THE BIOTIC EFFECTS OF PUBLIC PRESSURES ON THE ENVIRONMENT

Monks Wood Experimental Station
Symposium No.3

Proceedings edited by Dr. E. Duffey

THE NATURE CONSERVANCY
Natural Environment Research Council

Price 10s net

THE BIOTIC EFFECTS OF PUBLIC PRESSURES ON THE ENVIRONMENT

A Symposium held at Monks Wood Experimental Station
March 20/21 1967

N.E.R.C.
November 1967.

THIRD SCIENTIFIC STAFF SYMPOSIUM

'THE BIOTIC EFFECTS OF PUBLIC PRESSURES ON THE ENVIRONMENT'

P R O G R A M M E

MONDAY 20 MARCH 1967 - Lord Howick in the Chair

TUESDAY 21 MARCH 1967 - Dr. M. W. Holdgate in the Chair

PARTICIPANTS

BARKER, G.	Warden/Naturalist, Old Winchester Hill N.N.R.
BROWN, A. H. F.	Merlewood Research Station
BURTON, T. L.	Centre for Urban and Regional Studies, Birmingham University
COLLIER, R. V.	Warden, Castor Hanglands N.N.R.
COLLING, A. W.	The Nature Conservancy, Edinburgh
DAWSON, W. H. F.	County Naturalists' Trust
DUFFEY, E.	Monks Wood Experimental Station
ELLIOTT, R. J.	The Nature Conservancy, Attingham Park, Shrewsbury
ELLIS, E. A.	Wheatfen Broad, Surlingham, Norfolk
FORMAN, B.	The Nature Conservancy
FRAZER, J. F. D.	The Nature Conservancy
GAY, P. A.	Regional Officer, South-east England
GEORGE, M.	Regional Officer, East Anglia
GOMM, F. R.	Warden/Naturalist, Cornwall and Isles of Scilly
GORDON, Miss N. J.	Regional Officer, North and Central Scotland
GREAVES, Miss J.	National Parks Commission
HAMMOND, E. C.	Warden/Naturalist, Kent
HARTLEY, Miss J.	National Parks Commission
HOLDGATE, M. W.	Deputy Director (Research), The Nature Conservancy
HOWELLS, G.	Deputy Regional Officer, North Wales
HOWICK Lord	Chairman, The Nature Conservancy
HUDSON, M. J.	Assistant Regional Officer, Midlands
HUXLEY, T.	Regional Officer, South Scotland
JENKINS, D.	Assistant Director (Research) Scotland, Nature Conservancy
KERR, A. J.	Deputy Regional Officer, South Scotland
LANE, R.	Warden/Naturalist, Tring Reservoirs

LEE, R. K.	Lindsey County Council
McCARTHY, J.	Deputy Regional Officer, North England
MELLANBY, K.	Director, Monks Wood Experimental Station
MOORE, N. W.	Monks Wood Experimental Station
MORTON BOYD, J.	Regional Officer, West Scotland
NEWBOULD, P.	University College, London
NORTON, G. A.	University College of North Wales, Bangor
OSWALD, P. H.	Education Advisory Section, Attingham Park, Shrewsbury
PENDLEBURY, J. B.	Monks Wood Experimental Station
PERRING, F. H.	Monks Wood Experimental Station
POORE, M. E. D.	Director, The Nature Conservancy
RACKHAM, O.	University of Cambridge
REYNOLDS, F. L.	Conservation Officer, Surrey Naturalists' Trust
SCHOFIELD, J. M.	Deputy Regional Officer, East Anglia
SKELLAM, J. G.	Head of Biometrics Section, The Nature Conservancy
SMITH, A. E.	Principal Advisory Officer, County Naturalists' Trust
STRAW, F. I.	Lindsey County Council
STREETER, D. T.	University of Sussex
TEAGLE, Mrs. W. G.	Wardens, Studland Heath N.N.R., Dorset
& WATSON, A.	Unit of Grouse and Moorland Ecology, Banchory
WATT, A. S., F.R.S.	University of Cambridge
WAY, J. M.	Monks Wood Experimental Station
WELLS, D. A.	Monks Wood Experimental Station
WELLS, T. C. E.	Monks Wood Experimental Station
WHITE, D. A.	Deputy Regional Officer, South Wales
WILLIAMS, O. B.	C.S.I.R.O., Australia (visiting research worker); Monks Wood Experimental Station
WILLIAMSON, K.	British Trust for Ornithology, Tring, Herts

