MANAGEMENT OF AQUATIC VEGETATION

Management of Vegetation in or Near Water

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INTRODUCTION

The management of vegetation in or near water is a subject that in recent years has aroused a great deal of controversy, not only as a result of a quickening of public interest in nature conservation, but also concerning the various methods of control employed. This has been particularly evident in the use of aquatic herbicides.

The extent of aquatic weed control varies enormously in different localities, from the Highlands of Scotland and Wales where it is generally carried out only for sporting purposes, to the fen lands of East Anglia where it forms an indispensable part of the very existence of the area.

This paper attempts to assess the nature and extent of aquatic vegetation and the needs for its control both in relation to the uses of watercourses and to the statutory obligations of the responsible authorities.

Costs of vegetation management are examined, as are the effects of recent conservation legislation and other outside pressures.

Finally, future prospects in this field are discussed, together with the urgent need for further and continuing research and development of improved control techniques.

TYPES OF WATERCOURSE

Natural

The character of watercourses vary very much in accordance with the physical geography of the area through which they flow.

Mountain streams are invariably clear, fast flowing and shallow in contrast to the lowland rivers, which are slow flowing and usually turbid and comparatively deep. In the mountains and hills, valleys are steep sided containing even swollen streams within narrow limits. Down in lowland areas, rivers have wide flood

plains with extensive water meadows that are inundated when the rivers are in spate. In certain areas, either due to the pressures of urban development, or the requirement to extend arable farming within the flood plain, embanking and realignment schemes have been carried out, changing the character of the river and its margins.

The character of a watercourse also determines the nature of the aquatic vegetation within it. Young mountain streams flowing fast over rocky beds will allow little or no vegetation. The little that does appear during quiet summer periods is soon uprooted following heavy rain. As soon as the flow reaches the point that sedimentation begins, more permanent aquatic vegetation is able to establish itself. Growth can become very dense even in comparatively fast flowing rivers, as can be seen in the Spey, the Eden or the Dove.

Aquatic vegetation, like terrestrial plant species shows preferences for particular soil types. In addition, the chemical composition of the water body will control the species that can grow within it.

Man made

Man made watercourses were first constructed in Great Britain by the Romans for the transportation of troops and supplies through difficult terrain. Many more were cut in the Middle Ages to provide access by boat to towns and villages from the nearest navigable river. During the industrial revolution the bulk of the present canal system was built.

By far the most numerous man made watercourses however, are land drainage channels, the total length of which is estimated to be in the region of 128000 km (Price, 1981), of which approximately 15% are maintained by Internal Drainage Boards. They can vary in size from small field ditches to large arterial drainage channels, with water widths in excess of 30 metres. It is within this category of watercourse that the most stringent standards of aquatic weed control are maintained.

THE NEED FOR CONTROL

Most waterbodies in Great Britain, and particularly in England, are managed in a variety of ways in the interests of water supply, land drainage, navigation, angling or other recreational activities. Vegetation control to a greater or lesser degree is invariably a part of that management.

It is accepted that aquatic plants fulfil an important role as primary producers of food and dissolved oxygen, as well as helping to prevent bed and bank erosion. On the other hand they often interfere with man's interests (Robson, 1976). Obstruction to flow caused by vegetation increases the risk of flooding, reduces the effectiveness of land drainage works, causes siltation of channels and can block culverts and pumping station intakes (Table 1).

Table 1
Classes of aquatic vegetation

Type	Common examples	Problems caused
Emergent monocotyledons	*Phragmites communis* – Common reed *Sparganium erectum* – Bur reed *Glyceria maxima* – Reed sweet grass *Typha latifolia* – Reedmace	Resistance to flow Siltation in shallow channels Access for angling etc
Emergent dicotyledons	*Alisma plantago-aquatica* – Water plantain *Rorippa nasturtium-aquaticum* – Watercress *Hippuris vulgaris* – Mares tail	Resistance to flow Siltation Interference with angling and navigation
Floating leaved plants	*Lemna minor* – Common duckweed *Potamogeton natans* – Broad leaved pondweed *Nuphar lutea* – Yellow water lily *Polygonum amphibium* – Amphibious bistort	Resistance to flow Interference with angling and navigation Amenity Filtration of potable water and deoxygenation (*Lemna* only)
Submerged vascular plants	*Ceratophyllum demersum* – Hornwort *Ranuculus spp* – Water crowfoot *Callitriche stagnalis* – Water starwort *Potamogeton crispus* – Curled pondweed	Resistance to flow Interference with angling and navigation Danger to bathers
Filamentous algae	*Vaucheria dicotoma* – Cott *Enteromorpha intestinalis* – Bladderweed *Cladophora glomerata* – Blanket weed	Resistance to flow Blocking of culverts and pumping station intakes. Interference with angling and boating, including clogging engine cooling systems. Filtration Amenity competition with ornamental plants. Decaying mats cause de-oxygenisation of water. Danger to bathers
Periphyton and Phytoplankton	*Achnanthes spp* – Pennate-diatoms *Stephanodiscus spp* – centric diatoms *Microcystis spp* – Blue green algae bloom	Amenity Filtration Potable water taste and odour

Observations made by people involved in weed control before the Second World War suggest that the volume of aquatic plants has increased markedly in recent years. This can be attributed at least in part to the extra nutrients present in the water of lowland rivers and drainage channels resulting from sewage effluents and the leaching of chemical fertilisers.

Heavy weed growth interferes with navigation, sailing, angling and other aquatic sports. Floating plants can, by preventing light penetration, cause deoxygenation of water, and in the case of duckweek (*Lemna* spp.) and filamentous and unicellular algae are unsightly, particularly on amenity waters.

High populations of some phytoplankton are troublesome in potable water supply sources, affecting odour and taste and creating difficulties in filtration processes.

The extent and degree of aquatic weed control varies according to the purpose and use to which the watercourses affected are put. Natural watercourses with no navigation or flood prevention function, and remainder arms of the canals system are not likely to require extensive weed control, except to assist recreational pursuits.

Whilst boat traffic in commercial and cruising canals has been shown to reduce plant growth (Murphy & Eaton, 1981) most of these channels still require some form of regular weed control; but, as in the case of all classes of waterway, unnecessary removal of aquatic plants is undesirable both on account of wasted expenditure as well as from the point of view of nature conservation. Land drainage channels and channelised sections of rivers can be coupled together in that they are civil engineering structures, the size, depth and gradient of which have been carefully designed to collect and transport flood flows at acceptable levels, without overtopping of banks, to a point of outfall. In this way they can be compared directly with urban surface water sewers, which fulfil a similar function. In the fenland areas, a large proportion of which lie below mean sea level, the very existence of the life of the region depends on the proper function of these watercourses.

In order that they do function in accordance with their designed capacities, they must be maintained to a very high standard at all times of the year. Silt deposits and other obstructions must be regularly removed and, above all, aquatic weed growth must be kept down to insignificant quantities. Miles (1976) showed the disastrous effects on water surface gradients in fen drainage channels that failure to remove weed growth can produce.

In many fisheries, without some form of careful weed control to provide clear "swims", successful angling can become impossible. The invasion of emergent weeds into shallow channels encourages siltation, often to the detriment of a fishery. Kelsall (1981) describes how dense "jungles" of submerged weed will extract oxygen at night from the water through respiration in sufficient quantities to cause distress to fish populations.

It can be seen therefore that there is an enormous variation in the need for aquatic weed control, both regionally and between different categories of watercourse. This results in a corresponding difference in the extent of weed control operations carried out (see Table 2).

Table 2
Regional variations in the extent of Aquatic Weed Control.

Water Authority River or Land Drainage Area	Total length of maintained watercourses (km)	Artificial or embanked channels as a proportion of total (%)	Proportion of channels on which regular weed control is practised (%)
Anglian Water Authority	6592	18*	60*
North West Water Authority	3527	9	3
Severn Trent Water Authority	3500*	10	95
Southern Water Authority	2765	17	76
Wessex Water Authority	2355	25	25
Yorkshire Water Authority	1724	58	23
Forth River Catchment	560	3	2*
Tweed River Catchment	800*	14	1*
Middle Level Internal Drainage Districts	950*	100	100
Welland & Deepings Internal Drainage District	669	100	100
Southern W.A. Internal Drainage Districts	940	100	100
Middle Level Main Rivers	176	95	90

*Estimated figure

CHOICE OF METHOD

In making a decision on the method of weed control to be employed on a particular channel, an engineer has to consider a number of factors, including:

i The degree of control required
ii Species spectrum of target plants
iii Ease of access to the watercourse
iv Attitude of the Water Authority to the use of herbicides
v The presence, if any, of rare or protected plants

Hand cutting

The traditional methods of handcutting using scythes and shears have been in use for hundreds of years and are still widely used. Whilst this method of cutting is decreasing, it is somewhat surprising that it survives at all in these highly mechanised times, particularly since it is probably the most expensive method of control.

The answer to its continued use however, lies in the fact that hand cutting can be employed at any time of the year. In watercourses where herbicides cannot be used, or where this use would be unsuitable, access to the channel sides with machinery in arable farming areas is often difficult or impossible during the summer. It is during the summer period however, that growing crops are at their most vulnerable to flooding or waterlogging, and consequently land drainage engineers in particular are most keen that weed clearance should proceed without delay. The most recent examples of weed cutting machinery to come on to the British market have been designed with access problems in mind, and it is the introduction of these machines that may well result in the final disappearance of hand cutting as a viable method of control.

Mechanical cutting and removal

For the past 15–20 years mechanised cutting of aquatic weeds has meant either the use of weed cutting boats or weed cutting buckets mounted on to hydraulic or dragline excavators. These machines are often supplemented by tractor mounted flail mowers to cut bank vegetation above the water line.

In common with hand cutting, mechanical cutting of weeds has the effect of stimulating the regrowth of vegetation, particularly with perennial plants. As a result it is often necessary for the cutting operation to be repeated at least once, and in many cases twice or even three times during the growing season. Consequently whilst mechanical cutting is invariably cheaper than hand methods, the annual costs can still be very high.

As has been mentioned earlier, access to watercourses for land based machines in arable areas can present difficulties, and in addition problems often arise in the disposal of cut weeds removed from the channel.

The disposal problem is particularly acute with filamentous algae *Vaucheria spp*, the notorious Fen cott, which cannot be placed on adjoining arable fields, since, unlike other vegetation, it is extremely slow to decompose and will remain in fibrous mats for anything up to three years.

Filamentous algae are also hazardous to weed cutting boats which are unable to make progress through the dense floating blankets, and in these conditions the cutting mechanisms are totally ineffective. Since cutting is impractical the only mechanical method of dealing with filamentous algae is removal by specially constructed buckets, known as cott rakes, mounted on to excavators.

Apart from disposal difficulties already described, it is not possible to physically remove all the algae from the channels, and the remainder will quickly multiply to reinfest the waterway.

Price (1981) describes in detail the comparative advantages and disadvantages of individual weed cutting machines in regular use in Great Britain, together with more advanced machines recently developed in Holland and West Germany. These machines have been designed to overcome the problems of access in arable areas.

The first is a four wheeled vehicle fitted with two reciprocating cutter bars, and which operates within a small drain straddling the waterway. Cut weed is removed from the channel by a mechanical rake mounted on the same machine. The machine is extremely fast in operation compared with the traditional machines and is capable of speeds in excess of 400m/h. The second machine is a bicycle type tractor with a stabilising wheel mounted on an hydraulic arm situated on the channel batter. The machine carries a long reciprocating cutter bar and a rotary weed rake to remove the cut weed. The operating speed of this machine is extremely fast, clearing half the growth from a small channel at a rate of 1600m/h.

Within the limits of those channels for which these new machines are suitable, it is clear than they are likely to be of great benefit, particularly to Drainage Authorities, in reducing costs of weed control.

Aquatic herbicides

The introduction of aquatic herbicides over 20 years ago, and the development of improved products in more recent years, has had a marked effect on aquatic weed management, particularly in land drainage channels. Where access to watercourses was restricted by arable crops, they became an obvious alternative to hand roding in order to provide open watercourses during the summer.

Their success has been due, not only to their general efficacy, but also to the cost effectiveness of their use.

Aquatic herbicides, in common with agricultural products, require clearance under the Pesticides Safety Precautions Scheme (PSPS). The scheme consists of a formal agreement between Industry and Government under which manufacturers provide all necessary data to enable potential risks arising from the use of herbicides to be carefully assessed and appropriate safety precautions defined.

Full clearance, when given to a product, indicates that when it is used in accordance with the instructions displayed on the product label, it is considered safe for use in *all* categories of water.

Following PSPS clearance most products are submitted to the Agricultural Chemicals Approvals Scheme (ACAS), which is a voluntary scheme operated by the Departments of Agriculture in the UK to enable users to select appropriate proprietory brands of herbicide for their particular requirements and to discourage the use of unsatisfactory products.

For the users of herbicides, the Ministry of Agriculture, Fisheries & Food have published "Guidelines for the use of herbicides on weeds in or near watercourses and lakes" (MAFF, 1979).

Bearing these facts in mind, it is regretted by many users and potential users of herbicides that many Water Authorities in England and Wales ban them in potable water supply channels and discourage their use elsewhere.

The attitude of the Water Authorities has had, in recent years, an adverse effect on the development of new aquatic herbicides.

The ever increasing volume of test data required in obtaining clearance under PSPS has resulted in a rapid escalation of the cost of getting a new product on to the market. With the prospect of sales of that product being limited to use in non-potable water, there is little chance of the development costs being recouped from sales in the UK. Therefore, unless there are expectations of large worldwide sales, or a dual role of the herbicide in agriculture as well as in aquatics, then it is unlikely that development will be undertaken. This is a pity since in many ways herbicides have a less damaging effect on the aquatic environment than mechanical maintenance methods. Wade (1981) states that, contrary to popular opinion, "the use of aquatic herbicides over the past 20 years has had very few deleterious effects on the status of aquatic machrophyte species in Great Britain either nationally or regionally".

From an efficiency point of view herbicides are more suited to the requirements of land drainage engineers than mechanical methods. Whereas cutting of vegetation tends to stimulate regrowth, chemical treatment either kills completely or drastically reduces and weakens any regrowth. The use of herbicides in the early stages of growth not only prevents flood hazards developing through dense weed growth, but also renders unnecessary the cost and difficult problems associated with cut weed removal and disposal.

Nevertheless, there are practical problems faced by engineers in the use of herbicides. Most of the present range (Table 3) require virtually still water conditions. Unexpected water movement following heavy rain can either delay treatments or ruin treatments already carried out. The modern agricultural practice of overhead irrigation is causing problems in many drainage districts where the supply pumps can cause sufficient movement of water to affect herbicide treatments as much as 4 km away.

Only one cleared herbicide, terbutryne, will control *Vaucheria spp*, and even with this product it is classified as moderately susceptible. Unfortunately terbutryne is unsuitable for use in watercourses with an organic substrate.

The present range of herbicides for the treatment of submerged weeds and algae also suffer from the fact that treated water is unsuitable for overhead crop irrigation for at least one week and can, in the case of chlorthiamid, be as long as four weeks. Most of the herbicides are comparatively slow acting and consequently require near still water conditions in order to be thoroughly effective. Table 4 shows the comparison between the currently available herbicides.

Table 3
Herbicides cleared for use in or near water

Chemical	Type of application	Commercial clearance status	Approved under ACAS	Max. flow rate of water-course	Time of application	Plants controlled
Asulam	Foliar spray	Provisional	No	N/A	July/ August	Waterside plants, Bracken, docks
Chlor-thiamid	Granules into water	Provisional	Yes	90m/h	March/ April	Some sub-merged and floating weeds
2,4–D amine	Foliar spray	Full	Certain products	N/A	Early summer to September	Emergent broadleaved weeds and weeds on banks
Dalapon	Foliar spray	Full	Certain products	N/A	Spring to late summer	Reeds and some emergent mono-cotyledons
Dichlo-benil	Granules into water	Full	Yes	90m/h	Early spring	Some floating and submerged weeds
Diquat	Foliar spray or into water	Full	Yes	90m/h	Through-out the year	Some floating and submerged weeds and algae
Diquat alginate	Viscous gel direct to water	Full	Yes	1800m/h	Late spring early summer	Some floating and submerged seeds and algae
Fosamine ammonium	Foliar spray	Provisional	No	N/A	July/ September	Some deciduous woody plants
Glypho-sate	Foliar spray	Provisional	Yes	N/A	July/ September	Water lilies, reeds and emergent weeds
Maleic hydrazide	Foliar spray	Full	Certain products	N/A	March/ September	Suppression of grass growth on banks
Paraquat	Foliar spray with Dalapon	Full but poison rules apply	Gramo-xone S only	N/A	Spring to late summer	To enhance action of dalapon on reeds
Terbu-tryne	Granules into water	Full	Yes	20m/h	April/ May	Some floating and submerged weeds and algae

Table 4
Time required for effective control, and minimum safe period before use of water for irrigation

Herbicide	Still water period required for effective treatment (days)	Minimum period between treatment and irrigation use (days)
Terbutryne	7–12*	7
Diquat	½	10
Diquat alginate	Nil	10
Dichlobenil	7	14
Chlorthiamid	7	28

* 12 days required for moderately resistant species

The introduction of diquat alginate this year has provided for the first time a herbicide that can deal with submerged weeds in water flowing faster than 90m/h. The herbicide is formulated to contain diquat in a viscous solution which is sprayed on to the water surface. On contact with water the solution gels and sinks on to the submerged weed where it sticks to the foliage. In flowing water the gel is broken down into small strings which are distributed amongst the biomass. This herbicide is particularly suited to situations where localised treatments of weed clumps are required.

Biological control

Where watercourses pass through grassland, cattle and sheep grazing can be an efficient method of controlling emergent weeds at the water margins. This can only be achieved on unfenced banks and the trampling of the waters edge can have a deleterious effect on the channel which will outweigh the benefits of weed control.

A great deal of experimental work has been undertaken into the use of herbivorous fish, namely Chinese Grass Carp (*Ctenopharyngodon idella*) for the control of aquatic weeds. Numbers of fish are now being released in certain limited locations to test the effect of their grazing. It is thought that the chance of ecological damage occurring is slight, and in the UK climate these fish are extremely unlikely to be able to breed naturally.

Shading

The use of shading of a watercourse using hedges and trees planted on the southern banks is used extensively in Northern Germany and in other parts of Europe. The reduction of light reaching the water surface discourages the growth of water plants.

Dawson & Kern-Hansen (1979) have shown how shading can be used as a management technique. It is plain that on many watercourses such a plan can be used to good effect although the disadvantages arising from restriction of access and the accumulation of leaf and wood litter must be taken into consideration.

STATUTORY OBLIGATIONS

Water, navigation and drainage authorities as well as private and municipal managers of amenity waters are bound by a number of Acts of Parliament relating to their various functions.

Water Authorities and water companies have obligations under The Water Act 1945 to protect the quality of water abstracted for public supply and to supply only wholesome water. They also have to take steps to protect fish life under the requirements of the Salmon and Freshwater Fisheries Act 1975. The Control of Pollution Act 1974 extends wide powers to Local and Water Authorities. Part 2 of that Act required the Water Authority to be consulted whenever herbicides are to be used in water entering a river system.

The Wildlife and Countryside Act 1981 has added new responsibilities for all authorities to take into account the conservation of wild plants and animals when considering the management of watercourses generally. The Act enables the designation of Sites of Special Scientific Interest which may be watercourses or lakes. Where a watercourse is so designated its management must be agreed with the Nature Conservancy Council with a view to avoiding damage to the special interests of that particular site.

On the other hand Navigation authorities and Drainage Boards have responsibilities under numerous Navigation Acts and the Land Drainage Act 1976 to ensure that their watercourses are maintained in a fit state to fulfil their primary function.

Difficulties are expected to arise where the requirements of these Acts conflict with interpretations of the Wildlife and Countryside Act 1981.

Finally, the Conservation of Wild Creatures and Wild Plants Act 1975 which has been re-enacted by the Wildlife and Countryside Act 1981 lists very rare plants which it is an offence to destroy.

COSTS OF WEED CONTROL

Figures for the cost of aquatic weed control are not readily available but I estimate that in England and Wales the total cost at today's values would be in the order of £11 million annually. An approximate break down of this figure is as follows:–

Drainage Boards	£4 million
Water Authorities	£4.5 million
Other	£2.5 million

Whilst these figures are only a broad estimate, they do provide an indication of the size of the operations on a national basis.

The comparative costs of various types of weed control are very difficult to assess. Much will depend on the quantity of weed present in a watercourse, problems of access, the depth and width of watercourse and many other factors. In an effort to arrive at an equitable comparison, I have produced two tables (Tables 5 & 6) which compare costs for different methods given identical tasks. Figures shown are produced from costings provided by a number of drainage authorities in the South and East of England.

ENVIRONMENTAL ASPECTS

Irrespective of conservation legislation most managers of watercourses are keen to preserve wildlife habitats as far as possible within the limits allowed by their responsibilities, to ensure that the channels under their control carry out their proper function. This is clearly a much easier task in upland areas and in natural rivers and streams elsewhere. In fenland drainage districts and in channellised lowland rivers, where the channels have precise engineering functions, the opportunities are more limited. Nevertheless many authorities do take specific steps to aid conservation. In my own Authority's area for example, efforts are made to provide nesting sites for water birds by leaving isolated clumps of emergent weeds along the fringes of larger channels, the commencement of bank mowing is delayed until the ground nesting birds have reared their young, and redundant sections of drain are specifically managed to provide suitable spawning areas for fish. No aquatic weed control is carried out unless it can be properly justified.

