Management of Vegetation

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PREFACE

Society creates structures and landscapes with enthusiasm, and allocates money and resources to them with a liberal hand, but it pays less attention to their subsequent management and maintenance, which often fall victim to economies of every sort. In the UK the landscape and the vegetation have largely been deliberately created by man, or have developed as an incidental result of his activities. The significant areas of natural and semi-natural vegetation that occur on land not used for productive agriculture and forestry are often managed on an *ad hoc* basis, or not at all.

It is the first proposition of this introduction that in a country so densely populated and with growing intensity of pressures for the optimum use of land, that the management of these non-productive areas, including the vegetation they support, should be the subject of much more attention, planning and management skills than they are.

In addition, many different central and local government bodies, public companies and private organisations control large areas of land, whose management for the primary landuse might be modified at little or no additional expense to benefit other interests such as amenity, wildlife conservation,recreation, and sport, where these are not themselves the primary landuse. The banks of motorways for instance are engineering structures, but coincidently the vegetation on them can be managed for amenity and nature conservation. In this way areas of land not directly used for agriculture and forestry (many of which however do occur on farmland or in forestry plantations) have a multiple use potential, and it is desirable that this should be taken into account in their management.

Management of land generally involves management of vegetation, and it is the management of this vegetation that was the primary concern of the meeting at Wye College. The planning and organisation of vegetation management operations vary widely, and it is probably fair to say that whilst some organisations go into the matter in a great deal of detail, others are less interested. In whatever way land and vegetation is managed, costs are involved at some stage or another, but it is often difficult to value the benefits in cash terms. Sometimes the costs of management are precisely budgeted for, and accounted for, but in other circumstances they are combined under general budgetary heads that include operations such as snow clearing and litter collection that conceal the actual costs of vegetation control, and so deny any assessment of what is actually being spent.

The benefits of managing vegetation for a primary landuse, such as an engineering embankment for a road or a water impoundment, where soil erosion, fire control, accident prevention, pest control or public liability might be the objective, can be calculated in terms of the costs of any of these events occurring. An income can also be derived from the management and use of land for other purposes, such as sport and recreation (spectator events, shooting, golf) and, here the benefits can be measured in terms of what the

public is prepared to pay. But, in other cases, where land is being managed for amenity or especially for wildlife conservation, the benefits have defied many attempts at objective valuation, so that the value to be put on these operations can only be judged in terms of income foregone by not managing for production (agriculture and forestry), or by measuring the additional costs incurred by not managing in the most economical way for the prime use of the land. Benefits but not in monetary terms, can be judged in terms of public response to an amenity, or by the public's actual use of an area; and in conservation terms by success in maintaining populations and communities of plants and animals. However, no generally acceptable method of accounting has been proposed that enables the value of these benefits to be compared with the costs of providing them. Yet money is a resource in exactly the same way as land and water, or any of the other natural resources, and the practicality of matters is such that natural resources cannot be managed without money. As a consequence, consideration of economic factors is as fundamental to the management of natural and semi-natural vegetation as it is to the practice of agriculture and forestry. However, the detailed analysis of costs and benefits (however estimated) of the management of non-productive land is often lacking, and evidence for this is apparent in the papers that follow.

Whilst money is one of the resources, the success (or benefit) of its use is measured in terms of the achievement of objectives. Objectives can only be reached by defining standards of management that satisfy them. Thus if the objectives of managing a woodland are amenity and conservation, these might be defined in terms of the structure of the wood (ground flora, under-storey and canopy), its species composition, and the distribution and the age classes of its components. On the other hand the standards for herbage by roadsides for the objectives of the highway engineer might be height of vegetation and control of scrub; or for the Country Park manager at picnic sites the control of nettles and thistles. In some circumstances it will be perfectly acceptable to do nothing and to let vegetation develop in its own way. Nevertheless this should be a positive management decision related to agreed objectives for the land in question, and taken with full understanding of the longer term ecological and economic implications. Too often areas are allowed to go 'wild' by default, with the result that expensive and destructive restoration programmes eventually have to be undertaken. Thus the objectives of management and the standards required to meet them need to be thought out, critically taking into account ecological factors such as the dynamics of development of vegetation and the growth patterns of the species involved.

It is therefore the second proposition of this introduction that ecology and economics should go hand-in-hand in the management of natural and semi-natural vegetation, and that the understanding and practice of these two should be basic skills for land managers. Further, that the importance of an understanding of ecology allows the manager to take advantage of natural processes at little expense, rather than try to oppose them at great expense.

Although there are many organisations, large and small, together with private individuals, who have an interest in managing land, the types of plant growth to be managed, the objectives, standards and methods of management are limited. At their simplest these can be set down as lowland and upland wetlands, grasslands, scrublands and woodlands; managed for functional reasons (prevention of fire, pest control, public liability), and additionally, or primarily, for amenity, recreation, wildlife conservation and sport; by mowing, grazing, burning, cutting, fertilising, draining, or spraying; using animals, hand labour, various kinds of machine, and chemicals.

These are matters that it was thought would be of interest to a meeting of senior representatives of national organisations that either own land or have responsibilities for managing it, or (like the Countryside Commission) have a statutory interest in its management, together with representatives of professional Institutes and Associations, advisors and research workers. In the event 76 delegates representing 53 organisations attended the meeting, providing an unique gathering of varied experiences and responsibilities. The speakers were provided with a brief in order to give a common framework to the papers, and were asked to consider in addition to the particular aspects of their own topics: the objectives and standards of vegetation management; economics; methods of management, successes and failures; problems; new developments and needs for research. The programme was arranged to provide time for formal and informal discussions. These proceedings record the papers and the formal discussions but unhappily the informal discussions, which probably included as much again of interest, cannot be presented. Nevertheless it is hoped that these proceedings of a meeting that was deliberately kept small in numbers to encourage discussion between all the participants, may act as a catalyst to provoke much wider discussion of the topic of the management of natural and semi-natural vegetation that is of importance, and has had too little attention paid to it.

J M WAY
Ministry of Agriculture, Fisheries
and Food
March 1983

ACKNOWLEDGEMENTS

Thanks are due to the Institute of Terrestrial Ecology and subsequently to the Ministry of Agriculture for giving me the opportunity and facilities to organise the meeting, and to members of their staffs who helped me in so many ways. And again to the Programme Committee who turned a *pot-pourri* of ideas into a practical programme and provided encouragement at every stage. Mrs Rosemary Bishop and her staff at Frank Bishop Conference Planners, and Mr Alwyn Austen and the staff at Wye College used their considerable experience to muster the delegates and provide the domestic arrangements, which were, I think, thoroughly appreciated. Further thanks are due to the British Crop Protection Council for sponsoring the meeting, especially to Mr Dennis Higgons for advice at critical moments, and to Dr Ken Woodford the Managing Editor for help and technical advice in the production of these proceedings. I should particularly like to thank Professor John Fryer, Chairman of the Weeds Subcommittee of BCPC and Director of the Weed Research Organisation for the personal encouragement that he gave me right from the beginning, and the members of the Weeds Subcommittee for their support. I also wish to thank the speakers for all their trouble in the preparation of their papers in the hope that they will feel that this publication does justice to them. Also to the five Chairmen for so ably conducting the sessions, and to all the delegates who collectively made the meeting a success.

J M WAY

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D R H Price	Anglian Water Authority
W F de Salis	Country Landowners Association
J F B Tew	Ministry of Agriculture Fisheries and Food

CHAIRMEN AND CONTRIBUTORS

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Chairman	I A M Lucas	The Principal, Wye College (University of London)
Speaker	Professor F T Last	Assistant Director, Institute of Terrestrial Ecology
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SESSION 3		
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SESSION 4		
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SESSION 5		
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SESSION 6		
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CONCLUDING STATEMENT

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INTRODUCTION

The Ecology of Management of Vegetation

F. T. Last
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Natural and semi-natural vegetation: what do we mean? I think I can do no better than reiterate what Tansley wrote in 1939 –

> "Over nearly the whole of England we have now only much modified remnants of the original covering of plants that had adjusted itself to the sub-Atlantic climate 2000 years ago; and the same is true of the "Highland zone" of the west and north of the British Isles up to a considerable height on the hills".

Thus, by implication very little of the vegetation can be defined as strictly natural.

> "Nevertheless much of the country is still occupied by communities of native plants, though no longer moulded by "nature" alone . . . . . This form of semi-natural vegetation is joined by a second category . . . . . of communities deliberately initiated by man for his own purposes, but consisting of native plants".

THE RESOURCES

But how extensive are these resources? To answer this question I have resorted to information provided by (i) Callaghan & Jeffers, and (ii) derived from surveys linked to a system of land classification evolved by Bunce. Callaghan & Jeffers (personal communication, 1980) indicated that 92.6% of the land area of Great Britain (England, Scotland and Wales) or 22.6 million ha, could be designated as rural. Of this area 13.5 million ha were regarded as being cultivated with 9.1 million ha having natural and semi-natural vegetation. The latter area, 9.1 million ha, was arranged in 4 subdivisions – (i) rough grazing, 6.6 million ha or 27% of the total land area of Great Britain, (ii) woodland, 0.6 million ha, (iii) inland water, 0.3 million ha and (iv) other semi-natural, 1.6 million ha (Table 1).

While giving a useful overall appraisal of the situation, these figures lack ecological detail. The manager of vegetation needs to know how the different

land-uses are geographically distributed and how they are related to environmental factors. Fortunately these questions can be answered, at least in part, by reference to the system of land classification (or habitat characterisation) which my colleagues in the Institute of Terrestrial Ecology, notably Dr R.G.H. Bunce, have recently devised making use of existing maps concerned with climate, topography and solid and drift geology and to some extent human artefacts (see Bunce & Last, 1981). For the central 1km^2 of each of the 1,228 squares, individually measuring 15km x 15km into which Great Britain was divided, it was possible to obtain, from existing maps, the mean numbers of days with snow falling, the mean daily duration of bright sunshine, maximum elevation, the distances to the south coast (a measure of latitude and associated changes e.g. daylength), the presence of sand, boulder clay . . . . . and many more comparable pieces of information. These were then subjected to Indicator Species Analysis (Hill *et al,* 1975) which successively separated the 1228 squares (15km x 15km) into 2, 4, 8, 16 and 32 land classes, the decisions at each stage of the analysis being reached after considering a range of critical attributes (i.e. polythetic). For instance the first division depends upon (a) numbers of days with snow falling, (b) daily duration of sun, (c) maximum elevation, (d) distance to south coast, (e) height of hill behind and (f) length of minor roads. As can be seen from Fig. 1 land classes 1 to 8 inclusive are mainly, but not exclusively, located in Wales and the southern half of England with land class 1, the most abundant, accounting for 7.2% of Great Britain. Groups 9–16 are located in the Midlands and northern parts of England and Wales, land classes 25–32 are concentrated in Scotland while classes 17–24 range from Dartmoor in the south of England to the Shetland Islands in the north. As is obvious the characterisation of land classes 17–24 is dominated by high altitude which brings together the Welsh mountains, the Pennines of England and the Borders and Highlands of Scotland.

Land class 1, typical of the South downs of England, includes gently rolling country with moderate relief:

> with 93% at altitudes ranging from 0 to 198m, a slope of 3°, a mean minimum January temperature of 0.6 – 2.0°C, a mean number of days on which snow falls of 10–25, and a mean daily duration of bright sunshine of 5.6 – 6.5h.

In contrast Land class 32, typical of bleak and windswept areas of Northern Scotland and the Shetland Islands, has the following characteristics:

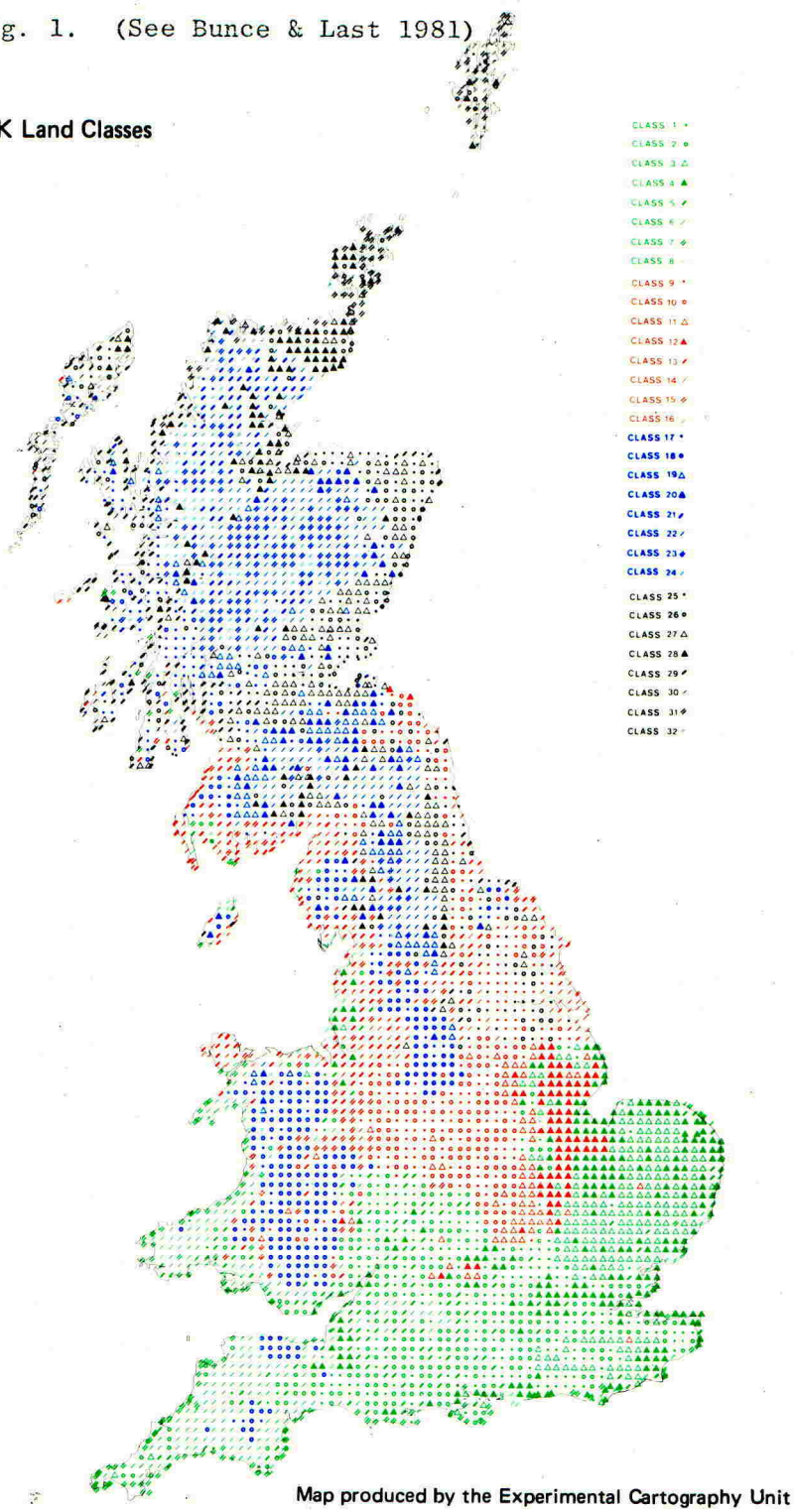
> 69% is at altitudes ranging from 0 to 76m, with a slope of 7°, a mean minimum January temperature of 0.6 –2.0°C, a mean number of days with snow falling of 41–55, and a mean daily duration of bright sunshine of 4.0 – 4.5h.

To enable a vegetation survey to be made, a similar approach was adopted by my colleague Dr Sargent to the classification of British Rail land adjoining the permanent way. Based primarily on altitude, climatic variables and a blend of soil and geological data, she separated 32 classes which were subsequently aggregated to 25 (Fig. 2).