INTRODUCTORY REMARKS

E. Duffey
Monks Wood Experimental Station

One of the main objects of the meeting is to provide an opportunity for research and conservation staff to discuss problems of mutual concern and interest. The new emphasis of the Conservancy's scientific policy linking the work of the research stations more closely to the practical problems of wildlife conservation, underlines the need for staff who plan research in conservation ecology to be fully aware of the type of information required by those who have to apply ecological knowledge in their management and advisory work. These two functions of the Conservancy's scientific staff tend to lead to a natural divergence of ideas and attitudes between the Conservation and Research branches unless a conscious effort is made to create closer links and better communication between them. We are still the only State organization in any country responsible both for managing nature reserves and for research on management problems. We should make the fullest use of this unique opportunity.

The theme of this meeting could include a wide range of very different subjects but only a few can be found space in our two-day programme. We chose to give as much emphasis as possible to the "biotic effects" of public pressures because we are all biologists of one sort or another. Nevertheless, we recognize that an equally important part of the problem is concerned with sociological and planning aspects of human activities in the countryside. The Conservancy will probably have to contribute to studies of this kind in some cases but generally these are the responsibility of the professionally trained planner and social scientist. Means must be found to enable Conservancy staff to co-operate more closely on joint studies with them in order to demonstrate the value of ecological knowledge in land-use planning which meets the needs of all sections of the community.

When this theme was first proposed, a comment was made that there were so few facts available about biotic effects of public activities and so little experimental work has been done that discussion on it would be premature. It is true that factual data and experimental results are extremely meagre but nevertheless the problem exists and is growing at an increasing rate. It is precisely because of these reasons that I believe the time is right to discuss it. In addition, some of the contributions, particularly those in Session I, have a strong controversial flavour. They are concerned primarily with attitudes, principles and policies in conservation where wildlife is affected by the use that people make of the countryside. None of them is new; they have been argued at length for a good while but now that we have the benefit of seventeen years' accumulated experience, we should expect to see the emergence of generally acceptable solutions.

In conclusion, I hope that at the end of the two days, we shall have improved our minds on four points: a better idea of the nature and complexity of the subject; the most urgent problems requiring attention; the most profitable lines for study and research; that all of us will have a better idea of the experience, knowledge and opinions of other members of the scientific staff.

CONSERVATION POLICY AND INTRODUCTIONS TO NATURE RESERVES

D. T. Streeter
School of Biological Sciences, University of Sussex

The question of introductions is probably one of the most controversial of all those concerned with nature reserve management. Precedents exist for almost every type and degree of deliberate introduction so inevitably anyone ill-advised enough to embark on a discussion of the problem is going to tread on someone's toes.

The question of introductions to reserves cannot really be treated in isolation from the whole problem of species introductions to the environment as a whole. A nature reserve is only a special part of the environment set aside for a specific reason and many could be seriously affected by the invasion of species whose initial point of introduction was elsewhere than the reserve itself.

However most deliberate introductions to reserves do not involve alien populations. By alien population, I mean in this context one which is beyond the normal natural limits of its geographical range. There is of course a well-known, dare I say notorious, exception to this. That is the introduction in 1927 of the Dutch sub-species of the Large Copper, Lycaena dispar batavus to Woodwalton Fen to replace the British sub-species that became extinct in the middle of the last century. Possibly the earliest deliberate re-introduction of a native species that had become extinct was that of the Capercaillie, Tetrao urogallus to Perthshire from Sweden in 1837. This had become extinct in England about 1660 and in Scotland and Ireland almost exactly a century later.

There seems as yet to be no generally agreed policy on the question of introductions either on the broad field or to reserves in particular. Elton wrote in 1958, "I see no reason why the reconstitution of communities to make them rich and interesting and stable should not include a careful selection of exotic forms, especially as many of these are in any case going to arrive in due course and occupy some niche", and last year Yapp suggested that a whole host of extinct species such as the wolf, boar and bear should be re-introduced to the British countryside.