The Wildlife and Countryside Act 1981 lays down hard and fast rules for the management of watercourses within Sites of Special Scientific Interest; but without a general awareness and a willingness to enhance the natural environment on any site wherever possible, the Act will not have achieved its purpose. It would be helpful if there was a better understanding on the part of conservationists, the public and the media, of the statutory responsibilities and the technical problems faced by river management authorities and drainage boards.

FUTURE PROSPECTS

Major strides have been made in recent years, sadly not in the UK, in the development of new sophisticated aquatic weed control machinery which will overcome some of the outstanding difficulties currently facing water engineers.

In many situations weed cutting is an inefficient way of removing weeds from drainage channels, acting as a stimulant to growth as well as being comparatively costly. It can also be argued that the removal of cut weed and its deposit, together with large populations of invertebrates, fish fry and other

Table 5
Comparative costs of controlling 2m wide fringe growth of reeds on one side of large water-course

Method of control	Cost of single treatment/ km (£)	Remarks
Weedcutting boat with dragline at intervals to remove cut weed	40	Maximum of two cuts for full control. No access problems
Hand cutting – weed raked to bank top	150	As above No access problems
Weed cutting bucket mounted on hydraulic excatator	120	In arable areas one cut only after harvest, unless compensation paid
Bicycle tractor with cutter bar and weed rake	50	Based on figures from one UK user only
Tractor mounted spray using glyphosate	25	Access problems in August where root crops are present
Hand spraying using glyphosate	30	No access problems but even application is difficult
Helicopter spray using dalapon	63	No access problems. 150 km can be completed/day

Table 6
Comparative costs of controlling submerged weeds in a drainage ditch with water width 3m/depth 1m

Method of control	Cost/single treatment/km (£)	Remarks
Weedcutting boat with dragline at intervals to remove cut weed	50	Usually 3 cuts/season required in drainage channels. Not suitable where piped culverts are present
Hand shearing and removal	175	2 to 3 cuts required in drainage channels. Labour intensive and slow
Weedcutting bucket on hydraulic excavator	140	Problems of access during summer in arable areas
Berkenheger 3001 wheeled excavator working within the drain profile fitted with cutters and rakes	100	Very fast and thorough. Limited to certain sizes of channel
Herbicide granules (dichlobenil)	86	Easy to apply. No weed removal. Single treatment lasts for year
Herbicide granules (terbutryne)	82	As dichlobenil but still water essential. The only herbicide effective against *Vaucheria spp.*
Liquid herbicide injection (diquat)	80	Contact herbicide Some problems of regrowth
Removal of filamentous algae by dragline excavator with cott rake	300	Expensive. Problems of disposal and regrowth

fauna on to adjoining land is not in the best interests of nature conservation. The early use of appropriate aquatic herbicides would seem to offer the prospect of controlling the weed without damaging other life. Unfortunately, the present range of cleared aquatic herbicides do not cover the full range of requirements. At present there are no herbicides for the following:–

i To control perennial submerged weeds and the more resistant filamentous algae in flowing water or in channels where flow can only be stopped for short periods.

ii Herbicides of all types with a rapid rate of chemical degradation allowing treated water to be safe for irrigation use much more quickly than at present (See Table 4).

iii Herbicides for the control of emergent plants in the early stages of growth.

iv An efficient algicide capable of controlling *Vaucheria spp.* and other resistant forms of filamentous algae, which is also effective in channels with an organic substrate.

It is clear however, that such new products are unlikely to be developed unless there is a prospect of a much wider use of aquatic herbicides. Such a wider use will only come about if there is a drastic change of attitude on the part of Water Authorities.

Until this happens there will be a heavy reliance on the use of cutting machinery which at present, despite comparatively high unit costs, is the method employed on about 85% of all aquatic weed control work.

CONCLUSIONS

It is generally agreed that in most watercourses, lakes and ponds the presence of aquatic vegetation of one kind or another will at some time run contrary to man's interests to a greater or lesser degree. Where this occurs it is desirable that the water engineer should take action to correct the problem.

Natural rivers and streams, together with lakes and other amenity waters are able to tolerate much greater quantities of water plants than those channels which perform a land drainage or flood prevention function. Consequently standards of vegetation control will be vastly different. Drainage and flood prevention watercourses are engineering structures and must be maintained as such. Very little weed growth can be allowed in these channels.

Despite the development of new improved weed cutting machines, there remains a pressing need for a wider range of aquatic herbicides than are presently available, but the prospects of this materialising are not good. Biological methods of weed control and shading of watercourses may be of use in the future but are unlikely to be widely used. In the meantime, the increased use of the current range of aquatic herbicides would improve the efficiency of weed control operations and greatly reduce costs.

When the optimum use is made of all types of vegetation control methods that are available, the benefits in both economic and environmental terms will be considerable.

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DISCUSSION FOR MR CAVE

Mr Small Referring to the use of Chinese Grass Carp, what happens when the fish have cleared the vegetation on which they are feeding, and what effect do they have on populations of other fish?

Mr Cave (Speaker) The Grass Carp can be managed in the same way as a flock of sheep on land. That is they can be brought to a watercourse, left there for a period, and then, when they have done the job, moved on somewhere else. Grass Carp are herbivores, and there has

been no evidence from experiments carried out over the last fifteen years that they affect other fish. It is virtually impossible for them to breed naturally in this country, because water temperatures are too low, so that they have to be reared under artificial conditions.

Sir Ralph Verney Could Mr Cave elaborate further on the question of the use of herbicides and of biological controls for weeds in watercourses. It is very attractive to develop chemicals and they can be varied enormously, but there is considerable uncertainty in the Water Authorities, and particularly by their lay members, about the safety and use of chemicals. Is there no scope for control by ducks, geese, invertebrates or fungi, which would be more acceptable to lay opinion. Is there not a case for putting more resources into research into biological control rather than chemicals?

Mr Cave (Speaker) Generally speaking the professional staff of water authorities, who have gone into the subject of the use of herbicides deeply, are not hostile to them. It is people who speak from the heart who tend to argue against herbicides without thorough knowledge, and it is a bit disturbing that emotional decisions are being taken that affect practical situations. At the same time drainage authorities live by their rates, and must do everything reasonable to make their operations as cost effective as possible.

The trouble with ducks and geese, and invertebrates, and that type of thing, is that with drainage channels one is looking after engineering structures which must be maintained to a standard to enable them to function properly. It is very difficult to use biological controls to give a guaranteed result, but I agree that more resources for research are certainly required.

Mr Guiver There are other reasons than water authorities's objections to the use of aquatic herbicides in potable water supply rivers and reservoirs, that have restricted the development of potentially effective products. The herbicides that are available do not eliminate the problems, for instance, of having to remove dead emergent weeds mechanically. Nor do they prevent the colonisation by unsightly algal growth of waters cleared of submerged weeds. Thus, even some land drainage engineers themselves have not adopted the use of herbicides because they are not wholly effective.

In any case it seems doubtful if the market for herbicides could be made much larger to justify the cost of their development (compared to their terrestrial uses), even if there was scope for use in potable water supply rivers.

Briefly on the use of Grass Carp, much work is still needed, and they should not be considered as the solution to all aquatic weed problems. A combined approach is probably needed for the future, with proper consideration being given to all three methods of weed control: mechanical, chemical and biological.

Mr Spencer-Jones In answer to earlier comments where the attitude of water authorities was said to have restricted the use of aquatic herbicides. Some authorities are relaxed and most co-operative, whilst others, as a matter of policy, altogether refuse to use them. Potential markets, which are very difficult to assess, owing to the lack of statistical data are inevitably affected.

All aquatic herbicides now cleared for sale through the Pesticide Safety Precaution Scheme (PSPS), have a worldwide large volume market on major agricultural crops, such as cereals, maize, cotton, rice, etc. Their additional development for aquatic use helps to cover the astronomical costs of toxicological testing, and companies increasingly are having to get the greatest 'mileage' out of each and every compound in order to obtain an economic return. If Water Authorities have a hardened attitude to the use of chemicals, this additional development is not encouraged.

There is also a need to avoid a 'them and us' attitude over herbicides. Herbicides, machinery, Grass Carp, shading – these are all tools of the trade, should be regarded as such and their use integrated. Herbicides are now being used in an increasingly sophisticated and responsible manner; an example is the 'Weed Wiper' for glyphosate, which provides control of emergent monocots, without the risks of spray drift, or of the herbicide even entering the water.

Dr Green The weed infestations shown in the slides as being representative of typical problems, all appear to be in highly eutrophicated waterways. Under more natural, less nutrient rich conditions the populations of these plants would be much smaller.

Isn't the management thus dealing with a symptom of the problem, and not the cause? In many places such eutrophication would be largely attributable to runoff of agricultural fertiliser. Why not control this? Are there not powers under the 1974 Control of Pollution Act?

If this is not possible, what about the possibilities of biomass harvesting as described by Professor Last in the first paper?

Mr Cave (Speaker) There was a study commissioned by the Department of Energy a few years ago at Sheffield University, to look into the question of using the biomass from aquatic weed control operations. The conclusion was that it was an impracticality. The problem is one of logistics, of getting the material from the site cheaply to a place where it can be converted into energy.

Mr Robson The control of submerged weeds with Grass Carp has considerable promise in some situations in the UK, as a background control agent supplemented with cutting or herbicides as required. In the Netherlands, use of these fish in this way is claimed to have reduced maintenance costs by 40%.

Classical biological control with insects has been successful to a limited extent in warmer countries on alien (introduced) weed species – e.g. on water hyacinth in the USA – using insects collected from stands of the plant in its country of origin. In Britain the mixed plant communities that we have, do not lend themselves to this kind of management, because as one plant is removed it is replaced by another, which may not be attacked by the same insect as the first species.

GRASSLANDS and HERBACEOUS

Management of Herbaceous Vegetation for Amenity and Recreation

W. N. G. Gilmour
Association of Metropolitan Authorities

When I agreed to present this paper giving some indication of the way in which we do or could make provision for natural or semi-natural herbaceous vegetation, the brief which I was given included the request to give some indication of the extent of each area presently managed by local authorities. This statistic was to exclude formal grass areas such as football fields. I do not know if such a statistic is available but I have not been able to trace one. Indeed it is difficult to be sure that such statistics as are available, for such classifications as 'Public Open Spaces' are all for the same kind of area.

The local authority, especially in the urban areas, is faced with the problem of having to provide for the majority of its ratepayers a standard of maintenance which is acceptable to them and to do so with an ever decreasing work force. This decrease in the number of employees over the years has been necessary in order to cope with the financial constraints placed upon local authorities both by central government and by the ratepayers.

The consequences of the reductions in manpower may be seen in the modifications which have taken place in parks and open spaces. They are generally changes to enable the area to be maintained by mechanical means.

Whatever the changes, when it comes to grass lands, and these must make up the largest proportion of natural/semi-natural herbaceous areas, there is no doubt that the majority of city dwellers demand that the grass is maintained in a mown condition – "That's what we are paying our rates for" is the oft heard statement if the grass is not mown to an acceptable level.

One should remember that to many thousands of people the areas of public open space around their dwellings is the nearest thing they will have to a garden and they expect to see it looking as though it belongs to them.

An unmown area is a piece of 'waste land' that does not 'belong' to anyone. It is a good place on which to get rid of rubbish.

Rubbish requires hand labour and vehicles to clear away and so it is cheaper to mow the grass in the first place.

Uncut grass areas also present a fire risk. One statistic which I do have is that in South Yorkshire during 1980 there were 1,162 grass fires and in 1981 1,061. The cost of dealing with these in terms of fire brigade cost is that one fire tender turned out for one hour costs £40 per hour. That is the cost over and above the cost of maintaining the unit on standby. To this can be added the costs of replacement of damaged property such as fences and trees.

Having said all that there are still some places and some ways in which the local authorities can encourage and positively plan for areas to be maintained to give natural or semi-natural effects.

In the organisation of mowing large grass areas, the larger the area cut in a single pass of the machine is generally the cheapest method. Large machines are, however, more difficult to manoeuvre especially into and out of sharp corners or through areas of young trees. It is, therefore, worth considering leaving difficult areas such as these and bankings unmown during the normal mowing cycle.

Some 'formal' sports areas require that certain areas be treated in this way. I have in mind the 'roughs' of the golf courses where a variety of different management programmes is not only acceptable but positively encouraged to give a variety of interests to the courses.

The traditional spring bedding displays have in many instances been replaced by large areas of naturalised bulbs such as crocuses and narcissi. In order to allow the bulbs to regenerate naturally the foliage must be left uncut until the latter half of June at the earliest. This enables many areas to develop a different flora from that of the general mown areas.

Woodlands as such are being dealt with in a separate paper but the floor of the woodland is another obvious area where the encouragement of natural vegetation is acceptable by the city dweller, though some plants such as the bluebell may need a positive protection programme in order that they may survive.

Another kind of area that has some potential for maintaining in a 'natural' state is the disused burial ground but even here the public prefer to see these in a 'maintained' state. The result of this is that more and more of them are being cleaned up and levelled so that they can be machine mown. The actual cleaning up is being carried out through the encouragement of the central government to use Manpower Services funds to employ men on hand labour type schemes of a creative nature. Schemes of a recurring maintenance nature are not acceptable!

On the fringes of the urban areas or in the rural areas it is less difficult to adopt a 'natural' approach to the management of grass areas. In Country Parks it is, for example, in keeping with the area to maintain by grazing and, by the selection of different animals, to have different pastures.

If maximising income is not an important criteria (with some authorities it is) then the grazing need not be of best quality grazing grass mixtures or be boosted with fertilizers. It is possible to arrange for such areas to be grazed by

local farmers at minimum cost to the farmer and also to build into the licence the right for the authority to use the fields for other purposes from time to time during the year.

Also in association with Country Parks some fields or parts of them can be cropped in the historical way, allowing the poppies to bloom and perhaps even re-introducing some of the other weeds of the arable fields killed out by the requirements of modern farming methods. Crops grown in such a way can be hand harvested and then threshed using the old mechanical methods thus providing a spectacle of living history.

Within Country Parks and like areas there is the possibility of setting aside areas to be managed as nature reserves. In these areas a variety of management programmes and techniques can be set up. Besides the ultimate results giving interest to the visitor to the park, the programmes and techniques themselves can provide a source of interest. These can be the basis for informative displays, leaflets and part of guided tours.

Within the urban areas small areas within school grounds can be similarly developed as nature reserves and here they can form part of the natural history studies within the school.

The creation of new open spaces from derelict and degraded areas is presenting the opportunity to experiment with the creation of different swards using new cultivars and minimum top soil. The establishment of these swards though slow is encouraging, but only time will tell if they are able to withstand the pressures that future use may demand of them.

From the point of view of the person interested in encouraging a diverse flora in a grassland situation it is, unfortunately, the case that the gang mower is the cheapest method of ensuring that the sward is maintained as the public generally wish to see it. It is also one of the most simple methods so far as training and supervision of staff is concerned. It should be appreciated that even with our present high level of unemployment there is little incentive financially or otherwise for men to accept manual work. The basic rate of pay for a manual worker with a local authority is £69.60 per week. Add to that the requirement for the authorities to employ as few men as possible and one can perhaps understand some of the difficulties facing the manager who wishes to adopt methods of maintenance other than routine mechanical mowing.

DISCUSSION FOR MR GILMOUR

Mr Small It was mentioned that the amenity areas were being managed for people, have you been able to enlist their support in any form of work force?

Mr Gilmour (Speaker) Yes, we engage the voluntary corps who are keen to come in and do some of the management work, and we can get small areas treated in this way. But it would not be possible to use voluntary labour for the bigger jobs. We have something like 300 volunteer 'footpath' wardens, who take part in a scheme to walk and report on things that

are going wrong, such as farmers ploughing where they shouldn't; or where things need doing, such as mending drains or stiles.

Other opportunities arise from the Manpower Services Commission schemes (MSC). We can get people from the MSC, but only for new work. We are not allowed to use them for maintenance. The problem here is that in a sense we are increasing our own difficulties by tidying up areas that we are not able subsequently to maintain. There is a wonderful sense of creation when people go in and do something, and frustration when they go back twelve months later and find that it has not been maintained.

Mr Lucas (Chairman) Do formalised Victorian parks really represent what people want now, or have tastes totally changed?

Mr Gilmour (Speaker) Over a period of time people will accept a certain standard, and come to think of that as normal. But if you show them how it could be improved they will appreciate it. One of my last slides was of a park in Holland where the Dutch people go in their thousands in the spring time, and pay to go in. If one was able to offer people something like that round their flats, rather than just monotonous green grass, or a wilderness of banking, then I am sure that is what they would prefer.

Mr Parker What is the attitude of staff towards the areas of unmown land that you are leaving around the edges of parks and playing fields, and do you save any money by leaving these areas unmown?

Mr Gilmour Where you have got a resident man, at a school for example, his attitude will be that to leave these areas to go wild is deplorable. But the number of places where we can afford to have a resident man or team is decreasing rapidly. We now depend more on mobile gangs, who move around from one school or housing site to the next, and there is no personal involvement.

But the other dilemma is that it is very difficult to explain to staff what you are trying to achieve, and with some of the unskilled labour to apply the more sophisticated management techniques that are being proposed.

Professor Moore In the course of carrying out a study on the effects of building a small new town in Cambridgeshire on the local fauna and flora, I have noticed that children have quite different requirements from grown-ups. It is very striking how children always make for places where there are still big trees, big slopes to run up and down on, and so on. Are you able to cater deliberately for the needs of the different age groups. What do you actually do?

Mr Gilmour (Speaker) I think the short answer is 'Yes', we do try and cater for the different age groups. It is a constant struggle really between designing a housing estate, and trying to put into it what you think the children will want and use. It's very nice if you have banks, and mature trees, and especially water. So you try to provide water, and leave areas for the children, and trees where they can put ropes and be able to swing about on them.

Management of Herbaceous Vegetation on the Sides of Roads and Motorways

A. P. Dunball
Department of Transport

CLASSES AND MILEAGE OF ROAD: TRUNK ROADS AND COUNTY ROADS

In 1937, with the passing of the Trunk Road Act, 4,500 miles of main road were lost to local authorities and became the direct responsibility of the then Ministry of Transport. These roads were the main arterial routes considered of national importance and essential for the economic life of the country. Subsequently, Central Government has retained responsibility for the development and maintenance of trunk roads.

From the mid 1950's the trunk road network has been enlarged and improved, and the motorway system has been developed – motorways being trunk roads where special design standards and traffic regulations apply. Additionally, since the passing of the Trunk Roads Act, the responsibility for roads in Wales has passed to the Welsh Office.

As at 1st April 1980 there were 6,210 miles of trunk road in England (which includes 1,335 miles of motorway). The increase in trunk road mileage between 1937 and 1980 does not represent the mileage of new road constructed as, where existing trunk routes are replaced by entirely new roads, the former lose their trunk road status and become the responsibility of the local Highway Authority.

Prior to 1st April 1967, the non-trunk roads – which are the responsibility of the local Highway Authority – fell into four categories: Class I, Class II, Class III, and Unclassified – the Classified Roads being supported by Government Grant for improvement and maintenance at rates of 75%, 60% and 50% respectively. The Local Government Act 1966 defined Principal Roads (roughly equivalent to the Class I Roads), Classified Non-Principal Roads and Unclassified Roads. As at 1st April 1980, the mileage of these roads in England was 15,259, 49,016 and 90,260 making a total of 154,535 miles of non-trunk road and an overall total of 160,745.

EXTENT OF VERGES AND MARGINAL LAND

Most roads have grass verges to accommodate drainage, underground public utilities and to provide passage for pedestrians. They are also needed for the storage of snow displaced from the carriageway and to accommodate signs, lighting columns and other street furniture. Verges are not merely marginal land, but form part of the design of a road and the Department of Transport's recommended verge widths (Table 1) are contained in the publication "Layout of Roads in Rural Areas" (HMSO, 1968).

Table 1
Layout of roads in rural areas. Recommended verge widths (HMSO, 1968)

Type of road	Recommended kerbside treatment	Minimum kerbside treatment
Dual carriageway and three-lane single carriageway roads	3.50m verge comprising edge lining on hard strip 1.0m wide and remaining width grassed	2.0m verge comprising edge lining on hard strip 1.0m wide and remaining width grassed
Two-lane single carriageway roads with a design year flows exceeding 6000 pcu's/day *	3.50m verge comprising edge lining on hard strip 1.0m wide or kerbs and remaining width grassed	2.0m verge comprising edge lining on hard strip 1.0m wide or kerbs and remaining width grassed
Two-lane single carriageway roads with design year flows between 3000 and 6000 pcu's/day	3.50m grass verge: edge lining or kerbing not usually required	2.0m grass verge: edge lining or kerbing not usually required
Two-lane single carriageway roads with design flows under 3000 pcu's/day	2.0m grass verge: edge lining or kerbing not usually required	1.50m grass verge: edge lining or kerbing not usually required

On motorways the recommended verge width is 1.50m

*Passenger carrying units

Roads constructed to high design standards have additional marginal land in the cutting and embankment slopes needed to provide satisfactory vertical alignment, and widened verges on curves to give the forward visibility necessary for the design speed of the road. The extent of the total grass areas, as distinct from verges, on roadsides varies considerable from an estimated 18.47 acres/mile on the M3 (Way, 1976) down to virtually nothing on narrow West Country lanes enclosed by Devon banks. Road mileages in England as at 1st April 1980, and estimated areas of marginal land associated with each class of road are set out in Table 2, and Table 3 gives similar information for England and Wales.

