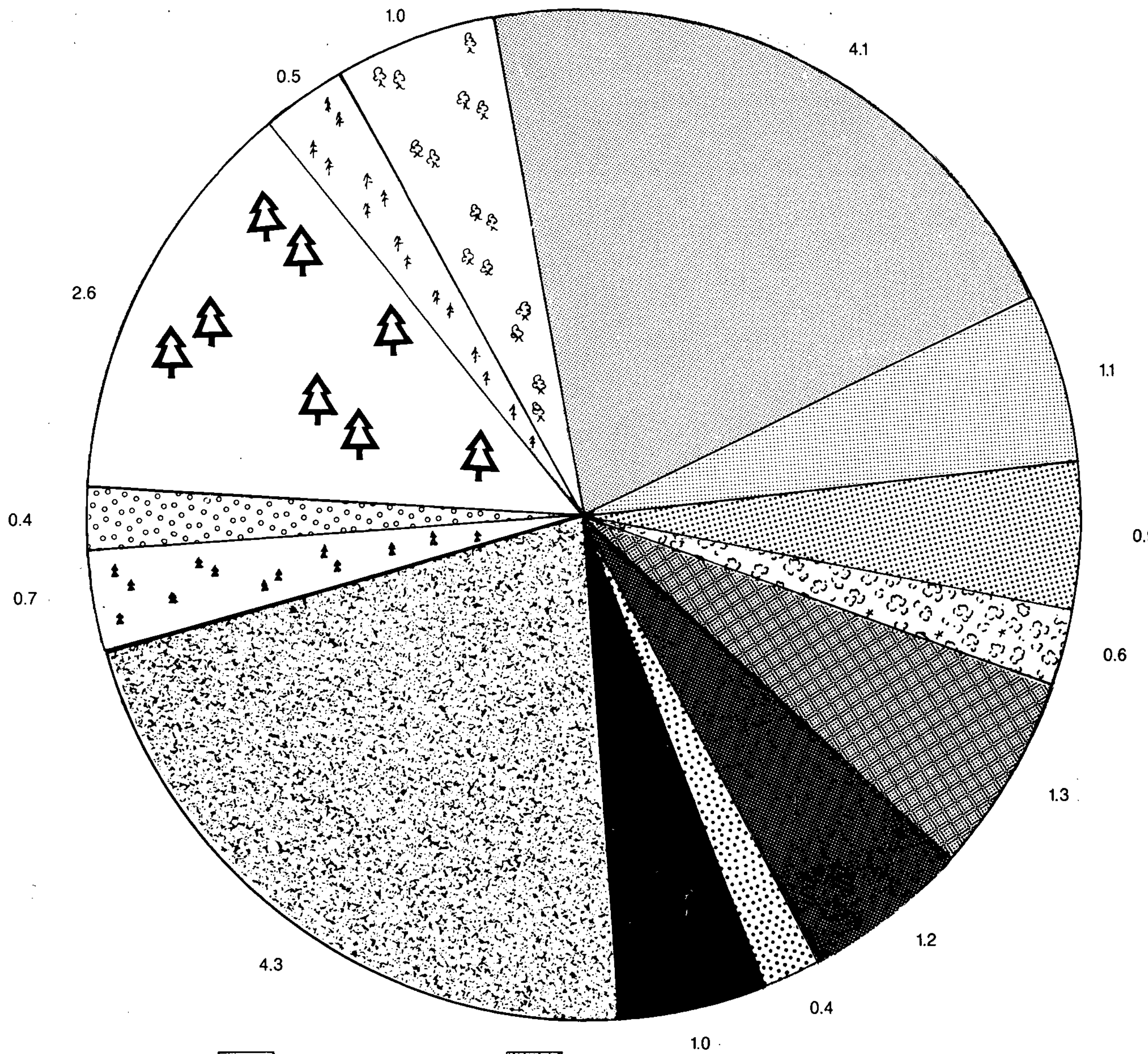


Figure 4. Area of woodland types on the Culm Measures (total 20.1 kha)

2.3 Non-economic factors affecting afforestation

A number of land use policies affect the degree to which afforestation would be an acceptable land use in a given area. Often such policies are an intrinsic component of the package of measures linked to the designation of land for a number of statutory purposes. Land designated for its scenic importance (Areas of Outstanding Natural Beauty (AONB)), its scientific (Sites of Special Scientific Interest (SSSIs)) or conservation value (National Nature Reserves (NNRs)) are examples of ways in which a control, with varying degrees of formality, through consultative procedures, is exercised over land use in general, and forestry in particular.

The incidence of such designations was recorded for the sample squares, and their likely effect on the acceptability of conifer afforestation at different



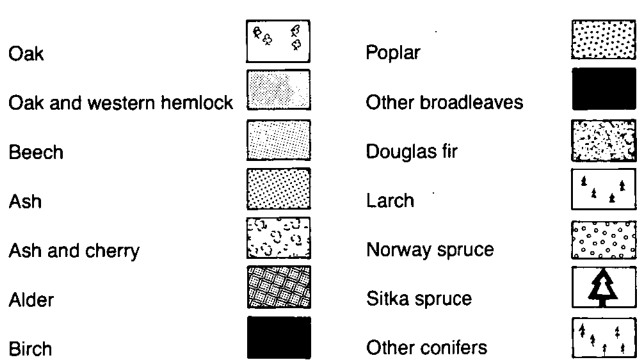


Figure 5. Area of woodland types on the Culm Measures after management (total 20.1 kha)

scales of operation estimated. The consideration and putative application of those policies to the sample squares were undertaken by the forestry/ landscape officers of the 2 local authorities (Devon and Cornwall) affected. In this way, it was possible to assess the degree to which economic conifer afforestation would conflict with stated policies as they apply to land subject to different designations on the Culm.

Clearly, however, concern for the environment is not limited to those areas already subject to some statutory or local designation. This concern is reflected in the standard consultation procedures that the Forestry Commission undertakes with district councils when considering planting grants and felling licences. The model can be used to identify the fraction of any particular habitat likely to be affected by any predicted level of afforestation, and so indicate the impact that such afforestation might have on conservation.

2.4 Management of existing woodlands

Silvicultural description of the woodlands The 310 kha of the Culm carry some 20 kha of woodland cover, amounting to about 6.5% of the area. However, the woodland is unevenly distributed, with concentrations in the dissected landscapes associated with the river valleys of the Taw, Torridge, Tamar and Exe and the more sheltered areas to the east. The exposed plateau land of the central areas of the Culm around Holsworthy exhibit a much lower percentage of woodland cover.

The woods are primarily broadleaved with only about a quarter of the area conifer-dominated. However, significant areas (4.3 kha) are particularly poorly stocked and may reasonably be classified as broadleaved scrub (Figure 4). Such areas comprise a relatively large fraction of that woodland remaining in the more difficult agricultural areas of the Culm.

About 50% (10.2 kha) of the total area of woodland is dominated by one broadleaved species or another, with oak (*Quercus* spp.) accounting for almost half of such woodlands. Most of the woods show symptoms of a history of either neglect or overexploitation. This is particularly true of the oak woods, where only 20% of the area is averagely stocked, and 67% overstocked, often with particularly large (40 cm) trees. The understocked woods have apparently been 'creamed' over the years, the best-quality timber trees having been removed and little attempt at restocking. Such woods are more frequently subjected to intensive grazing, and show an increased invasion of pioneer species, such as birch (*Betula*) and ash (*Fraxinus*) which tend to exacerbate the problems of future management.

The timber quality in almost all the woods is poor, though the sites often exhibit a capacity to grow good-quality timber, especially oak. External access to the woods is not often a significant problem, though internal access is more intractable and rides are rarely present.

2.5 Future management of existing woods

The survey data collected from the woodlands on the Culm have been analysed to yield both the areas of the woodland types outlined above, and their primary features relevant for the prescription of future management options. The main features identified for these prescriptions are dominant species, mean diameter at breast height, and number of stems per hectare. Woods possessing these features were further analysed to establish the extent of other factors such as fencing, difficulty of clearance, necessary drainage, etc. The costs of bringing such woods into management were a function of the woodland features so analysed. The benefits of the management system were ascribed exclusively to the timber product, sold standing, no account being taken of added value. The costs were timed (where possible) to match the cash flow of the stand, with the standing crop constituting a resource valued as a 'free good' (ie no account taken of historical capital). In this way, it proved possible to produce some 69 woodland 'models' which may be used to estimate the financial performance of the woods on the Culm. These estimates can be made by reference to the net present value (NPV) of the woodland enterprise, supplemented with data on the turnover associated with bringing the woods into management. Figure 5 shows the distribution of woodland types after being brought into management.

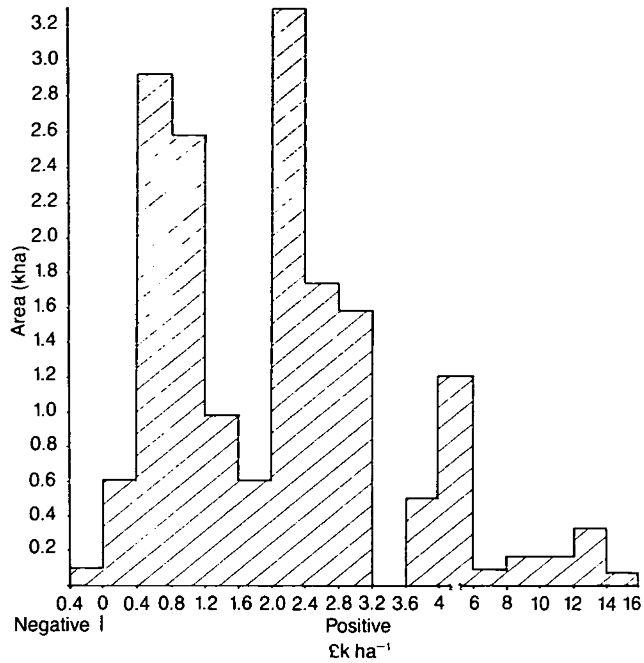


Figure 6. Net present values (£ ha^{-1} [5%]) of woodland on the Culm Measures

Management of the woods would produce an average NPV (5%) of £2,943, equivalent to an annual income of £147 ha^{-1}. Figure 6 shows that there is a considerable variation in the financial performance of the woodland of the Culm, ranging from low values, generally associated with understocked woods, to the high values for woods overstocked with native timber trees. Examination of the turn-

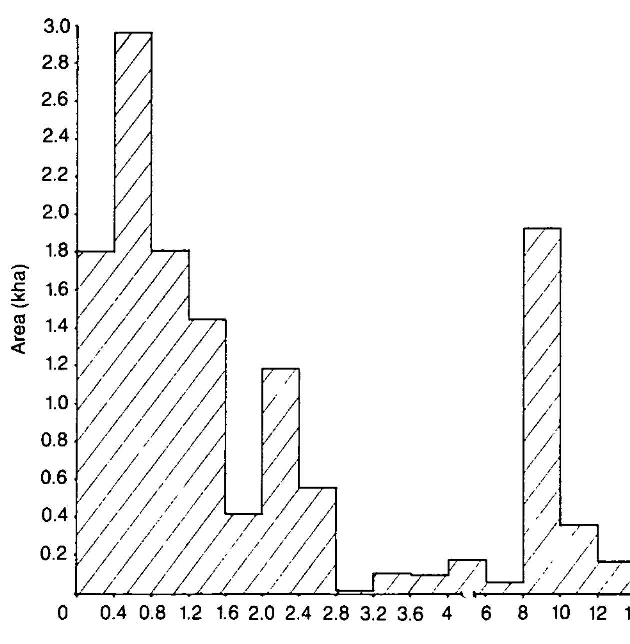


Figure 7. Turnover (£ ha^{-1}) during the first 10 years of management of woodland on the Culm Measures

over of the existing resource over, say, the first 10 years after management shows an average of £1,868 ha^{-1} (Figure 7). It is this value which could be exploited to minimize the initial cash flow problems associated with bringing previously unmanaged woods into production.

3 Contribution to farm incomes

The study methodology enables the results to be expressed in terms of the 'average' farm on the Culm Measures. Clearly, such a concept is meaningless out of context of the variation that exists within the total population. However, it can be used to illustrate the potential change in farm income resulting from a combination of afforestation and management of farm woodlands. The average farm on the Culm extends to about 49 ha, with 75% of the land area as grazing. The rough grazing amounts to about 4 ha per farm. An average stocking rate of 1.39 livestock units (LU) ha^{-1} gives a total population of 51 LUs on the farm. On average, these are in the ratio 42:40:18 dairy/beef/sheep. Net farm income, including grants, subsidies and fiscal support, is about £8,050.

The economic potential for the afforestation of agricultural land is limited to areas with an annual net return of less than £42 ha^{-1}. Such land is typically the poorest of the rough grazing, with a current stock carrying capacity of less than 0.6 LU ha^{-1}. Consequently, the 9.4 kha of economically afforestable land amounts to about 3% of the land area

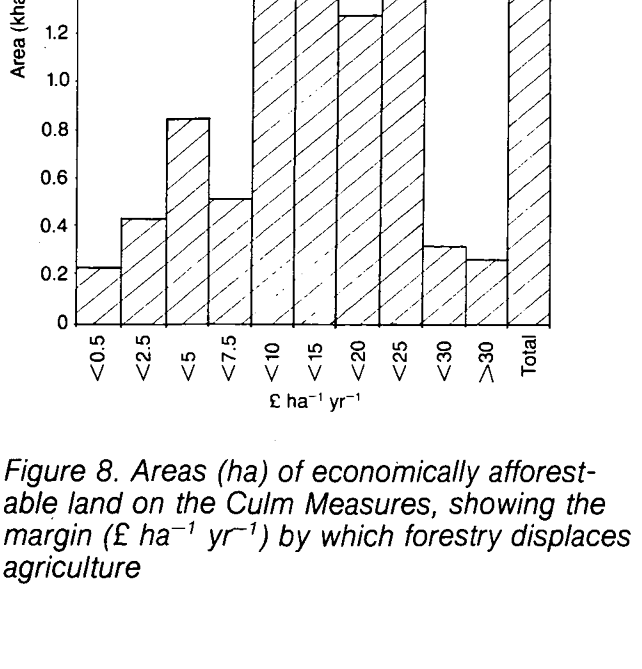


Figure 8. Areas (ha) of economically afforestable land on the Culm Measures, showing the margin (£ ha^{-1} yr^{-1}) by which forestry displaces agriculture

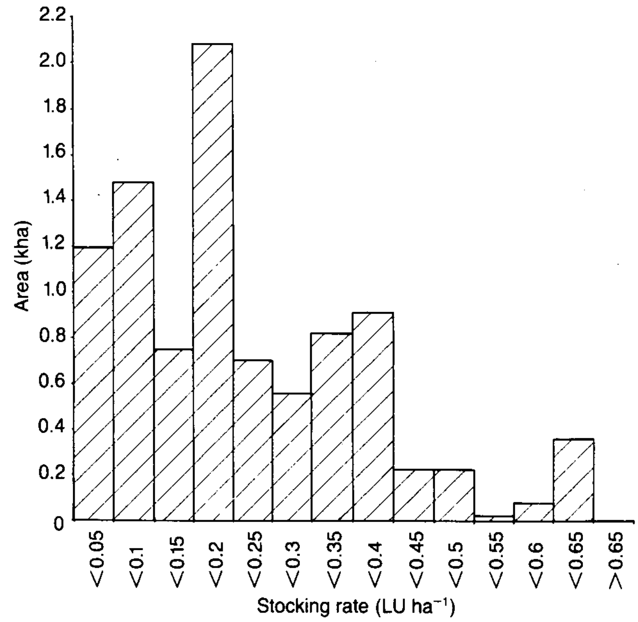


Figure 9. Areas (ha) of economically afforestable land on the Culm Measures, showing the stocking rate (LU ha^{-1}) of the land displaced by forestry

of the Culm. The profitability of forestry on this land is such that it provides for an average annual increase in return of about £14 ha^{-1} (Figure 8) over that of the agriculture it displaces, and results in the loss of an average of 0.21 LU ha^{-1} (Figure 9).

When considered in the context of the 'average' farm on the Culm, it is apparent that the economic potential for afforestation is limited to about 1.8 ha per farm, with an estimated increase in net farm income of about £25 per year. The consequential loss of some of the grazing land would have an insignificant effect on the total numbers of livestock, amounting to a reduction of only 0.23%.

Agricultural and forestry land together amount to about 277 kha, of which 7.3% is woodland. Assuming that all this woodland is in farm ownership, its management might produce a return of £10,530 per farm (5% discount rate), equivalent to an annual income of £526 per farm. Turnover from these woods during the first 10 years after being brought into management might amount to £6,680 per farm.

Management of existing woodlands and new afforestation might, therefore, result in increases of about 6.8% in farm incomes. Where farms tend to have a greater fraction of their land under trees, then this potential is clearly greater. Such areas exist in the northern and eastern parts of the study area, and less in those areas which suffer the greatest agricultural disadvantage. Management of woodland in these areas might be less likely to augment farm incomes.

4 Environmental effects

4.1 Designated land

The consideration of designations of land such as Areas of Outstanding Natural Beauty was referred to above. The model enables the identification of such areas predicted to be economically afforestable. It also identifies whether such designations are likely to either positively or negatively affect the potential for forestry (Table 2).

Table 2. Effects of designated land on the economic potential for forestry: basic scenario

Designated land score		Area (ha)	% of economic potential
	−5	818	8.7
	−4	727	7.7
'Inhibitory'	−3	743	7.9
	−2	57	0.6
	−1	277	3.0
	0	109	1.2
	+1	234	2.5
	+2	326	3.5
'Supporting'	+3	216	2.3
	+4	—	—
	+5	—	—
Undesignated		5 890	62.6
Total		9 397	100.0

It is apparent that some 28% of economically afforestable land is subject, in some degree, to policies inhibitory to coniferous forestry at the scale envisaged. Whether the application of these policies would be such as to effectively prohibit afforestation through the withholding of the planting grant, thus making the forestry enterprise less competitive with agriculture, is not known. However, it is very rare that planting grants for the afforestation of agricultural land are refused in lowland north Devon and Cornwall.

4.2 Habitat impact

The model also predicts the fraction of particular broadly defined habitat types which are identified as exhibiting an economic potential for forestry. However, the degree to which planting of such land would be subject to an inhibitory policy similar to those which might operate in currently designated areas is not known with any certainty. Consequently, the model does not include scores reflecting this controlling influence on the planting of agricultural land outside designated areas.

Table 3 shows the areas of habitat types affected by the economic potential for afforestation.

Table 3. Areas of habitat types

Habitat type	Area (kha)	% economically afforestable
Productive grassland	220.4	1.2
Less productive grassland	2.2	16.4
Rush-dominant areas	6.7	34.8
Bracken, gorse	3.3	72.5
Moor and heath	1.8	76.0

Productive grasslands Typically, these areas comprise rye-grass (*Lolium perenne*) with sparse to moderate rush (*Juncus* spp.) infestation in wetter areas. They are capable of relatively high stocking where soil conditions permit, and are generally well fertilized and managed with reseeding where necessary. It is essentially an homogeneous habitat of low value for wildlife. Some 35% overall (2.7 kha) of moderately rush-infested grassland is affected by an economic potential for forestry. However, certain land classes (1, 2 and 7) show a particularly pronounced loss (91%, 63% and 82%) respectively. Non- or sparsely rush-infested grass is not affected by forestry.

Less productive grasslands Typically, agrostis/fescue (*Agrostis/Festuca*) grows in mixture on generally less intensively managed sites, often with sparse to moderate rush infestation on the wetter sites. Species variety is greater than the more productive grasslands, but without providing a particularly important wildlife habitat. Some 24% overall (283 ha) of rough grass shows an economic potential for forestry, concentrated in land class 4 where moderately rush-infested rough grassland is also affected. Some 16% of this habitat type is affected by the economic potential for forestry.

Rush-dominant areas Rough grazing resulting from increasing dominance of rushes in the grass sward often occurs in the wettest areas on the heavier soils. Of a total area of 6.7 kha on the Culm, some 35% is economically afforestable. In the densely infested areas with no grazing value, forestry is limited only by its capacity to withstand the often high windthrow risk typical of many such sites. Thus, although land class 5 has the greatest area of this habitat type (2.3 kha), only 15% shows an economic potential for forestry.

Bracken and gorse The generally drier land char-

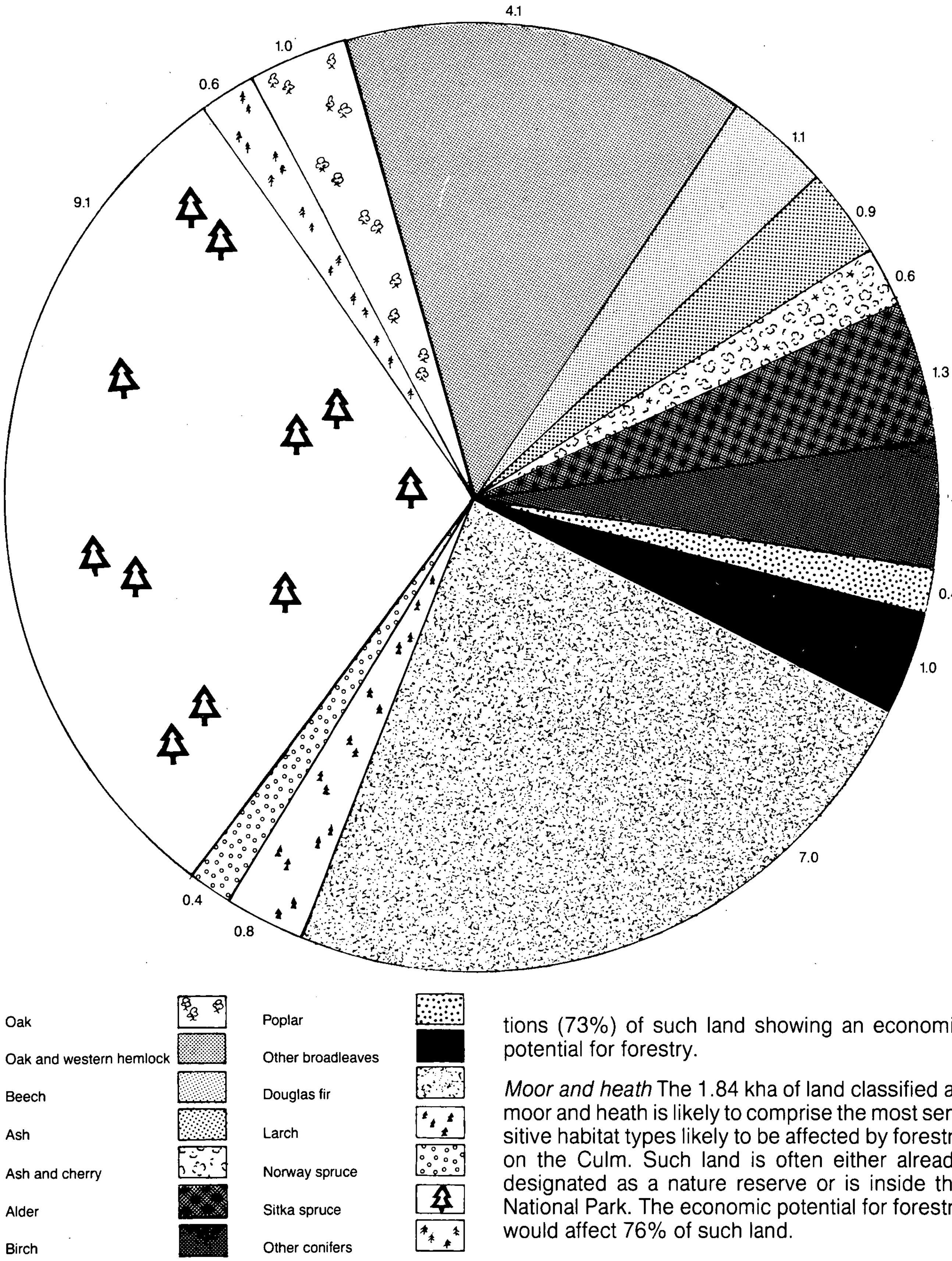


Figure 10. Area of woodland types on the Culm Measures: afforestation and existing woods after management (total 29.5 kha)

acteristics of bracken (*Pteridium aquilinum*) and gorse (*Ulex europaeus*) vegetation, coupled with its low value in agriculture, result in significant fractions (73%) of such land showing an economic potential for forestry.

Moor and heath The 1.84 kha of land classified as moor and heath is likely to comprise the most sensitive habitat types likely to be affected by forestry on the Culm. Such land is often either already designated as a nature reserve or is inside the National Park. The economic potential for forestry would affect 76% of such land.

Caution should be exercised in interpreting the results of the land use model in terms of predicted effects on different habitat types. The construction of agricultural land use models did not require a detailed consideration of species mix, which is pertinent to a description of habitats. Accordingly, there is some confusion between the different habitat categories. In particular, the area of heath and moor is likely to be an underestimate at the expense of areas of less productive grassland, rush-dominant areas and land with bracken and gorse.