I shall try to outline some of the considerations which seem to me to be important in any attempt to arrive at objective views on introductions to reserves, although as I have suggested the whole problem of introductions on the broad scale affects reserves. There is, however, insufficient time to deal with the broader issues here.

Introductions to reserves are normally made for one of four reasons:

1. To prevent site erosion

Examples under this heading include the planting of marram, Ammophila arenaria, sand couch, Agropyron junceiforme and even pine to stabilize mobile dune systems. The planting of Spartina to stabilize coastal mud flats, and trees on catchment areas to control erosion, are among other instances that can be quoted.

2. To provide an economic crop

It is only rarely that introductions under this heading are carried out after the establishment of a reserve but many reserves are inherited part or all of which are already subject to some form of agricultural or forestry management.

3. To create new habitats

The creation of new habitats frequently forms an important aspect of nature reserve management plans. The justification that is usually given for this is that it increases the ecological diversity of the site. Many new habitats formed in this way are open habitats or habitats representing a previous stage in the succession and thus do not involve the deliberate introduction of new species. Further, it is hoped that the species characteristic of the new habitat will appear naturally by the normal processes of invasion and establishment.

If one starts with the premise that introductions to reserves of species not previously present are undesirable, then the construction of, say, a pond would be considered unexceptional, but an artificially planted reed bed would be considered a monstrosity. In both cases, one is simply creating a new habitat. However, the creation of the reed bed would be smiled upon if subsequent diligent searching proved that in one corner of the reserve a few scattered and depauperate stems of Phragmites were already present. The pond may have been created in the hope or certainty that it would eventually be occupied by wild fowl. In order to speed up their appearance decoys might be put down which would now render the exercise suspect. If, after the decoys had successfully discharged their function, they were put into the pot, then no doubt the wound would heal in time. But the cynics would then question the sense of the last action if its only purpose was to render the operation respectable. There would seem to be a certain amount of illogicality in attitudes towards species introductions in this context. The real question at issue here would seem to be whether or not it is desirable to create new and additional habitats on reserves at all.

4. To protect individual species

It is introductions under this heading that give rise to most of the difficulties and differences of opinion. A species may be introduced into the reserve from outside because it is rare or threatened. The degree of rarity may only be local or it could be national or international. The last hardly applies in Britain, but conceivably might if the populations of either the gannet, Sula bassana or the grey seal, Halichoerus grypus ever decreased to danger level. The St. Kilda house-mouse, Mus musculus muralis would have qualified under this heading and other island sub-species might well do so. Species might also be introduced to reserves because they are considered to form a typical or integral part of the ecosystem being managed. This need not involve species that are particularly rare.

Two interacting considerations would appear to contribute towards the formulation of an objective policy on introductions to reserves which would eventually find expression in reserve management prescriptions. These are firstly the purpose for which the reserve was established and secondly ecological considerations. The purpose for which a reserve is established will clearly have a large influence on the policy regarding introductions. Broadly speaking nature reserves are established primarily for their high scientific interest or because they are ideally suited for the teaching of field biology or for a combination of both these reasons.

If a reserve is established primarily for its high scientific value it is likely that it will have been established as part of a series designed to represent the whole range of British natural and semi-natural ecosystems. In a sense this is a rescue operation as on many reserves the ecosystems that the reserve is supposed to demonstrate are already changing in a direction away from what we regard to be typical. That is, they are either deficient in some detail or have acquired non-typical characteristics. If the reserve is to provide future generations with examples of natural and semi-natural ecosystems then there appears to be no apparent reason against making up the deficiencies by reintroducing the missing components or removing those which are atypical. This is acceptable providing that the introductions are genuine and characteristic components of the ecosystem under consideration and that the introduced individuals are taken from neighbouring populations. Care should also be taken to ensure that the population of the introduced species is not allowed to exceed, under management, the numbers that it would be expected to reach as a component of the community under natural conditions. Also, this outlook rigidly excludes the introduction of aliens, in the sense already defined, to reserves and also suggests that consideration should be given to removing them if they happen to be already present.

Where educational reserves are managed so as to illustrate ecological principles as exemplified by natural or semi-natural ecosystems the same criteria relating to an introductions policy would apply.