Table 1
Areas in million ha of different land uses in Great Britain (England, Wales, Scotland) (after Callaghan & Jeffers, personal communication, 1980) (Percentages of total area of GB in italic type)

- **TOTAL** 24.4 *(100)*
  - Rural 22.6 *(92.6)*
    - Cultivated 13.5 *(55.3)*
      - Grassland 7.2 *(29.5)*
        - Leys 2.1 *(8.6)*
        - Permanent pasture 5.1 *(20.9)*
      - Arable 4.8 *(19.6)*
        - Cereals 3.7 *(15.1)*
        - Root crops and vegetables 0.7 *(2.8)*
        - Fallow 0.4 *(1.7)*
      - Forest 1.4 *(5.9)*
        - Coniferous 1.4 *(5.8)*
        - Coppice <0.1 *(0.1)*
      - Orchards <0.1 *(0.3)*
    - Natural and semi-natural 9.1 *(37.3)*
      - Rough grazing 6.6 *(27.0)*
      - Woodland 0.6 *(2.5)*
        - Broadleaved 0.3 *(1.3)*
        - Scrub etc 0.3 *(1.2)*
      - Inland water 0.3 *(1.2)*
      - Other semi-natural 1.6 *(6.6)*
  - Urban 1.8 *(7.4)*
    - Amenity 0.5 *(2.1)*
    - Other 1.3 *(5.3)*

Fig. 1. (See Bunce & Last 1981)



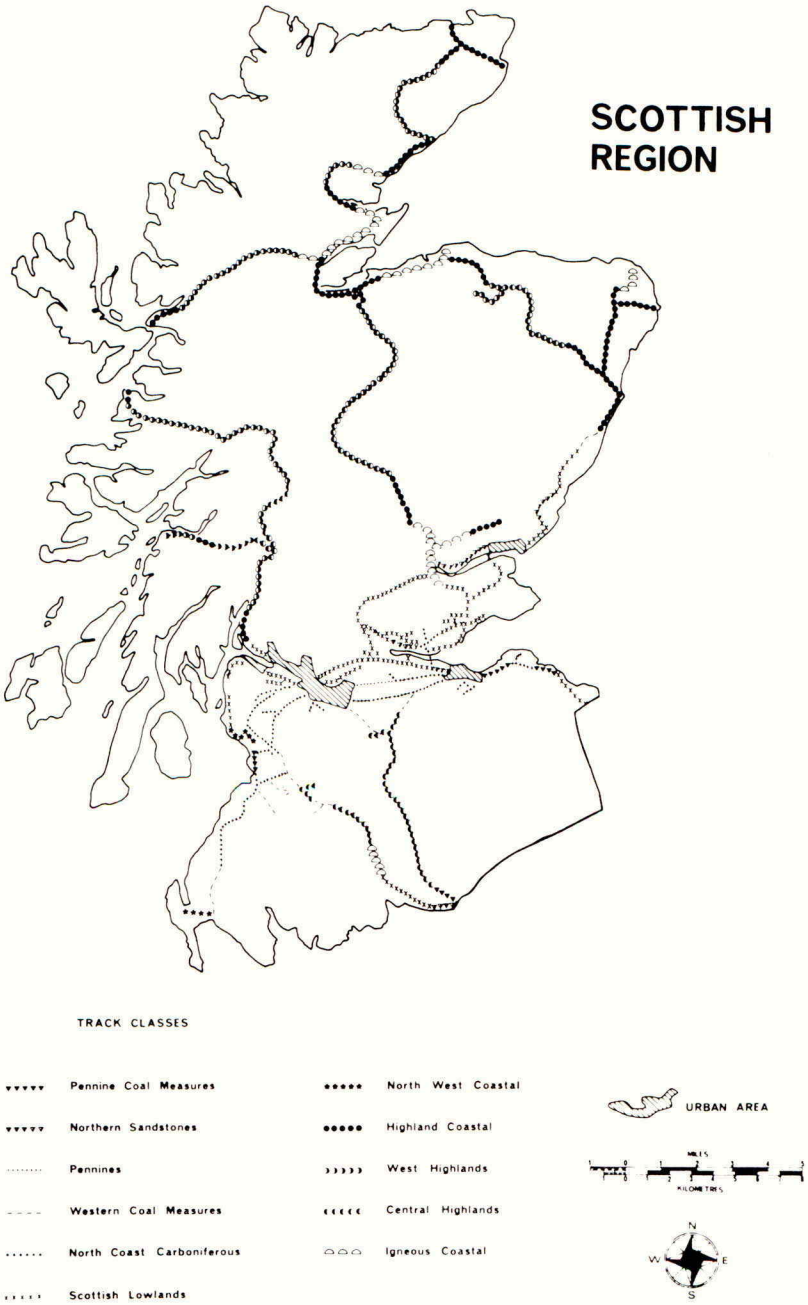


Figure 2. Map showing the location of different habitats, 'track classes', in the Scottish Region of British Rail where 11, of the 25 classes found in the UK, occur (Sargent & Mountford, 1980).

Reverting to the land classification of Great Britain: having divided the country into 32 land classes (or habitats) the next step was to make detailed surveys of randomly chosen replicate squares (1km^2) within each land class. Details were recorded of the occurrence of different breeds of cattle and sheep, of field boundaries, buildings . . . . . and, more importantly for our immediate purposes, the distribution of different soil types and the occurrence of different types of vegetation. Thus we know that 53% of the soils in land class 1 are brown earths, 25% gleys and 15% gleyed brown earths whereas in land class 32 peats are the predominant soils (55%) with the remainder (45%) being more or less equally divided among peaty podsols (8%), gleyed brown earths (8%), brown earths (8%) etc.

Something similar has been done with types of vegetation with, for the purpose of this talk, the 67 categories being arranged in 4 groups –

I Leys and permanent pasture (*Lolium perenne, L multiflorum, Dactylis glomerata,* Hay/silage, *Phleum pratense)*

II Crops (wheat, barley, potatoes, orchards, oil seed rape etc.)

III Woodland ('natural' and man-made, deciduous, coniferous and mixed, shelterbelts and scrub)

IV 'Natural and semi-natural' (*Calluna vulgaris, Pteridium aquilinum, Deschampsia flexuosa, Juncus effusus, Erica tetralix,* herb rich grassland etc.) (Fig. 3).

As can be seen (Fig. 1, Table 2), natural and semi-natural forms of vegetation predominate in the wet and hilly regions of northern Britain, occupying virtually the whole of land class 23 (generally high land with many steep and rocky slopes (North-east Highlands of Scotland)), and being more or less totally absent from land class 3 (almost flat plain with intensive arable farming predominating; some copses and hedgerows but usually few trees (East Anglia and central plains)).

I am very much aware that this contribution could become a catalogue but, with succeeding contributions touching upon 'natural' woodland, hedges and roadside verges, it is perhaps permissible to include estimates of their land occupancy (Tables 3 and 4).

The total areas of broadleaved, coniferous and mixed woodlands, given at the foot of Table 3, differ slightly from the areas estimated by Callaghan & Jeffers, but nevertheless the trends are obvious. Small areas of mixed woodland are sporadically distributed throughout Britain, whereas productive conifers are concentrated in the uplands, wherever they occur, and other locations in north and north-eastern Britain: most of the assemblages of broadleaved trees are found in England and Wales. It will come as no surprise to find that the lengths of hedgerows and roadside verges differ greatly in the different land classes (Table 4). The density of hedgerows (km km^{-2}) seems to be greatest in land classes 6 (South-west of England and Wales), 3 (East Anglia and Central plains) and 9 (Midlands and North Wolds of England) while they are virtually absent from the high, rocky and exposed areas (land classes 19, 21, 22, 23, 24, 29, 30,

Table 2
Proportions of different land uses in the 32 land classes within Great Britain.

Land class	Land class as proportion of total area of Great Britain †	Proportion (%) of the area of each land-class occupied by different vegetation types *			
		Crops	Leys and permanent grass	Woodland	Natural and semi-natural vegetation excluding semi-natural woodland
1	7.2	24	45	2	8
2	5.1	18	30	18	5
3	5.2	64	22	2	0
4	4.8	29	15	0	0
5	3.7	17	30	6	8
6	4.6	17	57	8	2
7	0.8	9	25	3	18
8	0.8	8	17	1	12
9	4.6	29	34	5	3
10	4.5	35	34	10	5
11	1.8	57	22	1	0
12	1.8	68	11	1	0
13	3.0	19	32	3	18
14	1.1	25	16	0	6
15	2.1	27	36	8	9
16	2.2	22	47	2	14
17	6.8	4	56	13	21
18	3.8	0	8	5	69
19	2.2	2	20	26	49
20	2.0	4	41	2	45
21	2.9	0	0	19	77
22	5.9	3	7	35	44
23	3.5	0	0	0	99
24	2.3	0	0	7	80
25	3.9	45	38	2	6
26	3.4	19	42	6	11
27	3.8	29	40	9	9
28	2.7	3	31	9	46
29	1.4	0	1	3	42
30	0.6	0	0	6	78
31	0.6	4	14	1	44
32	1.0	4	11	7	56

† Total land area of Great Britain, 23.3 million ha

* Across the table totals would add to 100% if areas of roads, railways, footpaths, bare rock etc. were included.

Table 3
Distribution (1,000s ha) of broadleaved, coniferous and mixed woodlands in Great Britain as related to land class

Land class	Types of woodland			Land class	Types of woodland		
	Broadleaved	Coniferous	Mixed		Broadleaved	Coniferous	Mixed
1	33	15	1	17	33	172	31
2	95	102	<1	18	7	38	1
3	10	<1	<1	19	<1	138	<1
4	10	<1	<1	20	3	2	1
5	71	30	9	21	6	128	<1
6	39	69	3	22	<1	478	7
7	<1	<1	<1	23	<1	<1	<1
8	2	<1	<1	24	11	36	<1
9	35	39	7	25	<1	<1	1
10	23	58	37	26	4	23	12
11	<1	<1	<1	27	18	82	2
12	11	<1	<1	28	<1	48	4
13	11	17	<1	29	9	5	2
14	1	<1	<1	30	<1	8	<1
15	21	9	24	31	<1	<1	<1
16	16	3	3	32	<1	15	<1

Total areas – c. 470,000ha, broadleaved
1,500,000ha, coniferous
150,000ha, mixed

31 and 32) of Scotland. Overall it is estimated that there are c. 810,000km and 930,000km of hedges and roadside verges occupying c. 160,000ha and 93,000ha or 0.71% and 0.41% of the area of the UK respectively. But, so what? There is virtually no end to the figures that my colleagues and I can generate, some of the estimates being more accurate than others. We could give the botanical details of the different hedgerow assemblages and types of roadside vegetation found in the different land classes and possibly these pieces of information could influence management procedures in predictable ways. But *surely we should be concerned with change?* As is well known the numbers of different species of shrubs and trees are good guides to the ages of hedgerows (Pollard *et al.* 1974).

ATTITUDES TO MANAGEMENT

In the last two or three years it has become only too obvious that we urgently need a *comprehensive method of monitoring our rural environment.* In the increasingly political and sometimes emotive 'field' of atmospheric pollution (including acid rain) we tend to deduce what occurs in rural areas from concentrations of pollutants measured in towns and cities – a less than desirable

Figure 3. Distribution of vegetation, natural and man-made, in Great Britain (Lawson & Callaghan, personal communication).

Table 4
Lengths and areas of hedgerows and roadside verges in different land classes within Great Britain

		Hedges			Verges		
Land class	No. km^2 in GB	Mean length (km)/km^2	Predicted total length (km)	Predicted total (ha) area	Mean length (km)/km^2	Predicted total length (km)	Predicted total (ha) area
1	16875	5.74	96863	19373	5.25	88590	8859
2	11970	3.94	47162	9432	5.50	65835	6584
3	12240	8.06	98654	19731	7.75	94860	9486
4	11379	2.28	25944	5189	2.50	28448	2845
5	8550	3.04	25992	5198	5.50	47025	4703
6	10845	10.61	115065	23013	7.25	78626	7863
7	1755	2.81	4932	986	3.50	6143	614
8	1901	1.20	2281	456	3.75	7129	713
9	10755	6.50	69908	13982	4.00	43020	4302
10	10440	4.87	50843	10169	6.00	62640	6264
11	4320	5.71	24667	4933	7.50	32400	3240
12	4230	5.13	21700	4340	4.25	17978	1798
13	7020	5.22	36644	7329	4.25	29835	2984
14	2538	2.37	6015	1203	3.75	9518	952
15	4815	5.05	24099	4820	5.75	27686	2769
16	5040	4.41	22226	4445	4.50	22680	2268
17	15750	4.43	69773	13955	2.00	31500	3150
18	8865	0.13	1152	230	1.50	13300	1330
19	5130	0.00	0	0	2.50	12825	1283
20	4590	0.02	92	18	3.75	17213	1721
21	6660	0.00	0	0	0.00	0	0
22	13680	0.00	0	0	0.50	6840	684
23	8235	0.00	0	0	0.00	0	0
24	5310	0.00	0	0	1.00	5310	531
25	9090	2.84	25816	5163	5.00	45450	4545
26	7830	2.91	22785	4557	9.25	72428	7243
27	8910	1.03	9177	1835	4.75	42323	4232
28	6210	1.00	6210	1242	2.75	17078	1708
29	3326	0.00	0	0	1.00	3326	333
30	1490	0.00	0	0	0.50	745	75
31	1332	0.00	0	0	0.50	666	67
32	2226	0.00	0	0	1.50	3339	334
Totals (rounded to 2 significant figures)			810000	160000		930000	93000

situation which, as far as acid rain is concerned, has been corrected by the establishment of a rural network of rain collectors in northern Britain. But we shouldn't adopt a restricted definition of "rural environment". We should be broadly concerned with changes in all forms of land-use. I suggest that repeated total enumerations of the replicate squares, 1km^2, already surveyed by Bunce and his colleagues, at intervals of 3, 4, 5 (?) years might effectively provide indicators of change enabling us to set events in land classes 1, 2, 3 . . . . against the overall perspective of Great Britain – we would be in a position to consider the implications of change. We are all aware of the continuing loss of hedgerows and the consequent depletion of wildlife habitat but how many of us appreciate that there has been a 30% loss of broadleaved woodlands in Scotland in the period from 1945 to 1975 (Parr, 1981) – we have been concerned with local details, tactics, rather than strategy; we have also been overridingly concerned with the *meritorious*, namely Nature Conservation Review grades 1 and 2, rather than the *ordinary*.

As a forester wishing to ensure that scientifically interesting assemblages are retained, as a tree improver concerned with the conservation of genetic resources and as a member of Society concerned with the maintenance of landscape, I question whether we always use the full range of arbiters for deciding what should or shouldn't be protected. We rightly get "worked-up" about the retention of sites graded highly in the Nature Conservation Review while accepting, often without demur, the loss of sites less prized in a strict conservation sense, but which in reality may have a much bigger landscape, aesthetic impact. But "Rome was not built in a day". However I think that it is now important to increasingly stress the value of the ordinary without minimizing the importance of conserving sites graded 1 or 2.

With Tansley's definitions of natural and semi-natural vegetation in mind, our attention usually first turns, when we are concerned with aspects of management, to nature conservation. In the *Nature Conservation Review* (Ratcliffe, 1977), it is indicated that –

> "Nature conservation in Britain should centre around the safeguarding, through statutory scheduling and appropriate control and management, of a fairly large number of key areas representing all major natural and semi-natural examples of important habitats with their characteristic and carefully selected communities of plants and animals".

Later on I want to refer to the distinction between conservation and preservation, but for the present I wish to press two points, one, the truthful statement made in the Review *viz.* that the Review relates to the intrinsic scientific or nature conservation interest of *known* sites and second, the early emphasis on the designated conservation of sites in the top two (1 and 2) of 6 grades. With the powers incorporated in the newly enacted Wildlife and Countryside Act (1981), it is hoped that the genuine inclinations of conservationists to embrace the "ordinary" in addition to the "meritorious", so safeguarding landscape, will be expressed.

In the Conservation Review, nine criteria are listed as guides to site selection – extent, diversity, naturalness, rarity, fragility, "representativeness", recorded history, position in an ecological/geographical unit and potential value. But what should be the objectives of conservation? Shouldn't there be an explicit reference to the conservation of genetic resources and in particular the range of variation within-species – the course of British agriculture and horticulture would have been vastly different had the wild sources of our domesticated plants, mainly originating from Mediterranean environments, not been available to us. Does our method of designating National Nature Reserves and Sites of Special Scientific Interest give us adequate 'cover' – I'm sure the answer is likely to prove to be "no". In the meantime it is desirable to extend our knowledge of ecotypic variation highlighted by the observations made on heather (*Calluna vulgaris*) by Grant & Hunter (1962) and Bannister (1978), and the common salt-marsh grass *Puccinellia maritima* by Gray & Scott (1980). When grown together (collaterally), heather from northern sites flowered sooner than plants from more southerly locations; collections of common salt-marsh grass from the west, of both Scotland and England, grew less than those from the east while Scottish populations produced plants with larger proportions of flowering tillers than English plants. Is it conceivable that ecotypic differences exist between silver birches (*Betula pendula*) growing in land class 2 (Long rounded slopes particularly associated with the chalk downs of south east England) and land class 22 (Rounded moorland hills of the Southern Uplands of Scotland)?

