Forestry & Farming in Upland Britain

Selected Papers presented at the British Association for the Advancement of Science, 1979

FORESTRY AND FARMING IN UPLAND BRITAIN

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FOREWORD

The papers presented here were written for the 1979 Meeting of the British Association for the Advancement of Science at Heriot Watt University in Edinburgh. They are now being published because of their value and interest to many who could not attend the BA Meeting but who are directly involved or genuinely concerned in the future of the British uplands.

The range of subject is comprehensive, covering productive agriculture and forestry and their future inter-relations in the uplands, wildlife conservation, public recreation, landscaping, and social needs and implications. On each subject an authoritative writer has assembled useful information and advanced ideas for future development with careful regard to important interests other than his own. The papers thus collectively provide informed and balanced proposals for development, and though some differences of view remain, there are here constructive ideas for that co-operative use of the uplands essential to the national interest.

The value of these papers however depends most directly on the knowledge and ideas of the authors and in this we, as chairmen, have been unusually fortunate as the reader will see. To these authors and to all those who gave of their time to the Forestry and Agriculture Sections of the BA we are sincerely grateful as we are also to the Forestry Commission and to the Agriculture Section for this chance to publish and to the British Association for their permission to do so.

Presidents, at BA79 of
Section M Agriculture
Sub-section K* Forestry

THE ROLE OF AGRICULTURE AND ITS RELATIONSHIP WITH OTHER LAND USES

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THE ROLE OF AGRICULTURE AND ITS RELATIONSHIP WITH OTHER LAND USES

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INTRODUCTION

More than one third of land area of the United Kingdom has been described as upland and hill land (NEDO, 1973) extending to 5.78 million hectares (m ha) in the United Kingdom and 5.43 m ha in Great Britain. Consequent on joining the European Economic Community and using different criteria as defined in EEC Council Directive 75/268, which emphasises the importance of social criteria, the Less Favoured Areas (LFA) extend to 7.65 m ha which is 41% of the total utilisable agricultural area of GB. Some 3.95 m ha (51.6% of LFA) is classified as rough grazings, i.e. unimproved native grasslands. These indigenous pastures are defined not by altitudinal ranges alone but have developed because of specific climatic and soil factors and have characteristic vegetational components which may be modified to some extent by agricultural practices while the farming system is predominantly extensive sheep farming. The LFA also include substantial areas of permanent and sown enclosed pastures and limited areas of tillage.

For almost two centuries, these areas have experienced depopulation, have limited job opportunities and in general have poor social services. Of the primary industries in these areas, agriculture, fishing and forestry, the first is of major importance for economic, social and ecological reasons.

In upland and hill agriculture in Great Britain there are 5.639 million ewes and 831,000 beef cows contributing around 50%

and 25% of home produced lamb and beef respectively. The EEC-9 produces only 64% of its consumption of sheep meat and the accession of Greece, Spain and Portugal would only marginally increase self-sufficiency in an extended EEC but would increase export opportunities (Meat and Livestock Commission, 1978) for the United Kingdom. It has been suggested (Wilson & Brickstocke, 1978/9) that the prospects for the sheep producer have never been better.

The limitations due to climate, soils and topography dictate a pastoral agriculture with livestock production as the main farming activity.

Hill farms

Sheep

Following the sheiling system (Symon, 1959) and the introduction of sheep, hill farming changed very little although in recent years there has been a considerable reduction in the number of people employed on hill farms, numbers declining in Scotland from 2268 to 1795, a drop of 20% between 1968 and 1973. Hill farms have a high proportion of rough grazing usually 90-98% most of which is utilised by sheep. The variation in indigenous vegetation between farms, described by Newbould (1979) later are reflected in sheep carrying capacity. Thus the best grassy hills have a year-round stocking of a ewe to less than 0.75 ha whereas the predominantly blanket bog grazings of the west and north often carry less than one sheep to 1.5 ha. Of the total hill sheep population in Scotland one third is stocked at one ewe to between 0.8 and 1.2 ha, but one quarter have 2.5 ha or more per ewe (Cunningham et al, 1970). The average size of regional flocks does not vary greatly, from 850 to 1000 ewes so that the range in stocking rate gives rise to an average farm of around 830 ha in southern Scotland reaching 5000 ha in Sutherland. However, within regions substantial differences in both farm and flock size are to be found.

Output per farm is influenced by individual sheep performance as well as by flock size, and a major determinant of sheep performance is lambing percentage. The crude lambing figure derived from the ratio of sheep under one year old in June to the number of breeding ewes present in the previous December, obtained from statistics of the Department of Agriculture and Fisheries for Scotland, gives a value of 82% in 1970 and 83% in 1971.

Quite large regional differences in lambing performance occur. In the lamb-crop year 1970 the average percentage of lambs weaned in eighteen farms costed by the West of Scotland College of Agriculture in the Highland area was 76%, and in south-west Scotland (fourteen farms) 88%. In the same year the North of Scotland College of Agriculture reported that 75% of twenty-three costed farms returned figures of less than 70%, with some below 60%.

The poorer land carries fewer ewes and those ewes produce fewer and less well-grown lambs. Most of the lambs from hill sheep farms are sold as stores for further fattening on farms at a lower elevation. In a costed farm sample in south-east Scotland approximately 80% of the lambs sold are stores; the corresponding figure in the north of Scotland is upwards of 90%.

Year to year fluctuations in lambing performance within regions are also of importance. For example, the same group of sixteen farms in the south-east of Scotland produced figures of 85%, 74% and 87% in 1968, 1969 and 1970 respectively.

On those farms with nutritionally poor vegetation and low stocking rates lamb growth and therefore weaning weight, and ewe and lamb mortality also tend to be poorer.

Since lamb sales account for 60-70% of the income of hill farms a significant increase in lamb production by improving lambing percentage and/or keeping more ewes will have a greater proportional effect on output than any other change.

Beef cattle

Because of increasing costs of purchased fodder beef cows are being increasingly limited to relate to the area available for conservation on the farm (i.e. that part of the enclosed land on which cutting/harvesting equipment can be safely used). In Scotland only 20% of beef cows receiving Livestock Compensatory Allowances are on true hill farms due to the relationship between area and inbye land and cow numbers, this being remarkably constant at 0.2 to 0.3 ha mowing grass per cow (Cunningham & Smith, 1978). Compared with upland cow herds those on hill farms have 3% fewer calves and calf growth rates are significantly lower at 0.7 kg/day with calves being on average 35 kg lighter at weaning. There is also a high proportion of light-weight calves of below 200 kg liveweight produced and these are at a severe disadvantage in competitive markets. There is an increase in cow mortality and barrenness is 4-5% greater on hill farms. Such levels of performance are probably largely a consequence of the poorer nutritional environment in which many hill cows are kept though the use of traditional breeds may also be a factor. Hill sheep farms show levels of net farm income (which includes return on tenant's capital) substantially lower than most other types of farm in Scotland when compared within size class as determined by a labour input scale based on standard man days. Indeed gross output per £100 inputs is, on balance, slightly higher in hill sheep farming than in other types of farming. Net income per £100 gross output is comparable with that of other types.

Gross output per £100 labour is, however, significantly poorer than in most other types of farming. But machinery and power costs are of a much lower order in hill sheep farming, reflecting the difficulty of mechanising the work, and gross outputs per £100 labour and machinery are very similar as between hill sheep farming and other types. The return on tenant's capital (calculated as 'Management and Investment Income' as percentage of tenant's capital), at 10%, is also very similar to the general rate of return in Scottish agriculture.

Future developments

One possible approach to improving net incomes in hill sheep farming is to reduce costs. McEwan and Whitehouse (1972) examined the outputs, costs and incomes of a group of high and low performance (in net income terms) hill sheep farms. The chief characteristic of the high performance group lay in substantially lower costs rather than in higher output. This indicates the crucial importance of a wise deployment of resources and the importance of the ability of the farmer in this respect. But to an unknown extent possibilities in this regard may be constrained by the characteristics of individual farms. One of the major differences between the high and low performance farms was in labour inputs, but the decline in the labour force in the last two decades raises the question as to how much further this could progress without serious prejudice to production.

A more positive approach to the economic problems of individual hill sheep farms lies in increasing the size of the farm business. There are two possibilities. The first is increasing farm business size through the acquisition of more land; the second is achieving the same end by means of intensification within existing units.

Harkins (1970) has discussed the question of the amalgamation of holdings in hill sheep farming. In his view, where this can be done by renting additional land, and especially where the additional land is contiguous with, or in the neighbourhood of, the original farm, amalgamation may be an attractive possibility. Where the extra land has to be acquired by purchase more serious difficulties are encountered. If the whole of the capital is borrowed, whilst ultimately the net worth of the farmer will have increased by the value of the extra land and stock acquired, annual servicing charges have to be met. In fact, even if less than half of the capital has to be borrowed, in current circumstances the annual service charge would require at least the whole of the trading surplus of the new unit, and the farmer's own share of the capital investment would attract no return.

There may well be individual cases in which, for a variety of reasons (e.g. considerably better than average benefits in terms of overall resource utilisation or in economies of scale, usually cheap land or cheap capital, or a personal taxation position) the case for amalgamation may be justified.

The opportunities for amalgamation seem to occur but rarely and therefore increasing the size of farm business in most cases will be dependent on a programme of intensification.

Upland farms

These farms may have all or at least 50% or so of their land as enclosed sown or permanent pastures and depending on topography a much greater opportunity to conserve winter fodder. Depending on the amount and quality of rough grazing it will have a varying role in the farm. In many areas of the country this part is not specifically identified or allocated being common grazing managed in a hill sheep system apart from the upland unit itself. These certain areas.

In Great Britain upland and hill agriculture contributes 25% of beef supplies (Baker, 1975) and 50% of home produced lamb and mutton. In Scotland total lamb and mutton production amounts to 56,000 tonnes (Anon, 1977) which is about 24.5% of United Kingdom production and of this the hill and upland sector is contributing around 77% (41,145 tonnes). Even though lambing percentages were increased by 10% units in the Scottish lowland flock, this would only yield around 750 tons lamb. It is in the 'uplands' that technical innovation in sheep production could have a dramatic influence. Spedding recently stated "the availability of land is commonly discussed in terms of competing demands for the lowland areas, but it is worth reflecting on the very large areas of 'rough grazing' and permanent pasture in the United Kingdom. Quite small increases in output per hectare from such areas could clearly result in very large increases in total production, primarily of some of those animal products that are becoming increasingly hard to justify from arable land".

The paper which follows deals with the factors limiting plant and animal production in these adverse environments and indicates some of the technical solutions derived from research and also discusses some of the problems still confronting the biological research scientist.

However, one point clearly emerges and that is the advances which have been achieved when scientific results have been integrated into new and effective systems at the farm level. The practical application of the two-pasture system, described in more detail later by Eadie (1979) has shown most encouraging results (Table 1) and is being promoted on a trial basis on commercial farms by the Scottish Agricultural Colleges. Traditional systems

TABLE 1. Production increases in hill farm improvement schemes with the two-pasture system in Great Britain

Location, area and period	Sheep breed	Land improved %	Increase in ewe nos. %	Increase in wt. of lamb output %
Southern Scotland Sourhope 283 ha 1969-1976	Cheviot	7*	55	130
West of Scotland Lephinmore 444 ha 1956-1976	Blackface	11	120	190
Northumberland Redesdale EHF Dargues Hope 162 ha 1969-1976	Blackface	13	125	290

* In addition to 20 ha (7%) improved by surface treatment some 100 ha of Agrostis-Festuca grassland have been enclosed and improved by grazing control

produce 6 to 16 kg liveweight of lamb per hectare (Cunningham & Maxwell, 1979). At Redesdale Experimental Husbandry Farm output has been increased from 16.0 kg/ha to 51.8 kg/ha in eleven years on Dargues Hope hill unit and on Pwllpeiran EHF from 11.2 to 48.8 kg/ha. At Sourhope lamb output increased from 28.0 kg/ha to 62.2 kg/ha between 1968 and 1977. An increase of about 35 kg additional liveweight production from a hill flock would appear to be technically possible in the appropriate environment which probably includes a wide range of hill land.

The question naturally arises as to what the ceiling may be. Given adequate access it would be possible to continue the process of land improvement so progressively creating a transition from a hill farm to one more of an upland type. In doing so the available area of rough grazing would decline and ultimately its ability to offer other than moderate nutritional provision, particularly in winter, would mean escalating feed costs and the need to have concern about the ecological consequences of a heavy grazing pressure. To meet the higher costs more productive stock such as crossbred ewes would have to be introduced at some stage. If there were no opportunities for the production of home grown winter bulk fodder due to say lack of suitable access etc., the unit would require to remain essentially a hill farm. The number of sheep which can be handled effectively by one man is another consideration. Depending on the topography, farm layout, etc., it would appear that if accepted practices of sheep husbandry were to be maintained in the new system a ceiling per man could well be around 800 to 1000 ewes producing a 110% or so lamb crop. Assistance in any event would be needed for shearing and clipping while essential movement of ewes and lambs, i.e. the separation of twin and single suckling ewes post lambing, is a time consuming task. The extent to which an easy-care philosophy in which the desirable management and nutritional provision is ensured could lead to even greater numbers per man assisted by better design o. fixed equipment such as dosing races, dipping facilities, identification of foetal numbers, and so on, is largely a matter for speculation.

Substantial increases in production on upland farms are also possible. Intensification of beef cattle from the traditional one ha per cow and calf to 0.4 per cow is now common. In recent years the clean grazing system devised and developed by the East of Scotland College of Agriculture has shown impressive increases in production (Speedy, 1977). On a number of commercial farms summer stocking rate of ewes has increased from 7.5 to 10 ewes/ha up to 12 to 15 ewes/ha. This has allowed land to be released for other enterprises to give an overall increase of 23% in the area of cereals and 21% and 14% for sheep and cattle numbers respectively.

More intensive stocking, new grazing management strategies and reduced neonatal mortality could make a significant contribution to output in the upland sector. Assuming an additional 20 units lambing per cent, an additional 2,800 tons lamb could be produced in Scotland. It is indeed the hill areas which have the greatest potential for increasing production.

Use of rough grazings

There is, I believe, increasing recognition that much better use of our vast resource of hill land is required now and in the future. There is no gainsaying the fact that increased supplies of home grown timber will be desirable since most predictions point to a future scarcity. Because of the uncertainty of prediction and many other reasons, I would not think that the arguments, however strong, would justify allocating all of 'the potentially' afforestable land for this purpose. While large may be beautiful in the eyes of the foresters, the Kielder and Galloway type blocks of massive forest have little general public appeal. We are neither self sufficient in timber production (8%), nor in lamb production (56%). If economic production is attainable we ought to optimise our use of hill land to a much greater degree than is presently achieved. There are major constraints to this. An important and significant one is the large areas of common land throughout the country where progressive policies are largely inhibited. Since little of this land can be released for forestry greater pressures arise in the selection of the remainder of hill land which becomes available for forestry. In the context of a wider assessment and opportunity much of this land presently allocated to forestry could with advantage be retained in farming. There is a considerable consensus which indicates that integration of forestry and agriculture is the way ahead. A precise and clear definition which is universally acceptable perhaps still eludes us but most are agreed that some degree of mutual benefit is implicit, to either one or both forms of land use.

What is probably most important is that the changes effected should lead to an increase in the overall economic benefit to the nation. At a research level computer modelling techniques have been developed (Maxwell, Sibbald & Eadie, 1979) which allows a more objective examination of a range of forestry and agriculture land use options of a particular area or farm. The method is dependent on knowledge and experience of hill soils and vegetation coupled with an ability to assess their potential for each land use. The model includes such constraints as seem relevant to each, for example, minimum size of forest block and of the agricultural unit, including for the latter scale of business, multiple use of roads and the allocation of unplantable land to agriculture, much of which at present is virtually abandoned. For each solution obtained the output, fixed costs and net annual cash flow of the restructured agricultural unit is calculated and the Net Present Values of both agriculture and forestry are presented. The combined highest values may be regarded as the best choice but other considerations such as amenity etc. may be equally or more important in some circumstances.

There is as yet very little evidence of integration of agriculture and forestry becoming widely practised and there is probably a need for a more significant initiative at two levels :-

(a) institutionalised authorities

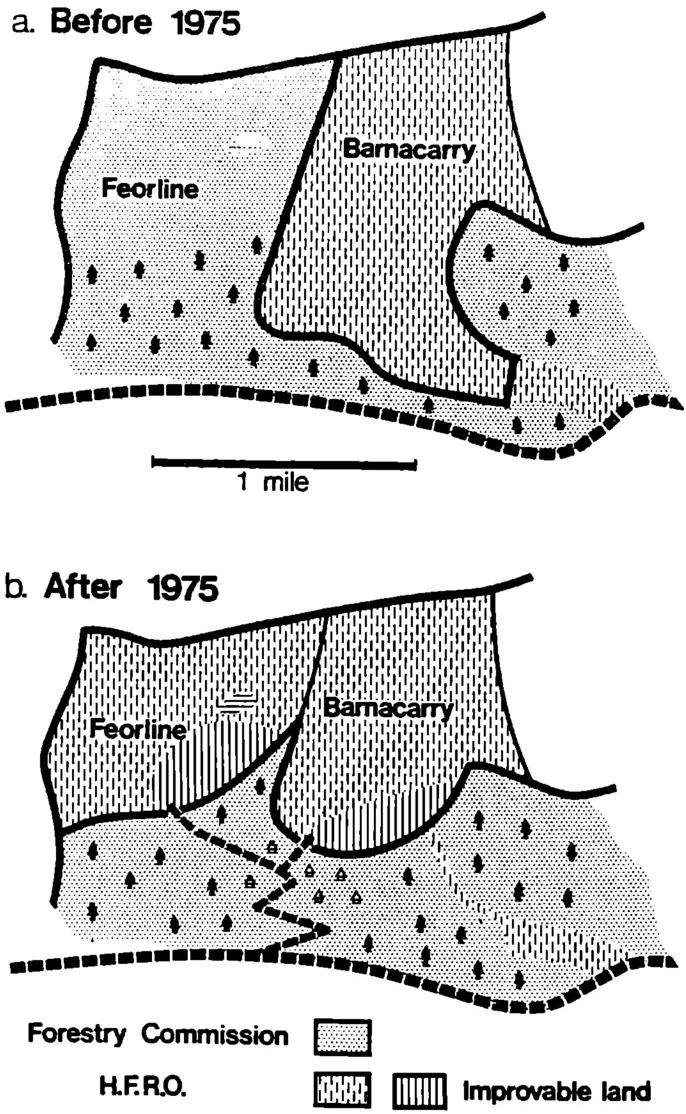
(b) agricultural entrepreneurs (landowners/farmers).

The current practice of land being made available for planting on a whole farm or farms basis severely militates against integration. The agricultural departments are required to decide only whether to permit planting or not and not to examine or propose an integration scheme, nor are they allowed to hold land which might be integrated with an adjoining unit. Yet our econometric studies suggest nonetheless that the allocation of only part of the farm could well optimise the overall economic advantages. It is not incumbent upon the authorities - agricultural or forestry so to evaluate land offered for planting. If however, landowners and farmers could be encouraged to offer some part or parts of a farm for forestry benefits to both the national and the individual interest would ensue. The mechanisms by which such a policy might be achieved will be the subject, I would expect, of debate and argument later this week.

However, some points may be pertinent here. Capital for improving hill farms is notoriously scarce. Traditionally the industry rarely has a run of sufficiently profitable years to generate investment funds because of as in recent years, price fluctuations, inflation and the burden of escalating costs or the ravages of the weather and high losses of animals. As the two papers which follow indicate, we now have a much better understanding of the biological and economic problems of hill farming and the means are available over a wide spectrum, if not all, for a considerable enhancement of production and productivity at the farm level. Capital obtained from the sale of part of a hill farm could be effectively invested to substantially increase output well above the levels obtained from traditional systems.

The Hill Farming Research Organisation and the Forestry Commission have collaborated in a joint integration exercise on their respective holdings at Lephinmore (Barnacarry) and Feorline. Barnacarry extends to 400 ha, has carried around 160 to 200 ewes on a traditional system with lamb crops at weaning varying between 69-85%. Access to implement change was well nigh impossible and the installation of a road was certainly unjustified on a cost benefit basis. HFRO sold to the Forestry Commission 95 ha of which 92 ha was plantable and in return obtained 71 ha more accessible land which was suitable for planting but also agriculturally improvable, plus 80 ha unplantable at no value. The balance of advantage 21 ha, as then valued, was adequate to allow the Forestry Commission to instal a 1.8 km road seven years ahead of schedule so as to allow HFRO access to both Barnacarry and Feorline and also to construct a further 0.3 km of road exclusively for agricultural use (Fig. 1). The potential of the new unit may well be 500 ewes and because of the access can be integrated with the remainder of the farm. Of course, not all circumstances are similar but improved access, a major constraint to land improvement

FIGURE 1. Scheme of integration at Lephinmore, Argyll, agreed between the Hill Farming Research Organisation and the Forestry Commission, 1975



on many farms, cash to pay for that improvement and indeed better day to day access are major benefits amongst others from integration.

It is sometimes argued that the use of new technology to increase production from hill farming could compensate for the loss of hill land to forestry and sustain current levels of output. This proposition merits some examination. If 32,300 ha were planted each year of land capable of producing 12 kg lamb live-weight/ha (equivalent to one ewe on 1.5 ha) the loss of lamb production over a ten year period would be 3.876mkg (NFU, Scotland, 1978). While an increase of 35 kg has been achieved, a more modest expectation might be an increase after ten years of 15 to 20 kg of saleable lamb. To meet the above loss over ten years 260,000 ha would require to become involved in improvement schemes at the rate of 26,000 ha per annum so that by the end of ten years the loss would be totally balanced for the first block planted.

On average around 10% of a hill farm might have to be improved to achieve this increase which at present at a cost of £300/ha gives an expenditure of £780,000 per annum and £7.8 million for a ten year commitment. There would be an annual increment of around 1.5-2.0 kg/ha lamb produced of economic benefit and in effect investment would probably be spread over five to six years. Our calculations on a net present value basis show that the return to the additional output will generate similar returns to those from forestry. Much of the land which has the agricultural potential indicated has already been planted, particularly in the south of Scotland. Indeed 33% of the plantable land (2.45 m ha in Scotland) has now been planted. If the 2.0 m ha of unplantable land, much of it at high elevation, is discounted then it is largely from the plantable land remaining, i.e. 1.650 m ha, that both increased food production and more timber will be obtained. It is a simple and naive argument to contrast the United Kingdom and Continental countries in regard to the proportion of land allocated to forestry. There is no common basis of comparison and so we must examine the implications of what we do in relation to the production of primary products here. Broadly, if we are to maintain present levels of output from hill land and assuming improvement were to occur at the levels previously postulated, which is coubtful, then at least half the present fund of plantable land would have to be retained in agriculture.

As has been suggested by Sheppard (1957) innovations will be quickly adopted if they involve little cost, minor change, are easily taught and give quick returns. The inherent traditionalism of the hill farmer, the lack of confidence in the future market prices, the inevitable lag in the generation of increased returns from investment, all suggest a slow rate of improvement. While I detect an awakening in the hills in the impressive and encouraging example of the pioneers, increased expansion is probably to a large extent dependent on market forces. I consider that the rate of increase in hill farming production is unlikely to continue to compensate for the loss of land to forestry unless new policies are implemented.

The argument is sometimes advanced that agriculture employs fewer people per unit area than forestry. This argument is too simplistic since amongst other issues it is also of importance as to where people live and the cash which they generate and which may flow through local services. Income is seasonal in upland and hill farming but it does have an annual cash flow. Calculations (Smith, 1979, unpublished) suggest that those engaged in the uplands generate annually a gross revenue of about £7,000 to £11,000 or so per man depending on the class of farm. Much of this is spent as rewards to labour and some part of other costs will also flow through local services doing much to sustain them. This is an aspect which needs further study in relation to change in land use.

Red deer and deer farming

The use of the 'upland middle range' for improvement for agriculture or for afforestation may lead to a loss of wintering ground for feral red deer and concern has been expressed by the Red Deer Commission (1978). Although it is uncertain as to the extent to which migration of displaced animals may occur, it would appear to be essential to cull, otherwise the problems to agriculture of marauding deer could well become more serious. Perhaps the loss of revenue from stalking and venison sales could be compensated for by deer farming on the better hill areas and enclosed land retained in agriculture. In some circumstances it could be associated with a sporting enterprise with a sharing of labour. While the Hill Farming Research Organisation/Rowett Research Institute joint experiment has used extremely poor land to successfully farm red deer, it should be borne in mind that initial capital investment for fencing and pens can be high. Fencing costs per animal will be reduced as stocking rate is increased and also as the number of paddocks required drops. Higher stocking densities being associated with more productive land, they will also, given good management, lead to better animal performance. Evidence in the UK (Blaxter et al, 1974) suggests slaughter of farmed deer at 16-18 months of age. When run on reseeded land at Glensaugh during their second summer stags have reached 90-100 kg liveweight at slaughter in contrast to those from the hill which have averaged 70-75 kg. The work of the

Highlands and Islands Development Board in Morven should resolve some of the problems of handling large numbers and the relationship of improved land to rough grazing. The experience of the New Zealanders is of relevance where with a phenomenal expansion over a few years they now have a farm population of 60,000 deer (Drew, 1976). Tame hinds have been stocked at 10-14 hinds/ha but problems have been encountered at calving which may require a short term relaxation of stocking density. On first class land with stocking rates of 26.4 to 31.4 yearling deer/ha, carcass gains in three successive years were 520, 740 and 720 kg/ha over a 180 day period which compares with a 4-year mean of 443 kg carcass beef/ha using Aberdeen Angus Friesian-cross cattle on similar land (Drew & Greer, 1977). Recently a successful deer farmer, Dr. J. Fletcher, stated that red deer offers a chance of producing low-fat meat more cheaply than beef or lamb in both financial and energy terms.

An estimate of the possible gross margins which might be obtained on an upland unit has been made by Young (1979). These suggest that upland farms with enclosed sown pasture and a hill outrun for wintering could well be an attractive enterprise especially if breeding stock could be sold or a farmhouse sale of venison developed. It has been suggested that farmed venison is a new product. Tests show it to be uniform with a delicate flavour (Forss & Manley, 1977) which may be preferable to the British palate than the strong gamey flavour of feral deer.

There is as yet insufficient evidence from commercial enterprises to indicate whether deer farming in present circumstances is economically more attractive than existing livestock enterprises. But it is difficult to imagine why deer farming has expanded so rapidly in New Zealand and not in Great Britain.

Conservation

It is important that in a dynamic and changing agriculture in the hills that due account is taken in regard to conservation as it applies to plants, wildlife and so on, and also environmental conservation, implied as a wider concern for the environment (Nicholson, 1971).

As is clearly illustrated by Newbould (1979) hill sheep farming is not leading to degradation of the environment by inducing an unacceptable change in the vegetation of the hills, neither is it depleting the inherent fertility of hill soils.

Sites of special scientific interest, as designated by the Nature Conservancy in their Nature Reserves, do not in any significant measure conflict with agricultural interests.

However, concern is sometimes expressed at the loss of indigenous vegetation because of agricultural improvement schemes. Understandably this may be a cause for disquiet where the area of open moorland is limited, such as Exmoor. Most reclamation tends to occur on the periphery of the moorland areas. Studies of such land, for example, the Lammermuirs in south east Scotland, and the Derbyshire Peak District, show that substantial areas have been cultivated in the past, sometimes more than once, and have been allowed to revert to native vegetation. There surely can be little complaint if this class of land is returned to more productive pastures if it is economically justified.

There are a number of other issues, including sport, amenity and recreation, that merit brief mention in a wide ranging paper but may be considered in greater detail later in the week and in no sense can be discussed fully here.

Sport

Sometimes I detect rumblings of conflict between grouse shooting interests and agricultural ones. There are vast areas of heather dominant moors and their levels of sheep production vary widely being highest on those which have the best ratio of grassland to heather. But sheep production is low relative to grassy hills. HFRO is currently testing the idea of introducing 30% of reseeded grass, in a matrix, into a limited area of dominant heather on a hill farm - about 1 ha for every 10 ewes. Because the heather will be more intensively grazed and so maintained in a young nutritious state, ideal for sheep and grouse alike, we do not anticipate that this should be in any way antagonistic to the grouse population, yet hopefully it will lead to a significant improvement in the performance of a sheep flock.

Amenity and recreation

As agriculture is intensified in the 'uplands', it will probably become more sensitive to public access. Greater control over grazing management, required to intensify stocking, will be at hazard from open gates, damage to fences and walls and also from uncontrolled dogs.

Land reclamation, scrub clearance, bracken spraying will all modify scenery, but not necessarily for the worse. Much of our landscape is man made but it cannot remain a museum, only evolve. We do not know enough about the effects on agriculture of the constraints imposed by planning controls and recreational activities in National Parks and elsewhere. It is encouraging to learn that this is a topic of investigation in Cumbria by Edinburgh University. Hopefully the data will improve discussion and lead to the acceptance and promotion of agriculture in association with other activities.

The Government White Paper - 'Farming and the Nation', published earlier this year, states - "there is a common bond of interest between those engaged in the production of food and those whose first priority is the amenity of the hills. It is farming, and the other employment generated by farming which keep rural communities in being and ensure that basic services are there for the many people who enjoy visiting these scenic areas".

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THE LIMITATIONS AND POTENTIAL FOR PASTURE PRODUCTION FROM THE HILLS AND UPLANDS

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The limitations and potential for pasture production from the hills and uplands

by

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INTRODUCTION

Pasture production from the hills and uplands of the United Kingdom is limited by a large number of factors which originate from the prevailing climatic, physical, biological, animal production (i.e. farming system) and socio-economic environments. This paper briefly examines the former three areas of limitation to production, indicates how some of them can be overcome or tolerated, describes responses which have been achieved and those which might be possible, i.e. potential production, and discusses the ecological consequences of increased production and utilisation of these pastures. Aspects of the remaining sources of limitation are covered in the preceding (Cunningham, 1979) and following (Eadie, 1979) papers at this meeting.

Attention is directed mainly at hill soils and vegetation, which are relevant to the major part of the land used for hill sheep and to about 50% of that used for upland sheep and beef cattle farming systems as defined in the previous paper by Cunningham (1979). However, broadly similar soil types appear in both hill and upland situations, and although in the latter soil fertility and the climate are often more favourable to pasture production, particular problems can occur due to waterlogging and to gleyed soils which are not dealt with in this paper.

LIMITATIONS

The biological limitations to pasture production can be summarised into five main groups (Table 1). Despite this apparently clear-cut categorisation a feature of many of the limitations is their complex inter-relationships which often confuse understanding of their direct effects on pasture production. A limitation is described as permanent if it is beyond man's present or anticipated expertise to alleviate it. The prime example in this category is climate, many attributes of which impose severe constraints to pasture growth with only the possibility for man to provide shelter by site selection or tree planting to reduce the effects of wind. On the other hand, the limitation to pasture growth imposed by the utilisation system is described as temporary since it is entirely managed by man who can decide which animal, or mixture of animals, to graze with, and with what intensity. Methods to deal with some of the other temporary limitations by processes often broadly described as land improvement, will be discussed later. The prime aim of such methods is to improve the quality of pasture for grazing animals for the reasons to be described by Eadie (1979) and although long-term benefits to the land in enhanced fertility and in better physical condition of the soil may follow, they are more aptly described as pasture improvement.

Climate

The climate of the hills and uplands is broadly cool, wet and windy (Gloyne, 1968; Francis, 1978) and it deteriorates rapidly with rise in altitude (Hunter and Grant, 1971). However, there are regional variations within this overall description and the main characteristics of four of the chief upland climatic zones and where they occur are shown in Table 2. The prime climatic

TABLE 1. The main limitations to pasture production from the hills and uplands, listed in decreasing order of permanence both within and between main groups

CLIMATE	Radiation Temperature Rainfall Wind
SITE	Rocky Steep Aspect Wet Access
SOIL	Parent material Stones Depth Texture Organic matter Trace element imbalances Available K Available P Available N Acid
VEGETATION	Woody/deciduous Season of growth Growth rate Competitive
UTILISATION SYSTEM	Cattle Sheep Intensity

Table 2. Description, occurrence and main features of upland climatic zones in Great Britain

Description	Location	Mean annual temp. (^{o}C)	Rainfall (mm)
Very cold and very wet	Scotland > 700 m	4	>4000
Cold and wet	High Wales SW England Pennines Lake District West Scotland	4-8	>1000
Fairly warm and wet	Wales SW England	>8	>1000
Cool and fairly wet	N Yorks Moors Eastern Pennines Eastern Scotland	<8	<1000

(Newbould and Floate, 1979)

factor which affects plant growth is low temperature.

In general, temperature influences plant metabolism and thus the duration of growth; in particular it influences leaf expansion, extension and respiration. The marked effects of low temperature on leaf performance affects the interception of solar radiation and thus photosynthesis. Temperature, with light intensity and day-length, affects the induction of floral initiation, and it also influences the rate of development of the inflorescence and its time of emergence. Low temperature, coupled with low levels of nitrogen, decrease the number of vegetative grass tillers initiated. A combination of all these influences produces the characteristic early production of few widely spaced grass flower heads sometimes seen on exposed improved hill pastures.

An important consequence to all plant growth in the hills and uplands is that the season of growth, however its minimum temperature threshold is defined (i.e.>4.8, 6 or 10°C), is short by comparison with lowland standards. For example, if 6°C is used as the lower limit for plant growth there are no growing days throughout the year at the top of Ben Nevis, and the number ranges from only 160-200 days over the bulk of the hills and uplands. It is of interest that the Isles of Scilly are the only areas in the United Kingdom that usually have 365 growing days in the year. Furthermore, 75% of the growth which does occur in the hills takes place in a six-week period, usually during May and June (see curve A-F, Fig. 1). However, provided temperature and light levels are suitable, acid grassland can grow at other times of the year. Other indigenous species, e.g. heaths, grow only in the summer but remain winter green, while yet other species, e.g. *Molinia*, *Trichophorum* and *Juncus* sp., senesce quickly in autumn and die back rapidly. Even when lime and fertilisers are added and perennial ryegrass and white clover are sown resulting in a large increase in annual yield of dry matter, there is little change in the seasonal pattern of growth (see PRG-WC, Fig. 1) although there are some reports (Armstrong, 1979) that the improved pastures start growth earlier in the spring and continue longer in the autumn than indigenous types. The shape of the seasonal growth curve which would most benefit the hill farmer is that shown as ideal on Fig. 1. This has early spring growth (1), the continued production of high-quality herbage through late spring and early summer (2), the ability to respond to a mid-summer rest with good and extended autumn growth (3), and the capacity for the herbage to remain winter green for as long as possible (4) (Newbould, 1974).

Small increases in altitude have large effects on plant growth. For example, Hunter and Grant (1971) found that the annual DM yield of S.23 perennial ryegrass declined by 2% for each 30 m rise in elevation although this was influenced by season; the decline in spring per 30 m rise was 5% compared with only 1.8% in autumn. Indigenous _Festuca rubra_ also showed reductions in DM yield in spring of 5% for each 30 m rise in altitude (King _et al_, 1967). However, the overall effect of altitude was not always as clear cut. Some of the highest yields were often found at intermediate altitude (300-380 m) because growth was reduced by moisture stress at lower altitudes (230 m).

Interactions amongst altitude, wind exposure and soil moisture status were also observed; in dry spells, yields from exposed intermediate altitude soils were depressed more than similar sites in wet spells or on sheltered sites of higher altitude.

Rainfall is high on average and it generally increases with

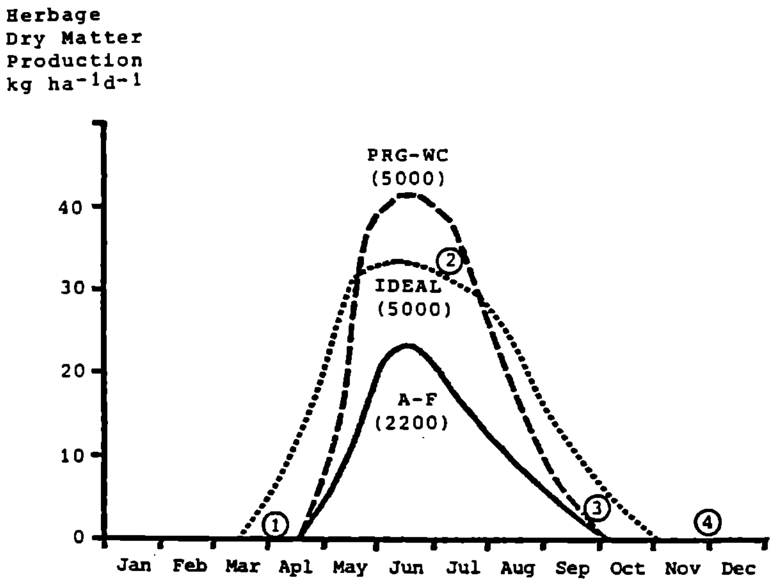


Fig. 1. Typical seasonal growth curves of three hill pastures on a brown earth soil; A-F = unimproved acid grassland; PRG-WC = improved pasture of perennial ryegrass and white clover; IDEAL = improved pasture of grass and legume with, as yet, unspecified herbage plants. Annual herbage DM production (kg/ha) shown in brackets. See text for explanation of circled numbers

altitude and with proximity to the sea. For example, the average annual rainfall at sea level at the HFRO Lephinmore Research Station on Loch Fyneside, Argyll, is 1790 mm (70 in) but at 500 m above sea level it is about 2300 mm. Moreover, the rainfall at sea level increases by approximately 5% for each mile the measurement point on the loch-side is moved away from the open sea; thus, at the landward end of Loch Fyne, some 15 miles farther inland from Lephinmore, it reaches 3000 mm per year. The high levels of rain falling from low lying clouds means less direct input of radiation, and large quantities of soil water depending on the soil type and the topography. Run-off and run-on are important considerations; the former, coupled with shallow brown earth soils of low water holding capacity, can result in drought conditions during dry spells in the season making seed germination difficult and reducing herbage growth (Hunter and Grant, 1971). The latter encourages the development of peaty gley soils on the lower slopes or valley bottoms. In the freely draining soils any nutrients which may be mineralised or added to the soils as fertilisers must be taken up rapidly by plants or they are quickly leached.

Direct solar radiation on the hills varies from about 1.5 $MJm^{-2}day^{-1}$ in winter to about 15 $MJm^{-2}day^{-1}$ in summer (Alcock, 1975). In lowland Britain the highest level in summer would be about 21 $MJm^{-2}day^{-1}$ but probably the most important difference between hill and lowland is the lower levels in spring on the former sites. The overall differences in radiation receipt between hill and lowland are not great and, as will be shown later, it is unlikely that lack of solar radiation is ever a major limiting factor. A recent paper by Harding (1979) shows that solar radiation receipt in the uplands decreases with altitude by 2.5-3.0 $MJm^{-2}day^{-1}$

due to increased cloud cover. However, in cloudless conditions solar radiation increases by about 15% per 1000 m, and because mountain tops are often above the clouds the radiation receipt, for example at the top of Cairngorm, is 35% greater than at lower altitudes.

The large number of windy days, coupled with intensity of winds found in the hills, affects plant growth. The wind both dries and cools moist soil (Smith, 1975; Grace, 1977). Cooling is direct when the air is cooler than the soil, and by evaporation of water when part of the latent heat is obtained from the soil. It has been estimated that this cooling can decrease the temperature in the vicinity of sown seed by 1-2^{o}C and so lengthen the time required for germination and seedling emergence (ADAS, 1979). The growth of plant leaves is decreased, both by the movement of leaves caused by the wind and by increased water stress. Some of these effects can be alleviated by careful siting of areas chosen for pasture improvement and by the provision of shelter belts of trees, although the latter probably have a more direct effect on hill farming by providing some protection for the grazing animals. However, Russell and Grace (1979) recently showed that, although the provision of a shelter which reduced the wind speed by 27% had no effect on dry matter production of Festuca arundinacea and Lolium perenne in spring, in a subsequent regrowth period the dry matter production was increased by up to 28%. The precise reasons for these beneficial effects of shelter are not clear but the authors suggest it may be due to reduced mechanical stimulation of the plants and to accompanying changes in the distribution of assimilates.