One reason often given to justify introductions on grounds other than the straight protection of a rare species is that it increases ecological diversity. The argument is especially used in connection with the creation of new habitats. This concept should be examined in terms of (i) the effect that increased diversity has on the reserve and (ii) whether that effect is desirable.

The addition of new populations to a particular community inevitably increases the species diversity. High species diversity appears to be an essential component of ecological stability and a characteristic of the more 'mature' ecosystems of any one climatic region. The possible theoretical reasons for this have been discussed by Hutchinson (1959) and Margalef (1963). This appears to imply that if the objects of management were to maintain an area at an early successional stage, that is, 'immature' stage, then management prescription should seek to reduce rather than increase species diversity. Conversely, if the area under consideration was at a later successional stage, then an increase in species diversity would appear to be desirable in order to increase stability as an inherent characteristic of the ecosystem being managed. Experience shows that if it is necessary to alter an area from a later to an earlier successional stage, then normal management practice appears to involve an artificial reduction in species diversity by, for example, scrub clearance. So far the preceding theoretical argument appears to hold. The difficulty which arises lies in the fact that management prescrptions are usually such as to require the permanent maintenance of the early successional stage so achieved, or in other words, the maintenance in a stable state of an inherently non-stable system. Hence, for any nature reserve the amount of management required is inversely proportional to the maturity of the ecosystem being managed.

A further point that requires consideration is whether in the more mature ecosystems the highest species diversity always occurs in the same components of the ecosystem. For example mature woodland can be characterized by a relatively low species diversity in the vegetation with a large number of herbivorous animals associated with each plant species as compared with well established grazed limestone grassland which has a high species diversity in the vegetation with relatively fewer herbivorous animals per plant species. One of the ways to ensure high species diversity in woodland would then appear to be to encourage those tree species in the canopy with the highest number of associated insects and to discourage those with a lower number of associated animal species. Southwood (1961) has suggested that the number of insect species associated with a particular tree is a reflection of the cumulative abundance of that tree in the particular country throughout recent geological history which means that the dominant native trees will have the most insect species. and recently introduced ones fewest. This is a further argument for discouraging alien species as large numbers of aliens will thus result in a reduction in the potential species diversity. In addition Southwood points out that after the historical factor has been taken into account, some species appear particularly susceptible to insect colonization and these include members of the Rosaceae, such as apple, Malus sylvestris, hawthorn, Crataegus spp. and sloe, Prunus spinosa, and the Salicaceae (willows). The introduction and encouragement of these species in woodlands would then be expected to lead to increased species diversity and thus enhanced stability.

However, it is essential to bear in mind that in order to achieve maximum stability adequate diversity must be maintained in each trophic level. As the higher trophic levels contain fewer species and fewer individuals they are particularly vulnerable. This highlights the importance of predator conservation. If the total predator pupulation ever dropped to an insignificant level consideration might have to be given to reintroduction in order to maintain ecological stability in the environment as a whole.

Stability is not always achieved by increasing habitat diversity. Moore (1962) has pointed out 'the smallest viable size of a habitat is the smallest which supports a viable population of its key species'. Key species in this context are described as those which, if removed, would result in a radical change in the ecosystem. The size of a viable habitat varies with the habitat, hence the smallest viable size of a reed bed is considerably less than that of an oak wood. If the habitat is too small it is unstable or in other words, too small to support the minimum species diversity necessary to maintain stability. It is therefore important that if new habitats are to be created on reserves they should be large enough to be viable units. This leads to the further consideration that new habitats should not fragment existing habitats to the extent of reducing them to a size which approaches the viable limit. Care should also be taken to ensure that any new habitats created are relevant to those already in existence, such as the creation of a reed bed at the end of a lake or a glade in a wood.

A strong argument against introducing populations to new areas is that it results in a disruption in the natural pattern of genetic variation within the species. Unless there is complete certainty that the species concerned is absent from the area to which it is intended that the introduction should be made, this can seriously affect the results of genetical experiments. For this reason the point must be reiterated that was made earlier that if introductions to reserves are undertaken it is important that the individuals selected for introduction should come from neighbouring populations and not from a different part of the geographical range of the species. On the other hand, if the species concerned has been reduced to the level of a few small isolated populations, genetic isolation will ultimately lead to a reduction in genetic variability of the populations so reducing their survival potential. In this case the choice has to be made between conserving the genetical interest of the situation for a relatively short term by keeping the populations in isolation or taking steps to improve the chance of survival of the species by controlled mixing of the populations to increase their genetic variability.