Table 2
Roads in England. Mileages and area of marginal land as at 1st April 1980.
Data: HMSO (1981); Way (1970, 1973, 1976).

England	Miles	Km	Average acres /mile	Average ha /km	Estimated total acres	Estimated total ha
Trunk roads	4,875	7,845.3	6.0	1.51	29,250	11,837.0
Trunk road motorways	1,335	2,148.4	12.6	3.17	16,821	6,807.2
Principal road motorways	61	98.0	12.6	3.17	769	311.2
Principal roads	15,198	24,453.1	4.0	1.01	60,792	24,601.6
Classified non-principal roads	49,016	78,881.4	3.58	0.90	175,863	71,169.5
Unclassified roads	90,260	145,255.4	2.7	0.68	243,702	98,622.8
Totals	160,745	258,681.6			527,197	213,349.3
			Totals adjusted to allow for urban streets (minus 16.8%)		438,628	177,506.6

Table 3
Roads in England & Wales. Mileages and area of marginal land 1st April 1980.*

England & Wales	Miles	Km	Average acres /mile	Average ha /km	Estimated total acres	Estimated total ha
Trunk roads	5,894	9,485.3	6.0	1.51	35,392	14,322.8
Trunk road motorways	1,410	2,268.4	12.6	3.17	17,769	7,190.8
Principal road motorways	61	98.0	12.6	3.17	769	311.2
Principal roads	16,724	26,914.5	4.0	1.01	67,171	27,183.2
Classified non-principal roads	56,728	91,292.4	3.58	0.90	203,480	82,345.7
Unclassified roads	99,434	160,020.0	2.70	0.68	268,884	108,813.6
Totals	180,251	290,078.2			593,465	240,167.3
*As Table 2 with additional figures for Wales			Totals adjusted to allow for urban streets (minus 16.8%)		493,762	199,819.2

The total areas in both Tables 2 and 3 have been reduced by 16.8% to allow for urban streets which have no grass verges. This figure is that used by Way (1973) being at that time the percentage of the total road mileage found within the Greater London Council, and in County Boroughs. This figure has not been up-dated, as with the demise of County Boroughs no similar figure is available. However, it would be fair to assume that since the earlier estimates were prepared there has been more road development in rural areas than within towns, so that the figure of 16.8% could be considered as high, and the consequent reduction in the total area unrealistically large.

MAINTENANCE AUTHORITIES AND THEIR FINANCE

The Department of Transport appoints agents to maintain trunk roads and motorways on their behalf, these normally being County, or Metropolitan Highway Authorities. The Department seeks annual estimates from the agent Authorities for the work necessary, and allocates funds at the beginning of the financial year. The funds allocated may fall short of those sought by the agent Authority. The Department of Transport may consider its agents' estimates inflated, or that some of the work proposed was unnecessary. Additionally the Government, through its Ministers, exercises financial control according to its policies, and may well place a ceiling on expenditure far below the estimate of the Department's agents. With the present constraints on public expenditure priority is given to funding the maintenance of the structure of highways to the detriment of routine maintenance operations, such as grass cutting which may not be considered cost effective. On county roads the local Highway Authorities can, in theory, maintain to whatever standard they wish. However, in practice, they tend to follow the pattern set by the Department of Transport for trunk roads and motorways, and with the present financial constraints on Local Government expenditure they would find it difficult to justify higher maintenance standards than those attained by a Central Government Department.

MANAGEMENT OBJECTIVES

All highway management operations must be primarily designed to ensure the proper functioning of the road, and the safety of those using it; but when dealing with roadside vegetation directly, other considerations may have to be taken into account. Disregarding these for the present, one can define the objectives of verge management as follows:—

i To provide full visibility for the drivers of vehicles, particularly at junctions, and across left-hand bends. While the height of the driver's line of sight is regarded as 1.05m, he may be required to see across a left hand bend to the rear light of a vehicle ahead at a height of 0.26m.

ii To prevent the obstruction of signs. While the majority of these are carried at such a height that they are unlikely to be obscured except by overgrown hedges, or the lower branches of trees, tall weed growth could restrict the visibility of signs from a distance when on a curving vertical alignment. It may be necessary to cut the herbage on motorways so that the kilometre marker posts remain visible.

iii To prevent the herbage falling or flopping on to the running surface of the road, thus reducing its effective width.

iv To allow the free passage of pedestrians. Where there are no footpaths it may be necessary to maintain the verge vegetation so that long grass does not encourage pedestrians to walk on the metalled surface of the road.

v To control vegetation in discharge ditches, and on the granular fill of french drains so that their efficiency is not impaired.

While these are the main objectives of herbage management on roadsides, there are others which are not vital for the proper functioning of the road but, nevertheless, are of great importance. In the first place a landlord must behave in a neighbourly manner and consider the interests of adjoining land owners. In this context he will need to control injurious weeds to prevent them from spreading on to his neighbour's land. The Department of Transport requires its agent Authorities to prevent the seeding of the injurious weeds listed in the Weeds Act (1959) should adjoining landowners complain. The weeds proscribed are spear thistle (*Cirsium vulgare*), creeping or field thistle (*Cirsium arvense*), curled dock (*Rumex crispus*), broad-leaved dock (*Rumex obtusifolius*) and ragwort (*Senecio jacobaea*). Additionally, it must be necessary to control weeds such as wild oat (*Avena fatua*) and weed beet (an annual variety of sugar beet) where they are likely to be detrimental to adjoining crops. Roadside vegetation cannot be permitted to harbour diseases which may be of economic importance to adjoining crops – for example, fire blight (*Erwinia amylovora*) on hawthorn (*Crataegus monogyna*) and other rosaceous trees and shrubs where these adjoin orchards, and bacterial canker (*Pseudomonas morsprunorum*) on *Prunus avium* in cherry growing areas. Similarly, vegetation may have to be controlled when it is found to be harbouring rabbits or other vermin which may damage adjoining crops.

While unmown grass may be acceptable in rural areas, in urban and semi-urban situations some regular management is necessary for reasons of visual amenity. Normally an acceptable appearance can be achieved with 8–12 cuts/year, depending on rainfall and the length of the growing season.

The Department of Transport accepts the need to carry out special maintenance programmes on roadside verges of particular botanical interest. In these instances the Department looks to the appropriate County Naturalist Trust to identify such sites and to put forward their recommendations for management. It has always been accepted that a diverse flora on roadsides is desirable; and to encourage this the Department of Transport and its predecessors has strictly controlled the use of selective weedkillers and other chemical sprays. Similarly,

it has always been opposed to excessive grass cutting which favours few broad-leaved plants. The benefits of this policy are obvious to the observant road traveller who cannot fail to miss the large stands of cowslips (*Primula veris*), primroses (*Primula vulgaris*), vetches (*Vicia spp*), cow parsley (*Anthriscus sylvestris*), ox-eye daisy (*Chrysanthemum leucanthemum*), dandelions (*Taraxacum officinalis*) and other showy plants.

MANAGEMENT STANDARDS

Prior to 1975 the Department of Transport set out in some detail the standards to which grass areas on trunk roads and motorways were to be managed. These were not restricted to fulfilling the objectives set out above, but additionally related the standard of management to the type of landscape through which the road was passing. In areas of grazed meadow land regular cutting of grass areas would be encouraged, whereas, where roads passed through woodland, only weed control should be practiced so that the regeneration of woody species would be encouraged. Between these two extremes there were varying standards to cope with differing types of landscape and the demands of visual amenity.

In terms of visual amenity these standards could be regarded as ideal, but in practice they were wasteful in resources. There is no doubt that, with a wide range of grass cutting machinery to hand, many of the Department's agents were maintaining to "produce a neat and tidy appearance" – a standard that cannot be justified. Not only does neatly mown grass appear incongruous in the countryside, but regular mowing severely restricts the number of broad-leaved plant species which can establish themselves in the sward.

In 1975 the Department of Transport issued a new instruction which restricted grass cutting to that necessary for the proper functioning of the road, on the lines set out above. While this was primarily designed to eliminate unnecessary expenditure it also restricted the activities of the tidy minded and was to some extent welcomed by conservationists.

METHODS AND COST OF MANAGEMENT

On roadsides the methods of herbage management are limited to mechanical and hand cutting, and the use of herbicides and other chemicals. While herbage may be taken as hay, and tethered goats and ponies may occasionally be seen on roadsides, grazing is not a practical form of management. For obvious reasons burning cannot be considered as an alternative for cutting.

In rural areas cutting is carried out by the use of flail mowers of one type or another depending on the size of the area involved. As these machines can manage herbage of almost any height, and pulverise the cut material so overcoming the problem of clippings blowing on to the carriageway, they have

virtually replaced other forms of mechanical cutting. Occasionally adjoining landowners may cut verges for hay using the traditional cutter bar, but the presence of litter and other extraneous material likely to affect the palatability of the hay, and even damage the cutting equipment, generally makes roadside hay-making unattractive.

In urban areas Highway Authorities invariably delegate their responsibility for verge maintenance to the local parks department who have a full range of cylinder, rotary and flail mowers suitable for all the site conditions they are likely to encounter.

The chemicals used in the control of herbage are generally grass growth retardants and herbicides. The former are commonly based on maleic hydrazide and when applied early in the growing season will inhibit grass growth for 10–12 weeks depending on the formulation and the amount of active ingredient applied. This material is useful in areas where high quality turf of lawn standard is not required, and yet a short sward is needed. The manufacturers of this chemical have equated the cost of the spray treatment as roughly equal to the cost of cutting grass twice. Where grass only has to be cut to preserve full visibility, and a height of 300mm can be accepted, there would be no financial saving in the use of chemical retardants as this standard can be achieved with two cuts. However, on the central reserves of dual carriageway roads, where lanes have to be closed so that cutting equipment can be operated safely, spraying may have an advantage over cutting. The main disadvantages of this material are the short application period if greatest efficiency is to be achieved, and the amount of water required on motorways and rural roads where no ready supply is available.

The range of selective herbicides available for broadleaved weeds – such as 2,4-D and MCPA with various additives – have an important part to play in verge maintenance. In many areas, once the tall-growing herbaceous weeds have been removed, the grass species can be left uncut as their ultimate height is unlikely to affect the proper functioning of the road. Non-selective herbicides may be used along french drains, beneath guard rails, around the base of lighting columns, signs and other street furniture.

Comparative costs of the different types of management are not readily available; the Department of Transports' agents are required to maintain grass areas to the minimum standard laid down, and the Department exercises financial control through their allocation of monies. It is not possible to isolate the cost of grass cutting as this expenditure is included with other verge maintenance operations under the heading "Grass Cutting, Siding, Hedges and Trees". Siding is the operation of cutting back grass edges to prevent their encroachment on to carriageways or footpaths. On trunk roads the highway boundary, and the hedge – where one exists – is the responsibility of the adjoining owners and the Department of Transport should not incur expenditure on the management of trunk road hedges. Where hedges have to be cut back as they are obstructing the highway, the costs should be recovered from the owner. On motorways the Highway Authority owns the boundary and is

responsible for its management, and hedges were planted on the early motorways (M1 St Albans – Crick; M6 Preston and Lancaster By-passes; M5 Strensham – Lydiate Ash; and M50 Ross Spur). At that time it was proposed that hedges would form the permanent bounday of the motorways – the fences being allowed to fall into disrepair. However, the difficulty of getting really stock-proof hedges in some areas, and the heavy maintenance costs, led the Department to abandon hedges and to rely on fences as the permanent motorway boundary. The management of trees, the final item under this Grass Cutting, Siding, Hedges and Trees heading refers to the management of mature trees. Generally, the maintenance of young trees planted as part of the landscape treatment of new roads is financed from a different source.

Grass cutting and siding probably account for 90% of the expenditure under Grass Cutting, Siding, Hedges and Trees, and the other items all form part of the management costs of the marginal land associated with highways. The national cost of this work for 1979/80 is set out below in Table 4.

Table 4
Roads in England: expenditure on grass cutting, siding, hedges and trees 1979/80.

Class of road	Total (£)	£/mile	£/km	£/acre	£/ha
Motorways	485,888	364	226	29	71
Trunk roads	1,462,634	300	186	46	114
County roads	28,311,000	176	114	58	154

CONCLUSION

The standards to which roadside marginal land is managed – and particularly that on trunk roads and motorways – have since 1975, been reduced to the absolute minimum necessary. The figures shown in Table 4 are for 1979/80 – the last financial year for which full details are available. It is likely that the amount spent in 1980/81 will be considerably less in real terms.

While initially there was some criticism when the amount of grass cutting was reduced, there was not the outcry that many anticipated, and the problems forecast have not yet proved to be so great as to indicate that the current policy is ill-advised. In some areas there has been an increase in the population of injurious weeds, but there has also been an increase in the range of broad-leaved plants generally which can only be advantageous to the aims of conservationists.

The fear that uncut areas will become colonised with scrub and eventually trees, to the detriment of herbaceous species, is a real one, but it is only on motorways and major trunk roads that substantial areas can be left unmown. Reference to Table 2 indicates that the areas of verges and marginal land associated with motorways only represents 3.33% of the total and that on motorways and trunk roads 8.88%. It could be argued that, while there will be a decrease in herbaceous plants, habitats for nesting birds and other wildlife

will be increased. The rate at which hardwood species will colonise is extremely variable and depends on climate, soil types and the presence of propagules. Observations on roadsides indicate that even in favoured situations extensive shrubby growth will only occur after a 10 year period.

It can be argued that a Highway Authority has a duty to manage the marginal land associated with roadsides, so that the original landscape objectives are achieved, and that the relationship between areas of grass, shrubs, and trees should be maintained, and the contrast between enclosure and open views preserved. However, it is doubtful if a Highway Authority is justified in incurring expenditure on the management of land purely to favour herbaceous plants, and to prevent the development of woody species.

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DISCUSSION FOR MR DUNBALL

Mrs S E Wright I am concerned that there seems to be a rejection of the idea of leaving some areas of new motorway and roadside verges free of topsoil, so as to allow natural regeneration of local species of plants to take place. Could not other nearby areas receive compensatory larger amounts (and so a greater depth) of topsoil, since carting surplus topsoil any distance from the construction site is costly. I know that vegetation takes a long time to re-establish, and that we do not seem to be prepared to wait. We ought perhaps to learn to be more patient.

Is the general policy for management of herbaceous vegetation on highway verges to maintain a herbaceous cover, or is natural succession to scrub and woodland being allowed?

Mr Dunball (Speaker) On the question of using less, or no, topsoil. We have done this particularly on the chalk, sometimes at the request of the Nature Conservancy Council, and in other places where the slope is too steep to stick the topsoil on. We do also use varying depths of topsoil: we specify 12 in (30 cm) for areas that are to be planted with trees and shrubs, and 6 in (15 cm) elsewhere. In fact there is a lot of variation because the manner in which the soil is spread does not guarantee an exact depth. However, one cannot spread more than 12 in, because where there is more than that the surface becomes unstable. The

problem is largely one of cost, and of disposal of topsoil from the area of the construction of the carriageway. Nevertheless, I feel that it is an odd concept to do away with topsoil and grow plants on subsoil, even if it is supposed to get a more diverse flora.

I agree that we shall get diversity as a consequence of the progression to scrub that you mentioned. I have accepted in my paper that there are going to be problems with a lot of scrub on certain roads, where the verges have not been mown since the day they were constructed. On the Stevenage by-pass for instance, we are now clearing trees and scrub. We wouldn't want a situation where one travelled all the way from London to Carlisle enclosed by woodland.

Mr Spencer-Jones Should motorway verges be managed as areas for rare or indigenous plants? They cannot be seen by the speeding motorist, who is also prevented by law from stopping. It seems to me that motorway verges are the wrong sort of place in which to try and preserve areas of wild plants.

Mr Dunball (Speaker) The percentage of land tied up in motorway verges, as against that associated with the rest of the road system, is not very great, but there is a great deal of emotive talk about motorways in particular, because people use them a great deal. Nevertheless, if we have got the land, and it is a resource, we should use it in the best way we can. Only one person in the vehicle is driving, and the other one-and-a-half (said to be the average) are likely to be pretty bored. So that if there are interesting plants, and variation between woodland and open fields, so much the better. But again there is the problem of whether an authority responsible for roads and traffic should spend money on creating a diverse flora, or of managing the roads for reasons of amenity, rather than for getting traffic moving.

Mr Lucas (Chairman) We have talked about the flora. Is there a possibility of animal life coming in to such an extent that it becomes a hazard on the motorways?

Mr Dunball (Speaker) No. There is no evidence of that.

Mr Smart It is important to keep in perspective broad considerations other than conservation which should weigh heavily in coming to a general strategy for roadside management. There is a need for policies based on regional characters as the framework for more detailed solutions.

There is also the loaded question of steering, or of educating, public taste. Some problems stem from decisions related to different sets of objectives. Steep, glazed, unstable engineering earth slopes create problems of sward establishment, and produce visually unrelated physical forms, which a more comprehensive solution would avoid by allowing regraded slopes to merge with, and support, the husbandry of neighbouring farms. Pressure to produce instant landscape compresses natural processes and produces less than totally satisfactory results, whilst the motorway speed of travel requires a breadth of treatment which is meaningful against the scale of the motorway.

The Management of Herbaceous Vegetation for Wildlife Conservation

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INTRODUCTION

Herbaceous vegetation mostly created and maintained in the past by the unenclosed pasturing of stock is a resource of considerable importance for the conservation of wildlife and landscape as well as for the provision of informal recreation in the countryside. Such vegetation embraces a wide range of plant communities. They vary from species rich downland and other limestone grasslands over calcareous rendzina soils to species poor heathlands over acidic podsols and meadow grasslands over waterlogged gleys. Gimingham (1972), Duffey *et al.* (1974) and Smith (1981) have described them in detail. All are typified by consisting mainly of short or tall swards of grasses and accompanying forbs, though heathland which is not very heavily grazed or trampled is commonly dominated by bracken (*Pteridium aquilinum*), or by dwarf shrubs, particularly the commoner heathers (*Calluna vulgaris, Erica cinerea, E. tetralix*) and smaller gorses (*Ulex minor* and *U. gallii*).

Although most such grasslands and heathlands are not strictly natural communities, being on land cleared from forest by man and maintained by his stock, they are nonetheless of very considerable ecological interest and importance for wildlife conservation. It is probable that they are close analogues of quite natural ecosystems maintained before the advent of agriculture to Britain by wild cattle (*Bos taurus*), wild horses (*Equus* spp.) and other native herbivores; domestic stock have merely taken over from the wild grazers which are now scarce or extinct. Forest clearance may have greatly expanded the extent of these ecosystems, but they are mostly unsown and justifiably regarded as semi-natural, even though now maintained by human agency. They are the nearest approach found in the British Isles to the steppe and Mediterranean ecosystems of the continental land mass. Many species of limestone grasslands and heathlands are from these continental ecosystems, most, like the early spider orchid (*Ophrys sphegodes*) and Dartford Warbler (*Sylvia undata*), being rarities which only gain a slender foothold in the British Isles.

These ecosystems are also attractive for informal recreation. Large numbers of people use them for picnicking, rambling and many other unorganised activities. A number of factors make them so attractive for these purposes. Limestone grasslands and heathlands are open and dry, their plant communities are aesthetically pleasing, and in areas of predominantly enclosed and ploughed agricultural land they afford rare and welcome access to large tracts of open country. In addition, much of their remaining extent is on hills and escarpments too steep to plough and these positions usually command fine views.

Before the development of modern intensive agriculture after the 1947 Agriculture Act, extensively managed grassland and heathland was a much more important part of the rural economy than it is over most of the country today. Huge tracts of heath, moor and hill grassland were grazed by sheep under systems of traditional pastoral husbandry which were not only important for producing wool and mutton, but for transferring fertility to the arable by folding and manuring. Large areas still survive in the north and west, but, because of their infertility and unprofitability by modern standards, only with the help of hill farming subsidies. Here and elsewhere the great grazing lands of down and dune, moor and marsh are rapidly giving way to improved enclosed pasture or to arable cropland. The loss of these habitats has been documented by Goode (1981). Downland in Hampshire and Sussex has, for example, declined by 20% since 1966 and heathland even more. This loss of habitat leads directly to loss of species, and the fragmentation and isolation of habitats threatens others which require specific habitat features or large areas. In 1930 the snakeshead fritillary (*Fritillaria meleagris*) occurred in 116 10km squares; with loss of meadows it now occurs in only 17. In the last ten years sand lizard (*Lacerta agilis*) localities on southern heathlands have fallen from 159 to 42.

Those areas of herbaceous vegetation which remain, mostly outside the modern agricultural system, are thus of considerable wildlife importance. Amenity grassland, defined as all grassland which has recreational, functional or aesthetic value, but which is not used primarily for agricultural production, has been estimated to cover some 4% of the land surface of the British Isles (NERC, 1977). This includes intensively managed grassland in playing fields, urban parks and domestic lawns, but well over half is extensively managed semi-natural grassland in nature reserves, country parks, commons and other public open spaces, road and rail verges, airfields and golf course roughs. Despite its extent this semi-natural grassland accounted for less than 10% of the total expenditure on amenity grassland management in 1973. This is, of course, in a large part because it requires less management than more heavily used amenity grassland; but this also reflects its lack of proper management. It is one of the great embarrassments of the conservation and amenity movements that many protected areas are scrubbing over fast, losing their open, herbaceous swards and characteristic species under an ever advancing front of rank grass and thorn.