The models for the management of the existing woodlands have been developed to reflect current policies as they affect broadleaved woodlands. In general, the models employ the species dominating the site so as to retain the present diversity of woodland type. The only significant exception to this general rule is where there is no standing value to the present woodland cover (the 4.3 kha of poorly stocked woods shown in Figure 4). In these instances, a conifer replanting model has been applied because it is felt that, where high clearance costs are coupled with no standing value, it is more likely that the owner would press for a faster return than that attainable with most broadleaved woodlands. It is recognized that such areas would be defined as essentially broadleaved in character, and so fall within the ambit of the broadleaves policy recently adopted by the Forestry Commission. Consequently, there would generally be a presumption against replanting with conifers in such areas. The provision of the higher planting grants available for broadleaves may be a sufficient incentive to encourage the replanting of such land with broadleaved species.

Figure 10 illustrates the breakdown of the Culm's woodland area, taking account of both the predicted 9.4 kha of afforestation and the management of the existing woodlands.

5 Conclusions

Although the study is not yet fully complete, it is apparent that the classification/modelling approach provides a useful and flexible tool for the estimation of possible land use change. The study has shown that the management of farm woodlands and the afforestation of marginal agricultural land can contribute to farm incomes, raising them on average by about 7%. The losses of agricultural land are generally small and limited to those areas of the farm where stocking rates are very low. Thus, the risk to agricultural income on the farm is generally low.

However, management of the existing woodlands provides a greater opportunity than afforestation. The exploitation of this underutilized capital resource can contribute significantly to farm incomes and in ways which need not, in any major respect, conflict with the broader aims of wildlife and landscape conservation.

The National Countryside Monitoring Scheme

J BUDD
Nature Conservancy Council, Peterborough

1 Introduction

The passage through Parliament of the Wildlife and Countryside Act 1981, and the continuing debate that the Act has engendered have increased concern about the ways in which the structure and appearance of the countryside have been, and may in the future be, affected by changes in farming, forestry and other land uses. Much of the concern has focused on the changes since the last war, coinciding with fiscal and strategic policies to increase farm output and the nation's timber reserves. Intensified husbandry and economies of scale have had substantial impacts on rural land management and infrastructure, mediated by improvements in farming and forestry technology.

Large-block conifer afforestation, and the conversion of heathland, semi-natural grassland and moorland, native woodland, and wetland into arable land have altered (and also simplified) much of the rural landscape. Surveys by the Nature Conservancy Council (NCC) and others have shown that changes differ in kind and extent in different parts of the country. However, comparisons between habitats and geographic areas have been hampered by differences both in survey method used and in their comprehensiveness, while large parts of the country have not been surveyed at all.

Consequently, the NCC has begun a survey of change in countryside features throughout Britain, in a manner which permits local as well as general trends to be identified. The aim is to obtain comprehensive data for all parts of the country. The survey is being carried out on a standard basis so that different places and features may be compared, using methods which will withstand critical examination. The information will be relevant to assessing the effects of past, present, and future countryside policies, and the NCC anticipates that the data will be of value to a wide range of agencies with interests and responsibilities in the rural environment.

2 Aims

The aims of this project are to establish a standard, technically robust system for providing quantitative data on the distribution and extent of defined structural components of the rural landscape since the 1940s to the present, and, in addition, to provide quantitative data on change and interchange that have occurred between these components over this time period. The most important components in terms of conservation are the natural habitats making up the 'wider countryside'. The aim of this survey is to provide as many data as possible on these habitats.

The quality and amount of these data is very much dependent on the data source. Only standard black-and-white vertical aerial photography can provide the necessary data. Comprehensive air photo cover exists for the whole of Great Britain at 2 dates, the 1940s and the 1970s. It is also possible to identify from the aerial photography the rural components necessary for this study. The initial habitat list has been developed further in order to maximize the advantages and reduce the disadvantages associated with aerial photography as a data source. The resulting habitats are listed in Table 1. Not all habitat types will exist in every county or district; neither will each type always be accurately distinguishable from other related types. Accordingly, for some geographical units, the list of features will be less detailed than for others, and the list is structured hierarchically to allow estimates to be calculated from combined feature types.

3 Method

Cost alone would preclude a study based on complete coverage of the country, but such a study would also ignore the benefits in time and materials of statistical inferences derived from random samples. The project is thus sample based, and uses aerial photography as its data source. Using Cumbria as an example, the following section shows how these 2 components are combined to produce the required results.

3.1 Stratified sample

Widely separated parts of Britain differ greatly in land type and land use. Features which are abundant in one region are scarce or absent in others, and vary in occurrence and extent even within similar geographical areas only a short distance apart. Absolute and relative amounts of change can differ in a similar way. In order to allow for these national variations, the study is stratified by county (district in Scotland).

Variability also exists within counties. These variations have the same effect on sampling intensity within counties as between counties; hence, the sampling design is further stratified into broad land types, ie upland, lowland and the intermediate ground. This stratification helps explain some of the variability between samples, thus increasing the accuracy of the estimates.

A county is stratified into the above broad land

Table 1. List of feature types to be monitored

Group A	Group B
Hedgerows and tree lines*	Hedgerows without trees Tree lines, including hedgerows with trees
Woodland	Semi-natural broadleaved woodland * Broadleaved plantation Semi-natural mixed woodland Semi-natural coniferous woodland Coniferous plantation * Mixed plantation Young plantation Recently felled woodland
Parkland	
Bracken	
Scrub*	Tall scrub Low scrub
Heathland *	Dwarf shrub heath lowland Dwarf shrub heath moorland * Montane heath Maritime heath
Mire	Blanket mire * Lowland raised mire
Wet ground	
Marginal inundation	Swamp and fen
Open water*	Standing natural water Standing man-made water Running natural water Running canalized water
Grassland	Unimproved grassland * Semi-improved grassland Improved grassland * Machair
Arable*	
Bare rock and soil*	Unquarried inland cliff and outcrop Quarries and open-cast, including spoil Other bare ground
Built*	

*Habitats where 10% net change is estimated with 95% confidence

types using the land classification system developed by the Institute of Terrestrial Ecology (Bunce & Smith 1978). The land classes are defined according to physical geography and land capability, and, for the purpose of this study, are amalgamated to give 3 broad land types. The coastal land classes are included within the lowland land type.

Results will be presented as the average over the various land classes sampled within each broad land type, and then weighted according to the relative abundance of the different land classes within each broad land type.

3.2 Aerial photographs

It is most important that there is complete or nearly complete air photo cover from which the sample is selected; otherwise, the sample may be subject to unknown bias. If there are small gaps in the cover, then the method of weighting the estimates by land class/type abundance within the county will minimize this effect.

In the case of Cumbria, complete cover existed at the 1:25 000 scale for the 1970s (Ordnance Survey cover) and 90% cover for the 1940s at 1:28 000

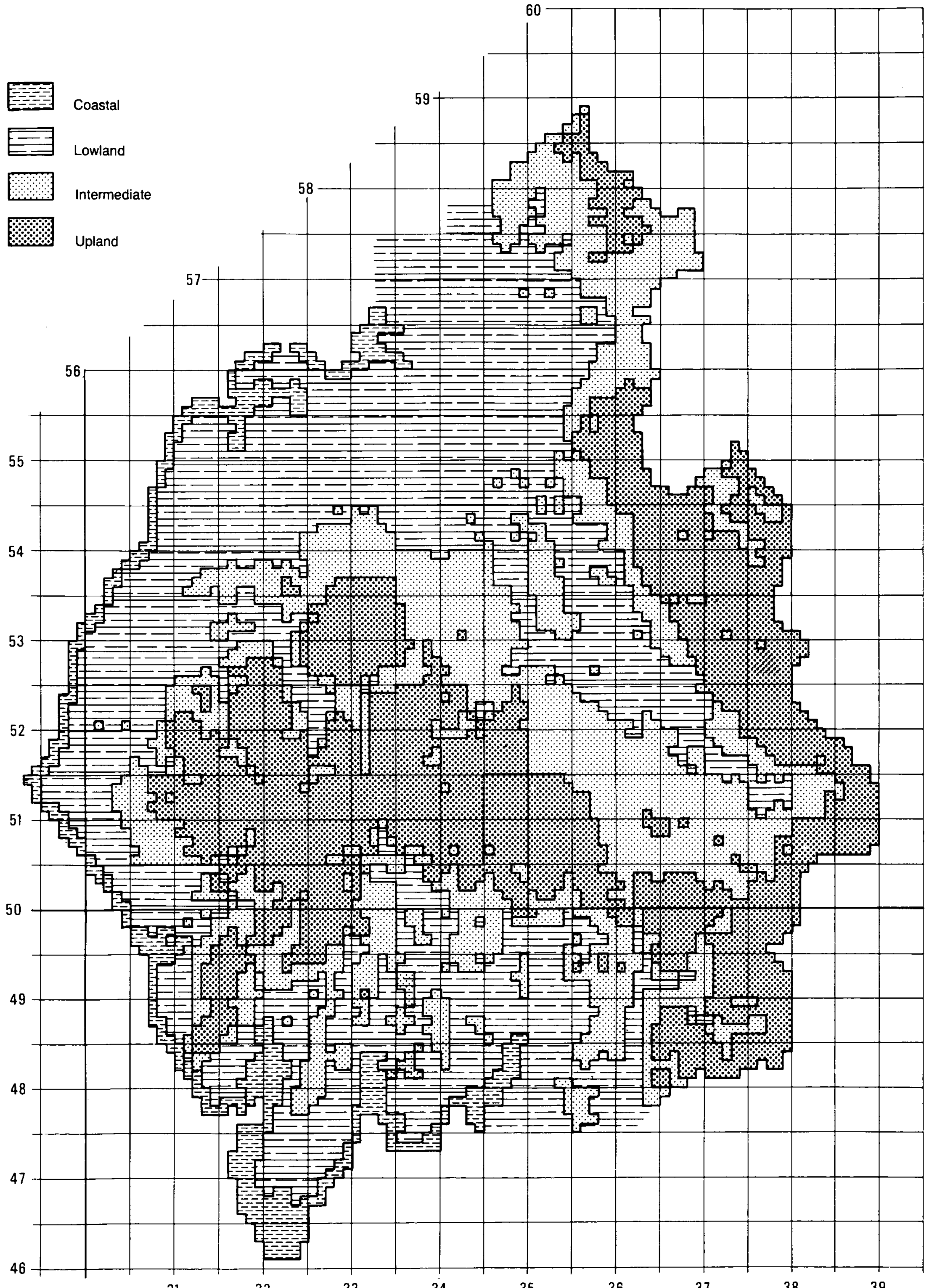


Figure 1. Stratification of one km squares for Cumbria

scale (flown by the RAF). This was the only suitable photography found after an exhaustive search (Budd & Anderson 1984). This scale of photography was a good compromise, in that it was not so small that it was impossible to identify the required habitats, but not so large that it would take an excessive length of time to collect the data. As the scale of the photography increases, there is a geometric increase in the time taken to collect the data from a specific area.

Thus, the availability of aerial photography was an important factor in determining the monitoring period, though these dates are also ideal in terms of the changes that have occurred in the wider countryside. The basic time period for monitoring is the end of the 1940s and the beginning of the 1970s. Wherever possible, photography for Cumbria is selected within ±2 years of the mean survey date (1947 and 1973). Where this is not possible, the overall estimates can be standardized by calculating annual rates of change.

3.3 Sampling

At a scale of 1:25 000, one air photo covers approximately a 5 km square. Sampling will therefore be from numbered 5 km square blocks of the National Grid. The use of the Grid prevents independently selected sample sites from overlapping. Although sampling units are 5 km squares, estimates are produced for one km squares within the sampling units, so that estimates of extent and change in habitat features can be obtained for the smaller one km land units. The 5 km and one km squares are both stratified into upland, intermediate and lowland land types (Figures 1 & 2). Sampling is from a list of all candidate units within the county, thus giving equal probability of selection of each unit, irrespective of its size; units of unequal size (such as along the county boundary or in coastal areas) will thus be sampled on an equal footing with central units. The result should be approximately equal numbers of units selected from each land type. If one land type covers a much smaller proportion of the county than the other 2, then approximately equal numbers of sampling units will still be selected from each type by continuing the sample until the required number for the smaller land type is reached (ignoring superfluous units selected for the larger land types).

For Cumbria, it was decided to select initially a 20% sample to allow for the greater heterogeneity of the habitats within the county. It was found, however, that a 10% sample was sufficient to reduce the standard errors below the standard set (Figure 3).

Figure 4 demonstrates the procedures used when sampling 2 time periods. Air photo cover is shown for one 5 km sample square at 2 dates (Time 1 and Time 2). The stereoscopic cover at Time 1 is approximately 50% and at Time 2 85%. Within each 5 km square, data are to be collected only from whole or parts of one km square having stereoscopic cover for Time 1 and Time 2.

3.4 Air photo interpretation

Interpretation of the aerial photographs is fundamental to this monitoring project. Thus, considerable time has been spent in developing the air photo interpretation techniques. As part of this development an air photo interpretation key has been produced (Nature Conservancy Council 1985), designed to help the interpreter to carry out his or her work efficiently and consistently. Many of the problems associated with the identification of the habitats listed in Table 1 are highlighted, as are the ways of solving them.

It was mentioned earlier that 1:25 000 scale aerial photography was most suitable in terms of habitat interpretation and efficiency of mapping. However, if the quality of the photography is poor, then mapping and interpretation are impossible, regardless of photo scale, so only good-quality imagery can be used. Some of the early photography was of poorer quality, but it was found that by close comparison with the more recent image it was possible to extract the required habitat information.

Seasonal effects are also very important when interpreting aerial photographs, as the habitats observed on the photographs can vary considerably through the seasons, some seasons being better for identifying habitats than others. A problem occurred, for example, in the Cumbria study when discriminating between improved grassland and arable feature types: much of the aerial photography for Cumbria had been flown in June, when it is extremely difficult to distinguish these 2 feature types. The best time for discrimination is the autumn. On the other hand, the summer months are best for interpreting woodland feature types. Some of the early photography was flown during the winter, making it very difficult to identify the broadleaved woodlands. This also applied to tree lines, but cross-checking with the more recent photography helped to overcome the problem.

Contextural information is also valuable when distinguishing certain habitats. Some habitats are characteristic of certain locations and are rarely found elsewhere. If this is the case, then this information can be used to reduce the number of potential classes to which an area on the ground can be assigned. Awareness of agricultural methods is one important form of contextural information. If the interpreter is familiar with farming practice, he can use this to aid the classification of agricultural land habitats.

Field visits were made to each sample square to

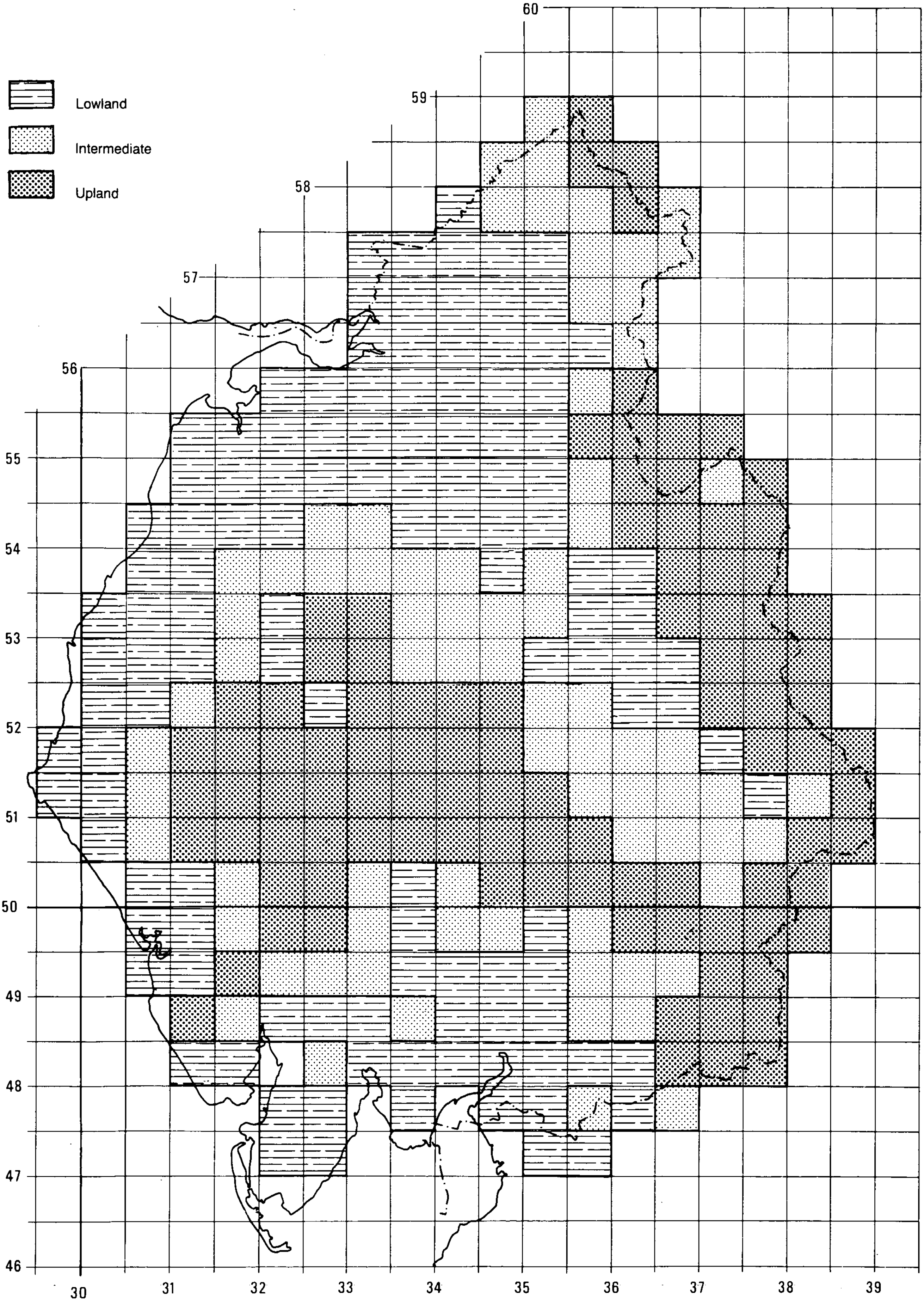


Figure 2. Stratification of 5 km squares for Cumbria

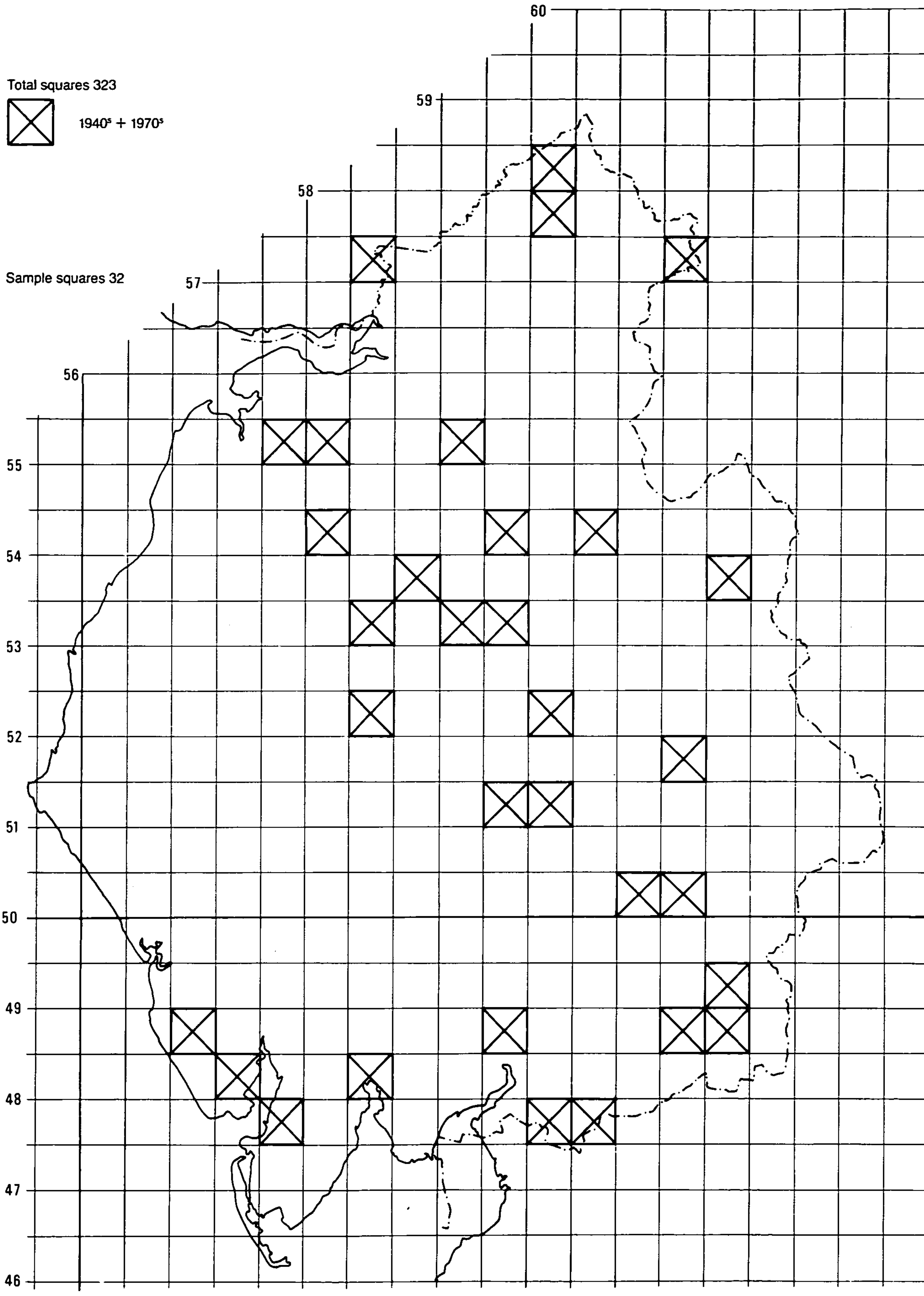


Figure 3. Sample squares selected for Cumbria

Table 2. Estimates of habitat extent and change in square kilometres for the county of Cumbria from the 1940s to the 1970s. Estimates for the whole county (total area 6689 km^2)

Habitat type	1940s (km)	1970s (km)	Increase (km)	Decrease (km)	Net change (km)	Net change (%)
Broadleaved woodland	219.5	183.8	69.3	105.0	−35.7	−16.3
Broadleaved plantation	0.0	0.1	0.1	0.0	0.1	0.0
Coniferous woodland	0.3	0.0	0.0	0.3	0.3	0.0
Coniferous plantation	51.7	117.2	81.6	16.1	65.6	126.9
Mixed woodland	26.8	57.8	41.8	10.8	31.1	116.0
Young plantation	26.7	45.7	39.8	20.8	19.0	71.2
Felled woodland	0.0	0.7	0.7	0.0	0.7	0.0
Parkland	12.1	17.2	9.5	4.4	5.0	41.3
Scrub tall	27.4	26.4	14.6	15.6	−1.0	−3.6
Scrub low	86.6	114.0	86.0	58.6	27.3	31.5
Bracken	98.9	164.6	94.3	28.6	65.6	66.3
Dwarf shrub heath lowland	116.2	33.7	4.2	86.7	−82.5	−71.0
Dwarf shrub heath moorland	298.5	89.6	1.6	210.5	−209.0	−70.0
Blanket mire	617.6	540.7	0.9	77.8	−76.9	−12.5
Lowland raised mire	143.7	116.0	0.0	27.1	−27.1	−18.9
Wet ground	14.1	15.8	11.9	10.2	1.8	12.8
Marginal inundation	0.7	0.8	0.2	0.1	0.1	14.3
Standing natural water	29.8	29.1	0.0	0.7	0.7	2.3
Standing man-made water	4.1	3.2	0.1	1.0	−0.9	−21.9
Running natural water	12.6	12.6	0.0	0.0	0.0	0.0
Running canalized water	0.5	0.5	0.0	0.0	0.0	0.0
Unimproved grassland	1325.3	1362.1	387.4	350.6	36.8	2.8
Semi-improved grassland	395.8	448.8	279.9	226.9	53.1	13.4
Improved grassland	2419.4	2348.0	552.7	624.1	−71.4	−2.9
Arable	580.0	704.5	428.8	304.3	124.5	21.5
Cliff	17.2	17.9	1.4	0.7	0.7	4.1
Quarry	6.0	13.1	8.0	0.9	7.1	118.3
Bare ground	0.4	0.6	0.4	0.2	0.3	75.0
Built land	155.2	221.9	71.7	5.0	66.8	43.0

check the interpretation of the aerial photographs, and involved checking the areas where it had not been possible to identify the feature types from the aerial photography. These field checks applied to both early and recent aerial photographs. It was even possible to find evidence in the field to help with the interpretation of the early photographs. Some habitats could be identified more consistently than others; broadleaved plantation was difficult to separate from semi-natural broadleaved woodland, for example. Tests are in progress to assess the interpretation accuracy for each habitat.

3.5 Data collection

A photogrammatic plotting machine was used for the interpretation and mapping of the habitats. This machine had several advantages:

i. high-quality stereoscopic image
ii. high magnification (8x)
iii. the altitude of habitats above Ordnance Datum (OD) can be measured
iv. canopy height can be measured
v. vegetation boundaries can be located with high degree of precision.