How do you as managers select your plants? Do you ever consciously think of their growth strategies, their responses to stress, disturbance and competitive exclusion (Grime, 1979)?

Although I suspect that most of you are practical managers I wonder if you have ever stopped to think about the relevance of nucleic acids, which your biologically inclined schoolchildren will know about, to the different plants that you manage, recognising that nucleic acids fundamentally control plant form and function. We tend to think of our plants as being annuals or perennials, members of the Ranunculaceae or Compositae but additionally it seems that we could classify them by the sizes of their nuclei, plants such as bluebell (*Endymion non-scriptus*), creeping buttercup (*Ranunculus repens*), sweet vernal-grass (*Anthoxanthum odoratum*), which start shoot expansion early in the season (March/April), having large amounts of nucleic acids whereas those starting late in the season (June) e.g. birdsfoot-trefoil (*Lotus corniculatus*), butterbur (*Petasites hybridus*) and rosebay willow-herb (*Chamaenerion angustifolium*), have small amounts. What is the ecological significance of these differing amounts of nucleic acid? Large amounts (= large genomes) seem to be associated with the capacity for early and rapid expansion of relatively short-lived shoots, formed in cold weather, whereas small amounts are associated with plants whose entire growth is more or less restricted to the summer season (Grime & Mowforth, 1982). For the future we may identify different populations of the same species by the amounts of nucleic acids within their nuclei.

VEGETATION DYNAMICS AND THE TOOLS OF MANAGEMENT

At this stage I would like to revert to the objectives of management: are they concerned with maintaining the *status quo* (preservation) or should they be aligned to conservation, always accepting that doing nothing could be a perfectly acceptable approach to management in some circumstances. But we shouldn't imagine that things will stand still. I would like to refer to the study of a detached part of the Salisbury Plain, namely the Porton Ranges on the Hampshire/Wiltshire border (Wells *et al.* 1976).

Table 5
Indicator plant species in chalk grasslands of different ages (after Wells et al. 1976)

Indicators characteristic of chalk grasslands less than 50 years old	Indicators characteristic of chalk grasslands more than 130 years old
Arrhenatherum elatius (Oat-grass)	*Asperula cyanchica* (Squinacy wort)
Acinos arvensis (Basil-thyme)	*Carex caryophyllea* (Spring sedge)
Anthyllis vulneraria (Kidney-vetch)	*Filipendula vulgaris* (Dropwort)
Agrimonia eupatoria (Common agrimony)	*Helianthemum chamaecistus* (Common rockrose)
Cerastium arvense (Field mouse-ear chickweed)	*Helictotrichon pratense* (Meadow oat)
Linaria vulgaris (Toadflax)	*Pimpinella saxifraga* (Burnet saxifrage)
Pastinaca sativa (Wild parsnip)	*Polygala vulgaris* (Common milkwort)
Potentilla reptans (Creeping cinquefoil)	
Silene vulgaris (Bladder campion)	
Vicia cracca (Tufted vetch)	
Vicia hirsuta (Hairy tare)	
Vicia sativa (Common vetch)	

It is part of the largest block of semi-natural vegetation in southern England, namely 16,190ha of chalk grassland, and was the focus of an important historical investigation of vegetation changes. By studying the Tithe Commutation Surveys (c. 1840), the Ordnance Survey of 1856/85, the Land Utilization Survey of the 1930s and other records, Wells *et al.* were able to identify the dates when different parts of the Porton Ranges were last cultivated. With this information, and records of the floristic composition of the different areas of grassland, they have been able to identify the successional stages in undisturbed chalk grassland listing 12 species that were characteristic of chalk grasslands less than 50 years-old, whose frequency thereafter declined, while 7 other species started to appear in grasslands more than 50 years-old (Table 5). In considering the management of the different assemblages within the Porton Ranges, do we wish to allow the 'young' grasslands to mature and if we do, are we taking steps to ensure that other new areas, which would not, in themselves, be considered to be particularly meritorious, are brought into the succession? On the other hand is it our declared intention to maintain the present *status quo,* preservation? But in either instance do we know sufficient to achieve our

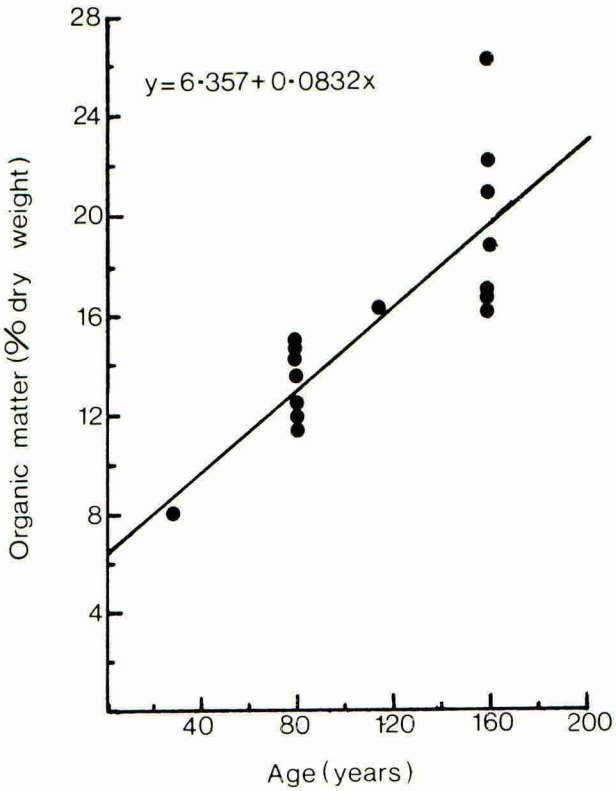


Figure 4. Mean percentage organic matter in the 0–10cm depth from chalk soils on seventeen transects on the Porton Ranges plotted against mean age of grassland (Wells *et al.* 1976).

declared objectives? In the time available to me I cannot possibly deal at length with plant succession but I would however like to reflect on the schematic relationship proposed by Wells *et al.* for the Porton Ranges (Fig. 5). Plant succession depends upon complex interrelationships in which soil nutrients have a major influence. As inferred in their scheme, nutrients progressively accumulate as swards get older. Wells and his colleagues found the proportion of soil organic matter was larger in old, than in young, grasslands (Fig. 4), the mean annual increment, 0.08%, being similar to that in chernozems (Kononova, 1966), but larger than that in Broadbalk wilderness at Rothamsted (Jenkinson, 1971). Further, Wells *et al.* found that the rankings of soil organic matter and an NPK index were directly proportional. Are these changes 'driving' the succession of plant assemblages or *vice versa*, a matter of great importance if we wish to preserve existing assemblages. What is the role of ants; although *Lasius flavus* feeds largely on aphids and coccids colonising foliage can we be sure that they are not 'driving' the plant succession? 14–16 ant mounds

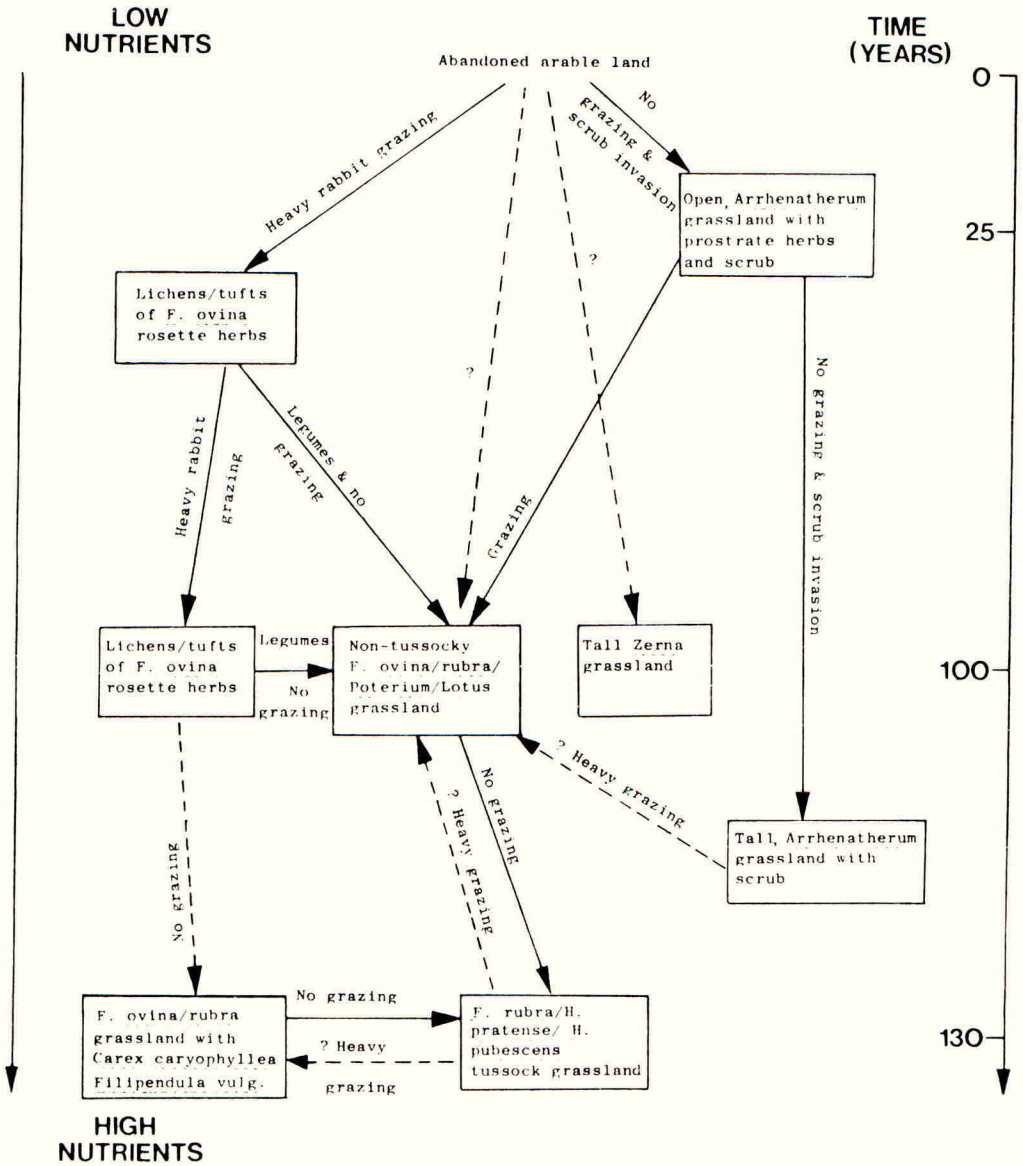


Figure 5. Schematic summary of the relationship between chalk grassland-types, management and soil nutrients (Wells *et al.* 1976).

per $6m^2$ were found in grasslands more than 100 years-old; <1 per $6m^2$ were recorded in grasslands less than 50 years-old. In addition to nutritional factors, the species composition of plant assemblages was strongly dictated by the activities of herbivores (primarily rabbits). Thus, open *Arrhenatherum elatius* grassland with prostrate herbs and scrub "progressed" to non-tussocky *Festuca ovina/F. rubra/Poterium sanguisorba/Lotus corniculatus* grassland if grazed,

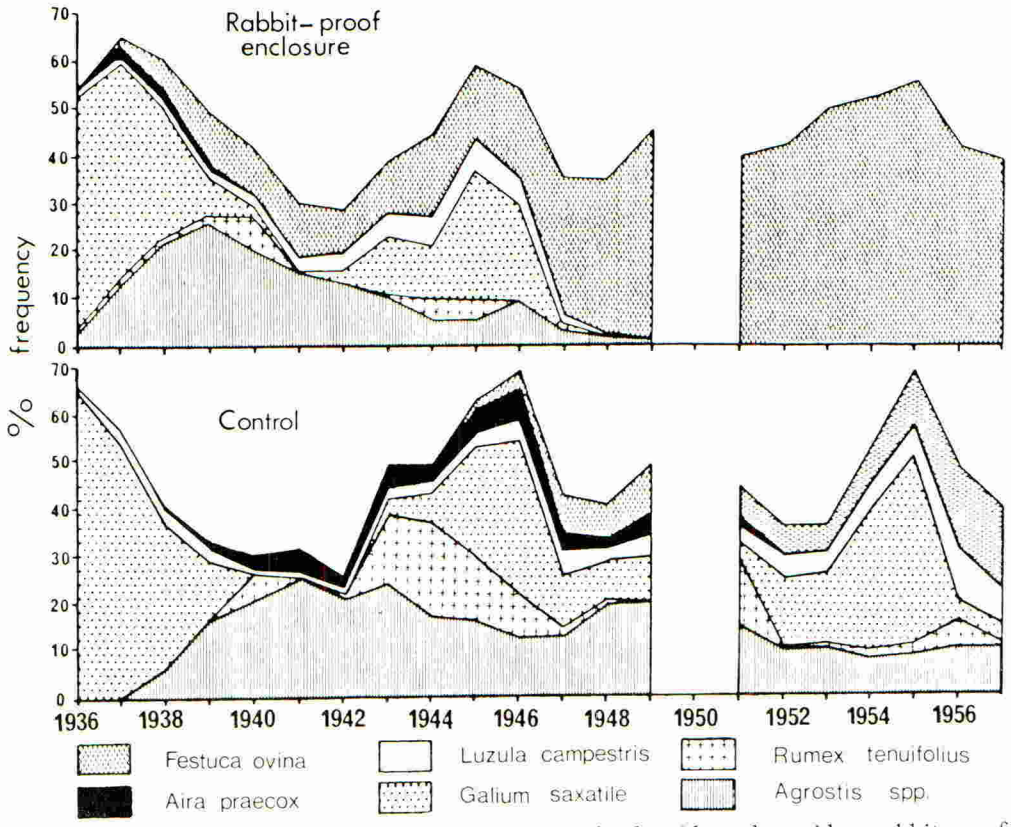


Figure 6. Changes in species composition of a grassland inside and outside a rabbit-proof enclosure in the English Breckland (Watt, 1960).

and to tall *Arrhenatherum elatius* grassland with scrub when herbivores were absent. Significantly most of the young stands of juniper (*Juniperus communis*) have developed since the outbreak of myxomatosis in 1954.

Despite the evidence for the effects of grazing I still think that we are reluctant to accept that herbivores play a probably overridingly important role in fashioning our vegetation. Most of us are aware of the classic set of circumstances described by Watt (1960) when an area of the English Breckland was protected from the damage done by rabbits. The exclusion of rabbits very soon favoured the build-up of *Festuca ovina* to the more or less virtual exclusion, within 12 years, of all other plant species. Watt's observations also served another purpose, namely to highlight the annual variations with strong seasonal differences in the amounts of *Aira praecox, Galium saxatile* and *Rumex tenuifolius* (Fig. 6).

As a forester I might be expected to say a few words about the impact of grazing by deer and squirrels on the growth and regeneration of our native woodlands. However, I can't attempt to be comprehensive and for this reason I have decided to turn instead to the management of unenclosed rough grazings

for hill sheep, viz. blanket bog (*Calluna/Eriophorum/Trichophorum*), dwarf shrub heath (*Calluna*), grass heath (*Nardus/Molinia/Deschampsia*) and acid grassland (*Agrostis/Festuca*), all of which have strongly seasonal cycles of production with 75% of their annual biomasses being produced in 6 – 8 weeks in the early part of the growing season (Newbould, 1981). While I might wish to argue that the land occupied by these assemblages might be advantageously converted to the production of timber, my colleagues at the Hill Farming Research Organisation would wish to press the argument in favour of sheep (Newbould, 1981).

> "Many tonnes of utilizable dry matter are available in a relatively disease-free environment on relatively cheap land of which significant parts are improvable . . . . . In fact if all available knowledge was applied, one is led to believe that the major limitations to overall production are not climate, plant species and soil fertility but the availability of expanding markets" (Cunningham, 1980).