Site

Pasture production is directly limited to some extent by the large number of rocks and the wetness of some areas. The latter can be removed or alleviated by high cost drainage schemes but the small benefit in extra plant growth is difficult to justify on a cost basis. In some cases utilisation can be improved but often a few relatively inexpensive open surface drains have the desired effect. Steepness and difficult access are not direct limitations to pasture growth but they do impede pasture improvement. A further important characteristic of site is aspect; large differences in the nature of existing vegetation on contrasted slopes of the same soil can be seen in many hill areas. Thus, the south facing sunny slopes are often green and grassy while the north facing side is often a black and heathery vegetation complex. Quantitative work in the United States (Bennett et al, 1976) and in New Zealand (Radcliffe et al, 1977) have shown that pasture production can differ between sunny and shady sides of a hill but that utilisation may also differ. There are also interactions between level of sunshine and water holding capacity of soil to such a degree that, contrary to expectation, pasture growth of sown species may be higher on the shady than the sunny side (Radcliffe et al, 1977). However, early spring growth was always greater for all species on the southern exposure (Bennet et al, 1976).

Soil

Within the limits set by the climate and sites it is the nature of hill soils that determines pasture production (Floate, 1968, 1977; Alcock, 1975; Ball, 1978). Most hill soils are acid and low in available plant nutrients. This follows because of the nature of the parent material, the high rates of leaching and the accumulation of organic matter either within the profile or on the soil surface, a process whose extent increases with altitude.

The total nitrogen content of hill soils varies from 0.4-1.4% of the soil weight, i.e. 4-14,000 kg N/ha, but only about 0.1% is inorganic and the bulk of the latter is in the ammonium form and not nitrate as in lowland soils. The total phosphorus content of hill soils ranges from 0.07-0.12% of the soil with 60-80% in organic and 20-40% in inorganic forms but with only 1-5 ppm in the labile pool, i.e. available for absorption by plants. The content of organic matter ranges from 9-36%, the water holding capacity and the capacity to 'fix' phosphorus are high and the content of calcium and the level of soil mircroflora and fauna activity is very low. Earthworms are either absent or present only in low numbers.

It is possible to find almost all the main groups of hill soils (Table 3) in a topographic sequence on one hill side, although the distribution depends in some part on the nature of the parent material and the degree of drainage. Thus, poorly drained gleys are found in the valley bottoms, brown earths on the lower slopes and peaty podsols and deep peats above 600 m (Floate, 1977). The increasing organic matter and associated cation exchange capacity, coupled with the loss of bases by leaching, result in the development of acidity and base unsaturation with exchangeable aluminium appearing in brown podsolic soils and exchangeable hydrogen in peat. Because of the low temperatures and reduced activity of micro-flora and fauna the rate of decomposition of the organic matter is slow with few nutrients, especially nitrogen and phosphorus, being mineralised.

In situations like this and where little of the existing vegetation is utilised, few nutrients are returned to the soil by grazing animals. Thus, both the micro-organisms and the herbaceous plants lack available nutrients and it is the low level of available soil nitrogen in particular which is the most critical soil factor affecting pasture production (see p.23 and Fig.4) In deep peat soils low amounts of available potassium may also occur and in some areas certain trace elements such as molybdenum, sulphur and boron may be in short supply.

Vegetation

Detailed descriptions of the individual plants, and of the botanical composition of the many upland pasture community types are available (McVean and Ratcliffe, 1962; King and Nicholson, 1964) and, more recently, by Hill and Evans (1978); a brief summary only is provided in Table 3. However, there is, as yet, little precise information on the overall distribution of the different types throughout the United Kingdom and many can occur within small distances of each other on one mountain, or even on one hirsel or small area of a hillside. The precise nature of the vegetation and its distribution, both locally and nationally, is determined by the climate, the soil (pH and drainage class) and the history of burning or grazing to which it has been subjected (King, 1977). Thus acid grassland or Agrostis-Festuca swards, sometimes with Ulex (gorse) and Pteridium (bracken), occur on the brown earth soils. When drainage becomes poor the vegetation contains more Molinia, Eriophorum, Trichophorum and Juncus sp. The peaty podsol soils with iron humus pans in moderate rainfall areas are colonised by Calluna; with the very acid and wet peat soils, blanket bog vegetation becomes dominant. A characteristic of all but the acid grassland types is the slow rates of growth, the marked seasonality of production and the generally 'woody' framework, while all except the heaths show a

Table 3. Summary of the main soil and vegetation types of the hills

Soil	pH	Vegetation type	Principal species
Brown earth freely drained	5.3-6.0	*Agrostis-Festuca* grassland high grade or spp. rich	*Agrostis tenuis* *Festuca rubra* *F. ovina* *Poa spp.* *Trifolium repens* Herbs abundant
Gleys poorly drained	5.3-6.0	As above with wet-land spp. *Carex, Juncus*	*Carex spp.* *Juncus spp.*
Brown earth freely drained	4.5-5.2	*Festuca-Agrostis* grassland low grade or spp. poor	*Agrostis spp.* *Festuca ovina* *Pteridium aquilinum*
Gleys poorly drained	4.5-5.2	As above with *Nardus* and wet-land spp. *Carex, Juncus*	*Nardus stricta* *Carex spp.* *Juncus spp.* *Deschampsia caespitosa*
Podsols Peaty podsols freely drained	4.0-4.5	*Nardus* or *Deschampsia/* *Festuca* grass heath	*Nardus stricta* *Deschampsia flexuosa* *Festuca ovina*
		or	
		Calluna shrub heath	*Calluna vulgaris* *Vaccinium spp.* *Erica spp.*
Peaty gleys poorly drained	4.0-4.5	*Molinia* grass heath	*Molinia caerulea* *Festuca ovina* *Deschampsia flexuosa* *Calluna vulgaris*
		or	
		Calluna/Molinia heath	
Deep blanket peat poorly drained	3.5-4.0	*Trichophorum/Eriophorum/* *Calluna* bog	*Trichophorum caespitosum* *Eriophorum spp.* *Calluna vulgaris* *Molinia caerulea* *Sphagnum spp.*

(HFRO 1979a)

lack of winter greenness. Moreover, many of the better grasses are very competitive to the introduction of plants such as white clover.

For animal production, the quality of the herbage is as important, or more so, than the quantity of dry matter. The average annual production of dry matter and the seasonal variations in pasture quality of indigenous vegetation are summarised in Table 4. Both are low by comparison with lowland permanent pastures where dry matter yields of 5-6000 kg/ha and a quality index varying from 78-66 might be commonplace.

Utilisation system

The intensity of utilisation, which is often very low in traditional hill sheep farming systems (Eadie, 1971), influences pasture production. If only 20% of the pasture grown in the short season is used the remainder senesces *in situ*; this accumulates and stops radiation reaching the young, more photosynthetically active leaves. The use of cattle, either grazing with or after sheep, can remove a great deal of the grass flower heads or accumulated dead herbage so that the species of animal, or mixture of animals, and their intensities of grazing influence pasture growth. This subject is discussed more fully in the following paper (Eadie, 1979).

Relationships amongst soil, vegetation and utilisation

Just as there are interactions between climate, site and soil characteristics which determine the nature of the vegetation, so there are relationships amongst soil, vegetation and intensities of utilisation.

In any grazing system each vegetation type attracts a different grazing pressure and seasonal pattern of grazing (Hunter, 1962) which directly influences sward composition and indirectly affects

Table 4. Dry matter production and quality of native hill pastures

Vegetation type	Dry matter yields, kg/ha	Basis	Quality index : digestibility as a percentage of DM			
			May-June	September 1st cut	September regrowth	January-March
Agrostis-Festuca (acid grassland)	2200 3200	sum, monthly cuts total green DM	70-76	45-55	65-73	40-50
Festuca-Deschampsia (grass heath)	2240	sum, monthly cuts	(65-75)	50-55	(65-73)	-
Nardus (grass heath)	1000-2240 4000	sum, monthly cuts total green DM	60-70	45-50	-	35-40
Molinia (grass heath)	1110	sum, monthly cuts	60	-	-	-
	1700	green DM April-Aug.	65-70	45-50	-	(38-litter)
	2000-4000	total standing crop	-	-	-	-
Calluna (shrub heath)	1750-3400	current shoots heather cover 85%+	60	50	55	40
Trichophorum/Eriophorum/ Calluna (blanket bog)	1450-1700	current shoots heath + green material grasses and sedges	60-68	40-55	-	-

(HFRO 1979a)

the nature of the underlying soil. Low grazing pressure leads to selective grazing and shrubby and other avoided species are uneaten and tend to become dominant. In this scenario little vegetation is eaten and returned to the soil as excreta. It is known from Floate's (1970) work that the nutrients in excreta are more available for subsequent plant uptake than if the same plant material had senesced in situ and become litter. Also, in the low grazing pressure situation it is necessary to control the shrubs periodically by burning or all access is impossible. The heat of the fire and the return of nutrient as ash can affect soil development.

High grazing pressures lead to unselective grazing and the dominance of prostrate plants is favoured. Moreover, the more even return of excreta containing available nitrogen and phosphorus benefits the more responsive, faster growing species of plants.

Although the list of limitations to high quality pasture production sounds daunting it is noteworthy that there are about 6 M ha of rough hill grazings in the UK which produce about 2300 kg DM/ha each year without improvement and that a significant portion of this DM, i.e. that from 1 M ha, has an organic matter digestibility of 65-70%, at least for a short period in the spring. Since much of this pasture can only be utilised by grazing animals the skill of the animal producer is required to design systems of grazing to make effective use of this unique national resource. So successful are the new systems (Eadie, 1979) that methods to resolve some of the temporary limitations to pasture, as described in the next section, need to be applied to only a fraction of the total area of hill land. For example, it has been suggested that the minimum amount of pasture to be improved in quality and quantity to have impact within a cost effective scheme need be only 0.40 ha per 6-7 existing hill ewes (Cunningham, 1972). For an average Scottish hill sheep flock of 800 ewes grazing about 1000 ha this would necessitate improvement of 53 ha or approximately 5% of the total area.

METHODS TO OVERCOME TEMPORARY LIMITATIONS

The changes in management to increase the level of utilisation needed to overcome the limitations of existing practices in hill sheep farming will be described in detail by Eadie (1979). In essence, the requirement is to improve the quality of herbage available to stock at two of the three key times in the animal's annual nutrition cycle, i.e. during lactation and prior to mating. Thus, it is necessary to increase pasture quality on a small part of the hillside, usually the most productive areas; these areas are used from April to June and August to November. The larger area of unimproved rough hill grazing is used from June to August and from November onwards. The third key time, i.e. late pregnancy, is met by feeding the ewes concentrates in the six weeks prior to parturition.

In the majority of situations little improvement in pasture quality follows enclosure and the control of grazing itself; it is then necessary to remove the interrelated limitations to vegetation and soil. The exception is the better acid grassland swards on brown earth soils; however, in all cases, the first input to any pasture improvement scheme should be a fence. There is little evidence that the simultaneous addition of lime and phosphate to these pastures brings about significantly appreciable changes in dry matter production although the nutritional content of the herbage may be improved. The control of weeds, e.g. bracken, on some acid grassland sites may produce extra production of dry matter which might have better quality (Davies et al, 1979). Similarly, the control of *Molinia* and *Nardus* invading *Agrostis-Festuca* swards, by cutting, intensive grazing or the use of herbicides, may be beneficial although the rate of improvement will be slow.

If the area to be improved is other than acid grassland there is little alternative to the complete replacement of the indigenous vegetation by introduced plant species usually of lowland origin. The nature of the soil, the competitiveness of the indigenous plants, the demands of the farming system and the finance available, determine whether this is achieved by oversowing with little soil disturbance or by full cultivations. The objectives of any method are to establish a new sward as quickly as possible and at an economical cost. This usually requires the complete elimination of competition from regenerating indigenous vegetation, the removal or comminution of organic litter or trash, the preparation of a moist and firm seed bed, and the provision of a more alkaline soil with a higher quantity of available nutrients. The broad principles of pasture improvement have been known for many years (Stapledon, 1935, 1944) and general summaries of suitable techniques are available (NSCA, 1972; Frame, 1973; Newbould, 1976) but no all-pervading blueprint is possible because of site and system differences.

It is a salutory and humbling experience for a modern experimenter searching the literature to discover that his predecessors or pioneer farmers have described in detail many of the procedures which he naively still considered novel. These pioneers may not have had the support of quantitative measurements to understand all that was taking place but the ideas and motivation were there. A case in point is the technique to improve peatland which became known as 'Muirfad' after the farm where it was first successfully tested in 1930 (Gardiner et al, 1954). The latter authors emphasised the following features of the technique which are as true today as they were in the 1930s: Heavy dressings of phosphate as slag both to ameliorate the peat and to attract stock to the treated areas, no cultivation to avoid breaking surface crust of peat, continuous access by stock to cover seed and to graze off rough indigenous herbage, plus the treatment of relatively small areas each year. Nowadays we would use a combination of lime and phosphate, and we rely on fences to control grazing and not the attraction of slag treated vegetation. Moreover, and most importantly, we understand how best to use the improved pasture in the whole-farm grazing strategy. Pasture improvement techniques of this general form were used in the application of the 'two-pasture system' at the Lephinmore Research Station of HFRO (Eadie et al, 1976; Eadie, 1979). A distinguishing feature of present procedures is that the white clover seed to be sown in the deep peat soil is inoculated with Rhizobium trifolii effective at fixing nitrogen, recent collaborative research having shown the considerable benefits for this treatment (Newbould et al, 1979). Investigations are in progress to examine the further benefits to white clover establishment on deep peat of introducing mycorrhizal fungi. In laboratory tests the dry matter yield of white clover has been increased four-fold and the uptake of phosphate by 250% by increasing the levels of root infection with the fungus from 5-50% (Rangeley et al, 1979).

Research is continuing to refine methods, to make them more predictable and to reduce costs wherever possible. Recently a pioneer crop procedure has been devised and tested successfully at Redesdale EHF (ADAS, 1978) to deal with wet and rocky land with peaty podsol soils and wet heath vegetation. This necessitates using chemicals to kill the sward and sod-seeding a crop or crops of fodder turnips, before sowing down to perennial ryegrass, timothy and white clover.

A list of some of the main processes with their relative cost is shown in Table 5. It should be emphasised that the use of ploughing, with or without tile drainage, is included for comparison purposes only since they have little real application to hill pasture improvement, and are mainly relevant to enterprises on upland farms with higher production, such as crossbred sheep, suckler cows, conservation and forage crop production.

The general procedure in all schemes is to destroy the existing vegetation by burning, cutting or heavy grazing, to add lime (5-7 t/ha), phosphate (40-60 kg P/ha), nitrogen (40-120 kg N/ha), potassium (60-90 kg K/ha) and seeds of better grasses (25-30 kg/ha) and white clover (3 kg/ha) either by direct drilling or after light or heavy cultivation. Whatever the strategy, the process is described as land improvement, reseeding or hill pasture improvement, although the former term is usually reserved for the rapid but expensive process of complete sward replacement involving cultivation and the introduction of seeds.

All plants require nitrogen for growth and even in lowland situations the soil itself cannot supply sufficient for economic crop production so farmers rely on annual dressings of nitrogen fertiliser. It is a major criticism of most British farmers that they fail to treat grass as a crop believing it to be something that just grows, with the result that, on average, only about 90 kg N is added per ha; in Holland, by contrast, the

Table 5. The main processes of hill land improvement and their relative cost

Fence to control grazing	Cost relative to fencing
Alone	1.0*
+ herbicide : dalapon (to reduce *Nardus*)	1.3
: asulam (to control *Pteridium*)	1.7
+ lime and phosphorus	2.1
+ lime, phosphorus and white clover seed	2.2
+ lime, phosphorus, nitrogen, potassium, white clover and grass seed	
by oversowing	3.2
by light cultivation	3.7
by ploughing	4.4
by oversowing after two pioneer crops of Dutch turnips	4.4
+ deep tile drainage	7.6

* The base line was taken as £85, i.e. the gross cost per ha of enclosing an area of 8 ha with a cheap mains electric fence costing 60 p/m.

(HFRO, 1979b; ADAS, 1978)

average annual rate of application per ha is nearly 400 kg N. The average amount added to hill and upland pastures of about 14 kg N/ha is much less than the national average which is not surprising in view of the economics of this type of farming and is not too serious a deficiency provided an alternative source, i.e. a legume, is available. It will be shown later that significant responses to added fertiliser nitrogen can be obtained, especially with the introduced grasses, but the extensive systems of production cannot afford the annual recurrent cost. Therefore, hill and upland pastures need to rely on atmospheric nitrogen fixed by a legume, usually white clover, to provide nitrogen. Thus, the emphasis in any hill pasture improvement scheme is to create the soil conditions to establish and maintain the growth of this plant (Munro, 1970; Newbould and Haystead, 1978).

Controversy still exists as to what are the best grasses to sow with the clover but there is general agreement that the key to hill pasture improvement must be white clover.[1] For this reason the main thrust in research and development work on hill pasture improvement recently has been to define the soil physical and chemical and the plant competition conditions best suited to the predictable establishment and continued maintenance of white clover, it being assumed that if clover can be established and maintained so will productive grasses.

For example, white clover needs a pH of about 5.5 to grow well; therefore, it is necessary to add lime to many hill soils to achieve this. In mineral soils the aim is to reduce the quantity of soluble aluminium in the soil solution which interferes with the growth of both the plant and the indigenous symbiotic rhizobia. In peat soils it is the exchangeable hydrogen that must be reduced. Laboratory tests on the soils often indicate a need for 15-20 t lime/ha in the top 0-10 cm of soil but, fortunately in view of the present economic situation, it is found that applications of 5-7 t/ha on the soil surface are adequate to enable white clover to establish and to persist for at least 5-7 years when further maintenance dressings of lime may be required.

Phosphate is also required to ensure the growth of white clover and the nodules which contain the symbiotic micro-organism Rhizobium and where nitrogen fixation occurs. Phosphate is becoming increasingly expensive in both financial and energy terms. Data is missing for a complete analysis to be done but the work of Slesser (1973) at Strathclyde indicates that all plant systems give a better response to energy subsidy than animal-based ones. However, the two response curves are closer together when the animal system is a marginal or hill land one. Thus it can be argued that energy-rich phosphate is well used in these areas. An additional argument is that fertiliser should be used in the most responsive soils and this must include the mineral hill soils where there has been no history of added phosphate as in lowland situations.

RESPONSES

Observed

Several workers from Wales (Munro *et al*, 1974; Alcock, 1976; Hughes, 1976) have recently described various aspects of the influence of soil, climate and plant material on pasture production from the hills and uplands. Overall, they suggest that intensively managed perennial ryegrass swards, ie. with adequate levels of nitrogen fertiliser, on a brown earth hill soil can produce 10 t

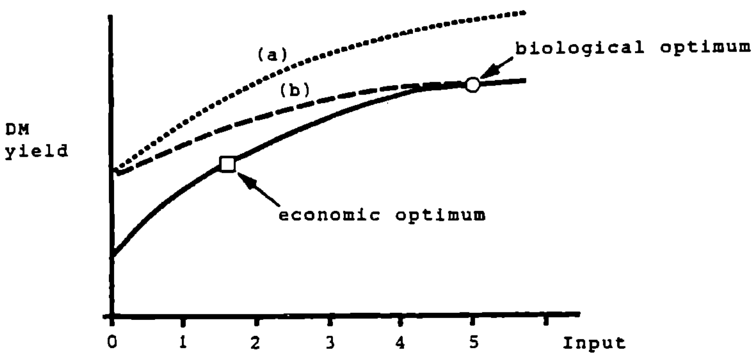
DM/ha at 300 m altitude in a favourable season, although this can drop to 4 t/ha in three years out of ten due to winter damage and low spring temperatures.

However, before further considering the levels of biological response found after improving hill pastures it is worthwhile to emphasise that the biological optimum may be well above the economic optimum which is ultimately chosen by the farmer (Fig. 2a). It is evident though that the information about the former is needed to allow the latter to be selected. Much interest also attaches to the slope of the response curves should it prove possible for new plant material to be introduced, which will increase the pasture production without additional inputs. The subsequent realisation of curve (a) rather than curve (b) would be a major success but the latter appears more likely.

It is also evident from Fig. 2b that response alone cannot be the sole criterion and that both the base line level and the cost of obtaining a given response are important. The DM yield of PRG/WC established on deep peat is almost four times greater than for the indigenous blanket bog while the same comparison for a brown earth soil produces a two-fold response but the yield of indigenous acid grassland is almost twice that of blanket bog. Moreover, it should be noted that because of the higher maintenance needs of pasture on the bog that the monetary costs of the inputs are much higher than on the brown earth.

There is a great deal of information on the responses in plant growth achieved after adding lime and nutrients to hill soils. However, much of it comes from experiments carried out in soil in pots in the glasshouse or in small plot field experiments which are sampled by cutting. It is extremely difficult and logistically very expensive to do meaningful experiments with

a) Principles of biological response curves



b) Observed responses to sward replacement on two hill soil types

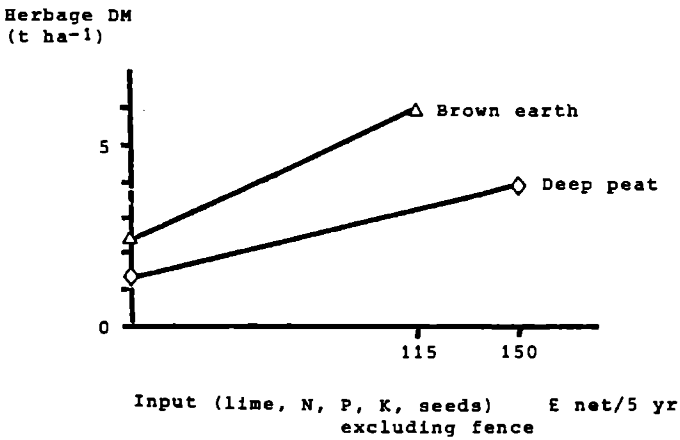


Fig. 2. Biological and economic responses. Principles and observation.

grazing animals which take account of the effects of utilisation and the recycling of nutrients. Since extra pasture of higher quality is only of value when assessed in animal production terms it is not easy to obtain meaningful figures to illustrate the responses to hill pasture improvement. Moreover, DM yield, even of the magnitude found by the Welsh workers, is no absolute guide to value; quality must be assessed too. Thus, the figures presented in this section are a guide only and the true test of pasture improvement lies in extra animal production and a satisfactory bank balance. Moreover, responses are unpredictable between seasons and can vary considerably from site to site.

The likely average responses in yield and DDM% of four of the main plant communities based on information obtained at HFRO and elsewhere are summarised in Table 6.

In the absence of data from whole-farm systems to be presented by Eadie (1979) the best guide, i.e. taking account of both yield and quality factors, to the levels of response to be expected from inputs of lime, phosphorus and seeds is obtained from carefully monitored small-scale grazing experiments of the type described by Floate _et al_ (1973) and Eadie _et al_ (1979). These authors studied three sward types - _Agrostis_-_Festuca_ on brown earth, pH 5.8; _Molinia_/_Nardus_ on peaty podsol, pH 4.0, and _Nardus_ on peaty podsol, pH 3.8, at about 300 m altitude on the Sourhope Research Station of HFRO. After enclosing, cutting and burning the indigenous vegetation the following five treatments were applied: grazing control: lime (6.3 t/ha): lime and phosphate (1.25 t slag/ha): lime, phosphate and white clover seed (1.4 kg S.100, 0.84 kg Kent Wild White/ha): lime, phosphate, white clover and grass seed (22 kg perennial ryegrass/ha plus 40 kg N/ha at time of sowing). Similar quantities of lime and phosphate were applied as maintenance dressings, where appropriate, after six years. The plots were grazed with wether sheep at three times in the year over a period of eight years except for the Nardus site where it was seven years. To equate the grazing pressure, i.e. dry matter per sheep per unit area, between treatments the stocking rate for each plot was judged by the observed quantity of herbage dry matter at the start and finish of each grazing period. Relative production is shown in Fig. 3 by the average annual number of grazing days.

Grazing control alone enhanced the number of grazing days in the acid grassland (Agrostis-Festuca) but had much less effect on Molinia- and Nardus-dominant swards. Lime and phosphate had little significant additional effect over grazing control in all three swards and it required the introduction of white clover and perennial ryegrass to achieve the best responses. The number of grazing days was always greater on the Agrostis-Festuca than on the Molinia and Nardus sites.

With the assumption that a sheep consumes 1.4 kg DM/ha/grazing day and that, under these experimental conditions, it utilises 70% of the herbage on offer, the average number of grazing days (3855) found for the best sward on the Agrostis-Festuca site converts to an annual herbage DM production of 7700 kg/ha. In some individual years of the experiment similar calculations indicate a dry matter yield of about 10,000 kg/ha; it is interesting to note that yields of this magnitude were achieved with nitrogen supplied by white clover and the soil and not the fertiliser bag, as in the work from Wales quoted earlier.

Responses to pasture improvement of this magnitude, particularly where account is taken of herbage quality or to those shown as likely in Table 6, would be sufficient to enable the

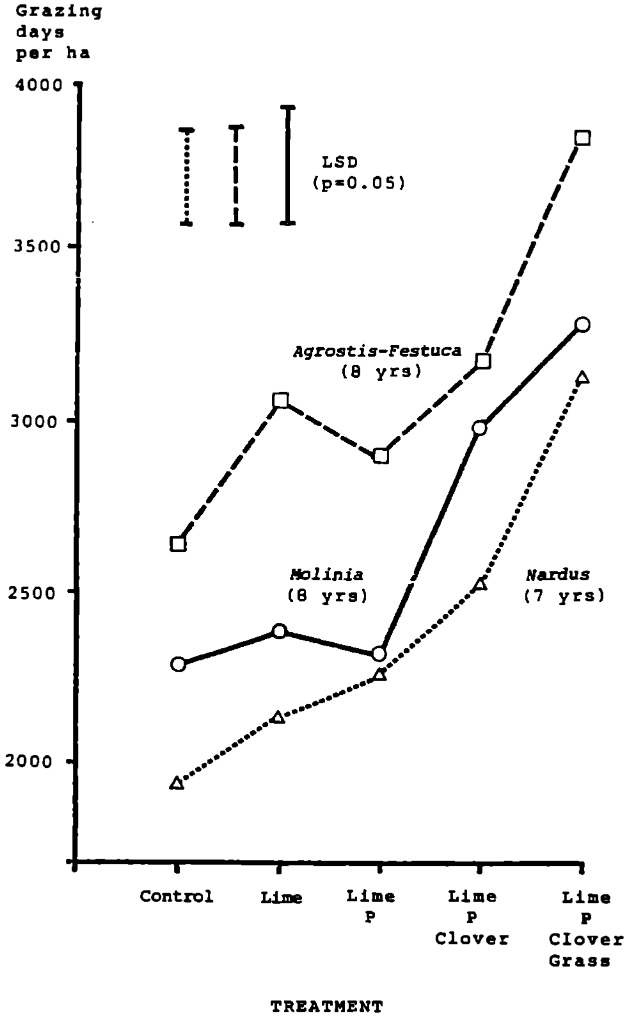


Fig. 3. Effects of sward treatment on the number of grazing days per hectare over three grazing periods per season supported by three contrasted hill vegetation types in southern Scotland (Eadie *et al*, 1979). Mean results for seven or eight years.

Table 6. Likely responses of four indigenous hill vegetation types to pasture improvement by moderate grazing control alone or to the establishment of sown pasture (PRG/Tim/WC) with good control of grazing. Estimated average annual levels of DM (kg/ha) and seasonal range of digestibility (DDM%)

Indigenous sward	No fence		+ fence		+ fence and sown pasture	
	Yield	DDM	Yield	DDM	Yield	DDM
Acid grassland (sp. poor)	2500	76-40	2800	76-50	6000	78-66
Dry shrub heath (Calluna)	2000	60-40	2000	60-50	5000	78-66
Wet grass heath	1500	70-35	1600	72-55	4500	78-66
Bog	1400	68-40	1400	68-40	4000	78-66

(after Newbould 1976)

successful operation of the new strategies of grazing to be described by Eadie (1979). Apart from finance and motivation, a critical requirement is access to sufficient suitable land so that lime and fertilisers can be spread, cultivations can be carried out if required, and equipment to sow seeds can be operated. Therefore there would appear to be no insurmountable biological constraints to the development of more economically viable farm systems in the hills. However, precise information is lacking on the amount of readily accessible and suitably situated improvable land in the hill areas of the United Kingdom. Each existing farm unit, or potential farm unit, has to be examined individually to determine the areas most appropriate for enclosure, for pasture improvement and for stock. It has been estimated (SADC, 1973) that there may be up to 1 M ha of acid grassland, i.e. brown earth soil, in Scotland alone but there is little information on where this lies in relation to individual farms or areas of not so easily improvable rough grazings, etc. More detailed surveys of hill soils and vegetation and of agricultural capability are now in progress by MAFF and DAFS although they may not produce information relevant to this particular question.

Potential

Potential pasture production is that which exists in possibility but not yet in reality. In the broad sense the observed responses described above are potential since at the moment they are only achieved on research stations and on a small number of commercial farms. A further more esoteric level of potential production lies above the best already achieved, that is when all the known temporary limitations are removed. Thus it is instructive to calculate the levels of dry matter pasture production which could be achieved on a hill soil when each of the main limiting factors is considered in isolation, i.e. the other factors are regarded as non-limiting. Radiation, temperature, water and soil nitrogen level have been examined in this way for a perennial ryegrass/white clover sward on a brown earth soil at 200 m altitude near Edinburgh (Fig. 4). This is a very simple type of modelling of which there are some very elegant and precise examples (Monteith, 1965; De Witt, 1971). Alcock (1975) also calculated potential pasture production from the hills on a number of contrasted bases more precisely than attempted here.

For radiation, using levels actually measured in the summer of 1975, it was assumed that there were no temperature, water or soil nutrient limitations, that a LAI (leaf area index) of 4-5 was maintained, i.e. sufficient to intercept all the light, that 4000 cals are needed per g DM, that the mean utilisation of light energy was 2.5%, that 1 watt hour m^{-2} is equivalent to 85 cal m^{-2}, and that the plants had a shoot/root ratio of 2:1. The total amount of dry matter calculated to be produced from April to September (183 days) was 19 t ha^{-1} or 12.6 t ha^{-1} of shoots.

For temperature, it was assumed that although the threshold for grass growth was $6^{o}C$ and for clover $8^{o}C$ a median of $7^{o}C$ should be taken which was exceeded on each of the 183 days. In the absence of water, radiation or soil nutrient limitations, and with an average net daily shoot growth rate of 4 g m^{-2}, the annual net growth of shoots would be about 7.0 t ha^{-1}. However, as already described for acid grassland swards, some growth can occur when temperature and light conditions are suitable both earlier and later in the year than April to September, so that higher yields than this estimate can be expected in practice although there is great variation between seasons.

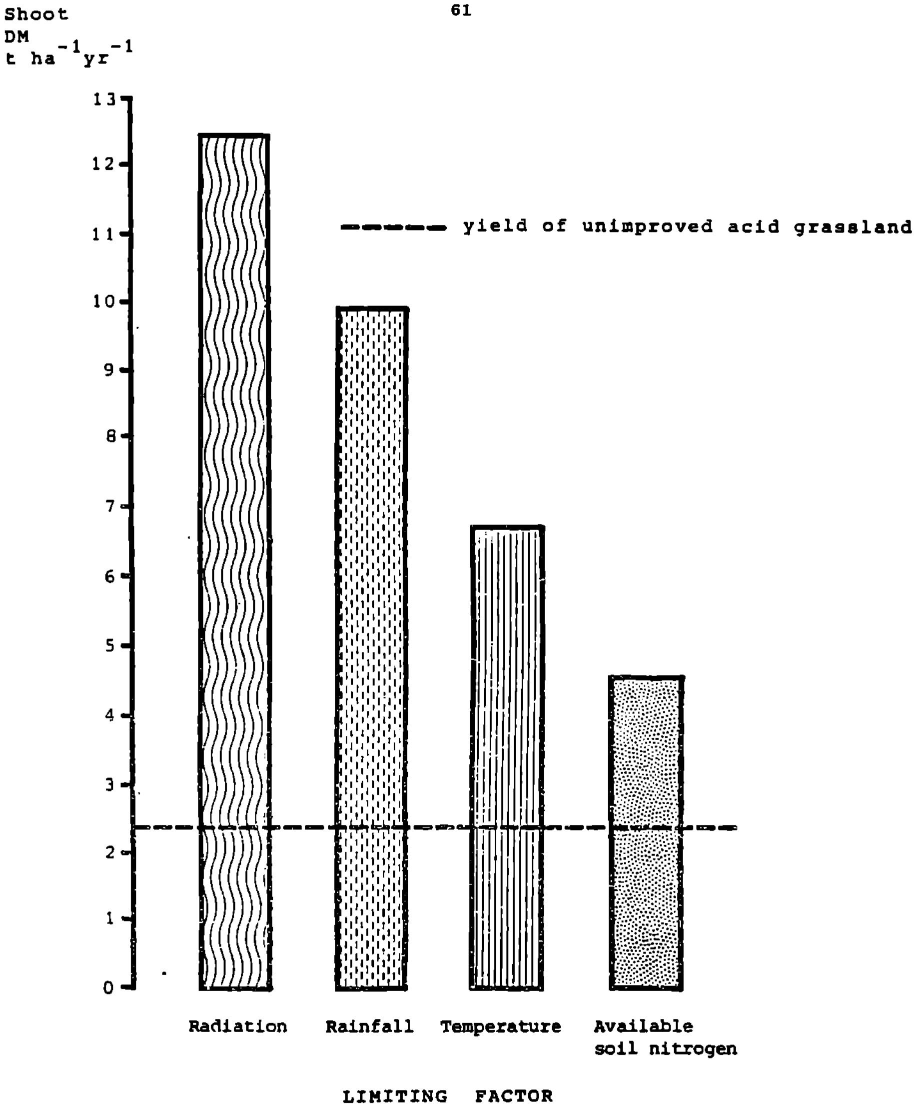


Fig. 4. Estimated potential herbage production (t DM ha^{-1}yr^{-1}) by a ryegrass/white clover sward on a brown earth soil at 200 m altitude at Bush Estate, Edinburgh, with existing average levels of radiation, rainfall, temperature and available soil nitrogen taken in turn as limiting

For rainfall, with no other limitations and the assumptions that 500 g H_2O is needed per g of herbage DM, that 50% of water falling as rain is lost by leaching and evaporation and with an annual rainfall of 1000 mm, the annual yield of herbage DM would be 10 t ha^{-1}.

With no climatic limitations on plant growth, the estimate of potential production determined by the quantity of available nitrogen was based on 60 kg N mineralised and 90 kg N ha^{-1} fixed and transferred by white clover each year (Munro and Davies, 1974). Higher amounts of nitrogen fixed by white clover have been recorded (Haystead and Lowe, 1977) but comparable information on the mineralisation of soil nitrogen is not available. With an average nitrogen content in the herbage of 3.2% the potential yield of dry matter would be about 4.7 t ha^{-1}.

The results of these calculations, though approximate, emphasise the key role of soil nitrogen as a limiting factor in hill pasture production. If there were no financial constraints on the use of fertiliser nitrogen it is seen that much higher yields than those usually observed, i.e. at least up to the limit set by temperature in the east of Scotland, could be achieved.

It is considerations of this type, in addition to the high quality of white clover herbage for animal nutrition, that has led to the increasing efforts of research workers to optimise the establishment, growth and symbiotic nitrogen fixation by this plant. Unfortunately, white clover is more sensitive to low temperatures than grass and its early spring growth in the hills is poor. Thus it is hoped that the efforts of the plant physiologists and breeders to find new cultivars of white clover or other legumes able to tolerate the environment of the hills of the UK will succeed (Breese, 1976; Ollerenshaw _et al_, 1976).

In addition, new grasses are required which can fully utilise the transferred clover nitrogen and also with lower temperature thresholds or the ability to resist frost (Munro, 1976).

It is encouraging to note that, should cheap sources of nitrogen fertiliser ever become available again or the national priorities demand food at any price, there are still possibilities to increase pasture production in the hills. In the uplands, even at present price levels of fertiliser nitrogen it is presently economical to extend the growing season for pasture with fertiliser nitrogen both in spring and in autumn so giving the grazing manager more flexibility. A long-term solution to the overriding nitrogen deficiency of hill soils would be to find means to increase mineralisation of a portion of the large amounts of organic matter, possibly by introduction of micro-organisms adapted to the low temperatures and high acidity of hill soils.

To summarise the responses, both observed and potential, it appears that a realisable target for hill farmers with well-managed sown grasses and white clover on brown earth soils should be between 5 and 10 tonne DM ha^{-1} yr^{-1}, with proportionately lesser amounts for the other soil types, as indicated in Table 6. It is of interest to compare this target with that set by Cooper (1970) for lowland grassland farmers using nitrogen fertiliser of 20 t ha^{-1} yr^{-1} and to appreciate that the best farmers have already reached 15 t ha^{-1} yr^{-1} (Cooke, 1979). If traditional hill farmers could approach their targets as closely as this on even a small portion, say 5-10%, of the previously unimproved areas of their total land, production of weaned lamb (kg ha^{-1}) could be more than doubled (Cunningham, 1979; Eadie, 1979). Thus, the potential for the application of the principles of pasture improvement to hill and upland agriculture is enormous.

ECOLOGICAL CONSEQUENCES OF INCREASED PRODUCTION AND UTILISATION OF HILL PASTURES

Arguments are advanced that the hills and uplands are already overgrazed and that the sheep is responsible for much of this (Darling, 1955; McVean and Ratcliffe, 1962). This criticism, which may rest on different interpretations of the word 'overgrazed', is often applied to the west coast of Scotland with the implication that grazing by sheep has alone brought about the present environment of deep peat and blanket bog vegetation. In truth, the former woodland cover, which possibly reached up to 1300 m in altitude and consisted of birch, pine and hazel with oak and alder on better low-lying ground, began to decline before man's intervention, possibly due to a change in the climate from cool but dry to cool and wet. Simultaneously peat, bog and heath started to develop. This process was accelerated as primitive man practised a shifting agriculture with burning and felling of trees on the drier slopes of the hills and then with increasing use of timber for charcoal, ship building, general construction and iron ore smelting and the extension of agriculture to the higher hills. Sheep were only introduced in large numbers some 200 years ago. There is no clear indication whether the influence of climate or man was the greater in bringing about the vegetation we see today. It is also extremely doubtful, at least with the heather moors on freely drained acid soils, that a tree cover would redevelop should present management practices for game and sheep be stopped.

With the acquisition of knowledge and an ever-increasing understanding of relationships amongst soil, pasture and grazing animals (HFRO 1979c) it is evident that any deleterious effects which occur are due to the grazing management (or lack of it) imposed by man and not to the sheep itself. As explained earlier (p.43) and in the following paper, overall levels of utilisation of existing hill pastures are very low although the best of the existing plant communities may experience much higher grazing pressures. Early work by Hunter (1962) indicated that sheep are selective grazers in that they can distinguish between acid grassland on brown earth soils, which they graze heavily, and heather moors or blanket bog on peaty podsols or deep peat soils which they use only lightly. The consequence of uncontrolled grazing in pastures of very varied community types is to decrease the total nutritional value of the pasture since the grasses selected against come to dominate the sward in markedly underutilised forms and the number of sheep are reduced to those that the preferred communities can carry for a year. Thus, at the times of maximum grass growth more grass is produced than can be grazed and even the better areas become underutilised and decline in quality.

A further consequence is that the unpreferred species such as Molinia, Nardus, bracken, gorse and heather become taller and and more dominant and unpenetrable so that they have to be reduced periodically by burning. It is uncontrolled burning of vegetation on deep peat soil or mismanagement of heather burning that is thought to be a major cause of the areas denuded of vegetation, which may then become susceptible to erosion. A major bonus of improved hill sheep systems is the provision of fences both to keep stock on improved pastures, so concentrating return of excreta, and to keep them off unimproved areas. Thus, the season and intensity of use of the latter can be better controlled to reduce the growth of tall woody plants and to lessen the need for burning.