This machine is designed to produce paper maps using the pantograph and plotting table attached. However, in order to automate the process of area and length measurement, the machine has been modified so that the mapped data can be recorded as digital X, Y, and Z co-ordinates. The X and Y co-ordinates describe the boundaries of the feature types, while Z represents the height above OD. The digital data are stored on a computer and can then be used to calculate areas and lengths of habitats. It is also possible to compare 2 sets of data to identify the changes in habitat area and length. Finally, the computer prepares the results for use in the statistical programs.

4 Results

4.1 Estimates of habitat area

Estimates for each habitat for the 1940s (1945–49) and the 1970s (1970–76) are shown in Table 2. These estimates are calculated from the results of sampled areas, and derived statistical estimates are based on the habitat area within each ITE land class, multiplied up to give overall estimates.

It is clear from Table 2 that grassland is the dominant habitat, covering over 61% of the county, both in the 1940s and the 1970s. The second most dominant group are the moorland habitats (including dwarf shrub heath and blanket mire), which covered 17% of the county in the 1940s, but had reduced to 11% by the 1970s. Most of this decrease has been caused by losses of dwarf shrub heath, of which there has been a 70% loss since the 1940s. At the other extreme, coniferous plantation has shown the largest gain of 127%. Estimates of habitat have also been produced for the 3 broad land types and also for each of the 16 land classes. These estimates are not given here because of lack of space, but can be found in the National Country-

Table 3. Estimates of changes between habitats within county (km²)

1970s	1940s Losses																
Gains	Broad	Conif	Mixed	Park	Scrub	Brack	Heath	Mire	Minund	Swater	Rwater	Ugrass	Sgrass	Igrass	Arable	Baregr	Built
Broad	114.5	2.9	6.4	0.2	27.6	0.2	10.4	1.0	0.0	0.0	0.0	7.3	2.4	10.1	0.2	0.0	0.8
Conif	10.8	57.5	1.5	0.4	5.6	0.3	20.0	4.3	0.0	0.0	0.0	30.2	13.3	18.2	0.5	0.0	0.2
Mixed	25.9	3.0	16.0	0.2	2.8	0.5	2.3	0.7	0.0	0.0	0.0	4.0	1.1	1.3	0.0	0.1	0.0
Park	3.0	0.0	0.1	7.7	1.8	0.0	0.2	0.0	0.0	0.0	0.0	1.1	1.4	1.6	0.2	0.0	0.0
Scrub	18.5	3.7	0.6	0.5	43.9	2.9	6.1	10.8	0.2	0.4	0.0	26.6	9.9	15.0	0.4	0.3	1.0
Brack	2.9	1.2	0.1	0.0	4.1	70.3	10.6	1.3	0.1	0.0	0.0	64.0	6.5	2.8	0.4	0.1	0.1
Heath	0.6	0.1	0.4	0.0	0.0	0.0	117.7	3.8	0.0	0.0	0.0	0.0	0.6	0.0	0.1	0.0	0.0
Mire	0.0	0.0	0.0	0.0	0.0	0.0	0.0	656.4	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0
Minund	0.0	0.0	0.0	0.0	0.5	0.3	1.0	0.3	4.5	0.1	0.0	7.5	1.2	1.1	0.1	0.0	0.0
Swater	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.2	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Rwater	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.1	0.0	0.0	0.0	0.0	0.0	0.0
Ugrass	6.1	4.6	0.4	0.5	7.7	14.7	208.7	81.1	8.5	0.2	0.0	974.7	29.7	22.5	2.2	0.5	0.2
Sgrass	6.5	2.2	0.4	0.9	5.9	6.9	23.7	0.6	0.6	0.0	0.0	125.5	168.9	99.2	6.9	0.3	0.3
Igrass	23.0	3.0	0.8	1.7	10.7	0.9	9.2	0.8	0.7	0.3	0.0	71.7	144.9	1795.3	282.6	0.0	2.3
Arable	2.2	0.0	0.0	0.0	0.8	0.1	1.9	0.0	0.0	0.1	0.0	5.8	10.4	407.2	275.7	0.0	0.2
Baregr	0.4	0.0	0.0	0.0	0.3	1.9	2.2	0.1	0.0	0.0	0.0	2.0	1.6	1.1	0.0	23.6	0.0
Built	5.0	0.2	0.1	0.1	2.4	0.0	0.7	0.0	0.0	0.6	0.0	3.3	4.4	43.8	10.8	0.3	150.2

Table 4. Interchange between habitats for the county of Cumbria (interchange of greater than 10 km^2 for the county). Estimates in km^2

		Area of land class within county (km^2)			
		1969	2003	2717	6689
From	To	Upland	Intermediate	Lowland	County
Broadleaved woodland	Mixed woodland	0.3	2.2	23.3	25.9
Broadleaved woodland	Scrub low	1.6	4.6	9.6	15.3
Broadleaved woodland	Improved grassland	1.2	10.4	11.4	23.0
Young plantation	Conifer plantation	0.6	13.1	0.5	14.1
Scrub low	Broadleaved woodland	0.6	6.6	14.2	21.5
Bracken	Unimproved grassland	7.9	5.3	1.5	14.7
Dwarf shrub heath lowland	Broadleaved woodland	0.0	7.8	2.6	10.4
Dwarf shrub heath lowland	Conifer plantation	0.6	9.9	3.0	13.4
Dwarf shrub heath lowland	Unimproved grassland	5.9	9.9	0.4	16.2
Dwarf shrub heath lowland	Semi-improved grassland	0.8	12.3	3.4	16.5
Dwarf shrub heath moorland	Unimproved grassland	171.3	19.8	1.4	192.5
Blanket mire	Unimproved grassland	71.6	2.7	0.0	74.3
Unimproved grassland	Conifer plantation	1.0	17.6	5.0	23.5
Unimproved grassland	Scrub low	5.6	5.7	13.0	24.4
Unimproved grassland	Bracken	22.9	16.1	25.1	64.0
Unimproved grassland	Semi-improved grassland	54.7	51.4	19.5	125.5
Unimproved grassland	Improved grassland	5.4	33.5	32.9	71.7
Semi-improved grassland	Conifer plantation	0.0	11.6	0.3	12.0
Semi-improved grassland	Unimproved grassland	8.5	13.0	8.2	29.7
Semi-improved grassland	Improved grassland	12.1	72.1	60.7	144.9
Semi-improved grassland	Arable	0.8	2.8	6.9	10.4
Improved grassland	Broadleaved woodland	0.5	4.2	5.4	10.1
Improved grassland	Scrub low	0.8	3.3	8.7	12.8
Improved grassland	Semi-improved grassland	8.0	35.6	55.6	99.2
Improved grassland	Arable	2.9	129.7	274.6	407.2
Improved grassland	Built	0.5	5.2	38.2	43.8
Arable	Improved grassland	0.1	69.9	212.6	28.6
Arable	Built	0.0	0.5	10.3	10.8

side Monitoring Scheme report for Cumbria (NCC 1987).

4.2 Interchange between habitats

Table 2 provides the estimates of each area for each habitat and the gains and losses that have occurred. The Table does not, however, show how these changes have taken place. Table 3 is the interchange matrix for the whole county. The habitats have been summarized into 17 groups in order to reduce the size of the matrix. *Broad* (ie broadleaved woodland) can be used as an example of how to interpret the matrix. The diagonal values, ie 114.5 km for *broad/broad*, represent the area of a

Table 5. Estimates of hedgerow and tree line length in kilometres for the county of Cumbria

	Upland	Intermediate	Lowland	County
Hedgerows				
1940s	267.0	6359.8	15480.6	22107.4
1970s	164.8	4245.0	12092.5	16502.2
Gains	49.8	791.0	2593.3	3434.2
Losses	152.1	2905.8	5981.5	9030.4
Net change	−102.3	−2114.8	−3388.2	−5605.2
Net change as a percentage of the length in the 1940s	−38.3	−33.3	−21.9	−25.4
Tree lines				
1940s	134.0	1002.2	1437.9	2574.1
1970s	105.7	901.1	1370.1	2376.9
Gains	11.5	262.0	372.9	646.4
Losses	39.8	363.2	440.7	843.6
Net change	−28.3	−101.2	−67.8	−197.2
Net change as a percentage of the length in the 1940s	−21.1	−10.1	−4.7	−7.7
Hedgerow to tree line change	22.9	135.9	159.0	317.9
Tree line to hedgerow change	8.5	80.5	106.7	195.7

habitat that has remained unchanged during the study period. The column under *broad* represents the losses: these have been mostly to *conif* (10.8 km), *mixed* (25.9 km), *scrub* (18.5 km) and *grass* (23.0 km). Gains are shown in the rows, and for *broad* these have been mainly from *scrub* (27.6 km), but also *heath* (10.4).

Table 4 summarizes the interchanges greater than 10 km for the county, and significant geographical differences can be seen where the interchanges occur. Within the lowland and intermediate land classes, for example, there has been a considerable amount of interchange between grassland and arable due to crop rotation. The biggest interchange in the upland land class is dwarf shrub heath moorland to unimproved grassland, 171.3 km in all, with blanket mire to unimproved grassland the second largest at 71.6 km.

Unimproved grassland shows large gains in the upland land type from the moorland habitats, while in the lowland land type there are large losses of unimproved grassland to arable land. The result is a very small net change.

4.3 Linear feature estimates

Hedgerows have undergone considerable change during the 30 years of the study period, over 9000 km having been lost since the 1940s (Table 5). There has been a small gain in hedgerows, but these gains are less important than they might appear in that the quality of the new hedgerows as habitats is much less than the older hedgerows. The percentage loss for hedgerows varies across the land classes, from 38.3% in upland through 33.3% in intermediate to 21.9% in the lowland classes.

4.4 Discussion of results

The last section concentrated on the results for Cumbria, providing estimates of extent and change for each habitat. When interpreting these results, it is necessary to take into account the standard errors associated with them. The principal criterion was that, for 12 of the habitats (starred in Table 1), a net change of 10% in extent should be detected with 95% confidence. This criterion was met for the county estimates, with the exception of coniferous plantation.

The estimates for each time period have larger standard errors than the change results, because there is a certain similarity within the change data between the estimates in the 1940s and 1970s, thus reducing the standard errors. Most of the estimates for the county are estimated with 95% confidence.

The results for Cumbria demonstrate clearly the usefulness of the stratification in reducing sample variability, because of the high correlation between the land class and habitat composition. Land classes 9 and 10, for example, had 50% of all the bracken (*Pteridium aquilinum*) estimated within the county.

5 Acknowledgements

Thanks are expressed to the staff of the AFRC Unit of Statistics at Edinburgh University for their help with the project, in particular Dr Chris Kershaw, who designed and created the statistical software for the analysis of the data. Thanks also go to George Jolly who designed the sampling and statistical procedures used in the project.

6 References

Budd, J. T. C. & Anderson, H. L. 1984. *Aerial photo cover of Cumbria, 1945-1983.* (CSD report.) Peterborough: Nature Conservancy Council.

Bunce, R. G. H. & Smith, R. S. 1978. *An ecological survey of Cumbria.* Kendal: Cumbria County Council and Lake District Special Planning Board.

Nature Conservancy Council. 1985. *National Countryside Monitoring Scheme: air photo interpretation manual.* Peterborough: NCC.

Nature Conservancy Council. 1987. *Changes in the Cumbrian countryside, first report of the National Countryside Monitoring Scheme.* Peterborough: NCC.

Statistical and spatial analysis of land resource data

P A BURROUGH and J VAN KEULEN
Department of Physical Geography, University of Utrecht, Utrecht, The Netherlands

1 Introduction

A series of interactive menu-driven programs has been developed for statistical and spatial analysis of land resource data. The programs have been designed for researchers, university students and resource developers, working with small data sets and minor projects. The programs have been written in IBM-PASCAL for the IBM-PC, the IBM-PCXT, and compatible machines such as the COMPAQ, the COMMODORE PC, the ERICSSON PC, or the Olivetti PC, all using MS-DOS version 2.0 or subsequent versions. The minimum requirements for most programs are an internal (RAM) memory of 256K and at least one 360K dual density, double-sided 5¼ inch floppy disk drive: an additional drive and/or a Winchester drive will facilitate use of the programs, particularly with larger data sets. A graphics-quality matrix printer, such as the EPSON FX-10, the STAR SG-10 or the IBM GRAPHICS printer, is also required. It is estimated that the minimum hardware requirements (excluding the pen plotter used in the PLOT program) can be purchased for substantially less than £1,500. A high-quality graphics screen is not essential.

2 Data input

Data input to all programs is via standard ASCII text files that can be prepared with the IBM Personal Editor program. This is a powerful multi-purpose word processor and screen editor. Except for the PICTURE package, all programs accept a common input format of NROW (sites) x MCOL (attributes) data matrix of real data. When X and Y co-ordinates are an expected part of a data set, they should be placed in the first and second data columns respectively. All statistical programs allow the user to define a value with which missing values can be identified. The input to the PICTURE package is somewhat different, being a matrix of N x M integers (in the values range 1—16) defining the area of the map.

3 Data output

Data output is either in the form of screen displays, printed tables on the matrix printer, printed maps on the printer operating in graphics mode, plotted graphs, or new data files in ASCII format. A unique feature of many of these programs is their ability to store the most recently used parameters and derived data in internal files, so that it is not necessary to re-enter all control values every time the program is executed.

4 Programs available

The following programs are now available.

4.1 PLOT

This is an interactive plotting package that allows the user to define and enter titles, axes, axes labels, scales and legend, and to choose format (A4 horizontal or A4 vertical), line signatures and symbols through menu-entered commands. Standard graphs and histograms can be drawn (Figure 8). The current version drives a Hitachi 671-20 6-pen plotter, but other plotters could be driven using slightly modified versions of the current software.

4.2 PICTURE

This is a package for printing continuous-tone or shaded thematic maps on the matrix printer. Raster (gridded) maps having up to 16 different classes coded by the integer values 1—16 can be plotted in many ways. If the data range is not 1—16, this can be modified by preprocessing. Each map can be printed out at m scales (m = 1 means one pixel per grid point, m = 2 means 4 pixels per grid point, etc). Each pixel is a square made up from a 3 x 5 array of dots that can be programmed to give various tones or symbols (Foley & van Dam 1982). The package is in 2 parts. In the first, the user can assign graphics shading symbols to the data values and may add up to 5 lines of title, a scale bar and a legend. The resulting symbol file can be rearranged, if desired, by using the IBM Personal Editor before processing in the second part. Here, the user may choose one of 6 different shading systems (Figures 1, 2, 3, 6). Maps can be printed directly or saved as files for later printing. The package is very useful for displaying simple maps quickly and clearly (eg see Burrough 1986).

4.3 TP

This program transforms data to take account of non-normality, missing or extreme values. Data can be standardized to zero mean and unit variance, in the range 0-1, or reclassified at will. Logical combinations of existing columns of data are possible. Histograms can be displayed directly on screen and printed if desired (Figure 4). The program consists of a set of menu-driven modules that allow the user to make most commonly used transformations without having to type in formulae (Figure 5). The program is fully self-documenting, with extensive HELP facilities that can be directly called up to explain the main menus.

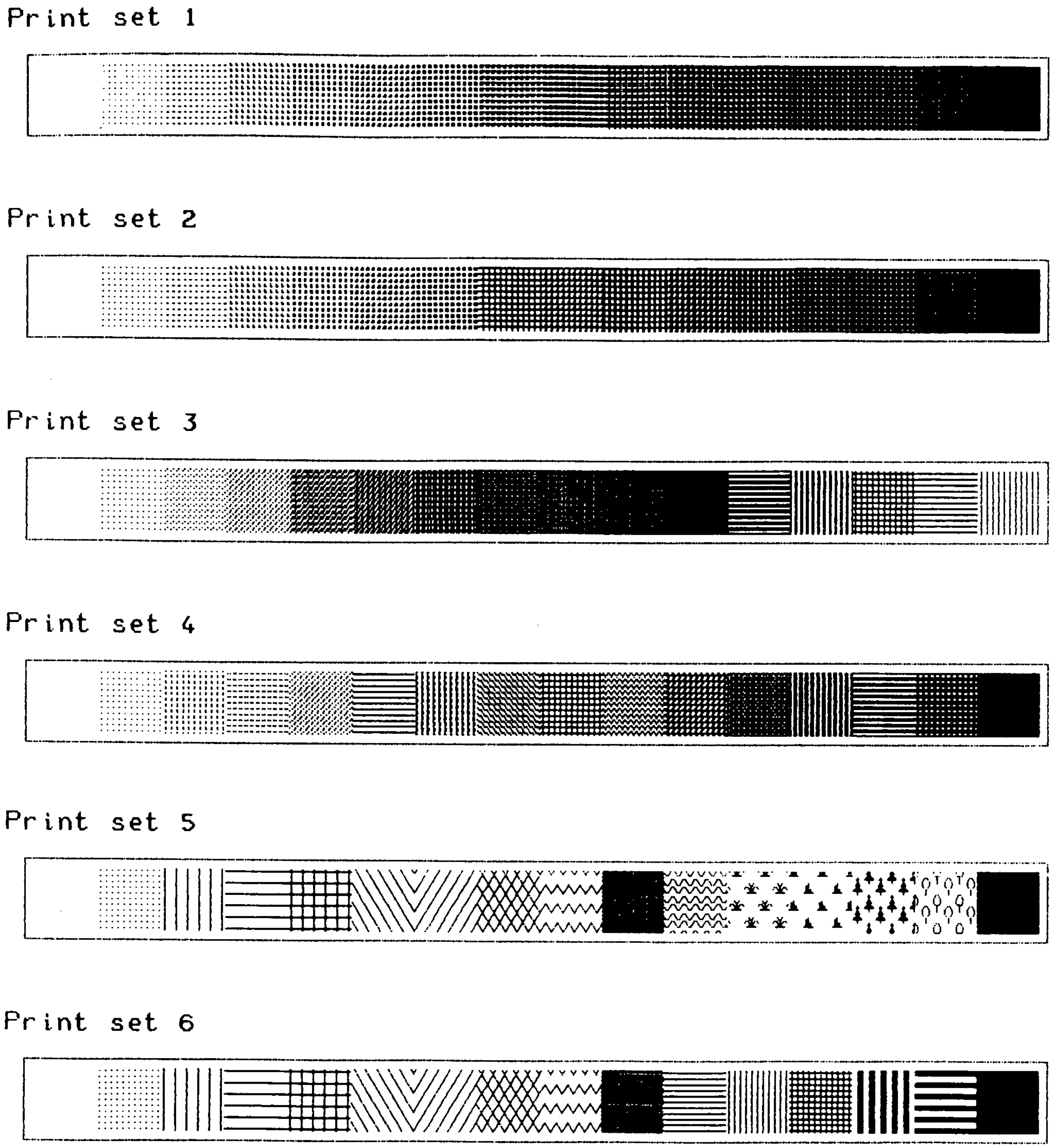


Figure 1. The 6 shading sets available with the PICTURE program

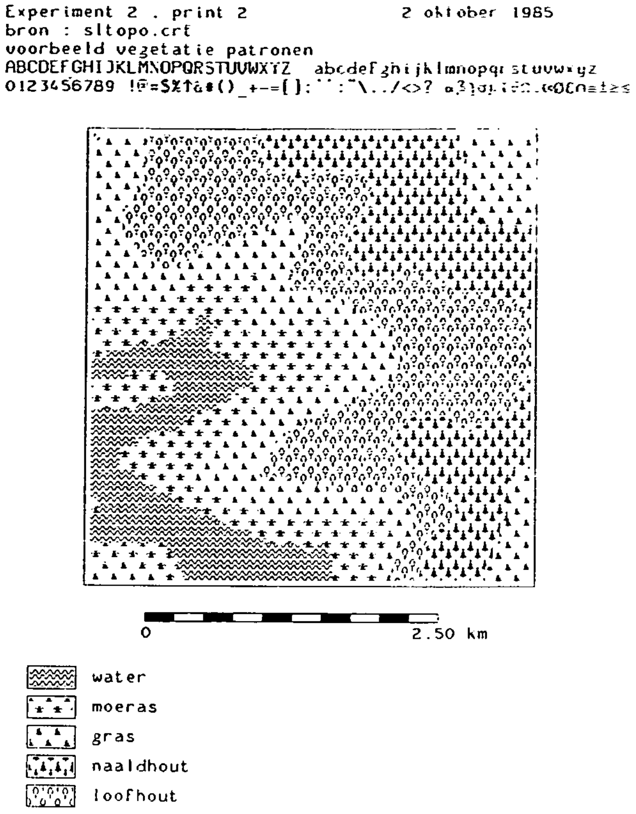
5 New developments

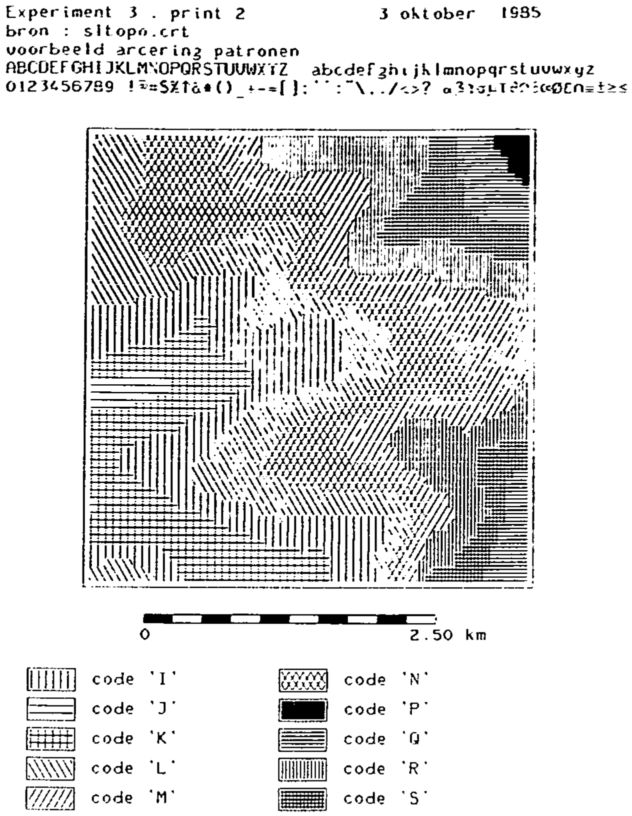
Three other packages are in the last stages of development.

5.1 Global and local interpolation from regular gridded or irregularly spaced point data using trend surfaces, linear interpolation, inverse-distance interpolation and gridding. The output can be displayed using PICTURE (Figures 6 & 7 — note that the Figure legends reflect the conversion of the real numbers from the interpolation to the 0—16 class input for the display program).

5.2 Computation of experimental semivariograms from regularly spaced and irregularly spaced data points. The semivariograms can be calculated for various compass directions allowing directional analyses. The program uses an iterative procedure to fit spherical or exponential models to the experimentally derived data (Figure 8; Burrough *et al.* 1988). A Winchester disk (IBM-PCXT) is highly recommended for this procedure. Journel and Huijbregts (1978) and Webster (1985) give details of the use of semivariograms in spatial analysis.

5.3 Linear interpolation and analysis of one-dimensional transects. Data from regularly or irregularly spaced transects can be interpolated and resampled to give regularly spaced series of points. The





Figures 2, 3. Examples of maps obtained using the thematic shadings

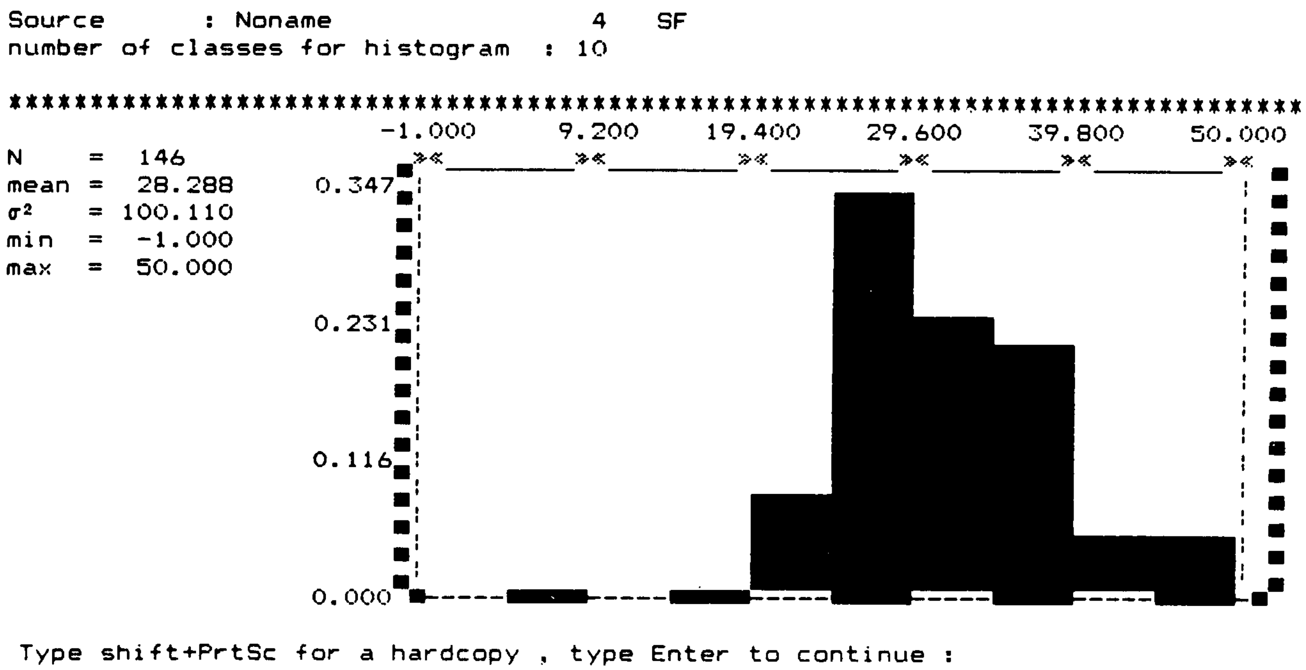


Figure 4. Histogram of data values obtained using the transformation program

data can be modelled using various one-dimensional methods of curve fitting, moving averages, etc.