OBJECTIVES OF MANAGEMENT

The functions of herbaceous vegetation in different situations may dictate different management objectives. Relatively short swards may be desirable in golf course roughs to facilitate the finding of balls and to expedite play; rather longer swards may be desirable on airfields to discourage bird flocks and minimise the risk of air strikes. On road verges even taller swards may be tolerated provided they do not threaten sight lines and road safety. In rural country parks, commons and other public open spaces even bracken and some scrub and trees, with the herbaceous vegetation confined to glades, may be thought desirable for informal recreation; though in some more urban situations where assault is considered a hazard, the less cover, the happier the land manager. Likewise on river and sea flood protection walls and berms water engineers are primarily concerned with preventing the ingress of woody species whose roots eventually die and create holes and weak points in the flood defences. In all these situations the protection of wildlife is very much an incidental, albeit important, byproduct, or at least secondary objective, of the land management policy.

In nature reserves, Country Parks, National Parks and other protected areas it is a primary objective. Here the intention will usually be to maintain particular assemblages of plants and animals. These are usually characteristic of herbaceous swards of differing structure. Thus most of the desired plants and many animals of downland are most abundant in a short springy turf, but some butterflies and other insects require areas of taller and ranker vegetation. In heathland managed for wildlife, however, it is usually regarded as desirable to hold the succession at the dwarf shrub stage, for it is an old heather sward which seems to be a critical requirement of rare and characteristic species of heathland like sand lizards and Dartford warblers.

The ecological goals of management are often constrained by a number of factors, particularly cost and feasibility. For these reasons, herbaceous vegetation is often managed at less intensity than desired. Fortunately many species favoured by more intensive management and shorter swards are able to survive, but not flourish, under less intensive regimes. But very few can survive under thick scrub and, once a closed canopy has developed, herbaceous swards can be very difficult to recover. In all cases the minimum objective of management of herbaceous vegetation must therefore be to prevent the development of a closed scrub canopy.

ECOLOGICAL PRINCIPLES UNDERLYING MANAGEMENT

Grasslands and heathlands in Britain are plagioclimax communities only maintained by external agencies such as grazing, mowing, trampling and burning from process of natural succession to scrub and then, finally, woodland. An

understanding of the processes driving these changes and of the mechanisms by which they can be manipulated is essential if one is to control succession in order to maintain open herbaceous ecosystems.

All these agencies arrest succession by two quite different mechanisms. First they act physically by damaging and excluding colonising species more than the species of open swards. Thus woody species such as shrubs and trees with their growing points in exposed apical buds are constantly cut back by grazing, mowing or fire, whereas grasses and rosette herbs with growing points at, or below, ground level can more readily and continuously repair the losses of tissue. Rhizomatous species, such as tor grass (*Brachypodium pinnatum*) and bracken which are, respectively, common colonisers of downland and heathland are susceptible to trampling; but fine leaved grasses like sheeps fescue (*Festuca ovina*) and rosette herbs like daisies (*Bellis perennis*) and ribwort plantain (*Plantago lanceolata*) are more resilient. Some competitive grasses like tor depend upon the build up of a thick litter of dead leaves to suppress other species. Grazing, cutting or fire prevent, or consume, this accumulation.

The second main way by which these agencies favour the species of open swards rather than the colonisers is by maintaining low fertility. The vegetation and soils of limestone grasslands and heathlands are very impoverished, particularly of the major nutrient elements nitrogen and phosphorus. It is this infertility which is largely responsible both for the characteristic species richness of limestone grassland and species poorness of heathlands. More vigorous nutrient-demanding species are constrained, or excluded, by it, allowing a wide range of the typical slower growing and less demanding grasses and herbs to flourish. Heathlands are species poor because not many of these species are adapted to tolerate the toxic concentrations of iron and aluminium which come into the soil solution under acid conditions. Nutrients commonly accumulate with succession, particularly during the shrub stages when nitrogen-fixing legumes like gorse (*Ulex* spp.) invade. If the scrub cover is removed species-rich, herbaceous swards are difficult to restore for the accumulated nutrients favour weedy competitive species like rosebay (*Chamaenerion angustifolium*) and nettles (*Urtica dioica*) (Green, 1972).

Grazing, mowing and fire can all remove nutrients and thus help control the succession by penalising the bigger and more demanding shrubs and trees. Traditional extensive grazing systems were designed as much to pump nutrients to the arable as raise stock. The downland sheep '. . . was held in the highest esteem for its folding quality, for its propensity to leave its droppings on the arable at night, and for its ability as a walking dung cart, robbing the downs for the sake of the tillage, ... ' (Kerridge, quoted in Smith, 1980). Mowing likewise removes nutrients if the cuttings are taken away as hay. So does burning, as much as 95% of the nitrogen and 25% of the phosphorus in the standing crop being lost in the smoke (Chapman, 1967).

Since modern agriculture is concerned with maximising production, and therefore also fertility, its objectives are quite the opposite to those of the amenity land manager, who will want to maximise diversity, or maintain

characteristic species of heathland, both of which mean low fertility. Agricultural grassland management which aims for fertile, high production low diversity swards, usually means ryegrass (*Lolium* spp.) monocultures. Where herbaceous vegetation survives outside the system of intensive agriculture, in hedge and road banks or elsewhere, it may still be subject to fertiliser drift. And it is likely to be no longer managed under extractive systems of rabbit grazing, burning or hay cutting, but swiped with flail or gang mowers which leave the cut material and its damaging nutrient load. This is why swards which were once a mass of primroses and other small wildflowers are now rank with tall herbs, particularly cow parsley (*Anthriscus sylvestris*), hogweed (*Heracleum sphondylium*) and nettles.

METHODS OF MANAGEMENT

There is a good deal of information now available on the management of herbaceous vegetation for wildlife. The more important work is described in Gimingham (1972), Duffey *et al.* (1974), Hunt & Rorison (1980) and Green (1981). Most of the work has been concerned with establishing the effects of different management techniques on the botanical composition of the sward. Apart from the work of Morris and one or two others on invertebrates (Morris, 1971), much less is known about effects on animals. Our knowledge as to how management systems found effective in trials on nature reserves might be more widely employed in a countryside where the rural economy no longer contains either the stock, manpower or markets appropriate to the traditional systems of management is even more fragmentary. It is this development of effective systems of management for wildlife and amenity which is the most urgent need if we are to maintain examples of herbaceous ecosystems (Green, 1973; Thiele-Wittig, 1974; Lowday & Wells, 1977; Large & King, 1978; Lefeuvre, 1980).

This discussion of management techniques therefore concentrates on these aspects, limiting the information to the more obvious practical advantages and difficulties of the different techniques and then illustrating them with my own experience in managing grassland on Wye Downs. Details of how different kinds of animals, different kinds of mower, or times or season of cutting produce different swards are available in the literature cited above. The one important distinction that always needs to be made is between the reclamation of swards which have been under-managed to a desired earlier seral stage, and the maintenance management of swards which are already at the desired seral stage. Some techniques are much better for reclamation than maintenance and others *vice-versa*.

Grazing

Most conservationists would regard grazing as the best means of maintaining most kinds of herbaceous swards. Unfortunately, the types of unenclosed grazing systems which maintained them in the past were very different in their ecological effects to the fenced and paddocked systems which amenity land managers are commonly forced to adopt on protected areas of limited size today. Grazing is therefore not always the best means of management.

Horses and cattle are better than sheep at reclaiming rank swards and scrub, but sheep are best at maintaining short swards. Rabbits, deer and other feral species once maintained large areas of herbaceous vegetation, but fencing costs and problems with adjacent landowners make them difficult to operate today.

Advantages	*Difficulties*
The most 'natural' method of management, stock simulate wild herbivores.	Fencing, water and shepherding costs high.
Impact on invertebrates and other animals minimal?	Tough stock suitable for rough swards difficult to buy and sell.
Remove nutrients if folding or zoning system used.	Effete modern stock breeds may need supplementary feed and its damaging nutrient input.
	Paddocked systems can increase fertility and reduce diversity.
	Stock needs override those of the sward.
	People and dogs disturb stock.

Mowing

Tall herb meadow swards and road verges were commonly cut for hay in the past and the aftermath grazed. Golf courses, airfields and other areas where mowing is still employed illustrate that it can produce swards suitable for wildlife. Mowing is most useful as a maintenance, rather than as a reclamation technique.

Advantages	*Difficulties*
One or two cuts per year may be quite adequate to maintain desired sward.	Only possible where terrain not too steep or uneven.
Season and height of cuts can be readily controlled to favour species in relation to their phenology.	Cuttings must be removed on all but most infertile areas and this is time consuming and expensive.
	Levels microtopography, anthills, etc. which are important for species regeneration.

Burning

Firing vegetation in the autumn or spring to provide a flush of new growth for stock was an integral part of the traditional systems of unenclosed grazing, as it still is where they survive in the North and West. It is also an important natural factor, caused mainly by lightning, in maintaining plagioclimax ecosystems throughout the world. Conservationists have largely disregarded it as a management tool, tragically, for it is arguably the most formidable and useful one available. Although fire is most effective as a reclamation technique, or maintenance technique in conjunction with grazing, it can alone maintain herbaceous vegetation.

Advantages	*Difficulties*
A natural feature in plagioclimax ecosystems.	Prejudice against fire as destructive agency.
Part of traditional pastoral husbandry.	Skill needed to control safely fire and delimit burn.
Only necessary on one occasion at infrequent intervals, perhaps 3–15 years?	Used too extensively or frequently may reduce invertebrate and other animal populations.
Removes nutrients in smoke.	
Prevents disastrous accidental summer fires.	
Easily and inexpensively undertaken.	

Chemicals

Herbicides and growth retardants have not been widely used to manage herbaceous swards for wildlife conservation. Where they have been employed it has usually been as accessories to the use of selective uprooting or cutting of trees and bushes as a reclamation technique to recover open grassland from scrub. Here brushwood killers have been widely and successfully used to prevent regrowth from stumps. Herbicides have also been tried to selectively control rank species such as tor grass. Chemicals like dalapon, which have a degree of specificity for monocotyledons, and asulam, which has been used specifically against bracken, have been successful in small trials. There are indications also that even total herbicides like paraquat can surprisingly selectively penalise the ranker, undesirable species and favour the smaller herbs. Growth retardants such as maleic hydrazide can certainly do this and serve as maintenance rather than reclamation tools.

Advantages	*Difficulties*
Only necessary at infrequent intervals.	Prejudice of conservationists against chemicals.
Easily undertaken and delimited.	Fears of side effects on animal life and non-target species.
	Expensive.

All these management techniques are ideally employed on a rotational basis so that there are always some areas being managed and some being rested and recovering. This ensures that there are always places where species can shelter from management, or flower and set seed to provide colonists which can re-stock any areas from which they may have been lost. This is particularly important with the more potentially destructive management agencies like fire and chemicals, but may be equally important with grazing or mowing which, if continuous, can preclude both flowering and the development of longer swards necessary for many invertebrates. Such rotational systems most nearly resemble both the natural perturbations now thought to be important in maintaining the diversity of many ecosystems (Connell & Slatyer, 1977; Whitmore, 1982) and the traditional systems of management where areas were regularly overgrazed then abandoned to recover. Some species such as juniper (*Juniperus communis*), may be absolutely dependent on such sporadicity of management for their regeneration. Juniper seems to need the bare soil created by over-grazing or fire for germination, but then needs several years free of grazing or fire, to which it is very vulnerable, before it is big enough to tolerate them (Ward, 1981; Miles & Kinnaird, 1979; Gilbert, 1980). Rotational grazing systems are difficult to implement because of higher fencing and watering costs and increased localisation of eutrophication in smaller paddocks. Management by mowing, fire or chemicals is, however, much easier to employ on a rotational basis.

A CASE HISTORY: BURNING AND GRAZING ON WYE DOWNS

Wye Downs have long been renowned for the richness of the plant and animal communities of the escarpment grasslands. Seventeen species of orchid, including the rare early and late spider orchids (*Ophrys sphegodes* and *O. fuciflora*) are recorded. The grassland is dominated by tor grass. This species forms continuous swards in the least disturbed areas and invasive patches in other areas which have been ploughed or otherwise agriculturally improved at various times and reverted to rough grassland. Much of the area is being colonised by scrub. This has evidently been progressing for a considerable time since most of the woodland on the escarpment is not present on old maps and thus has evidently developed secondarily from abandoned grassland in the last two hundred years. Management of the grassland in both Wye Downs National Nature Reserve, and the nearby Crownfield Down owned by Wye College, has concentrated on controlling scrub invasion and maintaining mixed short and longer sward grasslands suitable for maintaining their floristic and entomological richness.

On the Broad Downs area of the National Nature Reserve management for the last 20 years has been mainly by winter grazing with sheep under a grazing tenancy. This has been inadequate to maintain open swards and control scrub invasion for three main reasons. First, stocking densities have reflected the

needs of the sheep and the tenant, not those of the sward. More sheep would likely have better controlled the rank grass but at the expense of the condition of the sheep. Second, the grazing areas contain some relatively fertile and productive plateau grassland as well as the rough escarpment swards and sheep naturally prefer the former. Third, a winter grazing season has been used in deference to disturbance from people and dogs on what is a popular recreation area in the summer, and for fear that summer grazing would deflower and prevent seeding of the grassland plants. But there is little fresh grass on the area in winter and the impact of grazing is thus minimised. Under these conditions the tor grass develops a tall rank sward with thick litter and most of the grassland forbs are suppressed. More open swards with abundant wild flowers were briefly reclaimed by two periods of more intensive management in the early seventies. Summer grazing by cattle and spring burning were both, independently, shown to be very effective in controlling the tor grass and scrub invasion. Neither has been repeated and the sward continues its inexorable decline.

Management on the Crownfield Down was similar until 1979 and the sward had deteriorated in the same way. It had been laxly grazed with sheep throughout the year and occasionally burned. When it came into the full control of Wye College in 1979 the entire field was dominated by tall grasses, mainly tor grass, but also a small amount of tall fescue (*Festuca arundinacea*) and meadow and hairy oats (*Helictotrichon pratense* and *H. pubescens*). The sward was 35–50 cm tall and the ground covered by a thick deposit of undecomposed grass leaf litter. The standing crop of above ground vegetation plus litter harvested between the 26th August and 2nd September 1980 varied, in three replicates, between 773 and 1,330g m^2 dry weight, mean 1022g m^2. Few associated species survived under the tor grass, those doing so most commonly were sheep's and red fescue (*Festuca ovina* and *F. rubra*), salad burnet (*Poterium sanguisorba*), rockrose (*Helianthemum chamaecistus*), burnet saxifrage (*Pimpinella saxifraga*), hairy violet (*Viola hirta*) and yarrow (*Achillea millefolium*). In total 24 species were recorded in three, one m^2 quadrats surveyed for rooted frequency in 100 x 10 cm^2 subdivisions. The maximum number of species in any one quadrat was 17, the minimum 13 and mean 15 (Fig. 1, – *Poa pratensis* and *Rosa* spp. are the two species not recorded there for want of space).

This dense rank grassland was regarded as a summer fire risk. For this reason a large part of the Crownfield Down was burned by College estate staff in March 1980 as a precautionary measure to remove the fuel accumulation. The grassland rapidly recovered after the burn and the whole area was grazed for part of the summer by 20 sheep. Observation indicated that the sheep mainly grazed the more fertile grassland over the superficial deposits at the top of the slope and there was little indication on the sward of grazing where the recording was undertaken. There was, nonetheless, a marked difference between the burned and unburned areas when some vegetation recording was undertaken in late August. Three sample stands were recorded, each within 3–5 m of the corresponding unburned stands described in the previous paragraph. The

burned swards bore only a quarter of the standing crop of the unburned, varying between 240 and 343g m^2 dry weight, mean 300g m^2. Much of this difference is attributable to the almost complete consumption of the dead leaf litter by the fire, for in derelict tor stands the litter commonly accounts for about two thirds of the above ground standing crop. Some of the difference is, however, attributable to less vigorous growth of the tor grass after burning. This was reflected in the height of the burned swards (10–20 cm) being less than half that of the unburned.

The removal of the smothering litter and suppression of the tor grass allows those species such as salad burnet and rock rose which persist in thick tor infestations to flourish and greatly increase their rooted frequency, and a whole suite of species not evident in thick infestations re-colonise the sward (Fig. 1). In total the three sample stands in the burned area contained nearly twice as many species (40) as the unburned; in each individually 31–33 species (mean 32) were recorded. *Carex flacca*, both *Helictotrichon* species, *Thymus pulegiodes* and *Cirsium acaule* made particularly notable increases. Some of the colonising species clearly germinated in the bare soil left by the removal of the leaf litter and were seen as seedlings, presumably from seed already in the soil. Others seem to have spread rapidly by vegetative means. The one species which does not seem to have been able to take much immediate advantage of the control of the tor grass is *Festuca ovina.* The apparent vulnerability of this species to fire, and its replacement by *Helictotrichon* has been noted by Lloyd (1968).

The three sample sites were chosen to represent the natural range of vigour in the tor grass on the Crownfield Down; which seems, broadly, to be related to soil depth. When the performance of the tor grass at these sites, burned and unburned, is plotted against the number of species in the sward the negative relationship between its dominance and species number is quite clear (Fig. 2). The performance of the tor grass was crudely measured as both the total standing crop and the proportion of total species records it accounts for. The suppression of the tor grass is not so evident in the records of rooted frequency where it hardly declines from 100% even in the burned plots. Its decline is, however, more evident in cover records obtained with a pin frame. Cover sampling undertaken in 1981 shows it to have declined from 100% cover in unburned areas to as low as 50% in areas burned and grazed even though its rooted frequency was still 100%.

Subsequent management of Crownfield Down in 1981 has included further controlled burning, both alone and in conjunction with cattle grazing. In addition an enclosure has been set up within which the effects of fire, mowing and herbicides are being monitored in a series of replicate plots. The remarkable recovery of the sward by burning has been consolidated under the new grazing regime and in 1982 the sward has once again come to resemble a typical downland turf. Green-winged, fragrant and bee orchids not seen for many years have reappeared and butterflies have once again become noticeable as their food plants like horseshoe vetch (*Hippocrepis comosa*) and bird's foot trefoil (*Lotus corniculatus*) have increased in abundance.

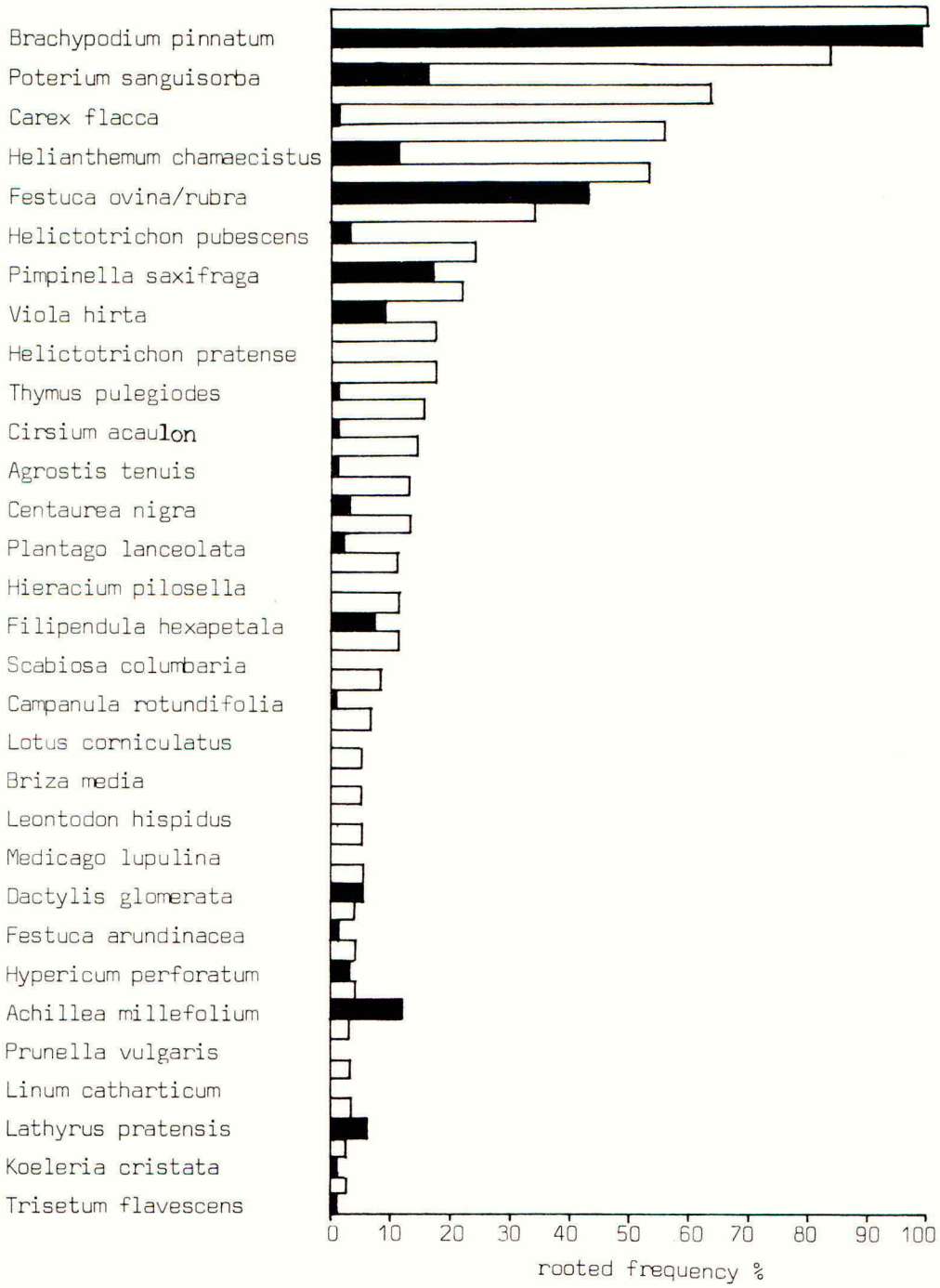

Figure 1. Grassland species composition on the Crownfield Down, Wye, without (black columns) and after (white columns) fire management.