Other important trends follow from the use of traditional grazing systems in that the flow of the principal nutrients (N and P) from soil to plant to animal and back to soil again - the so-called nutrient cycle - is slowed down. Visual examples of this phenomena can be seen at fence lines on hillsides of a common soil group (Nicholson, 1968; Floate and Nicholson, unpublished). The difference in vegetation on the two sides of the fence between a Calluna-dominant and a grass heath are often striking and reflect only small differences in grazing pressure. Examination of the soils indicates a better structure and more available plant nutrients on the grass heath side with the higher grazing pressure (Table 7). Neither grazing pressure would be regarded as high by modern 'two-pasture systems' standards. The inference that grazing enhances the return of available nutrients to the soil, so benefiting subsequent grass growth, has been authenticated by Floate (1970, 1977). Thus, contrary to much folk-lore, enhanced but controlled grazing benefits soils and pasture, and eventually animal production.

A further popular belief is that the selling of lambs, cast ewes and wool from hill sheep farms denudes the soils of nutrients. Data collected by the Muirburn Committee for Scotland (DAFS, 1977), see Table 8, indicate that even with production at much higher rates than so far achieved in the best of the two-pasture exercises and much above that found in traditional systems, rainfall brings in much more of the main nutrients than are sold off the farm, with the possible exception of phosphate. The losses due to burning once every ten years are shown for comparison. Admittedly, all of the nutrients in rainfall may not be retained in the soil depending on the time of year it falls, but the balance for traditional and for slightly improved systems is still likely to be positive. Further data are needed to quantify the losses

Table 7. Some characteristics of soils on the lightly (L) and heavily (H) grazed sides of fences. Means for five moorland sites.

Horizon	pH L	pH H	C (kg/m²) L	C (kg/m²) H	C/N ratio L	C/N ratio H	Total-P L	Total-P H
Ao	3.6	4.3	26.4	14.5	27.1	19.6	52	61
ABC	4.4	4.5	8.0	11.3	18.5	16.5	158	205
TOTAL*	4.1	4.4	34.4	25.8	24.0	18.0	210	266

* weighted to allow for the varying thickness of horizons within the profile.

(Floate and Nicholson, 1979)

Table 8. Inputs of four nutrients in rain and removal by burning of heather or sale of sheep under three intensities of use (kg/ha/yr).

		N	P	Ca	K
Input	Rainfall	9-15	0.2-0.5	6-8	4-13
Removal	Burning (1/10 yrs)	4-6	0.3-0.6	0.3-0.4	0.5-0.8
"	Sale of sheep SR 1.5-2.0 ha/sheep <70% lambing L wt sold 10 kg/ha	0.3	0.05	0.09	0.016
"	SR 0.5-1.0 ha/sheep 70% lambing L wt sold 40 kg/ha	1.2	0.20	0.36	0.064
"	SR 0.5-1.0 ha/sheep 100% lambing L wt sold 80 kg/ha	2.4	0.40	0.72	0.120

(DAFS, 1978).

Table 9. Nutrient turnover, removal and input (kg/ha) each year in traditional and improved hill sheep farming systems.

	Traditional	Improved	% increase after improvements
Nutrient turnover in soil compartment			
N	30.3	48.7	61
P	2.3	4.3	87
K	18.5	32.1	74
Nutrients removed in animal products (Lamb, ewe meat, wool)			
N	1.3	2.4	85
P	0.2	0.4	100
K	0.1	0.1	-
Nutrient input by dry and wet deposition			
N	10.0		
P	0.4		
K	4.0		

(Newbould and Floate, 1978)

of nutrients from fully improved hill pastures but the differences between input and output, especially where maintenance dressings of fertilisers are applied to improved pastures should again be positive.

Calculations for whole-farm ecosystems made recently on the basis of all available information (Newbould and Floate, 1978) also suggest that the one element which may not be in balance is phosphate (Table 9). However, as already described (p. 8) hill soils are very high in total phosphate held in organic forms and it is likely that increased grazing pressures will enlarge the pool of available phosphorus. Some reduction in organic matter, which will be needed to achieve this, may assist to alleviate some of the other problems of hill soils (Floate, 1977; Newbould and Floate, 1979). It is of interest that the thickness of the litter layer has been observed to decline with an increase in grazing pressure (Floate _et al_, 1973).

These points all combine to indicate that the consequence of the controlled, but more intensive grazing of indigenous hill pastures will generally be favourable. Sensitive vegetation types like blanket bog may need to be treated with greater care than more robust types, e.g. grass heath and acid grassland. However, experiments in progress at Lephinmore (Grant, 1979) suggest that stocking rates of up to 1 sheep/ha, i.e. 50% higher than those achieved so far with the improved systems on deep peat, will not cause significant changes in the botanical composition and productivity of these swards. A first indication of change with higher stocking rates is the decline of heather. However, if this slow disappearance of heather was repeated on drier sites it would turn out to be advantageous in the long run, provided the heather was replaced by more nutritious grassy species. In addition, the need to burn would be reduced.

Similar considerations to those described above apply with equal force to the small areas of hillside which are sown with lowland grasses and white clover, but with the added requirement that maintenance dressings of lime and phosphate are required at periodic intervals depending on the rainfall and soil type. A combination of nutrient input in fertilisers, high rates of pasture utilisation and enhanced nutrient cycling brought about by the enclosure and controlled use of these pastures helps to maintain the high level of fertility needed particularly for perennial ryegrass to survive and grow well.

CONCLUSIONS

1. Pasture production is limited in the hills and uplands by climate, topography, existing soil and plant characteristics and traditional levels of utilisation. Nonetheless, there is a large fund of pasture, albeit of poor to moderate quality by lowland standards, which is available and can only be utilised by grazing animals.
2. The present low levels of utilisation can be raised for most hill pastures with advantages to both soil and pasture, and with considerable long-term benefits to animal production.
3. The key limiting soil characteristics of acidity and low available nitrogen and phosphate can be ameliorated so that pastures with better quality herbage and with more extended seasons of growth than indigenous vegetation can be grown.
4. Climate cannot be altered but the sensible choice of the more sheltered, less waterlogged, accessible areas for pasture improvement schemes and of appropriate species for sowing, enable the production of high quality herbage to be markedly increased.

5. Significant increases in the quality, quantity and seasonal distribution of pasture produced from many hill soils are possible with existing technology. Moreoever, the potential exists for even bigger responses within the limitations set by climate, provided new plant material with greater tolerance of low temperature and with enhanced nitrogen fixing ability, cheap nitrogen fertiliser or alternative means to increase the release of nitrogen from soil organic matter, become available.

6. The introduction of more intensive systems of hill sheep production dependent on the use of improved pastures will not necessarily cause an increase in erosion, a dramatic change in the composition of hill vegetations or a loss of nutrients from the hills; on the contrary, the ecological stability of the pastures and the fertility of the soils will increase with time.

7. Increased utilisation of the large areas of rough hill pastures which follows the strategic incorporation into grazing systems of smaller areas of high quality pasture improved to the extent of observed responses, benefits both types of pasture, enhances the long-term fertility of the underlying soils, increases the output of meat and wool, makes hill and upland farming more economically viable and enables the nation to use a national resource more effectively.

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MAKING THE MOST OF BRITAIN'S UPLAND FORESTS

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Contents

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INTRODUCTION

Uplands It is a useful simplification to define the British Uplands as those extensive areas, substantially over 200m, where resident populations are sparse and land-use extensive rather than intensive. By this definition Scotland and Wales are almost entirely upland with the Central Scottish Lowlands and the Vale of Glamorgan the only significant exceptions. In England it is reasonable to include the upland areas associated with the Cumbrian Mountains, the North Yorkshire Moors and the Pennines as far south as the Mersey-Humber line and, in the south-west, the high moors of Devon and Cornwall.

Forest Design As considerable use will be made of this term it is worth explaining that 'forest design' is used here to mean a plan for generating or regenerating an area of woodland. Forest designs are usually presented as plans on a map of suitable scale and may be elaborated by elevations, sketches or models. Forest designs, like architect's drawings, describe and finalise intentions and then serve as a pattern for construction. The forester, like the architect, must reconcile conflicting needs in a solution which is both efficient and pleasing. Unfortunately he also shares with the architect the dubious privilege of having his errors preserved for many years for all to see.

Of course there is nothing new about carefully designed tree planting as many magnificent old estates bear witness, but the establishment or replacement of very large upland plantations primarily as sources of wood for industry is a modern practice requiring new ideas and original techniques of silviculture. There are already 1½ million hectares of forest in upland Britain, covering about 12 per cent of the total upland area, and, as will be mentioned later, this proportion is likely to increase.

THE UPLAND FORESTS

Species Britain still owes much to those landowners who introduced new forest trees, mainly during the last century and especially from North-west America. Sitka spruce (*Picea sitchensis*) is the staple of upland commercial forestry, forming about half of existing plantations and about three quarters of the stock used for new planting and regeneration. It is robust, productive and versatile in upland conditions and though it will be wise of foresters not to become over-dependent on it, there is little doubt that it will remain the major species.

Lodgepole pine (*Pinus contorta*), also from the Pacific coast of North America, has become important in recent years. Lodgepole pine from certain Canadian and Alaskan stands has a remarkable ability to grow well on the anaerobic and infertile deep peats of northern Scotland or, in the case of the pine from Alaska, to withstand severe exposure on the western uplands of Britain. The future of Lodgepole pine is not so assured as that of Sitka spruce. The pine is less productive and more susceptible to insect attacks, even so it remains for the present a valuable tool for forestry in the most difficult of upland conditions.

Douglas fir (Pseudotsuga menziesii) is another Pacific coast conifer of importance here. Although less able to thrive on peatlands or in exposure it is very successful in the valleys of the eastern and central uplands, and is increasingly being planted.

The Larches (Larix spp) are particularly valuable in forest design. Their spring and autumn colours are an attractive contrast to the permanent green of the other conifers. The 'Dunkeld' Hybrid Larch, (so called because it first occurred there) between European and Japanese larches is usually preferred if obtainable because of its fast growth and high resistance to fungal disease. Larch appears frequently in strips, especially on the edges of the older forests in the uplands where it was planted as a fire belt. Where it grows well it has the ability to suppress heather and bracken and so retard the spread of ground fires.

Scots pine (Pinus sylvestris), the only native conifer of commercial importance, is rather slow in growth and sensitive to exposure in comparison to the major exotics but is being improved by tree-breeding and holds a modest place, as do Corsican pine (Pinus nigra) (in the southern uplands only), Norway spruce (Picea abies), and some of the Silver firs (Abies spp).

It is probable that the relative importance of these species in commercial forestry will change in time but the main feature, the dominance of north American evergreen conifers, is likely to be permanent. No other range of species can match them for wood production in the British uplands.

Structure Upland silviculture is largely that of the even-aged stand. Although British forestry practice derives from that of Europe, and despite experiments and trials with two-storied and various irregular systems, the clear-fell- replant system which is a natural sequel to afforestation, remains the most practical in the British uplands. Areas of uniform plantation are cheaper to establish, tend, harvest and market than more complex stands. This circumstance is unlikely to change and, as far as commercial forestry is concerned, the pressure will be for larger uniform areas so as to reduce costs. It may well be however that we shall not see much increase in the scale of uniformity. The economies of scale fall away for many forest operations before areas get very large and, on the other hand, the terrains and soils of many upland sites are very variable. The days of the small 25 acre compartment in upland forests have gone and modern forests are based on compartments of 25 hectares or larger, but the size of the individually treated stand is likely to increase only in those areas, like the Scottish/English Borders, where site conditions themselves tend to uniformity over sizeable areas.

Special forest structures are always possible in British upland conditions. The University of Edinburgh has been operating a number of Forestry Commission woods by irregular systems quite successfully for many years, and regenerating one stand beneath another is occasionally practised. In areas of outstanding scenery, for example in the Tay Valley near Dunkeld, the Forestry Commission has maintained woods of mixed age and mixed coniferous and broad-leaved species by careful group fellings and regeneration. These systems are admirable but they are expensive ways of producing wood and there needs, therefore, to be a local justification for them.

<u>More than Wood from the Trees</u> The last 15 years has brought increasing demands on upland forests for recreation facilities, conservation of wildlife and the improvement of valued landscapes or, at least, care to avoid spoiling them. Upland forests, formerly laid out purely for timber production, have now to be designed with additional requirements in mind.

Dame Sylvia Crowe was appointed landscape consultant to the Forestry Commission in 1963. Emphasis on landscaping in afforestation has steadily increased since that time, accentuated by the designation of some upland areas as of outstanding natural beauty. The Forestry Commission now has a specialised Branch for landscape design and a developed methodology for economic comparison of designs. The sight of older plantations with sharp boundaries in hard contrast to the lines of the natural landscape gives a bad impression but the new generation of upland plantations will be more effectively blended into their surroundings as advocated in Dame Sylvia's booklet "The Landscape of Forests and Woods" (Forestry Commission Booklet No 44, pub 1979). Mr C R V Tandy, OBE, present landscape consultant to the Forestry Commission, will describe objectives, progress and techniques in landscaping upland forests in his paper prepared for this meeting of the British Association.

Rapid progress has also been made in providing recreational facilities in upland forests. The general rate of development is illustrated by the extent of facilities in Forestry Commission forests in 1978 which included, for example, 119 forest cabins and cottages for holiday use, 570 picnic places, 429 forest walks and 142 nature trails. Many of these developments, and those in private forests, have been in the lowlands and near urban areas, but the potential demand for recreational facilities in upland forests is clearly very great. Mr Donn Small, Deputy Surveyor of the New Forest, has organised the recreation facilities in that area for many years and is well known for his success in that most exacting role. The developments in areas like the New Forest are indicative of future developments in less populated areas and Mr Small's forecasts and advice will be especially relevant.

Progress is more difficult to measure in the modification of upland forests to conserve wildlife. The subject is complex and it is often not clear what local objectives ought to be There is much discussion of principles with which most people, commercial foresters included, would agree, but realistic objectives, quantitative advice, and criteria for success are often lacking. Two organisations, the Nature Conservancy Council and the Institute of Terrestrial Ecology, are working to make good these deficiencies. The NCC have recently made a special study of wildlife conservation in forests and the ITE have done research on the effects of forestry on the previous ground florae and our predatory and other birds.

One broad fact has emerged from these studies and has influenced the recommendations in the latter part of this paper, namely that while coniferous plantations are, on balance, beneficial in increasing and protecting a wider diversity of wild plant and animal life, any areas which carry broadleaved woodland, particularly permanent and preferably irregular, will increase the potential diversity of wildlife yet again.

We shall be fortunate at this meeting to hear two authorities on the subject, each with direct and up-to-date knowledge of practical forestry as well as experience in wildlife conservation. Dr Jean Balfour, Chairman of the Countryside Commission for Scotland and member of the Nature Conservancy Council, and Dr Richard Steele, Chief of Scientific Services of the Institute of Terrestrial Ecology have prepared related papers on the strategies and methods of conservation in upland forestry and, in particular, on what further knowledge is needed.

One wildlife problem - that of managing deer within forests - separates itself by urgency and importance from all others. The problem is most acute in the Scottish Highlands and in South West Scotland because of the heavy populations of red deer. Joint research by the Forestry Commission, the Red Deer Commission, the Institute of Terrestrial Ecology and the Nature Conservancy Council will show how deer may best be managed in forests. In the meantime, red deer damage is a pressing and costly problem and any features in forest design to assist will be welcome to foresters.

What are hill farmers to get from upland forests? The subject, often explored, has not so far led to many modifications of farming or forestry practice for mutual advantage. Sensible procedures in freeing ground for tree-planting without serious damage to local agriculture have been built up; there have been some experiments in mixing hill farming and forestry, and there is no doubt a good deal of local and mutual help and collaboration. From the point of view of forest design however, there have been few advances in designing the forest/farm interface to mutual advantage yet there would seem to be possibilities. The design and use of peripheral areas for the seasonal occupation by grazing animals and the re-seeding of rough ground beside plantations as a precaution against fire are ideas which seem to have got stuck to the drawing board. The matter is very much a joint one and will not be pursued unilaterally here, but, in considering how to get the most from upland forests the hill farmer is nearest and most directly affected. With this in mind, joint Forestry/Agriculture Session which concludes this Forestry Programme will be valuable to those considering the future of upland forestry and forest design.

Limiting Factors The development of British upland forestry during the last 50 years has been a fine achievement in silviculture. It has been a cause rather than an occupation for numerous foresters and forest research officers for many years. Repeated testing of combinations of tree species, provenances, methods of draining and cultivating ground for planting, and fertilizing and protecting plantations have led to productive planting on the poorest of upland peatlands and into severe exposure at up to 300m in the north-western uplands and 600m in more central and eastern areas. There are prospects for further improvement both in the sites which can successfully be planted and the rate of wood production per unit of area, especially by tree breeding and plantation fertilizing. This first phase of extensive upland forestry has, however, shown where some fairly solid limits might lie. Wind has proved the most effective limiting factor in silvicultural practice in the British uplands. Exposure to wind sets altitudinal limits to worth-while afforestation and, on some sites, fells immature plantations. Losses by windthrow are not simply due to the windiness of the site; they are influenced by soil type, by the method of cultivating ground for planting, by tree species and by the thinning treatment applied to the stand. There is no doubt that windthrow can be much reduced by silvicultural techniques but there is equally no doubt of its importance in the future design and management of upland plantations.

DESIGNS FOR THE FUTURE

In considering future forest designs it is appropriate to ask:

1. What demands are likely to be made of upland forests in future?
2. How might forests best be designed to meet them?

These are opportune questions. After 60 years of research and practice in upland forestry its potential and limitations are taking shape. The older upland forests are being replanted after felling or, in some cases windthrow, so designs are needed for the second rotations, and there are calls for the substantial expansion of upland forestry.

The Demands Britain's import bill for wood products is now £2,400 million. Wood supplies are expected to diminish and prices rise during the next 20 years. "The Wood Production Outlook in Britain by 2020" prepared by the Forestry Commission and "Forest Strategy for the United Kingdom" prepared by the Centre for Agricultural Strategy set out in detail the need for increased wood production in Britain. The important points for us are:

1. The likelihood of substantial expansion of upland forestry and the consequent importance of forest design to people who live, or derive a living in the uplands, or who have a real interest there and,
2. the importance of maintaining maximum wood production while meeting other demands on the forests.

Woods for a Purpose The requirements for economic wood production are in such direct conflict with those for most other objectives that it will seldom be possible to reconcile them in an individual stand. Economic wood production requires, as we have seen, the extensive use of fast growing exotic conifers in uniform and dense plantations which for efficient management, should be as simple as possible in both species composition and stand structure. Landscaping, conservation and recreation requirements are usually best served by predominantly broadleaved stands with preference for mixtures of species and irregular structures, often including a proportion of treeless ground. The requirements differ in this respect also, that while block clearfelling and replanting are generally the most cost-effective means of regenerating plantations for timber production, the needs of wildlife conservation and control, landscaping and recreation are usually better served by more gradual and less disruptive methods of regeneration. It will therefore be best in most forests to distinguish areas for intensive wood production from those for other purposes and to manage these areas differently. It is convenient to call the one 'commercial plantation' and the other 'amenity woodland' but it is an important and clearly desirable principle that <u>the amenity woodlands should be managed for the maximum yield of wood compatible with their other uses</u>.

It has been suggested that entire forests might be 'specialised' for particular purposes, but this is less desirable than setting aside areas for amenity woodland within larger forests. The amenity woodlands can be designed to landscape the commercial plantations and make them much the more acceptable in scenic areas; the amenity woods can be used, as will be seen, to partition the commercial plantations for management and fire protection and they will provide reservoirs for wildlife and opportunities for controlling these animals, especially deer, which are potentially damaging. There may be cases where large areas of forest can justifiably be managed for purposes other than producing wood but the general case is more likely to be that of the productive forest enhanced by minimal areas of amenity woodland, with that woodland as productive as possible.

I know of no way of <u>calculating</u> the area of land in a forest which ought to serve purposes in addition to the economic production of wood, and no alternative to some trial and error in arriving at an optimum overall design. One can however suggest criteria for comparing alternative designs for a given area, for example, that the best design is that which meets the special demands either with the minimum sacrifice in overall mean annual increment of wood or with the maximum estimated net discounted revenue.

A thorough knowledge of the ground is an obvious pre-requisite for any design. Thereafter it will usually be best to select the amenity woodland areas, leaving the balance of ground for commercial planting, because the woodland areas will be relatively small and associated with discernible landscape features.

Selection of Amenity Woodland Areas Watercourses transecting the planting area are the key to internal design in upland forests. Where watercourses are lacking the forester may have to accept dry gulleys or, in gentle topographies, slight valleys but it is convenient to include all these features under the term watercourses. Preference should be given to true watercourses though, when these are present, as in the majority of cases.

Selected watercourses are potentially valuable for landscaping because they accord with the land form. They are usually well placed, or can be selected, as locations for internal fire belts and they usually offer the most favourable potential wildlife habitats and thus the best prospects for wildlife conservation and control. The aquatic life of streams is also best conserved by keeping dense coniferous plantations back from the water's edge. If recreation is to be the dominant function of woodland areas then, again, the watercourses are often the most suitable lines for future forest walks or sites for camping.

By developing amenity woodlands along selected watercourses the commercial plantations can be partitioned for management and fire protection. If the amenity woodlands can be kept standing while the commercial plantations are being re-established after felling, the fire protection value will be considerable.

It will generally be best to select a minimum of watercourses for development into amenity woodlands and to concentrate on making a success of these, allowing the remainder to be included and ultimately masked in the commercial plantations. The number, location, size and shape of areas set aside for planting as amenity woodland will usually best be determined by the needs of landscaping and internal division for fire protection. These woods will divide, or partly divide the commercial plantations into 'cells' which can, if necessary, be sub-divided into compartments for forest management.

The species composition of amenity woods will be determined by site factors, including the risk of damage by red deer, by the needs of landscaping, which will usually require broadleaved species or larch, and the objective of maximum wood production. Though none of these measures is directly aimed at conserving wildlife, the establishment of such woodlands, particularly if varied in species and ages of tree, will generally widen the range of wildlife species in the forest.

These 'watercourse sites' tend to be the most fertile and sheltered and the most suitable for demanding species in the long term, but they present difficulties in the initial establishment of trees. Because they are fertile they are also areas of vigorous ground vegetation, necessitating the use of large planting stock and considerable weeding. These sites are also inclined to collect cold air draining from the slopes and thus be subject to unseasonable frosts, again requiring the use of large plants. Once cover becomes general, watercourses become popular with deer and, where red deer are involved, the choice of species is very much restricted. Once broadleaved woods have been established it is not so difficult to perpetuate them, especially if the tree species can be regenerated by coppicing, but initial establishment is seldom easy and plantings may need intensive tending for some years.

The Choice of Species In choosing species to form amenity woods it is best to consider separately those cases where red deer will, sooner or later, gain access. In cases where there is no such risk, species can be selected:

1. to meet landscape requirements and assist in wildlife conservation and,
2. for maximum volume or value of wood production.

A possible alternative basis for selection is to conserve the selected species, or selected material within it, that is, to use amenity woods as gene pools. This last is a special case which will not be considered further here.

The requirements of landscaping and wildlife conservation will usually require the use of broadleaves and the more common species are listed as an appendix to this paper along with their important characteristics.

It is worth drawing attention to some particularly useful broadleaves. Birch, for example, is an attractive and productive species, which can be established on a wide range of sites including, with drainage and fertilizing, deep acid peats. It will not thrive on very exposed sites but will respond to shelter, for example in low lying sites surrounded by commercial plantations, and it will withstand animal damage better than most broadleaves. It does not transplant readily but high survivals are possible with care, and birch can easily be raised in containers. It can be regenerated by coppicing and will, on many sites, regenerate itself by seeding given reasonable protection from grazing. Birch wood can be used for pulping and, though it is of no use for external woodwork, is readily accepted for indoor uses, plywood manufacture and fuel wood. Birch is quite capable of producing six cubic metres of wood per annum even on indifferent sites, and it responds well as a species to breeding as current research at the University of Aberdeen is showing. Although there are no great differences between the performance of the two common species, the Silver birch, Betula pendula has been more tested in modern experiments and can be more positively recommended.

Alders are obviously of interest in watercourse planting. Common alder, (Alnus glutinosa) is site tolerant, reasonably resistant to animal damage and readily regenerated by coppicing. Red alder, (Alnus rubra) is potentially much faster growing but is more susceptible to exposure and frost and is not able to sustain fast growth without access to fertile mineral soils.

On moderately fertile and rootable soils Sycamore (Acer pseudoplatanus) will grow quickly and is remarkably resistant to exposure. On the other hand it is easily suppressed by weeds when young and not resistant to damage by animals.

On sites both reasonably sheltered and fertile English Oak (Quercus pedunculata) and Common lime (Tilia vulgaris) are worth consideration as producers of valuable timbers with oak being particularly valuable for wildlife conservation. Wild Cherry or Gean (Prunus avium), Norway maple (Acer platanoides) and White beam (Sorbus aria) are all noted for their foliage colour and all, though slow growing, will produce valuable timber.

The choice is very wide and there are few sites where, with reasonable selection and care, broadleaved stands cannot be established.

In forests in red deer country the choice of broadleaved trees is best restricted to those species which are either unpopular with red deer, or can be used purposely to attract them into deer pastures for population assessments and to facilitate shooting. There is a good deal yet to be learned about the location and design of red deer pastures within forests but in the meantime pastures can usefully be created in the amenity woodland areas of the 'watercourse' sites.

For amenity woodland planting which is to survive red deer damage one can recommend Birch and Common alder on the poorer sites, Common lime, Beech and Hornbeam under more favourable circumstances. General experience, and observations made by the Institute of Terrestrial Ecology at Banchory, show these species to be less attractive than other common broadleaves, and they will survive in the presence of red deer provided more attractive species are present. It seems well worth designing amenity woodlands with these more attractive species available on otherwise open deer pastures, while the dense stands are composed of the less attractive species. There is no shortage of attractive species and the following are from a longer list quoted by Dr B Staines, of the Institute of Terrestrial Ecology at Banchory:

Goat willow	- <u>Salix caprea</u>
Aspen	- <u>Populus tremula</u>
Rowan	- <u>Sorbus aucuparia</u>
Ash	- <u>Fraxinus excelsior</u>
Lodgepole pine	- <u>Pinus contorta</u>
Norway spruce	- <u>Picea abies</u>

To this list we can add one exotic which has remarkable powers in attracting red deer - Balsam poplar - <u>Populus trichocarpa</u>. All these broadleaved species readily coppice and can provide permanent and attractive browse on deer pastures provided they are 'caged', that is grown in metal sleeves so that deer, while they can browse the shoots, are unable to destroy the entire tree. There are a number of shrubs which can be similarly employed.

<u>The Management of Amenity Woods</u> The systems of management of amenity woods will clearly be as varied as their circumstances and the purposes they serve, but the advantage will often lie in rotations longer than those of the adjoining commercial plantations so that they may provide protection from fire and reservoirs for wildlife while the commercial plantations are being cleared and re-established. In some cases forms of selection system may allow constant regeneration of the amenity woods and coppicing and singling may provide very reliable means of regeneration.

Whatever the methods of management adopted, I believe that amenity woodlands of the kind suggested could greatly improve the appearance of upland forests, provide reserves of wildlife and of those tree species formerly conserved in hedgerows, supply places for recreation and scientific study, and, with sensible silvicultural tending, provide small but valuable quantities of the finer timbers. In short they might be made to add greatly to the quality and interest of upland forests at a very reasonable cost.

The recommendations in this paper are personal to the author and not to be taken as the official view of the Forestry Commission.

BROADLEAVED SPECIES ON UPLAND SITES

SPECIES	SITE TOLERANCE							REGEN		WOOD PRODUCTION	
(1)	(2) PEAT	(3) WET MINERAL SOIL	(4) INFERTILE MINERAL SOILS	(5) EXPOSURE	(6) FROST	(7) WEED COMPETITION	(8) ANIMAL DAMAGE	(9) SELF SEEDING	(10) COPPICE	(11) VOLUME PRODUCTION	(12) VALUE
COMMON ALDER *Alnus glutinosa*	1	2	2	1	2	1	2	1	2	2	1
RED ALDER *Alnus rubra*	2	2	1	0	1	1	-	-	2	2	1
GREY ALDER *Alnus incana*	2	2	1	0	1	1	1	-	2	2	1
ASH *Fraxinus excelsior*	0	1	0	0	1	0	0	1	2	2	1
ASPEN *Populus tremula*	-	2	1	1	2	1	1	-	2	1	1
BEECH *Fagus sylvatica*	-	0	0	1	1	1	0	2	0	2	2
BIRCH *Betula pendula*	2	1	2	1	2	1	2	2	2	2	1
HORSE CHESTNUT *Aesculus hippocastanum*	-	-	-	1	1	0	-	-	1	1	1
SWEET CHESTNUT *Castanea sativa*	-	1	0	-	1	1	1	0	2	2	1
WILD CHERRY-GEAN *Prunus avium*	-	1	0	-	1	0	0	1	1	1	2
BIRD CHERRY *Prunus padus*	-	1	-	0	1	0	0	1	1	0	0
ELMS *Ulmus spp*	Not recommended because of Dutch Elm Disease										
LIME *Tilia vulgaris*	-	1	0	1	1	1	1	0	2	2	2
NORWAY MAPLE *Acer platanoides*	0	0	1	2	2	0	0	0	1	2	1
ENGLISH OAK *Quercus pedunculata*	0	1	0	1	1	2	1	1	2	1	2
SESSILE OAK *Quercus petraea*	0	1	0	1	1	2	1	1	2	1	2
RED OAK *Quercus borealis*	1	1	2	1	1	1	0	-	1	1	1
RAOUL *Nothofagus procera*	-	2	1	-	1	1	-	-	-	2	1
ROBLE *Nothofagus obliqua*	-	2	1	-	0	1	-	-	-	1	1
ROWAN *Sorbus aucuparia*	2	1	2	2	2	2	2	2	1	0	0
SYCAMORE *Acer pseudoplatanus*	0	0	1	2	1	0	0	2	2	2	2
WHITEBEAM *Sorbus aria*	1	-	1	1	1	-	-	1	1	1	1

- SOME CHARACTERISTICS OF COMMON SPECIES

NOTES
(13)
SITE TOLERANCE - Cols (2) to (8) - 0 = fails or grows very slowly. 1 = moderately tolerant. 2 = tolerant. - = not tested. REGENERATION - Cols (9) and (10) 0 = unusual, even under favourable conditions. 1 = occasionally successful. 2 = regenerates freely. - = root known. WOOD PRODUCTION - Cols (11) and (12) - 0 = negligible. 1 = moderate. 2 = good - = no information.
The only native species - valued for wildlife conservation. Effective coloniser of gravels and raw alluvial deposits.
Starts rapidly on peat but subject to severe damage by frost and for exposure unless it can reach fertile mineral sub soil.
As for Red Alder.
Native. Valued for conservation. Little tested - assessed from general observation. Regenerates freely from root suckers but difficult to root from cuttings and grow from seed.
GYC 6 on moderately favourable upland sites.
Silver birch. Valued for landscaping and wildlife conservation. Performance of White Birch (B. pubescens) similar but not so well tested.
Valuable for landscaping. GYC on moderately favourable upland site.
Native. GYC on moderately favourable sites in experiments in uplands.
Survives, but tends to be of very poor form in exposed sites.
GYC 6 on moderately favourable upland sites.
Valued for Conservation. Susceptible to frost and annual damage but persistent in recovery.
Slow growing. GYC 4 on moderately favourable northern sites. Faster in west and south.
Exotic. Valued chiefly for autumn colours and ability to grow on poor sites.
Southern Beech - exotic from South America - not extensively planted.
As for Raoul
Not widely tested but can be established on peat given drainage and fertilizing.

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FOREST STRUCTURE FOR CONTINUED TIMBER PRODUCTION

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Forest Structure for Continued Timber Production

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1. Introduction

For effective management a production system must be organised so that each unit of production can be identified for accounting or record purposes. In forests the administrative unit is the compartment, with fixed, recognisable boundaries but the production unit is the sub-compartment or stand. A stand is an area of forest which is distinguishable (and mappable) by reason of its species, rate of growth or age and is not permanent. Stands must therefore be redefined at intervals (Osmaston 1968). Classical forest management developed the concept of the working circle made up of felling series in which the silvicultural treatment of each stand is similar, with the objective of producing a fairly uniform product. Within a felling-series the age classes, and thus the fellings, are usually distributed to meet the requirements of successful regeneration while, at the same time, producing a relatively steady outturn of material. This yield is calculated from estimates of the increment of the various stands. The distribution of fellings in time and space provide the forest with a structure, which in favourable environments may be simply a contiguous series of stands of progressively greater age. In more extreme environments the fellings and the resulting stands are often more dispersed and variable, leading to a complex forest structure in which the yield regulation and production has to take account of storm damage and other hazards.

In Britain the rate of land acquisition and the development of afforestation techniques, has resulted in phases of rapid planting. Thus upland plantation forests generally have an unbalanced age-class distribution of which the effect on forest structure, is mitigated in many cases by differential growth rates and windthrow of immature stands.

The advent of large-scale industrial wood processing and the use of modern transport have removed the need for sustention of production and labour requirement over small areas and timber sales tend now to be planned at Forest District level. Production forecasting, in the Forestry Commission, is based on an inventory of sub-compartments in each forest, the rotational age being computed from a knowledge of growth rate, to maximise the financial yield from each stand (Johnson 1973). The timing of the felling of the individual stand may be varied by local management to allow for non-standard treatment, retention for amenity or recreational purposes but normally stands are clear-felled at rotational age for replanting, thus tending to perpetuate their existing distribution.

The structure of the forest (i.e. the distribution and size of individual stands) is important to successful management for continued or improved timber production as well as enabling the forest to meet the multiplicity of other demands made on it by society. This paper considers the factors which influence the development of forest structure in upland forests and how these might lead to structures appropriate to some of the typical land forms that have been afforested.

2. Existing structure of forests

To provide a basis for discussion of stand size and distribution in upland forests three existing forest areas have been selected as being representative of common topographic types in Scotland.

(1) Newcastleton Forest. 3700ha. This area is typical of much of the rounded, relatively smooth topography of the Borders on predominantly Carboniferous lithology, with precipitation reaching about 1400mm on the higher slopes at about 500 m a.s.l.

(2) Kilmichael Forest. 8400ha. An area of complex glaciated topography at relatively low elevations on metamorphic and igneous rocks of Dalradian lithology with a precipitation of around 2000 mm.

(3) Strathyre Forest. 4700ha. Deeply dissected topography with much of the forest relatively sheltered on the steep lower slopes of mountains which attain 800 m with a precipitation up to 2000 mm.

From the distribution of 5-year age-classes (Fig 1) it is clear that each of these forests has had a somewhat different history. Newcastleton has been planted in two phases, Kilmichael displays a marked peak of planting (70% of the area in 15 years) while Strathyre has an almost uniform distribution of age-classes. Each of these areas is now virtually 'planted up' and most planting in future will be in replacing existing stands.

Table 1.

MEAN STAND SIZE BY AGE CLASS (ha)

FOREST	FIVE YEAR AGE CLASSES *												Overall
	21	26	31	36	41	46	51	56	61	66	71	76	Mean
NEWCASTLETON	3.2	4.1	4.7	4.5	6.1	4.2	2.3	12.1	12.0	8.6	5.1	11.0	6.4
KILMICHAEL			0.8	2.5	3.0	11.0	25.2	13.7	17.4	21.6	24.0	16.5	13.7
STRATHYRE	0.5	0.5	6.4	5.0	5.2	5.9	4.2	3.6	4.9	8.9	4.1	6.3	5.2

* Each 5 yr age class is denoted by its first year.

Table 1 shows the distribution of stand sizes by age for each forest. In both Newcastleton and Kilmichael the mean stand size increased markedly in the post-war period when the capacity for site improvement through plough drainage became available. This increased stand area in recent years implies that it was considered less important to recognise site variation or that planting had extended onto predominantly organic soils of low quality which could be treated uniformly. In either case the result has been to place greater reliance on a few species, particularly Sitka spruce (Picea sitchensis Bong. Carr.). This can be seen in Table 2 where both Newcastleton and Kilmichael have 85 per cent of their area

Table 2

RELATIVE DISTRIBUTION OF SPECIES GROUPS (% AREA)

FOREST	PINES	SPRUCES	LARCH	D.F.	HEMLOCK	FIRS	OTHER
NEWCASTLETON	9.4	88.8	1.4	-	-	-	0.4
KILMICHAEL	6.9	84.6	4.6	0.4	0.2	-	3.3
STRATHYRE	11.3	71.2	14.3	1.4	0.6	1.0	0.2

devoted to spruce. Interestingly, the mean stand size at Newcastleton is only slightly more than that at Strathyre despite the much larger proportion of extensive gleyed and peaty soils in the former.

These data may be somewhat misleading because, firstly, they relate to subcompartments and may understate true stand area where they are separated by administrative compartment boundaries. Secondly, for calculating potential production mixed stands are allocated equivalent species areas thus stand size will again by underestimated. Thirdly, the inventories of large areas like Kilmichael which are not in full production need not be precise so that sub-compartments in these areas

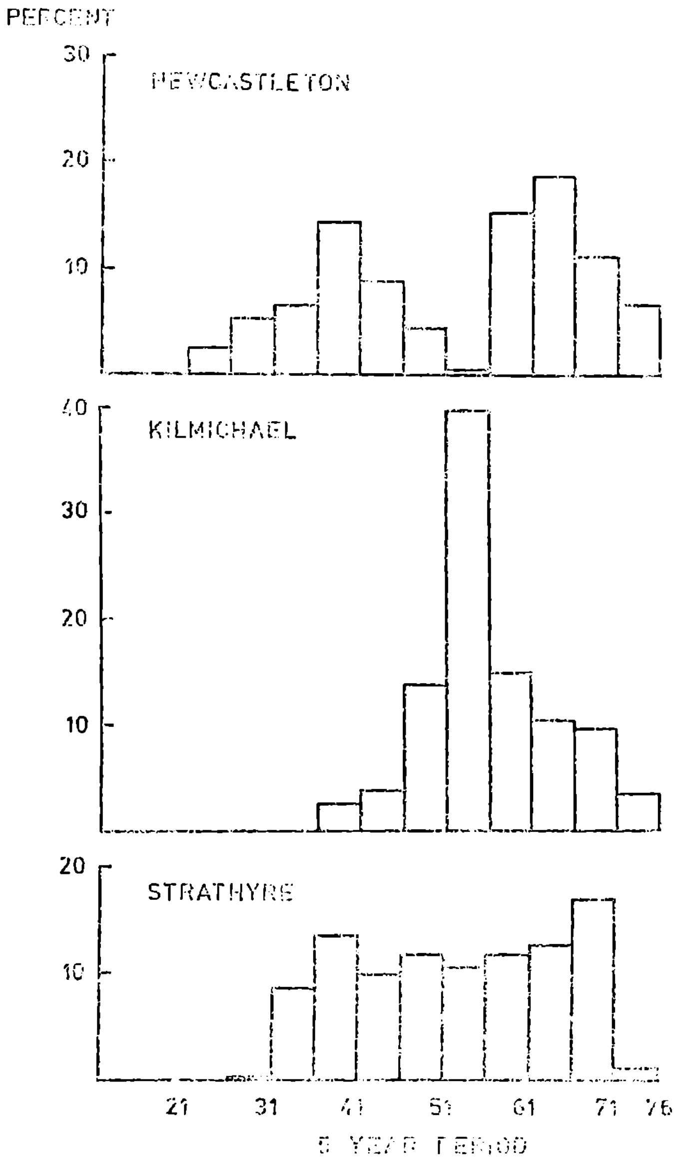

Figure 1 - Percentage Frequency of Age Classes

are not yet properly differentiated. Nevertheless, the stratification of stand size by age class provides a way of visualising the current forest structure.