Further details of all programs and costs can be obtained from the authors.

6 Acknowledgements

This report was made possible by the generous donation of an IBM-PCXT by IBM-Nederland.

```
Source       : Noname                    1   SF            Last column SF   :  7
                                                           Free columns DF  : 23
Destination  : Noname                    1   DF            Last column DF   :  7

********************************************************************************

   File transformation menu
   Choose:

     1  Logarithmics
     2  Trigonometrics
     3  Standardise
     4  Simple algebraïcs
     5  Interactive and actuator algebraïcs
     6  Boolean operations
     7  classify and histogram
     8  Entire file operations
     9  Continue to output

 Type number and press enter
```

Figure 5. Main transformation menu of TP program

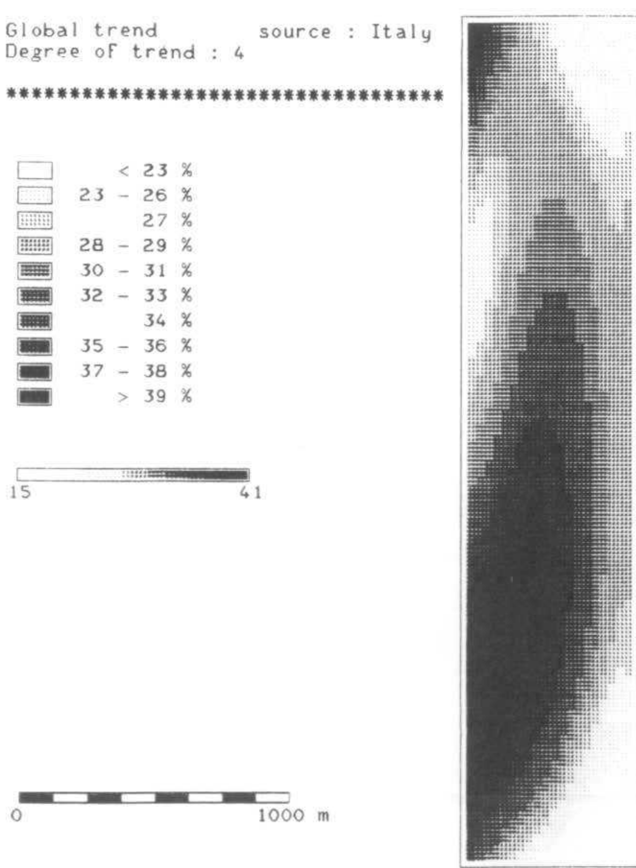


Figure 6. Global trend surface plotted using PICTURE

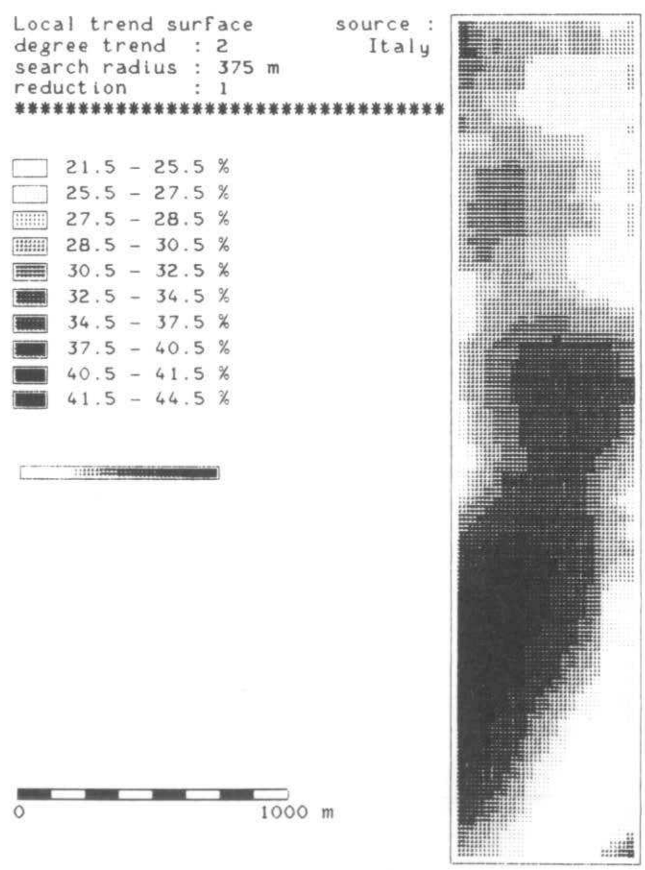


Figure 7. Local trend surface plotted using PICTURE

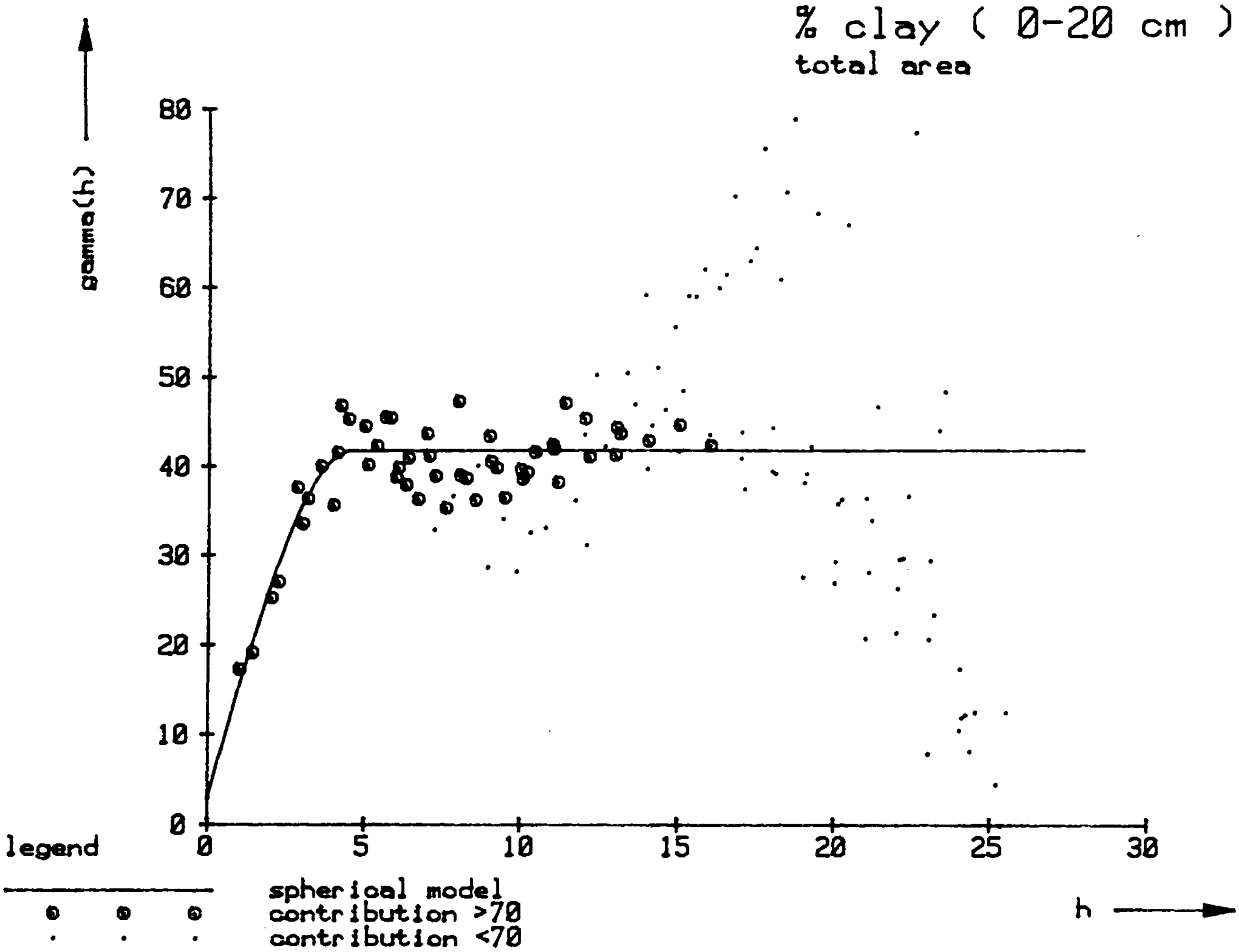


Figure 8. Semivariogram fitted to experimental data using SPHUNX program. Plot was made using the PLOT program

7 References

Burrough, P.A. 1986. *Principles of geographical information systems for land resources assessment.* Oxford: Oxford University Press.

Burrough, P.A., van Keulen, J. & Hazelhoff, L. 1988. *SPHUNX - an improved interactive procedure for fitting spherical and exponential models to experimental semivariograms.* In press.

Foley, J.D. & van Dam, A. 1982. *Fundamentals of interactive computer graphics.* Reading, Mass: Addison-Wesley.

Journel, A.J. & Huijbregts, Ch. J. 1978. *Mining geostatistics.* London: Academic Press.

Webster, R. 1985. Quantitative spatial analysis of soil in the field. *Adv. Soil Sci.,* **3**,1-70.

Classification models and water resource planning

K R BULL
Institute of Terrestrial Ecology, Monks Wood Experimental Station, Huntingdon

1 Introduction

The first question to be answered in the process of environmental planning is — what is there now (Bunce & Heal 1984)? We need an environmental description to provide a baseline or reference scale upon which measurements or judgements may be made. There is seldom a clear answer to any environmental question, and often there are conflicting interests to confuse the situation further. It is very important, therefore, to make the description as objective as possible. We have chosen water catchment areas as our units of description as the first step in this process.

River and lake catchments are frequently used as convenient units, both for scientific studies and for managing water resources. They ideally represent separate hydrological systems fed by identifiable sources (eg rainwater, springs) with identifiable sinks (eg the lake or river, evaporation, underground aquifers). Catchment areas can also be quantified using contour maps.

Rivers (and lakes) may differ considerably from one another in their hydrology, chemistry and biology; such differences may alter seasonally or even from day to day or hour to hour, as a consequence of a multitude of environmental factors. How, then, can we assess a set of catchments and obtain a meaningful baseline?

Total environment sampling of all catchments at all points in time is a practical impossibility, and even large numbers of on-site investigations, including chemical and biological sampling, are costly and wasteful of resources. *Random sampling*, although a valid statistical exercise, can only provide answers based on the whole population of water catchments. We may end up with a lot of information about the 'average catchment', which is of little use when answering specific questions. *Selective sampling* is an option frequently chosen, basing the selection upon 'expert choice or judgements'. Such samples are difficult to relate to the wider population, are open to criticisms of judgement, and may overlook important factors or relevant catchments. A *stratified sampling* approach is the only really effective way to answer the problem. This method creates a series of catchment 'strata', analogous to the social strata which have been employed so effectively for opinion polls and in consumer research. By this means, individual groups or strata can be assessed, either totally or by subsampling, without the need to sample the whole population in detail; however, any catchments assessed are done so in the context of a defined framework of catchment strata and environment parameters.

2 The classification

The methods have been developed from those used extensively by ITE for land use surveys, in Cumbria (Bunce & Smith 1978), Scotland (Bunce & Last 1981) and Great Britain (Bunce & Heal 1984).

The classification so far has focused upon nearly 90 river catchments which have been, or are being, sampled by the North West Water Authority as part of its investigations into the effects of acid precipitation on fresh waters (Crawshaw 1984; Prigg 1983). Although these catchments had the disadvantage that they had been chosen selectively, the availability of chemical and biological data was an important factor for this initial investigation.

The data base for the classification was confined to maps which give uniform coverage throughout England and Wales. Ordnance Survey maps (1:25 000) provided most of the topographic information, and British Geological Survey solid geology maps (1:250 000) and Soil Survey of England and Wales soil maps (1:250 000) were used for catchment geologies and soils. Meteorological Office rainfall maps provided rainfall data.

Our data base yielded a total of 105 descriptive attributes for our catchments. These attributes were assigned to each catchment in turn, and the resulting sets subjected to Indicator Species Analysis (ISA) (Hill *et al.* 1975). Further computations using Reciprocal Averaging Analysis (Hill 1973) gave additional information for comparison with the ISA results,and have been used to help verify ISA results in previous studies (Jones & Bunce 1985; Charter 1984).

The available chemical and biological data were used to verify the ISA classification, and the chemical data were also used as the basis for a separate ISA classification, both on their own, and also together with the other 105 attributes.

3 Catchments in Eskdale and Dunnerdale

The Rivers Esk and Duddon have been studied extensively in recent years owing to the concern over poor fish stocks and occasional fish kills (Crawshaw 1985). Chemical and biological information exists for 40 tributaries which drain about 70% of the total catchments of the 2 rivers. These tributaries formed the data set for our first ISA.

The ISA divided the catchments into 2 sets on the basis of 'upland' and 'lowland' character. Although apparently an obvious separation in hindsight, it has been achieved without subjective judgements, and it is particularly important as it reflects the chemical and biological differences of the 2 stream types. For example, all 10 tributaries with low mean Ca concentration (<2 mg l^{-1}) are found in the 'upland' catchments; and, whilst 75% of 'lowland' catchments have stone fly larvae present, only 12.5% of the 'upland' ones have records of this species.

An important observation from the analysis is the difference in character between the Esk and Duddon tributaries: there are more Esk tributaries in the 'lowland' class, whilst Esk streams are greatly outnumbered in the 'upland' class.

4 Other catchments in north-west England

Extending the model further to include catchments outside the Esk and Duddon gives a different ISA separation. The initial separation is one of size, and it is clear that most Esk and Duddon tributaries drain 'small' catchments, in contrast to the streams sampled outside Eskdale and Dunnerdale, which are mainly 'large' catchments. The subsequent classification of the 'small' catchments is similar to the 'upland'/'lowland' separation described above, most of the Esk and Duddon tributaries being distributed between the 2 classes, as before.

Chemical and biological data indicate that 'large' catchment streams are generally similar to 'lowland' streams. It is not surprising, therefore, that the ISA classification of chemical data separates 'small upland' catchments from the rest, with low Ca and alkalinity levels and high acidities and aluminium concentrations. Combining chemical and physical attributes adds little to the main divisions of the analysis.

Further extending the model to include an additional 15 catchments, many of them with different geologies from the southern Pennines, resulted in a separate geological class in the large catchment group consisting almost entirely of the new catchments. This geological feature, sedimentary bedrock, in contrast to the mainly igneous geology of the previous 72 catchments, is therefore a 'strong' indicator in the analysis. It is also likely to be an important factor in the chemistry and biology of the streams draining these catchments.

5 Discussion

Our main aim in this work was to combine the practical usefulness of water catchments with the proven analytical models previously used for land classification studies.

The divisions often appear obvious and predictable but they have been derived without subjective judgements. Furthermore, whilst it is easy to recognize extremes within any set, individuals form a continuum across the range so that intermediate types are not easily characterized. A small set of catchments may provide a simple classification model, with little need for a computer, but larger data sets, with their widely differing characteristics, increase the necessity for a good computer model.

We believe that models such as ours have great potential for future applications in assessing current resources and in the subsequent planning and monitoring of change. Our models, to date, are relatively simple with few catchments from a very large population, but the model is flexible, and more catchments may be added, as we have done, or additional data bases used to include additional attributes. Conversely, particular data sets may be selected for separate analysis to answer specific questions.

The ISA classification has the advantage of identifying important attributes, which may be used to classify individual catchments not included in the analysis, and may provide pointers for future investigations. Once the classification framework has been identified, it is much easier to attempt comparisons between catchments (eg 'twinning') or to identify changes with time. Differences and changes can also be seen within the context of the entire model and related to the population being studied.

An important aspect of classification models is their sensitivity to changes in attributes. We know that increasing the range of catchments changes the classification, and our analysis shows that our model is sensitive to sedimentary geology. We also know that some attributes may be omitted with little effect on the classification. The opportunity for such alterations in the classifications may have great importance for planners, and provides a predictive capability which may be a valuable decision-making tool.

The great advantage of our method is that, once set up, the model can be used and amended without the need for a great deal of expert support. It can thus provide a convenient resource base for those needing to quantify the environmental description of water catchments in space and time.

6 References

Bunce, R.G.H. & Heal, O.W. 1984. Landscape evaluation and the impact of changing land-use on the rural environment: the problem and an approach. In: *Planning and ecology*, edited by R.D. Roberts & T.M. Roberts, 154-188. London: Chapman & Hall.

Bunce, R.G.H. & Last, F.T. 1981. How to characterize the habitats of Scotland. *Annu. Rep. Edinburgh Cent. Rural Econ. 1980/81*, 1-14.

Bunce, R.G.H. & Smith,R. S. 1978. *An ecological survey of Cumbria.* Kendal: Cumbria County Council and Lake District Special Planning Board.

Charter, E. 1984. *A survey, classification and evaluation of small open waters in Cumbria.* MSc thesis, University College, London.

Crawshaw, D.H. 1984. *The effect of acid run off on the chemistry of streams in Cumbria.* (Report no. TSN 84/ 3.) Warrington: North West Water Authority.

Hill, M.O. 1973. Reciprocal averaging: an eigenvector method of ordination. *J. Ecol.*, **61**, 237-249.

Hill, M.O., Bunce, R.G.H. & Shaw, M.W. 1975. Indicator species analysis, a divisive polythetic method of classification, and its application to a survey of native pinewoods in Scotland. *J. Ecol.*, **63**, 597-614.

Jones, H.E. & Bunce, R.G.H. 1985. A preliminary classification of the climate of Europe from temperature and precipitation records. *J. environ. Manage.*, **20**, 17-29.

Prigg, R.F. 1983. *Juvenile salmonid populations and biological quality of upland streams in Cumbria with particular reference to low pH effects.* (Report no. BN 77-2-83.) Carlisle: North West Water Authority.

A land resource information system at the 1:25 000 scale

D A DAVIDSON* and G E JONES†
*Department of Environmental Science, University of Stirling, Stirling
†Department of Geography, University of Strathclyde, Strathclyde

1 Introduction

The aim of any information system is the provision of data in the most effective manner relevant to the needs of users. The emphasis in recent years has been on the technical development of such systems, and a range of approaches are in use, as reviewed by Professor Burrough at this conference. In Scotland, a Standing Committee on Rural Land Use Information Systems (RLUIS) was established in 1976 with the aim of examining information availability, user requirements and the scope for computer-based systems (Scottish Development Department 1980). One important result has been the trial project in Fife. As demonstrated in other papers from this conference, the Planning Department of Highland Regional Council has adopted the Institute of Terrestrial Ecology's system of land classification (Highland Regional Council 1985a). The system is the allocation of individual kilometre squares to land classes on the basis of climatic, geological, locational, topographic and artefactual information. The result is an impressive data base which provides a broad inventory of land resources within the region. The system has recently been used as a means of predicting the extent of amenity woodland (Highland Regional Council 1985b). The approach is highly suited to such a large and diverse area as Highland Region. When planning concerns much smaller areas, data on the one km square base are too generalized, and more detailed approaches become necessary. Such a situation arose with the project reported in this paper.

2 The land resource information system (LRIS)

The Campsie Fells form part of a broader set of volcanic hills extending from the Renfrew Heights south-west of Glasgow to the Sidlaw Hills north of the Tay. An *ad hoc* inter-regional group is concerned with land use in the Campsies, with representatives drawn from various bodies (eg planning departments, Forestry Commission, Department of Agriculture, and water authorities). The existence of such a group is a reflection of the land use pressures which are present on the Campsies. Proximity to the Glasgow and Edinburgh conurbations is expressed in demands for water and recreation. Furthermore, some of the land on the north-east margins in the study area is of very good agricultural quality. Extension of forestry is another critical issue in this area. Thus, the Campsies offered a very suitable locality for the development of a detailed land resource information system designed to aid land use planning.

Priority was given to developing a land resource information system which could store, process and present information in a detailed yet simple form. All the programs were developed by the investigators, as this gave them complete control of the system as it evolved. The ultimate programs for individual maps only required 50 lines of FORTRAN, with a further 50 lines for the legend. In many ways, the design of the legends proved more difficult than the mapping programs! An analytical scale of 1:25 000 was selected as the most relevant to the planning issues. Much effort was devoted to the compilation of a data base which was assembled from all available published sources. Data extraction on a 100 m grid seemed a suitable compromise between an ideal resolution and a realistic data base which could be assembled within 2 months. Following discussions with 2 planners, it was decided to select a transect of land (14 km x 5 km), to the west of Stirling on the Forth valley and extending from the flat carselands up and over the spectacular crags formed on the lava flows of the Gargunnock Hills to the upland Touchadam and Cringate Muirs. The Carron Reservoir formed the southern limit (Figure 1).

The study area was deliberately selected to encompass a wide range of topographic, climatic and soil conditions. The most northern part consists of the carselands formed during the Flandrian transgression by the estuarine depositions of silts and clays. Much of the peat which subsequently developed on these sediments has been removed by human activity, and the present-day soil is a poorly drained gleyed warp. The lower slopes fringing the carseland have brown forest soils developed on till dominated by Old Red Sandstone sediments. As elevation increases towards the crags on the lavas, drainage conditions deteriorate, resulting in a dominance of gleys. The parent material contains higher proportions of Carboniferous igneous rocks. The upland moors rising to 485 m have organic soils, whilst the area to the immediate north of the Carron Reservoir has a more varied range of soils from gleys to brown forest soils developed on a till consisting of lavas, tuffs and ashes. Within the study area, elevation ranges from 15 m on the carseland to 485 m at Carleatheran. Such an elevation amplitude is paralleled by a precipitation gradient from a mean annual rainfall of 1100—1200 mm on the carseland to over 1600 mm on the summit areas.

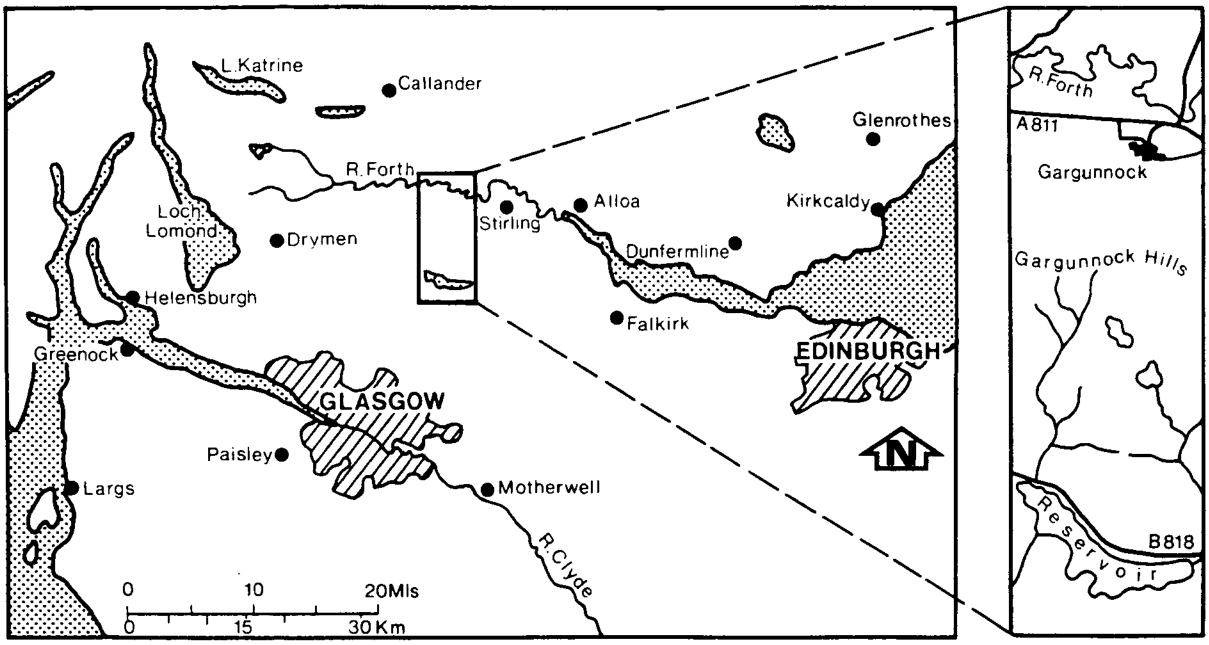


Figure 1. Location and topography of the study area in central Scotland

The 100 m grid resulted in 7300 cells, and data were extracted on the following attributes:

Grid reference

Elevation

Slope

Slope aspect

Presence/absence within each cell of:

- Streams
- Rock outcrops
- Marsh
- Roads
- Tracks
- Buildings

Solid geology

Drift geology

Soils (from Soil Survey 1:25 000 field sheets)

Land capability class

Vegetation

Land types (from aerial photo interpretation)

Tree species (for Forestry Commission land)

Yield class (for Forestry Commission land)

Exposure value (for Forestry Commission land)

Extraction of these data proved to be straightforward, albeit tedious. Data files were created on the University of Strathclyde's DECVAX system. The inevitable problem of varying data quality arose with the broad range of map sources. The first part of the project has given particular emphasis to presenting the topographic and soil data. Fortunately, recently published 1:10 000 Ordnance Survey maps were available for the former and, for the latter, the Department of Soil Survey at the Macaulay Institute for Soil Research kindly gave access to the 1:25 000 field sheets of the original soil surveyors. The legend for a conventional soil map usually gives information on soil type, parent material and drainage class. In practice, more specific details may be required about stone content, soil depth, or nutrient status. Maps predicting the distribution of such properties are only possible if access is obtained to field and laboratory data from the original soil survey. By courtesy of the Departments of Soil Survey and Mineral Soils at Macaulay, such data were obtained for 92 sites in the general Stirling area, 18 of these being within the actual study locality. Full field and laboratory data for 92 sites constitute a sizeable data bank, and use was made of a data base management system (Davidson & Jones 1985). The task was to be able to categorize soil series according to a wide range of physical and chemical properties. When records were sufficiently consistent and numerous, soils were categorized according to general pH values, depth of organic horizons, organic matter content of A horizon, exchangeable bases, percentage base saturation, soluble phosphate content of A horizon, sand content, silt content, stoniness and maximum rooting depth. Predictions about these soil properties can be viewed as an expansion to the soil map legend. The underlying and critical assumption is that the soil series are comparatively homogeneous in terms of these properties.