But what is the available knowledge that is not being applied fully? It is the need to establish improved areas of grass to provide the quality of feed to ensure that the nutritional requirements (i) of ewes during lactation and (ii) for body weight recovery during the summer, are met. But this recommendation doesn't lessen the need to rigorously manage the rough grazings. It is well known that recently burned patches of moor, bog or heath are grazed in preference to unburnt vegetation. However, if the burnt area is too small, grazing pressures may become too intense with subsequent irreparable damage. Similarly if the heather is too old when burnt it may be killed, being substituted by purple moor grass (*Molinia caerulea*) and deer-grass (*Trichophorum cespitosum*) which, because they die-back in the autumn, don't provide winter grazing. Obviously there is a delicate balance to be observed regarding the frequency of burning and the mosaics of burnt and unburnt heather in relation to each other and to reseeded areas, remembering that heather, but not reseeded grass, provides sheep with their essential trace elements, notably cobalt.

I don't think that I can overemphasize the role of grazing or simulated grazing as a management tool – it can have, however, some surprising side-effects which are worth mentioning as they have an impact on the cycling of nutrients. In recent years there has been a move to add white clover to improved grass swards. If, however, these swards are frequently defoliated to less than 3cm above ground, nitrogen fixation, by legume nodule bacteria, is greatly curtailed with roots and nodules simultaneously disintegrating with the release of 'nodule' nitrogen (Chu & Robertson, 1974). On the other hand 'moderate' defoliation (infrequent, with herbage cut to no less than 5cm) favours the clover component of the sward, the greater amounts of available light maximising clover productivity.

Having described the resource of natural and semi-natural vegetation it seems ironic that I, a forester by adoption, should be asked to consider its management, foresters being the main consumers of natural/semi-natural vegetation.

Why not afforest it? A glib suggestion but one that gives me an opportunity to stress the potential importance of atmospheric pollution when considering land management. In 1980, Harriman and Morrison found, in minicatchments in the head waters of the River Forth, that streams draining areas afforested with Sitka spruce (*Picea sitchensis*) were more acid than those from unafforested minicatchments (Fig. 7) with amounts of aluminium (200μg l^{-1}) and manganese (90μg l^{-1}) being doubled. Interestingly this effect on water quality, which didn't appear for some years after site preparation and planting, has been associated with a decrease in the diversity of benthic invertebrates, particularly mayflies, but not their biomass. Elsewhere a diminuition in plant diversity has been observed with effects on phytoplankton, mosses and aquatic macrophytes. Further, and very importantly, fish are no longer to be found in the acidified streams, a story very reminiscent to those of us familiar with the acid rain story in Scandinavia and North America (Last, 1982). While many steps in the jigsaw remain to be solved, it seems that evergreen conifers are efficient concentrators or pollutants. At a site not more than 80km from that studied by Harriman and Morrison, Nicholson and his colleagues (1980) found, in a stand of Scots pine (*Pinus sylvestris*) that the average pH of throughfall was 3.7 compared with 4.2 for incident rain, a x3 increase in acidity; in stemflow the pH was 3.3, an increase of x8. Acid rain is not a local problem – it is widespread. We know that rain on the eastern seaboard of Scotland is more acid (pH 4.2, 60μ equiv. H^+ l^{-1}) than that on the north-west (pH 4.7, 20μ equiv. H^+ l^{-1}) (Fowler *et al.* 1982). Our records for England and Wales are less complete (Barrett *et al.* 1982) but we shouldn't be carried away by a consideration of pH *per se.* Instead it seems that quantities of hydrogen ions deposited (Kg H^+ ha^{-1}) are of more significance. Thus, by integrating pH and amounts of rain, it seems that the largest H^+ inputs are received in parts of Cumbria (the Lake District) and the Southern Uplands and West Central Highlands of Scotland. This being so, it may become desirable to question the appropriateness of afforestation in those localities where acid rain is falling on inherently acid soils, a decision that would have obvious relevance to the management of rough grazings, heather moorland and freshwater ecosystems. Setting aside this 'special case' the management of aquatic plants is primarily concerned to ensure the efficiency of systems of land drainage with the removal of excessive, but not the total elimination of, plants from ditches and rivers. It is desirable to manage aquatic weeds to ensure effective drainage while maintaining habitat for aquatic animals, notably fish. It is essential to avoid the pitfall of creating deleterious decreases in oxygen concentrations and for this reason the recent development of spot herbicide treatments with diquat formulated with 3% alginate is to be encouraged (Barrett, 1981). Although we have had local problems with the introduced Canadian pondweek (*Elodea canadensis*), they have never reached the intensity of that posed by water hyacinth (*Eichornia crassipes*) in tropical and sub-tropical regions. In those regions a great deal of effort is being devoted to methods of biologically controlling water hyacinth, alligatorweed (*Alternanthera philoxeroides*) and others using fungal pathogens

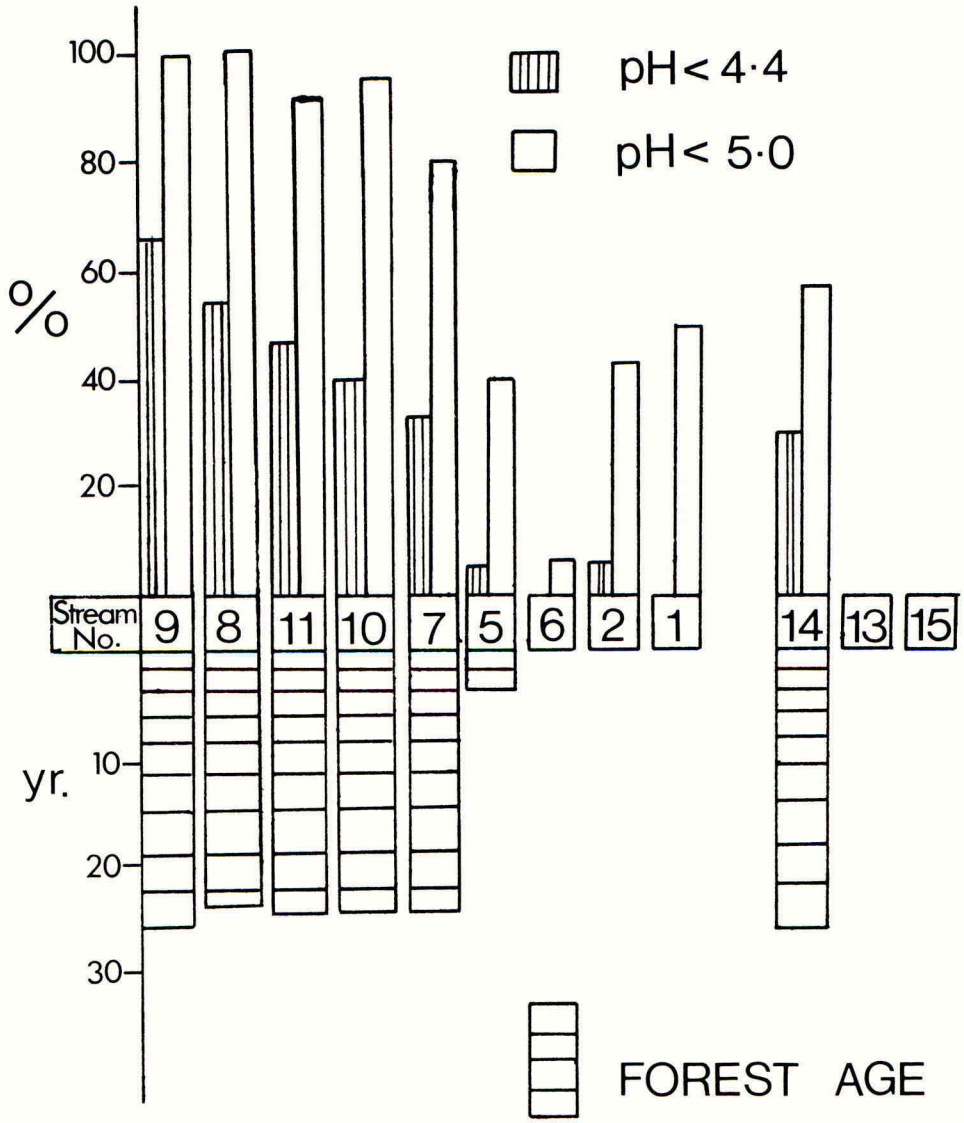


Figure 7. Relation between pH of freshwater streams and age of adjacent Sitka spruce plantations in minicatchments in the Duchray and Loch Chon catchments (Harriman & Morrison, 1980). (Annual deposition of hydrogen ions 0.6–0.8kg ha^{-1}).

(see Last, 1981) whereas interest in biological agents of weed control in Britain are centred on the possible exploitation of the grass carp (*Ctenopharyngodon idella*). By being herbivorous this fish can fill an unoccupied niche in British freshwater ecosystems, presumably with the minimum of disturbance (Robson, 1977).

Nobody today can be unaware of the "energy crisis". Are there ways in which natural and semi-natural vegetation can be managed to contribute to our supplies of energy without drastically changing the landscape? Desk studies and field experiments done by colleagues at Merlewood Research Station (Callaghan *et al.* 1978, 1981*b* and Lawson *et al.* 1980) suggest that bracken (*Pteridium aquilinum*) could become a natural energy crop. "It occurs over much of Great Britain; it gives large yields of dry matter in generally poor environments; it could be harvested immediately without costly cultivation and its harvesting would not significantly alter the use, amenity value, conservation role and landscape quality of the areas where it currently occurs". Very little is known about the longterm stability of bracken yields when subject to different harvesting regimes. Delaying harvest from summer to autumn is likely to decrease biomass yields from 9t (dry matter) ha^{-1} to 4.7 to 7.9t ha^{-1}; on the other hand it is likely to greatly decrease the removal of N, P and K whose tissue concentrations are maximal in the summer (Callaghan *et al.* 1981*a*). *A priori* it would seem, therefore, that summer harvesting would lead to ultimate extinction if for no other reason than nutrient exhaustion. In contrast harvests in the autumn are likely to ensure that the resource would be maintained. But, of course, the different harvest dates would yield materials of different sorts, the senescent material harvested in the autumn would probably be burnt directly or gassified to methanol whereas biomass harvested in summer would be digested anaerobically. Thus management practices, in this instance dates of harvest, are likely to have profound effects on the selection of conversion processes.

To some, this may seem fanciful, but is it, or will it be, in years to come – WASTE NOT, WANT NOT. Callaghan and his colleagues (1981*a*) made the following calculations for a northern farm measuring 100ha (Table 6).

Of course all sorts of criticisms can be thrown at these figures, but can we truthfully say that we have considered all the options available to us. Remember that there are 3,200km^2 of bracken in Britain not to mention the area of heather. Can they, or part of them, be used to minimize the energy problem in some districts of Britain without endangering or radically altering the landscape. Is it conceivable that attempts to sustain bracken yields for energy conversion are likely to be more rewarding than pasture improvements by its elimination. If not today, how about 5 years hence? Are there other candidate species?

At the beginning of this paper I referred to Tansley's definitions of semi-natural vegetation including "communities deliberately initiated by man for his own purposes, but consisting of native plants". With interest heightened by the inexorable decline in floristically rich and attractive grasslands, there has been recent interest in enriching newly formed grasslands. As is apparent there are

Table 6
Possible energy yields from the natural vegetation of a 100ha farm in northern Britain (Callaghan et al. 1981a)

	Area (ha)	Yield (t/ha)	Energy (TJ)	
Energy yield				
Dense bracken	20.7	8	3.48	
Sparse bracken	5.6	2	0.24	
Heather	17.2	1	0.31	
Scrub	9.2	5	0.83	4.86
Less				
Harvesting energy (300MJ/ha)			0.03	
50% conversion inefficiency			2.43	2.46
Net energy yield				2.40
Energy use on cattle and sheep farm (Fuel and electricity at 7.65GJ/ha)				0.36
Percentage energy self sufficiency				670%

many opportunities, for example the grasslands sown specifically for amenity in Country Parks, the verges of motorways and other roads, the areas requiring vegetation to ensure soil stability. Many of these opportunities have, however, been missed either by default or because the specialist amenity market was not considered sufficient to warrant the inputs needed to ensure dependable supplies of seeds. Times, however, are changing. Wells *et al.* (1981) enumerated the following criteria for species that may be considered:

i They should be regular members of grassland communities.
ii They should not be rare.
iii They should be relatively abundant in a variety of grasslands and preferably have a wide distribution in the British Isles.
iv They should be perennial, preferably long lived and with an effective means of vegetative spread.
v A high proportion of the species used should have colourful flowers, and these should preferably also be attractive to insects.
vi Highly competitive and invasive species, known to form single-species stands in the wild, are to be avoided e.g. *Brachypodium pinnatum*, 'Heath false-brome'.
vii Seed of these species should germinate readily over a range of temperatures and without special treatments to break dormancy.

Wells and his colleagues were also very much aware of the need to avoid tall growing species that might obscure roadside sighting lines. In the event their work has encouraged the development of many mixtures including, among others:

Anthyllis vulneraria (Kidney-vetch),
Chrysanthemum leucanthemum (Marguerite),
Galium verum (Lady's Bedstraw),
Hippocrepis comosa (Horse-shoe Vetch),
Lotus corniculatus (Birdsfoot-trefoil),
Lychnis flos-cuculi (Ragged Robin)
Primula veris (Cowslip).

Development has been rapid during the last few years with the requirement for a nurse crop being identified, for example Westerwolds rye-grass (a form of *Lolium multiflorum*) which germinates quickly and then dies back to allow the other sown species to establish themselves. Mixtures for different soil types e.g. heavy clay, limestone and alluvial, have been detailed but much remains to be done to increase precision and predictability. How should management practices be evolved to minimize the element of undesirable plant competition; are some species more difficult to handle than others, etc.? Is it possible that the future exploitation of short-herb mixes will parallel recent developments in agriculture where permanent (*Fustuca rubra/Agrostis* spp./*Poa* spp.) grassland has been enriched (in terms of quantity and quality (digestibility)) by the introduction of seed of perennial ryegrass (*Lolium perenne*) cv. Melle using a slot seeder (see Haggar & Squires, 1979 and 1982)? Would such a technique be appropriate for the introduction of short-herbs into amenity grasslands – a possibly fertile field for future experimental work bringing together agricultural developments and amenity interests. The possibility of tackling comparative studies with the agricultural white clover and the amenity birdsfoot trefoil, also a legume, appears attractive.

CONCLUDING REMARKS

Recognising that many of the succeeding contributions would deal in detail with the management of specific types of habitat I decided to range widely, choosing examples that illustrate many of the interacting facets that should be considered by managers. Essentially *ecosystems*, unless they refer to climax vegetation, *are dynamic* – it is "un-natural" for successions to be halted. In thinking about the role played by grazing or simulated grazing, when used as a management tool, reference was made to effects on the (i) *cycling of nutrients* and (ii) *competition between plant species.*

Based upon a series of land classes which reflect different ecological niches, the nature of the resource of natural and semi-natural vegetation has been elucidated. Although an enumeration of different land-uses linked with the distinctive environmental characteristics of different land classes is of value, this value would be greatly enhanced if *enumerations were to be repeated* at intervals so as to assess change. Such an approach would fulfil one of our major requirements, namely a *system of rural monitoring.*

In the past, attention has been focussed on the conservation of 'meritorious' examples of different plant assemblages; to ensure that our landscape is conserved it is recommended that more *attention* is *devoted* to the *'ordinary'*. The *conservation of genetic resources*, particularly within-species variants, should be an overt objective.

The management of natural and semi-natural vegetation does not preclude the *judicious exploitation of native plant species*. There is evidence to suggest that bracken could be a locally useful source of fuel, while many species of short-herbs could, with advantage, be sown to provide colour where the value of the sward is not judged by the yield of nutritious foliage.

In conclusion I would like to leave a series of keywords which should help to focus attention upon important facets of the management of natural and semi-natural vegetation – *resource, monitoring the rural environment, management objectives, temporal changes, competition, growth strategies, plant nutrition, grazing, energy* and *species diversity*.

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ESTATE MANAGEMENT and ECONOMICS

General Requirements for the Management of Vegetation

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I speak to you today as a Chartered Surveyor who has been associated with the management of large country estates for some 25 years or so. I have been concerned with the management of the large estate or the large farm, generally in the ownership of an individual or Trust although latterly I have been associated with the management of in-hand farms in the ownership of the Institution or Pension Fund.

It is axiomatic therefore that I must speak to you as an Agent for the private owner or major landowner. I cannot speak for the Statutory Authority or Government Agency, many of whom exercise control over large tracts of land. Nor indeed can I speak for the conservation lobby because I have no experience in serving those organisations other than in the field of negotiation for rights over a private estate.