An alternative approach is to divide the area devoted to individual species by the number of stands in which they are represented as in Table 3. The same constraints on interpretation exist as for

Table 3

MEAN STAND SIZES BY SPECIES (ha)

FOREST	SP	LP	SS	NS	LARCH	DF	WH	FIR	OTHER
NEWCASTLETON	1.2	11.8	7.3	4.4	1.7	0.5	-	0.5	2.7
STRATHYRE	3.3	3.0	9.3	5.4	3.0	2.7	1.5	1.3	0.5

Table 1 data but it can be seen that the largest stands are of Sitka spruce or lodgepole pine (Pinus contorta Dougl.) reflecting more recent planting on poorer sites. All other species occur in stands of a smaller mean size of about 5 ha or less.

The present situation in these three forests can be summarised, that i) they have been planted at very different rates, ii) the moist climate and associated poorly drained soils of Newcastleton and Kilmichael have led to a heavy dependence on spruce, whereas Strathyre with steeper slopes has a wider range of other species; iii) mean stand size at about 6 ha is remarkably similar in the very different topographies of the Borders and the southern Highlands, iv) mean stand size has increased in recent plantings, probably mainly due to improved afforestation technique.

The present distribution of age classes on the ground is that on a broad scale, the lower, more fertile soils carry the older stands with the younger stands on the poorer, more exposed sites. As rotation lengths are likely to vary between 45 and 65 years, a management policy of simply replacing each existing stand at rotation age in itself would lead to a continually changing forest structure. Productive stands might be harvested three times during two rotations of stands on poorer sites, thus the inherent variability of site potential induces a redistribution of age classes, or more importantly, stands at different development stages. This progression is quite readily modelled (an elementary example is given in Table 4) and forest structure can be predicted on the assumption

Table 4

Change in distribution of stand development stages with time. Forest assumed to have 5 site types and planted over 25 years

Yield class	24	20	16	12	8
Felling age	45	50	55	60	65
Present age	45	40	35	30	25
Year 10	5	0	45	40	35
20	15	10	0	50	45
40	35	30	20	10	0
60	10	0	40	30	20
80	30	20	5	50	40
100	5	40	25	10	60

that growth rates remain constant and that the forest is not subjected to environmental or biological disturbance. This assumption is, of course, invalid and so forest managers have in the past attempted to simplify the potential complexity by allocating areas of equal yield potential to separate working circles, where different silvicultural treatments were applied to counter anticipated hazards to the stands.

3. Factors affecting stand size and distribution

The criteria that may be used to determine the optimal size and distribution of stands may be categorised as environmental, biological or social and, although they interact, in the upland forest their importance is generally in that order.

a) Wind. The incidence of wind is the dominant environmental factor influencing the growth and development of upland forests. Increased windiness at higher elevations combined with ill-drained soils, that do not permit deep rooting, leads to the instability of tree stands. A prediction of the tree height at which serious windblow will begin can now be made from an assessment of site factors such as geomorphic shelter, soil rootable depth, and elevation. The resulting classification of sites in relation to wind throw hazard (Booth 1977) is a major advance, allowing the demarcation of areas where disturbance of stand structure through thinning is best avoided if windthrow is to be delayed. On gleyed soils in exposed situations the adoption of wide spacing at establishment, or an early reduction in stand density, may allow an increase in the rootable volume of soil available to the individual stem and may at the same time alter the stem form to reduce wind sway and consequent leverage on the root plate. Such low density stands may have reduced timber quality and pruning may be required. However, in one or two instances, stable stands, on otherwise unstable sites, have persisted with good stem quality because they were species mixtures, in which one component has been suppressed before the critical height for windthrow was reached. One of the main points for stand stability thus is the avoidance of any treatment that increases the aerodynamic roughness of the canopy as the critical height is approached. Windthrow may be delayed but is unlikely to be escaped on the really difficult sites.

The observation that marginal trees in windblown stands are less frequently blown suggests that it should be possible to create zones of relative windfirmess through the forest, by giving stand margins special treatment. Unfortunately, the evidence is that, where margins have been windfirm, either due to spacing or the use of species that have an ability to root more effectively than spruce, the stand behind the margin has not shown improved stability. On peaty or surface water gleys on exposed sites it is not possible to maintain a densely stocked stand of spruce to maturity (Day 1962) and if large dimension material is desired some sacrifice of total production is required. Whatever the success of measures to increase the stability of individual trees within a stand there is still the problem of designing felling coupes to avoid initiating unnecessary windblow.

The classic arrangement of coupes to reduce windblow at the time of harvesting was developed in the 18th century in Germany, where fellings were conducted in strips up to 60 m wide, working against the prevailing wind and often in a wedge shape. This technique, which generally makes use of natural regeneration, is still advocated in South Germany for soils with poor rooting properties (Rodenwaldt 1973). A similar approach has been suggested by Wendelken (1966) for shallowly rooted plantations of

Pinus radiata D.Don. on the gravels of Canterbury Plain in New Zealand. Here strip fellings, 80-160 m wide, working at right angles to the wind, are proposed. The opportunities for utilising such systems in upland Britain are very limited because of the considerably greater overall wind stress and the unpredictability of the direction of damaging winds, particularly in mountainous conditions. They might however be considered in areas where the onset of endemic windblow is not expected until late in the rotation.

The handling of large areas of high windthrow hazard, so as to keep felling coupes small enough to retain a hardly-won forest climate on exposed uplands, is a serious problem for forest management. At present, the usual practice is to replace patches of blown forest as they occur, to avoid sacrificing the remainder of the stand. This has the effect of diversifying the forest structure, but in an unplanned manner, which may lead to later problems where stand remnants become separated from extraction routes. Because unstable stands tend to occur on relatively extensive sites, an alternative policy of 'pre-emptive' felling in anticipation of windthrow results in large areas being clear-felled progressively over short periods, thus reducing climatic protection from surrounding older stands. These large coupes are relatively cheap to harvest but the economics are confounded by the loss of the unknown value of further increment and sometimes by difficulty in establishing the next rotation.

The recurrence periodically of catastrophic gales may set at nought the most careful treatments to reduce the effects of more frequent 'normal' gales. The experiences of 1953 in north-east Scotland and 1968 in west

Scotland demonstrated some increased resistance of margins, species and topographically sheltered stands (Andersen 1954, Neustein 1971). Locally, limitation to the extent of forest disruption might be obtained by a more balanced distribution of stands in different development phases, although some young stands on very unstable sites were damaged in 1968.

b) Fire. Periods of high fire risk are fortunately not usually prolonged in the uplands. The most serious hazard relates to plantations in the establishment phase when ground vegetation is still present. On some sites rapid invasion of vegetation after clearfelling may reintroduce the hazard, possibly increased by accumulations of debris from the previous stand. Most fires are checked at natural boundaries such as streams and ridges or at roadsides and maintained firebreaks. The limited experience of crown fires in Britain suggests that either a change of species or a break in the canopy at least slows the spread of the fire. Although the actuarial risk does not appear great, it does need some attention.

c) Selection of species. The afforestation of infertile, ill-drained and exposed upland has only been possible by using species with 'pioneer' qualities and then only after the development of site ameliorative techniques. Sitka spruce has been the main species used owing to its resistance to injurious agencies, ease of handling, rapid early growth and, above all, its high productivity. Without this species British upland forests would be incomparably poorer. Nevertheless the extent of the reliance placed on one species (about 80% of recent plantings) may be unwise. So far Sitka spruce has remained almost free of pests and diseases but the example of lodgepole pine where an endemic but hitherto harmless insect switched hosts may be pertinent.

The harvesting of first rotation stands should encourage a reappraisal of species selection. Firstly, the establishment of an ameliorated microclimate, the drying of some previously wet soils and the elimination of some competing vegetation should permit the introduction of other equally productive tree species that are not readily established in the open. Secondly, if the main objective is timber production, there are some sites that may in the long term not be so productive under spruce as other species. For example at higher elevations it appears that Sitka spruce can serve as a useful pioneer but may be overtaken in productivity by Abies nobilis while on drier sites it may be less productive than say Douglas fir (Pseudotsuga menziesii Mirb. Franco) or Western hemlock (Tsuga heterophylla (Raf) Sarg). The possible alternative species have, of course, their own silvicultural characteristics that limit their potential use to a particular range of site types. On present knowledge the alternative choices are unlikely to extend much beyond Douglas fir, Western hemlock and the Grand, Noble and possibly Pacific firs.

The implication of using species with mid to late seral attributes is that felling coupe and therefore stand size needs to be limited to that providing the requisite degree of shelter. The establishment and initial growth of any species in adverse climates, of course, is enhanced in sheltered conditions.

d) Deer. The creation of large areas of plantation forest has markedly expanded the available habitat for many animals which rely on forest cover. The extent of the increase in populations of roe and red deer in upland forests was recognised only relatively recently with the start of replanting programmes. The biology of deer in these forests is imperfectly understood and the elementary information required for management purposes is lacking owing to the unreliability of estimates of stocking densities. What is clear is that with relatively uncontrolled deer populations damage to second rotation plantings is related to the size of the felling coupe, as most browsing damage is sustained on the margins adjacent to existing stands that provide cover. The level of damage is influenced by the species used and the availability of alternative browse plants as well as by the proportion of the forest that is in the establishment or thicket phase. In the face of inadequate culling programmes forest management has tended to extend the size of felling coupes and attempt exclusion by temporary fencing while concentrating species selection on the least palatable species, usually Sitka spruce. This approach promotes large stands with little species variation.

The existence of excessive deer populations on open land above forests requires the erection and maintenance of costly fencing in an attempt to reduce the number of deer entering at the afforestation stage. A policy of exclusion in managed forest is illusory.

e) Harvesting and marketing. The economics of harvesting are so crucial to the profitability of timber production that it is desirable that the structure of the forest should be designed to facilitate felling and removal of produce. This would suggest that there should be an optimum size of stand or volume of timber removable from a given coupe to maximise efficiency of working. However, the benefits of concentrated working are predominantly administrative rather than technical as the need to transport labour and the use of self-propelled machinery allows a relatively small area to be worked efficiently.

Nevertheless, there may be economies of scale when costs are calculated on a unit area basis because the fixed costs of any operation (administration, transport of materials) is spread over a larger area. According to Row (1978) revenue per unit area hardly varies between sizes of coupe above about 10 ha so that the benefits of large scale working are mostly obtained from reductions in unit costs. At the other extreme the availability of labour and machinery conditions the maximum coupe size that can be cut in a reasonable length of time. The optimal size probably depends therefore on other factors such as accessibility, road location and space for landings. These factors are strongly related to the topography through the type of equipment used, for example, cable extraction on steep slopes. There seems therefore to be little constraint on felling coupe size from current harvesting systems although a spatial order of stands related to extraction routes is obviously desirable. The distribution of coupes within the forest may be more constrained by marketing problems if relatively small parcels of timber are handled at any one location but this is again an administrative rather than a practical problem.

f) Conservation and amenity. These influences on forest structure are mainly social in origin and are dealt with in detail in other presentations at this meeting. The needs of nature conservation within upland forests are sometimes difficult to meet as the requirements of different species of plants and animals can be contradictory. The policy adopted thus depends on value judgements of the importance of groups of organisms.

The main difficulty seems to be the imposition of an artificial ecosystem on an already unnatural man-made landscape. The assemblage of organisms already present in an afforestation area is thus often a result of geological accident, current climatic conditions and former land use. The needs of conservation are often expressed in terms of a desired diversity of habitats, with particular emphasis on stand margins, to provide supposed ecological stability. However, the evidence from natural ecosystems, in the north temperate forest at least, is that tree species are adapted to and depend on periodic disruption from windthrow and fire (Malcolm 1979). The size of the resulting stands and their specific composition therefore depend on the scale of the disruption, the variability of the site and the interval between disturbances. Large scale catastrophes on uniform site types give rise to large uniform stands. Economic management for timber production attempts to avoid the effects of haphazard natural disturbances but imitates them through the use of cultivation and clearfelling. The dispersion of these activities in space and time in a forest allows most associated organisms an opportunity to maintain viable populations. The size of stand optimal for wildlife tends to be smaller than that for timber production only.

The importance of forest structure for visual amenity and recreation has increased in recent years. The criteria used to order the forest for these purposes are subjective and in some cases the results may be ephemeral as both fashion changes and imposed patterns break down with rotational fellings and natural events. A general structure that is based on the main elements of the topography is however unlikely to be displeasing and can have a greater possibility of permanence.

4. Future forest structure

From the discussion of the factors affecting the size and distribution of stands within the forest it is clear that even in one area an optimal structure can not be proposed. In particular the upland environment is unlikely to allow any imposed structure to persist for long. The forest manager thus has to reconcile many conflicting, often unpredictable, demands in pursuit of continued production. If production is to be maintained, however, there must be some spatial order in the forest which is flexible enough to absorb environmental damage or changes in the demands on forest management.

Within a forest the site type provides a recognisable land unit on which stand size may be based in the first instance. Site types in Britain are classified in terms of their soil profile, itself an integration of environment and past treatment, and stratified by broad altitudinal bands to take account of local climate. If the effects of cultural treatments on the soil profile are allowed for, it is possible to delineate areas on which particular tree species are likely to show uniform responses and to roughly predict productivity.

One of the advantages of basing stand size and distribution on site classification is that the degree of definition can be varied to meet different objectives. For example, as site types are often related directly to topography they can be grouped in terms of their trafficability for harvesting machinery in a terrain classification (Rowan 1978). When new machinery is developed the grouping of the basic site units may be changed. A more precise separation of site types and therefore stands can be adopted in areas where landscaping is thought important. A similar system is adopted in Lower Saxony where data collection is site based on units of 0.5-3ha but management is based on sub-compartments with a minimum area of 3ha (Faure and Otto 1976).

The application of site classification in this way is, of course, not new as it forms the silvicultural basis for forest management in many parts of the world. With the degree of variability of geology, climate and soil in the uplands of Britain the different site types will inevitably be reflected in the structure of plantation forests in future. The scale of site variation obviously varies but certain broad groupings can be recognised which will need different approaches.

a) Relatively smooth topography - typified by the Border hills with Silurian or Carboniferous till as the soil parent material. Here variation is limited and most soils are gleyed with surface accumulation of organic matter. It then is important to emphasise minor topographic variations as they affect windflow patterns (Booth 1978). In this situation stands will naturally tend to be large and if dispersion of felling coupes and restricted stand sizes are desired the few relatively wind firm sites will need to be identified and possibly managed for this purpose using a less wind sensitive species than spruce.

b) Valley topography - typical of the central Highlands where site types tend to be stratified by altitude and divided vertically by natural features such as water courses or rock outcrops. Stand differentiation is not difficult and productivity variation will ensure structural diversity. Coupe sizes on the lower slopes may be small due to amenity pressure or systems other than clearfelling adopted in suitably sheltered locations.

c) Fluvio-glacial topography - a complex of relatively freely drained morainic soils in a matrix of peat-filled hollows. Site type and productivity variation can be extreme in very short distances making any uniformly applied treatment only partially successful. The scale of site recognition can be broad, accepting some sacrifice in production, or treatments can be more closely allied to site conditions to utilise the variation (Paterson 1975)

d) High elevations. This group may involve several topographic types but are worth separating out because climatic effects become dominant as the limits to productive forest are approached above 550m. The natural shelter, afforded by closed stands, for satisfactory growth becomes critical hence stand sizes must be small if early growth of second rotation stands is not to be as slow as the initial establishment. Productivity is inevitably low, and a system that allows for harvesting at fairly long intervals in small coupes will be most satisfactory for maintaining forest conditions and satisfying other demands.

5. Conclusions

Throughout the developed world there has been increasing pressure in recent years on forest management to modify its practices to take account of the needs of adjacent land use systems and to enhance the secondary functions of conservation and social benefit. In some places this pressure is extreme enough to inhibit any management at all. Much of the criticism of forest management for timber production has been ill-founded on examples of exploitation fellings in primary forest. There has been however a reduction in the scale of logging in many countries, for example in New South Wales felling coupes have been reduced from 200ha to a mean size of 11ha and are no longer contiguous. There has been a small increase in administrative costs but with benefit to other values (Humphreys 1977).

The situation in the British uplands is very different and afforestation has been successful largely because it has involved concentrating effort on site improvement and the use of a few species than can tolerate adverse conditions. Despite the large scale and rapidity of planting the mean size of subcompartment or stand recognised is not very large. The influence of environmental, biological and social factors, however, suggest that stand size should be related more closely to site type area in subsequent rotations, if the forest environment, in its widest sense, is to meet the multiple objectives of management. A forest structure thus based would allow differing levels of management intensity in different circumstances while dispersion of development phases ensures it continuity. While many sites have been improved for tree growth by afforestation the basic environmental influences still remain so that any imposed structure for simplified harvesting or visual amenity that ignores site variability is unlikely to be sustainable. A forest structure developed on the recognition of site differences is more likely to be resilient to environmental and biological hazards and changes in demand for its product and benefits.

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THE LANDSCAPE DESIGN OF HILL FORESTS

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THE LANDSCAPE DESIGN OF HILL FORESTS

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1. INTRODUCTION

1.1 The theme of the Forestry Programme at this Conference is specifically related to *upland* forests, though there does not appear to be a clear definition of the term in forestry terminology. Dudley Stamp defined 'Upland Britain' usefully as that north of a line from Exeter to Scarborough, but to use this would ignore the fact that there are lowlands in southern Scotland, and that there are hill forests in southern England. This is more than a matter of semantics because there are considerable differences - in character - in land uses - and in design problems between upland and lowland forests.

1.2 Perhaps this paper should begin by identifying the factors which distinguish hill forests in landscape terms. They would include:

- altitude (above agricultural land and below the tree line)
- either steeply sloping land or elevated plateaux
- severe exposure, high rainfall, snow, mist, low cloud
- generally poor soils of moorland, mosses and bog
- limited plant communities and sparse cover
- exposed rock, scree, unplantable land
- rapid streams in deep burns
- rich diversity of scenery
- farming limited to hill pasture and rough grazing for sheep
- limited access and possibly *no* vehicular access
- few public viewpoints and large tracts with no overlooking
- low-key recreational use, often of specialised interests.

1.3 From this list it is seen that hill forests differ from lowland forests in being less subject to urban pressures, having less demand for formal recreation, less heavy public use (except at key points due to winter sports or panoramic views). There is also less overlooking from public roads, and less conflict with agriculture, than in lowland forestry.

1.4 On the other hand hill forests have their own special problems including:

- greater conservation potential for wildlife
- damage by deer
- possible conflict with fishing and other sporting rights
- concentration of pressures on the few accessible places.

2. TRADITIONAL FORESTRY

2.1 In the past forestry has had a reputation for blanketing hills with square compartments of a single-species coniferous crop. Although this is rarely practised today, there are places where it still exists, and it is still an image in the minds of many people. This paper must briefly evaluate this early concept and study its advantages and disadvantages.

2.2 Straight compartment boundaries were simple, easy to lay out, permitted long straight fire breaks, made timber calculations easy and presented no problems in the planning of thinning and harvesting operations. Monoculture crops had similar benefits for ease of working and required little initiative on the part of the forest worker.

2.3 On the other hand they produced dark impenetrable blocks, created dull long straight rides and roads with a 'canyon' character; every indigenous tree was removed; all naturally regenerating broadleaves were grubbed out; compartment shapes concealed the subtleties of ground modelling, hid every natural feature and produced a large-scale landscape lacking interest and diversity.

2.4 This is a black picture and before we rejoice that it is past history, there is still a point of view which says that such an approach is still the right one for 'commercial' forestry, or that at least it is justified on high ground where it is not overlooked by the public.

2.5 Of course, the earlier hill forests are not all as depressing as I have suggested. Many of the older foresters were good sylviculturalists and - even within the rigid Brief that they were given - managed to produce an interesting pattern related to the ecosystem of a region by following the indications of soil, vegetation and climate.

2.6 Two conditions existed in the early work of the Forestry Commission which produced unattractive forestry. One was the need to acquire land as and when it was available - resulting in harsh straight ownership boundaries and undesirable compartment shapes. The other was the comparatively recent and sudden beginning of the Commission in 1918 which has meant that almost all the older Commission forests are of even age, and have not yet been through sufficient rotations to acquire the age-diversity which is an attractive quality of mature forests.

3. NEW DEMANDS ON FORESTS

3.1 The meaning of the word 'forest' has changed in history. In its earliest usage it was only marginally connected with trees. The Assyrian hunting forests were certainly not dense or lush woodland, and the word meant any land with sufficient cover to create a habitat for game animals.

3.2 In hot dry climate countries of the African, Indian and Asian Continents today the word 'forest' is more likely to refer to the scattered tree cover of a Savannah-type landscape, while, of course, in the hot moist climates of Central Africa and Malaysia the forests are true tropical rain forests.

3.3 In Europe which was totally covered with trees after the last ice age, those areas which were insufficiently productive to be worth clearing for agriculture were left as hunting forests, and were, of course, fairly densely wooded though with numerous clearings, and areas of scrub as well as forest trees.

3.4 Until comparatively recently, therefore, forests have been multi-purpose - providing building timber, fuel, game covert and some rough grazing, and relying almost wholly on natural regeneration. Whilst owners of estates have always encouraged regeneration and have done spasmodic replanting, it is only since the middle of the 17th century that afforestation for timber has been seriously undertaken. Official government action to grow British timber only began with the setting up of the Forestry Commission in 1918 and the Commission's Brief in its early years was solely to grow timber. In 1962 this Brief was somewhat widened to encourage recreation in forests, although the first forest park had been created in Argyll in 1936. More recently the Government changed the Commission's Brief again by a directive in 1972 that "more emphasis should be given to realising the recreation potential of State Forests, and to the interests of amenity".

3.5 Today, therefore, visual amenity for public enjoyment is given equal weight with the production of timber and can in certain instances even take precedence over it. Among the recreational demands now made on upland forests are:

- facilities for walking, camping, back-packing, nature study, climbing, skiing, riding, orienteering, ornithology, motor rallies driving on scenic routes, picnicking.

The forest designer, therefore, has to cater for many of these demands as well as visual attraction, and economic timber production in his work.

3.6 There may also be requirements to be met from statutory undertakers: Water authorities, electricity generation and supply, Hydro. Boards in Scotland, new roads and road-widening, and the demands of the best practice in ecological conservation. Planning authorities express demands for certain conditions to be met, in forest planning, though any conflicts are usually resolved by discussion.

3.7 Some of these demands are compatible, others are much less so. For example: Wildlife in the forests has come to terms with the normal forestry operations and even the large machines in use today only scare off animals and birds for a short period. They will even return when the machines are stationary. Public access, by contrast, may have a much longer-term detrimental effect on the wildlife of the forest. Recreational access may, of course, have to be closed during harvesting operations on the grounds of public safety.

4. THE ROLE OF THE LANDSCAPE ARCHITECT

4.1 It is, of course, only recently that the idea of a forest being *designed* came to be accepted. In 1963 the Forestry Commission showed foresight in appointing a prominent landscape architect - Sylvia Crowe (now Dame Sylvia) - to the post of advisor to the Commission, for which she did a stirling pioneer job of education by teaching and example for 13 years. Now the Commission has a Forest Design Branch with two in-house landscape architects, an exhibition designer, a head of branch concerned with interpretation of forests and forestry to the public, and several technicians. The author is successor to Dame Sylvia as landscape consultant.

4.2 It must be made clear that the landscape architect's role is a practical one, as part of a team in planning new forests, recreational areas, depots, car parks, and in advising on harvesting and replanting programmes to ensure good visual qualities. He is not there to put a 'cosmetic gloss' on forestry operations already planned by others.

4.3 Of course, the volume of afforestation and forest management being done by the Commission means that the available landscape expertise is only able to advise on a comparatively small part of the work and so, in practice, the designers are likely to have to concentrate on schemes which have a serious public, visual or ecological impact.

4.4 There is also a continuing educational role, by means of courses, seminars, discussions in the field, and by example, to assist Conservators, District Officers, and foresters in appreciating the benefits of good forest design and in helping them to see that a little foresight and imagination coupled with the application of a few design principles can make an efficient forest into an attractive forest with comparatively little (if any) loss in timber production.

5. CONSTRAINTS ON DESIGN

5.1 It is necessary to stress repeatedly the *practical* nature of forest design and to remove any misconception that it is mere 'beautification' or an idealistic attempt to portray growing timber as a romantic woodland scene. Although an attractive, or at least an acceptable, visual composition is the aim of the landscape designer, such an effect comes only as a result of marrying the demands of forestry and of other land uses into the form and character of the site with flair and imagination.

5.2 In order to do this successfully the designer must be aware of the materials, the processes and the needs of the user and he must not ignore the constraints placed upon him. In practice the practical constraints on the landscape architect working in upland forests are very severe.

5.3 Firstly, the forest must *work* as a piece of commercial forestry. It must be possible to plant it, manage it, get access through it, and eventually harvest it by normal methods. While some loss of plantable land is accepted as the price of amenity, this should not normally cause a loss of revenue exceeding 10%.

5.4 Secondly, there are the topographical constraints of slope, altitude, soil type, and physical features which may limit the variety of species and restrict the opportunities for creating design features of interest; land ownership which affects the compartment boundaries one might wish to propose; and statutory constraints such as rights of way, wayleaves for services, etc.

5.5 Thirdly, climate in upland areas may exhibit severe exposure conditions, heavy rainfall, frost and snow risks which further reduces the choice of species, causes a low and regular tree limit, ragged tops to planted hills, and the liability of a design being continually spoilt by snow-break and wind-blow.

5.6 Existing vegetation patterns can usually be a benefit rather than a restriction, and can be followed as a guide, but in upland areas indigenous vegetation may be extremely limited, and the local ecosystem severely constrained. In such a situation, the landscape designer has a very abbreviated palette with which to work.

5.7 Without extending this list indefinitely, it is possible to see that the practical limitations on his work give the designer scant opportunities for florid exuberance or the free expression of artistic whims, and the forest officers - while appreciating beautiful countryside - are severe critics of a proposal which looks good but will not work.

5.8 At this point one must remember the four-dimensional nature of forest design. No single sketch is capable of illustrating a design proposal. Even a perspective sketch which attempts to show solid geometry in three-dimensions cannot properly convey the depth between foreground and distance and the great acreages of plantable land which are often concealed in 'dead ground' behind near ridges.

5.9 Such a sketch is also effective only from one single viewpoint and a change of position gives an entirely different perspective. There is, therefore, no substitute for walking the ground and absorbing every change of slope, every shape and form of the topography and every natural feature.

5.10 The fourth dimension is, of course, *time*, and - like the use of a single viewpoint - the appearance of a forest at one particular point in time cannot convey the constantly varying pattern as seasons change, weather alters, trees grow, rates of growth vary in different species, and the whole forest matures. The long time scale of forestry is such an important constraint that the designer may have to look to future felling and planting regimes - even two rotations ahead - before a desirable effect is likely to be achieved.

5.11 The working forester uses a plan as his guide to planting, thinning and felling and all proposals must eventually be translated to a flat sheet of paper.

6. DESIGN PRINCIPLES AND THEIR APPLICATIONS

6.1 Forest design is a discipline that extends through all the stages of forestry, and is not merely applied at the initial planting operation. In fact, the incorporation of good design principles may be more noticeable during felling than at any other time. Moreover, the successful establishment of a layout or the improvement of an old and poor forest pattern, may - as was said earlier - take more than one rotation to accomplish.

6.2 Unlike designers working in clay, wood, graphics, - even architecture - the landscape designer starts from the existing materials and character of the site itself. His materials are rock, soil, water and living vegetation - most of which are already present in some form. It is essential, therefore, that he begins with both a broad and a detailed assessment of the site.

6.3 This assessment includes a study of the topography, geology, soils, climate, ecology, hydrology, etc., and may be expressed in plan form as contours, slope analysis, soil types map, altitude limits, exposure pattern, tree limit line, vegetation patterns, water and drainage patterns.

6.4 It is sometimes convenient to plot these as a series of tracing overlays, so that the coincidence of certain compatible factors and the divergence of incompatible factors can be noted. The selection of species will be made on the basis of practical data such as soil type, exposure, water table, and, of course, the demand for certain classes of timber. Close collaboration with forestry officers is, therefore, essential even at such an early stage.

6.5 As an area is studied for its design potential, other factors which have been identified in a less tangible way come to the fore. *Scale* is important and distinguishes the wide uplands of Scotland from the intimate landscapes of the Lake District and mid-Wales. *Regional character* is the almost indefinable stamp of character which identifies a piece of country and makes it different from any other - even though the rock, soil and vegetation may be similar. It may have a vernacular deriving from the land uses and skills of its inhabitants. *Agricultural* practices often impose a distinct character upon an area which can be sustained even into a different land use.

6.6 In addition to making these factual assessments, the designer must gain a deep appreciation of the character of the site, which is made up partly of the physical characteristics and partly of the feelings which the site evokes. Some of these feelings can be expressed only in abstract terms such as *idyllic, bleak, romantic, pastoral, forbidding*. Others can be analysed by the recognition of forces and tensions at work in the composition. For example, there is generally a strong downward thrust on the face of a spur, and an equal thrust upwards in valleys and gullies; flat terraces may be in repose while steep slopes can seem visually unstable, and sharp features on a face may set up strong lines of tension between them.

6.7 It is the work of the designer to recognize these visual forces at work and respect them in his design - where necessary resolving opposing forces so that the final composition appears to be at rest, or at least in equilibrium. (A painting or piece of sculpture may deliberately contain tensions to heighten the enjoyment of it as an art form, but this would hardly be appropriate to a permanent landscape.)

6.8 As the design evolves, qualities of the trees themselves become important:

Colours - even variants of green give a palette by which shapes and patterns can be created, with highlights and incidents from Birches, Larches and the occasional single Copper Beech or Norway Maple.

Seasonal change widens this palette with bright Spring greens, the Autumn golds and oranges of hardwoods and the changing colours of Larches in mass.

Textures vary from species to species, and broader textures are created by mixtures, by planting and thinning patterns, by age diversity, and - on an even broader scale - by felling coupes. The strongest texture changes are between grass and trees, or between Conifers and hardwoods.

6.9 Probably the strongest guiding principle upon the designer is the need to *fit* the new afforestation to the configuration of the ground so that the planting appears to have grown naturally rather than been imposed by the unfeeling hand of man. This aim is by no means incompatible with good forest husbandry - in fact it may be more efficient to go *with* the natural forces than to go against them.

6.10 Following these principles means using natural features as compartment boundaries; making internal boundaries and species changes on lines sympathetic to the hill shapes and lines of visual thrust; leaving rock features unplanted; using hardwoods in gullies and to break up hard edges; integrating meadows, pasture land and rough grazing land with forestry pattern; allowing the upper planting line to 'tail-off' as at a natural tree-limit; and careful marrying-in of new planting to existing (sometimes harsh) compartment shapes.

6.11 There is inevitably some loss of productivity in allowing for these landscape considerations to influence the layout, but the loss may be quite small. It occurs mainly by 'give and take' lines to avoid hard boundary edges, by leaving areas unplanted to achieve a desirable shape, by planting trees in places where they cannot be harvested and by leaving mature trees indefinitely as an amenity feature.

6.12 The Forestry Commission has expressed willingness to accept - as a policy - a relatively small proportionate loss of production in the interests of good design and amenity. The amount cannot be quantified as a national percentage. The designer can minimize this loss by careful planning so that the demands of landscape design coincide as nearly as possible with constraints imposed for other reasons and - for instance - that land to be left unplanted for visual reasons is (where possible) unplantable land or soil of low productivity.

6.13 Although every part of the forest should reflect the best design input possible, there are large high plateaux in hill lands which are not overlooked and where timber production can proceed unhindered; there are also public access places, viewpoints and recreational clearings where an even greater design effort is needed - even parts where recreational use takes precedence over forestry or where wildlife conservation is paramount. All these priorities have to be taken into account in the forest design and the designer must try to bring all uses into a multi-purpose landscape which works well, and is visually attractive.

7. CONCLUSIONS

7.1 This short paper has only been able to set out the major problems and indicate the broad principles of landscape design in hill forestry. Being itself little more than a check-list, it needs no further summary. A list of reference books and papers for further reading is appended.

7.2 Conclusions which may be drawn from a study of the subject are:

a) The design of hill forests has problems and constraints which are different in degree but not in substance, from those of lowland forests.

b) Forest design begins with the same analysis of site factors and characteristics as is done for silvicultural practices.

c) A well-designed forest does not necessarily cost more and is no less efficient than an ugly one. There may need to be a somewhat larger area of unplanted land and minor modifications to estimates of potential productivity.

d) There will be considerable benefits in public good-will, easier planning approvals, less objections in National Parks, and social gains on a national scale.

e) In paying attention to recreation, amenity, and visual design, the Forestry Commission is setting an example to commercial forestry concerns and estate managers.

f) Good design does not mean discarding good forestry practices, but merely applying them with imagination and flair in a form sympathetic to the configuration of the landscape.

g) The forest ecosystem should be respected in all new design concepts and new land uses. As Dame Sylvia Crowe states (FC Booklet 44): "Conservation of resource should always take precedence over demands for use".

7.3 In these crowded islands, the hill forests are one of the last havens of tranquility. They are appreciated as such even though they are criticised for changing the character of open moorland, creating gloomy Spruce tunnels, setting up 'Conifer factories', hiding views, limiting hill walking and so on. These criticisms are valid only if forestry is done badly or ruthlessly.

7.4 Well-designed forests can bring interest and diversity to hill land; can increase the range of wildlife habitats; can give screening and shelter; can bring life and vitality to decaying hill lands, supplement marginal hill grazing, increase employment; and can open up to public access and recreation areas hitherto unaccessible.

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RECREATIONAL POTENTIAL OF THE UPLAND FORESTS

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The Forest as a recreational resource

British foresters can be proud that, as early as 1935, provision was made for visitors to enjoy scenic surroundings within a forest by the creation of the Argyll Forest Park. This was followed in 1937 by Snowdonia, the Forest of Dean Parks in 1938 and 4 more Forest Parks up to 1955, totalling 430 200 acres (176 600 hectares).[1]

Further statutory provision was made in the Countryside Acts in 1967 (Scotland)[2] and in 1968 (England)[3], for the Forestry Commission to continue these early pioneering provisions for recreation. The two Countryside Commissions are charged with the enhancement of conservation and natural beauty of the countryside and to encourage the provision and improvement of facilities for people resorting to the countryside.

It was no surprise to British foresters, when in 1972, The Seventh World Forestry Congress declared that foresters had been pioneers in the struggle to rationally use natural resources and that forestry is not only concerned with trees but how trees can serve people.[1] A similar declaration was made at The Eighth World Forestry Congress in 1978 with greater emphasis that forests must be managed as a renewable resource so that the weakest and poorest people also benefit.

Lord Dulverton pleaded in 1973[4] to the Institute of Foresters "We countrymen have got to help, not capitalise, but actively to think and act to help our urban brethren to get their breath of fresh air and the sanity in the country".

However, as managers struggle with plans for recreation provision in the face of today's social criticism, the Director General of the Forestry Commission warned at the Eighth World Forestry Conference[5] "Only when the manager can fully reconcile potential revenue from wood production, soil protection, conservation and protection of employment, can he consider logically what sort of forest and associated recreational facilities are needed". He so wisely added, that in resolving these questions it is not uncommon that particular lobbies have a major influence on the decisions finally made.

In a major discourse on the inter-relationship between agriculture and forestry in the uplands of Scotland in "Scottish Forestry"[6] in 1978, Mr G G Stewart, Forestry Commissioner for Estate Management suggested that one guiding principl should be to ensure that land is used for the purpose for which it is best suit

There are a number of aspects of Scotland's climate according to Scottish Meteorological Office[7] which are not generally known or understood, but perhaps the main misconception is that Scotland is everywhere much wetter than England and Wales. Long term averages of rainfall calculated from actual measurements show that each year in England or Wales can be matched by one in Scotland, eg the Lake District in England or the Welsh hills with the Scottish Highlands, London by the Edinburgh area and so on. Many districts in the North and East Scotland have an average which compares closely during May, June, July and Aug the total rainfall over the same 4 months in parts of England. In contrast th rugged scenic areas in Scotland are very wet. Because the high hills cover a larger area than the English Lake District there is a greater area in Scotland with a natural rainfall exceeding 70 inches (178mm). By and large the differer sunshine duration between England and Scotland is not great, ranging from abot half an hour per day in mid winter to about one hour in midsummer in favour oi England. This occurs earlier in the season and a noteable feature of the summ in Scotland is the long drawn out twilight.

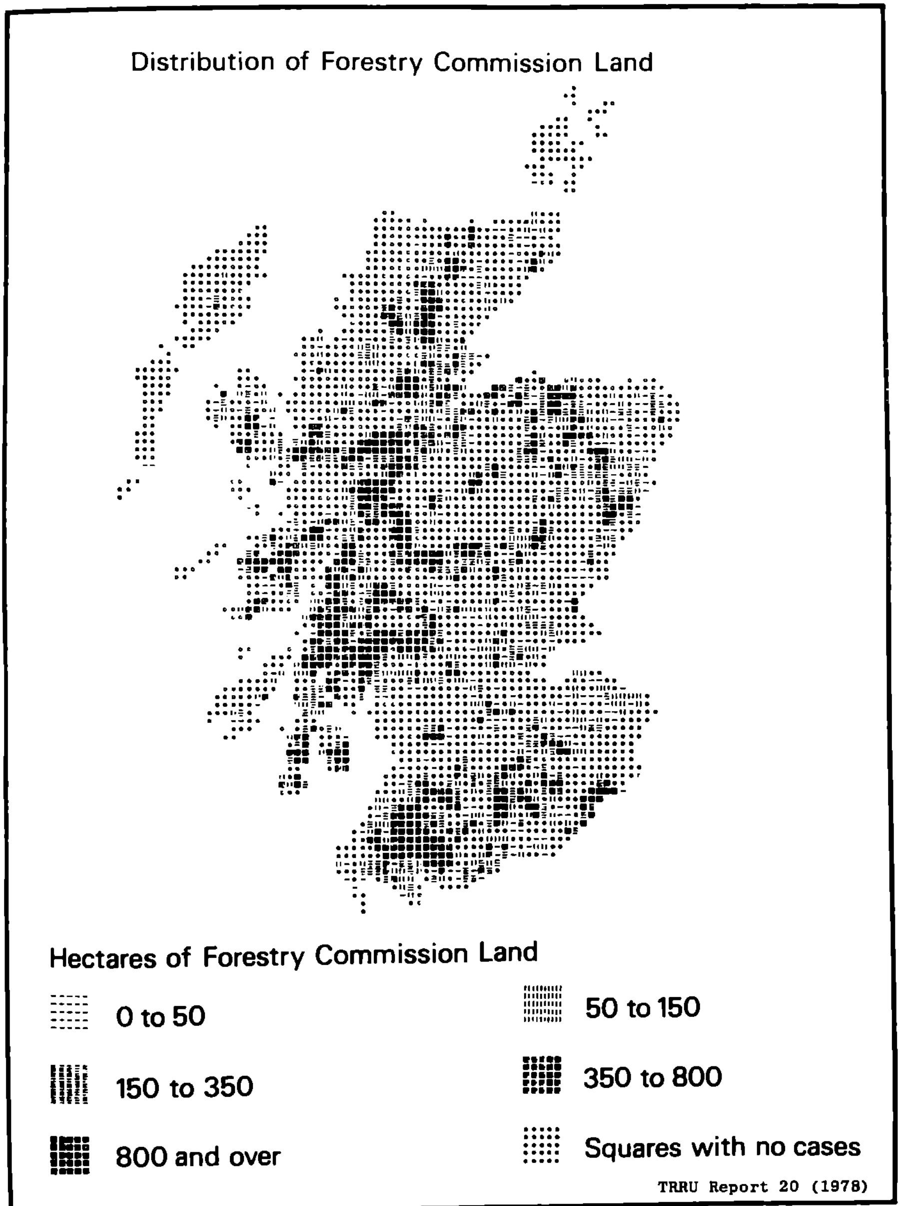

Figure 1 - Distribution of Forestry Commission Land in Scotland

Scotland's forests have existed for a very long time, dating from the early Celedonian Pine Forests with their associated wolves, lynx, bear and deer. The resurrection of the vast forests of today probably started as far back as 1737 when the John Menzies collection of larch was planted by the Duke of Atholl for timber growing purposes.