Lastly, introductions also seriously affect work on distribution patterns of species. In this country we probably have the most sophisticated programme of research into ecological distributions of any country in the world based on the Nature Conservancy's Biological Records Centre. In order to reduce the possibility of misleading results appearing as a product of introductions to reserves, or from experiments involving introductions in general, it is essential that these are fully and accurately documented and the details sent to the Biological Records Centre.

SUMMARY

1. Introductions should be kept to the minimum necessary for the furtherance of the objectives implied in the reasons for reserve establishment. This implies:

(i) only those species typical of the ecosystems represented on the reserve and of that particular region should be introduced;

(ii) individuals for introduction should be taken from populations in the same part of the geographical range as the reserve, except in the case of species close to extinction when other steps may have to be taken;

(iii) populations of introduced species should not be allowed under management to get unnaturally large;

(iv) special attention needs to be paid to species in the higher trophic levels which are particularly vulnerable;

(v) alien species should not be introduced onto reserves, and aliens already present should be discouraged or exterminated, except where they form part of an economic crop;

(vi) any new habitats created should be of a viable size;

(vii) new habitats created should not fragment existing ones;

(viii) new habitats created should be relevant to those already in existence on the reserve.

2. Exceptions should be made to these general principles where they affect specific research projects.

3. All introductions should be adequately recorded and details sent to the Biological Records Centre.

REFERENCES

ELTON, C.S. 1958. The Ecology of Invasions by Animals and Plants. Methuen.

HUTCHINSON, G.E. 1959. Homage to Santa Rosalia or Why are there so many kinds of animals? Amer.Nat. 93, 145-159.

MARGALEF, R. 1963. On certain unifying principles in ecology. Amer.Nat. 97, 357-374.

MOORE, N.W. 1962. The heaths of Dorset and their conservation. J.Ecol. 50, 369-391.

SOUTHWOOD, T.R.E. 1961. The number of species of insect associated with various trees. J.Anim.Ecol. 30, 1-8.

YAPP, W.B. 1966. Bring back the Bear. Wildlife and the Countryside, 257, 4.

SUMMARY OF DISCUSSION

The speaker was asked whether there would be any objection to past introductions if all of them had been fully documented. He said there would be objections in some cases, and he proposed two categories of these. The first concerned those species which had been previously recorded on a reserve and where in general, reintroduction was permissible. Secondly special consideration could be given to those cases where reserves had been established for rare species, for example, where the particular rare species was present just outside the reserve but possibly had never been recorded actually within the boundary. If such a rare species was threatened, then its removal to within the reserve boundary should be permitted. He thought that there was also some danger in giving too much artificial aid to certain rare species and gave as an example the Monkey Orchid in Kent which now numbered over a thousand plants and he thought that this locality was not what the original chalk grassland looked like. The problem of accidentally introducing seeds and spores, together with the transplants, was raised and the speaker thought that in most cases, because the introduced plant was being moved to a similar habitat, it was very likely that such seeds and spores would be present anyway or at least typical of that particular habitat.

Further discussion was centred on the definition of an alien. Was this term used in a local, national or continental sense? The speaker said that he had used the term in a national sense. It was pointed out that as scientists we should be concerned with ecological frontiers rather than political ones. The speaker expressed the view that the British Isles was a good ecological unit and at the same time, happened to be a political one as well. The importance of recording introductions properly was emphasised and the example given of Pinguicula grandiflora which was introduced into Cornwall from Ireland. The person responsible forgot where he had established it and then some ten to fifteen years later, a large area of this plant was recorded in the county but it was not known whether it originated from the Irish introduction. Other objections to introductions which were raised from the floor were as follows.

By moving plants about within the country, the distribution of genetic material would be affected and so interfere with the study of species variation. There would also be a management problem because we know so little about the behaviour of plants. It would be difficult to predict what sort of management would be required to maintain an introduced plant and one may not know how to cope if things got out of control. Even native plants sometimes behaved in an unusual way and the example of Chamaenerion angustifolium was quoted as a species which was fairly uncommon a few decades ago but suddenly began to spread and is very common at the present time.