In endeavouring to establish the general requirements for the management of vegetation there must at times be conflict between the owner and the conservationist. Interests are diverse and objectives varied. The art of compromise must prevail. It is on the problems of trying to reconcile these views that I address you today.

In the first instance let us consider the requirements of the landowner himself. He or she will have acquired the land by inheritance, gift or purchase. The unimproved grazings, meadows, dykes or ground cover will inevitably form part of a larger and much more intensively managed unit. Unless the owner is affluent or philanthropic, he will inevitably look for some sort of a realistic return from his property. Furthermore, the pressures to secure a return will be onerous, costs in all enterprises on the estate will have escalated, inflation will have taken it's toll and we have not seen a similar increase in terms of income.

On the contrary, the returns from the forestry enterprise at the present time are extremely low, margins on livestock enterprises have been squeezed, the returns from arable farming have been reduced and returns from House Showing (where applicable) appear to be in decline. Thus, it is not difficult to see that the large landowner has been under pressure to utilize all his resources to the full.

Let us now consider the requirements of the conservationist. He or she will be anxious to conserve and to effect management to preserve the natural vegetation of unimproved grazings, meadows, vegetation and so forth. This anxiety will not be subject to the pressures of a requirement to balance the books or to hold a property intact without recourse to sales for capital monies. The disciplines will be very straightforward, namely to preserve and conserve land with it's natural vegetation – not for the conservationist the problems of taxation or the problems of the maintenance of the whole estate.

The requirements are indeed diverse for if we are effectively to secure a successful management of natural vegetation then there has to be a meeting of the ways and an acceptance of, and respect for, the wishes of both parties. Fortuitously in different ways all parties share an inherent love of the countryside, a respect for stewardship and a desire to improve the heritage for the next generation. There are exceptions but I think the majority would accept my premise.

What are the general management requirements? In the first instance we must identify the parcels of land. In so doing we must be quite clear as to the area to be preserved, the reasons for the preservation and agreement as to the special dictates of management required. It is important in designating areas that owners are aware of the special needs of management and the need for conservation. Owners object most strongly to large tracts of land being designated as areas where normal commercial management is not acceptable and their own powers are restrained. In an age where preservation and conservation have become so cherished excessive zeal in requirements for conservation has done much to hinder the relationship between the landowner, the farmer and the conservationist. Better that a smaller area be managed well after a full and adequate discussion with the owner rather than to see conflict and subsequent neglect of management over the larger area. Goodwill on both sides will achieve so much. Identification of parcels of land be they hedgerows, unimproved grazings or dykes is therefore of paramount importance.

I would make a plea for understanding. Here I am looking for an acceptance and respect of the owners position and that of the conservationist. It is important that an owner should be made aware of the necessity to employ special managerial skills to particular areas of his property. The advantages of such a management application will not always be of immediate or financial benefit to the owner but the longer term benefit to the estate and countryside in particular will be immense. Owners will respond just so long as they feel that the demands of such a management are not unreasonable and that there are very special reasons for the management of these unimproved areas. The conservationist or advisor will in turn have to accept and respect that the owners and occupiers of land must make a living, that unimproved grazings or similar make little or no direct contribution to the estate or farm. However, with a measure of understanding on both sides I feel that an agreement by way of a compromise will be achieved.

In areas of unimproved grazings or herbaceous and woody vegetation the flora or fauna, particularly if there are rare species, might well be of interest to the general public. Access is therefore of prime importance. Information irresponsibly relayed to the media might well result in large numbers of people visiting a site and the management of an area of natural vegetation can be damaged or destroyed in a very short time. Natural vegetation lends itself to a habitation by wildlife and nothing is gained by over-promotion in the media. Owners do not welcome hoards of people visiting their estates or farms and the control of access is a major consideration.

I would suggest that if these areas are to be managed and preserved effectively it is essential that the owner should seek advice on techniques of management. Objectives of that management will have to be defined. The management of the unimproved areas must be reconciled with the more intensively managed parts of the estate. Management of the unimproved areas will be equally demanding and will exercise disciplines of techniques beyond the normal management of the estate or farm.

The staff on the estate or farm must be aware of the management needs of the hedgerows and unimproved vegetation. The requirements of such areas must be fully explained. In a similar way staff must be advised that treading with vehicles or the poaching of land by livestock can cause considerable damage. Ill considered drainage schemes on adjacent land may well affect the natural vegetation of unimproved grazing or woodland. The misuse of fertilisers and sprays on adjacent land may well occasion irreparable damage to such areas. For instance drift from spray applicators in high winds can be a major problem.

If the staff are made aware of the problems they will usually respond. There is no doubt that the management of such areas will occasion difficulties. Communication and education are of major importance. I recall one estate on which I enjoyed management responsibilities and which enjoyed at one time a good reputation for a partridge shoot: the property was well endowed with grass banks either side of the numerous roads. In an effort to improve the shooting we adopted a policy of not cutting the grass banks until after harvest and no sprays were utilized in close proximity to the banks. The net result was that the partridge shooting improved, but only to a degree, we had a proliferation of well grassed banks with an abundance of wild flowers and weeds and worst of all an encroachment into the fields of sterile brome! So much for the management.

I would suggest that the management should be monitored. Nothing will be achieved by ignoring these particular areas. Regular inspections should be made to see that fences are in good order, hedges cut as required, ditches cleaned and maintained and the areas generally meeting the objectives of management. Regular meetings of all parties will help – there is a constant and ongoing requirement for monitoring management.

However we must ask just what are the objectives of management: the owner of the large farm or estate will be looking for a return from the intensively

managed part of the estate and, subject to the adequacy of that return, may well be prepared to accept that other parts of the estate will contribute little or nothing to the profit and loss account. Such areas of necessity will centre on hedgerows, unimproved grazings, road and rideside verges and other areas that are not cropped.

These areas can make a positive contribution to the amenities of the property and thus to the capital value of an estate or farm although by their very nature they have a limited use and thus will make only a minimal financial contribution.

Finally there is the situation on the larger estates or farms where the immediate management has been taken out of the hands of the owner. We have seen already that the increased financial pressures on landowners and farmers has necessitated further intensification of land use and with it a greater pressure on the appearance of the countryside. This agricultural change has been accompanied in turn by the upsurge of an increasingly vociferous group of conservation bodies with their own proposals for the protection and management of the countryside ranging from planning controls to outright purchase of the land. Between these extremes falls the management agreement. This is a relatively recent innovation which has attracted considerable comment be it favourable or otherwise. I think it is a fact that following Lord Porchester's 'Study of Exmoor' these agreements have become the principal means by which the shrinking acreage of moorland on Exmoor has been maintained. The Halvergate Marshes in Norfolk were the subject of considerable heated and at times acrimonious debate where it was suggested that annual payments of up to £80.00 per acre should be paid to farmers as compensation for fore-going the benefits of improved drainage.

Agreements can be costly, but they do appear fundamental to Government thinking in terms of the conservation of the countryside and indeed form an important part of the Wildlife and Countryside Act. However by definition a management agreement must be an arrangement between an owner of land and a public body under which the owner will accept reservations, restrictions and obligations upon the management of his land in return for a compensatory payment. Nothing could be calculated to upset a landowner or farmer so much as the hint or threat or indeed the imposition of reservations and restrictions on the management of his land for the benefit of the community at large.

It is a bitter pill for the owner or farmer to accept and whilst every consideration has been given to the payment of compensation this is more often than not insufficient to appease the owner or farmer against the loss of total control over his own land. However, management agreements are here to stay and under the Wildlife and Countryside Act 1981 Section 39 wide powers are given to county and district planning authorities to make them. The aim can be for the conservation or enhancement of the natural beauty or amenity of land or the promotion of its enjoyment to the public. The conservation of natural beauty is widely defined by the Act and embraces flora, fauna and geological and physiographical features. Furthermore, there are positive powers to restrict

agricultural operations. The agreements will be binding on successors in title unless they state otherwise and owners should wherever possible ensure that his interest will be free of this continuing encumbrance. Furthermore, the 1981 Act either offers agreements to owners who are refused a Ministry of Agriculture capital grant in a National Park or other designated area. Compensation for these agreements must be calculated in accordance with ministerial guidelines. The Nature Conservancy Council has powers under Section 15 of the Countryside Act 1968 for the protection of sites of special scientific interest. An amendment under the Wildlife and Countryside Act formalises the use of these agreements for nature reserves where another agreement has already been made (Section 72 (8)). There is no doubt that there has been a marked increase in the use of Section 15 agreements as confirmed in the Annual Reports of the Nature Conservancy Council from 1973 onwards. Finally under the National Parks and Access to the countryside Act 1949 Section 64 there is provision for an access agreement to be made by a planning authority to allow public access to 'open country' which by definition can consist of mountain, moor, heath, down, cliff or foreshore. Provision is again made for payment of compensation.

Landowners and farmers must appreciate that there are now principal powers to make agreements for the conservation or preservation of certain features of the countryside. The reconciliation of opposing views – often so very strongly held, will not be easy. Nonetheless by a measure of understanding by both parties some form of compromise will be necessary and is feasible. All parties must try and make them work because, given the adequate funding, management agreements are here to stay. The management agreements will however relate only to those parcels of land where the sites are generally to be of very special or scientific interest. There will remain many, many areas of open space often in the form of roadside waste, odd corners of fields, tracks and rides or even woodlands where a management agreement will not be made nor indeed is one required. It is to those areas where in my opinion the owner must devote some of his energies and expertise in maintaining the existing vegetation. Alternative uses will present themselves to an owner but it is my experience that if the vegetation will not stand the treading from the feet of the general public, and if you try to generate income from these parcels, then sooner or later people will be involved. It is to control the numbers and of necessity to restrict the access which will make the demands on management.

I have spoken deliberately on the question of generalities of management. I have not endeavoured to encroach on the papers to be presented by the other speakers. They will have the expertise and special knowledge available to them to deal with specific managements. As a Land Agent I feel it is one of my duties to try and reconcile the wishes of the owner and conservationist.

It is a daunting challenge but if we readily identify the areas, achieve some objectivity in management and secure good communications then I feel that effective management of natural vegetation can be accomplished. The management agreement proposed by the Nature Conservancy Council or a Local Authority need not be too difficult for an owner to accept if prior to securing

the agreement every opportunity has been taken to understand and respect the points of view of both parties. If the conservationist has not been too zealous and avaricious or the owner too conservative then management agreements can be made to work. Owners will never completely enjoy them but at least the owner will be relieved of his management responsibilities and in theory will be recompensed for the loss of his interest. However, how much better if both parties can agree a basis of management between themselves without recourse to formal documentation. That must remain the course to be followed.

DISCUSSION FOR MR CLEGG

Dr. Holdgate May I make a plea that we recognise that this meeting is not just about the management of semi-natural vegetation for wildlife. As Professor Last pointed out, when we talk about such semi-natural systems we are talking about 37% of the surface area of the country. Mr Clegg's paper discussed the problems of managing such habitats in the lowlands, but most of this vegetation is in the uplands. There we are talking about how management, enlightened by ecological science, can be more cost effective, yielding useful crops to the community in the form of sheep, deer, grouse – or even bracken – in a fashion that does not destroy either the attraction of these areas for the tourist, or those parts of them that are of high scientific interest.

The challenge is much more substantial than the resolution of conflict over parcels of semi-natural land in the intensively managed lowlands, important though that may be.

Mr Cobham I was rather surprised that lowland habitats and non-farmed areas were virtually dismissed by the speaker as only making a minimal financial contribution through generating income, either by way of habitat or cover for game, timber production, recreation, or shelter for crops and livestock. It is all too easy to polarise attitudes and say that such and such an area should be for production, and such and such another area for conservation, whereas really in the lowlands (as in the uplands) we need to be looking at the use of the land in an integrated manner.

Mr Clegg (Speaker) In fact income generated from these areas has been very limited, and this is one of the difficulties. I would like to ask you (Mr Cobham) for a bit more elaboration on how you see the income potential from the areas you mention. I don't frankly see it is a particularly large one, and I don't think it is a major contributing factor to the future well-being of an estate.

Mr Cobham In connection with sport, well managed cover is important, be it for rough shooting or for game. Even on unmanaged shoots some income can be generated from casual sporting days, at least to the point of making a contribution to the cost of management. There may not be a profit, but we should be looking at all possible ways, however small, of making a contribution to costs. In connection with timber, scrub oak can, for example, be extremely useful for on-farm fencing, if there is labour available. It may not be income generating, but there is material produced for farm or estate use, thereby saving money. There is also evidence, particularly concerning vegetable production in the fens, that significant yield improvements can be obtained from the provision of shelter. The management of vegetation specifically to provide shelter can yield tangible benefits.

Mr Lucas (Chairman) Would anyone else like to contribute on the thesis that by managing natural vegetation on estates, you can generate more income than has perhaps been suggested by the speaker?

Mr Barber Too much emphasis is given to the potential income to a landowner from the peripheral, non-farming, parts of estates. Small scale shooting, or opening parts of the estate to the public, for instance, have to reach a threshold point in income terms before they begin to offset the disadvantages (such as the costs and the irritations) of public access. Once a landowner opens parts of his estate to other people, he loses some of his autonomy, and the threshold level in terms of income set against irritation will be different for different people.

Mr Parker Will management agreements really satisfy both the owners and the conservationists? Will owners still feel that they want more money, and the conservationists more control; and do calls for understanding on both sides sound too much like industrial relations negotiations?

Are management agreements second best for full ownership by the conservationist (excluding the complications of compulsory purchase orders and so on)? I am thinking specifically about the lowlands, where there are many small pieces of land to which perhaps the public would like to have access, or where the conservationist would like to protect wildlife. Wouldn't it be better to just buy these pieces, and isn't a management agreement second best?

Mr Clegg (Speaker) On the question of purchase, the situation of the land must be of paramount consideration; there would be no point in a landowner disposing of a particular parcel of land that was in a critical position, for instance in the centre of an estate, where access would create all sorts of problems.

The anxiety about management agreements is that, at the end of the day, they are a form of compromise, and they are an imposition on somebody's autonomy. In theory the owner agrees and the other party agrees, but the question is just how far that agreement is achieved in practice. The funding of acquisitions is not easy, but I would presonally welcome purchase as the more acceptable alternative to management agreements, always depending on the location of the parcels of land involved.

Mr Lucas (Chairman) In a sense the whole theme of the paper was about education. So far as the public in general is concerned, there continues to be a good deal going on. But is there also a need for more formal education, for land agents for example. Is there a knock-on effect on the understanding between the competing interests when courses such as those at the Royal Agricultural College highlight the problems?

Mr Clegg (Speaker) I think so, because I don't think that in its entirety the 1981 Wildlife and Countryside Act is working as well as people might have wished. It is still in its infancy, but I think that as with all things, compromise was an important feature of the Act and that we have not yet got the complete answer. There is a further need for study, and certainly for education. I think that these matters will be part of the curriculum for future estate managers.

The Economics of Vegetation Management

R. O. Cobham
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"I often say that when you can measure what you are speaking about and express it in numbers, you know something about it, but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind."

Sir William Thomson (Lord Kelvin), 1889

INTRODUCTION

The challenge

As a nation we possess substantial natural and semi-natural areas. One report of the Institute of Terrestrial Ecology (ITE) 1981, estimates that these areas account for over 37% of the total UK land and inland water surface; and for almost 40%, if urban amenity land is included.

The components – rough grazing (26.9%), woodland (2.5%), inland water (1.3%) and other semi-natural areas (6.6%) – are regarded as valuable resources (Helliwell, 1969) : as visual assets; as part of our archaeological and historic heritage; as sources of food and revenue from hunting, fishing etc; as genetic reserves for Man's survival; as a biological "buffer" against pests; as a wildlife refuge; as educational material, as recreation facilities . . . . . In short, these areas are frequently expected to fulfil not one but a multiplicity of functions, as in the case of moorlands, chalk downland and primary woodland.

However, despite the fact that these areas are large, we do not know precisely, either at any one time or more importantly from time to time, how much of them we possess as a nation. Furthermore, we do not appear to know how much is spent upon their management and therefore whether or not what we do spend is too little, too much or –by coincidence, intuition etc. – 'just right'. In short, we are surprisingly ignorant about the extent of our semi-natural vegetation, about its condition nationally and about the total resources which are devoted each year to its management.