The distribution of Forestry Commission forest in 1978[9] appears in the main on the central west highlands associated with some of the finest European scenery that exists, that serene topographical feature when the sea, lochs and mountains fuse together. This great solid landmark offers to visitors a complete visual contrast and perhaps sanity to those urban dwellers seeking a change from the "geological" concrete monoliths that the architects have forced them to dwell in.

Table 1 - Land Use Forestry Commission Scotland as at 31.3.78 in hectores[8]

Conservancy	Total	Plantation	Scrub	For Planting	Agriculture and Others
N	282674	129250	535	25711	127178
E	117016	92134	379	7249	17254
S	176696	131845	176	12151	32524
W	212605	118939	2259	25791	65616
Total Scotland	788991	472168	3349	70902	242572*
% of Total	- -	60	-	9	31

The land use contained within the total land holding of 788 991 hectares (31.1.78) contains under 1% of retained scrub for special landscaping and conservation purposes but more important is that 31% of non plantation land classified is under agriculture and other. Under a land use policy "that land is used for the purpose that it is best suited", some of this land is already used for recreation and is likely to be more beneficial, jointly to the recreationalist and agriculturist and could be considered as future potential recreational land.

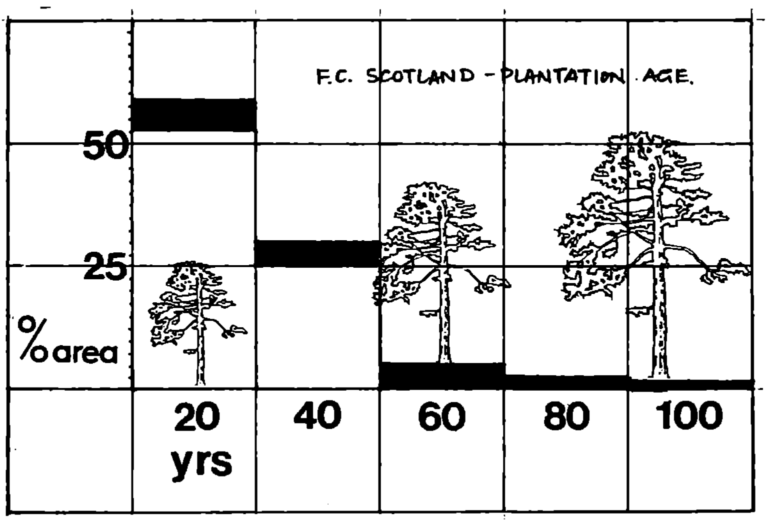

Figure 2 - Forestry Commission Plantations in Scotland Age Range by Area

The age range of these forests has some significant bearing on the attractiveness to the visitor. Susan Jones of Kinghurst Primary School Warwickshire described in 1973 this attraction: "When looking at an oak tree it is timeless, our predecessor, it outlives us all". Young thickets and pole stage plantations be they oak or pine provide little visual scope for such thoughts. It is our more maturing woodlands that act as a primary target for the viewer and these poets.

The young plantations, however, of today will surely be the "timeless predecessors" of tomorrow. Even more important to the visitor is the mixture of open space, be it heathland, rock faces, agricultural holdings, with the forest wrapped around to highlight the scenic colours.

An essential feature of the highlands and indeed the lowlands, is the excellent network of superb roads that offer easy access to shore, mountain and forest by the car. I will return to whether in 1980 onwards the visitor will be able to afford or to have the fuel to use them. This rather brief description of the highland forests indicates that they have a structure and setting most beneficial and suitable to attract visitors.

Patterns of Management

The management of Scottish forests has been gradually changing over the past fifty years, with greater emphasis on productivity, the contribution to visual and scenic amenities and indeed the active conservation of all aspects of wildlife and indigenous tree species, for example the Caledonian pine. They are being enriched as a result of visitors and residents involvement with their structure and appearance. The great surge of knowledge of wildlife and the countryside may be partly due to television with its visual contribution to knowledge. Increased leisure time, coupled with improved mobility and increasing environmental understanding must all add to a greater understanding of what makes the countryside, and more especially forest, so attractive to visitors from all over the world.

The Forest Manager, however, must know more thoroughly "his client", the visitor: whether resident or holidaymaker. Clawson and Knetch[10] observed that "a good measure of how recreationalists view quality is what they do, rather than what they say!"

The Forest Visitor and His Needs

A great deal of knowledge has accrued, chiefly through questionnaires but often accompanied by detailed observations. I do not believe there is a great difference between the residents' and the holidaymakers' needs and requirements. I am impressed by the volume of words and facts published by the excellent series of Scottish Tourism Recreation Planning Studies.[9.11] Similar studies in Hampshire and the New Forest yield factual information and overall I believe there is a constant behaviour factor common to the north and south of the border.

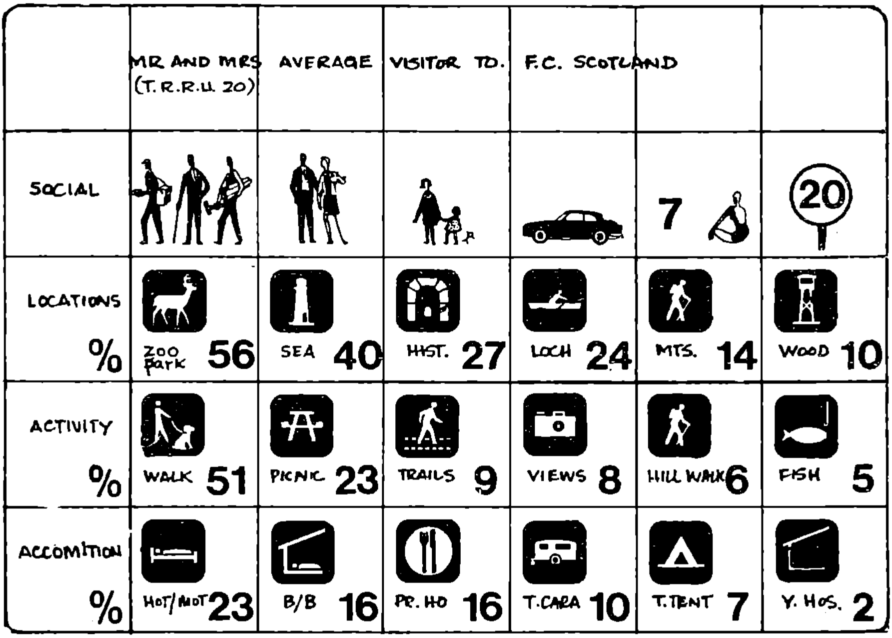

Figure 3 - Mr and Mrs Average Visitor to Scotland

For instance, as a generalisation, the visitor is more likely to be one of three social classes: unskilled, skilled or semi-skilled, married, will travel by car approximately 20 miles, is more likely to visit parks and historic buildings and woodland, preferring walking and picnicking with his children, on average 1.4 under 5 years old. He may spend on an average of 7 days for his main holiday and if Scottish in origin will use private houses without payment and come from the Strathclyde region and if a "foreigner" will come from likely the South East of England or Europe.

The behaviour, whilst in the countryside or forest, has not attracted a great deal of research. However, several behaviour patterns become obvious and are most valuable criteria when considering design and extent of facilities. The semi-detached residential background I believe influences their car parking behaviour, there is no need to demarcate parking spaces - they will park next to each other. In a camp site where no pitch demarcation is made, they will take up a position next to someone else, almost in a semi-detached manner. They will choose a fringe of scrubby trees, wall, fence - to provide that psychological security of rear protection. They will explore, but cautiously, and only if provided with route or waymarking aids and a re-assurance of returning to place of start. The types of litter left behind consists mainly of beveridge containers, sweet/cigarettes and cigarette wrappings.[20] Their curiosity is highest at the start of an exploration and lowest at the end. This curiosity is heightened when accompanied by children and when combined with an opportunity to exert physical exercise the overall experience becomes more satisfying and rewarding. This satisfaction gives the resource manager his greatest reward. Visitors respect naturalness and tidiness and all "forest furniture" must be well executed and of substantial material sizes, to endure the varied pressures of use and occasional vandalism. Visitors respond well to the use of all their senses: sight, hearing and smell. Facilities for the disabled will increase the reward for managers if they take the time to study for themselves how visitors behave and respond to his environment.

Detailed studies of day visitors' passive activities in Scotland, Dumfries and Golloway, Lake District, Forest of Dean, Dartmoor and the New Forest show some interesting similarities as follows:

Table 2 - Comparison of Visitors' Activities (Major) in the Countryside (% of all activities)

Region	Walking	Picnic	Viewing Sea/Loch	Origin of Data
Scotland	24	10	15	TRRU 25 [11]
(FC Scotland)	51	23	8	TRRU 20 [9]
Dumfries & Galloway	16	25	8	Structure Plan June 78 [12]
Forest of Dean	39	63	-	FC Bulletin 46 [13]
Dartmoor	37	25	19	NP Plan 77 [14]
Lake District	38	32	12	CC BTA Rep 1969 [15]
New Forest	32	40	45	Cons. Study 71 [16]
Average of Sample	34	31	18	

A significant difference, however, is recorded in (TRRU 20) where the woodland visitor activities in Scotland show a low percentage of visits to woodlands as compared with other passive pursuits. Table 3 this may be due to critical travelling distance acceptable to the potential visitor. The computerised maps of FC woodlands within 20 km of the large areas of population, show an interesting lack of matching and indicates a critical factor in future potential for recreation (Figures 4 and 5).

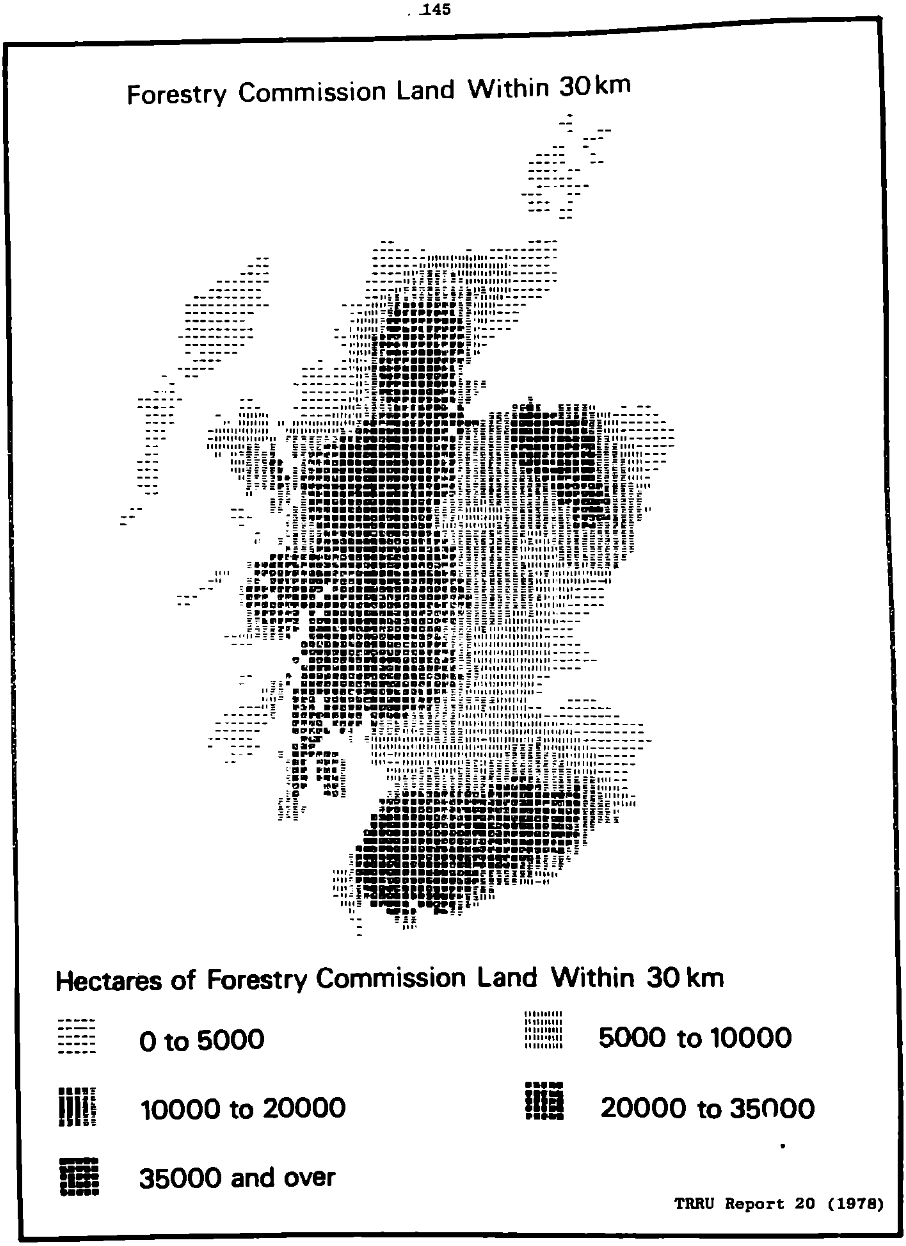

Figure 4 - Forestry Commission Land within 30 km

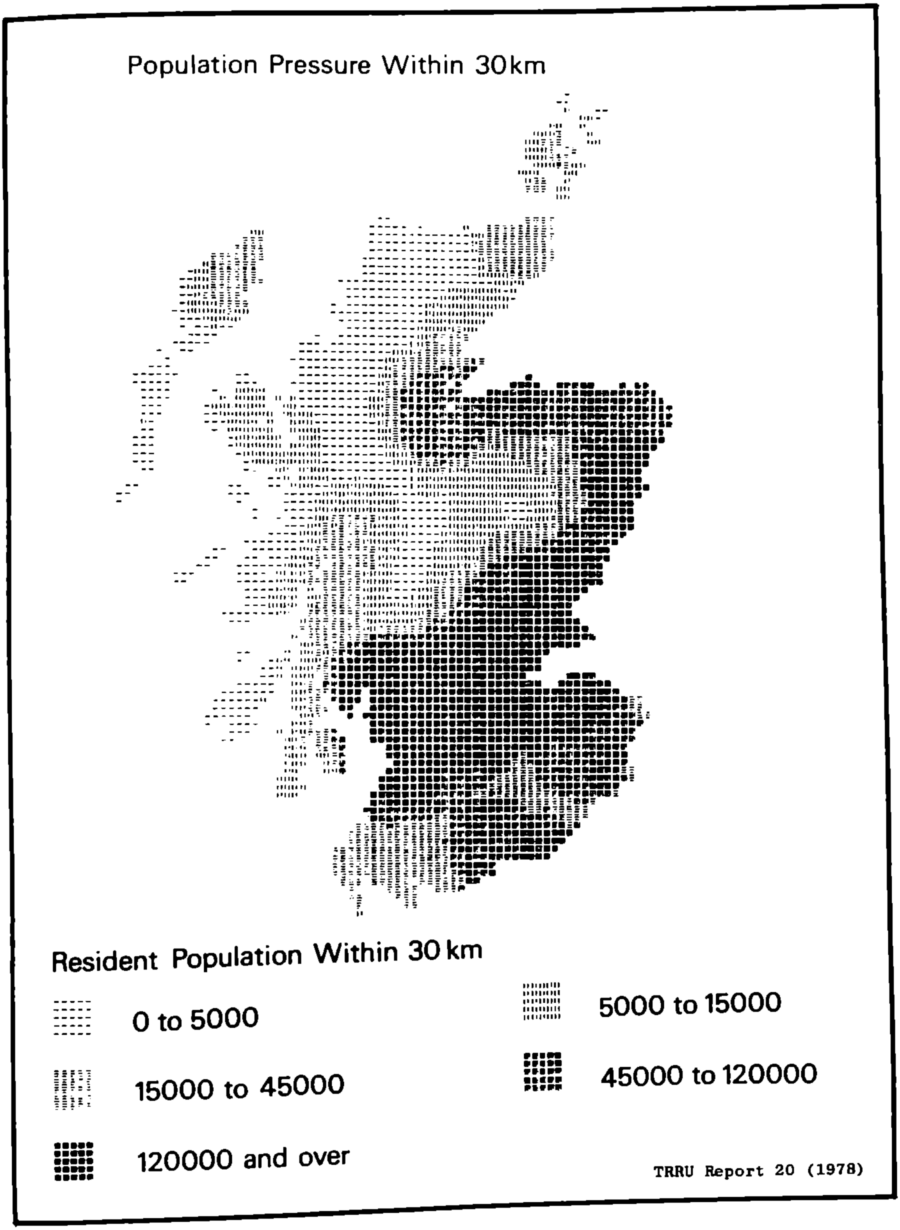

Figure 5 - Population Pressure within 30 km

Table 3 - TRRU 20 Informal Pursuits of Visitors in Scotland (percentages of all activities)

Parks	Beach	Historic Houses	Loch	Spectator	Coast	Mts	Woodland
56	40	27	24	32	14	14	10

From detailed analysis of the same preferred activities of holiday-makers, similar proportions arise. That is, approximately one-third of visitors prefer walking, sight-seeing, picnicking (in woodland and near water) and visiting historic places. Monuments, I understand, attract visitors for approximately 6½ minutes if no other form of entertainment, like refreshments or souvenirs, are provided.

In assessing what type of accommodation visitors use whilst on holiday we must take account of the variety of types offered, for instance:

Table 4 - Percentage Use of Holiday Accommodation by Types

Region	Hotel/ Motel	Private House	Static Caravan	Touring Sites	Others	
Scotland[11]	19	43	11	23	4	
Dumfries[12] & Galloway S Plan	13	33	15	35	4	Considered surplus against demand
Lake District[15]	40	22	Unknown	33	5	Considered inadequate to meet peak demand
Southern[21] Region England	79?	3	4	14	Unknown	Inadequate to meet peak demand

This table shows the predominance of private houses in Scotland as holiday accommodation with a large camping provision, compared to the high percentage of hotel and motel accommodation in the South of England. One can be deceived by using percentages of total accommodation as a capacity indicator, for instance the 14% in the Southern Region of England includes 6000 camping pitches provided in the New Forest alone, whereas the total peak camping capacity in the Forestry Commission sites in Scotland is only 1200 pitches.

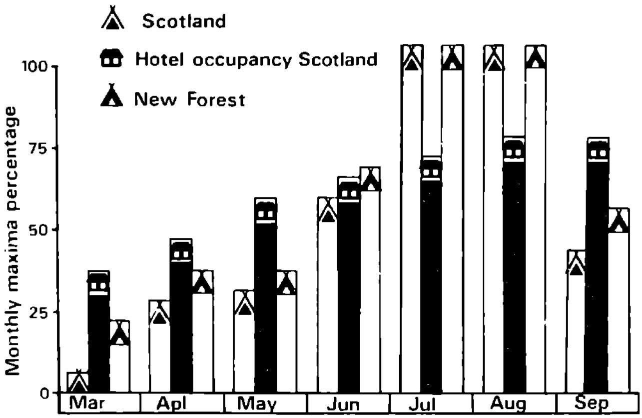

Figure 6 - Occupancy comparisons between Scottish Hotels and Forestry Commission Campsites

An important factor, in an examination of what already exists, in the types of accommodation, is the percentage utilisation over the total holiday season or, indeed, the total annual visitor season. There are obvious differences between the north and south of the United Kingdom simply because of climatical extremes. For example, the utilisation of the Forestry Commission car parks in Scotland is approximately 200 car visitors per space provided compared with 1038 car visits per space in the New Forest. However, the utilisation of Scottish Forestry Commission campsites is averaging 52% and at times exceeds existing capacity during June, July, August. It is difficult to obtain accurate figures for the Scottish holiday season and the woodland visitor season. Data from the Forestry

Commission sources displays a comparatively short season excepting for active winter sports such as skiing in certain locations. The season appears to be from May to the end of September with high pressure during July and August.

The inter-relationship between climatic and biological factors in Scotland may contribute to a better understanding of the holiday patterns. In examining the beneficial factors such as hours of sunshine, holidays such as school vacations and comparing them with non beneficial factors such as rainfall, the most beneficial period to potential holiday enjoyment appears to be when the average hours of sunshine and minimal rainfall coincide. This period is April, May and June. However, statutory holidays such as Bank Holidays and school vacations occur during July and August when the average hours of sunshine reduce with a corresponding increase in the monthly rainfall.

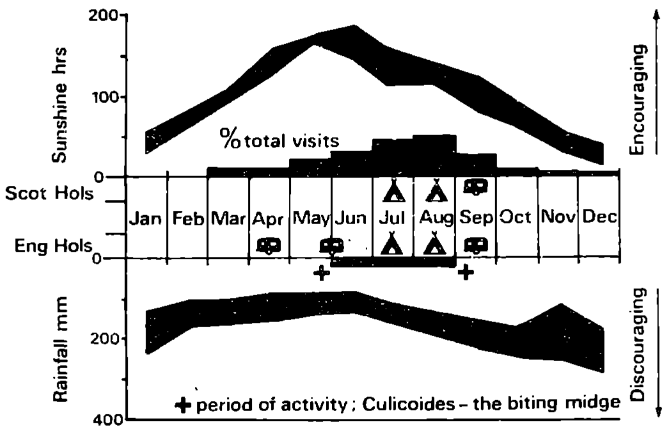

Figure 7 - B.I.T.E. - Biological Interference to Enjoyment

Nowhere, how can I find research evidence that has been directed towards solving the greatest detraction to Scottish holidays that I have experienced - Culicoides Sp - the Biting Midge. Entomologists, I believe, agree that its period of emergence and need for human blood shows a relationship and coincides with the main holiday period of June, July and August. Figure 7, B I T E "Biological interference to enjoyment". I have had many exasperating and distressing experiences, culminating in 1978, when the camp warden gleefully refunded my advanced camping fees, with the comment "oh, only 30% of my fees are returned because of the midge!" I suggest that this is an area where eco-rec research might make a major contribution to the future potential enjoyment of Scotlandsrecreational possibilities.

The recent creation of forest cabins by the Forestry Commission in Scotland has added immensely to the increase in enjoyment of Scottish forests. It is interesting to note that although domestic holidaymakers primarily spend their holidays in relaxing, an increasing number are seeking more active recreational pursuits. The location of these forest cabins are in a unique position to further this possible increase of more active pursuits. The present total provision of 285 bed spaces provides an increase of 20% of the total of Forestry Commission accommodation for tourists in Scotland.

An interesting feature regarding land use, is the type of land used for cottage letting, cabin schemes and touring campsites. A very high percentage are of agricultural type land with only four campsites in Scotland placed within plantations. This, I believe, is an important factor that must be taken into account when considering the users' enjoyment. Similar campsites in plantations both in the Forest of Dean and the New Forest have indicated a lower utilisation per pitch when compared to more open grass and heathland sites. I believe, that while campers display traditional and inherited needs for visual protection the seclusion offered within plantation recreates a natural fear of the unknown and dark interiors. This use of non-forested land could well assist in the multiple land use approach already well established in the New Forest and gaining strength in the Highlands.

During the initial study survey of movements of visitors in the New Forest in 1969/70 it was most apparent that the open spaces and the heathlands, were a major attraction to car bound visitors. There were over 1200 access points from the county highways giving easy access to the open areas of over (18 500 hectares) 46 000 acres thereby creating miles of compacted and eroded heathland. Clearly it was necessary in the interests of conservation to counter this by the closure of these access points and the positive provision by carefully selected parking places.

I note with considerable interest a report by the Scottish Countryside Commission 1978 "Vehicular tracks in upland Scotland"[17] that within an area of 10 kilometres of Braemar, there were approximately 200 kilometres of road tracks (75% serving forestry, 10% agriculture, 15% sporting and other recreational activities). This report concludes that in the long term it seems likely that the demand for more tracks penetrating remote ground will continue. This aspect of access may be scenically detracting, but may well offer remote areas a minor potential recreational future, with adequate control of access from tracks.

Can forest management respond to the changing needs of the public?

As we have seen forest managers need not make major sacrifices in their primary role as growers of timber and trees. In high pressure areas such as the New Forest[18] and the Forest of Dean approximately 1% of land has been set aside for specific recreation. Manipulation of tree spacing well in advance of any development within a plantation for car parking or campsites ensures the tree ultimate stability. So often bare land or land for various reasons that is not planted and is accessible by forest tracks or roads can be the nucleus of informal recreation facilities.

I firmly believe that the forest visitor, be they resident or holidaymakers desire peace and quiet and primarily naturalness. They have chosen to see the natural countryside and it should be offered to them without trappings if this is at all possible.

Experience has shown that once a facility has become established and well used, it will become necessary to provide hard-wearing surfaces both for feet and vehicles. Providing the surface materials are compatible with the local countryside there should be no visual conflicts. Hardwearing paths and roads considerably reduces wear and tear on adjoining vegetation - they act as a waymarking system.

A great deal has been written supporting the need to inform the visitor, resulting from the great interpretive movement that gained momentum in the early 1960's. Many of our so called visitor interpretive centres are a form of entertainment with the accompanying souvenirs. I question this need to always interpret the resource for our visitors, as nowhere have I seen ample justification that he has required it or been rewarded by it. Modern visual aids such as television can more readily and more professionally keep our visitors informed. It is so easy to fall into the trap of educating rather than offering the natural surroundings for enjoyment possibly in ignorance. The constant very high percentage in the returns from questionnaires, that walking and picnicking are the most important requirements of the visitors, re-emphasises this need for caution. Considerable professionalism and very high cost changing of interpretive displays have seldom really been cost benefited to the authority who produces them. I find, in my many travels around facilities, a constant repetition of what I call the "plantation P year syndrome", ie that European larch was planted in 1927 etc. In my view each forest should have a particular theme that should be kept to that area and would encourage visitors to make a tour of the forest areas of the United Kingdom without attracting boredom by constant repetition.

Subtle waymarking is adequate to give the urban dweller, so accustomed to all forms of sign posting, the reassurance that foresters welcome strangers and even directs them back to where they started, Recently in the South of England the local press asked me what I was going to do to prevent walkers in the New Forest getting lost - "Nothing", I replied and added that I was so delighted to know that it was still possible that the New Forest can be considered as wild, in spite of an estimated 6 million annual visitors. The sense of exploration and this combined sense of fear must in the long term be rewarding to our visitors who I believe should not be subjected to sophistication and any form of entertainment, which is provided elsewhere.

The majority of camping facilities use land that is not afforested and so does not place pressures on potential plantations. As seen, most campers prefer openness with edge seclusion, as long as three sides are protected and the front is clear they are content. We have, however, in this country become so regulation minded that one aspect of camping will soon disappear - the ability to get away from all mod-cons. Regulations demand that mod-cons must be provided in accordance with the local health and planning requirements. Is it possible to reconsider the relaxation of such regulations and offer the campers who wish, a much more informal facility. In the New Forest, a joint study recognised as early as 1970 that in the major conservation and recreation projects designed to protect this ancient heritage one constant theme occurred throughout - retain as near as possible the sense of enjoyment of the forest that the users have enjoyed in the past. In the camping scene it was proposed and has been completed that informal camping areas should be provided, where all "mod-cons" were brought by the camper, a sort of "bring it yourself". All that has been provided by the Forestry Commission are facilities for disposal of liquid and litter together with cold water. Control is exercised simply by preventing entry to campers who do not bring their own facilities. This type of camping site has many advantages not least a considerably less capital input and fewer artofacts within the countryside. A recent analysis of the campers wishes, found that they were divided equally between those who want and those who do not want all mod-cons.

Perhaps the woodland manager is in a unique position to provide further informal facilities, well screened by the product of his silviculture especially as the capital invested on all mod-cons sites provides such a poor financial return due to the shortage of the camping season. Hygiene is the most important aspect of camping management and provided adequate control is exercised there should be no hazard.

I find it most interesting in reading the outcome of the Starrs Series 25 (June 77)[11] on the pattern of outdoor recreation in Scotland, particularly the section on active pursuits as distinct from passive recreation.

"It is inappropriate to approach the provision for leisure and recreation by head counting alone no matter how they are formulated, they are insufficient indicators of recreational needs. What is required is an understanding of the LEISURE SYSTEM, which characterises community life within a specific area".

The evidence presented shows a wide divergence in the percentage of participants in active pursuits. It cannot naturally show as yet any trends. The data available in 1976/77 showed the following pattern:

Country Walking	Golf	Fishing/ Sea Angling	Cycling	Boat/ Sail Canoeing	Motor Sports	Pony Trekking	Skiing	Mountaineering	None	
21	12	11	3	7	2	2	2	1	61*	% participants.

I am sure we will find say in 10 years, the influence by television or sporting magazines that an increase in active pursuits will reflect not only an increase in leisure time but this growth will be born out of a sense of frustration and an increased desire to do exercise both for mind and body as a satisfactory pursuit. Eight of these pursuits above are possible within forest areas.

In the field of recreation one is never surprised that individual active pursuits gain popularity over a short time. Such is the case of growth in the interest of orienteering. The surge of interest in physical fitness has resulted in orienteering pressures in the New Forest that have required a ceiling to be placed on the total numbers of participants. The only concern I have with this excellent activity is the wide spread penetration into areas which have been reserved for peace and wildlife conservation. The solution has been in our multiple land use policy, is by allocation of areas for such purposes.

Preparation and planning for new recreation

The forest manager primary decision to provide for recreation must be based on hard factual information. There are many inter-conflicting opinions or environmental factors that could be eroded by the introduction of public pressures. I believe the basic principle is simple. Examine and assess whether an area is of interest to visitors, identify that interest, and ascertain if there are fragile eco-biological assets that need continued protection. The question what will the benefits be. Will they be financial, social, psychological, ecological, or removed pressures from elsewhere? Determine clear objectives and how they are to be achieved and do not combine one with the other. Important aspects in achieving these objectives will be, whether the area is accessible by public transport on highways or forest tracks and within residential visitors travelling range, capable of expansion, provide visitor satisfaction and will fit into a regional or local planning strategy. Forest recreation must not be competitive with other facilities and it should be in complete harmony with the surrounding countryside and similar existing or new proposals. The overall co-ordination and co-operation of other statutory authorities is an essential feature of success and fulfilment for both manager and visitor. I am impressed by this approach being made in Scotland.

Forest recreation in the future

I am often challenged by those thousands who advise me on how the New Forest should be managed - what about the future?

I read with considerable interest the voluminous navigational chart entitled "A guide to the preparation of initial regional strategies" STARRS NO 2 undated.[19] This document covers a wide range of sport and recreational activities, including active outdoor pursuits, visits to places of interest, informal recreation and tourist accommodation.

A most important point made in it is in defining expected demand as "The number of outings in normal peak periods for an activity that the population of residents or tourists will wish to undertake". This emphasis on peak periods is worthy of examination, as it infers that managers must consider this short period, when use is greater than capacity has been designed for. I question, whether recreational facilities are to be designed to meet these occasional peaks. Situations get out of control and the manager is constantly forced to consider peak periods only. Should he plan for normality and exercise capacity control or should he plan for estimated peaks. How is he to protect the natural resource he is managing? In the New Forest, due to attempting in the past to constantly increase our capacity to meet peak demands we are left with under utilised facilities during the rest of the season. We now adopt the view that we provide for normal summer use and exercise capacity control at peak periods by in the camping world advanced reservation systems and the use of emergency overflows. This has involved extra administration but at least goes some way towards controlling the use of the fragile resource that I am responsible for. I am sure all natural resource managers would welcome a restructuring of our national holidays to perhaps level out pressures more evenly during the year. There might then be a few less natural resources being eroded due to uneven pressures.

The mode of travelling in the future is at present in some doubt arising out of the current energy crisis. The main means of travelling in 1973 and I believe still are in 1979 - 60% by private car, about 16% by coach, with 11% walking and 6% by train. Records indicate that travelling by car is as high as 80% in Galloway and as low as 49% in Midlothian. The future therefore of woodland and forest recreation being so dependant in Scotland upon the private car or coach and not very accessible by public transport, must undergo a change and perhaps a decline unless other means of transport are made available. The freedom of choice would be curtailed but access to forests could be still possible and more economical per person if coaches or bus services were operated at popular times. The camper and the caravaner may well be severely curtailed in travelling long distances and could resort to journeys nearer home as happened in the 1974 fuel shortage. It is possible that holiday makers will change their mobility - using trains or buses for travelling and remain comparatively static at the destination. One wonders whether there will be a resurgence of the use of bicycles particularly now that the folding bicycle has come here to stay. Perhaps that rail travel could provide an economic alternative for many and that coach services from local stations might aid visitor access to the forest. It will be necessary to re-examine the accessibility of forest facilities and relate them to other forms of transport and possibly develop services as pioneered by the English Countryside Commission in the Lake District and the Peak National Park.

I find it most interesting that the authors of the Dumfries and Galloway draft Consultative Structure Plan of 1978,[12] highlighted that existing facilities for both hotels and touring camping were in their opinion over-provided even including and allowing for the projected demand in 1980. Their conclusions were that no further facilities should be provided. I would expect that if similar analysis were applied to other regions of Scotland, a similar pattern might emerge.

At present, data indicate, that a very high percentage of forest recreational pursuits are in the passive range, due possibly to a high percentage of mature visitors being recorded. The present younger generation is already showing an increasing awareness and participation in the social and personal satisfaction of participating in more active pursuits. They will I am sure, respond more favourably to the provision within or association with forests for such active pursuits as climbing, sailing, canoeing, cycling, orienteering, horseriding and trekking etc. This re-emphasises the conclusion reached by STARRS that forest recreation must be part of the leisure system and not a specific resource as it exists at present.

In conclusion, I am left with the impression that with the exception of July, August, forest recreation facilities in Scotland are under utilised. A re-examination is needed to relate new facilities to areas of demand, probably closer to centres of population and compatible to the pattern of holidays of the future.

It is still perhaps some time, before the forest visitor will be computer guided to an artificial bionic fully equipped camping pitch or car park, provided with synthetic country odours.

I hope that the forester in the future will still be prepared for the next challenge. He will have at his command highly sophisticated equipment and machinery to automatically measure harvest and replant his crop. Perhaps from his bio-electronic and air-conditioned capsule he will wave to visitors who will be armed with electronic interpretive aids which will be recreating the forests of yesteryear as an historical memory.

Acknowledgements

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NATURE CONSERVATION IN UPLAND FORESTRY

Objectives and Strategy

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Nature Conservation in Upland Forestry - Objectives and Strategy

INTRODUCTION

Hills and uplands extend to about 6.6 million hectares or 29% of the land surface of Britain and are especially characteristic of the north and west. These uplands are difficult areas for human habitation because of poor soils, low temperatures and high humidity and, in the past, have been mainly used to support an agriculture based on extensive cropping of the natural and semi-natural vegetation by herbivores. There are 7½ million sheep or about 60% of the total UK sheep population in the hills and uplands (CAS Paper No 2, 1978).

Afforestation in the uplands started towards the end of the 18th century when the 4th Duke of Atholl initiated a planting programme which resulted in the establishment of 4,000 hectares of mainly European larch in the Perthshire highlands. However, it is in the past half century that the very substantial increases in the extent and rate of upland afforestation have occurred. Today there are 1.5 million hectares of land under forests in upland Britain fairly evenly divided between state and private ownership. More than a third of these upland forests consist of one tree species, Sitka spruce *(Picea sitchensis)*. Other trees planted extensively in the uplands are Lodgepole pine *(Pinus contorta)*, Norway spruce *(Picea excelsa)*, Scots pine *(Pinus sylvestris)* and larch *(Larix spp)*.

Large-scale afforestation has developed in the uplands because, although the uplands are marginal for agriculture, they provide excellent growing conditions for trees. Indeed, conifers grow better in upland Britain than in most other European countries. It is estimated (CAS Paper No 2, 1978) that there are still some 2.5 million hectares of land in the uplands that could be afforested with only a very small loss of agricultural production. There is little doubt that afforestation of the uplands will continue but the rate and extent of planting and planting localities remain to be determined.

Forestry has a major influence on upland wildlife. It brings about substantial changes resulting in the loss of moorland and wetland habitats and the creation of new forest habitats. The effects of forestry in the uplands should be considered so that nature conservation objectives can be determined and conservation measures adopted.

ECOLOGICAL CHARACTERISTICS OF THE UPLANDS

Britain lies in the north temperate zone but it differs from much of continental Europe in having a strongly oceanic climate which is reflected in the soils and vegetation and the flora and fauna of our uplands. These uplands cover large areas of northern England, Scotland and Wales with small outliers in south-west England, and are the most extensive semi-natural habitat in Britain.

The high precipitation/evaporation ratio associated with oceanic climates promotes the leaching of exchangeable ions whilst low temperatures slow down the chemical weathering and humus decomposition. There is thus a general tendency for upland soils to be acidic and base-deficient with acidic humus horizons. On permanently waterlogged soils this bias towards mor humus horizons is developed further into a layer, often very thick, of acidic blanket peat. The heavy rainfall also results in the extensive occurrence of gley soils. Soils of a better base status are usually confined to flush situations. In the higher mountain areas there is a prevalence of skeletal and immature soils and the effects of solifluction are pronounced.

The original pattern of plant and animal communities as determined by climate, topography and soil has been profoundly altered by man. For most of the post-glacial period woodlands have been the climatic climax formation over most of Britain and their extent in the uplands has been limited by high altitude, severe wind exposure and waterlogged ground. Most of the lower levels of the uplands were forest-clad except on the wettest ground and the present limits of tree growth range from about 600m in south Wales and the eastern highlands of Scotland to 300m or less in the north-west highlands.

The ecological characteristics of the uplands are described and analysed in the Nature Conservation Review (Ratcliffe, 1977). Oakwood, and particularly Sessile *(Quercus petraea)* oakwood, occurred extensively on the lower elevations of the uplands. On richer soils ash *(Fraxinus excelsior)* and Wych elm *(Ulmus glabra)* occurred with the oak and on limestone areas ash can form more or less pure woodland. Birch is a climax species in the uplands and was and is widespread both in mixture and in pure stands and on a variety of soils. *Betula pendula* is more characteristic of the east and *B. pubescens* of the west with sub-species *odorata* in the north-west. Alder *(Alnus glutinosa)* occurs along lake and river margins but can form pure thickets. Rowan *(Sorbus aucuparia)* is widely distributed but holly *(Ilex aquifolium)* occurs more locally. Juniper *(Juniperus communis)* is a common associate of Scots pine and birch in eastern Scotland.

Native Scots pine *(Pinus sylvestris)* is thought to occur only in the Highlands of Scotland where it forms climax forest. Scots pine flourishes on strongly podsolised acidic soils and represents a southern and western outlier of the Boreal coniferous forest of northern Europe. The pine forests of Speyside, Deeside and the Beauly catchment represent the largest areas of native woodland remaining in Britain. The Scottish pinewoods are further distinguished by having a distinctive ground flora containing species such as Creeping lady's tresses *(Goodyera repens)*, twinflower *(Linnaea borealis)*, Common wintergreen *(Pyrola minor)*, One-flowered wintergreen *(Moneses uniflora)*, Serrated wintergreen *(Orthilia secunda)*, Lesser twayblade *(Listera cordata)* and Chick-weed wintergreen *(Trientalis europaea)*.

The natural upper limits of woodland are marked by a zone of tall scrub often composed of the same tree species, such as oaks, Scots pine and birch, that dominate the forest below. The tall scrub zone gives way to shrubs of medium height such as juniper and willow *(Salix spp)* which in turn merge into ericacious dwarf shrub heath. On the predominantly acidic rocks and soils of the British uplands the zone of dwarf shrub heath consists largely of Ling heather *(Calluna vulgaris)* which is replaced at the highest altitudes by moss heath with an abundance of *Rhacomitrium lanuginosum*, lichen-heath, or a bare stony surface with the sparsest plant growth.

This pattern of vegetation zonation is affected by local variations of topography. Flushes contain a wetland vegetation of a special kind dominated by bog moss *(Sphagnum spp)* and sedges *(Carex spp)* perhaps with some birch, alder and willow. Open unstable habitats on mountains, eg cliffs, broken slopes, screes, erosion features, flushes and rills provide habitats for many small, competition-sensitive montane and sub-montane plants.