INSECT INTRODUCTIONS

J. F. D. Frazer
The Nature Conservancy

It is the Nature Conservancy's policy to regard introductions with great caution. As far as Reserves are concerned, this is normally taken to include species which were formerly there and have subsequently become extinct. It is considered undesirable that even these should be reintroduced, other than after careful consideration and as part of an experimental approach which should be carefully documented. Before the rationale of this is discussed it is desirable to consider the background against which such introductions would take place.

We are a small country kept apart from Europe for the past few thousand years by a mere twenty miles of sea. Our insect fauna is continually changing, and is by no means in balance even with that just across the Channel. Inside the country there are numerous different habitats, and the more uncommon (or less well-known) insect species are often associated with but one of these or with a particular seral stage. There will therefore be natural changes in the insect fauna of a Reserve as the habitats themselves change. This, coupled with the conservatism of collectors, may well explain in part the frequent complaint that the butterfly fauna of the New Forest is a poor remnant of what it was. The effect on the insect numbers may be relatively direct, by restriction of suitable habitat or foodplant, or it may act via changes in predator, parasite or disease levels.

Some migrant species are more or less continuously entering the country, and if the weather is suitable and foodplants occur, those which are at the edge of their range may establish colonies for a year or two. Then a build-up of parasites or predators, or a change in the weather may eliminate them. It is possible that this type of fluctuation was behind the occasional presence of the Mazarine Blue butterfly, Cyaniris semiargus, Rott. in certain British localities during the last century, with only one or two recorded since. Other immigrants (e.g. the Oleander Hawk Moth, Daphnis nerii L.) may find the climate too severe for their foodplant, so that their reproduction is prevented. Offspring of immigrant coliad butterflies may be fortunate enough to survive one winter in a few sheltered localities, but the odds are against later generations of the same stock getting through the next.

It is salutary to look more closely at the way in which foreign species can enter this country, and hence how they may become available as prospective tenants of Reserves. Possible means are:

1. On the wing, whether travelling involuntarily on the wind (e.g. the Vestal moth, Rhodometria sacraria L.), or aided by it (French 1964), or wholly under their own power. An example of the last is the Milkweed butterfly, Danaus plexippus L. which I have seen in Queensland soaring unconcerned on a gale force wind. In many cases, such migrants may appear on any Reserve which happen to lie in their flight-path. Whether they stay there will depend not only on their degree of migratory restlessness, but also on the presence or absence of suitable terrain and foodplants.

2. On their foodplants: gardening and agriculture are widespread and implicit in this is the transport of plants from one country to another. The bug Graphocephala coccinea Forst. has been found for example on imported American rhododendrons at Bedgebury Arboretum (C.A. McDermott, pers.comm.). Several exotic species of woodlice have occurred at Kew (Fitter 1945) while twenty-one foreign species of Thysanoptera have been reported from glasshouses in this country (Morison 1959).

3. In timber: various timber-feeding beetles have entered the country (Hickin 1959).

4. Among stored products: The Australian beetle Lathridius bifasciatus (Reitter) as a pest of tobacco in its native land. In this country it was reported from Godstone in Surrey during 1949 but out of doors it is now plentiful as far afield as the Midlands and has even been noted as far north as Edinburgh (Shaw 1966).

5. In aircraft: it is normally assumed that measures generally adopted to prevent mosquito transfer from one country to another should be adequate to foil other insects. But are they? A recent note (Feltwell 1967) points out that at Orly Airport, Paris, the loading of baggage under strong lights at night lures numbers of cockchafers, Meloleutha meloleutha L. to the aircraft. These are subsequently liberated on to various airports in the U.S.A. and elsewhere.

6. In ships: the possibilities here range from assisted passage on the upper works to storage amongst the cargo or even in the ballast (Lindroth 1957). Two examples will suffice. There is the recorded suggestion of Newman (1955) that the Camberwell Beauty butterfly, Nymphalis antiopa L. reaches us mainly in timber ships from Scandinavia. Secondly is the magnificent opportunity formerly offered to so many creatures to travel with the stems of bananas reaching us from West Africa and the West Indies, but probably now decreasing. Snakes, geckoes, treefrogs, small monkeys, bushbabies, rodents, giant millipedes and a great variety of invertebrates have travelled in this way. Potential colonisers may well have been amonst them.