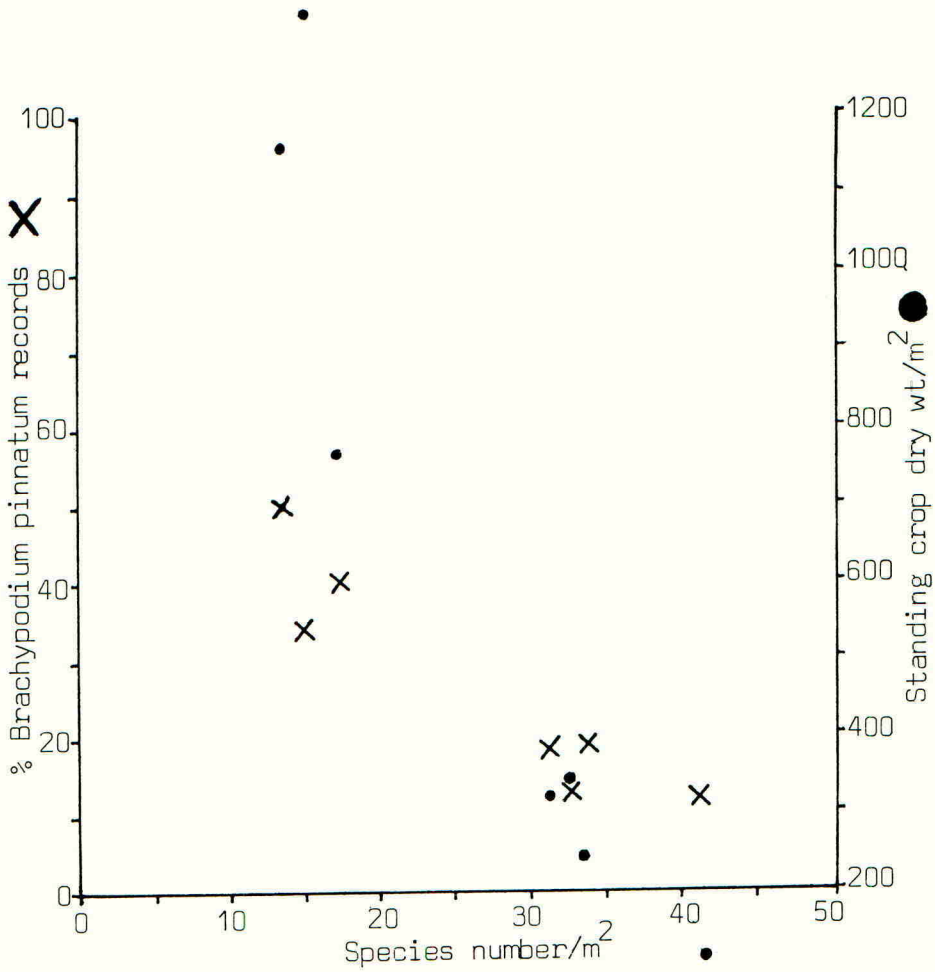

Figure 2. Grassland species number and tor grass (*Brachypodium pinnatum*) dominance on the Crownfield Down, Wye.

CONCLUSION: A PLEA FOR THE WIDER USE OF FIRE MANAGEMENT

Fire is a willing servant, but a hard master. There is no doubt that if not very carefully undertaken burns can quickly get out of control. Fires which are progressing nicely one minute can be raging infernos the next if the wind suddenly changes. The effects of fire are also very different under different conditions. Downwind, or headfires, are, for example, much faster over the ground than backfires into the wind. For this reason they are more difficult to control. But their speed means that temperatures reached in any one spot are lower than in slower and more intensive backfires, and some areas are usually skipped altogether. These facts may mean that headfires allow more plants and animals to survive than backfires.

The season of burning can also make big differences in the effects of the fire. Controlled management burns undertaken within the statutory burning season of 1st November to 31st March (The Heather and Grass Burning (England and Wales) Regulations, 1949) are usually made in early November or late February and March when the vegetation is dry, but the ground still damp. The underground parts of plants, and seeds and animals which are then in the soil are relatively unaffected by such burns. Heather, for example, rapidly regenerates from its roots and seed in the soil. But accidental summer fires when the ground is dry commonly burn off the surface layers of soil, killing roots, seed and soil animals. The bare mineral ground may then be colonised by purple moor grass (*Molinia caerulea*), bracken (*Pteridium aquilinum*), or birch (*Betula* spp.), or alternatively disastrous erosion may ensue (Maltby, 1980).

Fire frequency is another important factor in determining the effects of fire. Artificial fires which take place more frequently than natural fire episodes can prevent species obtaining dominance which would otherwise do so (Moll *et al.* 1980). We are only just beginning to understand the role of fire in natural ecosystems and it is clear that there is still much to learn of the responses of individual species and how these determine the composition of the vegetation (Walker, 1982).

It is not surprising that this lack of knowledge and the unpredictability of fire, coupled with safety considerations, has led many conservation land managers in Britain to reject it as a management tool. But others have abjured it on much more suspect grounds, based on well-meaning, but naively misguided ideas of minimum disturbance in protected ecosystems which fail completely to appreciate recent advances in knowledge on the ecological and historical factors which created and maintained them (see, for example, Walker, 1982). Concern is continually expressed for the fate of animals in fires yet there is very little evidence that they do not, in time, recolonise burnt areas. Indeed there is every reason to suppose that they must have survived in plagioclimaxes because of fire, not despite it. Fire is a perfectly natural occurrence in British ecosystems. Twenty-three fires due to lightning were recorded in Galloway on two days in June 1970 (Thompson, 1972). Effective fire control and, more importantly, the small size and isolation of inflammable ecosystems, now unfortunately prevents the spread of such natural fires. Fire return intervals at any one spot are thus much longer than they would naturally be.

This reduction of fire episodes leads to the build up of dead litter fuel in the ecosystem so that when fires do occur they are far more intense and damaging. The disastrous accidental fires of the hot summer of 1976 which devastated heathlands and grasslands in Britain, many of them nature reserves, would not have been anything like as damaging if sites had been managed on a rotational system of controlled winter burning. If, in the light of this experience, conservation organisations fail to implement fire management, any recurrence of fires like those of 1976 would represent culpable negligence on their part. The National Park Service in the USA has learned this lesson and recently changed

its policy from one of fire control to one of fire management. North American experience in fire management has recently been comprehensively reviewed by Heinselman (1978).

The way in which herbaceous vegetation in nature reserves, Country Parks and other public open spaces is being lost almost everywhere to an advancing tide of scrub and woodland testifies to the lack of success of many grazing, mowing or scrub-clearance policies and systems of management. Greensand heathlands in Kent, which were described and photographed in early ecological studies as open heather communities are now very ordinary secondary birch/oak woodlands in which heather survives only in rides or heathy glades. Conservation land managers who persist with present management methods must ask themselves whether they want grasslands and heathlands to continue to change inexorably in this direction, with the prospect of a few rare insects, sand lizards or Dartford warblers hanging on in woodland glades only by assiduous 'gardening'; or whether they want to maintain open grassland and heathland ecosystems, even if without their more vulnerable species. If the latter objective is favoured then there is no really practicable alternative to using fire much more widely as a management technique.

Lloyd (1968)	*'In the absence of grazing periodic spring fires in grassland communities have the effect of maintaining the floristic diversity of the communities and checking scrub invasion. Only rarely do fires appear to be detrimental to the communities in which they occur.'*
Vogl (1974)	*'Grassland managers, from private ranchers to agency directors, should be "encouraged" to experiment with fire and learn to use it as an effective tool. It is time that we realise that "playing with fire" will not necessarily lead to getting burned and just might help us to relearn a lost art and gain a powerful and natural tool.'*
Webb (1980)	*'Burning still remains the simplest and most effective way of maintaining heathland.'*

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DISCUSSION FOR DR GREEN

Mr Gilmour Is it true that farmers burn straw to increase fertility, because if so, it seems odd that you were saying that you burn to reduce nutrients in the soil?

Dr Green (Speaker) Studies on burning on heathland have shown that something like 80–90% of the nitrogen in the standing crop, and as much as 25% of phosphorus, go up in the smoke. Many people think that because potash is left on the soil fertility is increased, but potash is rapidly leached, certainly from porous soils. So burning removes nutrients from 'natural' ecosystems in one way or another, and this must be the case for agriculture as well.

If a farmer were to plough in straw, the process of microbial decay of the straw seems to take nutrients out of the soil in the first part of the breakdown process, so that it is perhaps to a farmer's advantage in this case to lose the nutrients locked up in the straw by burning. If he ploughs in the straw he may not get any direct benefits from the nutrients in it, and it is much easier for him to replace them with inorganic fertilisers.

Mr Carter Burning straw does result in loss of nitrogen and phosphorus but not potash. Ploughed-in straw, whether long or chopped, has other detrimental effects on the following crop. Work at the Agricultural Research Council's Letcombe Laboratory has shown that over a number of years yields of crops following the ploughing-in of straw may be reduced by 10–20%, compared to crops where the straw had been burned-off or carted. This has been attributed to products from the straw that inhibit germination.

Mr Peters The paper indicates that some habitats can be reconstituted. If this is possible, then how important in terms of priorities for conservation are such habitats? Can you comment upon the need for islands of the original habitat type, their size and number, and management to maintain them as adequate resources?

If such an approach to reproducing habitats is possible, how are priorities to be reached in nature conservation terms? Should we not concentrate on habitats that cannot be reproduced?

Dr Green (Speaker) On the first part of the question, it is indeed relevent to ask whether, if a habitat can be reclaimed, we need to manage it in the first place? But with grassland you can only allow natural succession to go on for relatively few years, because once scrub becomes established, nutrient accumulation takes place, and these nutrients once in the soil are very difficult to get rid of. This build-up also takes place on heathland under gorse and broom, on sand dunes under sea buckthorn, on peat bogs with bog myrtle, and in fens with alder; all of which fix nitrogen. Even on downland where you haven't got nitrogen fixing species, scrub acts as a sieve taking nitrogen out of the air in dust and in rain, and brings nutrients up from the lower soil horizons with its roots. In addition, birds perching in the bushes contribute significant quantities of nutrients. Thus, once scrub is established there can be an increasing pattern of nutrient enrichment, so that management is required to prevent scrub establishment proceeding too far.

Questions of island biogeography and of the sizes of habitats required for survival are more important for woodlands, and for animal populations than for grasslands. It has been

shown that you need a wood of about 100 ha in order to have a reasonable probability of finding all 50 species of lowland, woodland birds common in this country. The general relationship is that for every tenfold reduction in area of an isolated, island, habitat, the number of species is halved. Whilst this seems to work for animals, and especially birds, it is not so critical for plants. The main size consideration which is important for plants is the viability of the management unit. If there are many small areas, it is much more difficult for example to set up grazing systems to make the whole thing worthwhile.

Mr Burdekin How far do the measures taken to conserve vegetation in downlands and heaths, at the same time act as management techniques for landscape and recreation? I wonder whether in this case you are in the very fortunate position of being able to conserve the vegetation, but at the same time satisfying some of the other demands which the general public is making on these areas.

Dr Green (Speaker) We first used burning for the management of downland at Wye as a result of advice that I had from a Nature Conservancy Council warden at the time when I was the NC Regional Officer. He persuaded me that burning was, firstly, part of the traditional management system, and that, secondly, if the vegetation in an area with such recreational pressures was not burnt deliberately in the winter, it would be burned accidentally by the public in the summer. Winter burns which take place in February or March interfere little with recreational use.

The one possibly unacceptable aspect of burning is the danger it poses to small animals, for which reason most amenity land managers are very reluctant to use it. Against this one can argue that one only burns limited areas, in a mosaic pattern, so leaving populations of insects and other animals in the unburnt parts to recolonise. To some extent these animals have to take their chance – they have survived in the past because of burning and not despite it; they are much more likely to be severely affected by uncontrolled summer fires. If the grassland is not burnt it will be invaded by scrub, so that the species characteristic of open ecosystems will disappear, and much of the recreational and landscape value will be lost as well. Fires in grassland and in woodland are a natural feature of wild ecosystems, and are a way (along with floods, avalanches, pests and diseases) by which diversity is introduced into areas that would otherwise be entirely dominated by very few 'most successful' species. With controlled burning, one can limit the extent of any particular episode, and prevent the build-up of plant litter which provides the fuel for very disastrous accidental hot fires, rather than light ground fires which occur when fuel is limited.

The problem with conservation in Britain is that management has almost been a dirty word – at one time there was an idea that if you had a protected area, you put a fence round it and left it. This has of course changed now, but it is still prevalent in some parts of the continent. But even now conservation managers in Britain are far too timorous. There is still too much concern for "gardening" for sand lizards, or Dartford warblers, or particular orchids, when it would be much better if there was more ruthless management, even to the extent of really devastating some ecosystems on a rotational basis. That would do more good for plants and animals than just sitting back or pussy footing around.

Mr Barber This last point about timorousness in land management. During my association with the Royal Society for the Protection of Birds (RSPB) as Chairman over the last five years until quite recently, the thing that I am most proud of is the way that the RSPB has developed this dynamic habitat manipulation on its reserves of about 120,000 acres. I have

been trying to persuade other organisations to adopt the same sophisticated techniques. I believe that this is an incredibly important aspect of the whole thing that we have been discussing, that is to introduce dynamism into land management. We need to persuade as many public and private, and voluntary, landowning bodies as possible to go along that route.

WOODLANDS and FORESTRY

Management of Woodland and Woodland Vegetation for Amenity and Recreation with Particular Reference to the New Forest

Donn Small
Forestry Commission

INTRODUCTION

Since the enactment of the Countryside Act 1968, the Forestry Commission's (FC) use of many of its 965,000 ha of forests has been transformed by the provision of a wide range of recreation facilities for visitors. In Great Britain over a wide range of soils, terrain and crops there are in 1982 – 35 camping sites (plus 5 leased sites and 42 youth sites), 876 car parks with 23,700 car spaces, 594 picnic places, 654 walks and trails, 30 visitor centres, 23 arboreta, 6 forest drives for cars, and 166 cabins and holiday homes. Estimates of the total annual visits to its forests are 26 million day visits and 1.7 million camper nights, i.e. for every hectare of plantation there are 27 daily visits and 2 camper nights. In addition there are very many special activities catered for. For example the New Forest alone accommodates riding, cycling, back packing, orienteering, sponsored walks, rides, barbecues, youth activities (including the Duke of Edinburgh's tests), Scouts and Guides, model aircraft, boats and yachts, hunting, and wayfaring for schools.

Nationally, the FC, under its environmental improvement policy has not harvested in the region of some 8,500,000 cu m of maximum yield production, or about £1.8 million/annum in terms of wood revenues not realised, together with an additional direct cost of £800,000/annum on environmental work, so that the total cost can be estimated at £2.6 million/annum (Forestry Commission, 1982).

I am responding to the British Crop Protection Council's invitation to address this Seminar as the Deputy Surveyor of the New Forest, where a considerable experience has been gained on the subject to be discussed.

GENERAL BRIEF WITH REFERENCE TO THE NEW FOREST

Take a fragment of ancient woodland, bond it with commercial oak, beech and fir plantations, intermix with heathland and bogs, graze with ponies and deer,

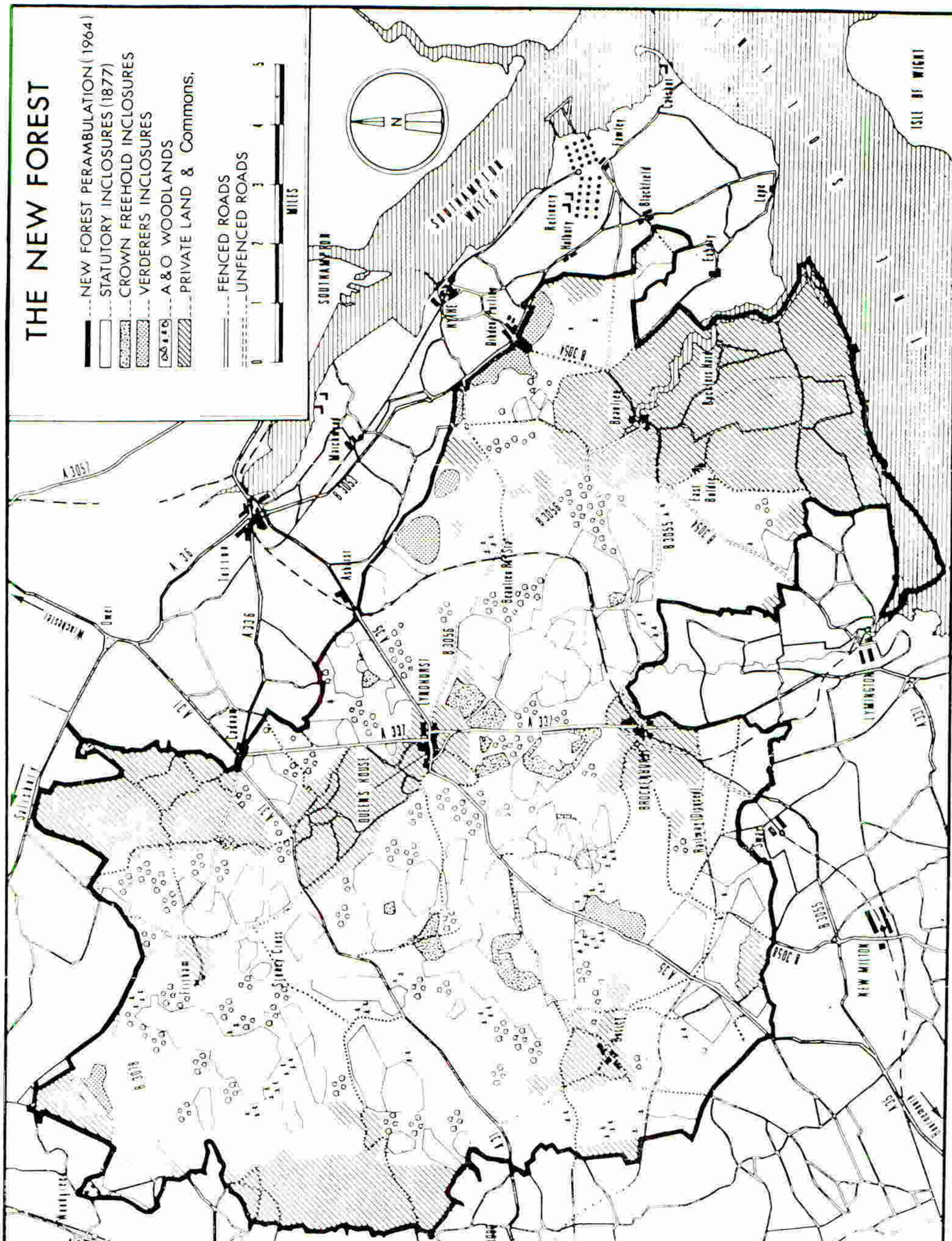
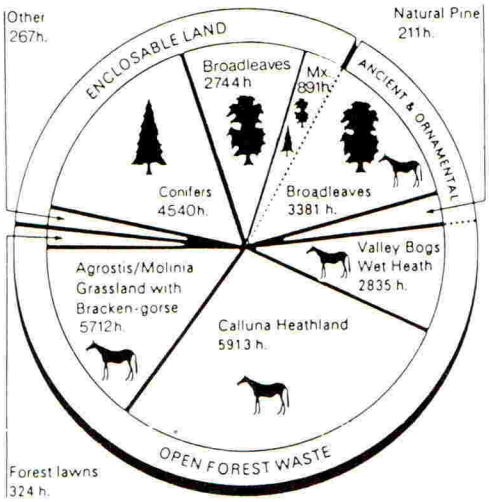


Figure 1. The New Forest.

Distribution of Vegetation within Forestry Commission Areas

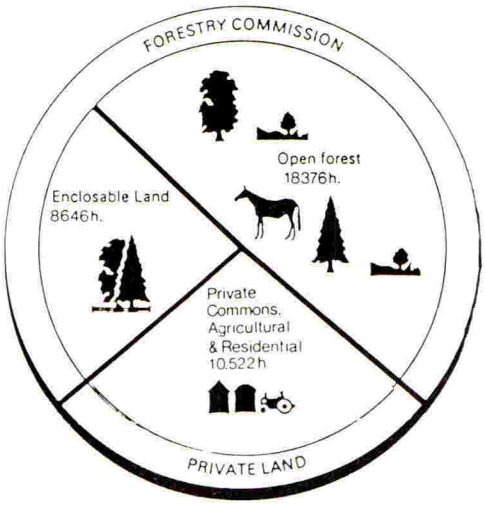


Total Area 27022h. (66773acres)

Figure 2. Distribution of land ownership within the Perambulation.

Distribution of Land Ownership within the Perambulation

Figures show total area in hectares. 1 hectare = 2.47 acres



Total Area 37544 h. (92773 acres)

Figure 3. Distribution of vegetation within Forestry Commission areas.

stir well and blend into an attractive heritage in England – add tents, caravans and motor cars, 6 million annual visitors, add emotion and reaction to taste and you have a recipe for conflict – The New Forest.

The New Forest contains within its ancient boundary – the perambulation (Fig. 1) – 37,675 ha, of which 75% is managed by the FC and 25% is privately owned consisting of farms and residential communities (Fig. 2).