With increasing drainage impedance there is a gradual development of raw humus and peat and an increasing proportion of water-loving plants in the vegetation. Dwarf shrubs such as Ling heather may remain dominant in mire communities but there is an increase in grass and grass-like plants more characteristic of wetter ground such as cotton-grass *(Eriophorum vaginatum)* and *(E. angustifolium)*, deer-grass *(Trichophorum cespitosum)*, Purple moor-grass *(Molinia caerulea)* and Bog asphodel *(Narthecium ossifragum)*. On the wettest areas bog mosses *(Sphagnum spp)* predominate. Blanket mires fed by rainwater (ombrogenous mires) and overlying badly drained ground occupy vast areas of upland, especially in north Scotland. These ombrogenous blanket mires support a vegetation characteristic of acidic conditions but soligenous mires (resulting from drainage water) show a wider floristic variation according to the nutrient content of the drainage water. Blanket mires were formerly too wet for tree growth but in more recent years they have been extensively planted with trees after draining and ploughing.

Much of the British uplands are now managed for, or at least strongly affected by, herbivores mainly Red deer *(Cervus elaphus)*, sheep and Red grouse *(Lagopus lagopus)*. The loss of forest over the past two thousand years resulted in vast expanses of Ling heather but where deforestation was followed by heavy grazing and burning the result was often grassland rather than moorland. Similarly, grazing in woodlands results in a predominantly grassy field layer with the loss of many of the dicotyledonous herbs that once occurred. Thus, within the zone of possible tree growth in Britain, the uplands are largely covered by derived grassland and dwarf shrub heath maintained in this state by grazing and burning. Grassland tends to predominate in the wetter west and on the more basic soils and heather moor in the drier east and on more acid soils.

Characteristically upland lakes have a low productivity due to lack of nutrients and a neutral or slightly acid pH (oligotrophic lakes). Most of these were formed by processes of glacial erosion but there are smaller examples in areas of morainic deposition. Those lakes associated with the blanket mires of the north and west of Britain are much influenced by dissolved humic acids and the water becomes brown-stained and much more acid. Such water bodies, which are termed dystrophic, can vary in size down to small pools and have a characteristic flora and invertebrate fauna.

Upland streams are the commonest and most widespread of all natural water-bodies in Britain. Like the lakes they are usually oligotrophic or dystrophic. These rivers and streams have a predominantly bryophyte flora and in shaded locations, such as in woods, and under oceanic conditions a very rich Atlantic bryophyte flora can occur.

There are few mammals or birds exclusive to the uplands. The Red deer *(Cervus elaphus)* has become adapted to tree-less mountain terrain and is now more characteristic of such country in Britain than it is of the forests which are its main home in mainland Europe. The feral goat *(Capra hircus)* has lived wild and unmanaged in the uplands for a very long time and is a well established member of the upland fauna. Perhaps the most truly upland mammal is the Mountain hare *(Lepus timidus)*. Of the small rodents the Short-tailed field vole *(Microtus agrestis)* is particularly associated with the uplands. It is the great increase in numbers of these small animals, following the luxuriant growth of vegetation after fencing and tree-planting, that attracts mammal and bird predators to young plantations. There is also a melanic race of the Water vole *(Arvicola amphibius reta)* in the Highlands of Scotland.

The fox *(Vulpes vulpes)* is widespread and Pine marten *(Martes martes)* and Wild cat *(Felis sylvestris)* although more local in distribution have extended their range in recent years. Otters *(Lutra lutra)* occur in upland lakes and rivers and badgers *(Meles meles)* are found at the lower elevations especially where there are trees.

There are three species of birds which are montane or alpine, the Snow bunting *(Plectrophenax nivalis)*, ptarmigan *(Lagopus mutus)* and dotterel *(Eudromias morinellus)*. Mountain cliffs are breeding refuges of a characteristic group of predators: the Golden eagle *(Aquila chrysaetos)*, peregrine *(Falco peregrinus)*, kestrel *(Falco tinnunculus)*, buzzard *(Buteo buteo)* and raven *(Corvus corax)*. All these birds have a large territory size.

The lower, more gently contoured moorlands are the haunt of northern, sub-montane birds such as the Red grouse *(Lagopus lagopus)*, Golden plover *(Pluvialis apricaria)*, dunlin *(Calidris alpina)* and merlin *(Falco columbarius)*. Grouse moors and young plantations are the favoured haunt of the Hen harrier *(Circus cyaneus)*. More widely distributed species are Meadow pipit *(Anthus pratensis)*, skylark *(Alauda arvensis)*, wheatear *(Oenanthe oenanthe)*, Ring ouzel *(Turdus torquatus)*, Carrion/Hooded crow *(Corvus corone cornix)*, snipe *(Gallinago gallinago)*, and curlew *(Numenius arquata)*. Black grouse *(Lyrurus tetrix)* occur in conifer woods.

The goosander *(Mergus merganser)* and Red-breasted merganser *(M. serrator)* are the most characteristic breeding species of duck on the large, nutrient-poor lakes. There are also small numbers of mallard *(Anas platyrhynchos)* and teal *(A. crecca)*. Small indigenous breeding populations of Greylag geese *(Anser anser)* are found on the lochs and lochans of the Highlands.

The Red-throated diver *(Gavia stellata)* nests on small peaty lochans and the Black-throated diver *(G. arctica)* occurs on large lochs preferably with islands. Common sandpipers *(Actitus hypoleucos)* and dippers *(Cinclus cinclus)* are widespread and common around the margins of stony-shored lakes and the Grey wagtail *(Motacilla cinerea)* on lakes and streams. The greenshank *(Tringa nebularia)* is also found under similar conditions but is confined as a breeding bird to the Highlands of Scotland. Very locally there are also breeding colonies of Great skua *(Stercorarius skua)* and Arctic skua *(S. parasiticus)*.

As with the plants, there is a well defined geographical-ecological group of birds associated with the Scots pine forests of the Central highlands of Scotland and especially Speyside. These are the capercaillie *(Tetrao urogallus)*, crossbill *(Loxia curvirostra)*, siskin *(Carduelis spinus)*, Crested tit *(Parus cristatus)* with the Golden eagle and goshawk *(Accipiter gentilis)*. The osprey *(Pandion haliaetus)* has recolonised the highlands in recent years.

Less is known about the distribution of invertebrate animals in the uplands. Dragonflies and water-bugs are characteristic groups of upland water bodies. Chironomid larvae are often extremely abundant and the biting midges of the uplands are notorious. A few butterflies, eg the Mountain ringlet *(Erebia epiphron)* are confined to the uplands and in recent years the Chequered skipper *(Carterocephalus palaemon)* has become restricted to woodland edges in the western highlands of Scotland.

SPECIAL NATURE CONSERVATION FEATURES OF THE UPLANDS

The strongly oceanic character of the British uplands which is reflected in the soils, flora and fauna, is not duplicated elsewhere in the world. The uplands of Britain are more closely related to those of Scandinavia than central Europe, but our upland flora is poor compared with continental upland areas and grazing and burning over a very long time have resulted in rather uniform conditions over large areas. However, the uplands of the north and west still contain large continuous areas of semi-natural vegetation and some of the features of the uplands are of major nature conservation value nationally and internationally.

No continental European uplands have a comparable extent of vegetation dominated by Ling heather *(Calluna vulgaris)*, Heath rush *(Juncus squarrosus)* and Dwarf furze *(Ulex gallii)*. The high atmospheric humidity associated with an oceanic climate meets the needs of many moisture-loving plants and the fern, filmy fern, moss, liverwort and lichen floras are especially rich. Indeed, Britain is the European headquarters of many Atlantic species and the oakwoods in our western oceanic areas are of international significance for their rich Atlantic flora. A further feature of interest in such woodlands is the strong development of bryophytes and lichens and the Common polypody fern *(Polypodium vulgare)* as epiphytes. The equable temperatures of our oceanic climate allow the local survival both of southern, warmth-loving plants and also of a relict flora of an earlier cold glacial period, the montane elements of which cannot tolerate high summer temperatures.

Plant formations of strongly oceanic character such as blanket mire and moss heath are more extensively developed and better represented in Britain (and in Ireland) than in any other part of Europe. Indeed, few areas in the world show such a spectacular development of ombrogenous peatland and the best British examples are of international importance.

Montane zones, occurring in the higher mountains in Britain, are especially extensive in Scotland. The dwarf shrub heaths, grasslands, peatlands, moss and lichen heaths, and rock communities of this zone are nearer to representing the natural condition than any other ecosystem in Britain. The montane flora as a whole may be regarded as a relict but this is shown in different degrees. Some montane plants are widespread and in all suitable habitats, eg *Saxifraga stellaris, Carex bigelowii*, and some, eg *Saxifraga cernua*, are known only in one or a few scattered localities although other localities appear suitable. The majority of British montane plants are classified as Arctic-Alpine, but some are Arctic-Sub-arctic, eg *Saxifraga oppositifolia, Silene acaulis* and a very few are Alpine, eg *Gentiana verna, Cherleria sedoides*. Other oceanic flowering plant species which reach their greatest European distribution in Britain include community dominants such as ash *(Fraxinus excelsior)* and bluebell *(Endymion non-scriptus)*. Holly *(Ilex aquifolium)* and White beam *(Sorbus aria agg)* in the tall shrub layer are also notable in Britain. The British uplands are one of the main European strongholds for birds such as the peregrine falcon *(Falco peregrinus)* and Golden eagle *(Aquila chrysaetos)* and are important wintering haunts for wildfowl and waders. A number of insular races and sub-species of a variety of fauna also occur in the uplands.

NATURE CONSERVATION OBJECTIVES IN THE UPLANDS

Nature conservation is accepted by both the Government and the public as a proper and important use of land and other national resources. The question is not whether wildlife should be conserved but rather what, where, how much and how? So that wildlife needs can be judged in relation to other land-uses and integrated with them, the objectives of nature conservation must be defined as must the strategy proposed to achieve these objectives.

In broad terms, the nature conservation objectives in the uplands are the same as those which apply generally in Britain. These are based on the twin approaches of identifying, protecting and maintaining a series of representative sites and the assemblages of plants and animals they contain (intensive conservation) and also of maintaining native plants and animals over the range of their distribution as abundantly as possible (extensive conservation) (Steele, 1972 and 1975). The basis for intensive conservation, that is nature conservation practised on sites devoted exclusively or mainly to wildlife, has been well developed. Extensive conservation has been less fully thought through and the possibilities and limitations of this second approach are not properly understood.

Intensive conservation - safeguarding selected sites

The conservation of nature in selected sites has been the main plank of conservation policy in this country. Two important White Papers (Cmnd 7122, 1947 and Cmnd 7235, 1947) emphasised that the practice of nature conservation in Britain should centre around the statutory safeguarding of a number of key areas which should adequately represent all major types of natural and semi-natural vegetation with their characteristic assemblages of plants and animals and habitat conditions of climate, topography, rocks and soils, and biotic influences. Geological and physiographic features should also be represented for their intrinsic interest. Such key areas, which we now call nature reserves, were:

> " .... to preserve and maintain as part of the nation's heritage places which can be regarded as reserves for the main

types of community and types of wild plants and animals represented in this country, both common and rare, typical and unusual, as well as places which contain physical features of special or outstanding interest .... Considered as a single system, the reserves should comprise as large a sample as possible of all the many different groups of living organisms, indigenous or established in this country as part of its natural flora and fauna and within them the serious student whatever his intent and whether he be professional or amateur, should be able to find a wealth of material and unfailing interest."

This concept, namely that the practice of nature conservation should be centred on nature reserves and that nature conservation and research should go hand-in-hand, was accepted when the Nature Conservancy (NC) was constituted in 1949 as the national government agency for nature conservation and by its successor, the Nature Conservancy Council (NCC) in 1973. The NCC has as its first function the establishment, maintenance and management of nature reserves and these are defined (National Parks and Access to the Countryside Act, 1949) as:

"lands managed for the purpose

(a) of providing, under suitable conditions and control, special opportunities for the study of, and research into, matters relating to the fauna and flora of Great Britain and the physical conditions in which they live, and for the study of geological and physiographical features of special interest in the area, or

(b) of preserving flora, fauna or geological or physiographical features of special interest in the area

or for both these purposes."

Identification of sites. To identify an adequate representation of key areas, the major types of natural and semi-natural vegetation with their characteristic assemblages of plants and animals must be described and located. Such descriptions have been made by many people over many years and this knowledge, with new information was brought together into the Nature Conservation Review (Ratcliffe, 1977 (a)). Under the chapter headings "Uplands", "Woodlands", "Peatlands" and "Open Waters", the nature conservation characteristics, but not the geology nor the physiography, of the uplands are described and key biological areas are identified on the basis of detailed criteria. These criteria include the extent of a site, its diversity and naturalness, the variety of species or communities it contains, the fragility of the site, its representativeness and position in an ecological/geographical unit, its recorded history and its potential for conservation development. The first objective of nature conservation in the uplands, namely the selection of key sites related to the natural diversity of the area has, therefore, been largely completed.

Extent of representative sites. The question: "how many sites and how much land is needed to retain an adequate representation of existing upland communities and species?" is important but difficult to answer. The uplands represent variations along many different gradients and every area has some differences from all other areas. In this sense each area is unique. To maintain everything as it is now is clearly out of the question and a good deal of subjective assessment is needed to decide what is "adequate". The selection of upland sites in the Nature Conservation Review was based on the collective judgement of many knowledgeable people and represents the best and most feasible estimate in the light of existing knowledge and resources. Additional information may result in some amendments to the list of sites but these will probably not be substantial. SSSIs too are scheduled on the best available information and these schedules are regularly revised.

Extensive conservation

The major purpose of nature reserves is "to defend the irreplaceable" (Ratcliffe, 1977 (b)) and nature reserves of one sort or another are at the heart of the effort to conserve nature in Britain. The protection and effective management of nature reserves for the purpose for which they were established is an essential objective of nature conservation practice. However, even though nature reserves and sites of equivalent status cover a substantial area in the uplands they cannot by themselves maintain wildlife as abundantly and as widely distributed as at present. To maintain wildlife extensively, conservation measures must be applied extensively.

Extensive conservation has as its aim the maintenance of wildlife in as great a variety and abundance as can be achieved on land managed primarily for other purposes. There are two aspects to it. First, what should and can be done to maintain the communities and organisms which already exist in the uplands? Second, what should and can be done to develop new communities in the new habitats that are being created in upland Britain by afforestation?

Maintenance of existing communities and species. How far conservation in upland forests should be concerned with maintaining the present occurrence and distribution of communities or species will depend on a number of factors. Resources will always be limiting and a system of priorities is needed. How should these priorities be decided? The extent to which a community or species occurs and the pattern of its distribution is clearly an important factor. But how much effort should be put into maintaining species which are at the extreme edge of their ranges in Britain but occur more abundantly elsewhere, eg the Red kite *(Milvus milvus)* in mid-Wales, compared with species which are more comfortably at home here? The former are in critically small numbers and so are much more sensitive to small changes in the environment and a disproportionately large effort may be necessary to maintain them. A great deal more information is needed for many of our species before we can determine what constitutes a viable population and know how to maintain that population.

Creation of new communities. The afforestation of the uplands with mainly non-native conifers is creating new habitats and conditions which have not occurred in Britain before. Lodgepole pine is not a substitute for Caledonian pine and Sitka spruce forests are not surrogate heaths. Yet comparisons of this sort are often made. Such comparisons miss the whole point of these new opportunities and severely hamper our ability to develop the wildlife possibilities of the upland forests. Information is needed about the new situations and the management regimes which create and maintain them before realistic conservation objectives can be set. What are the habitat characteristics of upland conifer plantations? Which native species are likely to adapt to them if introduced? Should native species be introduced into these plantations? Should non-native species be introduced? Animals and birds have been freely moved in the past but there seems to be a much greater reluctance to move plants. The reasons are not clear. Why, for example, should not *Trientalis europaea* or *Moneses uniflora* be introduced into suitable conifer plantations? A further question that might be asked is how far should non-native broadleaved trees be used in non-native conifer plantations? A great deal of hard and clear thinking and much experimenting is needed before realistic conservation objectives can be set for the new conifer forests in the uplands.

Losses and gains

Afforestation of the uplands results in the creation of new habitats which are established as the result of profound changes in the environment. Such changes arise from operations which include the draining and ploughing of land, fertilisation of the soil, planting of non-native trees, weed control (which is the control of the indigenous flora), pest control (which is the control of the indigenous fauna) and the control of grazing and fire. Afforestation does not result in the re-establishment of some earlier condition found in Britain nor is it helpful to equate these new plantations to native British woodland types. Afforestation results in new and different conditions which must be recognised for what they are if they are to be developed to the best advantage for wildlife.

The vast bulk of the new forests are composed of alien conifers grown to maximise wood production. In this respect afforestation is comparable to intensive farming. To achieve maximum production as much of a site as possible must be kept covered with trees and this factor, together with the growth characteristics of the trees planted, results in dense canopies and heavy shade. The combination of non-native trees, with an impoverished dependent fauna as compared with native trees, and heavy shade makes such forests unfavourable for many forms of wildlife. There is also the loss of wildlife which results from the destruction of existing habitats.

In creating new forests in the uplands something is lost and something is gained. The wildlife losses due to afforestation must be clearly recognised but so too must the potential gains. Trees in an otherwise treeless landscape add to habitat diversity and accommodate species which would not otherwise survive. The extent to which the flora and fauna of upland plantations can be developed and maintained depends on what foresters are prepared to do to foster wildlife. If only those areas unusable for tree planting including roads, rides and firebreaks are dedicated to wildlife then the wildlife value of plantations will be limited. If foresters are prepared to go further along the lines suggested later in the paper upland forests will become major strongholds of wildlife.

Compromise is needed at two stages. First, there must be a balance between the land that is planted and the land left unplanted. This helps to ensure the widespread survival of existing communities and species. Where this balance should lie and what unit of land should be used in deciding the balance are matters for discussion and will depend on local circumstances. From the wildlife aspect, the Watsonian vice-county may be an appropriate planning unit in terms of its size and biological characteristics. Second, compromises are needed in the management of upland areas as they are being developed for forestry and after the establishment of forests. Such compromises will include a determination of the pattern and area of existing vegetation to be incorporated into the planting plan and modifications to standard silviculture and management regimes to favour wildlife.

REVIEW OF AFFORESTATION IN RELATION TO WILDLIFE

Compared with Continental Europe, the upland vegetation in Britain is impoverished in species with the exception of bryophytes (Dickson, 1973; Welch, 1974) and pollen and fossil remains suggest that comparatively few species have become extinct in Britain since the end of the last Ice Age (Welch, 1974).

More recently, grazing and burning have substantially modified vegetation and have resulted, for example, in the extension of *Molinia caerulea* in the western highlands and the destruction of the tree and scrub cover which formerly existed over much of the hills and uplands. The removal of grazing animals does not necessarily result in a reversal of this process and the re-appearance of trees and shrubs. This may be due to the lack of a seed source, or, where seed exists, to the growth of tussocky grasses (Ball, 1974) which create conditions unsuitable for the establishment of tree seedlings.

The increase in floristic richness is related to increasing pH and nutrient content (Grime, 1973) rather than to climatic and soil moisture gradients (McVean and Ratcliffe, 1962). Such floristically rich areas are small and often associated with high altitude or rock outcrops and are therefore unlikely to be affected by afforestation. Some important wetland and native deciduous woodland areas occur in the planting zone and should be protected as special sites or, if they are small, incorporated into the design of new forests.

The planting of an additional 1.8 million hectares (FC, 1978) still allows for considerable open areas in Scotland and leaves virtually untouched the uplands of the English and Welsh national parks and Areas of Outstanding Natural Beauty. Nevertheless, many fine heather moors will fall within potentially plantable land in Scotland and any planting programme must ensure that substantial examples of these moors are maintained in their present state.

The relationship between birds requiring large territories and afforestation needs further investigation. Eagles have a territory size of 4,800 hectares to 7,200 hectares on average (Newton, 1972) in which to find their food. It is suggested that further afforestation by reducing the area of open country would reduce the available food supply. It has been shown (Marquiss, Newton and Ratcliffe, 1978) that there has been a reduction in numbers of ravens in southern Scotland and Northumberland because of increasing afforestation.

Much of the literature on flora and fauna and forestry is concerned with changes brought by afforestation of the existing habitat. Lack and Lack (1951) observed the loss of heathland birds following afforestation and the changes from birds dependent on scrub to birds dependent on trees in maturing pine plantations in the Breckland. Hope Jones (1966) discusses the changes in bird numbers and species composition, following afforestation of dune land at Newborough Warren. Phillips (1973) writes of the occurrence of whinchats in young afforested areas, on what was previously heathery grounds and comments on their even spread. Batten and Pomeroy (1969) describe the effects of the Nature Conservancy's afforestation on the island of Rhum on bird populations there. Ploughing appeared to be a major factor in thé doubling of bird density in the first year, due probably to increased food availability and shelter. The bird density in the eight year-old plantations was seven times greater than densities on the newly planted moorland. More recently, Moss (1978) has quantified the gains in songbird densities following the establishment and growth of plantations.

The total densities of 400 - 500 pairs/km^2 in spruce plantations are greater than those on the unplanted moorland but the species composition is different. He also states that diversity of tree species, woodland structure and soil fertility are influencing factors, and that spruce plantations support a smaller number of bird species and lower densities than broadleaved or mixed woodlands.

The varied wading bird community of moorland, including Golden plover *(Pluvialis apricaria)* and dunlin *(Calidris alpina)*, is eliminated by afforestation. The only wading species which can live in woodland, the woodcock *(Scolopax rusticola)*, does so only when the woodland structure and composition are diverse.

Two papers offer quantifiable advice relating to birds. Williamson (1972), in discussing bird life in coniferous forests in Herefordshire, recommends the retention of broadleaved stands in an irregular pattern including some isolated broadleaf trees. Broadleaf blocks of under half a hectare in conifer forests are unattractive to birds and two blocks of a third to a half hectare sited close together are better.

Moore and Hooper (1975) in looking at bird populations in widely scattered woods mainly in lowland England but including the Cheviots and the Outer Hebrides regarded them as ecological islands and suggested as a rule of thumb that to double the number of species in a wood its area must be increased tenfold. They go on to indicate minimum areas for a nesting pair of several woodland species. These areas apply to conditions different from those mainly found in upland afforestation but can provide pointers. Moore and Williamson both indicate that large woods are better than small woods but suggest that several small deciduous blocks are better close together or replaced by one large one.

Helliwell (1971) compared open hill with plantations at Cairnsmore of Fleet. In considering 'conservation value' he has favoured moorland birds against songbirds, large mammals against small, and animals against plants, thus arriving at a 'weighted' view and one which favours the existing habitat. Using this approach he suggests that planting of up to 30% of the open hill is beneficial to wildlife generally, with a sharp falling off of the benefit when 50% or more is afforested.

A number of Forestry Commission records discuss individual mammals, birds and insects. The Red squirrel (101 A M Tittensor) depends on forests since pine seeds are its staple food. A continuous supply of cones (pine and larch are preferable) depends on a good age class distribution to maintain trees of cone-bearing age and also the retention of some old trees. Pine martens (64 H G Hurrell) too find the forest a good habitat if suitable crags or rocks in which to breed and small mammals, birds and berries to eat are available. Blackgame (66 C E Palmar) which can damage newly planted trees have increased with afforestation and forests, provided there are some small open patches, suit them well. Very small mammals such as woodland mice (118 J Gurnell) live largely on seeds and berries, and are themselves a source of food for larger animals and birds. Butterflies (65 T C Robinson) are few in species in the hills and uplands. Some continue to depend on moorland (eg, Mountain ringlet), but others are likely to be favoured by the sheltered forest rides or road verges where grasses, herbs and some shrubby plants grow.

The copious literature on Red deer is reviewed in "Ecology of Red Deer" (ITE, 1977) including their effects on plantations, the damage caused to trees and the problems of excluding them from forests. The Red Deer Commission in its 1977 and 1978 annual reports states that Red deer populations in Scotland are too high and should be reduced but the current sporting arrangements, combined with existing legislation, makes this unlikely and poses problems for foresters and conservationists alike.

Little had been written about the changes in vegetation arising from afforestation, until a recent group of reports commissioned by the Nature Conservancy Council from the Institute of Terrestrial Ecology (Natural Environment Research Council). Hill (1978) compared land planted with Sitka spruce between 1933 and 1950 in Clwyd, Wales with adjacent unplanted land. He found that the numbers of plant species remained much the same but the character of the flora changed. Most of the new vascular plants appeared on roadsides, while most of the new bryophytes, which are shade-tolerant, appeared under the trees. There was a loss of bog and marsh plants. The additions to the flora were mainly 'lowland' type plants and though the commoner moorland plants persisted there was only a small increase, mainly of bryophytes, in the woodland plants.

Stevens (1978) investigated the length of time seeds from certain moorland plants remain viable in the ground after afforestation. Samples were taken from Douglas fir planted in 1927 in Gwynedd, Wales, from Sitka spruce planted between 1932 and 1971 in Dumfriesshire and Clwyd and from pine and larch planted between 1932 and 1950 in Dyfed, Wales. A number of moorland plants were shown to have seed which had survived for 40 years and which could germinate when the forest was felled. The original populations of plants, the soil conditions, the litter layer and the seeding substratum all influence results, and are more important than the tree species and its age. Seeds which are slow to germinate, such as those of whin *(Ulex europeaus)* are at a disadvantage in re-establishing themselves when trees are felled. This in turn affects the ability of such species to persist through the second rotation. Birch seed can persist in the ground, though the seed is more often blown in and can be inhibited by strongly growing vegetation.

Hill and Hays (1978) studied the vegetation under a variety of experimental tree plots established in 1933, on a heather moor in Gwor. These included alder, birch, pine and Sitka spruce. The vegetation under the first three species was broadly similar but it was markedly different under Sitka spruce. Hill and Hays suggest that this difference is related to the dense thicket stage in the spruce and postulate that vascular plants do not persist below about 10 - 20%, and bryophytes between 2 - 9% relative illumination, though the latter can be more sensitive to local influences such as the build-up of the litter layer.

Helliwell (1978) considered the floristic diversity in some Swedish forests and related this to possible management of coniferous forests in Britain. As with Grime (1973), he found that species diversity decreases with increasing soil acidity. His findings also agreed with others that species numbers in plantations are strongly associated with the amount of light reaching the forest floor. He goes on to suggest that the numbers of species in plantations are directly proportional to the amounts of light penetrating the canopy and that diversity of plant species can be encouraged by preventing complete canopy closure.

Evans (1978) studied road vegetation in a number of forests in Wales, south-west Scotland and northern England. He found the diversity of vascular plants much greater on the road lines than within the forest itself, and that the verges were the preferred zone due to disturbance and sometimes to the effect of the road stone used. In the study area, the average area of road lines was 6.8 ha/km^2 (or about 7%) of which 1.6 ha/km^2 (or about 1.5%) were verges. It was found that rides were less diverse and that their vegetation was similar to the adjacent unplanted moorland.

These papers are valuable in providing information about some of the vegetation changes which take place in areas planted with trees, but many unanswered questions remain. A significant number of papers have been written on birds and deer in forests and more recently, on vegetation changes and patterns, but there is still very little precise information on which to base the design of a forest pattern for nature conservation and wildlife diversity. General principles have been put forward by Steele (1971) but nowhere is advice detailed and quantified in a way that is of practical use to the forest manager in the uplands. In 1967 George Ryle, speaking at a Society (now Institute) of Foresters' discussion meeting on "Wildlife Conservation in Forestry Management", stated "foresters should take advice from naturalists". In 1979 we should ask whether the naturalist can give the forester the advice he needs. There are many questions. What are the area/edge effect relationships in upland forests? What percentage of a coniferous woodland should be developed for wildlife? How should this be done? Should the development be as a number of small areas or as one or two larger ones? When does an area or 'island of difference' become so small as to be ineffective? How important for wildlife are water courses and open water? Should areas with water be linked with wildlife areas? How does an increased density of roads and rides affect wildlife? What kind of forest structure will most benefit wildlife? Should a distinctive forest flora be encouraged to develop and then be maintained and much less emphasis placed on the retention of moorland plants? Must any deciduous trees planted be native? What are the effects of fertilising the tree crop on the vegetation?

A great deal has been done by the Forestry Commission and others to provide for nature conservation in forests and Glen Affric, Grizedale and Glen Tanar are good examples. Nonetheless, if the design and management of new forests is to reflect the maximum benefit to plants and animals consistent with the primary purpose of timber production much more information is needed.

PROPOSALS FOR SAFEGUARDING KEY SITES

No one under-estimates the importance of conserving our special sites. Fraser Darling, writing in 1947, referred to the problem of maintaining and regenerating the important semi-natural woodland fragments of the West Highlands, and his concern is repeated more than 20 years later in 1969 by Kenneth Williamson in relation to the value of these same woods as bird habitats. Changes, even since the publication of the Nature Conservation Review in 1977, highlight the continuing loss of some of our best sites and recent surveys commissioned by the NCC show that perhaps a third of the area of broadleaved woodland in Scotland has been lost since 1947.

The Nature Conservation Review (Ratcliffe, 1977) lists key conservation sites in the uplands and describes the criteria on which selection was based. Few other countries are as fortunate in having such a base on which to build the strategy for safeguarding their flora and fauna.

Once identified, key sites must be protected. Different statutory designations such as National Nature Reserve (NNR), Local Nature Reserve (LNR), and Sites of Special Scientific Interest (SSSI), are available and how they are used will depend on the value attached to the site and the protective strategy adopted. All Grade 1 and 2 sites in the Nature Conservation Review have been notified as SSSIs. They are however of National Nature Reserve status and should be given this higher degree of protection. The SSSI designation is also accorded to a large number of other sites which form part of the national network of areas especially valuable for wildlife and physical features. In addition to sites statutorily declared by the Nature Conservancy Council there are non-statutory nature reserves under the control of voluntary conservation bodies such as the Royal Society for the Protection of Birds, the Scottish Wildlife Trust and County Trusts for Nature Conservation.

Many land users, including those concerned with development, dislike protective designation of land as was shown by the widespread opposition to the proposed North Pennines Area of Outstanding Natural Beauty or the Highland Regional Council's concern about the implications for development of the publication of 'Scotland's Scenic Heritage'. Designation is often regarded as a way of sterilising land rather than as a help in reaching well informed decisions. Such concern can relate to the criteria used for designation and the extent of land involved. Sites of Special Scientific Interest are sometimes questioned on both counts.

In relation to potentially plantable land in Britain, about 120,000 hectares designated as NNRs or listed in the Nature Conservation Review (NCR) lie in Scotland. These sites are those greater than 200 hectares in area. There are a further approximately 200,000 hectares which are SSSIs not included in the NCR and which as yet have not been related to potentially plantable land. In England and Wales some 190,000 hectares which include NNRs, NCR sites and SSSIs over 400 hectares in area, coincide with potentially plantable land. However, even the largest planting alternative suggested in the Wood Production Outlook in Britain (FC, 1978) excludes plantable land lying within English and Welsh National Parks and Areas of Outstanding Natural Beauty amounting to about 650,000 hectares and probably more than half the 190,000 hectares of English and Welsh conservation sites occur here. For nearly 30 years designation of SSSIs has been used by nature conservationists to protect the scientific interest of these sites. Such designation has proved to be a useful if somewhat limited tool requiring consultation between planning authorities and the NCC when a proposed development falls within the planning acts but not for land use changes that do not. Changes of land use concerned with the practice of forestry and agriculture are not caught by the system except where, since 1974, there is consultation with the Nature Conservancy Council when Dedication Basis III applications are being considered.

During the last decade the continued intensification of agriculture and the expansion of forestry has posed new problems for nature conservation and more changes have taken place in the countryside outwith development controlled by the planning acts than in the past. It should now be considered whether the arrangements following designation as an SSSI require strengthening. There may be a need to introduce notification of a proposed change of use in management within a site where such changes are not covered by the planning acts but may have serious implications for the scientific integrity of the site. Notification could take the form of an advanced warning by the owner or occupier of intent and allow a short period, say up to three months, to elapse before commencing work. The period would be used for a discussion of possible safeguards for wildlife interests and to try to reach mutually acceptable agreement on the future management of the site.

Nature reserve agreements and leases are of long-standing. They are entered into voluntarily between the Conservancy and owners, and in the past often for a nominal fee. They include a commitment by the owner to manage the land for nature conservation along lines agreed with the NCC at the time of the agreement or lease. Such arrangements, although there are difficulties arising out of partial control and the limited period, have on the whole served nature conservation well. What the attitudes of owners will be when these leases and agreements come up for renewal remains to be seen. Although it can be fairly argued that in the long run ownership of the best conservation sites should be vested in the NCC this is not possible with the level of resources currently available to NCC.

Many organisms cannot be satisfactory protected solely on a site basis, eg birds, and nature conservation legislation must be used to safeguard them.

PROPOSALS FOR IMPROVING THE NEW FORESTS FOR WILDLIFE

This paper has underlined the lack of available information on which to base advice on nature conservation especially in relation to the design and management of new forests. These matters are particularly relevant now when consideration is being given to a substantial increase in afforestation in the uplands. Even though information is so limited some practical suggestions concerning the design of new forests for nature conservation are put forward. These suggestions may serve to develop ideas which could form a basis for defining 'the securing of environmental benefit', one of the objectives in forestry Basis III dedication schemes. We are not concerned in this paper with the landscape aspect of forest design but recognise that there can be coincidence of interest between good landscape and forest design for nature conservation.

Size of wildlife areas

If new forests are to provide opportunities for nature conservation and wildlife diversity how much of them should be developed for this rather than for timber production? The level of investment required to buy land and establish plantations encourages the fullest use of land for growing timber. There will therefore be a tendency for forest land set aside for special purposes such as nature conservation to be the minimum necessary to achieve conservation objectives and foresters will seek to locate such areas so as not to hinder silviculture and harvesting in the surrounding forest.

At present the Forestry Commission allows for a 15% reduction in volume production when making forecast calculations. This reduction takes account of land under roads and rides, of very small unplanted areas, very small pockets of scrub, and reduced production due to check or cleared windblow. In conifer plantations established before 1940 about 10% of the land is classed as being on non-standard regimes for amenity and landscape reasons which also allows part of the crop to be grown beyond the normal rotation. Since the middle sixties the Commission has maintained their existing area of broadleaved woodland (35 - 40,000 hectares) most of which is lowland in character and mainly situated in England. More important in much of the uplands is the 'retained scrub' category. This is scrub woodland growing on land acquired by the Commission which is not yet planted. Currently this stands at about 7,000 hectares of which nearly half is in Scotland.

It is proposed that 5% of the forest should be used primarily for nature conservation and that this 5% should be seen as a part of the non-standard regime area, encompassing broadleaf woodland and retained scrub where these occur. The allowance of 15% loss of volume production also enable small unplanted areas which increase the conservation value of a site or act as refuges for rare plants to be retained. This proposal does not apply to completely separate blocks of 50 hectares and under. Such small areas have a considerable interaction with the surrounding habitat and a nature conservation block within them would be less than 2½ hectares and so unlikely to be very effective (Moore and Hooper, 1975). It could be argued that blocks of 100 hectares and under also should be excluded but the view is taken that a conservation block of 2½ - 5 hectares can be effective when surrounded by other woodland. These prescriptions refer to forests with no special nature conservation features. Special features will need special consideration.

A strategy for improving upland forests for nature conservation and wildlife should seek to encourage the development of new communities in addition to maintaining the old. The 5% nature conservation blocks should be used to provide conditions specially favourable to wildlife and can be linked with other valuable wildlife features such as stream sides and gorges. The retention of a further 5% of the forest beyond the normal felling age to create small areas of mature forest adjacent to or linked with nature conservation blocks would help to provide continuity from one forest rotation to another. Larch, planted on rocky outcrops and as a scatter through the forest, encourages the development of a richer ground vegetation. Wide road verges increase the value of the 'edge' effect. Small areas in the forest with high scientific interest or containing rare species should be left in their existing state. In some cases it may be possible to incorporate such areas into the nature conservation blocks.

Design of forests for wildlife

How can the 5% for nature conservation be best deployed? What is the desirable relationship between numbers of areas and size of areas? One large area is regarded (Moore and Hooper, 1975) as better than several smaller ones and specifically it is suggested that in general wildlife areas should not be less than 5 hectares and preferably not less than 10 hectares in extent. Within a forest of 400 hectares it may be desirable to plan on one large area which in this case would be 20 hectares. Forests greater in size that 500 hectares might, for example, contain one 20 hectare block and one 10 hectare block managed specially for wildlife.

The evidence, at least for birds, shows a direct relationship between woodland size and bird numbers and it could be argued that the larger the block the better and that to restrict its size to 20 or 25 hectares is arbitrary. However, in the uplands, the nature conservation blocks being specially created will lie within much larger areas of forest and there are other factors such as climate, soil fertility, silviculture and management which may limit the extent of the areas which can be set aside.

Generally it is suggested that the nature conservation blocks should be planted with birch, perhaps some hazel and with alder in wetter sites. It would be expected that rowan would establish itself from berries brought in by birds. There can be no objection to the inclusion of scattered non-native hardwoods if these will grow where native hardwoods do not although birch is seen as the main hardwood constituent of these blocks. Birch is a very important tree in the uplands where it flourishes and can be allowed to persist into old age. It is a soil improver (Miles, 1977) and its light shade provides conditions for a varied flora beneath its canopy which can in its turn provide shelter and food for birds and animals.

In some places birch may already be present and be regarded as retained scrub and therefore included in the forest plan but in others it may have been grazed out and will require re-establishing. Useful work on the re-establishment of native trees including oak was carried out on the island of Rhum by the Nature Conservancy (Miles and Kinnaird, 1979).

Location of wildlife areas

Where should wildlife areas be located in the forest? If the forest contains water courses, the nature conservation block should be situated beside or across these. In the uplands, streamsides and gorges often contain trees and shrubs and will already be wildlife refuges. The linking of such areas with the nature conservation blocks should enhance the wildlife possibilities of both. If the nature conservation blocks can be linked with or include any small areas of high scientific interest or rare species that is also desirable, but if a choice has to be made, priority should be for their location to be on a water course. On the whole, it is also better to site a nature conservation block within the forest, particularly when linked to a water course, rather than on the forest/moorland edge.

Over the forest as a whole it is suggested that 5% of the forest should be allowed to grow beyond normal felling age but not necessarily until the trees fall down or become rotten, though the value of dead and decaying wood for birds and invertebrates is recognised. This percentage is seen as the proportion of the area which could reasonably be included in the non-standard regime as currently practised in older Commission woods. Rotations in the private sector are normally longer than in the Commission.

Shorter rotations allow for a greater proportion of bare ground in the forest at any one time so it may be argued that this gives greater opportunities for subsequent recolonisation by plants. Such plants are not forest species and depend on the viability of the buried seed which grows quickly after a forest is felled. Whether these plants will persist after the second rotation or what the likelihood of dominance by grasses such as *Deschampsia flexuosa* will be is still uncertain. The purpose of retaining some areas of mature conifer forest grown on a longer rotation is to encourage the development of a woodland flora and fauna which may then colonise the shorter rotation forest areas. There may be merit therefore in linking at least part of the 5% of older plantations with the nature conservation block. Careful planning of the forest blocks and rotations before planting begins will be necessary if there is to be a continuous link between the older blocks and the nature conservation areas.

Larch, at present, has an accepted place on certain sites such as rocky outcrops, and as a scatter tree in plantations, usually for amenity reasons. Its location is largely dictated by terrain but growing some larch by the forest road or adjacent to streams can provide additional advantages for nature conservation while as scatter trees in the forest immediately round the nature conservation blocks they can break the canopy and perhaps assist the spread of species.

Forest practices in relation to wildlife

This paper assumes that most of the new forests will be planted with Sitka spruce except in the most difficult sites where *Pinus contorta* was (until Pine Beauty Moth appeared) the preferred species. There is unlikely to be any significant species switch in the second rotation. The proportions of Scots pine and larch currently being planted at 20% and 12½% respectively of the conifer total are likely to continue to drop. There may be opportunities on good sites for expanding very slightly the area of Douglas fir which is currently about 4%.

There is concern about the long-term effect of conifer afforestation on soils. Adverse effects may be more of a problem on brown earths, where podsolisation is shown to be accelerated (Miles, 1977), rather than on peats, on which much of upland afforestation takes place. More needs to be known on this subject and also on the part birch might play in maintaining soil quality.

Modern forest practice includes crop fertilisation and it is likely that at least in some situations this will increase. In the poor acid soils of most forest lands any increase in fertility is likely to result in a greater variety of plants.