7. As castaways: Welch (1964) has recorded a small number of the beetle Pycnomerus fuliginosus Erichson from Australia, found at Slapton, which may have had origin in logs cast ashore. Four specimens were found alive on logs and another in a felled tree half a mile inland. He refers to the discovery of four foreign species alive in pitprops washed ashore after they had been in the sea three weeks (Bartlett 1918 1921).

8. Parasites travelling on birds, bats, domestic or farm animals, wild animals or man. Normally these will not become established but there is always the possibility of their finding alternative hosts. As they are potential carriers of disease for man (e.g. the plague flea, Xenopsylla cheopis) or other animals (e.g. the rabbit flea, Spilopsyllus cuniculi), their introduction could produce major effects on local populations of their hosts.

9. Species deliberately introduced by man. Some of these will be mentioned below in the course of discussion. Meanwhile, attention can be drawn to the documentation by Ford (1945) of the introduction of the

Map butterfly Araschnia levana to the Forest of Dean in 1912 and its subsequent elimination on account of its being an alien species. In the last few years, a commercial firm has been offering larvae of this species and inciting its customers to liberate them in this country, at the same time impressing on them the need for secrecy.

What then are the arguments against the introduction of adult stock or any of the pre-imaginal stages? In the first place, being of alien origins they will be carrying a new set of genes, unadapted to the local conditions and pressures. For better or for worse, these will thereafter be present in the stock. If by any chance the native race is not extinct this pollution of their gene pool will, of itself, confuse the scientific issues involved in any research. Consider for example the story of the Large Copper butterfly at Woodwalton Fen. The native stock of the nominate race, Lycaena dispar dispar L. became extinct over a century ago. Duffey (1967) has pointed out that this disappearance took place before the final draining of the fens and destruction of the insect's habitat. The closely related Dutch race, L. d. batavus Oberthür was reintroduced some forty years ago, but although it survived for some years both at Wicken Fen and Ashton, Northants. (M. Rothschild, pers. comm.) before the habitats there were destroyed, it has failed to survive unaided in the wild at Woodwalton Fen (Duffey 1967). Later introductions of 80 adults and 81 pre-adults to Wheatfen Broad in 1949 (Ellis 1950) and others to the Downpatrick Marshes in Northern Ireland in 1965 were unsuccessful, the species vanishing within a couple of years. Is the atypical behaviour and high mortality recorded by Duffey (1967) possibly because dispar and batavus are two subspecies derived from some Doggerland ancestor which spread outwards to produce forms adapted to the British and Dutch environments respectively? Or is the species at the edge of its range at Woodwalton Fen and so more vulnerable? After all, it died out elsewhere in Britain (e.g. the Somerset wetlands) a century ago.

The story is, however, further complicated. 550 adults and some pupae of the subspecies rutilus were liberated into what is now the Bure Marshes National Nature Reserve in 1926 (Gurney 1927) and something like 150 larvae were seen before hibernation. The few fullfed larvae and pupae seen in July 1927 produced adults, but no subsequent ova were found (Gurney 1928). Earlier, in 1909, larvae had been released into Wicken Fen without result (Ford 1945). Ssp. rutilus was also introduced into a snipe-bog in Co. Tipperary over fifty years ago (Ford 1945) and has only died out there within the past five years (M. George, pers.comm.).

Species which man deliberately seeks to introduce may be classified as:

A. Wholly alien in the context of our knowledge of the past two centuries or so, which is all that encompasses our entomological knowledge. They may be subdivided into:

i) Overtly harmful species e.g. the Colorado Beetle, furniture beetles, termites etc. Some, such as the Colorado Beetle, are already the subject of legislation. The rest are unlikely to be the subject of attempts at introduction by any sane entomologist other than under the strictest conditions so that they can be wiped out before there is any chance of their getting out of hand.

ii) Potentially dangerous species. There was a proposal in 1964 to introduce the American bumblebee Bombus americanorum for experimental purposes, but the idea was criticized at the Entomological Liaison Committee of the Nature Conservancy and the project was dropped.

iii) Species which appear at the time to be harmless. It is perhaps only necessary to mention the Grey Squirrel, Coypu and Mink under this heading but amongst insects, attention should be drawn to the Gipsy Moth, Lymantria dispar L. and the Small White butterfly, Pieris rapae L. which increased to pest proportions after their introduction into the United States. De Worms (1959) has drawn attention to the number of persons rearing "silkmoths", some of which are now appearing here in the feral state.