The brief

The brief for this paper requested that attention should focus on 'the costs and economics of vegetation control, together with the possibility of deriving some income from the operation'. Against that background a number of topics were

specified: 'analysis of the methods and units of costing; the comparative manpower, machinery and material costs of management operations; cost: benefit appraisal allowing for conservation and amenity aspects; the control of costs and the influence of costs upon objectives and standards'. Some – with whom the writer has some sympathy, might reply 'that is a tall order!', whilst others might feel that they are being invited to eat a highly indigestible meal without the aid of any liquid refreshment. However, initial impressions can be misleading!

Indeed arising out of this introduction there are a number of important and provocative questions which need to be identified and answered, at least in part.

THE KEY QUESTIONS

'What is the economics of vegetation management'?

This can be described briefly as the study into the allocation of scarce – be they national or local – resources between the competing ends or objectives of management.

'So what!' some may exclaim.

'Why should we be interested in the economics of vegetation management'?

An interest in economics implies a quest for the 'optimum' resource allocation, where 'optimum' usually means 'the most efficient' or 'best' in terms of total welfare and its national distribution. Unfortunately in most branches of economics the summit is rarely ever accurately perceived, let alone achieved. That, however, is no reason for ceasing the quest. Indeed in the case of vegetation management there are good reasons for accelerating the activity.

Economists, as advisers to policy-makers and decision-takers, are interested in at least two types of allocation, namely:

i The allocation of scarce land, labour and capital for the purposes of managing semi-natural vegetation *in competition with* alternative claims for the use of those same resources, e.g. for the further intensification of agriculture, additional afforestation, the development of high technology industries, the maintenance of social services to help the aged or handicapped . . . . . .

ii The allocation of whatever public and private funds are designated to vegetation management *between* the different types of vegetation (marsh, primary woodland, etc.) and the different forms of management (high technology, labour intensive, etc.).

If an economic case is to be made for altering one or both of these allocations, then a series of further questions needs to be posed.

'How, as is often asked (Whitby et al. 1974), can the choice of more appropriate allocations be made in the face of uncertainty about the outcome of each potential allocation'?

The starting point must surely be to measure the present 'state of the art'.

First, despite the publication of annual and other reports by the statutory agencies, such as the Nature Conservancy Council (NCC), the Countryside Commission (CC), the Forestry Commission (FC) and ITE, we do not know the extent and condition of our semi-natural vegetation areas. Indeed, were it not for data collected and handled with the aid of informed guess-work by a few researchers, notably Peterken (1981) into semi-natural woodlands and Blackwood & Tubbs (1970) into chalk grassland, the picture presented in Table 1* would be even more rudimentary.

The figures in Table 1 are, of course, inadequate on their own for resource planning purposes. Additional information about the geographic distribution of the areas, the levels of change in terms of gains as well as losses, their condition, their types of use whether for single or multiple purposes and the methods and levels of management, is required. Armed with this fuller picture, an economist can begin to help with choices, concerning for example the location and type of additional afforestation and the impacts which it can have upon upland and lowland wildlife.

Secondly, with few exceptions (Royal Society for Nature Conservation, 1981) until recently the decision-takers and their advisers appear not to have recognized that the management of semi-natural vegetation is a subject worthy of consideration in its own right, rather than being subsumed by a variety of other subjects, e.g. the management of national parks and country parks; public expenditure on parks, pleasure grounds etc. (CC, 1979). Even where figures are quoted, they need to be treated with great caution as was recently highlighted (MacEwen & MacEwen, 1982) concerning the £680,000 expenditure on 'conservation and estate maintenance' by the ten national park authorities in 1979/80. The authors point out that the classification of *"expenditure between functions made by the Association of County Councils is arbitrary and, in the view of several National Park Officers, it seriously understates the expenditure on positive management and the conservation of landscape. One officer went so far as to say to the authors that in his view his entire budget contributes towards conservation in one form or another through management, administration, deer control, wardening, tree planting, the educational effect of the information services and so on. There is substance in the argument and allowance must be made for it."* This comment provided the basis upon which the figures presented in Table 2 were compiled.

Table 2, containing unfortunately large numbers of question marks, indicates that information about the costs of vegetation management is not only fragmented, but scanty. The figures displayed in Table 2 represent the results of an

* Tables are presented at the end of the paper.

attempt to assemble the best possible estimates through extensive searches of published sources, supported by correspondence. Even then the accuracy of some of the figures is open to doubt. For instance, the guesstimate given for the private sector is based upon extrapolation of the figures obtained from an intensive survey of only nine lowland farms. It could therefore be significantly wrong. Also the figures may include expenditure on some vegetation which is not strictly semi-natural. Furthermore the picture is only a partial one, since it does not include all of the public sector organizations. It should, however, be borne in mind that the absence of some organizations is due to the fact that, although they are responsible for large annual expenditures on the management and maintenance of amenity areas, much of this is not associated with semi-natural vegetation.

When any further attempts are made to obtain a comprehensive expenditure statement for all semi-natural vegetation areas in Great Britain, it will clearly be necessary to present the statistics using a common base date.

The total estimated cost displayed is surprisingly low when compared with the annual expenditure by consumers for instance on parks and pleasure grounds (£457 million), on countryside sports (£958 million) and on admissions and recreational services (£1,461 million). Clearly accurate figures are required in order that rational choices can be made about the deployment of national resources.

The lack of comprehensive financial information raises a big doubt about the extent to which discussion and planning takes place between the major Government agencies (Ministry of Agriculture, Fisheries and Food (MAFF), FC, NCC, CC, etc.) concerning the allocation of scarce resources for vegetation management. There is no evidence of an annual or periodic national expenditure review or round-the-table discussion. Instead sectoral views seem to be the norm and over-views tend to be confined to public enquiries, at which the discussion is often of a competitive rather than a co-operative or complementary nature.

The compilation problems arise not only from the lack and inadequate definition of financial statistics, but from the fact that there are so many organizations involved in one or more aspects of vegetation management (Harrison *et al.* 1977; MacEwen & MacEwen, 1982). Those listed in Table 3 are but a generalised summary. They also arise because there is no mandatory, universal requirement for public landowners/managers to prepare management plans detailing the resources required and actually used in managing the semi-natural vegetation for which they are responsible. However, the problems of such measurement pall into insignificance when it is realized that a high proportion of the economic decisions concerning vegetation management are taken in the private sector, about which there is relatively little information. It is unusual for those in the private sector to record the costs directly associated with managing semi-natural vegetation. They are usually subsumed as part of the functional costs involved in running either the business or estate. With the trend towards owner-occupied holdings and the pre-occupation with

farm business considerations, as distinct from estate management, there is evidence (Newby, 1978, 1980) that the conservation and management of semi-natural areas are increasingly disregarded by certain types of farmer. It is important that the motives and constraints which affect management in *all* the different facets of the private sector should be better known.

Having highlighted the handicap, from which those concerned with improving both national resource allocations and vegetation management suffer, it is important to emphasize the need for remedial action. A Government initiated and sponsored project is required to achieve three essential tasks:

i To define the physical and economic data which requires to be recorded regularly for the benefit of all those concerned with the allocation of budget funds.

ii To identify the administrative adjustments required to enable the data to be assembled and to be made readily available to those responsible for the 'public purse', as well as advisers, landowners and their managers.

iii To oversee the implementation of improved resource evaluation and decision procedures and to monitor the impact which these have on the use and management of semi-natural vegetation areas.

In concluding this recommendation, it is important to indicate some of the large-scale benefits which should accrue, namely a better understanding of:

i The resources and funds required to achieve the present management tasks.

ii The management improvements that could improve the cost-effectiveness of those resources.

iii The levels of state intervention required in future to optimize cost-effectiveness and to ensure that as many of the existing semi-natural areas as possible are conserved.

iv How to re-allocate resources most successfully, in the face of continuing economic restraints.

Against this background a series of guidelines, examples and suggestions are offered concerning the type of economic data which needs to be collected and prepared to aid the decision-takers. At the same time it is important to point out the types of information which can mislead.

These suggestions are based on a major piece of R & D work – the Demonstration Farms Project – undertaken by the author for the CC in England and Wales since 1975, supplemented by experience on various public and private estates, including Blenheim.

ECONOMIC GUIDELINES AND PITFALLS

Cost concepts and yardsticks

For the unwary, calculating costs is paved with pitfalls (Reid, 1963; Price, 1978), especially since the task concerns five different professional interests –

the cost accountant, the economist, the business manager, the valuer and the work study officer – each of which has devised particular concepts and measurement methods. Consequently the number of terms used to describe costs rivals the varieties of Mr Heinz: *inescapable, unavoidable, fixed, common* and *joint; overhead, indirect* and *supplementary; escapable, postponable* and *variable; direct* and *prime; public* and *private; historic or true . . . . . real, unit, subsidized, net, 'knock-on', hidden, shadow, social, opportunity, discounted* and *imputed* costs are but some of the terms which could be used to describe the financial resources involved in establishing and managing vegetation.

One of the main 'battles' which previously occupied the different professional interests concerned the means of fairly apportioning *overhead* costs (rent, rates, depreciation etc.) between the various items being measured. For the business manager such apportionments are often thoroughly misleading, with the result that today they have been almost totally discarded. The same, to a lesser extent, is true of *historic* costs, though in the case of vegetation management the summation and comparison of the direct costs incurred, say since Doomsday, in managing the main countryside features –primary woodland, Saxon hedges . . . . . – would make interesting reading, especially if adjusted for inflation.

In this somewhat confusing and arid arena, there are, however, thankfully only a relatively few main cost considerations which need to concern those involved with vegetation management. These are now described.

First, there are the costs which are directly attributable to managing an area of land or water from year to year, e.g. the casual labour, fuel and materials specifically involved in hedge-cutting or ditch and bank cleaning. (Depending upon whether or not the permanent labour involved is a fixed cost or not, it should be excluded from or included in the figures.) These costs vary directly with the number of units (hectares or kilometres) of the particular vegetation feature being managed. Compared with the costs involved in managing land for commercial cropping purposes, the *variable* and *direct* costs of managing semi-natural vegetation are normally low, as shown in Table 4. Whether the direct costs are of the *variable* or *avoidable* type depends upon whether or not they have to be carried out by contract, casual or permanent labour. In the latter case, the direct costs shown for semi-natural vegetation in Table 4 are likely to be much lower, since the *variable* cost is usually confined to the purchase of materials such as fuel.

Secondly, the 'opportunity' cost incurred in managing land in a particular way compared with the most lucrative alternative. This in effect is the 'margin' or profit foregone per unit of land, for instance in conserving a hectare of primary woodland rather than in using the land for soft-wood or wheat production. The magnitude of these costs varies greatly, ranging from zero or even negative values (Price, 1978; Warren & Harrison, 1978) for many sites, and indeed for large areas of land where commercial agricultural or forestry operations would not be economically justified, to very substantial sums: *"through sterilization of productive activity on the land. These high costs mean that the*

total commitment to landscape preservation is only rationally pursued in very few areas of densely populated countries" (Price, 1978). Examples of the high costs are shown in Table 5.

The opportunity costs displayed relate solely to those areas where production is foregone. Their magnitude indicates the level of goodwill towards conservation that still exists in many sectors of the landowning and farming population. Indeed the figures may surprise some people whose attitudes towards farmers have been influenced by the strident comments of certain landscape 'journalists'. Whilst to many occupiers such opportunity costs are academic, since they have no intention of converting the areas to commercial use, there are others in the Halvergate Marshes and Somerset Levels, for instance, for whom they are of major importance. It is suggested that such costs need to be borne in mind whenever new capital or management grants and incentives affecting landowners and occupiers are being devised.

Thirdly, the 'discounted' costs which it is expected will be associated with managing an area of land for the foreseeable future using a number of methods. Discounting is based on the well acknowledged maxim that 'a bird in the hand is worth more than two in the bush' i.e. the requirement to spend £1 in the future is less painful than a similar commitment today. The process of discounting enables the usually dissimilar annual cost profiles of a variety of management methods to be compared more realistically than is achieved by just totalling the annual costs for the timespan under consideration. Discounted costs tend only to be calculated on special occasions, when investment decisions or choices between management strategies or methods are being made, for example:

i Whether and when it is economically justified to buy a precision fertilizer spreader which will conserve cereal production costs as well as the botanical value of hedge bottoms.

ii The choice between labour intensive and capital (machinery) intensive methods, which can amount to the same as the choice between a high-maintenance-cost solution (car parking on grass) and a high-initial-capital-cost solution (construction of a hard standing area).

Finally, the principal 'fixed' cost resources (permanent labour and machine hours) directly associated with the management operations. Initially they are expressed as the number of standard man or machine days involved in achieving one or more levels of maintenance. In order to compare the effectiveness of different management methods or systems, it is usually necessary to present the figures in financial terms using the appropriate unit costs, as shown in Table 6. The choice between managing an area of semi-natural vegetation, using direct or contract or voluntary labour or various combinations of these, is dependent upon the correct calculation of the combined variable and fixed costs. All too often it is not possible to arrive at the actual variable and fixed costs associated with the management of semi-natural areas, since they are entangled in the accounts of one or more of the following: the farming, forestry, sporting and recreation enterprises and the overall estate. The figures

in Table 6 have purposely been presented in physical terms, so that their expression as variable or fixed costs can accurately reflect whether the work is undertaken by permanent, contract or voluntary labour.

However, despite the importance of the four cost considerations outlined and even when they can be measured, pre-occupation with them should be avoided. They represent only part of the picture.

Cost effectiveness: macro-scale

The primary consideration, it is contended, should be 'cost effectiveness'. This is the relationship between the actual or predicted expenditure on the one hand and on the other the actual or predicted value of the benefits; in short, the estimated 'value for money'.

Assessment of cost effectiveness is a complex subject. The measurement of value (for whom and over what time period) is not only fraught with difficulties. It is made harder because of the intangibles involved, such as the different wildlife, visual or cultural values, or lack of them, associated with the range of land management methods (semi-natural vegetation as compared with plantation or commercial crops). Despite some ingenious and sophisticated attempts to express such values for areas of semi-natural vegetation in monetary terms, for example using the travel expenditures by visitors (Clawson, 1959), the stated willingness of a randomly selected sample of people to pay for conservation, a seven category system for evaluating wildlife resources (Helliwell, 1969), and comparison of the average annual costs between a) providing 100 m of good thick hedge per nesting bird attracted, and b) putting a pheasant over the guns, there are some values which defy credible, financial quantification, e.g. for someone to derive pleasure from semi-natural areas does not require perpetual or indeed frequent use of them by the individual. There are values associated with knowing that the opportunity to enjoy them exists and indeed that they are being directly enjoyed by others.

In addition to these limitations there are differences of 'expert' opinion concerning the most appropriate methods of cost/benefit analysis, even in the case of those elements which can be measured. For instance it is the normal practice to discount all changes of value to the present for purposes of comparison, based on the assumption that consumers place more emphasis on consumption now than in the future. However, the validity of discounting the costs and benefits associated with conservation issues has been seriously challenged, on the grounds that the views and values of future generations are largely ignored and that the future is uncertain.

In coming to terms with the measurable items, especially where major land use or investment decisions are concerned, experience (Whitby *et al.* 1974) has shown that it is advisable to employ a number of economic yardsticks: the return on investment, cost/benefit ratios, the net present worth, the internal rate of return. To use only one effectiveness yardstick can be thoroughly misleading.

It is especially important to ensure that the time perspective is taken into account. For instance, the investment of £2500 on a 200 ha farm over ten years in replacing dead trees in semi-natural areas might be unacceptable to the owner, when viewed in isolation. However, when the expenditure is regarded in relation to the time over which the investment is likely to be enjoyed (say 150 years for lime, 200 years for beech and 250 years for oak), it can pall into insignificance, especially when seen in the context of the farm landscape as a whole. In simple expenditure terms the investment amounts to pence rather than pounds per hectare per year over the life of the appreciating and appreciated feature. The growth in real values with the passage of time and indeed the opportunity for the addition of new values cannot be over-emphasized. For example, when our historic parks like Blenheim were created, involving the retention of semi-natural areas along with the establishment of 18th century features, the values which would be derived from public recreation were not contemplated or foreseen. Even if economists had foreseen these values, the application of discounting procedures applied to revenues earned 150 years in the future would have rendered them virtually valueless. Yet how wrong that would have been. Thankfully economists – as we now know them – were not around then to influence the decision. It is to be hoped that the high 'costs' associated with the present vogue for achieving instant results, be they revenues or trees, will be recognized. A diverse and better balanced portfolio of semi-natural and man-made features would then be more easily achieved.