Size and shape of felling coupes are often a matter of concern to amenity interests, but generally the areas felled under current practice poses no major problems for nature conservation provided that wildlife areas within the forest are not fragmented.

Introductions

Opinions on introduction differ and there is room for debate and clear thinking. Few would question the re-introduction of the capercaillie and the ptarmigan would be an attractive addition to Galloway. It also seems sensible to hasten the development of a more diverse flora in spruce woods by introducing species such as *Trientalis europaeus*. A general rule may be to accept the carefully recorded movement of plants and animals from one part of Britain to another. Any introductions into Britain are a different matter and would have to be very carefully considered and licensed.

Advice, information and consultation

If extensive conservation is to be successful those responsible for land-use decisions and for the management of land must be aware of the conservation opportunities open to them and the obligations upon them. An important aid to nature conservation in the uplands must therefore be the provision of sound advice and information on nature conservation. This needs to cover a wide range of possibilities. More information is needed on the integration of wildlife conservation with forestry and this is especially important in relation to the harvesting and regeneration of the Caledonian pine forests. A series of demonstration plots of different management regimes showing the costs and benefits for both timber and wildlife supported by commercial and biological records would have a very powerful influence on the development of conservation measures in the uplands.

Consultation can come about through statutory provisions (eg, a change of use for Sites of Special Scientific Interest) or voluntarily. Consultations provide opportunities for making known the nature conservation values of an area whether this be at site, local, regional or national level, and of ensuring that these values are fully considered in the use and management of land. To be effective, consultation must take place early and not only must conservation objectives be stated but methods for achieving these objectives must also be suggested.

CONCLUSIONS

Forestry in the uplands has gone on for many years and will continue whatever the estimated target size of our national forests or the rate at which planting proceeds. The safeguarding of key sites in the uplands, as elsewhere in Britain, is one aspect of the nature conservation effort. The other is the development of the new conifer forests for wildlife.

In the urban lowlands, perhaps out of necessity, conservationists have come to understand that even the backyards of Birmingham contain islands of wildlife and the creation of the Cotswold Water Park and Strathclyde Park provided opportunities to encourage wildlife in new ways. Sadly, few conservationists have so far recognised the opportunities for wildlife provided by the new forests. Comments are restricted to deploring the loss of existing habitats and are not balanced by a realistic assessment of possible gains for wildlife. Some of this concern over loss of habitat is little related to nature conservation but is occasioned more by changes in scenery, dislike of conifers, and dislike of change generally. The loss of communities or species as a result of afforestation can give cause for concern but this is not to say that all afforestation is detrimental to wildlife. Grasping these new opportunities is largely about attitudes to change. The conservationist must realise that what is new is not necessarily a loss. It is for the forester to realise, and he is helped in this by the long periods over which a tree crop is grown, that what exists has taken time to develop and should not lightly be destroyed.

In this paper we have put forward proposals which we believe will help to integrate upland wildlife conservation with forestry. Our proposals will undoubtedly be questioned and hopefully this questioning will lead to better conservation practices in the uplands.

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THE ROLE OF AGRICULTURE AND FORESTRY

John B. Cameron
President
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THE ROLE OF AGRICULTURE AND FORESTRY

John B. Cameron
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Back in the days of that great musical comedy "Oklahoma", it was generally agreed that "the farmer and cowboy can't be friends." While we seem to have got over that great divide, the next great divide - or so we are told - is between the farmer and the forester.

Some of the press and television reports still suggest a struggle between farmers' interests and environmental groups on the one hand, and the Forestry Commission and private forestry interests on the other. The noise of battle is occasionally supposed to be heard reverberating around the Scottish hills and uplands.

In fact, the reverse is - and certainly ought to be - the case. I know that all three of us speaking this morning are anxious to see co-operation rather than conflict between the two sectors. The Union itself has never opposed afforestation in principle, and these views were reiterated in a policy statement we issued earlier this year, as those who read beyond the first few pages would discover.

Our anxiety is to ensure that new plantings are complementary to, rather than competitive with farming. Agriculture and forestry have an immense part to play in the greater economic wellbeing of Britain, and I wish firstly to discuss this aspect briefly.

The National Economy

Over and over again, Government white papers, official documents, official and unofficial studies have stressed the potential import saving role of both farming and forestry. However much oil and gas we get from the North Sea or the Caledonian Sea or wherever around our shores, the need

Section M (Agriculture) Joint with Section K (Forestry) to place our economic structure on a sounder permanent base is just as important as it has always been - not withstanding our newly found wealth - after all, the oil and gas reserves are essentially finite.

Successive governments - and this one too - have acknowledged the importance to the economy generally of an expanding farming industry, even though actual policies pursued may have fallen short of professed objectives. Nevertheless, the objective remains, and expansion of the sheep sector is an important and integral part of any expansion programme. The previous Government's White Paper suggested an expansion of 20% in sheepmeat production, and this is very closely in line with our own views of the position.

Agriculture and forestry, together with their ancillary industries, have demonstrated over the last thirty years the contribution they can make to the economy through vastly increased labour productivity (only exceeded by the very high technology industries, such as electronics). All the evidence suggests that these improvements in productivity will continue at a significant level. Apart from fuel, the other two of our three largest single import bills are for food, and timber and timber products. While in both of these sectors it is clearly impossible for us to achieve total self-sufficiency, farming and forestry both have a major contribution to make in marketing home production.

At the same time, both industries are of very considerable importance in maintaining a satisfactory social structure in the country areas. Both have a high employment multiplier effect, leading to a range of other jobs requiring varied skills which are dependent upon the prosperity of farming or forestry.

Competition for Land

The problem is that, on the face of it, expansion of both farming and forestry are incompatible objectives - at least in the hills and uplands of Scotland, where the vast bulk of any new planting must take place. On the low ground, farming has always had to compete - and usually lost -

against industrial, commercial, or residential developments and so many hill farmers have felt very keenly the pressure of forestry, with what many see as a limitless reservoir of cash to buy up much of the best hill ground.

Let us look back for a minute, not because I want to lecture again about the wrongs of the past, but because I believe it is important that the background to our attitude to forestry is understood, because I believe that then we can together more usefully tackle the present problems.

The last twenty years have seen large areas of some of the best of our hill and upland farms planted with trees, both by the Forestry Commission, and also by private forestry interests. There were obviously very good reasons why these purchases occurred in the way they did, but I will suggest in a moment very good reasons why we in the Union have called for a very basic re-thinking of these policies.

Progress of Afforestation

For many years, the Forestry Commission, with an internal if not publicly stated annual target acreage of land purchases, had to buy heavily in the land market in order to reach its targets. Over much of the same period, depending on the tax position under different Governments, private forestry interests were also in the market for land, although perhaps on a smaller scale. As the Forestry Commission, the N.F.U. and most recently, Russell Fairgrieve, M.P., all noted the effect was to push up the price of land with little regard to its agricultural value, and - some would suspect - little regard to its value for afforestation.

The end result was that land was planted without proper regard to its agricultural value, with little regard to the employment and social implications in the district, with little regard to the effect on the natural environment, and certainly with little regard to the effect on neighbouring farmers. While both Forestry Commission plantings, and private plantings subject to grant aid, had to have the approval of the

Secretary of State through the Department of Agriculture, it is now widely recognised that there were many cases let through the net which, in the last two or three years would have certainly been turned down for planting, because of the potential agricultural production.

The effect has been dramatic, so far as the future of the forestry industry is concerned. Even with no further new planting whatsoever, the Forestry Commission estimate that by 1992 to 1996 British timber production will be more than double the present level and around three times the present level by the year 2025. The capital commitments that have already been made to forestry should result in massive import savings regardless of the level of future new investment in new plantings.

But the effect of these new plantings has also been extremely significant outside the industry, because of the scale and concentration of plantings. There are many areas of Scotland, particularly in Galloway and Argyll, where hill and upland farming has been effectively eliminated, and the traditional landscape of bare rolling hills has been replaced by continuous lines of conifers marching to the horizon and beyond.

Social and Environmental Impact

The social and environmental impact has been extremely serious for these areas. While there has always been, and will continue to be, much argument about the relative levels of employment in forestry and agriculture, the effect of these huge afforestations was to push out the agricultural population, replacing them for a relately brief period by a temporarily larger work force brought in to establish the new plantations.

Because wide areas of the newly planted land was all of an age, often when the plantations were fully established the labour force in the glen concerned fell quickly, frequently far below the original level. Many of us know of forestry villages, which were built to accommodate forestry workers during the establishment stage, but some of which are now almost or completely empty, apart perhaps from use as summer holiday homes.

We also cannot forget the effect on the adjoining agricultural land of the establishment of these large plantations. In the early stages, erosion can become a very serious problem as run off from the newly ploughed and planted slopes is very much greater. We are already experiencing the threat of serious damage to the newest and fastest expanding sector of our industry - fish farming - from pollution, following erosion.

There is also the question of water supplies, once a forest becomes established. We know that a number of water authorities are concerned at the effect on public water supplies of the take up of water from large scale afforestations.

Nor must we forget the effect of blanket afforestation on the landscape, major conservation, tourism and recreation. The efforts of the Forestry Commission to publicise the recreational opportunities of their woodlands are most praiseworthy, but I would think it extremely unlikely that tourists will come to see a panorama of endless forests - they can see large plantations of conifers in a dozen countries, but our rolling hills have a special attraction.

The conclusion of all our thinking is that we must think in terms of smaller basic units of afforestation. I want to deal particularly with the complementary nature of agriculture and this type of forestry, but I think we should first further consider the implications of a continuation of the traditional approach to afforestation.

Threat of Land Use Controls

Already we are seeing very clear moves against blanket afforestation, quite apart from the agricultural interests. Local authorities and other representative organisations have expressed doubt about the effect on the environment, on tourism, and on the population structure of rural areas. There must be a very real danger that if we press on with afforestation of whole farms and glens, particularly in the more fragile areas, an irresistible pressure will grow up for planning or other controls on large scale forestry.

Such formal controls would be in no one's interest. We already recognise that in some areas afforestation may be the only economically viable solution for a whole district, and that in some cases the sale of land for forestry may well be the means by which hill farming can be revitalised.

I have already referred to expansion of sheepmeat production. It is inevitable that a large part of this expansion will have to occur in the hills and uplands, and any reduction in the total carrying capacity of our hills will jeopardise the objective. This is why we are opposed to the continued takeover of whole farms which are, or could easily become, viable economic units. That is not to say that there are some farms where the agricultural potential is so low that large portions cannot be passed for forestry.

Integration - Agricultural Aspects

We believe that in fact it is perfectly possible to integrate agriculture and forestry to such an extent that new plantings can go hand in hand with maintenance and indeed expansion of production from the hills.

There is a number of classic farms and estates already demonstrating ways in which integration can be achieved to the benefit of both agriculture and forestry, and I expect that many of you visited the Whitchester Estate yesterday afternoon and saw the possibilities at first hand.

What can be achieved through integration? Firstly let us look at the agricultural benefit.

There is considerable evidence that planting of shelter belts can have a significant effect on stocking rates through protection from wind and other adjustments to the micro climate. There is, of course, a possible disadvantage that sheep may be encouraged to seek shelter up against a shelter belt where snowdrifts may occur on hills that would otherwise be swept clear of snow by the wind; but this disadvantage can be largely offset by careful planning of the layout of plantations.

There is also the benefit of improved access roads and other facilities, which can be justified for forestry enterprises but can be made to serve both farming and forestry. There is plenty of evidence that easier access can very substantially increase the carrying capacity of many hill farms, through facilitating the application of lime, slag and other forms of land improvement.

Plantations can also assist in division of the farm into more manageable hefts, particularly in the provision of holding parks, which are vital for tupping and lambing, as well as affording means of grazing control.

But perhaps the largest spin off of forestry on the farm is from the extra cash that can be made available. Disposal of land to private forestry interests or the Forestry Commission can transform the whole economic position of many of our hill farms. Capital becomes available for land improvement with the tremendous benefits this can bring in the more favourable circumstances, improvement in the breeding stock itself, and many other improvements. The question of how a farmer can fund his own planting programme is one that I want to return to.

Integration and Forestry

Now from the forestry point of view, there are demonstrable disadvantages in the smaller plantation sizes and perhaps restriction to poorer quality land following upon an integration programme. We must recognise that these are disadvantages, but I believe that they are significantly offset by other factors.

Firstly, the agricultural and political opposition to blanket afforestation, and therefore to afforestation as a whole, will diminish, instead of possibly building up to a level which could make new plantings more difficult on any scale.

Secondly, as we have already noted, the historic way of achieving new plantings was to buy up whole farms or indeed whole estates, and this had the offsetting effect of pushing up land prices to levels which bore little relation to the agricultural value, and, I suspect, very often little relation to the afforestation value. The Forestry Commission's

Working Group, in their review, "The Wood Production outlook in Britain", drew attention to the effect of differential rates of planting on land prices.

If, however, a large proportion of new plantings are in these smaller units the effect on land prices would be far less dramatic and therefore the overall rate of return could be substantially improved.

In addition, in large scale plantings, establishment costs will include a substantial element for additional infrastructures such as housing, much of which may be under utilised for much of its life. A more gradual approach may enable afforestation to take place without disturbing the basic employment patterns of the district concerned, possibly even including part-time employment at certain seasons for agricultural workers.

Encouraging Integration

The basic problem is how to encourage farmers to interest themselves in this type of integrated scheme. Many will be firmly opposed to sale of land to either the Forestry Commission or private interests and thus losing control of important areas in the centre of their enterprise.

A more satisfactory solution to many farmers could be a leasing arrangement which a number of private forestry interests already offer to interested farmers. These possibilities should be further publicised, and the Forestry Commission should expand its activities in this area.

Perhaps the greatest potential lies in the farmer undertaking his own forestry work so that he, as well as the private forestry interests, are encouraged to plant small areas planting grants should be adjusted so that special encouragement is given to offset the additional costs of small scale plantations.

The farmer-planter faces two main problems - how can he ensure that he receives an income from the ground while the trees grow to maturity; and how will he secure proper management of his plantations and marketing of thinnings and the end product?

The vast majority of farmers cannot afford to dedicate substantial areas of land to trees so that their sons or grandsons can obtain the benefit, even though establishment costs may be subject to substantial grant aid. Apart from management costs, most of us will need some kind of income from all our ground in order to keep our heads above water, and find it extremely difficult to take the long term view which substantial afforestation requires.

The solution to this problem lies in introduction of a funding arrangement whereby the small planter can obtain advances of income on a crop of trees, while the plantation is maturing. This is not the time to go into the details of the scheme, but the funds should be available on an annual basis, related over a period of years to a certain proportion of the estimated value of the plantation at maturity. There would have to be some kind of escalator clause to allow for the fall in the value of money and the rising value of the plantation at harvest. I would think perhaps that the Forestry Commission may be the most suitable agency to undertake funding schemes of this kind, with appropriate Government encouragement.

The Forestry Commission should also consider widening its services to provide management and marketing assistance on a greater scale than at present. Some farmers may wish the Commission - or private forestry interests - to take over the complete management of their forestry enterprise, but others would only require advice on management techniques. The same considerations apply to marketing, where in some cases the planter and the Commission or private interest may agree that marketing of timber or thinnings will be entirely in the hands of the agency, on a fee or commission basis; whereas at the other extreme advice may be all that the farmer wishes.

Importance of Flexibility

The key note in any approach to this problem must be flexibility. The circumstances in each case will be different, and the degree of control and influence that a farmer-planter wishes to exercise will differ.

Inevitably, I will be asked what level of new plantings I believe could be achieved by the type of programme I have set out. I do not propose to answer this question, because I believe that many of the difficulties of the past have arisen from setting of too rigid targets for new plantings.

In the years since the war, the Forestry Commission has been encouraged to set itself annual targets for purchase of land and for new plantings. As a result, it has been obliged to enter into the market for land, some of which is generally recognised now as more suitable for agriculture than forestry, and which would not have been afforested but for the demand to keep "on target".

What I will say is that I believe the various interests can achieve a substantial level of new plantings but with minimal effect on agriculture, another industry which has so much to contribute to the national economy and the rural environment.

I now wish to turn briefly to the ways in which we believe this overall strategy can be achieved.

The two aspects of our policy statement earlier this year which came in for most criticism were the proposals for changes to the approvals procedure before grant aid is available for planting; and our proposals for an advisory committee on forestry to advise the Secretary of State for Scotland on land use where afforestation is proposed. I suspect that many of these objections have arisen from a misunderstanding of our position, and I welcome the opportunity to examine them more closely.

Consultation on Planting Proposals

In particular, it has been said that we run the risk of opening the door to planning controls on land and land use in agriculture and forestry by our proposal that consultation on planting intentions should not be restricted to the planting areas themselves, but should include those intimately concerned in the local community. We must recognise that all those in the village or glen, as well as the farmers next door to the land which is proposed for planting, have a very real and close interest in the implications of any substantial planting programme, and all that we are anxious to secure is that they are involved, through the Department's land officer, in consultation about any proposals rather than knowing nothing of it until the land is ploughed up.

If we are to protect ourselves from really draconian planning controls, in the future, then we must be prepared to recognise the widespread concern at the effect on agriculture and rural communities of plantings which are made without regard to these two basic interests. The present arrangements already provide for effective control of planting, since very few schemes have any prospect of coming to fruition, if grant aid is not available; and the Forestry Commission voluntarily submit themselves to similar disciplines.

I would say once again that all we are proposing is that the existing procedure should be expanded, so that local interests intimately involved have an oportunity to express their views to the Department's land officer on any planning proposal over a certain size.

Advisory Committee on Forestry

The other area where we have been criticised, has been on our proposal to set up an advisory committee on land use where afforestation is proposed. We see this committee as having two main functions; firstly, to prepare detailed guidelines for the Secretary of State and the Department of Agriculture when considering planting proposals; and, secondly, to make recommendations on appeals against the Secretary of State's decision on planting proposals, whether these are appeals against approval to planting programmes, or appeals against refusal of "Basic III" applications.

I have already touched upon much of the ground which we think would be covered by the detailed guidelines that the Committee would put forward.

We would hope that representation of both farming and forestry interests on the Committee, with additional advice from outside interests, as the Committee might think necessary, could lead to agreed guidelines for the Department's land officers in consideration of planting proposals, and our preliminary discussions with the other interested parties, suggests that agreement should be perfectly possible.

I am not suggesting that a rigid guideline should be laid down for each individual proposal for afforestation on a farm or for the level of afforestation in a particular glen. Clearly, the circumstances differ from farm to farm and glen to glen, depending upon the local agricultural structure, the employment and other prospects in the district, the degree of afforestation already in the area and such matters as the availability and nearness of markets for agricultural production and timber.

I think that over the last few years there has usually been a general satisfaction in agricultural circles at the Department's approach to afforestation proposals. What we need, however, is a positive involvement of the local community and for these vital matters of land use to be considered, not just by remote Civil Servants, but by those intimately involved at local levels. Justice may well be done - the important issue is that it must be seen to be done.

Where does this leave us?

The proponents of large scale new plantings must face up to a situation where blanket plantings are no longer acceptable, except in certain districts, which have no viable agricultural future. The limits of acceptability to other interests also appear to have been reached.

We all recognise that the case for additional forestry must be accommodated, and we believe that it can be accommodated within the existing agricultural structure, if there is goodwill by all sides and proper consideration and advice, with a flexibile approach.

It may be said that this is the wrong time to seek money from Government. Nevertheless, Ministers in the present Government have said over and over again, in opposition and in power, that plantings must be encouraged. If this is so, then I believe that they must take on board many of these points which both sides have made, and are agreed upon.

MAKING THE MOST OF BRITISH UPLANDS
RELATING FORESTRY TO FARMING

G.D. Holmes, CB, BSc(For), FIFor
Director General
Forestry Commission

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MAKING THE MOST OF BRITISH UPLANDS - RELATING FORESTRY TO FARMING

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Introduction

1. Relations between forestry and farming depend very much on the attitudes adopted by each industry towards the other's activities. These attitudes have been formed over a long period and have been largely conditioned by a traditional outlook which in the case of Great Britain is predominantly agricultural - there being little forestry tradition and virtually none of the farmer/forester tradition which exists in the more heavily forested countries of northern Europe. If these attitudes are to change, both sides must be willing to get away from historical perpectives based largely on reactions to past events and adopt a more forward-looking approach to their common problems. This year, which marks the Diamond Jubilee of the Forestry Commission, it is perhaps appropriate to review developments in forestry/farming relations over the past 60 years and to speculate on possible new directions for the future.

The Past

2. Unlike much of Europe and North America, most of the natural woodland in Britain has long since been cleared for agricultural and industrial development and, apart from a few fragments which may have survived from earlier times, the older woodlands which form such a significant element in the landscape today stem from planting carried out in the eighteenth and nineteenth centuries by large landowners. In this context, forestry was an integral part of overall estate management, but as the woods were usually in hand to the owner while the agricultural land was largely tenanted, a dichotomy of interest was formed which has since proved difficult to overcome. This was the general pattern of forestry in Britain in 1919 when the Forestry Commission was established - primarily to repair the ravages of excessive war-time felling in these estate woodlands. At that time, the area of productive woodland reached an all-time low of 800,000 hectares representing only 3½% of the land surface of Britain.

3. Between the wars, there was little change in the area and character of private woodlands, but the state embarked, for the first time, on large-scale afforestation in an attempt to build up a strategic reserve

of timber, and by 1939 had established nearly 150,000 hectares of new plantations throughout the length and breadth of the country. This first afforestation effort happened to coincide with a period of depression for hill farming so that extensive areas were sold for forestry and planted up with less concern for their intrinsic agricultural potential than would now be the case. At the time, however, this was not regarded as inappropriate and indeed forestry was seen as something of a panacea for the social problems of the ailing agricultural industry in the uplands. At the same time, social changes led to increasing demands for freer access to the countryside and because of the visual diversities of the private woodlands and the type of intensive silviculture being practised in the state forests, forestry was generally accepted as an element in the rural scene. The first rumblings of opposition to afforestation were, however, already coming from sensitive scenic areas such as the Lake District and the movement to establish National Parks in order to preserve the existing landscapes was rapidly gaining ground. The Forestry Commission incidentally was not slow to react to these new pressures and in 1935 established the first of its forest parks, - in Argyll.

4. The impact of the second world war gave rise to changes in both farming and forestry policies. The need to increase home food production led to revitalisation of the hill farming industry and the further inroads made into the country's timber resources led in 1943 to a review of forestry policy(1) which envisaged a productive forest area of some two million hectares being established by the end of the century. In 1949 the National Parks were established in England and Wales and the conservation movement was given new impetus. For the first time there was direct and keen competition for the use of available hill land from forestry, farming and environmental interests. A measure of consultation over the transfer of land from agriculture to forestry use was therefore introduced but only in respect of the state afforestation programme since the private sector was being encouraged by the new Dedication Scheme to concentrate on replacing woodlands felled during the war.

5. By the late 1950s, however, a new development was becoming apparent in the private forestry sector: this was the emergence of the forestry management companies who were able to attract investment funds into

(1) Post-war Forest Policy (1943) Cmd 6447 HMSO

forestry - primarily for the afforestation of bare land. The prices which these groups could afford to offer for land were relatively attractive to hill farmers and many sold out completely either on retirement or in order to reinvest the proceeds in more profitable lowland farming enterprises. Since there were no controls over the use of the land there often tended to be a large-scale switch from agriculture to forestry use in such areas. Also, as these investors were often in direct competition with the Forestry Commission for land for planting which came on the open market, it was difficult for the consultative procedures to be applied as rigorously to state afforestation proposals as might otherwise have been the case. During this period there was, therefore, a considerable upsurge in planting by both sectors of the industry and much of this took place on the poorer hill ground as new forest establishment techniques were developed. The adoption of more extensive management practices also resulted in simpler and more uniform systems which in turn led to widespread accusations of the perpetration of blanket forestry - held to be detrimental in terms of both land use and its impact on the environment. Following the review of forestry policy in 1972[2] the Forestry Commission was given a new remit with specific economic, social, amenity and recreation objectives and new grant arrangements were introduced for the private sector also with wider social objectives. The harmonisation of forestry with agriculture and the environment also necessitated a widening of the consultative procedures to include the private sector and also to embrace environmental as well as agricultural considerations. Calls for forestry to be brought directly under planning control were, however, firmly rejected by government.

6. Another factor which has influenced the pattern of forestry development is the way in which the land for planting is obtained. Although the Forestry Commission retains compulsory powers of acquisition, it has preferred not to use them and land changes hands on the open market between a willing seller (usually a farmer) and a willing buyer - whether the state or a private investor. In a period such as the present when hill farming is enjoying a measure of relative prosperity, insufficient land becomes available for sale and market forces push up the price to a level which is difficult to justify in terms of the use to which the land can be put. Also because of the random fashion in which

(2) Forestry Policy (Consultative Document, 1972) HMSO

land comes on the market it may be difficult in particular cases to make judgements in terms of rational land use and this has led to calls for a national land use policy against which such decisions could be evaluated. In the absence of any such overall plan it is all the more important that the factors which are taken into consideration in the transfer of land to forestry should be properly understood: otherwise the existing consultative procedures which in practice operate quite effectively can all too readily become discredited.

<u>The Present</u>

7. In the face of these difficulties in expanding forestry at the rate envisaged by successive Government policies, the Forestry Commission decided in 1977 to embark on a basic reappraisal of British long-term forestry strategy. This study was deliberately focussed on wood resources and the degrees of self-sufficiency attainable in the future. The prime aim was to assess the strength of the case for devoting more land to wood production in Britain. The Review of the Wood Production Outlook in Great Britain[(3)] which was published as a consultative report last year, attracted widespread interest and drew comments from over 100 organisations concerned with forestry, agriculture and the environment. It also led bodies such as the Nature Conservancy Council, the Countryside Commission and NFU of Scotland to review their own policies in relation to forestry. The Review clearly established a 'wood resources' case for the continued expansion of forestry which has not been seriously challenged by any of the commentators: what must be the subject of further and continuing debate, however, is the scale and rate of such expansion. The total area of rough hill grazing land in Britain is approximately 6½ million ha and the review contemplated the effect of no further planting or of planting a further one million hectares or a further 1.8 million hectares of this land by 2025. These figures indicate that even with the highest rate of planting projected, no more than 25% of the likely demand mid-way through next century can be met from home timber production and it is still a very open question whether a change in land use on that scale would prove feasible even over a period of 50 years. Yet it is during the first half of next century that greatest pressure will be felt on this country's ability to import its requirements of wood

(3) The Wood Production Outlook in Britain - A Review (1977) Forestry Commission

and wood products because of overall changes in the balance of world supply and demand and therefore of the real price of wood products. Because of the time scale inherent in forestry, action is required now if the rising pressure on wood supply and the balance of payments next century are to be eased.

8. It is just these differences in time scale which make consideration of alternative land use between forestry and agriculture, so difficult: inevitably, returns from agriculture look more attractive in the short-term and this tends to accord more with the time scale of the general public. It is also the case that, by and large, forestry can only expand production by increasing its productive area whereas there is considerable scope for intensification of sheep farming by more efficient use of better hill land. At the same time environmental interests are seeking to restrict development of both forestry and agriculture over increasingly large areas. In all these circumstances consideration of forestry strategy can no longer proceed in a vacuum. In framing its advice to Ministers, the Forestry Commission must, therefore, take account not only of its own Review and the reactions to it, but also of a number of contemporary studies of equal relevance. Among the most important of these in the agricultural sphere are the recent Farming White Papers[(4 & 5)] the Study of Forestry Strategy by the Centre for Agricultural Strategy at Reading[(6)] and the Policy Statement by the NFU of Scotland on Agriculture and Forestry[(7)]. In the sphere of landscape conservation there are the Sandford Report (1974)[(8)], the impending 1981 Review of National Parks Administration, the Porchester Report on Exmoor[(9)] and the subsequent Countryside Bill[(10)], the Countryside Commission's deliberations

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(4) Farming and the Nation (1979) Cmd 7458 HMSO
(5) Possible Patterns of Agricultural Production in the UK by 1983(1979)HMSO.
(6) A Forestry Strategy for the UK - Centre for Agricultural Strategy, University of Reading (not yet published).
(7) Agriculture and Forestry - A Policy Statement (1979) National Farmers' Union of Scotland.
(8) Report of the National Parks Policy Review Committee (Sandford Report 1974) HMSO.
(9) A Study of Exmoor (Porchester Report 1977) HMSO.
(10) The Countryside Bill 1978 (Bill 47) HMSO.

on Forestry Policy for wildlife conservation, the NCC's Nature Conservation Review[11], and their draft on Forestry and Conservation[12]: while the Countryside Review Committee in its Topic Papers, and especially the latest draft paper on Conservation and the Countryside Heritage, has much to say about the whole question of rural policies including the designation of land for conservation purposes.

The Future: The General Approach

9. Future options for the scale and rate of forest expansion are therefore still very open and must be debated in terms of national rather than sectional interests. After 30 years it is necessary to take a fresh look at existing national policies for the countryside which largely stem from the post-war era. It is perfectly feasible to integrate forestry into countryside management alongside the conservation of wildlife and landscape and increase agricultural production, but it needs a collective effort if the best balance of interests is to be struck.

10. How then is such a commendable state of affairs to be brought about? One approach which has attracted a certain amount of interest is that a national land use policy should be devised which could be translated into a strategy for optimising the use of this scarse resource and applied to such questions as the transfer of land to forestry through some form of national planning guidelines. The main weakness in this argument is that, optimising land use is essentially a dynamic process and what is considered best at one point in time can so easily alter with changing circumstances over a relatively short period. Nevertheless, some framework is necessary, within which to consider proposed changes in land use as they arise and this essentially requires a very clear statement of national policy in respect of each of the main land uses which in its formulation takes account of other legitimate interests. There are now some signs of a move in this direction but for too long forestry has often been regarded as little more than an optional extra, whereas it ought to be recognised as one of the main uses of hill land which must be clearly reflected in national policies for agriculture and conservation. Since 1972 at least, forestry policy has taken full account of these other interests and has demonstrated that forestry can

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(11) A Nature Conservation Review (1977) - Nature Conservancy Council and the Natural Environment Research Council.

(12) Nature Conservation and Forestry - Nature Conservancy Council (not yet published).

contribute to the benefit of agriculture and the environment by good forest design and the promotion of nature conservation, even within plantations managed primarily for production.

11. Another approach which has been mooted is that there should be a single central authority responsible for rural land use, under the aegis of either the agricultural or environmental departments. That this concept has failed to commend itself to bodies such as the Strutt Committee[13] and the Countryside Review Committee, which have given it careful consideration, is perhaps primarily a reflection of the current relationship between agricultural and environmental interests, particularly in England and Wales. It has nowhere been demonstrated convincingly, however, that the corporate wisdom of such a body would be greater than the sum of the expertise available in the existing Departments and agencies concerned with the countryside, provided they are encouraged to interact in a more constructive manner than has hitherto been the case.

12. A third approach promoted principally by the conservation interests is that land use in sensitive areas should be governed by management agreements and plans which may provide for financial compensation to be payable where the full productive use of the land is inhibited. Experience of the voluntary afforestation agreements which have operated to various degrees in the National Parks since the early 60s does not commend such an approach to forestry interests, as it is altogether too restrictive. Proposals to extend similar agreements to a much wider area of the countryside throughout Great Britain are even less attractive.

13. Perhaps the most contentious approach is the suggestion that forestry should be brought under development control. This has been mooted from time to time in various quarters but was perhaps most specifically articulated by the Sandford Committee, though subsequently rejected by Government. It is still espoused in England and Wales by the Countryside Commission and to a varying degree by the Local Authority Associations (who obviously have a particular interest in such procedures) both North and South of the Border. Suggestions have ranged from the general application of development control to all forestry operations, to the more limited application to afforestation of bare land in National Parks only. Such procedures are not considered appropriate for as natural a use of the land as forestry and would afford least scope for the flexibility essential to all decisions on change of

(13) Agriculture and the Countryside (1978) - Advisory Council for Agriculture and Horticulture in England and Wales.

land use: indeed, this might be regarded as the most stultifying approach of all. If development control ever were considered for forestry, it would become all the more difficult to resist its extension to those agricultural developments which are essential if both industries are to sustain increased production on a finite area of land.

14. A more pragmatic approach would be to proceed by reference to national aims to achieve a higher level of self-sufficiency in both food and wood within the context of good land use. Given the goodwill of both the agricultural and forestry industries these aims are quite compatible due to their largely complementary demands on the available land resource. If relations between forestry and farming are to be fostered in this way, however, certain developments will have to be given specific attention.

15. Firstly, wood production must be maximised from the existing forest areas. The scope for increased production from managed woodlands may not be high in the short term but in the longer term there is scope for increases of the order of 10%-15% from the introduction of improved genetic material and the adoption of more efficient management techniques. In addition to the managed woodlands there are some 300,000 hectares classed as unproductive and consisting mainly of broadleaved regrowth from felled or coppiced woodlands. Clearly it would be desirable to rehabilitate as much of this neglected resource as possible but due to competing claims for reclamation to agriculture, mineral working and other forms of development and to resistence to any change from conservation and sporting interests, it seems unlikely that more than about a third can be brought effectively into production.

16. Secondly, consideration needs to be given to the extent to which forestry development should be inhibited by conservation designations - even in the highest categories such as National Parks. Forty per cent of the technically plantable area is situated in England and Wales and virtually the whole of it is subject to a conservation designation of one sort or another - half the area lies within National Parks. Some accommodation must obviously be found if a reasonable share of forestry expansion is to take place South of the Border.

17. Thirdly, account needs to be taken of the existence of some 600,000 hectares of common land in England and Wales and a similar area of crofters' common grazings in Scotland within which afforestation is

virtually precluded because of the restrictions on the use which can be made of this land. Certain proposals have been put forward in respect of proposed new commons legislation in England and Wales and a Joint Working Party with the Crofters' Commission is looking at the position in Scotland, but the likelihood of any substantial developments on these under-utilised areas seems remote without fairly drastic legislative action. Certain EEC initiatives may, however, hold out a slender prospect in the remoter areas in Scotland.

18. Finally, there is the large area, particularly in Scotland, given over mainly to sporting interests, both deer forests and grouse moors, which may also carry a small sheep stock. Such areas could be transferred to forestry use with little or no impact on agricultural production but usually only at the cost of extinguishing the sporting interest. So long as these are viable activities in their own right little change in land use can be envisaged, but if their financial fortunes were to deteriorate they could make a significant contribution to the afforestation programme.

19. Whatever advances may be achieved eventually in these peripheral areas, the bulk of the land required for forestry will still have to come from areas presently used for hill farming, as it has done over the past 60 years. It is worth noting that despite the rapid expansion of forestry since the last war, hill live-stock numbers certainly in Scotland and probably in England and Wales as well, have been substantially maintained (see Appendix II). This process of atrition cannot, of course, go on indefinitely and in some parts of the country it is felt by the agricultural community that the limit has already been reached. As I said earlier, the key to further progress lies in the intensification of agricultural production on the better hill land thereby releasing the poorer hill land for forestry. The reluctance of hill farmers to adopt such modern practices stems partly from resistence to change but perhaps even more from the fact that the present financial support system is not well designed to encourage efficiency of production and thus tends to perpetuate the traditional extensive forms of husbandry. Undoubtedly

more intensive systems of hill farming require injections of capital which may not be immediately available to the farmer but this is just where forestry can offer benefits in cash or in kind in return for the release of hill land.

20. Integration of forestry and farming can offer a wide range of opportunities for developing the full potential of hill land to the mutual benefit of both partners. In its simplest form it may involve little more than the farmer selling off the least valuable part of his hill ground for forestry and reinvesting the proceeds on the remainder of his farm: most successful examples of this form of integration show that it is possible to achieve a higher level of production from the reduced area with only limited investment in agricultural improvements. Indeed, many farmers are of the opinion that most hill farms could release 10%-20% of their land for forestry in this way without adopting significantly different farming practices. Even at the lowest estimate this could yield an appreciable amount of land for forestry with a consequent substantial injection of capital for farming running into many millions of pounds. At the other end of the spectrum is the more fully integrated enterprise with substantial forest blocks sited so as to give maximum benefit in terms of shelter, fencing and roading in addition to the injection of capital. Such schemes can show even more spectacular results so far as agricultural production is concerned. There is, of course, yet another concept of integration which entails a number of small blocks of woodland sited so as to interfere as little as possible with the existing farming enterprise. Such schemes may be quite appropriate in the lowland situation but they are usually completely out of context in the uplands and are unlikely to contribute significantly to the main afforestation programme.

21. However, not all farmers may wish to part with their land - whether to the Forestry Commission or to a private investor. The small owner/ occupier in particular may prefer to retain control over his land while still appreciating the benefits of some forestry. In this case the leasing, or so-called partnership schemes may be more appropriate and these are now being taken up quite extensively as they become better known. Others again may wish to carry out the planting and woodland management themselves. Even if with the available grant-aid they can

finance the establishment of such woodlands, they are required to forego income from the land for the 25 years or so until some revenue is produced from the woodlands. These are the people Mr Dunning wishes to assist with his scheme but there are financial and administrative difficulties attached to the running of such schemes which should not be underestimated. In this country it is also said that farmers generally make reluctant foresters and the extent to which farmers may wish to become interested in such schemes remains to be seen.

22. If a farmer is to become interested in the management of existing woodlands on his farm or even in establishing new ones, the one thing he needs above all else is readily available and impartial advice. This is an area which, in the past, has probably been rather neglected, but with the introduction of the Forestry Commission's Small Woods Grant in 1977 covering areas down to one-quarter hectare and the availability of grants from the Countryside Commissions for even smaller areas, some steps have been taken to rectify this situation. The Forestry Commission has published its own booklet on the Management of Small Woodlands and has co-operated with the Countryside Commission in the production of the Countryside Conservation Handbook which will also include a section on this subject written specifically to appeal to small owners. In addition, the management of small woods will be a feature of most of the holdings included in the Countryside Commission's Demonstration Farms Project. This work led in turn to a specific study of small woods on farms being carried out in eight counties in England and Wales, and preliminary results from the first study area in Gwent were sufficiently encouraging to induce the Forestry Commission to embark on a pilot project in this area aimed specifically at getting small farmers to take an active interest in their neglected woodlands. Motivation of farmers is, of course, the key to success in all these schemes, and this is why it is of particular importance that ADAS and the NFU are both closely associated with the Countryside Conservation Handbook and Demonstration Farm Projects. In Scotland, the Advisers for the Colleges, and particularly the Socio-Economic Advisers, are also fully appraised of the opportunities for woodland management on farms. In the end, however, farmers are most likely to be motivated by successful schemes carried out by their fellow farmers, and this is perhaps one of the most promising features of the Demonstration Farms Project which embarks on the first demonstrations this year.

The Future; Scale and Location of Forestry Development

23. What, therefore, can be said about the future scale and location of forestry expansion? The Review of the Wood Production Outlook in Great Britain suggested that over 80% of future planting would probably take place in Scotland because of the environmental restrictions on land suitable for planting in England and Wales. This, however, would undoubtedly place a considerable strain on the hill farming industry in Scotland and perhaps a ratio of two-thirds in Scotland to one-third in England and Wales would be more appropriate. The fact that very little suitable land seems to come on the market in England and Wales however may tend to tip the balance northwards again. The area of rough hill grazing in Scotland is about 4.8 million hectares; is it unreasonable to suppose that something like 20% of it, say one million hectares, could be released for forestry development with agricultural production being sustained on the balance of 80%? This would infer a contribution from England and Wales of some half a million hectares; giving a total increase for the whole country of 1.5 million hectares and bringing the total production woodland area in Great Britain to some 3.2 million ha, or 14% of the land area. This seems a fairly modest target by comparison with, say, the existing 24% for France and 21% for Italy both of whom seem capable of sustaining their agricultural production while expanding their forest areas still further.