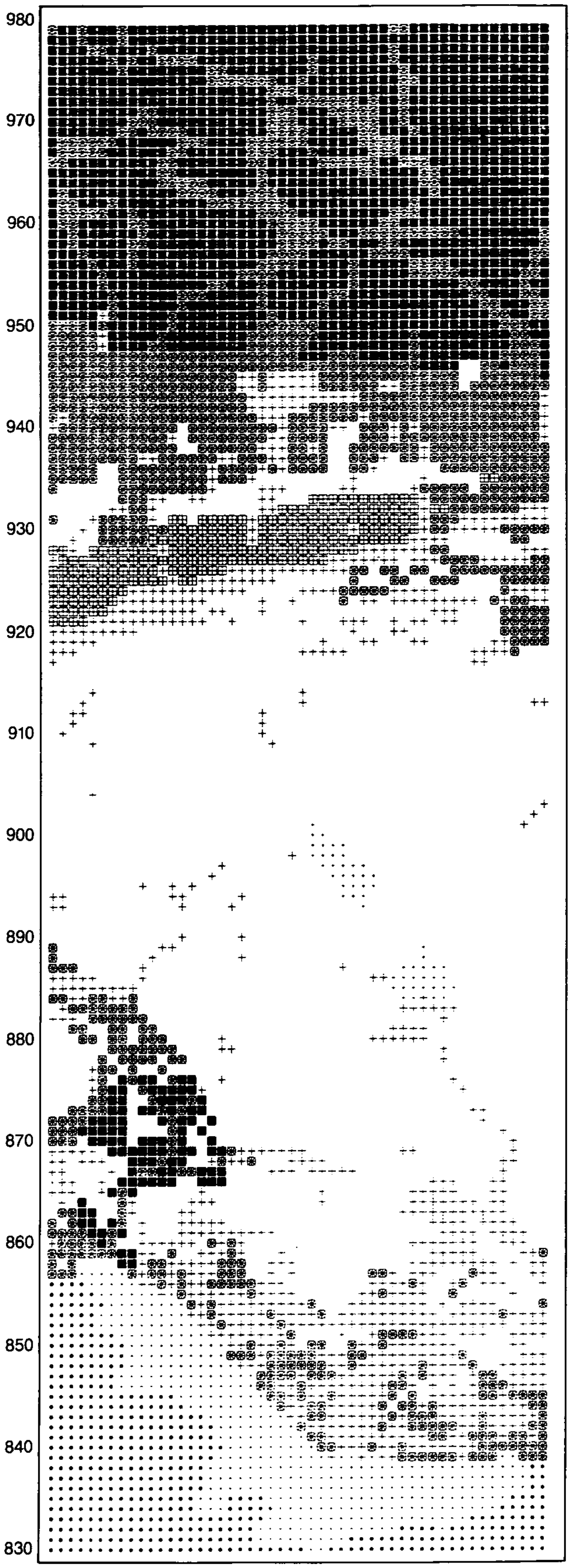


Figure 2. The distribution of percentage base saturation derived from Soil Survey data in the 100 m x 100 m grid cells of the study area

3 Mapping

As already stated, emphasis was given to developing short programs specific to the needs of the project. At the end of the first phase, programs for 30 different maps had been devised. These maps were produced on a high-quality CALCOMP plotter using GINO symbols. The maps can be grouped into the following categories.

3.1 Single-factor maps showing variation in specific variables as extracted from original data sources

These maps were the simplest to produce and consisted of plots using selected information on the main data file. They show distributions of slope classes, aspect, elevation, land use capability class and subclass, land type and vegetation.

3.2 Single-factor maps based on surrogate variables

Data on mean annual rainfall and temperature were obtained from meteorological stations, either in or adjacent to the study area. Regression analysis established strong relationships between elevation and these variables, and the regression equations were used to predict rainfall and temperature for each cell. Thus, maps of mean annual rainfall and temperature were produced.

3.3 Single-factor maps using Soil Survey data

3.3.1 *Use of soil map legend*

Information on the soil map legend is given about the major soil group, parent material types and drainage class for each soil mapping unit. It was a simple task to categorize soil series according to these 3 factors and to generate maps.

3.3.2 *Use of Soil Survey field and analytical data*

As already indicated, the use of a data base management program permitted the categorization of soil series according to a wider range of field- and laboratory-measured properties. For many soil series, the field and laboratory data base was insufficient for valid generalizations to be made, and the ultimate maps indicated those cells for which no classification was possible. This problem was encountered with a substantial number of the soil series, but in practice they were found to be of limited spatial extent. Figures 2 and 3 demonstr-

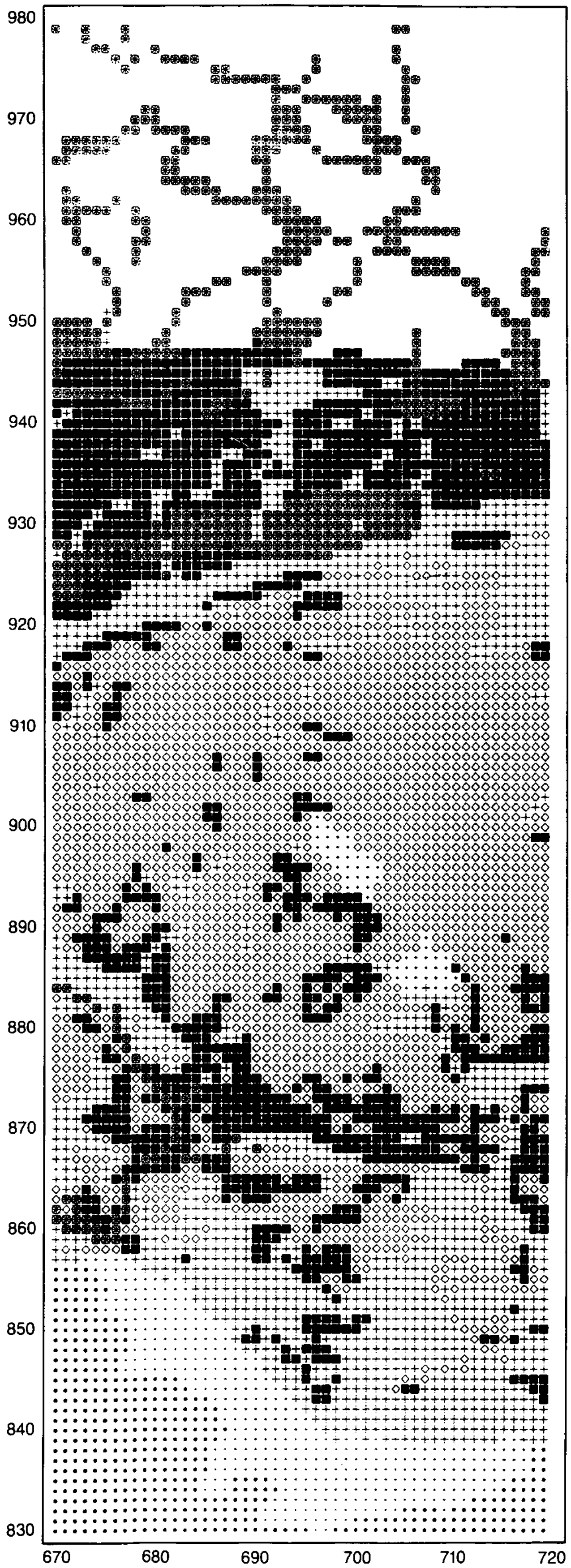


Figure 3. The distribution of sand content derived from Soil Survey data in the 100 m x 100 m grid cells of the study area

ate examples of single-factor maps using Soil Survey data.

3.4 Land evaluation maps

The potential of the land resource information system is best demonstrated by land evaluation maps which are of particular interest to planners. In practice, it is the combination of factors which determines the suitability of an area for a specific use. Thus, the production of land evaluation maps first necessitates the selection of relevant factors and then combinations of these variables in order to express overall land suitability. The process can be demonstrated by the classification of 'good agricultural land' which had to meet the following stringent requirements (definition 1):

Elevation:	150 m
Slope:	<3° degrees
Soil drainage:	free or imperfect
Maximum rooting depth:	usually >40 cm

Figure 4i illustrates the results for the area round the village of Gargunnock, where a few cells near to the village meet the requirements. The carseland is mapped as 'unique land' because this terrain type is of distinctive agricultural value. Figure 4ii demonstrates the results from a less stringent definition of 'good agricultural land'. In this case, the following conditions had to be met (definition 2):

Elevation:	300 m
Slope:	<11°
Soil drainage:	free or imperfect

The resultant distribution is more extensive. The ability to vary land suitabilty definitions and compare the results is a distinct advantage of the system.

The suitability of land for forestry is another issue of planning concern, and 2 methods were developed. The first was the simpler and was based on aerial photo-interpretation. It was noted that most of the existing forests managed by the Forestry Commission occurred on land type 6 (upland area, smooth slopes, no evidence of rock being at or near the

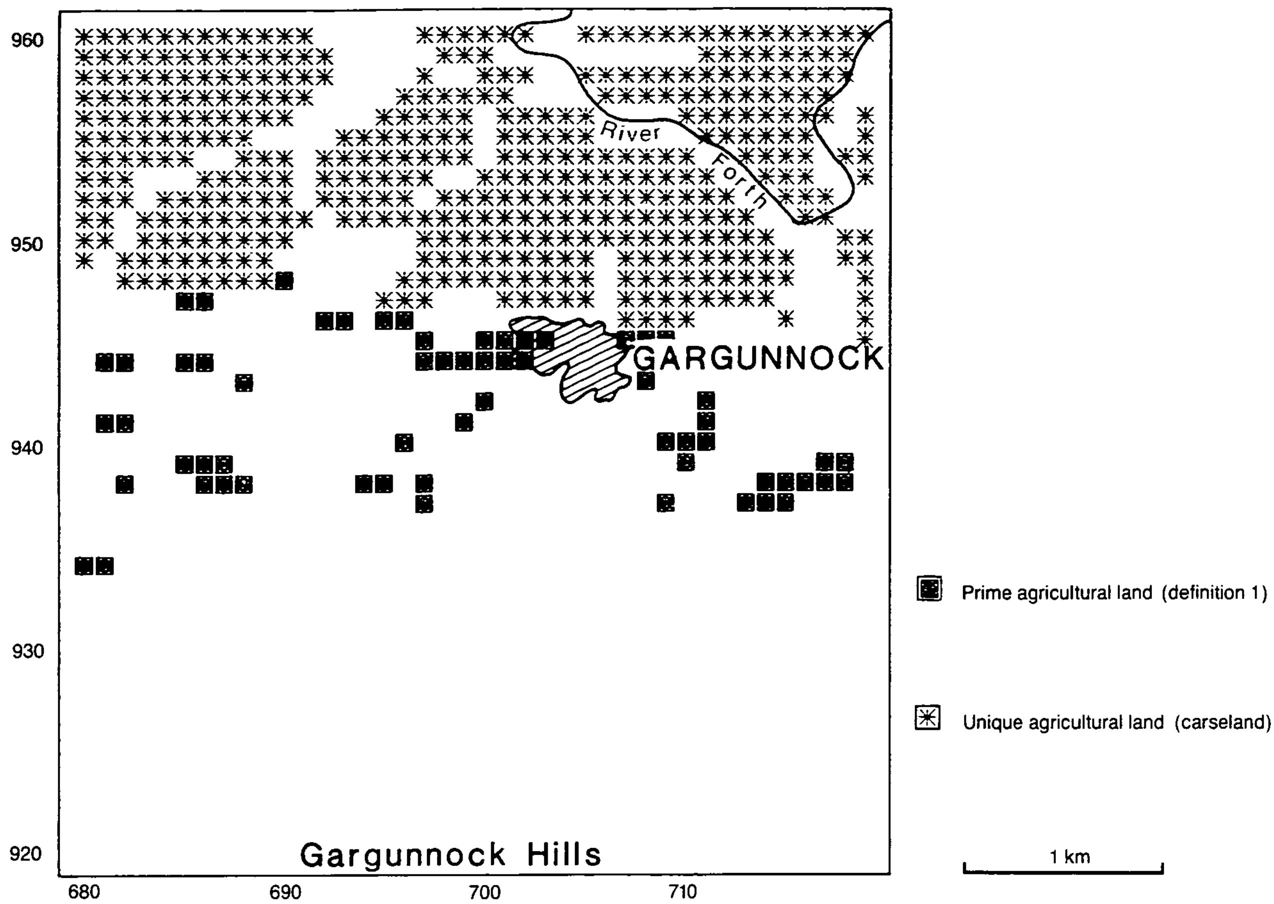


Figure 4i. The distribution of 2 types of agricultural land in the 100 m x 100 m grid cells in the vicinity of the village of Gargunnock

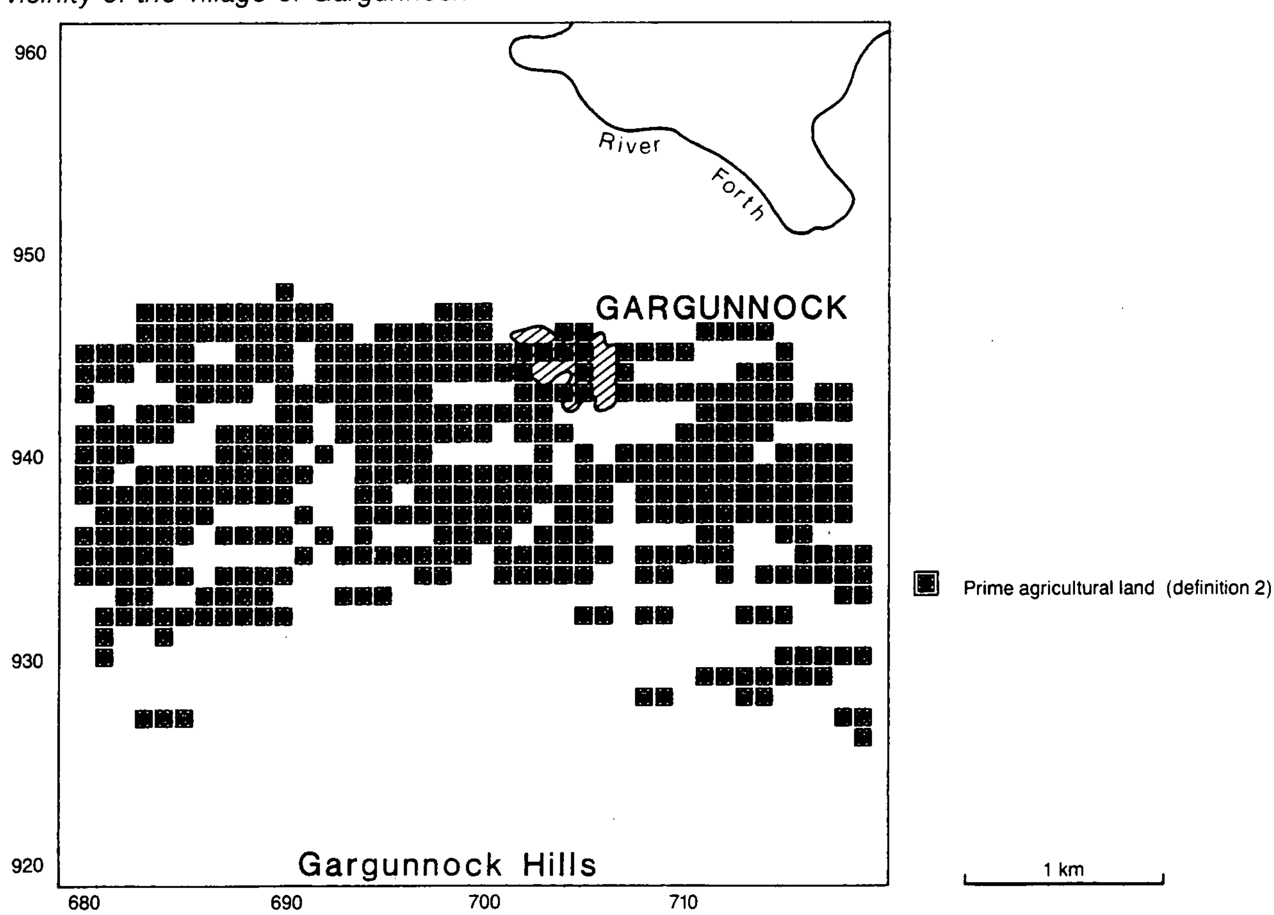


Figure 4ii. The distribution of prime agricultural land in the 100 m x 100 m grid cells using a more general definition, in the vicinity of the village of Gargunnock

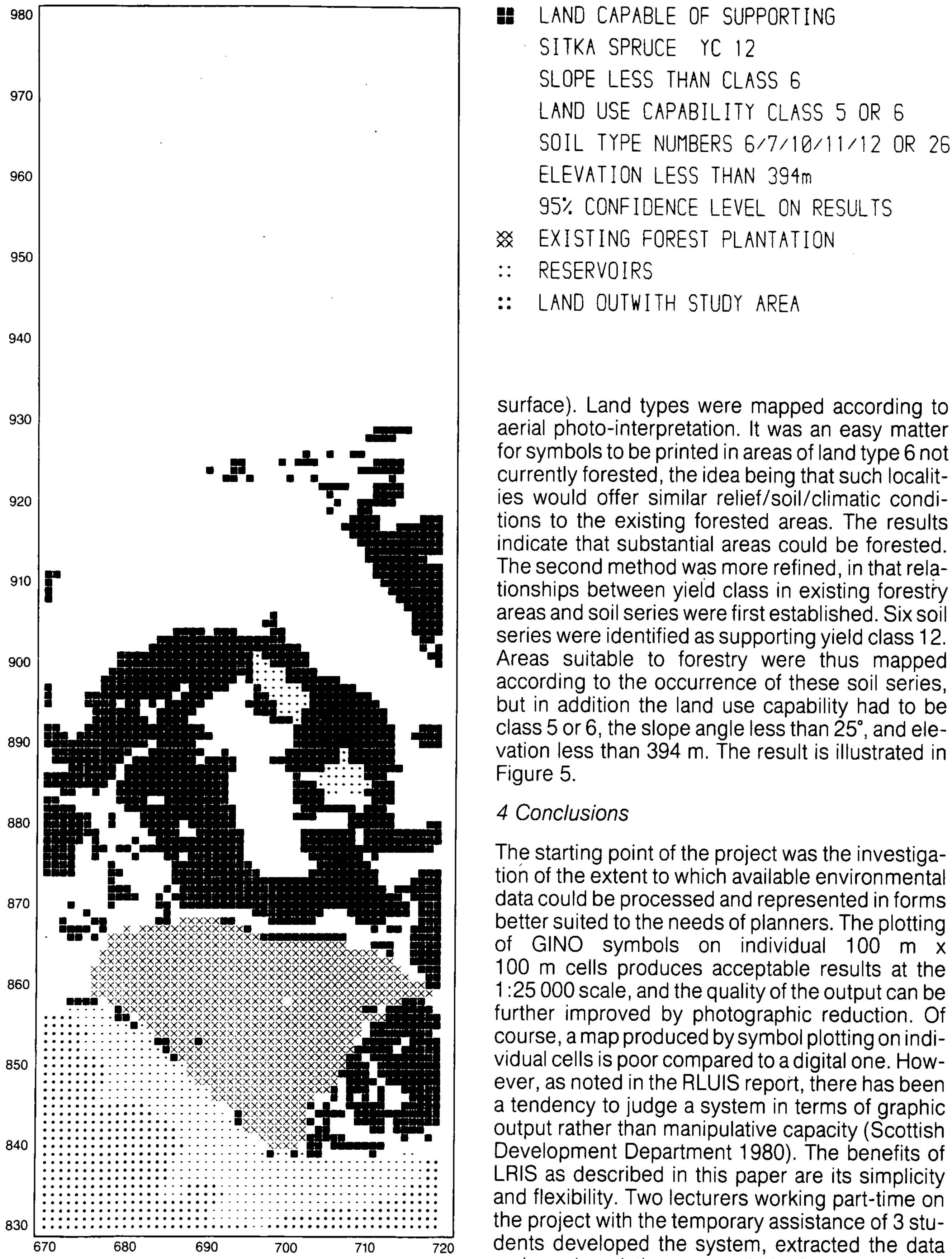


Figure 5. The distribution of potential forestry in the 100 m x 100 m grid cells of the study area

surface). Land types were mapped according to aerial photo-interpretation. It was an easy matter for symbols to be printed in areas of land type 6 not currently forested, the idea being that such localities would offer similar relief/soil/climatic conditions to the existing forested areas. The results indicate that substantial areas could be forested. The second method was more refined, in that relationships between yield class in existing forestry areas and soil series were first established. Six soil series were identified as supporting yield class 12. Areas suitable to forestry were thus mapped according to the occurrence of these soil series, but in addition the land use capability had to be class 5 or 6, the slope angle less than 25°, and elevation less than 394 m. The result is illustrated in Figure 5.

4 Conclusions

The starting point of the project was the investigation of the extent to which available environmental data could be processed and represented in forms better suited to the needs of planners. The plotting of GINO symbols on individual 100 m x 100 m cells produces acceptable results at the 1:25 000 scale, and the quality of the output can be further improved by photographic reduction. Of course, a map produced by symbol plotting on individual cells is poor compared to a digital one. However, as noted in the RLUIS report, there has been a tendency to judge a system in terms of graphic output rather than manipulative capacity (Scottish Development Department 1980). The benefits of LRIS as described in this paper are its simplicity and flexibility. Two lecturers working part-time on the project with the temporary assistance of 3 students developed the system, extracted the data and produced the maps within 6 months. Data extraction and input were the most laborious tasks, and potential exists for the input of data in digital form. Furthermore, current effort is being directed to the inclusion of LANDSAT data for the mapping of vegetation/land use, as well as for the identification of poor drainage conditions.

Despite such possibilities, the ultimate success of the system will depend on the extent to which planners find it of use in their formulation of policy.

5 Acknowledgements

The authors thank the Planning Department of Central Region and Ms Louise Livingstone in particular for assistance with the project. Soil data were kindly made available by the Departments of Soil Survey and Mineral Soils of the Macaulay Institute for Soil Research. Mr John Bibby offered useful advice on the study.

6 References

Davidson, D. A. & Jones, G. E. 1985. The use of a data base management system for the analysis of soil survey records. *Soil Surv. Land Eval.*, **5,** 88-92.

Highland Regional Council. 1985a. *HRC/ITE land classification system.* (Information Paper no. 5.) Inverness: HRC Planning Department.

Highland Regional Council. 1985b. *Amenity woodland survey.* (Information Paper no. 7.) Inverness: HRC Planning Department.

Scottish Development Department. 1980. *Rural land use information systems: report on a pilot project in Scotland.* Edinburgh: SDD Central Research Unit.

Relational data bases and digital mapping — a flexible approach to information management and display

R G HEALEY, B A MORRIS, A J ALEXANDER, D J BARTLETT and T C WAUGH
Department of Geography, University of Edinburgh, Edinburgh

1 Introduction

By its very nature, the planning process requires the timely collection and analysis of a range of different data sources, so decision-making can proceed on an informed basis. Recent developments in computer hardware and software technology have created a range of opportunities for improvements in the management of planning data, particularly in terms of making powerful analytical tools available directly to the end-user of the information. Although the advent of microcomputers has provided the initial stimulus for these developments, it is the availability of appropriate software which is most important in building a new generation of flexible planning information management systems.

This paper examines some of the basic requirements for such systems and indicates suitable software which allows them to be implemented rapidly in a cost-effective manner. Possible areas of application are then suggested, illustrated by a range of different example systems which have been developed in the Department of Geography, University of Edinburgh.