Part of the 'effectiveness' appraisal should, of course, include measuring or estimating any revenues associated with the various management options for the semi-natural areas. At the macro-scale there is unfortunately very little published information on the revenues earned in the management of even publicly owned or administered semi-natural areas from such sources as farm crops (hay and silage in particular but also cosmetics and dyes); construction materials (osiers, reeds and straw); timber (fuel, fencing, hurdles and turnery products . . .); livestock grazing; insect products (honey); country craft products; sporting licences, rents and game produce; sports on open water areas which are compatible with wildlife interests; recreation facilities (country parks, interpretive centres, trails, picnic and camp sites, literature sales) wildflower and tree seeds, etc. Most probably the reason for the lack of national or regional information is that the total revenue is:

i Largely regarded as incidental to the main commercial farming, forestry or recreation enterprise, i.e. it does no more than make a modest contribution to the overall costs.

ii Subsumed under other sources of income (visitor receipts for all rather than semi-natural vegetation areas).

However, if at a macro-scale the recreation and other revenues are to be included in the evaluation, so also must be the costs involved. These are not just the costs incurred in managing the semi-natural area but also in using it, for example as a recreation facility which involves private and probably public travel expenditure to and from the facility.

Thus, sadly again this paper can do little more than highlight a further important subject area where fact-finding, analysis and development planning is required. In view of the problems both experienced and facing those responsible for the conservation of semi-natural areas it is surprising that:

i This information has not been forthcoming to date; and furthermore,
ii The potential for improving revenue earnings and thereby reducing the demands on the public purse has not been identified.

In the final analysis, despite all the endeavours of the economist or the management adviser, the decision-taker is faced with having to make a value judgement. This does not invalidate the work of the economist, whose task should be to:

i Assess as accurately as possible those items capable of measurement.
ii Compile a comprehensive list of the immeasurable factors.
iii Describe as explicitly as possible, with the help of other disciplines, the intangible benefits and disadvantages associated with each of the alternative management regimes.

Table 7 provides a simplified example. It is a summary of the costs and benefits assessed in the course of preparing the integrated land use and management plan for the CC's Chalkland Demonstration Farm. This table has been prepared without reference to any standard procedure, since experience suggests that, as with issues concerning landscape aesthetics, the yardsticks for assessing vegetation management options need to be devised on a case by case basis. There is likely to be a core of yardsticks which are similar for all cases, but the characteristics of the sites themselves and the issues concerned will determine how best to proceed thereafter. The example given in Table 7 is for a relatively small exercise compared with the appraisals undertaken for issues of national importance: the Third London Airport, Amberley Wildbrooks . . . . . However, the principle of tailor-making the appraisal approach applies equally to such large projects.

In conclusion, it is suggested that biologists and land managers should not fall into the trap of trying to express all the repercussions of management changes in financial terms. Indeed economists themselves recognize (Price, 1978) that the financial evaluation of nature conservation values 'is at least as intractable as that of landscape'. Yet there was a strong feeling some years ago that the conservation interests would only gain the ear of decision-takers if they quantified everything in monetary terms. This it could be claimed is but a fashion. Decision-takers throughout time have been required to make 'value judgements' of a difficult nature, and have been required to weigh the philosophical as well as the political implications along with the economic. Thus, the writer recommends that in place of the search for optimizing economic expression we should seek to describe and where possible to quantify clearly, even in physical terms alone, as shown in Table 7A, the implications of the issues at stake. To attempt to simplify and to pander to the fashion for financial precision is to debase the roles of both advisers and decision-takers.

In short, experience has *somewhat* tempered the author's pursuit of Sir William Thomson's challenge! There can be no absolute evaluation technique especially where natural features are involved, as landscape architects have come to realize from trying to devise all-embracing scales for measuring beauty.

VEGETATION MANAGEMENT METHODS: EVALUATION OF OPTIONS

The micro-scale

Whereas the evaluation of the vegetation management options at the national or macro-scale is charged with problems, the appraisal of the alternative management methods and operations at a local or site specific scale is more straightforward. Indeed in the case of commercial land uses there are a variety of handbooks (e.g. Nix, 1981) available to assist the landowner and manager in choosing the most appropriate management method.

Unfortunately, to date, in spite of the growing volume of information on amenity land management, there is no comprehensive counterpart for semi-natural vegetation and amenity areas. However, despite the problems which arise because of differences between site conditions; latitude, longitude, soils and many other variables, the writer and colleagues are attempting to prepare one. This it is hoped will assist not only managers, but their professional colleagues who are involved in the important initial design work. The latter has often suffered greatly in the past from not being exposed to constructive criticism in relation to the longer-term management and maintenance implications. The distinction between capital and revenue expenditures (and budgets) is an unreal one and can lead to decisions, which, had the predicted expenditure patterns over the whole life rather than the first say five years of a project been examined, would have been taken differently and to greater advantage.

Table 8 provides examples of the comparative costs involved in using different management techniques for a variety of vegetation types. The data presented supplements that quoted by other contributors to the seminar and is drawn from both the Demonstration Farms Project and a selection of recently published reports. It is interesting to compare the costs presented in this table with the much higher opportunity costs shown in Table 5. However, it must be pointed out that the direct costs exclude the thinking time which is required on the part of the managers, which often is the scarcest resource!

To complete the picture, Table 9 lists some data collected on the levels of revenue which have and can be earned both as the main and by-products of managing semi-natural areas. For some landowners and occupiers who find difficulty in undertaking the management of valuable, semi-natural habitats there can be another solution. These areas can sometimes be let for a "peppercorn rent" on a long lease to a conservation organization, such as a County

Naturalist Trust. They can as a result be actively conserved through implementing a management plan specifically prepared by Trust members.

Most of the data given in these last two tables is related to land which is privately owned. There is no statutory requirement for private landowners to declare these costs and revenues in any accounts to the Inland Revenue. Thus the figures quoted are indicative of those from which national data will have to be derived for the private sector if at anytime they are required.

Motivations

It is to the private sector that we need to look when considering ways in which the effectiveness of management methods need to be improved. From working with a large number of landowners over the past ten years, four broad conclusions and recommendations emerge:

i 'Effectiveness' to the landowner, farmer or manager usually means *simplicity* and *convenience*. Often the direct costs and potential revenues involved are of secondary importance. Thus as many as possible of the vegetation management operations need to be capable of being performed in the less busy periods of the year. That usually means the winter months: machinery and herbicide manufacturers, please note.

ii The likelihood of conserving semi-natural features is greatly enhanced, if they can be managed as part of normal estate or farming operations. It has been shown that integration of commercial and conservation interests can be achieved at little cost, if full consideration is given to the main functional needs of the business.

iii Whereas the provision of direct management grants may not influence landowners greatly and indeed may not prove feasible within the European Economic Community machinery, the fulfilment of management agreement compensatory payments and the provision of fiscal reliefs are likely to be increasingly important. This relates, of course, to situations where the opportunity costs are high.

iv If landowners are to derive full value from the potential revenues, they will require significant help in marketing the produce. This was highlighted in particular by DART in the Small Woodlands Study sponsored by the CC for England and Wales.

Until recently the powers which existed to control management standards in the private sector were limited. These have been significantly improved, in theory, through the reform of the MAFF grant system and the provisions of the Wildlife and Countryside Act, 1981. However, this influence could be greater – and indeed could include a measure of cost control – if fiscal reliefs were to be extended, conditional upon the preparation and implementation of conservation plans. However, it is not just the private sector which is in need of carrots and sticks, the management practices of some of the public bodies are well recognized to require attention.

RECOMMENDATIONS

The investigations made in the course of preparing this paper suggest that the custodians and owners of semi-natural vegetation should not receive positive response to claims for more resources until it can be demonstrated that:

i The resources already allocated for the purpose are being efficiently used. This entails knowing the extent and nature of the basic land resource and the associated management inputs.

ii There is a capability exceeding that of competitors to use additional management resources more effectively on behalf of Society.

In general terms this paper has identified that a minimum of £103 million is expended annually on the management of some 6 million hectares of semi-natural vegetation. However, in the absence of comprehensive data, the paper has been unable to answer in what ways the allocation of national resources could be significantly improved. Instead an attempt has been made to indicate the levels of costs and revenues entailed in conserving and managing a selection of semi-natural areas using a variety of methods. However, whether and how, in the event of a continuing recession, we should face up to the possibility of having to relinquish additional semi-natural vegetation areas has not been attempted. That is another large issue beyond the scope of this paper. It too should not be answered by events or expediency, but by research.

Throughout the paper various explicit and implicit references have been made to the need for R & D expertise to be devoted to remedying the short-falls in our knowledge. Table 10 attempts to set a framework for discussion on the sequence of research, development, communications and decisions which need to be taken.

There is one further aspect of such work which from a simple economic standpoint deserves a mention, namely the need to find additional ways of effectively harnessing the surplus manpower resources potentially available. We have a variety of statutory and voluntary employment schemes. Is there scope either through these or additional initiatives to improve the management of semi-natural areas? The cost to the nation of unemployment is high. If more of the resources devoted to meeting that cost could be directed towards such management works, especially towards those areas capable of generating revenue, we should not only make economic, but social progress as well. It would be naive to ignore the real political and other obstacles preventing such progress. However, it is the economists' role to highlight the scope for resource re-allocations, recognizing of course the possible implications for the chemical and other service industries of a swing towards more labour intensive management methods.

CONCLUSIONS

The economics of vegetation management is largely 'virgin forest'. Whether it is semi-arid scrub or semi-tropical rain forest is left for the reader to decide. It is hoped that this paper has made the forest appear a little less like a jungle.

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DISCUSSION FOR MR COBHAM

Mr Cobham was questioned about some of the figures quoted in Table 2 of his paper, and agreed to amendments proposed by representatives of the organisations concerned.

Table 1
Estimated areas of natural and semi-natural vegetation in Great Britain

Habitat	Area x10^3 (rounded)	Proportion as NCR site † (%)	Year	Source
Coastal – mud flat, marsh, dune, shore, shingle beach	119-263*	100	1960 –	Ranwell (1982) (Pers. Com.) Ratcliffe (1977)
Woodland – ancient and recent semi-natural woodland	339	20	1978	Peterken (1981)
Lowland grass and heath – institutional ownership	289	13	1974 adjusted	NERC (1977) Ratcliffe (1977)
road verges and green lanes	214	–	1980	Dunball (1983)
Open water – standing, including reservoirs	244-310*	9	1977-1980	Moss (1981) ITE (1981)
Peatland	63-?	100	–	Ratcliffe (1977)
Upland grass and heath	1500-4057*	11	1956 1982	Lance (1982) (Pers. Com.). Bunce (1982) (Pers. Com.).
Lowland hedges – England and Wales only	135-174*	–	1963 –	Green (1981) Ratcliffe (1977)
Other – railway verges and tracks -	20	–	–	Ratcliffe (1977)
pipelines, wayleaves, mineral workings and tips, non-urban wasteland –	421	–	1979	Moss (1981)
Total	3106-6087**	15		

* Where a range of areas is given the source of the lower one is quoted first.
**This figure agrees with estimates provided by Bunce (pers.com.) and represents 26.5% of the total area of Great Britain.
† Nature Conservation Review (Ratcliffe, 1977).

Table 2

Estimated annual direct and associated expenditure on semi-natural areas by selected owners of land and way-leave rights in Great Britain

	Expenditure				Notes		
	Management	Education/ Interpretation	Research	Total	Year	Source	
	£(M)	£(M)	£(M)	£(M)			
CENTRAL GOVERNMENT							
National Park Authorities (NPA)	4.85	1.05	–	5.9	78/9	CC(1979A)	Revenue Expenditure: Recreation, Conservation, Estate Management, Administration
Nature Conservancy Council (NCC)	5.19	1.65	2.01	8.85	80/1	NCC (1981)	Revenue Expenditure: Reserve Establishment and Management and Advice
Department of the Environment (DOE)	–	–	0.25	0.25	81/2	Pers. com.	Centrally administered activities only
Countryside Commission (CC)	7.84	0.93	0.65	9.42	80/1	CC(1979)	England and Wales and CC for Scotland. Revenue expenditure
Forestry Commission (FC)	3.9	?	?	3.39	80/1	FC(1982)	Recreation and Amenity Subsidy
Ministry of Defence (MOD)	?	?	?	?			
Department of Transport (DTp)	29.76	–	–	29.76	79/80	Dunball (1983)	Grass cutting and siding only, excluding urban. England and Wales
Sub total	51.03	3.63	2.91	57.57			Compares with £457M (1978) Public expenditure on parks and pleasure grounds
LOCAL GOVERNMENT							
County Councils	8.92	?	0.86	9.78	81	Royal Society for Nature Conservation (1982)	
STATUTORY AGENCIES AND NATIONALIZED INDUSTRIES							
Central Electricity Generating Board (CEGB) and Regional Boards	8.00	–	–	8.00	81/2	Pers. com.	
Natural Environment Research Council (NERC)	–	–	5.00	5.00	80/1	NERC(1981)	Expenditure: Solid earth, inland waters, and terrestrial environment

Water Authorities/Drainage Boards	8.50	–	–	8.50	81/2	Cave (1983)	Personal estimate for cost of aquatic weed control + £2.5M other. England and Wales
British Waterways Board (BWB)	3.03	?	?	3.03	77/8	CC(1979A)	Revenue Expenditure: Recreation and Amenity
British Gas Corporation (BGC)	0.11	–	–	0.11	81/2	Pers. com.	Excludes mown areas
British Rail (BR)	0.21	–	?	0.21	74	NERC(1977)	Subject to error of +/– 25%
Sub total	19.85	?	5.00	24.85			
CONSERVATION ORGANIZATIONS Royal Society for the Protection of Birds (RSPB)	0.45	–	–	0.45	80	Pers. com.	
Royal Society for Nature Conservation (RSNC)	0.17	0.13	–	0.30	77	RSNC(1982)	Covering all County Trusts
National Trust (NT)	3.29	–	–	3.29	81	Pers. com.	
Sub total	3.91	0.13	–	4.04			
PRIVATE Private Landowners	6.80?	–	–	6.80	82	Cobham (1982)	Calculated from average annual expenditure from 9 lowland farms in England & Wales. Further investigation required.
Grand total	90.51	3.76	8.77	103.04			

Footnote: For the reasons given in the text (page) figures have not been included for the Sports Council, and other organisations such as the Property Services Agency (PSA) or the Scottish and Welsh Development agencies.

Table 3
Landownership in Great Britain: 1976/7

	Agricultural land* (Million ha)	Total land† (Million ha)	Semi-natural vegetation+ % of total land	Semi-natural vegetation (Million ha)
INSTITUTIONAL				
Local Government	0.37	0.42	5.1–10.7?	
Central Government	0.36	1.88	3.4–6.8?	
Statutory Agencies and Nationalized Industries	0.23	0.44	3.5–6.6?	
The Crown	0.17	0.22	3.3–6.6?	
Conservation Organizations	0.13	0.22	5.7–11.5?	
Educational	0.10	0.11	4.7–9.4?	
Financial	0.08	0.15	2.5–5.0?	
Religious	0.07	0.07	4.8–9.6?	
Total	1.51	3.51		
PROPORTIONS OF TOTAL AREA	%	%		
Institutional ownership	8	16.5	4–6? representing	0.14–0.23
Private	92	83.5	5-10? representing	0.87–1.74

Sources:
* Northfield (1977); Harrison *et al.* (1977).
† Harrison *et al.* (1977); Countryside Commission (1979).
+ Guestimate compiled from published figures for DOE, County Councils, BWB, Conservation Organizations; 5–10% of agricultural land assumed for others.

Table 4
Indicative annual direct and variable costs involved in managing different types of vegetation

Type of vegetation	Location	Cost (£/ha)	Year	Source
A. SEMI–NATURAL				
Long grass	South London Green Belt	0-23	1977/78	Warren & Harrison (1978)
Scrub		0-28	1977/78	id.
Heath		0-38	1977/78	id.
Woodland		0-65	1977/78	id.
Short grass		185	1977/78	id.
Woodland (coppicing 30 - 40 year rotation)	Essex	8	1981	Cobham (1982)
Woodland (coppicing 30 - 40 year rotation)	Essex/Suffolk	12	1976/77	id.
Hedges (av. 2 m wide)				
biennial flail	Hereford/ Worcs.	40	1980/81	id.
annual flail		75	1980/81	id.
coppicing		493-543	1980/81	id.
laying		920	1980/81	id.
Watercourse fringe (2 m wide)				
chemical	S./S.E. England	125	1981/82	Cave (1983)
mechanical		600	1981/82	id.
manual		750	1981/82	id.
Moorland –				
heather burning	Northumberland	5	1980/81	Cobham (1982)
heather cutting (contractor)	Northumberland	10	1980/81	id.
(Moorland Conservation Compensation Grant)	Exmoor	44	1981/82	MacEwen & MacEwen (1982)

Table 4 Cont'd.