This ancient forest since about 1079 has been the jewel in the crown of southern England and consists (Fig. 3) of a fertile blend of woodland both ancient (3,380 ha) and modern commercial plantations (8,646 ha), interwoven with fertile unenclosed heaths and forest lawns (14,427 ha). It is all owned by the Minister of Agriculture, Fisheries and Food and managed on his behalf by the FC, who together with the ancient but powerful Court of Verderers, established in 1877, now look after the health and welfare of some 5,000–6,000 ponies and cattle belonging to the commoners. Both the Commission and the Court are advised with mutual respect by the Nature Conservancy Council (NCC) (the forest has a status of a National Nature Reserve). The Hampshire County Council and the New Forest District Council play an equally important role in residential planning and highway management.

MANAGEMENT OBJECTIVES

The management of the New Forest as a whole is governed by New Forest Statutes dating from 1877 *et seq.* and by the Minister of Agriculture's Directive, known as the Mandate, from which the management objectives are derived, and which are stated in the 10 year FC Management Plan.

Primary objective for the whole forest

The New Forest must be regarded as a national heritage and priority given to the conservation of its traditional character.

Statutory inclosures

These are fenced areas for protection from grazing, and consist chiefly of timber producing plantations of oak, beech and conifers. The primary management objectives are as follows:

i The broadleaved areas to be managed primarily to perpetuate their visual amenity and conservation values, producing hardwood timber by sound silvicultural systems.

ii The conifer areas to be managed by sound silvicultural systems to produce high quality softwood timber, with, in selected areas, greater emphasis on the recreation and conservation value.

Ancient and ornamental woodlands

These are essentially the remnants of an ancient wood pasturage system, which was heavily exploited in mediaeval times for naval timber, but which today is regenerating outwards, expanding at the expense of the unenclosed heathlands, and is conserved purely for amenity and as a major biological resource. The objectives of management for these remnant areas are as follows:

i These woodlands to be regarded as a component contributing to the national heritage and priority to be given to the conservation of the traditional character.

ii These woodlands to be conserved without regard to timber production objectives.

Open forest wastes

These are the remnants of ancient but continuous heathland kept as such by repeated burning and still being invaded by natural pine and birch, together

with riverside woodland glades known as "forest lawns". This is a complex biological resource heavily grazed in places by ponies and cattle with increasing demands by various factions for either more intensive restoration or more intensive non-intervention. The management objective for this area is as follows:

> The open forest must be safeguarded as a component of the national heritage, and priority given to the conservation of its traditional character with an acceptable balance of the requirements of Commoner's grazing, biological diversity, and stability of surrounding woodlands for peaceful enjoyment by the public.

Recreation

It was in 1971 that major recommendations for the rationalisation of the recreational use of the forest were proposed, and were completed in 1978 by the FC. They were essentially to diversify the locations for car parking and picnicking in suitable locations, and to select areas for camping where infrastructure and ecological considerations made it practical. The objectives are as follows:

i To accommodate the existing public pressures within the forest without fundamentally changing its existing character.
ii To control this pressure with the minimum conflict between the many diverse interests.
iii To provide and maintain a high standard of quality of the facility.

Conservation

The principles of good conservation are practised in all areas of different land use in the forest. These principles are not the easiest to achieve and are governed by the following objectives:

> To maintain the ecological stability and diversity of the forest as a biological bank to afford further opportunities for education and research, recognising that the vegetation types are in constant flux.

WHAT STANDARDS AND METHODS ARE SOUGHT TO SATISFY THE STATED OBJECTIVES

Statutory inclosures

Sound silviculture is practised in all the plantations, taking into account the immense difficulties from the intimate size and age of management units (there are over 4,500 sub-compartments in a total enclosed area of 21,360 acres (8,646 ha), or an average of 5 acres (2.03 ha) each). Continuous regular

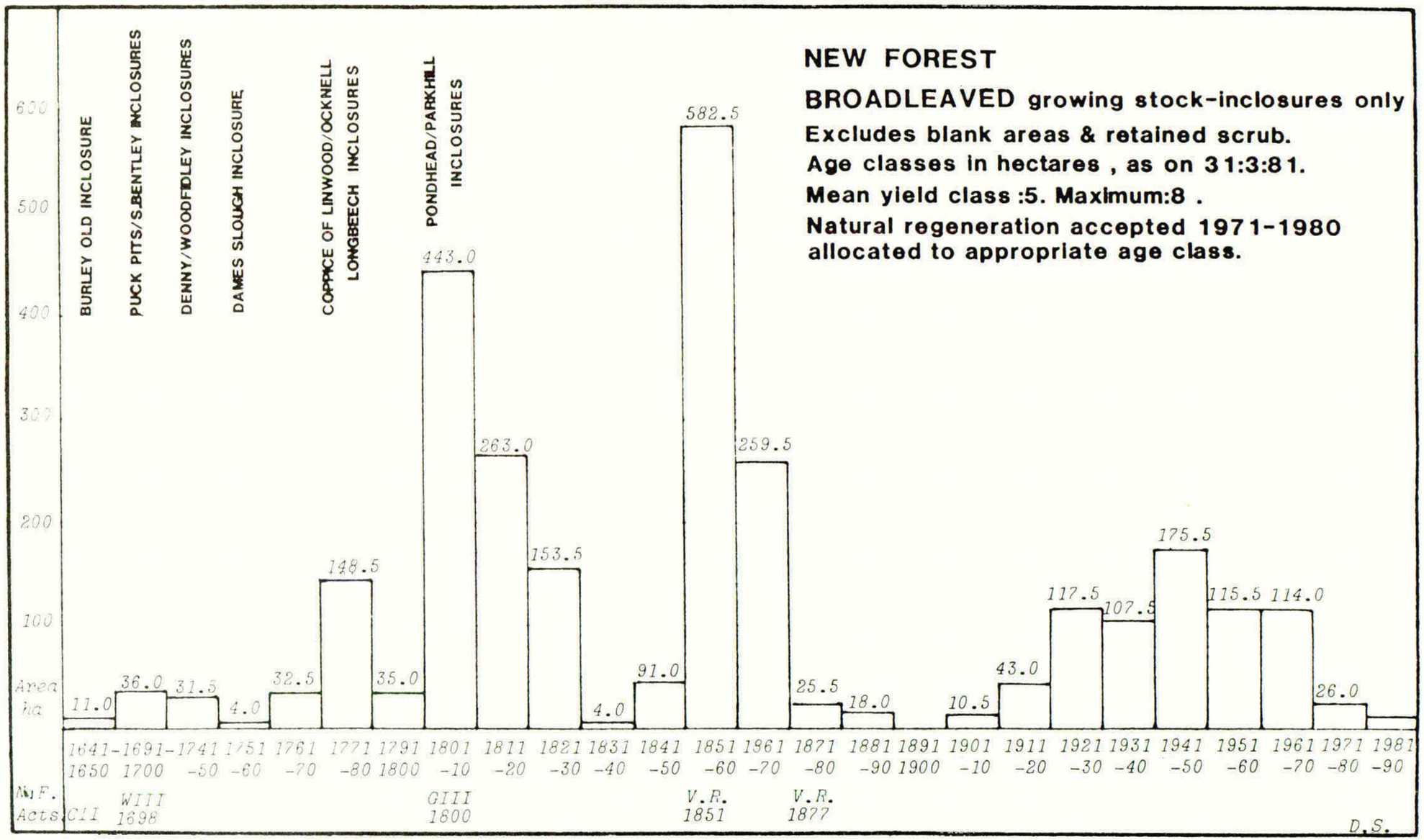
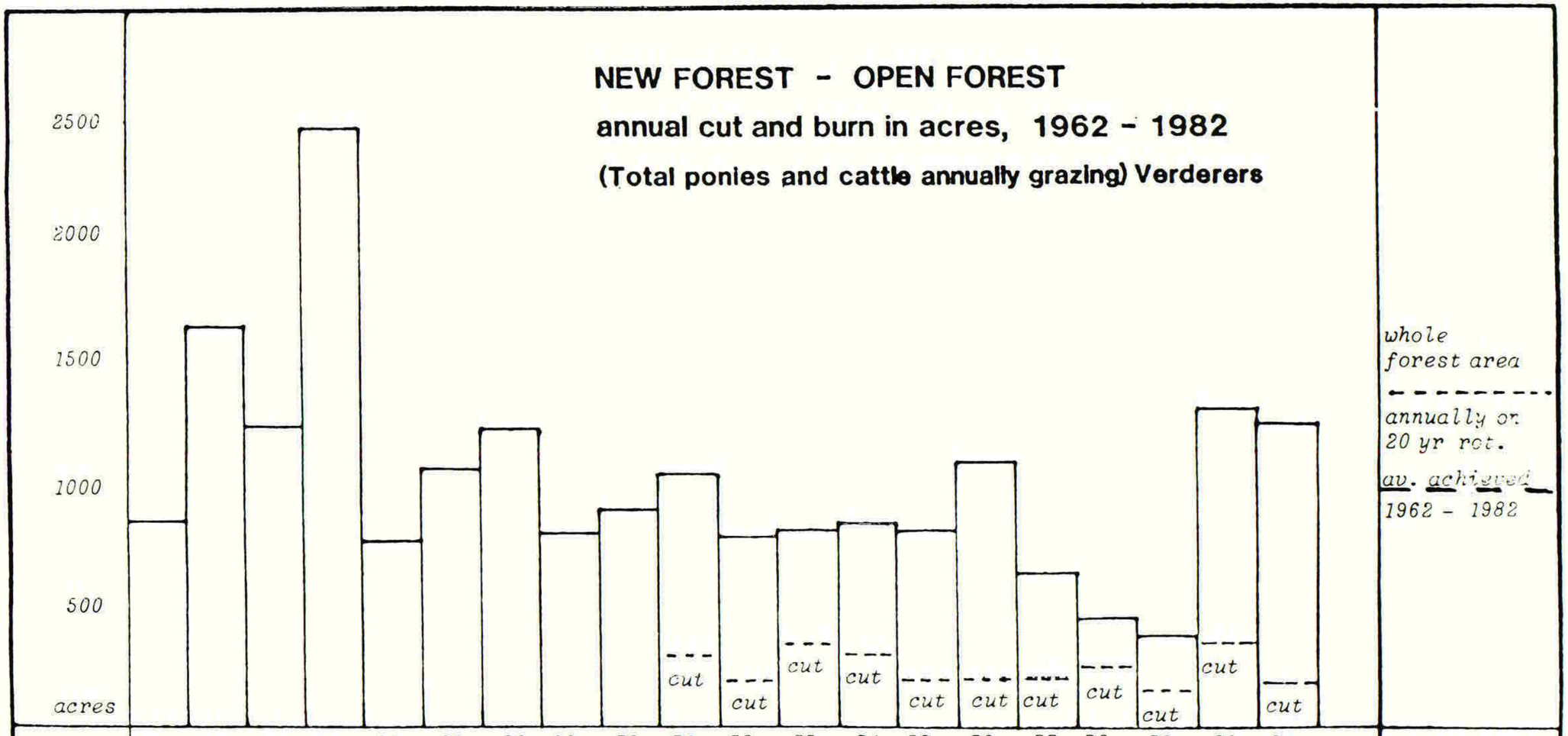


Figure 4. Age classes in ha (decadal from 1641) of broadleaved growing stock in New Forest inclosures as on 31.3.81.

thinning and replanting is carried out with modern power saws and small compact extraction tractors, and mini-forwarders to reduce the ground damage. Timing of activities is scheduled when practical to avoid the bird nesting periods and other conservation interests. Natural regeneration of both broadleaves (Fig. 4) and conifers is accepted and used in conjunction with detailed landscaping advice from our own landscape architects. The rotation for conifers is allocated as 120 years for the amenity working cycle and 50 plus for the economic rotations, with all broadleaves being managed on at least a 200 year rotation. The end result is a very diverse intimate mixture and structure within these inclosures. This we feel fulfils both our amenity and conservation objectives, but is enormously difficult to manage from a forestry production point of view. Access to these inclosures is by gravel tracks, where in many cases the verges are left to produce natural vegetation and only cut when excessive woody growth begins to erode the structure of the road itself. Archaeological and wildlife locations are recorded on our field maps to ensure that managers protect these fragile locations. The population of deer within the forest is controlled by culling by the highly trained team of Forestry Commission keepers to a size that is compatible with an acceptable level of damage.

Ancient and ornamental woodlands

Traditional tidiness has been a major criterion for management of the ancient pasture woodlands, brought about by intensive scavenging of fallen wood for fuel. More recently however revised conservation principles seek to increase the dead and rotting wood habitat by arranging for a percentage of all windblown trees to be left. This is beginning to create a conflict with the heavy fuel wood demand on this fragile resource. The aftermath of the 1976 drought was that over 20,000 dead and dying dangerous beech trees have been removed, but we still retain some 10 to 20 percent dead material on the ground. These woodlands are renewing themselves by natural regeneration, which is extending outwards, and in the period 1876–1972 over 500 ha of new regenerating woodlands has enabled us to practise a policy of minimum intervention. As soon as centres of very old woodland begin to deteriorate it is interesting that, with the heavy grazing intensity, these open gaps soon become enclosed woodland grass glades. Every year trees in these woodlands alongside highways, car parks and camping sites are inspected and if dangerous are removed. In contrast an area in the north was set aside in 1973 as "an inviolate area" where dead trees were allowed to fall and no debris was removed. The reaction from visitors is 'Oh, how untidy'. It may be that urban tidiness versus ecological litter might become a major conflict until there is a better understanding and appreciation of the principles when applied. Ancient rights of pasture and estover are still practised throughout these woodlands. These woodlands still remain today the most scenic resource in the forest and are much loved by painters, photographers and walkers.



YEAR	62 63	63 64	64 65	65 66	66 67	67 68	68 69	69 70	70 71	71 72	72 73	73 74	74 75	75 76	76 77	77 78	78 79	79 80	80 81	81 82	FOREST YEAR 1 APL-31 MAR
total acres	873	1671	1260	2501	796	1090	1237	804	920	1053	799	815	866	840	1116	658	487	368	1335	1291	19 year total 19445 acres
ponies	2035	2005	2181	2327	2462	2536	2727	2906	2814	2742	2982	3187	3154	3503	3589	3595	3748	3466	3430	3071	calendar year (top year)
cattle	2662	2229	2379	1972	2003	2345	1988	1625	1608	1601	1970	2053	3123	3184	2371	1827	1660	1944	2014	1682	
Total	4697	4234	4560	4299	4965	4881	4715	4531	4482	4343	4952	5240	6277	6687	5960	5422	5408	5410	5444	4753	excludes pigs donkeys sheep

Figure 5. Open forest waste – annual acreages cut and burnt. Annual numbers of ponies and cattle grazing. Ha = acres x 0.405.

Open forest waste

This is an enormously difficult part of the forest in which to achieve an equitable balance between traditional use and ecological stability. There is a constant invasion of woody growth into traditional woodland and riverside lawns, a constant evolution towards woodland by birch and pine on the heathland areas all contributing to a dissatisfaction from the Commoners, who witness a grazing resource rapidly changing and degrading. The FC is responsible for the maintenance and clearance of this open forest area to the satisfaction of the Court of Verderers and NCC (Fig. 5). It is often said and written that there is a head-on collision between the objectives of the conservationists and the Commoners. We endeavour to achieve a satisfactory solution by round-table discussions on all the annual programmes of cutting, burning, and drainage improvement on this complex part of the forest. There are naturally built-in legal constraints, such as protection of the bird nesting period and the muir burning statutes which permit burning only between November and March, a period which coincides with the period of highest rainfall. We do not use any chemicals in carrying out this work. There are and will be many many conflicts in the future but the major agency that will maintain the picturesque openess of the forest will remain the animals. Should the viability and economy of commoning change, and there are signs that it is beginning to do so, then the future of these vast open spaces could be at great risk, particularly if commoning disappèars and the graziers are lost for ever.

Recreation

In the period 1971–1978 a major project was completed by the FC to move uncontrolled recreation activities into those areas of the forest jointly considered to be able to accommodate them with minimal damage. 140 car parks, directly associated with the highway network were created from which walking and picnicking were made possible, and 15 campsites constructed where an infrastructure for common services was available. The anticipated and planned capacities were for 5,000 cars parked and 5,000 camping units. Monitoring since 1972 shows that these are the current peak demand levels. The standards of information signing, access surfaces (gravel for low use and tarred for heavy use), building design and internal facilities are in keeping with the natural surroundings and compatible with value for money and efficient low maintenance costs.

Conservation

Man may never know the full implications of his actions on the individual constituent of a conservation system. We endeavour to obtain as complete

knowledge as is currently possible on the life cycle and mechanics of the total system. Solutions arrived at in the New Forest have traditionally been a compromise between complete non-intervention and wholesale change. We have never really satisfied any one of the particular interests, be that naturalists, commoners or visitors. For a forest over which so much alleged study has been made we remain terribly ignorant, and I wonder if today research and study carried out in Universities is not often misdirected. The manager of natural resources is not often asked for his opinion on the aspect of his work for which further research is needed. In the interests of amenity and conservation we have accepted quite severe management constraints in the activities of thinning, felling, burning, cutting heathland, and the period of open forest restoration work which is avoided, for example, during the bird nesting season.

ECONOMICS OF MANAGEMENT SYSTEMS

All our operations in the New Forest are not only governed by Statute but by economic considerations. In financial terms our aim within the inclosures is to obtain the maximum return for the total volume of wood sold. This includes examining the most suitable species to be planted, improvements in fertilising, and protection of young trees with particular reference to broadleaves.

The majority of the forestry work is done by the FC's highly skilled industrial force but where appropriate we sell young crop thinnings standing to forestry contractors. A constant re-appraisal of all our forestry techniques is made to ensure that costs are minimised.

Over-night recreational facilities are operated on a commercial basis, and costs are kept down by the employment of seasonal staff on site and contractual services for all waste products. Overall supervision is by trained permanent forestry staff. I believe in the concept that foresters are not only qualified but are the best people to make contact with our visitors to ensure there is mutual benefit from the experience.

To place a value on the benefits of amenity and conservation should not be difficult. What does conservation cost? One solution is to compare a normal forestry practice of plant – clear-fell at time of maximum volume production, with a system where all the planted crop is retained until dead.

I believe the principles of conservation (i.e. the wise use of a natural resource to achieve stated objectives) can be applied to any timber producing plantation by the simple device of slowing down the changes, but always to harvest the interest on the initial investment. Conservationists have a habit of wisefully applying non-intervention systems with someone else's money! We believe that 10% of the maximum return is an acceptable level for the cost of conservation amenity. The rotation periods must not exceed the physical timber age of the species, e.g. 120 years for conifers and 200 years for oak in the south of England.

PROBLEMS

Any multiple land use management system associated with an ancient heritage is bound to attract adverse comment from those who jealously guard their personal interests. The closer to the resource the critic lives the more intensely he feels. Today's improvements in the media of communications, radio, film, and television, bring issues of the environment into the living room. Unless the resource manager devotes a considerable amount of his time to improve his communications, and has the ability to put forward his professional views in lay terms, and remains flexible to the other point of view – then the conflict will remain inflammable.

Much of today's environmental problems are due to increased mobility, lack of understanding and a strange philosophy that exploitation is fine somewhere else. We attempted in the New Forest to overcome this problem of communication by the establishment in 1971 of a 45 member organisation known as the New Forest Consultative Panel. This meets regularly and my responsibility is to ensure that all issues are well and truly aired and solutions found in areas of conflict.

The constant monitoring of the public use of the forest recreational facilities has shown its value in determining whether any one particular activity is or will create environmental damage, be it noise, visual intrusions or erosion of the resource. The constant care of car parks and campsites, together with forest walks, confirms that the maintenance of high standards is the most vital interface between the visitor and the resource manager. We are still studying the exploratory behaviour of the visitor from our network of car parks. In 1977 Miss C M Graham for her MSc thesis for Wye College, University of London, reaffirmed that the peak arrival time was between 1600 and 1700 hours, most families came out on Sunday, the average day was about 2 hours and the distance walked lasted approximately 30 min. This brief summary does not do justice to this excellent study.

At certain periods in the year, spring or late summer, the weather conditions together with wind create exceedingly dry heathland situations when fire is a constant worry. From records of fire since 1971 a very very low percentage of all incidents were caused by visitors. The remainder originated from highway verges or deliberate action. The change in the recreational pattern and the location of facilities has been a major benefit, as so many people are so well distributed and are constantly on watch. Strategically the forest is well served by a network of forestry gravel tracks and council highways, so access for fire appliances is fast and effective. Constant liaison with the fire service enables us to work closely with them and ensure that access and extinguishing fires is at maximum efficiency.

The herbivore population inclusive of the four species of deer (red, fallow, sika and roe), together with the commoner's cattle and ponies are often considered to be far in excess of the unenclosed forest capacity to support them.

A Select Committee in 1875 stated that of these the cattle were the more efficient and effective graziers for the open forest conditions, and this remains true today. However the true architects of the forest scenery are the ponies, and they are at present under intensive study to ascertain what other methods of management of the open forest might be considered to enable both cattle and pony to survive all the year round. Many ponies have to be removed during the winter at present as they are unable, unlike their ancient predecessors, to survive the rigours of winter.

The owners of these animals, the Commoners, practise today their ancient pasturage system; but they are also being studied as the economy of commoning under today's harsh economic conditions might not survive. The consequent loss of the New Forest pony would be a disaster as within 10 or 20 years the open character of the forest would evolve into woodland. I do not believe even today's foresters would relish such a major change.