2 Software requirements for a computerized rural information management system

A number of major requirements for the necessary software can be identified, as follows.

i. The system must allow data to be keyed in and updated, if necessary, in interactive, as well as batch, mode.

ii. It must be possible for the system to perform sophisticated validation and checking of the data on input, to provide a high level of quality control for stored information.

iii. It must be possible to cross-link between different data sets, which may have been created by several individuals or organizations. The manner in which these linkages are made must be flexible to allow problem-solving based on multiple data sources.

iv. The system should not be restricted to the storage of numerical information (eg census data), but should also include descriptions of available data sets in the form of a data dictionary, as well as other relevant information, including bibliographic sources.

v. In the context of rural planning, it is most important that the system allows *ad hoc* queries to be made from available data and that, where appropriate, the results of these queries can be displayed automatically in map form.

vi. The query facility should also permit spatial searching to be undertaken.

3 Meeting the requirements

3.1 Software for data storage and retrieval

In nearly all cases, the basic data storage and retrieval requirements for rural information systems can be met by existing data base management technology. A large number of general-purpose systems of this kind are now available, and the better packages allow even large and relatively complex data bases to be implemented quickly and efficiently. Any new information system should, therefore, be based on a software package of this kind if it is to be operated in a cost-effective manner.

Formerly, hierarchical or network-structured data bases (Date 1981) were the preferred type of system for large data handling operations, because of their superior performance in terms of data retrieval speed. More recently, however, the newer relational data bases have come to assume major importance, as their performance has begun to approach that of the older systems.

The particular advantages of relational data bases are 2-fold. First, all data are stored in a simple structural form and, second, it is easy to link different data sets for flexible retrieval purposes. These advantages arise because all data are held in the form of tables containing rows and columns. If 2 or more tables each have a column of data, some or all of whose values match between the tables, the software enables linkages, called relational joins, to be made using these columns, when required by *ad hoc* queries to the data base.

The combination of simplicity and flexibility of relational data base systems makes them accessible as data management tools for the end-user, who can establish his own data base applications of a straightforward kind, without having to call on assistance from specialists, as is the case with other types of system. Further, queries can be easily made to the data base, because there are no complex sets of fixed pointers to navigate between items of data. Finally, the tabular structure of a relational data base makes it amenable to the provision of 'front end' screen handling software, which enables data to be entered from the terminal into one or more tables simultaneously. On-line validation of information can be performed by checking data entered into fields on the screen against look-up tables containing lists of allowable values. Major proprietary relational data base packages, such as ORACLE, INGRES and MIMER, all provide facilities of this kind, as do systems developed originally for micros, such as KNOWLEDGEMAN, DBASE II and INFORMIX, albeit to a more limited degree.

A good example of the usefulness of the relational data base approach can be provided in connection with the integration of data about different sources of planning-related information. Two such sources are maps and aerial photographs, and it is frequently useful to know whether specific areas have both types of coverage or not. In its most basic form, a relational data base solution to the problem would contain 2 tables, one for each of the major data sets. Each row of the map table might contain information about individual map sheets, such as sheet number, sheet name, and the co-ordinates of the 4 corners of the sheet. In the aerial photograph table, appropriate information about each photograph would be held, including the date of the print, scale, and the co-ordinates of the centre point of the photograph. In addition, however, it is necessary to enter the sheet number of the map, perhaps at 1:50 000 or 1:10 000 scale, which covers the location where the photograph was taken. Subsequently, when a query is made, it may take the form of a window search on the geographical co-ordinates in the map table, to determine which sheets fall within the specified area. At the same time, a relational join may be performed, to link map and air photograph tables on the basis of the sheet number column that they have in common. For all maps meeting the initial window search criterion, the system will then match the resulting sheet numbers to the photograph table, to obtain information on the prints which fall within the boundaries of the sheets in question.

3.2 Software for digital mapping from relational data bases

While the use of relational data base technology provides powerful data manipulation and retrieval facilities, this advantage, of itself, is not sufficient to realize the full potential of the information system where problem-solving in a spatial context is required. It is necessary to provide an interface from the data base to digital mapping software. As with the data base system, it is sensible to employ a readily available software package, such as GIMMS, which is widely used in the UK. The interface should then provide a flexible linkage between the 2 systems, with all the power of each available to the end-user.

Two approaches to the interfacing problem can be identified, depending on the final requirements. In the first case, relatively high-quality map output is required for final presentation of results, necessitating a degree of design intervention by the digital cartographer during the data analysis phase. Under these circumstances, a loose coupling between the data base and mapping packages is required, as full automation of the linkage would hinder the map design process. This situation may change in future as the current prototypes of expert systems for map design become more sophisticated. Nevertheless, even with user intervention during the analysis phase, a very high degree of productivity can be achieved by careful interfacing work.

An example of this interfacing can be provided by the 1983 agricultural census of Belize, in central America, undertaken jointly by the Government of Belize and the Department of Geography, University of Edinburgh. Data for 87 variables for each of over 500 villages were collected, subjected to preliminary processing and then stored in an ORACLE data base table. At the same time, digital outlines in GIMMS format were prepared for the census enumeration zones used by the Belize Government. Each of these zones contains a number of villages. Data base query language macros were written to aggregate the village data for nominated variables into zonal values, omitting zones where no data were reported, and to write the information to GIMMS data files in the correct order for mapping. By editing standard sets of GIMMS commands and linking them to the appropriate files, it was possible to introduce a significant design element for each map, while still allowing rapid generation of the final product. In this way, once the method of interfacing was established, it proved possible to produce the basis for an agricultural census atlas in 2—3 weeks. Two examples of the standard of the final product are shown in Figures 1 and 2. Once plotted, each map can, of course, be modified very quickly to change class intervals, types of shading or symbolism, and pen colours, to match the requirements for publication.

This approach is expected to be particularly useful in the near future, when the very extensive 1985 Belizean Agricultural Census is completed with the help of the Food and Agriculture Organisation, providing data on over 300 variables for every farm holding in the country. As soon as the data are loaded into the data base, the mapping framework which now exists can be used to generate a very wide range of maps immediately. Further developments are also in progress to accelerate the design intervention work, by providing a front-end program that indicates the design choices at each stage and generates the appropriate GIMMS commands automatically.

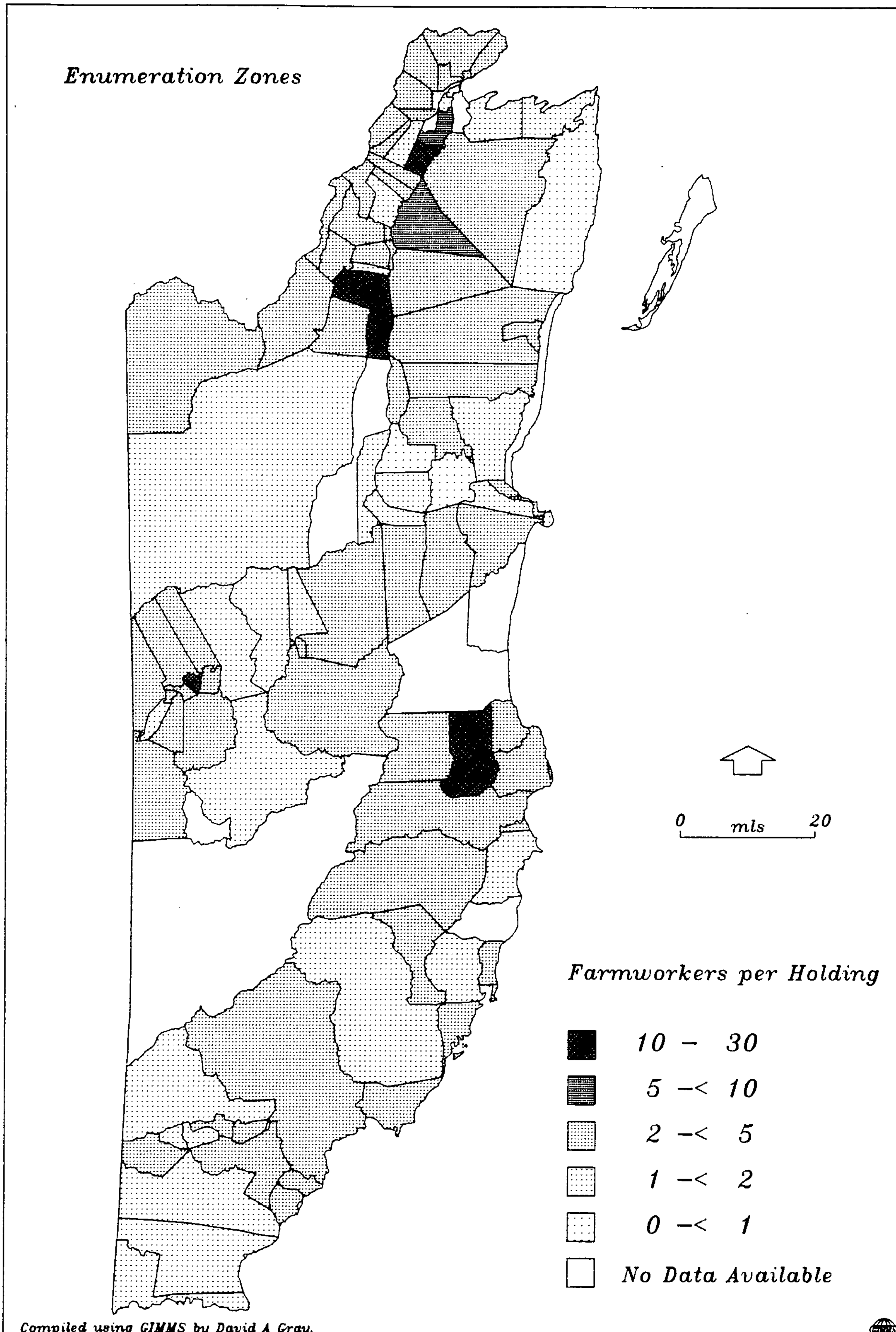


Figure 1. Belize: farm workers per holding

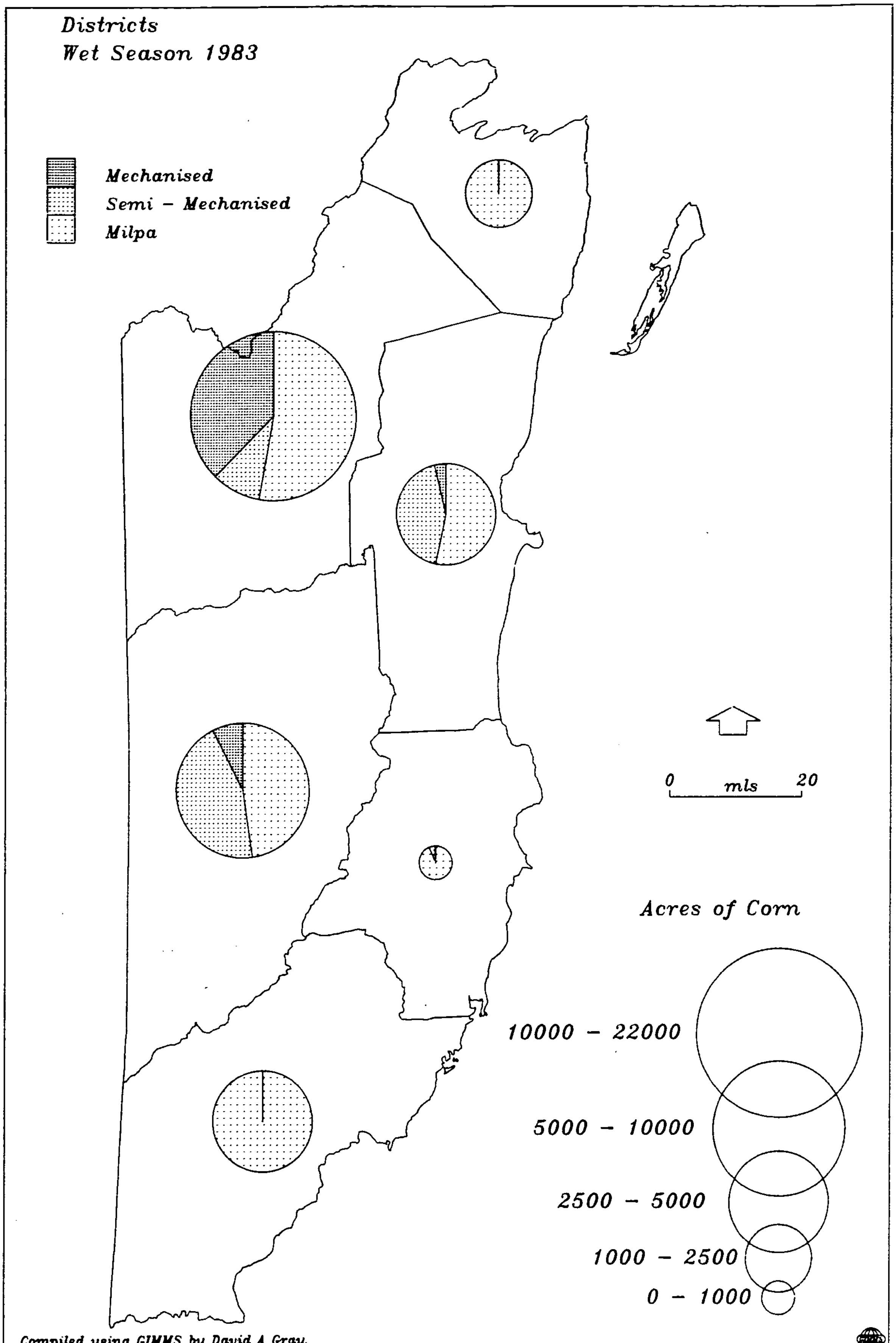


Figure 2. Belize: corn — volume and method of production

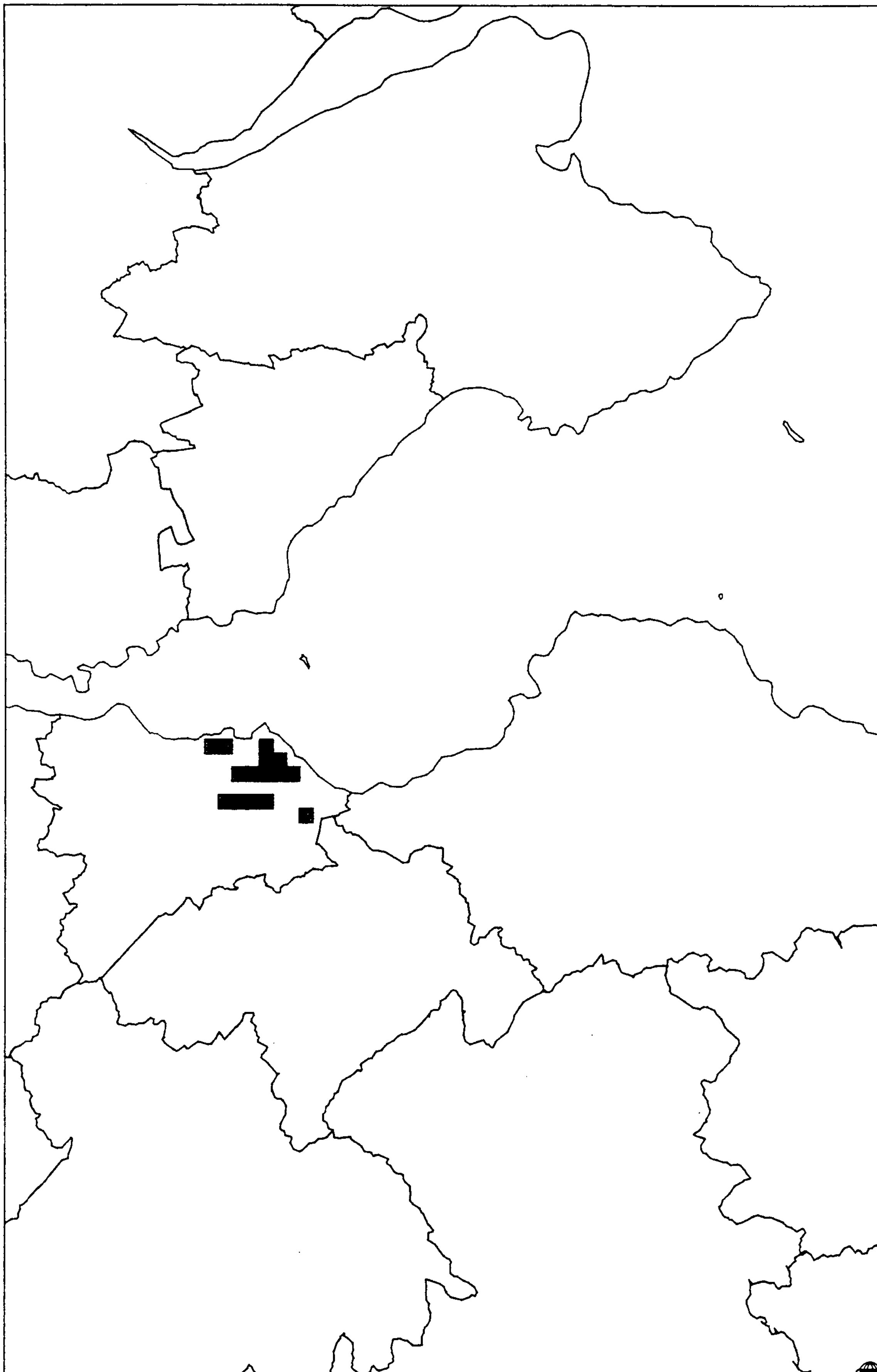


Figure 3. Scotland: one km grid squares with more than 8000 population, 1971 census

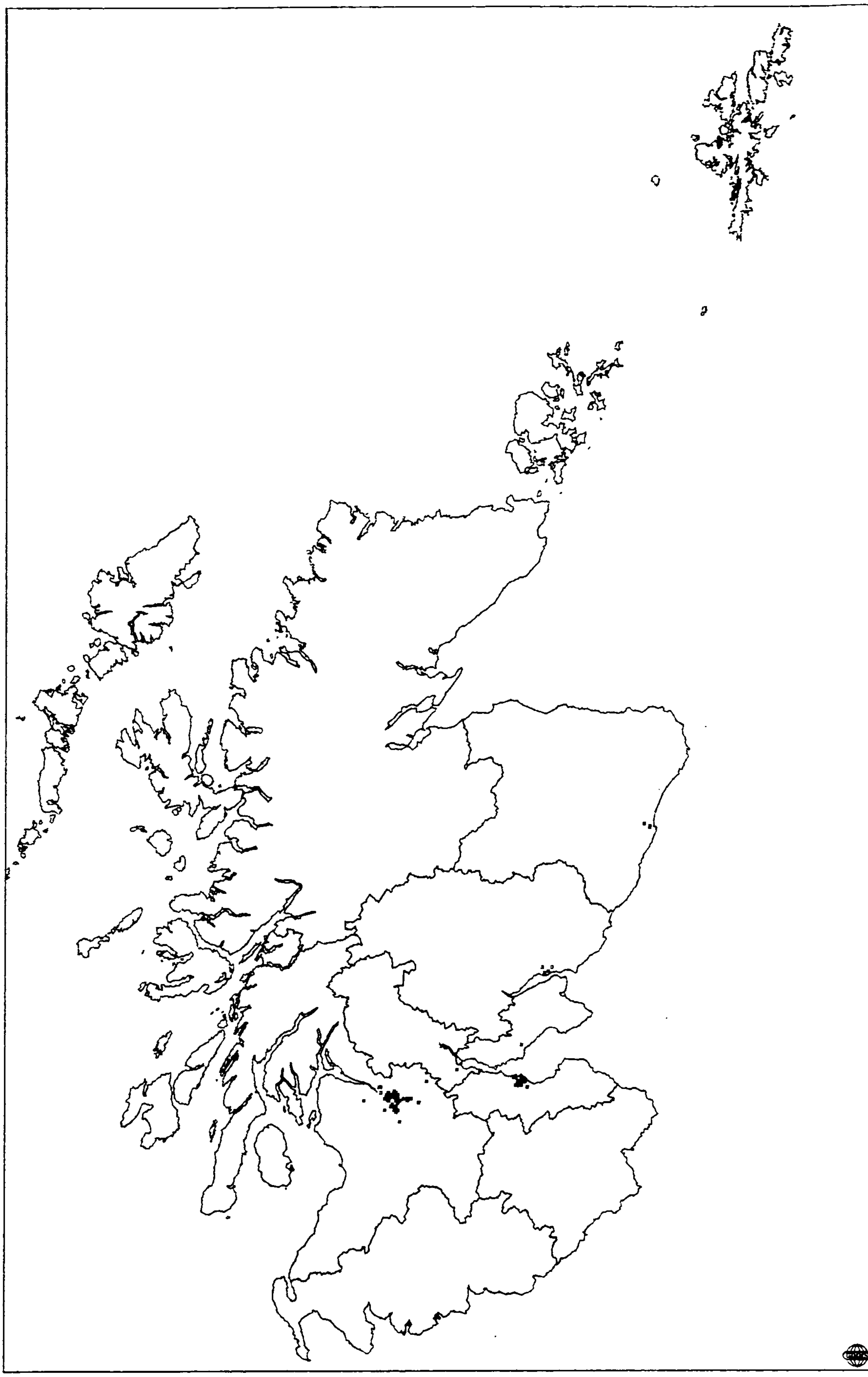


Figure 4. Window search on census data base — all one km grid squares with more than 8000 population along the southern shore of the Firth of Forth, 1971 census

The second approach to the interfacing problem becomes necessary when large volumes of data have to be manipulated in an exploratory fashion, to provide basic map output in a standard form. Because the map design element is minimal, this type of interface should be as automated as possible, for maximum speed and ease of use. To this end, one of the authors has developed an interfacing software tool called GEOLINK, which is currently implemented in the ADA language. It allows data returned in response to data base queries to be linked automatically with standard sets of GIMMS commands, for rapid data analysis and display. The system currently works for all applications requiring the plotting of standard symbols of various kinds on digital base maps. It has proved particularly effective for problems such as the generation of selective graphic indices from computerized map catalogues (Morris 1984; Morris *et al.* 1986).

In the rural planning context, one specific implementation of this approach to interfacing is of particular interest, ie the GRIDPLOT program, which makes use of the GEOLINK software. GRIDPLOT, as its name implies, is designed for mapping grid-based data, and it is currently used for exploratory mapping of the one km grid population census of Scotland for 1971 and 1981. The census data base contains approximately 28 000 rows of data for 1971, and a smaller number for 1981 because of a change in the definition of a populated square! One example of the use of the program is shown in Figure 3, which displays all of the one km squares in Scotland with a population over 8000 in 1971. The user has a choice of base map, depending on whether region or district boundaries are required, as well as a choice of scales for plotting.

The basic program also permits a considerable degree of spatial searching. In the first place, the data base contains the X and Y co-ordinates of the centre point of each grid square, so these can be used for window searching. Second, zooming in on a portion of the Scottish base map is supported, by choosing an appropriate scale and nominating the centre point of the area to be displayed. The map will then be scaled to A3 or A4 paper as required. Figure 4 shows an example of a window search, along a rectangular corridor covering the southern shore of the Firth of Forth. The resulting map, based on district boundaries, at a scale of 1:250 000, displays all the one km squares in the Edinburgh area with a population of more than 8000. Modifications to the basic program can readily be made to plot the results of inter-censal population change, by linking the 2 tables for the different census years.

4 Future developments

An important area for future work to extend the potential of these interfacing approaches is in relation to methods of storing digital map data within the data base itself, so they can be retrieved for selective plotting. Some pointers in this direction can be seen in the work of Tuori and Moon (1984), and preliminary investigations into the problem with respect to Ordnance Survey digital data are now being pursued at Edinburgh.

5 References

Date, C.J. 1981. *An introduction to database systems.* Reading, Mass: Addison-Wesley.

Morris, B.A. 1984. Computer generated map indexes: cartographic information retrieval using the ORACLE-GIMMS software interface. *Bull. Soc. Univ. Cartogr.*, **18**, 25-28.

Morris, B. A., Healey, R. G. & Waugh, T. C. 1986. From map catalogue to data base with graphics in view. In: *Ligue des Bibliothèques Européenes de Recherche,* edited by J. Elliot. (LIBER Bulletin no. 28.) Heidelberg.

Tuori, M. & Moon, G.C. 1984. A topographic map conceptual data model. In: *Int. Symp. Spatial Data Handling*, edited by D.F. Marble, K.E. Brassel, D.J. Peuquet & H. Kishimoto, Vol. 1, 28-37. Zurich: University of Zurich.

Measuring the areas of rural land use parcels

R P KIRBY
Department of Geography, University of Edinburgh, Edinburgh

1 Introduction

There is a continuing requirement for the area values of land use parcels in Great Britain. At a local level, management policy-makers need to know the exact areas of land involved in particular functions; new curtilages are constantly being defined, and parcels of land are subject to continuous physical change due to, for example, the amalgamation or division of fields, urban or industrial expansion, or the natural spread of bracken *(Pteridium aquilinum)* and scrub vegetation. At national levels, planning policies require to know the proportions of land devoted to different land use categories, these proportions often being derived ultimately from the summations of many individual measurements of individual parcels, which are in turn often selected on a sample basis.