24. Change of land use on this scale is, of course, not going to occur overnight nor is it going to proceed entirely at the whim of market forces. On the time scale which is being contemplated, 50 years, the average annual rate of change would be only some 30,000 hectares per annum, which is considerably lower than the rate of change experienced over the past decade. Although land suitable for afforestation tends to come on the market in a random fashion, the existing consultative procedures ensure that it is not transferred to forestry use in a haphazard way but only afte all the implications for agriculture and the environment have been given the most careful scrutiny. It is essential that the agricultural industry should have confidence in these procedures, which have been refined and updated over the considerable period during which they have operated to ensure that they are in tune with current national aims for the interests

concerned. Such transfers have to be evaluated, not just in terms of their effect on agriculture but in the context of the Government's wider social and economic objectives.

25. From the outset there has been support for forestry from all political parties and the target of 2,000,000 hectares of productive forest in Britain by the turn of the century envisaged in the paper on post-war forestry policy has been tacitly accepted at subsequent reviews. At current rates of planting this target will be achieved within the next 10-15 years, and it is therefore timely that forestry policy should be given a new direction and impetus based primarily on a reappraisal of the contribution which home timber production can make to the national economy. The recent agricultural White Paper 'Farming and the Nation' recognises that forestry expansion need not take place at the expense of agricultural production, though it must inevitably curtail the area presently used for extensive hill farming and may also lead to some loss of agricultural employment through increased productivity on the reduced farming area. Overall, however, forestry is seen as a useful means of strengthening the rural employment base since it is likely to offer considerably more direct employment than it displaces while the diversification of employment afforded can help to sustain the viability of the rural community. However despite the increasing quantities of timber to be harvested from the post-war plantations now coming into production, forestry employment would decline alongside agriculture due to continuing increases in labour productivity of the order of 2% per annum unless planting continues at a substantial level well into the next century. In these circumstances it is important that the hill farming industry should be encouraged to increase its productivity if sufficient land is to be released for forestry. To what extent this may be achieved as the result of exhortation, economic pressures or financial inducement is a matter for speculation.

Conclusion

26. The factors determining future forestry/farming relations may be summed up as follows:

i. The farming industry is currently reacting to increasing pressure from forestry and environmental interest in the hills and uplands of Britain: it is hoped this will lead to the development of positive and forward-looking agricultural policies aimed at higher food production from the better hill land.

ii. Continued Government support for forestry expansion must inevitably have repercussions on other land users and forestry needs to be recognised as a natural and productive use of hill land.

iii. Further forestry expansion will have to take place on a substantial scale if it is to have any real impact on future wood supply. Token concessions or small scale integration schemes will be of little avail.

iv. It is neither feasible nor desirable to attempt to secure harmonisation of forestry with agriculture and the environment by means of a comprehensive national land use policy. Rather this must evolve through the establishment of good relationships between the various countryside interests within a framework of national aims for each sector and the recognised principles of good land use.

v. There is a need to avoid a purely sectional approach to the resolution of conflicting interests if constructive solutions are to emerge .

vi. Integration of forestry and farming needs to be viewed on the national as well as the local scale and must not preclude the view that some hill farms may be unable to accommodate any forestry, while others can be transferred to forestry in part or even entirely with negligible loss of agricultural production; nor should the substantial injection of capital in addition to the other physical benefits of integration be discounted.

vii. Farmers and other small owner/occupiers must be encouraged to take an interest in the management of their existing woodlands, and to undertake the establishment of new ones. This will require substantial financial support by way of both capital and income and may prove an expensive way of securing a contribution to the overall forestry programme. Nevertheless it may be worthwhile.

viii. Finally, the case for achieving a prudent level of self-sufficiency is as sound for forestry as it is for agriculture. There seems little doubt that the necessary forestry development can be accommodated within the available land surface while still maintaining agricultural production and with advantage to the structure and viability of the rural community. It can be done in a variety of ways - by the state, institutional funds, private investors, traditional estates and by farmers and all will be needed if the long-term objective is to be met. Only by gaining the confidence of the farming community will it be possible to secure the necessary harmonisation of interests but looking back at what has been achieved over the past 60 years, despite all the many vicissitudes, there is reason to be confident about the future of forestry/farming relations.

APPENDIX I

POTENTIAL ANNUAL PRODUCTION

TRADITIONAL CUTTING REGIME

Rotation ages Broadleaves FC 100 years: PW 150 years

Conifers FC 55 years: PW 80 years

Millions cubic metres

	Year 2000	2025	2050	Sustained Yield
<u>Alternative 1</u>				
Broadleaves	1.3	1.4	1.6	2.3
Conifers	7.0	9.2	10.3	12.0
<u>Alternative 2</u>				
Broadleaves	1.3	1.5	1.7	2.6
Conifers	7.0	12.8	16.8	22.0
<u>Alternative 3</u>				
Broadleaves	1.3	1.5	1.7	3.0
Conifers	7.0	14.1	20.4	27.0

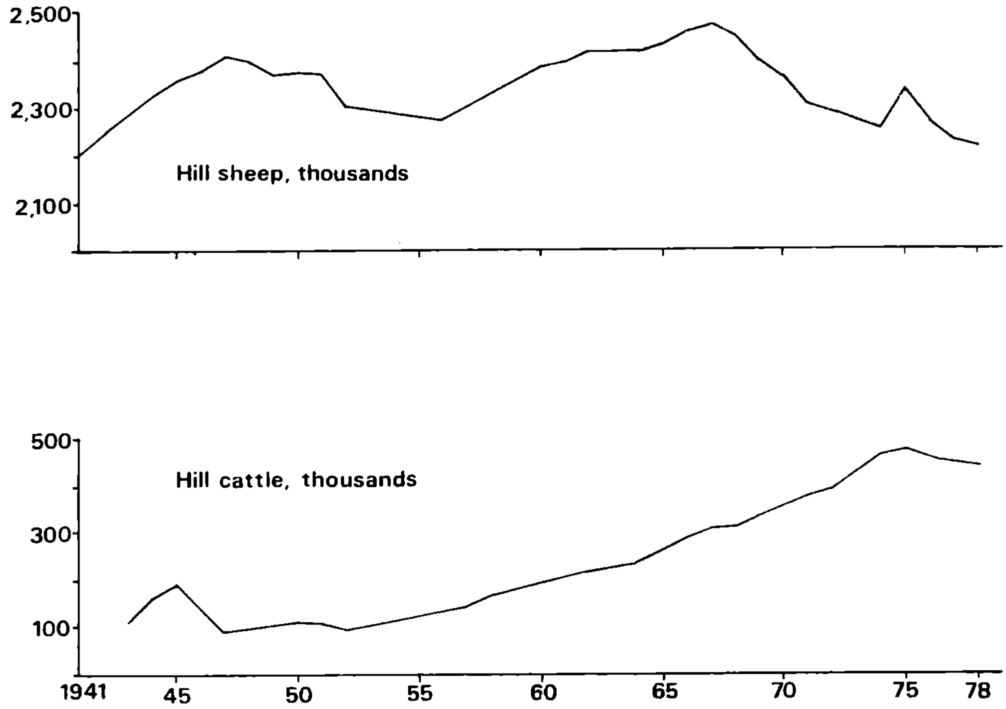
Alternative 1 = No further planting

Alternative 2 Planting further 1 m hectares

Alternative 3 Planting further 1.8 m hectares

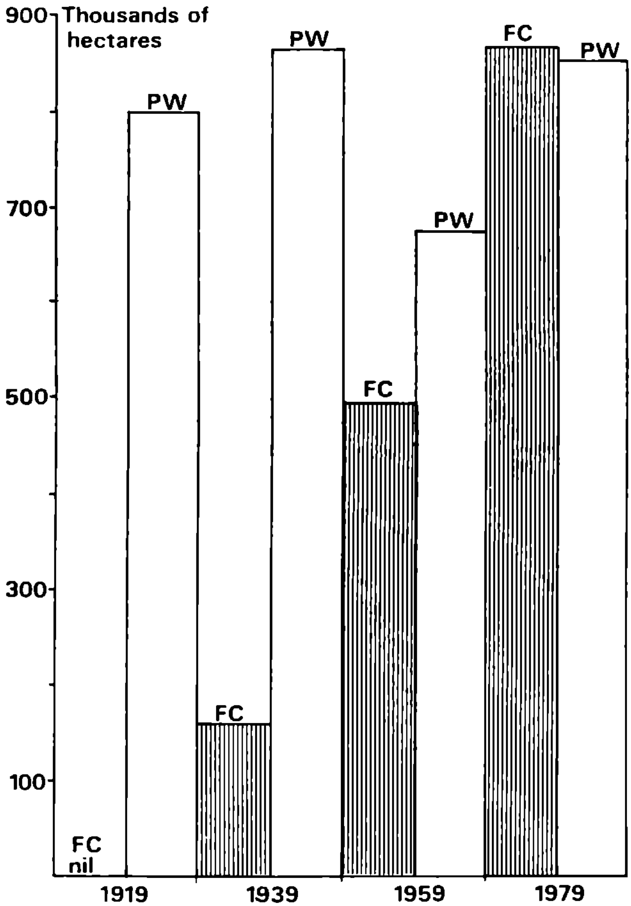
Appendix II

Hill sheep and cattle - Scotland



Appendix III

Productive forest area



LAND USE STATISTICS

Thousands of Hectares

Statistic	England	Wales	Scotland	Great Britain
Total Land Area	12 972	2 064	7 717	22 753
EEC Less Favoured Areas	(1 080)	(910)	(5 190)	(7 180)
Area of Bare Land Technically Plantable	900	400	1 660	2 960
Commons	425	180	585	1 190
Area of Rough Grazings	(1 080)	(620)	4 765	6 465
Area of National Parks	950	410	-	1 360
National Scenic Areas	-	-	1 002	1 002
Areas of Outstanding Natural Beauty	1 380	70	-	1 450
National Nature Reserves	27	10	83	120
Sites of Special Scientific Interest	483	186	587	1 256
Land Occupied by Red Deer	-	-	2 800	2 800

Areas in brackets are as yet unverified

TOWARD INTEGRATION IN THE UPLANDS

J.C. Dunning, JP
Commissioner
Countryside Commission

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TOWARD INTEGRATION IN THE UPLANDS

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Commissioner
Countryside Commission

INTRODUCTION

Mr. Chairman I must begin by congratulating the British Association on introducing this joint session of the Agriculture and Forestry Sections with speakers representing the principal interests in the uplands. The timing also could hardly be more opportune for such an initiative as we are standing today, as never before, at a confluence of crisis and opportunity which has yet to make its impact.

The changes which have taken place in the upland areas of Britain, more than 40% of our land area, during the past century are the most far reaching and dramatic in their history, and as we stand today at a possible turning point in this saga I would like us to stop and glance at the stream of events from which we have emerged as well as those we are about to enter. (1)

I live in a hill farming community in the centre of Cumbria. In 1827 our parish of some 4,000 souls, was self-sufficient except for the cart load of goods brought in over the hills twice a week by the village carrier, and no doubt some other items brought by various traders. It had a fair, a market, three primary schools serving village and outlying hamlets, a grammar school, four inns, four corn mills, a flax mill, four drapers, four blacksmiths, four boot and shoe makers, two dressmakers, one glazier, one druggist, five joiners and wheelwrights, five stonemasons and two slaters. There were six hundred inhabitants in the village and nearly a hundred and fifty farms in the surrounding hills. Today there are barely a third of the former number of farms, and most of them are one man farms where the previous number would often employ one or two men and a girl. There is uncertainty about the future of the one remaining school and the resident parson; there is a shop, a post office, two joiners and two jobbing builders. There are fifteen men living in the village who work locally, the remainder are either retired or commute to the nearest town sixteen miles away. First came improved communications, then mass produced goods, then larger scale, more centralised services. The process was encouraged by the growing, labour-hungry, urban based industries of the north, it was at once brutal and inexorable, and our village and parish like so many others was reduced to a quarter of its former size.

That dismal picture is repeated throughout the upland areas of Britain, in some places even more savagely, and the pressures which have brought us to this largely remain. But even more disturbing is the prospect immediately ahead.

It is widely predicted, both inside and outside the EEC Commission, that the growing surpluses in several agricultural commodities will lead to a crisis in the funding of the Common Agricultural Policy within the next year or so. How this might be resolved is open to speculation, but it is inevitable that there will be considerable pressure, from some other countries as well as the U.K., for reducing the overall cost of the CAP. The need to reduce surpluses in some commodities suggests that increasing costs may not be fully met in the intervention prices, which in turn could mean that the production of these commodities on farms where profits are marginal may be threatened, and less efficient producers or those situated in less favoured areas may be forced out of production. At the very least there will be a shake out of labour and an overall belt tightening which will have repercussions throughout the rural economy affecting not only primary producers, but also those who serve them.

In 1981 Greece will become a member of the Community with Spain and Portugal following within a few years. Inevitably the accession of these countries with their vast disadvantaged rural areas subsisting largely on products which are already in surplus in the Community will pose huge problems for the CAP. It would be idle to speculate here on how these difficulties will be solved, however, there are certain imperatives which we cannot avoid. Experience of the CAP so far has indicated that far from reducing the tendency towards regional economic imbalance its operation has tended to accentuate it, and unless the position was to be made even worse some additional input from Community funds would be necessary. Either way the problems of surpluses and of greater burdens on the structural directives will be increased and in the absence of a reduction in inputs the burden on the CAP will grow. These critical problems for the EEC which are now looming unavoidably before us are further complicated by the prospects of a further world recession associated with an immediate, and what may be recurring, crisis in the supply of energy during the remainder of this century. And as if this were not enough the high unemployment which has remained since the last recession now shows some signs of becoming more persistent with a movement throughout industry towards increasing automation which may bring about an even greater increase in unemployment than we had dared to predict.

It seems then highly likely that we face a downturn in the prosperity of European agriculture with the greatest impact falling – as always – on those areas where commodities are produced close to the margin of profitability and where a small change can mean the difference between viability and going out of business. Of course this situation is nothing new, what is new is that for the first time we do not have the option of sending redundant hill farmers, farm workers and their families to find a new life and employment in urban industry, quite the contrary, there are signs in many areas that the flow has begun in the opposite direction where disillusioned young people are leaving the cities to find a new life and lifestyle in the countryside. This prospect is not in itself a reason why a movement towards integrating policies and practices in our upland areas is necessary. They simply record that the former, easier option of reducing the upland population to match declining revenue is no longer either available or appropriate, and that like it or not we must now face the inevitability of a change of direction. The reasons remain the same as they have been for some years dominated by the expensive contradictions of a series of single purpose policies conducted by departments, agencies, and local authorities coupled with the responses and attitudes which these have invoked in local communities. However, it is one of those strange and happy co-incidences of history that what is now to be forced upon us is both timely and right and does not find us entirely unprepared. There has certainly not been a time when the resources of our uplands were more relevant to the immediate and future needs of the nation.

PRESENT TRENDS

The principal industry in the uplands is hill farming. It provides the major source of revenue towards sustaining upland communities, controls much of the land and its uses, is the main determinant of the evolving landscape, and strongly influences the remainder of the upland economy.

The Ministry of Agriculture in their role of encouraging a strong, efficient, well structured, and properly renumerated hill farming industry have achieved an agricultural success which is unequalled in Europe. However, this process has in many hill areas reduced the hill farming population by more than twenty-five percent in a decade pushing many hill communities towards collapse, stripping them of rural services, and handing over the valuable dwellings of a former community to weekenders or dereliction. In addition this exclusive concentration on agricultural revenue has encouraged and even confined farmers to investing in enterprises whose profitability was inordinately dependent on the level of subsidy, and which at times were at odds with other national objectives. This approach has also tended to stifle more profitable, and nationally relevant, potentials which lie fallow among the land and structures of hill farming.

The forestry industry has had an impressive record of development since the 30's, although early policies in the uplands attracted some criticism. That it remains relatively unloved by both hill farmers and conservationists must raise questions about how successful it has been in integrating its efforts with other purposes in the uplands. Whilst its failure to meet its own expansion targets,[2] let alone the broadly recognised scale of need, suggests that it has so far been unable to win the widespread confidence of landowners and farmers as a viable alternative land use.

Public recreation and the accompanying concern to conserve the beauty of the hills is the most important new factor in the uplands this century. However, those who devised our system of rural planning, shaped for the control of urban space, can have understood little of the organic interdependence of each segment of the upland economy, or its ever changing shape which like the wind must die when it stops. The life of many of our loveliest and most fragile mountain areas has died because we have stifled the propogation of new life, or have failed to encourage the forms of it which were best suited to the environment. Nor have we yet devised a means, which can be generally applied, of integrating farming and conservation so that both are readily strengthened in the process.

The rapid growth of tourism during the past thirty years has often been as something of an able bodied dependent. Far too little of the revenue from tourism in the hills has found its way back into the landscape and community which are the raw materials of its success, nor do I believe that we have yet succeeded in making available on a sufficient scale the riches which uplands are able to offer to the visitor.

Public bodies such as water authorities, national park authorities, and electricity boards have acquired ever increasing areas of land, or rights over land, in the hills. All too often they have pursued their central statutory purpose to the exclusion of other vital interests, and consequently to the detriment of the upland economy. Some improvements have been made, but they often amount to mitigation rather than an integration of purposes.

CHANGING PUBLIC ATTITUDES TO THE HILLS

Without doubt the most important fact in our time in the hills and indeed mountain areas of Europe generally, has been their discovery by urban industrial man as a source of physical and spiritual renewal. As we stand here in the last quarter of the twentieth century it is difficult to grasp the magnitude of the change which has taken place during the last century and a half both in our response to mountain scenery and the use which we make of the uplands.

The sense of isolation and vulnerability in the presence of wild and untamed nature, so well presented by Dr. Johnson on his tour of Scotland, or Gilpin in his description of the view from Dunmail Raise .. "With regard to the adorning of such a scene with figures, nothing could suit it better than a group of banditti. Of all the scenes I ever saw this was the most adapted to the perpetration of some dreadful deed." (I sometimes wonder when driving over there on a bank holiday whether things have changed much). The new vision arose on the wings of the romantic movement and was given expression by such as Wordsworth and Ruskin, and those leisured heroes of the golden age who explored the Alps and the less accessible parts of our own hills.

Industrialisation and its often depressing urban consequences exposed a need which for many the hills could answer. (3) "They set our feet on curves of freedom, bent to snap the circles of our discontent." Slowly as communications improved and affluence and leisure crept downwards through society the people came in ever growing numbers. First reverently, then more confidently, and finally with an alarming disregard, to build, to trade, convey, relax and play. Piece and piece the urban ills from which they sought release were brought with them, but the recognised need to protect the countryside did not find its way into legislation until 1947 and 1952. Since the war the pressure of visitors on many upland areas, especially those designated as national parks, has grown massively and increasingly this has posed huge problems of wear and tear on paths and bridleways, on fences and bridges, roads and transport, and public services such as toilets and refuse collection. It has imposed burdens on agriculture and forestry through damage, fire, dogs, and road accidents with animals. But what of future pressures. It is widely predicted that unemployment may rise from two million to five million in the next few years. Those who are attempting to predict the impact of micro electronics on industry, whilst cautious, at least recognise that working time is likely to be shortened.

However the changes now in train may manifest themselves we can predict with reasonable certainty that leisure time will continue to expand, and that we may expect that a proportion of this leisure will be spent in our hills. Already the scale of recreational demand in hill areas accessible to large conurbations is posing huge problems of wear and tear, damage, and conflict with agriculture and forestry. It is in these areas that we can now see most clearly the greatest long term threat to these beautiful places. What brought those seeking adventure and recreation in the first place was a sense of awe and wonder - "We look upon them and our nature fills with (3) lofter images from their life apart." Many of those once solitary places, visited only by shepherds and climbers, are now so thronged with people that their very fabric is threatened. On a summers day it is not unusual to record 6-700 people crossing the summit of Helvellyn. Soil and scree are simply worn away by the tumult adding to the erosion of slope and weather.

(4) "For the power of the hills is on Thee" wrote Wordsworth to a young lady on her first ascent of Helvellyn a century ago. He may ponder on the power he helped to unleash if he were able to join the queue to cross Striding Edge on a summers Sunday.

The greatest threat to the recreational importance of many of our hill areas today is that they will be robbed of their wonder. Robbed by the presence of so many people, robbed by the damage and litter they leave behind. Robbed by the necessity to warden, control, and guide them for their own safety and the convenience of others. Robbed by the degradation of economic decline, or alternatively by the sterile municiplisation of the hill. The danger is that the mystery and the message of the mountain will be lost; trampled to death like Stonehenge or Snowden .. and we will have gone full circle - they will be at peace again.

But it need not be thus, a great deal can be done to prevent it. The range of recreational opportunities must be broadened so that the pressure on some of our most vulnerable landscape is reduced, and agriculture and forestry are not damaged by the numbers of people. Much can be done still to increase the range of opportunities in hill areas, and this breadth must include commercial opportunities which will increase the revenue into the upland community making it better able to withstand the pressure upon it. The success of management (5) solutions in reconciling the pressure of public access with farming and forestry has been recognised for some time and is now being applied in all the national parks of England and Wales. An officer working directly with farmers and foresters at ground level is not only able to find ways of protecting farming and forestry from recreational pressures, it is also possible very often to provide more footpaths through more interesting places whilst at the same time separating visitors from vital areas such as meadows, buildings, and fields with bulls in them. However, the concept of a professional officer employed by or working close to the local authority can be developed much further to embrace other social and economic issues. As well as easing the pressures of recreation it is possible by the same means to plan and encourage within the parameters of area plans enterprises which will strengthen the farm economy and which relate to the recreational use of the area.(6)

The pressures on the upland landscape are becoming so complex and severe that they can no longer be dealt with successfully by allowing each department or interest to deal with its own problem in isolation. The prosperity, the structure, the land management policies, and the equipment of farming are of critical interest to the landscape and to recreation, as is every aspect of forestry, and the policies and practices of these industries will remain the major determinant of the landscape. The present practice of nibbling at the edge of mainstream policies for forestry or agriculture is as unsatisfactory for the landscape as it is for the industries. We must evolve the means to devise policies for each place which are best for hill farming, best for the rural economy and community in each particular place, best for forestry, and best for conservation and recreation. Such policies need by no means be an insipid compromise, indeed, they may often lead us into a completely new and integrated approach to our problems involving a wider range of economic possibilities from which to select a combination best suited to every interest and purpose.

POLICIES AND PATTERNS OF INTEGRATION IN THE UPLANDS

There are many hopeful signs. During the past few years a growing number of people have come to recognise the problems faced in the uplands. Perhaps the most important official response has been the setting up of the Countryside Review Committee[7] in 1974 by the Secretary of State for the Environment. Its terms of reference included examining the impact of existing policies on the countryside, and to consider whether changes of policy and practice are necessary in order to reconcile the various major policy objectives. The Committee included civil servants from all departments involved in the countryside including the Scottish Development Department, although its remit did not extend to Scotland. In its four discussion papers it has presented us with some new official thinking, declaring the inadequacy of a sectional approach to the countryside, the need for better co-ordination, accepting that conservation is an ethic, based on respect for the natural resources of the countryside which embraces the need for renewal and change. In the uplands it suggests a fresh look at the mix between agriculture and other objectives, as well as the methods of promoting hill farming.

In May 1977 the Minister of[8] Agriculture asked his Advisory Council for Agriculture and Horticulture "to advise on ways in which the Ministry could best contribute towards reconciling the national requirement for economic agricultural and horticultural production with the development of other national objectives in the countryside". This report went so far as to suggest how the much needed co-ordination should be set up, proposing an inter-departmental body at national level and a local forum in each county led by the local authorities.

More recently [9]a joint study group set up by the Franco-British Council published a report which was able to compare and highlight the relative strengths of the two systems of environmental protection and recreational provision. The French, as one might expect, were clear on their objectives; making the most of the designated area; education of visitors and the local community; and conservation of the area and access to it. The British, again as one might expect, were strong on the instruments, the Government agencies - the two Countryside Commissions, the national park authorities, and local authorities, the national park plans, the structure plans, and the area plans, together with more detailed techniques for implementation such as upland management and management agreements.

Of considerable significance is a study by the District Councils[10] Association called Strategy for Survival which represents their submission on rural recovery to the CRC. It notes with alarm the decline in younger age groups in rural areas generally, and among its eighty conclusions is a recommendation that District Councils should be the recognised co-ordinating agency for the promotion of rural industries and provisions of serviced industrial sites.

Several National Park Plans have given fuller recognition to the link between their responsibility to conserve the landscape and improve recreational opportunities, and the well being of the rural economy and community. Of equal importance is the pioneering work of the Countryside Commissions for England and Wales and for Scotland, especially in the development of countryside management which involves farmers and local people in carrying out conservation work and improving facilities for recreation, whilst at the same time providing a valuable stimulus to the rural economy in upland areas where it is most needed. Recent reports published by the Centre for Agricultural[2] Strategy at Reading University on both agriculture and forestry have highlighted their potential contribution to the national economy.

Taken together all these studies and publications, and many more which are not mentioned, present a formidable weight of argument for an integrated approach to the use of the resources of the uplands and also an impressive revelation of the importance of the many old and new possibilities which upland areas have to offer. Let us, therefore, examine these possibilities more closely.

Hill farming is not only the most important industry in our upland areas, it is also the pivot on which almost every other purpose in the hills depends. The Less Favoured Areas represent 42% of the farm land of the United Kingdom, and the sheer scale of the industry confirms its importance to agriculture and to the national economy.

The role of the hill livestock industry is unique to Britain, in that it is integrated with lowland agriculture so as to make the best use of both hill and lowland. From the hill ewe, and hill cow, the mothering qualities, hardiness and flavour, are passed down through crosses which add prolificacy, growth rate, and conformation appropriate to the potentials of land and climate. There are those who have cast doubts on the importance of the hills as a reservoir of hardy livestock, suggesting that the same output could be achieved more economically from an intensification of production from better land. However that argument fails to take in the low level of resource demand which can be achieved by an extensive hill farming industry as has been demonstrated in the past through the comparative ability of the hill farmer to survive through a period of general depression by his capacity to limit inputs. But such a discussion only arises among people who have lost sight of the central position of hill farming in the role and the future of the uplands. Conservationists are recognising more fully that above any other factor, the future of the upland landscape is tied to the future of hill farming. Not simply on whether it prospers, but how it prospers, the type of enterprise, the size of farm and enterprise in relation to the area. How the enterprise relates to other elements of the landscape such as forestry. How tourist enterprises and facilities for recreation are integrated into the land use pattern. How small craft industries or larger manufacturing industries are introduced for they too will influence the structure of the farm enterprise in the available opportunities for non-farming employment and entrepreneurship for young people and abler people who would otherwise have to leave the area.

Once again hill farming is at the centre, the recently published Northfield Report has suggested in the absence of completely reliable information that owner-occupation may be as high as 65% of the land. If that is so for the country as a whole then we might reasonably assume that with limited institutional interest in the hills, and fewer large estates, owner-occupation in the uplands may be as high as 75% or more in wide areas of the hills. Decisions that are made, therefore, on the future of hill farming, or forestry, on tourism on farmland, on the use of redundant agricultural buildings, on the use of land for small industries or services, and on mineral exploitation, these decisions will be made for the most part by hill farmers, subject to the determination of planning applications by otherwise passive local authorities.

At the beginning of the paper I drew attention to some of the dark clouds which are getting disturbingly close, how can hill farming best meet these threats? Of course it is paramount that every effort should be made to maintain the revenue into hill farming from its traditional products. It is equally important to retain the structural aids which have helped to stabalise the industry recently. But it must also make sense to add to the strength and resilience of the industry by bringing into use where appropriate the latent non-agricultural resources of the farm, such as tourism, recreation, manufacturing or service enterprises, or forestry.

Forestry is by far the most important of the latent potentials of the hills, and after food forestry products at a cost of £2,500 million (2) per annum represent our highest import. It is predicted that this figure will double before the end of the century in response to increased consumption and a growing world shortage resulting from the decline of indigenous forests and the inadequacy of cultivated woods to meet the demand. Currently our domestic output at only 8% of consumption is derisory when looked at alongside the potential of our upland areas many of which have conditions for tree growth which are unequalled in western Europe. Timber, it is argued, both in the inputs towards producing it, and in the mature crop, is our most efficient energy converter. The reasons for a substantial increase in timber production have been argued by every part of the forestry interest and by several academic bodies, and the Forestry Commission has produced alternative proposals for a substantial increase in output which could lift our self sufficiency substantially. The arguments as to why timber production should be increased are unanswerable, but what the various parties have so far not been entirely successful in doing is setting out convincingly how this might be achieved. There is suspicion of forestry on the part of those who looking at early mistakes in blanket afforestation feel that an expansion of forestry may be conducted with the same insensitivity as in the past. There are few farmers who are also foresters, the history of farming is rooted in the removal of the forest. Seeing no likelihood of farmers relinquishing land on the necessary scale to facilitate the proposed expansion of forestry some people have suggested draconian measures to secure it. However, among these various extremes is a mix of possibilities which could provide the most acceptable result for every interest. The present range of grants offered by the F.C. have an important place as have the established fiscal incentives which need to be strengthened. The important task which now needs to be done in the uplands is the encouragement of a firm movement towards the integration of hill farming and forestry. Most hill farmers are more interested in immediate and continuing revenue than they are in tax incentives related to the life of the crop.

There are many reasons why, given the financial feasibility of the operation, a hill farmer may wish to plant a proportion of his farm; it has been well demonstrated that up to perhaps 12% of a farm may be planted (11), without impairing the agricultural output of the farm, taking into account the improvement to the micro-climate, and other management gains which substantial blocks of woodland may provide; in addition the area of woodland will be a less labour demanding commitment which could be attractive to older farmers in particular. There are several possible ways by which this may be feasible. One might be to mortgage the crop on planting to the Forestry Commission and to receive from the F.C. an annual loan payment paid at a level which is not too unattractive compared with the alternative use of the land. Another might be to lease the land for the life of the crop to the F.C. or to a private organisation. A scheme has already been proposed for a share cropping arrangement between a hill farmer and a professional forestry organisation and this is worth further study. In addition as we move slowly towards a more purposeful management of commons, and the Dartmoor Commons Bill is an important landmark in this progress, the possibility of some forestry being included in situations appropriate to the economic uses of the common and to the ladscape, wildlife and recreational interests should be considered. Could not the interests of commoners and landowners be reconciled through a carefully prepared package of government support which ensured the advantage and protection of each interest?

The fact must be faced that unless ways are introduced which make forestry attractive to hill farmers the proposed scale of expansion cannot come about in most upland areas. In addition it is largely through a growth of the forestry acreage from within hill farming that forestry can make its best contribution to the upland landscape and the upland economy as a whole.

Tourism, of course, is the most important new resource to have emerged in the uplands in our time. Its rapid development has inevitably included many shortcomings of which the most significant must be the failure of an adequate proportion of the revenue from tourism to find its way back into the landscape which is the raw material of its success. However I would like to concentrate here on the potentials of agro-tourism whose benefits not only meet many of the criticisms of tourism in the uplands generally, but present an element in the upland economy whose integration with other objectives is both relevant to local and national needs, and to the developing aspirations of the visitor.

For some time now the largest growth area of the industry has been self-catering accommodation, which offers cheapness and informality and enables visitors to get close to the landscape and the community they have come to visit. There is a growing demand for different grades of accommodation from the bothay to the well appointed cottage or barn conversion in the more expensive range. There is also a real need for a more sophisticated marketing service perhaps under the joint sponsorship of the Farming Organisations and the Tourist Boards.

An experiment which was initiated by the LDSPB a year ago called UMEX III is (6) seeking to test the effects of adding one additional resource to the economic choices available to the hill farmer to see whether onto that additional economic strength can be woven other objectives such as landscape conservation, recreation and a more appropriate structure of farming enterprises. Some of the possibilities emerging from the first exploratory year are of great interest. For many high farms in the National Park the addition of a tourist enterprise to the farm comprising one or several self-catering units converted usually from traditional, but agriculturally redundant, farm buildings means that the farmer is released from the constraint of having to find an exclusively agricultural solution to family income. In several cases this has led to a complete re-examination of the farm enterprise. For example some farmers who have needed to retain a suckler herd on the farm, in spite of conditions being inappropriate, have decided to convert their antiquated byres and barns into self-catering units, discontinue the suckler enterprise, expand the flock of hill ewes, and summer some cattle from the lowlands. Is not that kind of sound integrated solution more sensible in its use of resources, in its adherence to national objectives in the hills, and in the greater strength of the farm business freed from total dependence on the store cattle and sheep market, and the retention of a cattle enterprise whose profit margin was unduly dependent on compensatory allowances? Is there not also in the light of these findings, and in response to further necessary constraints which may be placed on the breadth of economic choice in hill farming as a result of proposals in the new Countryside Bill presently being drafted, and also in response to the proposed removal of Development Area status from several upland areas, a need to involve MAFF more fully in this movement towards integration in the uplands? The immediate implementation of Article 10 of the LFAD by the Minister of Agriculture would go much of the way towards meeting this need. Many now believe that the time has come for the Minister to act on this vital step towards integration in the uplands.

The uplands provide a base for a whole range of small manufacturing industries whose sites and raw materials lie close to the farming economy, and are often dependent upon it. There is a new popularity for natural materials which compliment the bland impersonal fabrics of much modern construction and domestic design. It includes many small and medium sized stonecraft industries making a variety of products, Joinery and woodcraft enterprises are particularly important and new opportunities are being taken up in timber growing areas. The redundant buildings of an evolving agriculture often offer an ideal base for a range of small industries including potters, weavers and a variety of craft producers. The importance of these small enterprises to the upland economy should not be underestimated for they develop a much greater dependence on local services than do many larger businesses, producing in most cases a much stronger multiplier within the rural economy than larger, externally owned operations.

Hand in hand with these enterprises comes the strengthening of rural services and the establishment in larger rural centres of those more substantial businesses which provide the bedrock of employment and prosperity towards the establishment of which the H and IDB and the Development Commission have been so outstandingly successful.

What grounds do these possibilities offer for such optimism?

First is the fact that the resources of our uplands have never been so relevant to the needs of the nation. The fact of the growing opportunities will bring a response. Second is the traditional approach to small enterprise, kept alive in farming businesses. The very austerity of life in the uplands has always demanded resourcefulness, and a positive attitude towards enterprises and individual responsibility. Third, in recent years, in spite of the continuing agricultural decline, there has been much evidence of a desire on the part of young people from urban areas to live in the hills. Not only romantics looking for a new lifestyle, but particularly young people of energy and imagination looking for a healthy, more human community freed from the stresses, conflicts and anxieties of many urban areas, in which to raise a family. Prof. Peter Hall in his report 'Europe 2000' has predicted that the rural economy will be the most important growth area in the national economy during the next fifty years. Earlier in this paper the fears of the possible impact of micro technology on urban employment were listed, but for the rural economy, particularly the upland economy, they offer no threat only new opportunities. The possibility that the equivalent of a mainframe computer will be within the reach of any small business or enthusiastic individual within a few years raises many possibilities. No longer need the questions posed to the small entrepreneur be solved on a 'hunch', research and management aids will be within the reach of the very small enterprise as it is now with any large national organisation. The opportunities which this possibility opens offer a new competitive edge to upland based enterprises. But the future strength of small enterprises is based on the personal involvement, and the relationships between everyone involved in the enterprise, the common dedication to its success.

The existence of potentials, and even the enthusiasm and ability of a local population are not in themselves guarantees of success for the upland economy. The implementation of the steps towards integration of policies in upland areas is critical not only to the realisation of potentials but also in some areas to the avoidance of catastrophe.

The first steps at ground level will need in many cases to be tailor made to the needs and the problems of a particular area. There can be no fixed pattern which should be adopted. For example, the problems of protracted decline in population and economy which afflict the Western Islands of Scotland[13] may well demand a strong interventionist approach to provide the structure of services and initiate the enterprises on which a revival can be built, and the proposals of the H and IDB for achieving this are most impressive, based on action by the Board and using its organisation and experienced staff to push through a very detailed and ambitious programme, for an integrated approach to the economic revival of the Western Islands.

However such an approach may be entirely inappropriate in the North Pennines, where an ambitious project The East Fellside Project, aimed at revitalising the life and economy of the western flank of the North Pennines and conserving its unique character, has been initiated through the foresight of the Eden District Council supported by the Development Commission, Countryside Commission, ADAS, Cumbria Tourist Board and Forestry Commission. Here a much simpler, less interventionist approach is considered appropriate involving two project officers and a minimum of bureaucratic control within a community which is already motivated towards enterprise and where the potentials hang like ripe apples. In contrast again the LDSPB building on the pioneering steps towards the integration of farming and recreation in National Parks through the Countryside Commission UMEX[5] Experiments, initiated in 1977 the UMEX III Project which further aims to[6] integrate an additional economic resource tourism to the farm business within an already highly developed process towards the integration of farming and recreation in the now well established UM Service.

Each approach will be different according to needs and opportunities, but there are some guidelines which may be helpful and which may be applicable in the majority of cases. The initiative will generally come from local authorities, including of course national park authorities, who will co-ordinate the immediate steps towards integration bringing together and involving the appropriate agencies of government. In many cases the pattern may develop on the now well established project basis, with project officers working directly on practical programmes with the people on the ground. The professional skills and finance of departments and agencies would be made available to the project through their participation. However, there will be exceptions to this structure such as the H and I and perhaps other areas where other local authority priorities do not allow them to act decisively in an upland area for which they are responsible.

The role of government departments and agencies is critical to any progress towards integration. The Ministry of Agriculture has been constrained from moving as far in this direction as hill farmers and many of its own officers would like and to this end Ministers should implement immediately Articles 3.5 and Article 10 of the Less Favoured Areas Directive. Strong pressure for the implementation of these Directives has come from the farming organisations and the conservation lobby who are very conscious of their appropriateness at this time to the Countryside Bill which is presently being drafted.

The importance of Article 3.5 to integration in the uplands is of the utmost significance as it brings together agriculture and conservation within a single management package compensating the farmer for constraints on agriculture to meet national conservation policies through agricultural support thus enabling conservation to become a positive element in the enterprise structure of the farm.

The Forestry Commission needs to take another close look at the way it supports private forestry to ensure that every possible avenue forward is covered. Steps should be taken by government agencies concerned in the uplands to ensure that national departmental policies are sufficiently flexible to be capable of being fully co-ordinated at local level. There will be a growing need for some centre for the gathering and dissemination of information on integrated policies in Europe and the U.K., and for the promotion of research and projects for integrated development. When we consider the waste in potentials and public resources which conflicting objectives have brought about in the uplands there is obvious need for some public investment in evolving ways to avoid these conflicts and realise possibilities.

I see little need for any significant expansion in government financial aids. The present available range of aids covers most of the area of need.

Possible change in the CAP do, however, require some consideration. It is widely predicted that there will be difficulties in funding the CAP during the next eighteen months. Any reduction in intervention prices would be bound to strike first at those areas where profit margins are narrowest, the hills and uplands. In such an event it would be vital to ensure that the upland economy was not forced into further decline. One way of helping to sustain the strength of the upland economy is to stimulate the development of the non-agricultural sector where so many potentials are now emerging. An important proposal has been made for the establishment of an EEC Rural Fund by Mr. J. Corrie and Mr. J.Scott-Hopkins and this should be given serious consideration. Another interesting development has been the establishment, under the Directorate for the Co-ordination of European Funds, of a Free Quota Section of the Regional Fund. This comprises 5% of the Regional Fund and its use is at the discretion of the Commission. Recognising the absence of appropriate aids to the non-agricultural sector of the upland economy the scope for the Free Quota Section is of the utmost importance although it is very limited in scale. Perhaps it might also be considered that any change to the Guarantee Section should be matched by action to sustain the economics of LFAs. This might be done by setting aside a small percentage of the Guarantee and Guidance Funds to be applied to integrated rural development in LFA in line with the iniatives already taken in the proposals of the Commission.(13)

There has been a growing realisation over many years of the need to integrate our many purposes in the uplands. Inevitably the necessary changes will encounter caution on the part of some individuals and departmental interests, which largely accounts for the slow progress to date. But today we stand at another of those historic crossroads, where we cannot long remain as we are and the alternatives to a determined programme for integrated development in the uplands are distinctly unattractive. But the prospect is not bleak, never have there been so many converging possibilities, never have the means to furnish a renaissance in the uplands been more readily to hand.

Cautiously, but resolutely we must let slip the safety of our separate interests and responsibilities and edge our way upwards to restore the unity and vigour of the hills, and "break the circles of our discontent".

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