This is an important phase in the future of the New Forest for the managers, who await the results of these intensive studies to determine "wither dost thy ancient Nova Foresta go".

REFERENCE

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DISCUSSION FOR MR SMALL

Dr T W Wright The National Trust is finding itself increasingly constrained in woodland management by the question of safety for the visitor. What safety factors does the Forestry Commission have to consider in relation to woodland management for recreation.

Mr Small (Speaker) In accordance with our occupier's liability we have to remove dead and dangerous trees every year alongside highways, and in other places open to the public. In the drought year of 1976 we lost 20–30,000 two hundred plus year old beech trees, and these dead trees caused us enormous problems. For eight or nine years now we have had a continuing policy of inspecting trees and felling where necessary. Trees are inspected by my staff every year, and if they are dangerous we fell them without consulting anyone. The question of safety is a responsibility that the manager carries, and that applies to managers of other resources.

Mr Gilmour In amenity woodland areas, do the foresters still select the tallest, straightest, strongest trees when carrying out thinning, and remove the sometimes more interesting or picturesque mis-shapen trees.

Mr Small (Speaker) In the New Forest there are two types of amenity. There is the 'totally-left-alone' amenity where we don't bother with the trees at all, except to take the dangerous

ones out. Then there are the amenity conifer areas, where we do exactly what you say, that is we select to keep the best trees, because, besides amenity, we want some income. The income can come in very useful when the trees reach maturity and are felled, and cash is needed for replanting.

Mr Gilmour In looking after amenity woodland in urban areas one is not interested in commercial returns. In a city area one is concerned in providing pleasant areas for people, and I am quite happy to leave the mis-shapen trees if these are more interesting than the better grown more commercial specimens.

Mr Small (Speaker) What I am saying is that I believe that the healthiest, and straightest and most vigorous trees are also the most interesting ones, and the ones that will serve the amenity requirements the longest.

Sir Ralph Verney (Chairman) Would you like to say something about bracken in the New Forest.

Mr Small (Speaker) The Nature Conservancy Council (NCC) has said that we are not to use herbicides on the New Forest open forest spaces, and we don't. We know that the bracken area is gradually increasing, and I should be delighted to spray it with asulam to control it, but the use of chemicals in the forest is a highly emotive subject. One of the problems is that, because common rights are practised over three quarters of the forest, we would not be allowed to remove animals from the sprayed areas in the precautionary period after spraying. Coupled with this is the reluctance of the NCC to allow the use of herbicides in what is probably the country's best SSSI. But bracken should be removed in order to re-establish the grazing quality of the forest, and there is a real conflict of interest with the NCC over this.

Management of Woodland and Woodland Vegetation for Wildlife Conservation

R. C. Steele
Nature Conservancy Council,

INTRODUCTION

This seminar is concerned with the management of natural and semi-natural vegetation. The bulk of British woodlands is fairly recent plantations; often on ground that has not been forested in historical times, and is composed of non-native species. It is neither natural nor semi-natural and is not considered in this paper although it is of major importance for wildlife and will increase in value with time (see Steele & Balfour, 1979).

Virtually all woodlands in Britain have been modified by man to a greater or lesser extent. Some remain, however, which although not virgin forest are the direct descendants of such forests. They have been managed and may have been planted, but nevertheless retain many of the features of natural woodland and are characterised, as far as we can judge, by many of the species which inhabited them in their virgin state. It is to such woodland that this paper refers. A further term used is "ancient woodland" which refers to woodland that has existed during and continuously since the Middle Ages but may have been managed for centuries. The vast majority of semi-natural and ancient woodland in Britain is composed of broadleaved species but there are important and substantial native Scots pine areas. For the sake of brevity the term broadleaved woodland can be taken to include native pinewoods.

THE IMPORTANCE OF WOODLAND FOR WILDLIFE CONSERVATION

Woodlands once covered much of the land of Britain and indeed, were it not for man, would again develop extensively. It is not surprising therefore that many of our plants and animals are well adapted to woodland (Steele, 1971).

Some 236 species of vascular plant, excluding trees and the taller shrubs, occur extensively or mainly in woodland, or have a wider ecological range but often occur in woodland. Most of these probably need the shelter provided by

woodlands but for some there is a more definite saprophytic, parasitic and semi-parasitic association with woody species or litter, and many fungi form mycorrhizal associations.

Few species, or groups of species, of woodland plants belong to a particular woodland type or are characterised by specific tree dominants. The main exception to this are the group of northern pinewood plants. Other interesting elements of Britain's native woodland flora are the endemic *Sorbus* species found mainly in the west and north, and the oceanic (or Atlantic) plants. There are eight markedly oceanic vascular woodland species of which six are ferns, there is also a substantial oceanic moss and liverwort component which forms a phytogeographical element of which Great Britain and Ireland are the European centre. The lichen flora too contains a rich oceanic element.

Many mammals are associated with woodlands although few occur exclusively in them. Perhaps the animal most tied to woodlands is the Red squirrel (*Sciurus vulgaris*). All species of deer live in woodland or make use of them, as do the carnivorous and omnivorous land mammals and many rodents and insectivores. Most species of bat hunt over, or in, woods; many species nest in hollow trees, especially in summer and some may hibernate in such trees.

A large number, about 110, of the breeding species of birds in this country have some association with woodland, with trees, or with scrub. Of these about one third are invariably associated in the breeding season, and a further two dozen are mainly associated with these habitats. The passerines are especially well represented and of the British breeding birds of prey only two, the Peregrine falcon (*Falco peregrinus*) and Marsh harrier (*Circus aeruginosus*) have no association with trees. As with woodland plants, perhaps the best defined group of birds is that associated with the pinewoods of the central Highlands of Scotland. Of the rare woodland birds the Red kite (*Milvus milvus*) is a true relict now confined to limited areas of central Wales. Other species, such as the Osprey (*Pandion haliaetus*) and Wryneck (*Jynx torquilla*), are rare because they are at the fringes of their distribution.

A huge variety of invertebrate animals live in woodland (Steele & Welch, 1973). For example, probably more than half the British species of lepidoptera are to be found in native woodland, and the trees themselves support a large proportion of these. More than 100 species feed on oak (*Quercus* spp.), sallow (*Salix* spp.), birch (*Betula* spp.), and hawthorn (*Crataegus* spp.). Generally speaking the lepidoptera of broadleaved woodlands are very much more numerous than, and distinct from, those of conifer woodland, and the richness of the lepidopterous fauna of a woodland depends on its structural and floristic diversity.

Dying and dead wood is a major resource for animal species and Elton (1966) has estimated that if fallen timber and decaying trees are removed from a forest the whole system is impoverished by perhaps one-fifth of its fauna. Nearly 1,000 species of animals, of which a large proportion are insects,

are known to be associated with dead and dying trees.

EXTENT AND DISTRIBUTION OF NATURAL AND SEMI-NATURAL WOODLAND

The extent and distribution of natural and semi-natural woodland has been assessed by Steele & Peterken (1982). Of the 2,000 kha of woodland in Britain, some 660 kha are estimated to be broadleaved woodland. The 660 kha can be divided into: 367 kha high forest; 27 kha coppice; 266 kha unproductive, scrub and felled.

Distribution and ownership of the 394 kha of productive broadleaved woodland (high forest and coppice combined) is shown in Table 1.

Table 1
Distribution and ownership of productive broadleaved woodland in 1979 (kha) between Forestry Commission (FC) & private

	High forest		Coppice		Total	
	FC	private	FC	private	FC	private
England	39	256	1	26	40	282
Wales	6	27	-	-	6	27
Scotland	4	35	-	-	4	35
Great Britain	49	318	1	26	50	344
	367		27		394	

The distribution of the major woodland classes, both natural and planted, in upland and lowland Britain is shown in Table 2.

Table 2
Distribution of major woodland classes in upland and lowland Britain, 1965 (kha)

Woodland class	Lowland	Upland	Total
Conifer high forest	207.0	710.7	917.7
Broadleaf high forest	245.9	104.1	350.0
Coppice	27.3	2.3	29.6
Scrub and felled	198.9	246.9	445.8
Total	679.1	1064.0	1743.1

The distribution of broadleaved species is shown in Table 3.

Table 3
Extent of various broadleaved species in 1947 (ha)

	England	Wales	Scotland	Great Britain
Oak	250 528	34 079	30 649	315 256
Ash	46 511	6 226	3 174	55 911
Beech	49 749	3 230	20 915	73 894
Birch	62 434	8 937	87 785	159 156
Chestnut	15 822	67	11	15 900
Sycamore	23 860	2 566	4 262	30 688
Alder	4 060	2 839	3 030	9 929
Hornbeam	6 192	13	5	6 210
Poplar	1 234	47	-	1 281
Lime	553	26	-	579
Elm	7 672	403	2 783	10 858
Willow	2 011	276	204	2 491
Norway maple	82	3	-	85
Cherry	42	3	-	45
Hazel	24 562	2 567	1 319	28 448
Other	14 278	602	590	15 470
Total	509 590	61 884	154 727	726 201

The age-class distribution of broadleaved high forest is shown in Table 4.

Table 4
High forest by age-class (kha) in 1970

Country	Age-class								Total
	Pre-1901	1901 1910	1911 1920	1921 1930	1931 1940	1941 1950	1951 1960	1961 1970	
England	179.4	23.0	14.0	12.6	13.6	13.3	21.8	0.8	278.5
Scotland	29.4	2.4	1.2	1.5	1.3	1.6	1.7	0.2	39.3
Wales	16.0	2.5	0.8	0.9	0.8	0.9	3.1	0.5	25.5
Total	224.8	27.9	16.0	15.0	15.7	15.8	26.6	1.5	343.3

NB 1. Sources for the information contained in Tables 1–4 are given in Steele & Peterken (1982).
2. The totals in the Tables do not always agree with each other because the information given in the Tables relates to different dates as shown.

From these Tables it can be seen that broadleaved woodland in Britain has the following characteristics:

i Broadleaved woodland is overwhelmingly biased to private woodland in England.

ii It is strongly associated with the lowlands and lowland fringes.

iii In relation to species:

a. most species are strongly biased to England the exceptions being birch and to a lesser extent beech, elm and alder;

b. oak predominates in England and Wales but birch predominates in Scotland;

c. that over 90% of all broadleaved woods are dominated by five species, namely oak, birch, beech, ash and sycamore.

iv The age structure of broadleaved woods is biased to 19th century age-classes most of which are now beyond normal timber rotations.

CONSERVATION ASSESSMENT OF BROADLEAVED WOODLANDS

The criteria used in assessing the nature conservation value of woodlands are described generally in Ratcliffe (1977) and are elaborated in Peterken (1981). These are:

Size
(extent). In general the larger the woodland the more important it is for nature conservation especially if it is an isolated habitat island.

Diversity
Sites with a range of woodland types are valued more highly than those with one or a few types, and sites with more species are better than those with a few. Variety is preferred to uniformity but this depends of course on comparisons between similar types of woodland.

Naturalness
Woodlands which have been least modified in structure and composition by man are most valuable.

Rarity
Rare species or communities increase the conservation value of a woodland.

Fragility
Fragility can relate to internal factors e.g. successional change or the vulnerability of small populations, or to external factors e.g. human action; or a combination of the two. Fragile ecosystems and species have high value.

Typicalness
Good examples of common woodland types are as valuable as examples of rarer types.

Recorded history
Woods which have a well recorded history have great value especially in relation to scientific studies.

Position in an ecological/geographical unit
A wood which is contiguous with other types of semi-natural habitat gains in value.
Potential value
It may be possible to increase the conservation interest of a woodland where this has been diminished as a result of management.
Intrinsic value
Certain species, e.g. birds and conspicuous flowers appeal strongly to a great number of people and hence raise the value of a woodland in which they occur.

These criteria are valued differently by different nature conservation interests. Research may place a high value on typicalness and recorded history but the intrinsic appeal of a woodland may be most important for botanists and bird-watchers. The criteria mostly re-inforce each other but there are some potential conflicts e.g. between diversity and naturalness. Some criteria e.g. diversity can be objectively assessed while others, e.g. intrinsic appeal are largely subjective. Nevertheless, on the basis of these criteria and surveys of woodland some 60 kha of woodland are listed in *A Nature Conservation Review* (NCR) (Ratcliffe, 1977) as of such high value that they ought to be managed primarily for nature conservation. A further 60–70 kha are included as Sites of Special Scientific Interest (SSSI).

High value for nature conservation is very highly correlated with ancient semi-natural woodlands and most NCR and SSSI woodlands fall into this class. Peterken (1981) has estimated that there are some 300 kha of ancient semi-natural woodland which contain most of the NCR sites and SSSI, the future management of which is most important for woodland wildlife and its conservation.

PAST METHODS OF MANAGEMENT OF SEMI-NATURAL WOODLANDS

Rackham (1976) has provided us with a clear account of how semi-natural woodlands were managed in the past. He describes how by the thirteenth century, the place of woodland in the English countryside was well established. Woods whose primary function was to produce underwood and timber were differentiated, as they were earlier, from the various categories of wood pasture. They were properties with definite boundaries and were permanent features of the landscape.

The management of such woodland was both intensive and conservative. Woods were managed on the basis that if a tree was felled another would grow in its place. Surveys of that period either state a coppicing rotation for woods or give a figure for the expected annual return. Felling at fairly short intervals ensured vigorous re-growth and woods were fenced to keep out stock which might eat the young shoots.

Most of the woodlands were of the type we call coppice-with-standards. The woodland was made up of standard trees and underwood; the former produced timber at irregular intervals, the latter produced an annual return of wood. Wood was often the more important and features most persistently in the records.

The underwood or coppice was cut at short intervals, five to seven years was common, and the annual acreage fluctuated, probably depending on markets. The species mixture was much as occurs now in ancient woods namely ash, oak, hazel, maple, elm, lime, birch and crab-apple. The commonest recorded uses are firewood and fencing but building materials were also important.

The major use for timber from the standard trees was in building and oak appears to have been much the commonest timber tree. Trees of all sizes were harvested and regeneration does not seem to have been a problem.

GENERAL PRINCIPLES FOR THE MANAGEMENT OF SEMI-NATURAL WOODLAND

Coppice and coppice-with-standards, formerly much the most common form of management for our semi-natural broadleaf woodlands, are practiced now only on a very restricted scale as is evident from Table 2. The reasons for this are varied and include the need to build up Britain's reserves of wood, the higher yield of wood and money obtained from non-native conifers, problems with pests such as deer and the Grey squirrel, the much shorter time scale for a return on investment produced by conifers and so on. Whatever the reasons the present management of broadleaved woodland, and this with the addition of some 10 kha of native pinewood make up our semi-natural woodland, is unsatisfactory.

In seeking to develop more satisfactory management practices the following points need to be made:

i Utilisable timber should be produced in the majority of broadleaved woodland.

ii That nature conservation objectives should be prominent in old ancient, semi-natural woodlands and predominant in some.

iii That broadleaved woods should be treated by a variety of systems and long-established silvicultural practices should be maintained in those sites most important for nature conservation.

iv That in the management of broadleaved woodlands, preference be given as far as possible to native broadleaved species.

Peterken (1977) has described fifteen principles to be considered in determining the treatment for any area of broadleaved woodland. These can be broadly summarised as follows:

i Existing structures and treatments should be changed as little as possible. Thus high forest and coppice woods should so remain.

ii Traditional treatments should be retained or restored especially in the most important woods for conservation. Thus it is highly desirable to coppice much of the ancient, semi-natural woodlands.
iii A proportion of woods should be left untreated and interfered with as little as possible.
iv The more important a woodland is for nature conservation the more restrictive are the conditions that will be placed on wood production.

ECONOMIC CONSIDERATIONS

The cost of different silviculture and management options is clearly also a major factor in helping to determine what course of action to pursue. The dearth of good data led the Nature Conservancy Council to commission two research projects (Lorrain-Smith (1982) and Pryor (1982)) requiring economic analyses of a variety of woodland.

The woodland types studied were:

i Acid western oakwood
ii Oak-Ash woodland
iii Oak standards over hazel coppice
iv Beech woodland
v Sweet chestnut coppice
vi Coppice-with-standards
vii Highland birch woods.

The projects have just been completed and require detailed study but first impressions can be summarised as:

a. the value of the timber in many of the examples was surprisingly high;
b. the treatments applied to these standing crops have a far greater overall effect on profitability than the Land Expectation Value of successive crops;
c. at lower interest rates some hardwood options compare favourably with conifers at high price and productivity levels; however at lower levels of price and productivity and higher interest rates, conifers are almost always far more profitable;
d. the uncertainty associated with hardwood crops is considerably higher than with conifers because of the relatively much greater range in productivity and timber prices;
e. ash and cherry appear to be particularly profitable hardwood species;
f. some of the more unusual options, such as underplanting, appear to be much more profitable than is often suggested.
g. sweet chestnut coppice can be more profitable than Corsican pine under poor conditions and high discount rates but less profitable under good conditions and lower discount rates;

h. coppice options appear favourable in adverse conditions or with high discount rates but conifers were normally more profitable;
i. few birch options appear financially desirable even after the birch has been established.

In general, the possible variation in the large number of variables present in such situations makes it very difficult to generalise or to make accurate predictions of profitability.

MANAGEMENT TREATMENTS

On the basis of the foregoing considerations it has been proposed (Steele & Peterken, 1982) that four broad treatment types for broadleaved woodland should be recognised:

i Minimum intervention
ii Coppice including coppice-with-standards
iii Restricted high forest
iv Unrestricted high forest.

A brief description of the area and proposed treatments for each of these types is given below.

Treatment class I. Minimum intervention (22 kha)

The 22 kha proposed for this treatment is made up of 20 kha of unproductive, ancient, semi-natural woods and 2 kha of similar but recent woods. The aim for the woodlands is to maintain or restore near-natural woodland in both composition and structure, and to minimize human activity in them although some activity, e.g. controlling invasion by other trees or the intensity of grazing, may be necessary. Such woods would be important scientifically, by providing 'controls' against which the effects of different management practices could be assessed. Whenever possible such woods should have the status of nature reserves.

Non-intervention as a type of treatment can only be justified in the longer term on a limited number of sites although in the short term it would be expedient to apply it more widely whilst alternative treatments are being decided.

Treatment class II. Coppice (167 kha)

The proposal is to maintain 27 kha of exiting coppice and restore coppice treatment to 140 kha of largely unproductive, ancient, semi-natural woods. The preferred treatment would be coppice-with-standards. The standards should be oaks or other trees native to the site. Natural saplings would be

preferred, but planting would be acceptable in the majority of sites. Coppice would be cut on a rotation that would vary in relation to markets. Planting of coppice species not native to the site is undesirable: gaps should be filled by layering or natural regeneration, or, if planting is necessary, using species growing in the immediate vicinity.

Such woods would produce good quality oak and other timbers and a steady supply of firewood, pulpwood and specialist materials for crafts and turnery.

Treatment class III. Restricted high forest (197 kha)

After the minimum intervention and coppice types these are the most important stands for nature conservation. The principal restriction would be to use species native to the site which in most cases means the species which grow there now. Preference would be given to other than even-aged systems of high forest, e.g. to selection forest, two-storied high forest and high forest with standards. If even-aged systems are necessary, group, strip and wedge systems of felling and regeneration would be preferred. Alternatively clearfelling could be undertaken in very small groups. Rotations should be long, or the high forest with standards system adopted, in order to provide mature timber habitats. Natural regeneration would be preferred to sowing or planting but if this is impracticable, planting should be at wide spacing and any natural regeneration should be incorporated into the crop. Conifer nurses should not be used. Thinning should be as early and as heavy as is practicable and a mixed canopy should be retained as far as possible at least until the final thinning. This category is clearly very varied and requires much more detailed consideration.

Treatment class IV. Unrestricted high forest (274 kha)

A conservation case can be made for treating these stands as 'restricted high forest' but this is not easy to justify against the competing demand for intensive timber production. This treatment type contains those broadleaved woods in which more intensive forestry and a wider choice of broadleaved species is acceptable.

CONCLUSION

The proposals contained in this paper are based on those presented to the "Broadleaves in Britain" symposium, sponsored jointly by the Forestry Commission and the Institute of Chartered Foresters held in Loughborough in July 1982. They are also close to those made by the House of Lords Select Committee on Science and Technology in the Sherfield Report (1980).

Among other points the Committee recognised the importance of ancient woodland, proposed that a special category of "nature reserves" be established based on them, recommended that other broadleaved woods should be managed as productive sources of hardwood timber, and proposed certain developments in research, marketing, financial aspects and the role of the Forestry Commission (FC) to facilitate this.

The main feature of the proposals put forward here is that the sacrifice of potential timber production necessary for wildlife conservation should be concentrated in those woods of special interest, that is, mostly ancient semi-natural woodland which cover an estimated 300 kha. The management of these woodlands will depend upon three important aspects:

1. The development of appropriate silvicultural methods and treatments. There has been a welcome upsurge of interest and work recently, and the FC and others are taking important initiatives (see Malcolm *et al.* 1982).
2. The control of pests. The Grey squirrel is a major impediment in many parts of the country to broadleaved silviculture.
3. The development of appropriate financial incentives to the private growers who own most of the broadleaved woodland. There is a higher rate of grant for planting broadleaves and native Scots Pine but management grants, Capital Transfer Tax, and taxation relief are other important factors.

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DISCUSSION FOR MR STEELE

Mr Small 80% or so of the UK broadleaved high forest is even aged, and this is liked by the public and by conservationists. But many of the oak woods have reached maturity and are getting near their terminal age. How would the Nature Conservancy Council (NCC) want to regenerate these stands for future conservation purposes?