Data on areas will hardly ever be required by themselves, but will be associated with geographical locations and thematic attributes. Examples are the area of land in a particular parish occupied by woodland, and the proportion of land in a county that has changed its function from agriculture to urban within a stated period. Areas of land require to be defined in different ways, and this affects the methods by which they can be measured. For practical purposes, areas of land need to be defined, wherever possible, in terms of permanent visible boundaries, and so the field is the natural unit by which rural land use data are collected. The area of a field can be measured directly by simple ground surveying or indirectly from an existing plan or aerial photograph. An extra stage in the measurement procedure arises where the required areas of land do not correspond to permanent land parcels, as will occur, for example, in upland areas without field boundaries where land cover types merge into one another. New area boundaries must then be created on map or photograph for the purposes of the study.

2 Areas from Ordnance Survey maps and plans

Where permanent fields exist, their areas can be measured from official maps at 1:25 000 and larger scales. On the Ordnance Survey (OS) 1:2500 scale plans, the area values of individual parcels are provided directly. For each individual parcel, there is printed (i) a reference number based on the grid co-ordinates of the sheet boundary, and (ii) the area of the parcel in hectares and acres (acres only in pre-metric sheets). Figure 1 illustrates the numbering procedure, which has special rules for dealing with parcels intersected by the boundaries of the map sheet.

The area values are originally determined from the 1:2500 paper plans themselves by automatic reading planimeters, and checks on accuracy include double measurement of each parcel and summation of all values to agree with the total sheet value within a small tolerance. The values for area are published to 0.001 ha, or 10 square metres.

Notwithstanding these high levels of precision and accuracy, there are obvious limitations to the OS area values as a national set. First, the 1:2500 scale series covers rural areas (about 170 000 km^2) but excludes mountains and moorlands, where 1:10 000 or 1:10 560 is the largest published scale. Thus, there are no area data for most of Scotland, northern England and central Wales. Also, in built-up areas, individual parcels are aggregated for convenience into 'town areas' and measured as one parcel.

Second, OS parcels are defined semi-arbitrarily as any areas which are measured and published on the 1:2500 plan (Harley 1975). For example, even rural enclosures may be grouped together, and parcels may be terminated by such imaginary lines as administrative boundaries, or braced to include unfenced occupation roads and tracks. The parcels have no significance whatsoever in respect of property ownership. In summary, the selection of parcels and the use of braces by the OS are governed by practical cartographic convenience, so that the exact boundary of each individual parcel has to be scrutinized if the area value is to be used to its full precision. As a consequence, the area values are often likely to be used only as a check on the accuracy of other independently determined sets of measurements. Also, it must be remembered that the plans contain little direct land use information, so that for land use purposes other additional sources must, in any case, be found.

3 Methods of area measurements from maps and aerial photographs

The range of methods in common use is shown graphically in Figure 2, and a similar range specific to maps only is presented and described by Baxter (1976). In Figure 2, the simple methods are suitable only for small jobs where their slowness is not a liability and the cheapness of the tools involved may be an advantage.

Where many measurements are required, it is more cost-effective to use one or other of the methods shown in the lower part of Figure 2, ie:

- digitizing of polygons, with automatic calculation of areas

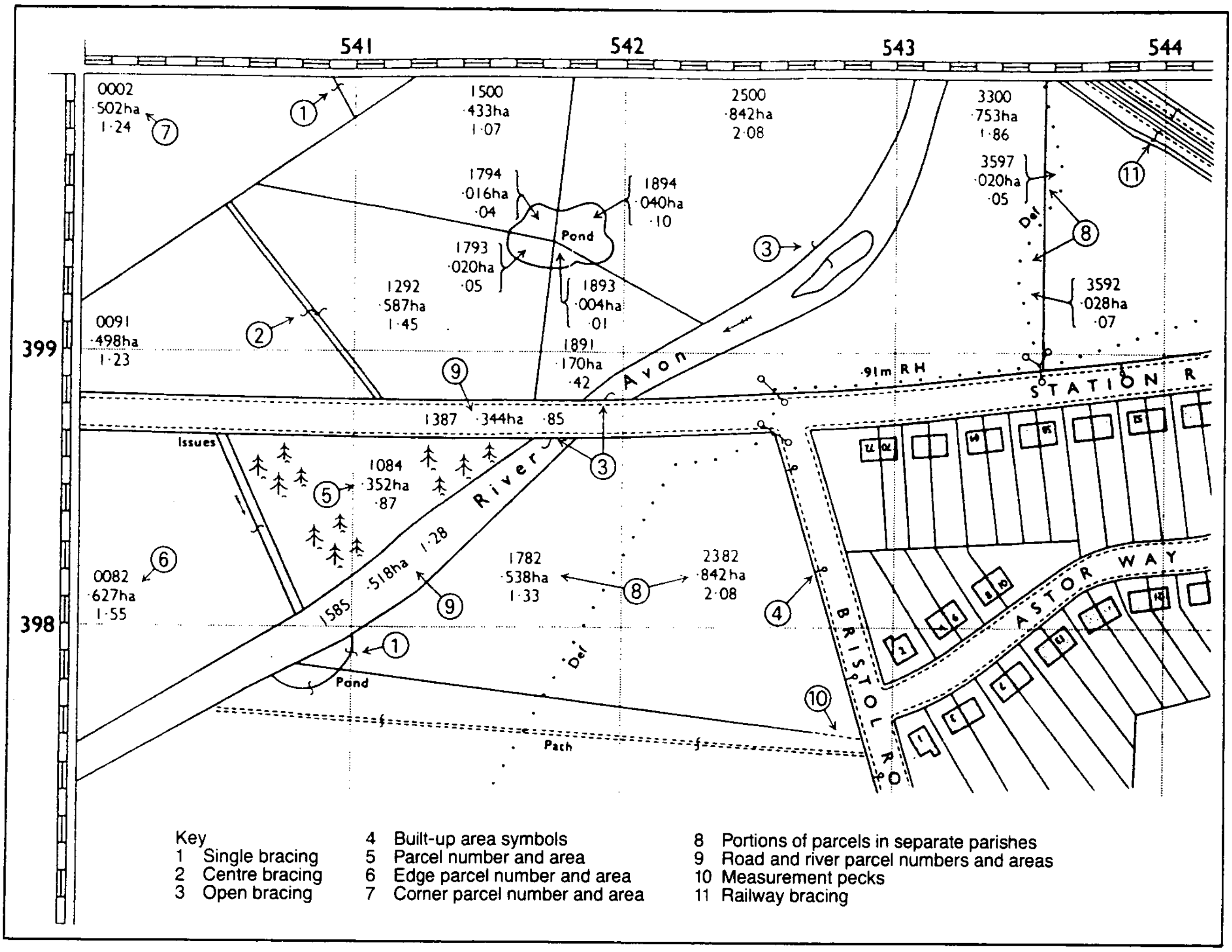


Figure 1. 1:2500 Ordnance Survey plan: methods of bracing and numbering parcels (source: Harley 1975)

— point counting by sampling from random/systematic grids with manual calculation of areas.

Although each of these methods may be applied to maps or vertical aerial photographs, they are otherwise very different in their approaches. Digitizing of polygons requires equipment in the form of an automatic planimeter or a digitizing tablet linked to some computer-based output system. Output will include the exact numerical area of each polygon traced, often as a by-product of a spatial data base whereby co-ordinates of the ground locations of points on the polygon boundaries are also recorded. In total contrast, point counting is a spatial sampling method requiring no equipment other than a translucent overlay suitably gridded with points. The density of points will be a function of the average size of the parcels to be measured, and the distribution of points may be systematic or (less commonly) random. The area of an individual parcel is found from the proportion of dots overlying the space of that parcel with respect to the number of dots occupying the total (known) area. This method does not give individual areas as accurately as by digitizing, but cumulatively the percentage cover of aggregated polygons of like attributes with respect to some known total area can be found quickly and with moderate accuracy.

The point counting method has a longer historical pedigree and its simplicity makes it a real alternative for measuring the cumulated areas of thematic distributions. The theoretical work by Frolov and Maling (1969) on the nature of sampling errors in point counting techniques has been further developed by C Emmott in the context of comparative land usage. Emmott sampled land use on a grid basis from source data of different dates, and arranged a computer output of listings of land use areas, land use change statistics and computer maps of land use and changes in land use. He has stressed that the role of the computer is to deal with the data production process; the human researcher is better than a computer at contending with the assembly of the raw data by interpretation and analysis of the aerial photographs and maps. This sound principle cannot be overemphasized: land use information systems with photographic remote sensing inputs are best characterized by manual interpretation and measurement, followed by computer processing of the interpreted data. Only in the case of digital data obtained from

Table 1. Usage of aerial photographs in national and regional projects

Project	Agency/ contractor	Measurement	Reference
Mapping 'developed areas' of England and Wales	DoE/Fairey Surveys	Digitizing	Smith *et al.* (1977)
Scottish coastal habitats	NCC/Edinburgh University	Pt counting	Kirby (1977)
Scottish lowland agricultural habitats	NCC/Edinburgh University	Pt counting	Langdale-Brown *et al.* (1980)
Broadland vegetation data base	NCC/NCC	Digitizing	Fuller & Drummond (1981)
Monitoring landscape change in England and Wales	DoE & CC/ Hunting Surveys	Digitizing	Hunting Surveys and Consultants Ltd (1985)
National Countryside Monitoring Scheme	NCC/NCC	Digitizing	Nature Conservancy Council (1985)
National land use stock survey (feasibility only)	DoE/—	—	Roger Tym & Partners (1985)

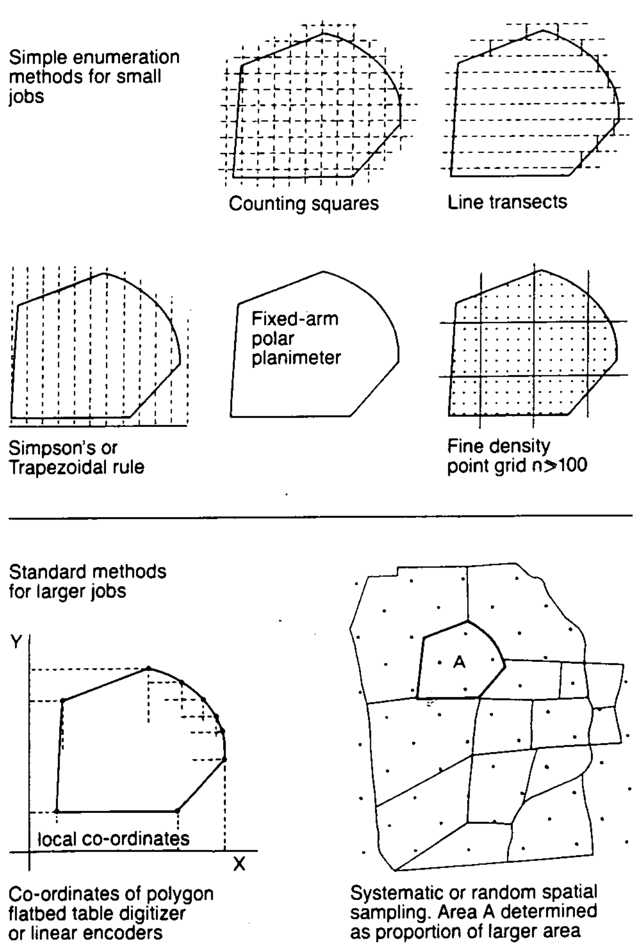


Figure 2. Methods for measuring area

scanning equipment carried by earth orbiting satellites does computer processing play a central part in land use interpretation.

4 The use of aerial photographs in Great Britain for rural information

Aerial photographs allow customers to determine land use by interpreting and delimiting boundaries as necessary, whether or not these boundaries coincide with lines shown on published maps. Photographs also allow interpretation of attributes from first principles and provide measurements of area and linear features. They reduce the need for costly ground survey and, if custom-flown at an appropriate scale (often between 1:10 000 and 1:30 000), they will provide levels of resolution unavailable from current or proposed satellite sensors. The situation is succinctly summarized by Holz (1985). 'It is clear that . . . (metric and supplementary aerial photographs) . . . can now be considered tested and proven because their application is frequent and widespread. Stereo photographs are still the best product available for the three-dimensional mapping of both land use/land cover and topography. Their use by government agencies, private companies, and individuals is virtually routine.'

The evidence from post-war initiatives in Great Britain confirms that aerial photographs are the best single source of area measurements for land use studies. As well as in local schemes, aerial photographs have been used in numerous national and regional projects, including those listed in Table 1. In each of these projects, the areas of a very large number of discrete land parcels have been measured from aerial photographs and the values subsequently aggregated according to thematic attributes or locations to provide statistics for classes or regions.

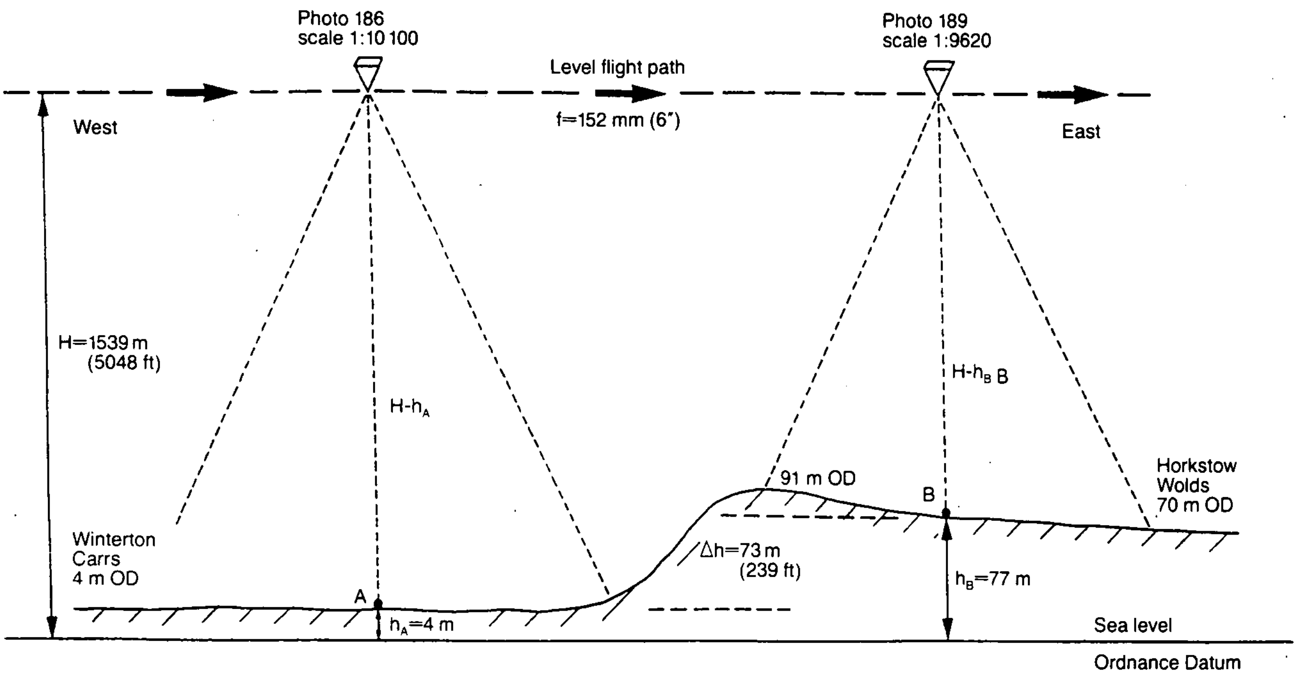


Figure 3. Typical scale change due to ground relief. Nominal photographic scale 1:10 000

5 Examples of area measurements from aerial photographs

Because of camera tilt or ground relief, a single aerial photograph may easily contain scale variations of ±5% of the nominal scale, with consequent errors in area measurements from that photograph. By digitizing from a stereo-pair in a photogrammetric plotter with rigorous restitution, the scale variations caused by tilt and relief will automatically be eliminated, and measurements for area should be comparable to those obtained by digitizing from a topographical map of similar scale.

This factor must be borne in mind when setting up a land use information system involving area measurement. If errors are not minimized, they may accumulate into total errors significant in magnitude even in comparison with the much more obvious errors associated with air photo misinterpretation and with sampling.

The examples presented below illustrate the orders of magnitude incurred when working from photographs. The examples contain small data sets based on aerial photographic coverage of the South Humberside district at 3 common photographic scales. The district chosen is ideal for air photo interpretation because of its simple topographic form, consisting of flat low-lying agricultural land (carrs) with many drainage channels, rising by a single scarp to smoothly sloping wolds (Figure 3). Air photo interpretation is further helped because the land parcels are mostly large rectangular enclosures, and there are few trees to obscure the enclosure boundaries. The results should be regarded as better than would be obtained in more typical British landscape conditions, with varied topography, irregular-shaped land parcels, and hedgerow trees.

In the first example, digitizing from single aerial photographs has been carried out on a Summagraphics flatbed digitizer which has a precision of 0.1 mm. In the Table of results (Table 2), N is the number of land use parcels digitized from the carrs or

Table 2. Examples of digitizing from single aerial photographs using a Summagraphics flatbed digitizer

Nominal air photo scale	Location	N	% errors (ha) $\bar{x}$	$\sigma n^{N}-1$
1:10 000	Winterton Carrs	28	− 3.77	1.95
(1976)	Holkstow Wolds	20	+11.71	1.19
1:30 000	Winterton Carrs	28	−15.23	3.14
(1975)	Holkstow Wolds	20	−13.65	4.90
1:62 000	Winterton Carrs	28	−9.83	7.45
(1969)	Holkstow Wolds	20	−6.77	4.24

from the wolds at each scale. Errors are defined as differences in hectares from the values on OS 1:2500 plans, and for each district the mean difference ($\overline{x}$) is expressed as a percentage. The results show large mean percentage errors, which have different explanations. At the 1:10 000 scale, the difference in surface height between the carrs and the wolds (Figure 3) means that any one nominal scale is a compromise, guaranteeing that errors will occur. Properly, different nominal scales should have been applied to the separate photographs containing the carrs and the wolds, according to Figure 3, which would have greatly reduced the errors. For the 2 smaller scales of 1:30 000 and 1:62 000, the carrs and the wolds are now both contained on the same photographs, so that different scales cannot be applied to each district. In any case, at these scales, the photographs have been taken from greater altitudes and the differences in surface heights OD between the carrs and the wolds become proportionally less significant. The large mean percentage errors here instead represent systematic bias, due again to using the quoted nominal scales, which are incorrect for the complete strips of photographs at each scale.

At all 3 nominal scales, random errors in digitizing by the operator are unavoidable. As the scale decreases, the images of land use parcels will be smaller so that the operator's hand movements will have proportionally greater effect in causing errors. From Table 2, the standard deviation of errors is seen to increase as scale decreases, to the level where working practices may be unacceptable.

In the second example, digitizing has been carried out on stereo-pairs of the same photographs in a Galileo Stereosimplex G6 photogrammetric plotter, fully orientated to ground control. The plotter is fitted with linear encoders operating via an MDR2a co-ordinate readout system to an Apple II microcomputer, programmed to provide the areas of polygons (and other information). In the Table of results (Table 3), the changes in the number of parcels between different dates reflect amalgamation or division of fields.

As before, the errors are defined as differences in hectares from OS values, and the results in this example (independent of sign) are all very small in magnitude. There is no systematic bias.

These far superior results, achieved by photogrammetric digitization from a properly controlled stereo-pair, depend on the floating dot being maintained on the model ground surface, as well as along the boundary line being digitized. This maintenance is aided by the optical magnification built into all photogrammetric plotters. The small errors, of the order of 1–3%, are probably near the unavoidable limit, and are due to a combination of floating dot errors for height and position and difficulty in deciding, even for this ideal landscape, exactly where the boundary is supposed to be, relative to ditches and small tracks.

6 Conclusions

It is suggested that digitizing photogrammetrically from a stereo-pair of aerial photographs, properly orientated to ground control, produces minimal errors of a random nature, and accuracy should be comparable to digitizing from a topographical map. Digitizing from a single aerial photograph may give substantial errors, unless the nominal scale is recalculated and, even so, relief may still cause significant scale variation. Point counting from a single aerial photograph using a fine-mesh grid overlay (results not presented here) is subject to the same geometric limitations, while also being intrinsically less accurate than digitizing.

Whereas the central concerns in national, regional and local projects for land use planning are likely to be the availability of appropriate data sources and the interpretation of these data sources, including how to define land boundaries and allocate categories, it is commonly necessary to obtain summary statements on the areas of land use parcels in each category. The way in which data on the areas of discrete land use parcels are gathered is fundamental to the accuracy of these data and, in this paper, some of the methods for measuring parcels have been examined. Published reports by commercial

Table 3. Examples of digitizing from stereo-pairs of the same photographs as in Table 2 in a Galileo Stereosimplex G6 photogrammetric plotter, fully orientated to ground control

Air photo scale	Location	N	Mean % errors (ha) Test 1	Test 2	Test 3
1:10 000 (1976)	Winterton Carrs	15	1.92	1.72	1.37
	Holkstow Wolds	5	0.61	0.93	0.43
1:30 000 (1975)	Winterton Carrs	14	2.24	1.30	1.44
	Holkstow Wolds	6	4.17	3.73	3.00
1:50 000 (1981)	Winterton Carrs	12	3.48	1.58	1.59
	Holkstow Wolds	5	1.27	1.13	1.08

companies and national agencies in Great Britain tend to list the methods used to measure areas, without indicating the nature or magnitude of likely errors. An exception is a recent report by Hunting Surveys and Consultants Ltd (1985) which properly attends to the errors due to geometric distortion in comparison to sampling errors and misclassifications during air photo interpretation. In this national survey, it was found that significant geometric distortions do occur when measuring from single photographs, but they are confined to a small proportion of upland sites with sloping terrain.

7 References

Baxter, R.S. 1976. *Computer and statistical techniques for planners*. London: Methuen.

Frolov, Y.S. & Maling, D.H. 1969. The accuracy of area measurement by point counting techniques. *Cartographic J.*, **6**, 21-35.

Fuller, R.M. & Drummond, J.E. 1981. Photointerpretation and computer aided cartography of broadland vegetation. In: *Matching remote sensing technologies and their applications*, 347-358. Reading: Remote Sensing Society.

Harley, J.B. 1975. *Ordnance Survey maps: a descriptive manual.* Southampton: Ordnance Survey.

Holz, R.K. 1985. *The surveillant science: remote sensing of the environment.* 2nd ed. New York: Wiley.

Hunting Surveys and Consultants Ltd. 1985. *Monitoring landscape change.* (Progress Report no. 4.) Borehamwood: Hunting Surveys and Consultants Ltd.

Kirby, R.P. 1977. *Remote sensing of Scottish coastal habitats.* (Research Report no. 34.) Edinburgh: Tourism & Recreation Research Unit.

Langdale-Brown, I., Jennings, S., Crawford, C.L., Jolly, G.M. & Muscott, J. 1980. *Lowland agricultural habitats (Scotland): air photo analysis of change.* (CST report no. 332.) Peterborough: Nature Conservancy Council.

Nature Conservancy Council. 1985. *National Countryside Monitoring Scheme: Cumbria report.* Peterborough: NCC.

Roger Tym & Partners. 1985. *National land use stock survey: a feasibility study for DoE.* London: Roger Tym & Partners.

Smith, T.F., van Genderen, J.L. & Holland, E.W. 1977. A land use survey of developed areas in England and Wales. *Cartographic J.*, **14**, 23-29.

A technique for assessing wildlife in an arable landscape

R A S STOREY and R TINKLIN
School of Science, Humberside College of Higher Education, Hull

1 Introduction

East Yorkshire is a region of England devoted to intensive arable agriculture. Within such a landscape, wildlife habitats are principally confined to hedgerows, small woodlands, roadside verges and small streams. Whilst accepting that the prime function of this landscape is productive agriculture, there is nevertheless room to enhance wildlife potential by appropriate management. As a basis for such management, it is necessary to identify, first, the features of wildlife value, and then to evaluate these features to permit comparisons between different areas.

2 Methods

As a basis for the development of an appropriate technique, an area of landscape was chosen, 1084 ha in extent. The area was selected as being typical of the region, showing the principal classes of land use and features of landscape, but was believed not to be of particularly high or low wildlife potential.

2.1 Terrestrial features

Within this landscape, the various features were evaluated by field observations using only roads and public footpaths as means of access. As an aid to evaluation, a matrix of 35 mm oblique colour photographs was taken from a light aircraft at an altitude of 300 m.

From the field observations, the following estimations were made:

i. area of woodland (expressed as a percentage of the total area)

ii. area of roadside verges and similar uncultivated sites (also expressed as a percentage of the total area);

iii. mean number of specimen trees (those not part of woodland) per one km square in 3 classes:
   — saplings and young trees
   — mature
   — overmature and senescent

iv. mean length of hedges per one km square in 4 classes of wildlife value (Tinklin 1980).

2.2 Aquatic features

The study area was crossed by several small streams and it was felt that these needed a separate assessment. The assessment of the wildlife potential of water bodies was restricted to locations in which open water was visible for most of the year. It did not include marshes, swamps and semi-aquatic zones, except where these formed part of the natural sequence of colonization at the margins of open water. The stages of evaluation involved locating the extent of the watercourses, and performing the assessment.