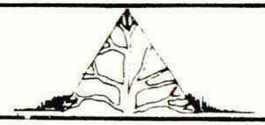
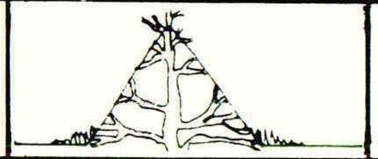
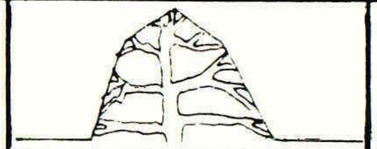
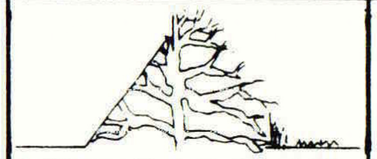
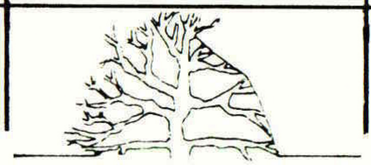
B. CULTIVATED				
Commercial Forestry				
(conifer/broadleaf 120 year rotation)	Eastern England	5-13	1978/79	Forestry Commission (1979)(Pers. com.)
Commercial Agriculture				
grassland –				
sheep		14-45	1980	Nix (1981)
beef	England	30-78	1980	id.
dairying	& Wales	50-100	1980	id.
cereals		100-170	1980	id.
roots, veg, fruit		500-1,000	1980	id.

Table 5
Conservation areas and expenditures for nine lowland farms in England and Wales: 1981/2

Farm type		Total area	Total conservation area	Total area not intensively farmed/forested	Proportion conserved	Proportion intensive production foregone	Average annual extra direct expenditure on conservation		Average annual opportunity cost total	Income foregone as proportion of total gross income
							Unit	Total		
		A	B	C	D	E	F	G	H	I
		ha	ha	ha	%	%	£/ha	£	£	%
1	Intensive dairy plus arable	294	18.7	13.5	6.4	4.6	0.49	144	5805	10-12
2	Intensive arable plus livestock	691	98.8	78.8	14.3	11.4	0.29	200	5700	13-15
3	Intensive dairy and arable	267	9.4	1.8	3.5	0.7	0.24	64	1440	2-4
4	Intensive dairy	104	13.2	4.7	12.7	4.5	0.92	96	940	7-9
5	Intensive dairy plus arable	296	15.7	7.0	5.3	2.4	0.27	80	3521	10-15
6	Livestock plus arable	237	25.7	9.1	10.8	3.8	0.36	85	2457	13-15
7	Intensive dairy plus arable	187	4.6	4.6	2.5	2.5	0.67	125	3003	12-15
8	Intensive arable and stock rearing	223	9.1	5.1	4.1	2.3	0.78	174	1380	5-7
9	Intensive arable and dairy	1183	194.4	126.6	16.4	10.7	0.34	402	13610	15-20
Total		3482	389.6	251.2	11.2	7.2				

Source: Cobham (1982) Cobham Resource Consultants. Work in progress.

Table 6
Indicative manpower and machinery resources required for hedge maintenance

Shape of cut	Frequency of cut	Shape of hedge	Number of flail passes Tractor gear 1st	2nd	Manpower and machine time required Min./ Man	Machine
A-shape	Annual		–	4	0.16	0.16
Wispy A-shape	Annual		–	4	0.16	0.16
Chamfer	Annual		1	4	0.18	0.18
A-shape	Annual/biennial*		1	2	0.10	0.10
Chamfer	Annual/biennial*		1	4	0.18	0.18

Coppicing	Every 15 years	–	One pass with tractor and shape saw	5.49	5.49
			One pass with tractor buckrake	2.74	2.74
Laying (manual)	Every 15 years	–	–	28.5	4.5
Laying (mechanical)	Every 15 years	–	–	7.0 –12.0	1.6-12.0 (flail) 3.9-12.0 (chainsaw + foreloader bucket)

*Only one side of hedge is flailed each year

Source: Cobham (1982) Cobham Resource Consultants. Work in progress.

Table 7
Appraisal of expected benefits and costs associated with implementation of integrated land use plan for an 1183 ha chalkland farm

Impact on cultivated/semi-natural areas	Physical change		Financial impact		
	Commercial gain (£)	Conservation gain (£)	Revenue gain (£)	Opportunity cost benefit (£)	Capital outlay (£)
A. Short term					
1. Farming improvements – field rationalization	2	–	1,200	–	1,280
2. Downland S.S.S.I. Conservation	–	58	451	minimal	–
3. Other Downland Conservation for wildlife & aesthetic benefit in preference to arable conversion	–	47	–	6,580	–
4. Conservation of scrub for sporting and wildlife benefit in preference to arable conversion	–	9	–	3,678	–
5. Conservation of ancient monuments at 16 scheduled sites (+ 100 ha occupied by unscheduled sites)	–	1.5	160	741	–
6. Visual amenity improvements – streamside, corner etc, planting	–	minimal	–	–	1,950
7. Other farming improvements F.H.D.S. Plan	–	–	7,500-11,700	–	50,000-78,000

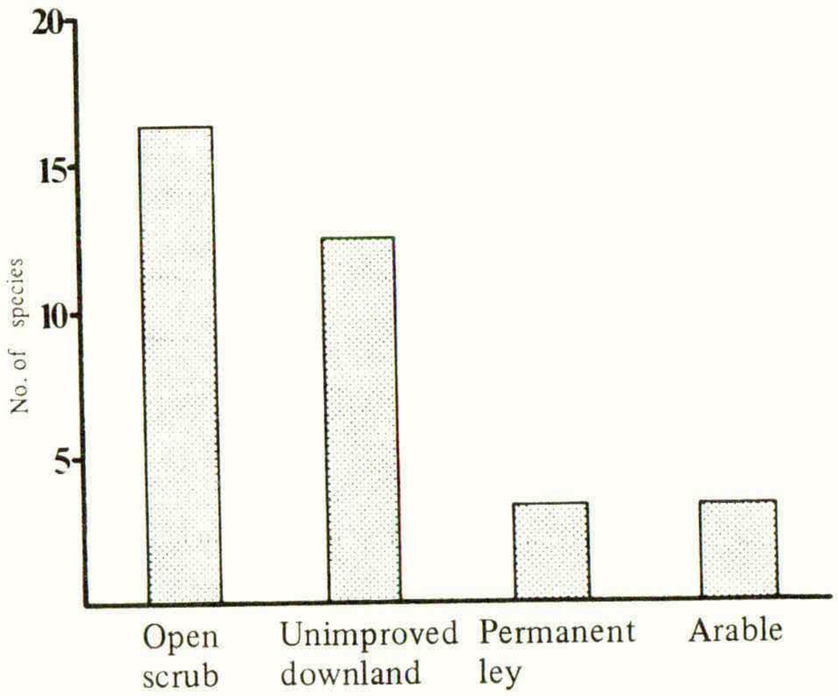
8.	New afforestation proposed	15.3	5.3	?*	–	6,120
9.	Improved management of existing woods	59.3	margins & rides	?+	–	–
10.	Improved sporting cover – hardwood margins/ rides	64	–	500	–	2,500
B. Longer term						
1.	Improved wildlife†	conservation of plant, bird butterfly etc species		?	?	?
2.	Enhanced visual amenity	conservation of landscape and historic features		?	CTT ex-emption substantial	?

* Predicted to be superior to returns from extensive livestock enterprise
+ Predicted to generate a return
† Source: see Table 7A Cobham (1982) Cobham Resource Consultants – Work in progress

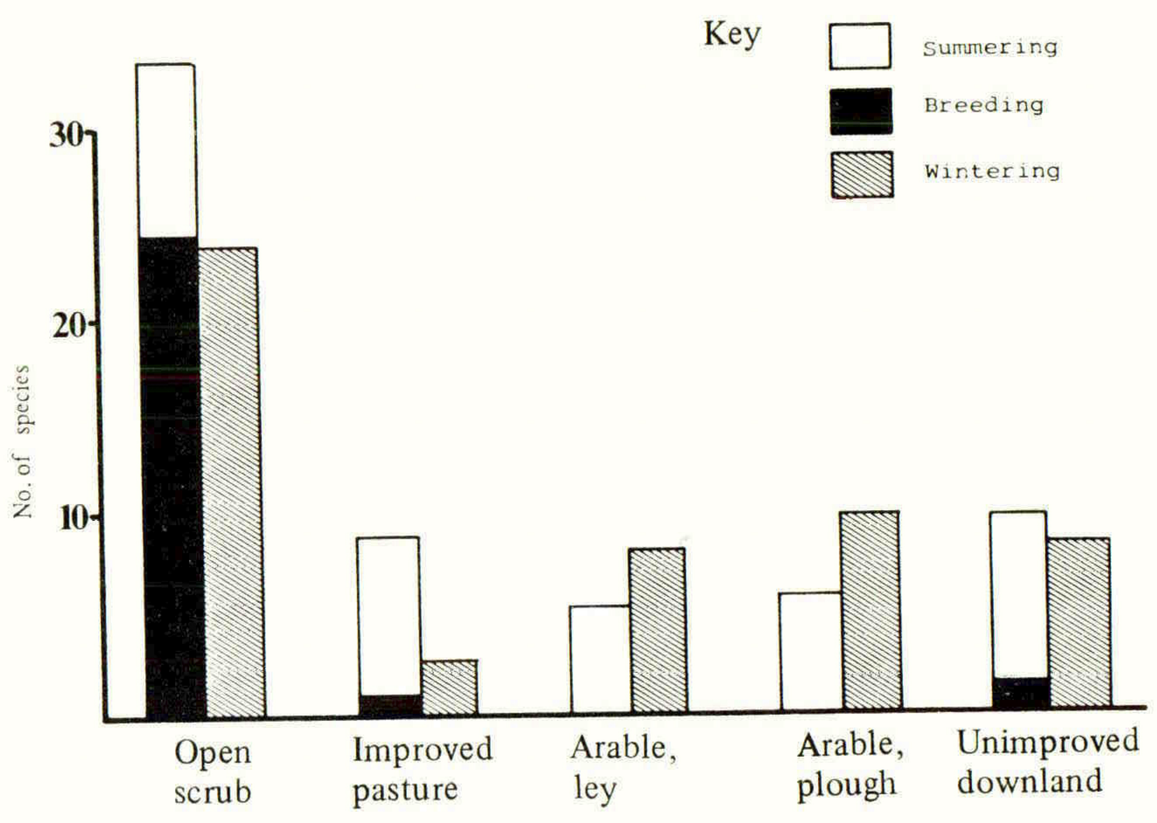
Table 7A

Appraisal of wildlife benefits associated with conserving 9 ha of scrub (initially for sporting purposes) on a chalk downland farm in preference to improving farm output.

1. No. of butterfly species (1980 averages)



2. No. of bird species



Note 1: The comparisons between the various habitats are based in all cases on an area of 9 ha.
Note 2: In the case of the Open Scrub, 11 pairs of breeding birds were found in the 1 ha plot at the extreme west end. This compared with a total of 125 breeding pairs in the 9 ha overall.
Source: Cobham (1982). Cobham Resource Consultants. Work in progress.
Rowe (1982) pers. com.

Table 8
Examples of comparative resource requirements for different management methods

Habitat	Condition	Method	Annual Costs Capital (£)	Annual Costs Variable (£/ha)	Comments
1. Moorland (<15° slope)	20-25 year old, leggy heather	Cutting with machine* – purchase	346	2.80	Litter delayed regrowth by approx one year
		Cutting with machine – contractor	–	10.00	Timing of operation very flexible
		Burning	90	5.00	High labour requirement Timing of operation less flexible

Notes:* Bomford Bandit 2500 (flail cutter) 2.5 m swath. Break-even point: Total cost of cutting (purchase) becomes cheaper than burning when heather area requiring treatment exceeds c.125 ha.
Source: Cobham (1982) Cobham Resource Consultants. Work in progress.

	Requirement	Method	Man h/$10^3 m^2$	Comments
2. Hay meadow	1-2 cuts/year	Reciprocating cutter Tedding Baling Collecting	35-45	
		Forage harvester	0.5-2	To cut after flowering would require mowing first

Source: Wright (1979)

Table 8 Cont'd.

	Requirement	Method	No tree/ha	Establishment cost (£/ha, excl. fencing)	Incremental growth: 2 yrs) cm
3. Oak woodland	Regeneration	Transplants + rabbit fence + herbicide for 4 years	1200	653	12.1
		Container grown whips and poly-tube (mini-greenhouse) + herbicide for 4 years	450	1005	101.5
		Transplants + poly-tube + herbicide for 4 years	450	1170	97.8

Source: Cobham (1982) Cobham Resource Consultants. Work in progress.
Tuley (1982)

Note: The figures provided in this Table are site specific and should not therefore be used as a basis for extrapolation.

Table 9
Indicative revenues to be earned from appropriate areas of semi-natural vegetation

Habitat	Commodity	Revenue (£)	
1. Grassland	Grazing licences/hay cropping	50-100/ha/year	(net)
2. Woodland	Coppice products	0-370/ha/year	(net)
	Firewood*	0-125/ha/year	(net)
3. Lowland woodland and adjacent farmland	Driven pheasant shooting 300 birds/day full board	up to 1000/gun/day (8 guns)	(gross)
	Walked-up pheasant shooting	70-150/gun/day	(gross)
	Pigeon shooting	40/gun/day	
4. Moorland	Driven grouse shooting – 100 brace	300-625/gun/day	(gross)
	Walked-up grouse shooting – 20-40 brace	80-120/gun/day	(gross)
	Red deer stalking (excluding trophy fees)	100-125/stag	(gross)
	Roe deer stalking (excluding trophy fees)	100-160/stalker/day	(gross)
		20-40/non-stalker/day	(gross)
5. Open water and adjacent areas	Goose shooting	45/gun/flight	(gross)
	Duck shooting	25-30/gun/flight	(gross)
	Fishing (2nd quality)	40/rod/week	(gross)
6. All	Holiday accommodation	70-150/week	(gross)

* Three-bedroomed house can be heated with the produce of c. 3 ha of coppice woodland managed on a 15-year cycle i.e. c. 0.2 ha cut annually.
Footnote: These figures have been assembled from case study sources and should therefore not be used as a basis for extrapolation.

Table 10

Sequence of important research and development activities towards improving the management of semi-natural vegetation

Stage	Activity	Main Components	Units	Decisions Required	
1	*Recognition of improvements required* *Commitment to rectifying inadequacies*				
1.1	Inadequate data	BCPC Seminar plus other initiatives, say working party of government agencies, landowners, professional institutes	Time	Partial or comprehensive R & D programme: location and timing of research	*
1.2	Improvement potential —management of semi-natural vegetation —use of public/private funds				
2	*Research and Development: past/present*				
2.1	Extent of semi-natural vegetation areas	Habitat types, ownerships, management agencies	Ha		
2.2	Condition of vegetation**	,,	Ha		
2.3	Function of vegetation Single uses: conservation; public access; recreation/education; sport; crop or by product Multiple use	,, —	Ha		
2.4	Deployment of existing financial resources for management	Direct and indirect expenditure	£	Inter and intra agency action	
2.5	Management methods used: inventory	High-low management levels High-low capital intensities Habitat types, ownerships, management agencies	Ha, £		
2.6	Cost effectiveness of:** existing financial resource deployment existing management methods	,,	£		
2.7	Extra funding required for management improvements	Habitat types, ownerships, management agencies	IIa, £		*
2.8	Landowner/occupier motivations	Habitat types, tenure types	Ha, £		
3	*Research and development: future*				
3.1	Alternative management systems**	Community management supported by professional advice Conservation of semi-natural habitats linked to productive enterprises Management backed by multiple compared with single agency grants	Ha, £		*
3.2	Resource deployment improvements** based on: a) existing public/sponsor funding b) additional public/sponsor funding	Habitat types and functions, ownerships, management agencies	Ha, £	Inter and intra agency action	* *
3.3	Data collection/assembly and communications systems	Government agencies, landowning and management agencies	Ha, £		*
3.4	Continuous evaluation	—			

*Main items where choice involved; **May be measured by many different criteria