Mr Steele (Speaker) We want smaller felling areas rather than the large clear fells often used for conifers. Its really scale with which we are concerned. We recognise that to regenerate those forests that are subject to an active management policy there will be a need to accept some flexibility in management, in order to get a proper age class distribution.

Mrs Wright Is there a potential for use of exotic broadleaved species in the schemes that you are promoting? Some introduced species do have conservation interest; for instance *Nothofagus* has been found to support quite a variety of insects.

Mr Steele (Speaker) The difficulty with most native species of trees is that they tend to be outperformed, both economically and in volume production, by non-native species. In many of our woodlands there has to be a use of some economic non-native species, such as poplars and *Nothofagus* for economic reasons. We need a graded management series from strict nature reserves with good representation of the natural development of native species, through managed woodlands of native species and woodlands of exotic broadleaves, to exotic conifer plantations.

Dr Wright The private forest and woodland owner is very grateful to the NCC for demonstrating how nature conservation can be fully compatible with productivity, and with economic returns, from woods that are not of the highest ecological importance. This is really getting through to the private owner, and is likely to lead to a very good response in the form of management and regeneration of broadleaved woodlands.

Sir Ralph Verney (Chairman) Are we right to accept the Forestry Commission's (FC) new plastic tree shelters without further experiment?

Mr Steele (Speaker) It is an experiment, which is initially very promising, but we need to develop it further. There is no doubt that if young trees can be protected at an early stage from rabbits and small mammals, growth rates can be quite excellent. What the FC is doing by sheltering the young trees is producing growth rates that will get them away quite quickly.

Mr Burdekin The technique is catching on quite widely, even before we (the FC) have been able to get a long term view of it ourselves, and we may yet find some snags. But we are pleased with the interest that is being shown.

On a rather different topic, we have at this meeting, been discussing mainly problems on land owned by public bodies or big institutions with substantial funds behind them. But with woodland, the emphasis is more likely to be with the private owner. What do we know about the interests and motives of the many thousands of private owners, mostly of small woods of say five – ten acres or so? Ought we to know more about them if we are going to try to convince them of the measures that we think they ought to take?

Mr Steele (Speaker) I don't think that we do know, but it is likely that they have a range of interests. My main concern is that most of these owners feel that they should be doing something much more actively with their woods. In many cases they will be quite pleased to learn that their low level of management is beneficial for wildlife.

What I am advocating is a system of forestry that may not bring in a large return, but which will not involve a substantial investment; I hope it will produce some good timber and some cash, as well as creating a valuable wildlife habitat. This is a way of making a better use of these woods, which at the same time is not incompatible with other countryside pursuits, and particularly the sporting interest.

Sir Ralph Verney (Chairman) It is worth mentioning the study in South Wales on small woodlands, and also the one being mounted in Norfolk, to find out why farmers have these little woods, and what they want with them.

Mr Shaw Interesting questions have been raised about how to promote the effective management of deciduous woodland, although the examples have been mainly at a fairly large scale. This issue is also fundamental to the conservation of small woods and copses, and I should like to explain the response in Norfolk to this need. In Norfolk, the major problem lies in the deteriorating quality of a large number of small fragmented areas of woodland. A recent survey by the County Planning Department has demonstrated that 80% of all small woods are unmanaged. The challenge is to stimulate their management.

Studies have suggested that there is a market for timber if a threshold can be achieved to justify the felling of woodland, and subsequently of replanting. The main obstacle to this is an organisational one. Under the auspices of the Norfolk FWAG, the County Council and the Countryside Commission have therefore funded the appointment of a Small Woods adviser, whose job is to act as a broker between individual landowners and the timber trade in East Anglia. The aim is two-fold: first, to demonstrate to farmers that there is a return on a timber 'crop' from copses, and secondly, to ensure the continued future of the small woodland as a major landscape feature in an otherwise intensively farmed countryside.

UPLANDS

The Management of Upland Vegetation for Amenity and Recreation

I. D. Mercer
Dartmoor National Park Authority

THE UPLANDS

It is necessary first to deal in definitions and these must be affected by the other titles that are being used at this Conference. The programme suggests to me that I must deal with herbaceous and low shrub vegetation above the 'limit' of cultivation. I must try also not to get involved in the discussion of that limit, for it is a fascinating topic and there is plenty of evidence that it has oscillated enormously through the last three thousand years. At the beginning of that time Neolithic and then Bronze Age men effectively inserted between blanket bog and forest in the south, and in the more mountainous regions between alpine communities and the forest, what for these purposes we might call moorland and upland heath. For our purpose also we must include the blanket bog and the alpine communities in the total concept of upland vegetation. Thus the whole might include up to nine or ten vegetation associations though the separation of all of them may not be useful in a management context.

Blanket bog, valley bog and mire will make up one important group. Heath and *Vaccinium* moorland another. Then we should recognise a great group of grasslands which one must accept grade with each other, and grade into heath and bog. *Agrostis/Fescue* grassland may be modified by the density of gorse present or by invasion by bracken, *Molinia/Calluna* moorland will grade into blanket bog or valley bog and grass heaths (without *Molinia*) will be an intergrade between many other associations.

One must superimpose the status of the land upon the vegetation classifications, which are mappable to certain scales. In a model upland there will be a central core that is unenclosed and this may or may not be common land in a legal sense. It will be surrounded normally by large enclosures of the same vegetation usually occupied by a single manager which may be called ffridd in Wales, or newtakes in Dartmoor, for instance. (You will expect me to refer to Dartmoor most of the time.) In the model, outside these large enclosures and below them altitudinally will be the field pattern of the local landscape.

This will normally be of improved grassland and even arable, right up to the moorland enclosure boundary but may of course also have reverted under recent lack of management to hold a similar set of vegetation associations to that above the cultivable limit.

AMENITY AND RECREATION

It is necessary then to look at the amenity and recreation needs which are implicit in the title. The elite of the early middle ages recognised the recreation value of upland, and chases and forests were developed in such landscapes. They also quite quickly recognised the need to have resident managers, of whatever lowly origin, to ensure that the chase remained open; so some settlement within the forest was allowed from the earliest times, but a hunting regime was imposed upon it. This situation seems to have held until the late 18th century when the Wordsworths of this world suddenly awoke, in other than huntsmen, the recognition of 'scenery' and the magic of the upland for those energetic enough to get to it. Wordsworth said that "every man with an eye to perceive and a heart to enjoy should have access to the hills". Thus have amenity and recreation, whatever your definitions of the words, been linked, from the beginning of modern appreciation of upland and its vegetation. One must accept that for this country the campaign which Wordsworth began in the late 18th century came to a head in 1949 with the National Parks and Access to the Countryside Act. In the next few years we designated 10 national parks all of which have upland and its vegetation as their core, though admittedly the Pembrokeshire Coast looks as though someone peeled the rind from round the core and left it hanging to the south. There is no doubt that while natural beauty is a phrase used in 1949 the pressure that brought about that Act of Parliament was a pressure concerned with access and thus with mild forms of recreation.

There is within that Act a list of the kinds of landscape on which local authorities and others might make access agreements and orders, and that list includes 'moor and heath'. The generic term applied to the list in the Act is 'open country' and that is a pointer to the qualities which the recreator is seeking as characteristics of the vegetation, for his purpose. Just as scientists apply their own specialist meanings to ordinary English words, so legislators, and inevitably therefore those who argue about legislation, begin to apply specialist meanings to phrases like 'open country' which since 1968 has included woodland for instance! Neither botanists in the mass, nor amenity society spokesmen, will agree about definitions of 'moor and heath' or about 'open country'; and between 1949 and 1981, of course, we have had a shift of concern within society at large that is away from a pure access pole towards a conservation of natural beauty pole. So that in 1981, the National Park Authority charged with dealing in access in 1949, is further charged to make a map of "moor and heath, the natural beauty of which in the the opinion of the

Authority, it is particularly important to conserve." At its last meeting the Association of National Park Officers had before it a paper whose heading was 'Is 1949 moor and heath the same as 1981 moor and heath?'.

OBJECTIVES

I will try and not get you any more deeply involved in that particular argument, but you can guess that I could not let an opportunity like this pass by without registering the problem. I must try to be objective about what is the management need for amenity and recreation purposes as far as upland vegetation is concerned. It is important first that we recognise that both the beauty and the recreational value of upland vegetation depend upon dimensions. The reason that an urban society rates moorland highly is because it is so different from the environment in which that society has to work and live for most of its year. The attraction for the viewer as well as the walker is the space involved. That which is emphasised by the long low profile, the soft summit and thus from its heart the distant enough skyline for 360° from the observer. That distance which allows the great bowl of the sky to perfect the particular experience of beauty. The satisfying dimension will of course shift as one moves position from summit to valley bottom within the moor, but the potential of total space must always be there. We must not forget that for a large number of people the untamed beauty or the beckoning mystery of moorland are most clear to them when viewed from outside, from just across the edge, from beyond the foreground of green fields and trees. Many of them will be content that that mystery should remain so. All of that dimension is just as important to those who do penetrate it, and wish to walk right across it, or all round it, or up and down it at great speeds. For them of course there is another dimension that is critical and that is the height of the vegetation. Knee high for them might create difficulties, so good descriptive words like dwarf, prostrate, close-cropped are very important from the walkers' point of view.

So we appear as a society to need large chunks of moorland that bear vegetation composed of good looking colours, that vary with the seasons, and remain less than knee high. The moorland situation that we have, was created and has since been maintained by hill farmers. For they, until very recently, in their own interests, grazed and burned to patterns. These two processes effectively maintained the dwarf character of the vegetation, and prevented it reverting to the scrubby woodland that it once was.

MANAGEMENT PRACTICES

As far as grazing is concerned, it needs to be continuous during the growing season for obvious reasons; and stocking rates need to be such as to maintain a pressure which is not maintained by selective grazing. If the sheep or the cow

can pick and choose then eventually the vegetation community will change, and that change will not be for the better as far as the amenity is concerned. Burning was doubtless the instrument of the original clearance and has proved necessary since, because the stocking rate has never been ideal, partly because that must depend upon the relationship of in-by land to moorland grazing either within one holding, or as common right grazing associated with the holding. Burning is now necessary to interrupt the natural life cycle of *Calluna* say, to encourage both new shoots from old stock, and germination in the light, *before* the natural collapse of the original heather plant. After ten years that original plant will be valueless from a grazing point of view, but it will still play an important role in both sheltering and hiding wildlife of various kinds. South of the grouse moors there is no vested interest in elderly heather, but the segment of society interested in the maintenance of habitat and populations of, for our purposes, upland birds, is growing rapidly. The manager of moorland for its natural beauty will ignore the nesting site of the golden plover, the dunlin and the merlin at his peril.

DARTMOOR AS AN EXAMPLE

My experience is limited but if I may tell you briefly of the Dartmoor situation I think it is not without its parallels elsewhere. Burning is now a folk memory on Dartmoor, those who still indulge it burn the same areas regularly, or deliberately set out to burn off that characteristic winter raffia that is *Molinia,* or leggy gorse. Accusations of over-grazing are also regular, but over-grazing evidence is confined to roadsides, that small area of moor just inside each cattle grid and sometimes the site of last year's fire. Within 200 yards of any over-grazed site you can be knee deep in clearly under-grazed vegetation. The cost of labour is clearly at the bottom of both these problems. It is in many ways too easy to collect hill farming subsidies now, without carrying through the practices that go with good stockmanship. We have far too few good shepherds, good herdsmen, moormen, agisters and all those people who between them maintained the moorland, at least in the state which has allowed it to survive to our own time through perhaps 100 years of diminishing attention.

To maintain the upland vegetation in its ideal state from an amenity point of view, only demands the same processes as would maintain it in an ideal state from a hill farming point of view. That hill farmers have not had to indulge in close shepherding and herding and programmed burning is a commentary perhaps on the effect of society's handling of agricultural finances since 1947. I have no doubt that the relevent European Economic Community directive could have been used to invigorate these processes in the hill farming community. Instead, European money has brought about pressures in the hills which appear to be attempting to change the upland vegetation and reduce its available area. The Exmoor situation demonstrated this, and the financial calculations that went with that process have led us further on down a particular

alley that seems to be intent on paying farmers not to do things, the profits from which were artificially created in any case. We are faced on Dartmoor with MAFF support for the conversion of moorland to silage-making ground, to increase the headage carried on particular farms. On a 600 acre farm of which 400 is moorland it is proposed that 160 acres of that moorland should be converted for silage production. At the same time the in-by land should go into an arable rotation of 7 years involving 7 ten-acre-blocks which will produce four years of grass, a year of roots, a year of oats, a year of roots. All this, it is claimed will support a thousand sheep and one hundred cattle with their followers. Will they be grazing much upland vegetation? In fact the lamb crop could be finished on the roots. In my innocence I had thought that the whole of the support system for hill farming was geared to the fact that that part of the industry was not able to finish a product, but had to sell everything as stores for others to profit from the finishing.

You will forgive my cynicism. Do not however misinterpret me. My next brother farms, and my eldest son is at the moment training to. I am full of sympathy for farmers, but the image of the steward which some farming organisations wish to promote is just a little tarnished at its edges. I see that the surplusses we have been producing in Europe are now beginning to be recognised by officials high in MAFF, and papers have been read during this summer about the possible need, in the near future, to reduce the intensification of the farming industry. The relevance of all this story to your conference and the title you asked me to speak to is that I suspect that a reduction in intensification will not be applied equally over the whole industry. There are those, after all, whose whole enterprise is intense and to ask them to reduce it, might be to ask them to go out of business. Even in this recent period of surplus production, wealth has not been easily available to the hill farmer and survival in the face of growing farm debts has been his main concern. Silage production is guaranteed annually, where hay making is a risk, so the shift to silage production is readily understood. That it should be encouraged to develop at the expense of the base of the hill farming industry, which is the moorland, is the worrying thing.

The attempt to deal with over production could see a withdrawal of energy from the hills; while it has been nice to claim that amenity and agricultural needs in the hills converge, that may not be for very long a safe bet. So to achieve the right management of moorland vegetation in the interests of society as a whole and for whatever purpose, the management agreement may well be the answer but not in the sense that it is used in the 1981 Act. In the conservation boom of the early 1970s many farmers said to me that they did not wish to be paid for doing nothing, or more accurately: for not doing something. The 1981 Act gears its management agreement to compensation for non-conversion of moorland. It would have been so much better, and it may now be necessary, to create a legislative management agreement situation to achieve the desirable maintenance system. Society will have to inject money into the hills, not as an acknowledgement of, and redress for, loss of profit; but as a wage, a rate for the job of managing the grazing and burning machine.

RESEARCH

I was asked to touch on research needs under this subject heading. We still need research into optimum stocking, in quantity and quality, on different vegetation associations, just as each of the ten or so associations present on Dartmoor probably demand different burning programmes where they need burning at all. We also need some research into public perceptions of the need for management and public understanding of the management techniques necessary. Perhaps I could pull all this together by reference to bracken.

Everyone appears to agree that bracken is invasive and that that invasion is observable now. I have always argued that bracken is like starlings and sycamore, a very successful species. It is not popular. It supports only 14 invertebrates, all of which land on your sandwiches, it wets you to the armpits in late July, it is a carcinogen and poisonous to mammals. It looks good for about 14 days when it is dying. Briefly in the early 1970s, asulam was within reach of many hill farmers. The helicopter could just be afforded for those with a big enough estate (aerial spraying is the only sensible way to deal with invasive bracken on rough terrain). Since then in the south certainly, little spraying has gone on. Interestingly, at the first proposal to spray bracken there was an amenity outcry geared to chemistry and water supply. In the decade since the first proposal on Dartmoor those who opposed it have changed their view, and now in 1982 are asking for bracken to be controlled.

Research is needed into the economics of the spraying operation now. Are alternatives available and feasible? Does the amenity bracken control lobby understand the processes available? How should the process be funded? Enough bracken for whinchats will be retained on rocky slopes and within 'bracken-and-bushes' enclosures, but a sizeable area of open bracken covered land should be tackled soon and that leads to the final, and general, problem.

Given that the total areal dimension is a critical characteristic in the amenity and recreation quality of upland vegetation, and the need to keep that vegetation below knee height is paramount, and the agricultural need to do the appropriate work is probably diminishing, then how should the optimum be achieved, and maintained?

PROBLEMS

Is there scope for management agreements in which 'amenity authorities' pay for farming endeavour, in a park-keeper sense? – like the MoD paying farmers as range clearers.

Is there scope for voluntary labour deployment in the burning, cutting or trampling operations component of control? If so, how should complementary grazing be managed – or even achieved?

Does the 'amenity authority' in the end have to become the effective owner, and employ statutory shepherds/keepers, and own the flock or the game, with

its public purse bearing the costs/losses involved in the maintenance operation? There might of course be lease-back options with the right conditions attached in better hill farming economic moments.

In all this, beware the special problems of common land management which all parties still do not face fairly. If legislation (private or public) gives a public right of access to common land *without* parallel obligation for management devolved upon some effective agency, then upland commons will follow many lowland commons into the thicket stage.

Given that, despite the claims that peace, quiet, solitude are major desires; moorland users nevertheless appear to want, as to the majority, to move in the mass, is there then scope for sponsored swipes, burns or tramples of vegetation on commons?

DISCUSSION FOR MR MERCER

Mr Eadie I was delighted to hear your references to the importance of man in the ecosystem, and especially in the hills where man may be the most threatened species. His problem is an economic one. Could you deliberate a bit more about the oscillations of activity in the uplands, and comment on the need for wider objectives for management than the agricultural interest. I have some difficulty in seeing that these wider objectives, if they constrain agricultural development too much, will be compatible with the economic well being of the people about whom you are concerned.

Mr Mercer (Speaker) Whilst most of what I said was about the actual physical oscillation of vegetation, it is absolutely right that this reflects oscillations in the human population. With reference to advising on management, we are dependent on the management systems that we know about, and in places we need to try to re-establish methods of management – such as burning, shepherding, and the traditional grazing systems with stock – that are now disappearing. The problem is a human one: many farmers don't wish to be paid to do nothing, or to work inefficiently as they see it, although some of them are prepared to be paid to take on other jobs, such as range wardens on the MoD land on Dartmoor. In this sense the principle of a hill farmer accepting another function besides farming is becoming established. But there has got to be a shift in general agricultural opinion for this to go very far, and more support from society for what it wants out of the hills. We need the agricultural gains in the uplands, but they will always oscillate in their productivity, and in the return to the farmer. Maybe we should try to arrange things so that there is a consistent return for those who live and work in the hills, with a contribution from amenity when agriculture is down, and a reduction in the contribution when hill farming is booming.

Mr Smart Does your experience of the multiple pressures and conflicting needs of land use suggest to you the need for a consensus, or coherent view, such as existed in the 18th century, but which does not exist at present, in order to provide a framework for the uplands? Have we a reference point from which we can evaluate competing interests such as you describe in your paper?

Mr Mercer (Speaker) I am sure that the population of minds from which the consensus was obtained in the 18th century was smaller than the consensus of minds that is now playing on the environment. The 18th century landowner was dominant, and whatever one's attitude to their social position, they made a huge contribution to the environment that we now enjoy. What we need is an unified consensus that is a substitute for that, and I don't know where you get it. Many of the lobbies and organisations that are supposed to support amenity authorities don't support them at all, and in fact treat them as much as a butt for their criticisms as organisations such as the National Farmers' Union, that are supposedly the natural opponents of the authorities. There is a terrible bigotry amongst the people who are the high-minded defenders of things that they don't actually have any responsibility for, that makes the job of those that do have responsibility almost impossible. A lot of the difficulty in getting a consensus is tied up there somewhere.

Dr Holdgate In many upland areas, visitors are now making a substantial financial contribution to rural communities. How far are Dartmoor farmers adapting their management systems to cater for visitors as a sort of subsidiary crop – for example by providing for pony trekking, by making access routes that steer people away from productive farmland, and by making other areas positively attractive to people?

Mr Mercer (Speaker) It certainly is a feature, but its not universal. The Dartmoor Tourist Association, which is representative of perhaps half of the people involved, claim to be turning over £4.5million in a year from tourism within the National Park – so if that's half, then maybe the total is more like £9million. If the stock on the hill is worth £7million then you can start to make comparisons.

As far as other ventures are concerned pony trekking is popular, and the ponies can be stabled in buildings that would otherwise be redundant agriculturally, which is an useful way of keeping another bit of the heritage actually in use.

There is no doubt that in some areas, on the most popular commons for access, sheep are being displaced by people. There is a very big problem with dogs, which are a major problem and there is a need for a consensus on how to deal with them. I accept the principle that if people are mixed with stock, then people must not be able to physically drive the stock out. As a consequence, in areas where people can roam at will (as opposed to being confined to bridleways and footpaths) there must be a stockproof fence, maintainable by the amenity authority. In one area we have a draft agreement that dogs will be kept out to prevent disturbance to stock; this is going to upset local people, who walk their dogs on this land now, more than the ramblers. In another case I know of a farmer who has had to modify the management of his sheep – his ewes and lambs – within the last six years because of the dog problem. He is looking for compensation for having to modify his management, for losing flexibility, which ultimately affects his farming capacity.

Mr. Barber (Chairman) There are very wide differences in the popularity of Bed and Breakfast in different parts of the country. We tend to think of the uplands as being an uniform sort of land, but they are nothing of the sort, with many different kinds of land use and people who inhabit them.

Professor Moore Farmers in the less favoured areas are supported financially for social reasons rather than agricultural ones, yet they get their support through the agricultural departments, and this can have unfortunate environmental consequences. Many of us agree