The extent of the aquatic habitats was determined by maps and air photographs, with confirmatory ground survey. Maps (Ordnance Survey 1: 25 000 and 1: 10 000) were useful initial guides because they showed more clearly than conventional air photos the routes of watercourses and the positions of ponds and springs. Infra-red and colour infra-red photographs were useful for updating the maps and confirming locations of recent drainage developments and stream realignments.

2.2.1 *Assessment scale*

The technique used for evaluation stemmed from previous studies on the drainage network of the River Hull valley (Pearson 1974; Higgins 1980). Aquatic habitats are governed both by the chemical properties of the water and by its movement. For many aquatic systems, it has proved possible to predict the composition of the aquatic community from a few 'key' measurable chemical and physical features or by indicator species that respond to these features. These features formed the basis for recognition and evaluation. Previous extensive and intensive sampling and subsequent cluster analysis showed that the River Hull followed a predictable sequence of zonation from origin to river mouth (Storey 1986), which held true for each tributary of the river and also the drains and ditches that form part of the drainage network of the area. Basically, the system can be divided into 5 zones with the richest (ie highest species diversity) in the middle reaches and progressive upstream and downstream extinction. Although, at points, the zones overlap to give areas of transition, the changes within a zone are less marked than those between zones (Table 1).

For the purposes of wildlife management, the middle reaches of the river and the large drains are accorded the highest status, 5 points. The tidal reaches, with the lowest diversity of both animals and plants, are rated one. Remaining zones, each different in their own ways, score intermediate values on this 5-point scale. The score for any zone is given on the basis of a 'good' representative stretch of habitat. Certain factors, such as overhanging tree canopies, pollutants and high con-

Table 1. Zones of the River Hull drainage network

Zone type	Description	Number of indicator species	Score for assessment purposes
A	Large, slow-moving middle reaches of river or larger drains	3–6	5
B	Rapid current, hard eroding substratum	1–3	3
C	Origins of the system, spring fed, liable to dry up during summer months	1–3	3
D	Minor drains, small size, variable characteristics	1	2
E	Tidal reaches, flow in both directions, turbid depositing substratum	0	1

ductivity, were found in previous studies to have an adverse effect on species diversity, so points are subtracted from the basic score for each factor that reduces the species diversity in this way (Table 2).

2.2.2 Zone recognition

Many of the factors responsible for the occurrence of the specific zone organisms are inter-related, which makes it possible to predict the quality of the water by noting just one factor rather than several or all factors. It is possible, for example, to relate the current speed of a stream to its substratum composition which, in turn, determines the composition of the benthic community. Animal or plant species that respond to particular environmental factors can also be used as indicators of these factors, and previous studies revealed that gastropod molluscs provide a reliable and economic means of recognition. The 2 key factors for the zones in the study area are shown in Table 3, and the occurrence of either one of these is likely to be diagnostic for the zone.

For a linear watercourse, it is necessary to record the extent of each zone, as well as its score. The exact method of determining the score for a whole stretch of water may well depend on the purpose for which a comparison is made with water elsewhere. It is probably seldom valid simply to add together the component scores to produce a final total for the particular sample stretch.

3 Conclusion

These techniques serve to quantify aspects of the landscape of value to wildlife, and thus to permit direct comparison between similar areas. Clearly, comparison of areas differing markedly in size and/or character is difficult, and other techniques may

Table 2. Factors reducing primary assessment

Factor	Description	Weighting
Artificial bank	Concrete, metal or timber wall preventing establishment of marginal species	–1
Light reduction	Bridges, complete tree canopies, complete cover by emergent vegetation	–1
Pollutants	Visible pollutants, turbidity, high conductivity	–1 or –2 (depending on severity)
Biotic factors	Overstocking of consumers/predators, eg duck and wildfowl, total cover by submerged species	–1

Table 3. Zone identification

Zone type	Key factor 1 Indicator spp. (gastropods)	Key factor 2 Number of species	Width (m)	Depth (m)	Current speed (m s^{-1})	Substratum
A Middle river reaches large canals & drains	B.t. and at least 2 others	3–11	3–11	0.8–2.0	0.1	Silt
B Swift-flowing tributaries	A.f. with or without P.j.	1–3	3–10	0.15–0.35	0.3–0.8	Stones, gravel, some sand/ silt patches
C Origins — liable to dry up in summer	L.p. and/or A.l.	1–4	1–5	0.2–0.3	0.0–0.5	—
D Minor ditches,	P.j. alone or with one other species (not A.f.)	Heterogeneous				
E Tidal reaches	None	0	3–20	Variable	0.6 in both directions	Silt

Indicator species: A.f.-*Ancyclus fluviatilis*; A.l.-*Anisus leucostoma*; B.t.-*Bithynia tentaculata;* L.p.-*Lynmaea peregra*; P.j.-*Potamopyrgus jenkinsi.*

be more appropriate for such situations. As has been indicated above, no attempt has been made to add scores together to produce a single score for the area. The great advantage of these techniques lies in the rapidity with which evaluation can be carried out. The evaluation times for the area studied were as follows.

Terrestrial features	—	6 hours
Aquatic features	—	4 hours
Total	—	10 hours

In this brief period, it was possible to build up a fairly detailed assessment of wildlife potential, sufficient to highlight the features of value to wildlife and to form the basis of future management strategies.

4 References

Higgins, J. 1980. *The River Hull Valley: man and nature.* Department of Zoology, University of Hull.

Pearson, R.G. 1974. *A study of the macro-invertebrate fauna of the River Hull.* PhD thesis, University of Hull.

Storey, R. A. S. 1986. Longitudinal zonation of gastropods in a chalk stream. *J. mollusc. Stud.*, **52,** 15-24.

Tinklin, R. 1980. North Humberside landscape biology survey. *Landscape Res.*, **5**, 30.

WORKSHOP REPORTS

Methods for the identification of priorities in rural planning

M BELL
Institute of Terrestrial Ecology, Merlewood Research Station, Grange-over-Sands

Mr V Goodstadt of Strathclyde Regional Council took the Chair and indicated the range of conflicts which can arise even within one region, eg farming versus forestry, urban fringe difficulties, green belt constraints versus development.

Many contributors echoed the feeling of the main conference papers, that the lack of a national strategic policy led to a displeasing *ad hoc* approach, not least in regard to forestry.

The representative of the Forestry Commission outlined the arrangements for consultation over the Forestry Grant Scheme, which highlighted one of the key debates: who sets the priorities? Highland Region planners were prominent in asserting the democratic supremacy of the elected local authority. A trenchant comment from a land agent moved the discussion into the much researched area of whether elected authorities truly reflected local desires, and he asked whether planning controls were, in fact, a tyranny of the majority over individual entrepreneurs, and noted in passing that certain planning authorities — such as the Special Planning Board — were dominated by ministerial nominees. (It is, in fact, numerically incorrect to assert that nominees have a majority in the Lake District SPB, but they may dominate.)This traditional debate over the administrative mechanisms of setting priorities showed us to be a long way from any type of purely technical exercise.

A number of participants drew attention to the rapidly changing nature of rural areas as a principal determinant of the prioritization process. There had to be in-built flexibility, yet decisions were being taken — eg to afforest peatland — without certainty as to whether the underlying resource would be sterilized.

Contrasts were drawn between a number of methods for identifying priorities, particularly in regard to whether they actually minimized or emphasized the conflict:

- personal consultation and amelioration of particular interest concerns, as when a private forestry company meets local bodies separately to discuss a scheme;
- strategic planning via elected members and extensive public consultation, with the planning authority then acting as initiator and persuador;
- a straightforward extension of development control powers;
- integrated policy frameworks from bodies like the Department of Agriculture and Fisheries for Scotland or the Ministry of Agriculture, Fisheries and Food, given that legislation now provides them with a wider remit;
- experimental practical projects which could be extended (with appropriate modification to local circumstances) if successful;
- traditional designations with the problems of overlap and apparent unconcern for 'the rest'.

Interestingly, there was no firm agreement on whether conflict was beneficial in testing priorities and examining data thoroughly; or whether it was better generally to avoid contention and utilize data to help steer a middle course. Whilst not disputing that facts were sacred, participants were aware that different actors in the debates on rapid land use change would tend to utilize them in their own ways. Careful, objective, presentation remained as necessary as ever.

Perception and interpretation of information for rural planning

C P MITCHELL
Department of Forestry, University of Aberdeen, Aberdeen

This well-attended workshop allowed a fairly free discussion of the topic, but was lacking in some respects by the general absence of planners; the majority of the audience comprised mainly potential suppliers of information. However, the experiences of dealing with the perceived needs of planners were quite salutary.

It is quite clear that, in most cases, the user of rural information is not wholly clear as to what information is actually needed to complete the proposed task. Many tasks are quite open-ended as regards data requirements. The attitude of 'let's see what we need as we go along' is not very helpful when designing data gathering and analytical procedures.

Inherent in this attitude is also one of the old ideas: 'it's safer to use what we have got'. In this environment, it is quite difficult to institute new procedures and ideas, but, as the enlightened view of the Planning Department of Highland Regional Council has so ably demonstrated, the new ideas do work and can readily be used to answer the 'what if' questions beloved of planners.

However, in order that new systems can be implemented, planners need to be aware of what is available, its uses and limitations. On the other hand, the planners need to communicate to the providers of information what it is that they actually need. In many cases, the answers from both sides are not clear-cut, and many other factors, such as costs, come into play.

It really is not possible for both sides to operate in isolation, and it was the opinion of the participants that, for really effective progress to be made, then the user and supplier should sit down together and arrive at the most appropriate solution by an iterative process. Points to be considered in this process include:

- the basic needs
- scale of data requirement (national, regional or local)
- access to and compatibility of existing data bases
- costs of acquiring new data
- anticipation of data requirements and how much redundancy can be allowed (ie can data be collected that might be used in the long term)
- costs of modelling/analysis
- flexibility of any analytical/modelling system
- linkages between socio-economic and spatial information
- need for pilot studies ('scoping studies') at the right scales
- realization that predictions of land use need interpretation.

Data needs for rural planning

R H HAINES-YOUNG
Department of Geography, University of Nottingham, Nottingham

A spin-off from the new computer-based techniques of data handling is that data sets constructed for sometimes quite specific purposes are potentially available for other uses. This situation has both advantages and drawbacks. The chairman, M E Taylor, asked the workshop to focus these issues by considering the following questions.

- Can the new technology provide the information which rural planners need?
- How does that information get used?

The resulting discussion can best be summarized under 2 heads.

1 The problem of integrated data use

The exchange and use of common data sets is hindered by 2 problems. On the one hand, formats may be incompatible; on the other, definitions of the data elements may be fuzzy, or so specific to the initial application that their use elsewhere is inappropriate.

Some felt that, because data sets would always have to be tailored to meet the need of specific users, problems of incompatibility would inevitably arise. It was suggested, however, that 2 steps might be taken to overcome some of the problems. On the one hand, the data should be stored in a disaggregated and unprocessed form. On the other, common spatial referencing systems must be used (eg National Grid, parish, etc). The experience of the Institute of Terrestrial Ecology was that standard sampling frameworks had facilitated more widespread integration of data sets in its organization.

It was suggested that it seemed evident that the modern state needed a basic 'data infrastructure'. Examples of such data sets would be the Ordnance Survey, and the Census of Population. The main problem was in identifying what that core of data should contain.

The workshop felt that problems of incompatibility and definition seemed to be scale-dependent. It is with goal-orientated data sets, collected for specific issues, that problems of incompatibility are most likely to arise. Such problems are less likely with the large infrastructural data sets. However, by their very general nature, they are not always going to provide the information which planners need. When employing any data sets derived from other sources, it was argued that users should be provided with information on the construction and interpretation of the data elements.

The chairman asked the workshop to consider the adequacy of sample data for planning purposes. As the planner is answerable to the public, and as the politician often finds sample data difficult to defend, should we not use the new technology to obtain more complete data coverage? It was felt, however, that the necessity for sample data was inevitable, and that that necessity needed to be communicated more clearly. For problems at a strategic level, sampling was required on grounds of time and cost-effectiveness. Sample data can be used to provide a framework within which more complete information can be collected at the local scale.

2 The user environment

The need to exercise caution when using data in the context of problems for which they were not initially collected led the workshop to consider the ways in which data are used by planners. Three constraints on use of data were identified.

The first constraint was lack of appropriate skills required for interpretation. It was pointed out that, although it might be laudable to store data in their most disaggregated form, this may impose severe problems on their use. The interpretation of soil survey data, for example, requires skill. Because planners do not have the appropriate background, it seemed evident that only the organization which collects the data can interpret them. Thus, preprocessing and classification of data are required before they are made available. It was pointed out, however, that this requirement assumes that the originating organization 'knows best', but is there any real evidence that organizations like the Ordnance Survey or Soil Survey are aware of the market? The general consensus was that processed and classified data would have to be provided as part of the basic infrastructure of society. This provision requires continued financial support for the appropriate organizations who can provide it. Unfortunately, the Government seems less and less willing to provide such support.

A second constraint on the way in which data are used by planners arises from ignorance of what is available. There was a strong feeling in the workshop that organizations should establish catalogues of their data holdings. Whether they could be established at a national scale was another matter.

The final constraint on use of information was ignorance of the data handling systems themselves. It was argued that systems already exist for many current issues, but planners lack the necessary background and experience to exploit existing technology. Pilot studies, such as the Rural Land Use Informations System, are required to point the way forward. Experience with such systems will enable planners to articulate their needs more clearly.

Although it was recognized that pilot studies involving the new technology will create an awareness of what is possible, it was felt that substantial barriers to progress remained. Progress with the new techniques of data handling assumes that data are available in machine-readable form. It was pointed out that much of the information required was only in paper map form, and there is a tremendous backlog of digitization required before the new technology can be applied. Given the costs which digitization involves, it was considered that organizations should take a critical look at their data requirements. The need to consider the quality of the data being input to the new systems was vital.

Questions of data quality led the workshop to the issue initially addressed, concerning the incompatibility and content of data sets. These issues were difficult to resolve. It was recognized, however, that access to the new techniques of data handling will cause planners to look much more critically at the data they use and the way in which they use them.

Final discussion

D K LINDLEY
Institute of Terrestrial Ecology, Merlewood Research Station, Grange-over-Sands

1 Introduction

The final discussion was led by Professor J T Coppock, with Professor P A Burroughs and M E Taylor on the panel. Professor Coppock opened the discussion by posing a number of major questions to the audience.

i. What feedback could be obtained from the displays that had been shown at the conference? Were they all displaying the same ideas and techniques?

ii. What role do academics have in the development of rural information systems?

iii. How cost-effective are the new developments? Should one develop systems in closed environments, or should they be developed at regional centres?

iv. To what extent do the existing systems answer questions posed by the planners?

v. Land values should be included in modern systems. Are data available which reflect changes in land values?

vi. What action is necessary in relation to:
— data
— systems of handling and processing data
— bridging the gaps between the developers and users of systems?

2 The displays

Many of the displays were based on microcomputers which had been used for developing systems over the past 2–3 years. They were all essentially based on raster information and used low-cost systems for their hardware. In contrast, Mr Healey demonstrated his system based on the VAX in the Department of Geography at Edinburgh University; it was accessed via the GPO network.

A general comment emerged that, although each display was interesting in its own right, it was difficult to link them together. A general note synthesizing the various concepts of the displays would have been useful.

3 The role of academics

Two positions could be taken when discussing information systems. An individual or organization could either be a 'trail blazer' or a follower waiting for a new development best suited to his needs. Academics were thought to fit into the former role. They were perhaps better able to take the longer view, being under less day-to-day pressure than, say, someone working in a planning department.

Academics were already working in the new area of data management. Correct data structures and enforced standards were needed to ensure that data could be made more easily available to a wide variety of users. A question that needed addressing was one of access to information stored within a centralized system, or within a regional centre.

Academics were probably in a better position to keep abreast with technological improvements in networking and distributed data bases. Both those concepts would have a profound effect upon the ease with which information systems could be accessed.

At present, the slowest computer was producing results much faster than the human brain could comprehend, so more research was required into how to improve the presentation of information to the user.

One advantage of distributed data bases was that it was possible to send a subset of data over the network and for the processing to be done by the local machine.

4 Cost-effective systems

For some Dutch projects, costs were shown to be in the following proportions:

— Collection of data	50–60%
— High-quality plotting	30%
— Computer work	10–20%

These proportions were likely, however, to vary widely according to the objectives of the project.

One of the reasons why the collection of data was so expensive was that it often contained a high element of field work. Often the different parts of an information system were inter-related in such a complex way that it was difficult to make general statements about cost-effective systems. Each individual scheme should be designed to be cost-effective.

Was it cost-effective for each local authority to develop its own information system? Would each local authority be prepared to pay for digitizing the 1:50 000 map information of its own area? For an information system to be cost-effective for a local authority, a rapid return by way of useful results was often required.

5 Planners' requirements

The planners amongst the audience expressed regrets that there had been numerous separate developments of information systems taking place at the national level. Professor Coppock mentioned that the Chorley Committee of the House of Lords would attempt to review the current situation. They would be considering digital mapping, remote sensing, and the handling of geographic data: in general, who holds what data and what they are doing with their data bases. It was suggested that the Government was less concerned with rural planning than with urban development; hence, there could be a danger that information systems could have an urban slant.

A planner generally needs information in a hurry, and it is often difficult to locate information. Several organizations might have the information available, but they may well have different timescales about how rapidly they should develop their information systems. They also probably consider that it is cheaper to develop their own systems, as different levels of accuracy will probably be required for different areas and objectives. Different incompatible systems will emerge which may not serve the needs of the planners. However, can organizations be forced to co-operate?

It was suggested that national agencies, once established, work best under constructive tension. An 'information supremo' may not be desirable from the Government's point of view.

6 Land values

Most land use changes have to go through planning procedures, even if only consultative, and, although these changes are documented, there is little co-ordinated information available on ownership. It would be valuable to have information readily to hand on land values and ownership so that the consequences of changes in both these areas could be predicted using socio-economic models.

Planners would find it beneficial to try to establish the optimum use of land from both the physical and economic viewpoint. It would be useful to know what drives land investment decisions by individuals.

No data bases on land holdings and land values have been set up. General national figures are available, but these are of less value in the regional or local setting.

7 Conclusions and recommendations

7.1 The balance between high technology and low technology approaches was discussed. It was concluded that more appropriate 'good' technology was needed to solve the information needs of the users.

7.2 Integrated solutions are required to prevent populations moving away from the rural uplands; the various agencies should collaborate to produce clearly defined objectives. From these objectives will emerge detailed information needs.

7.3 Planning systems should provide efficient ways of appealing against decisions. Easily accessible information systems should improve the chances of these appeals taking place.

7.4 The technology of networking and distributed data bases is moving ahead at a rapid pace. This development should increase the chances of successful implementation of useful, user-friendly, information systems.

7.5 There is a need to produce good catalogues of available data bases.

7.6 More thought and effort should be devoted to the new discipline of data management; the importance of defining the accuracy of information should be emphasized.

7.7 Exchange of ideas and improved communications between information users, information providers and system developers should be encouraged. Small workshops would be useful, and there was some feeling that the present meeting could be reconvened, say in 2–3 years' time.

Appendix 1: List of participants

Miss C E Appleby, Wiltshire Biological Records Centre, The Museum, 41 Long Street, Devizes, Wiltshire, SN10 1NS

Mr M Baldwin, Highland Regional Council, Regional Buildings, Glenurquhart Road, Inverness, IV3 5NX

Mr D Bartlett, Department of Geography, University of Edinburgh, Drummond Street, Edinburgh, EH8 9XP

Mr G Bell, Institute of Terrestrial Ecology, Bush Estate, Penicuik, Midlothian, EH26 0QB

Mr N Black, Highland Regional Council, Regional Buildings, Glenurquhart Road, Inverness, IV3 5NX

Dr P Bradbury, Department of Geography, University of Nottingham, Nottingham, NG7 2RU

Mr O Brandon, Dartington Institute, Shinners Bridge, Dartington, Totnes, Devon, TQ9 6JE

Dr J Budd, Nature Conservancy Council, Northminster House, Peterborough, PE1 1UA

Dr K Bull, Institute of Terrestrial Ecology, Monks Wood Experimental Station, Abbots Ripton, Huntingdon, PE17 2LS

Professor P Burrough, Department of Geography, State University of Utrecht, Heidelberglaan 2, P O Box 80.115, 3508 TC Utrecht, The Netherlands

Mr B Cameron, Highland Regional Council, Regional Buildings, Glenurquhart Road, Inverness, IV3 5NX

Mr C Claridge, Highland Regional Council, Regional Buildings, Glenurquhart Road, Inverness, IV3 5NX

Dr G Clark, Department of Geography, University of Lancaster, Lancaster, LA1 4YR

Professor J T Coppock, Department of Geography, University of Edinburgh, Drummond Street, Edinburgh, EH8 9XP

Dr D A Davidson, Department of Environmental Science, University of Stirling, Stirling, FK9 4LA

Mr S M Dowell, Room 6/64, Scottish Development Department, New St Andrews House, Edinburgh, EH1 3SZ

Dr A Fishwick, Lake District Special Planning Board, Cumbria County Council, Busher Walk, Kendal, Cumbria, LA9 4RH

Mr E Gilbert, Principal Survey Officer, Ordnance Survey, Romsey Road, Maybush, Southampton

Mr R Goodier, Nature Conservancy Council, 12 Hope Terrace, Edinburgh, EH9 2AS

Mr V Goodstadt, Strathclyde Regional Council, Strathclyde House, 20 India Street, Glasgow, G2 4PF

Dr R H Haines-Young, Department of Geography, University of Nottingham, Nottingham, NG7 2RU

Mr G Hatfield, Forestry Commission, 231 Corstorphine Road, Edinburgh, EH12 7AT

Mr R G Healey, Department of Geography, University of Edinburgh, Drummond Street, Edinburgh, EH8 9XP

Mr A J Hooper, Ministry of Agriculture, Fisheries & Food, Room 323, Great Westminster House, Horseferry Road, London, SW1P 2AE

Dr G E Jones, Department of Geography, University of Strathclyde, Livingstone Tower, 26 Richmond Street, Glasgow, G1 1XH

Mr H H Jones, County Planning Officer, Powys County Council, Powys County Hall Annexe, Spa Road East, Llandrindod Wells, Powys, LD1 5ES

Dr R P Kirby, Department of Geography, University of Edinburgh, Drummond Street, Edinburgh, EH8 9XP

Mr D J L Lee, Holker Estate Office, Cark-in-Cartmel, Grange-over-Sands, Cumbria, LA11 7PH

Mr G M L Locke, Forestry Commission, 231 Corstorphine Road, Edinburgh, EH12 7AT

Mr C McKerchar, Lecturer in Landscape Architecture, Edinburgh College of Art, Lauriston Place, Edinburgh, EH3 9DF

Dr M J Mitchell, Laud 314, Central Electricity Generating Board, 20 Newgate Street, London, EC1A 7AX

Dr C P Mitchell, Department of Forestry, University of Aberdeen, Aberdeen, AB9 2UU

Dr I Moffat, Department of Environmental Science, University of Stirling, Stirling, FK9 4LA

Ms B A Morris, Department of Geography, University of Edinburgh, Drummond Street, Edinburgh, EH8 9XP

Mr A D Payne, Senior Recreation Planner, North West Water, Dawson House, Gt Sankey, Warrington, Cheshire, WA5 3LW

Dr G Radford, Institute of Terrestrial Ecology, Bangor Research Station, Penrhos Road, Bangor, Gwynedd, LL57 2LQ

Ms S Reynolds, Department of Geography, University of Lancaster, Lancaster, LA1 4YR

Ms V Saunders, Dartington Institute, Shinners Bridge, Dartington, Totnes, Devon, TQ9 6JE

Dr P Selman, Department of Environmental Science, University of Stirling, Stirling, FK9 4LA

Dr R A S Storey, Biology Unit, School of Science, Humberside College of Higher Education, Cottingham Road, Hull, HU6 7RT

Mr M Taylor, Countryside Commission, John Dower House, Cheltenham, Gloucestershire, GL50 3RA

Mr P Taylor, Lake District Special Planning Board,

National Park Office, Busher Walk, Kendal, Cumbria, LA9 4RH

Mr D Thompson, Soil Survey, Shire Hall, Mold, Clwyd

Mr J Toothill, Lake District Special Planning Board, National Park Office, Busher Walk, Kendal, Cumbria, LA9 4RH

Dr A van den Berg, 'De Dorschkamp', Bosrandweg 20, Postbus 23, 6700AA Wageningen, The Netherlands

Dr N S Walford, ESRC Data Archive, University of Essex, Colchester, Essex, CO4 3SQ

Dr S Walker, Anderson Semens Houston, Templeton Business Centre, 62 Templeton Street, Glasgow, G40 1DA

Mr J Wright, Senior Surveyor ADAS, Ministry of Agriculture, Fisheries & Food, Eskdale House, Shap Road, Kendal, Cumbria, LA9 6HQ

Also from ITE, Merlewood Research Station, Grange-over-Sands, Cumbria, LA11 6JU

Dr R G H Bunce, Mr C J Barr, Mr C B Benefield, Dr M Bell, Mr D K Lindley, Mr A Nelson, Mrs H Ridsdale, Mrs M Whittaker

ISBN 1 870393 05 8
ISSN 0263-8614