B. Native species not as yet found in the particular Reserve. Here there are two snags. In the first place, would the species have a chance of spreading there naturally if unimpeded? To this is a backcloth of responsible entomologists all over the country who rear insects surplus to their own requirements and liberate these with a laudable conservation intent. But should this be done other than in the locality whence their stock came? Or even there?

Another serious doubt concerns the predator/parasite situation. Suppose species X and species Y have a common predator or parasite: undue flooding of an area with X may then give this its chance for expansion and so increase the pressure on Y. If Y is naturally the favoured host, this could have serious consequences for it.

C. Native species to be introduced again to a former haunt. But due consideration needs to be given to the question why the species died out earlier.

Had the habitat become unsuitable? Was predation too high? Or has it really died out completely? It is salutary to remember the case of the Rosy Marsh moth, Coenophila subrosea St. which disappeared from its only known haunts in this country about 110 years ago after the drainage of Whittlesea Mere but two years ago was re-discovered in Wales (Revell 1965). The Blackveined White butterfly, Aporia crataegi L. was believed to have become extinct here in the 1920s but the person who unsuccessfully attempted to reintroduce the species to another part of the country (where it died out rapidly) has since been able to record the presence of a small surviving colony in a part of its former range (Newman 1949, 1965). On the other hand, the Entomological Liaison Committee has recently approved an attempt to establish this species in Somerset (subject to due experimental safeguards), which is far outside the area in which it has been seen this century.

As a further warning, it should be mentioned that in 1964 the regional staff favoured the reintroduction of the Heath Fritillary butterfly, Melitaea athalia (Rott.) which had disappeared from Blean Woods National Nature Reserve, but this has since spread back into the Reserve as the coppicing cycle of management has gone forward. This species used to occur in discrete colonies in three areas in Kent, Sussex and Essex apart from its more diffuse distribution in Devon. With the disappearance of the original colony, a wholly successful introduction of Kent stock to the Essex locality was made, but I am personally glad that there was never any suggestion that the Devon type (which is very different both in appearance and behaviour) should be used.

The Large Blue butterfly, Maculinea arion L. is another species whose reintroduction to former haunts has been advocated. I understand that in at least one case, a collector provided and maintained a suitable habitat, introduced the butterfly and farmed it annually for the surplus. On the other hand, those who know the butterfly well state that (as well as being secretive) it ranges far in its flight and will soon colonise any habitat which is suitably managed within its restricted range.

Finally, one can perhaps come back to the fens and the case of a former resident, the Swallowtail butterfly, Papilio machaon britannicus at Wicken Fen. The Swallowtail died out at Wicken during the last ten years and no Wicken stock of the species has been discovered in captivity. It has therefore been proposed to reintroduce a stock of the correct ssp., but originating elsewhere. So far, attempts to re-establish this wild colony have not met with success, so the case is on a par with that of the Large Copper at Woodwalton Fen. Ethically speaking, the reintroduction of these two species to the wild (if it can be achieved) would seem to be free of the dangers of possible harm to others. It would re-establish butterflies which the public regards as an amenity, and could form the basis of important research into conservation methods and practices. Under the circumstances, the balance appears to be in favour of reintroduction.

Success has not always crowned the efforts of those attempting to reintroduce a species. Failure has been reported for the White Admiral butterfly, Limenitis camilla L. (Ford 1945) in an area where the species later appeared naturally. Similar failure attended the attempt to reintroduce the Scotch Argus, Erebia aethiops Esp. to Grange-over-Sands (Wright 1945).

When reintroduction is considered to be justified, what are the conditions necessary for success? First of all, there must be an adequate area of suitable habitats under proper management. This alone (as in the case of chalk grassland and the two Lysandra species) may so control predators and parasites as to enable the species to survive, but it can only be the case if the area is so large that predators and parasites living outside cannot penetrate to the centre during their wanderings. Shape as well as size may be important here. Secondly there must be adequate stocks of food both for adult and larval stages, and the right conditions for pupation. Some parts of the area must have a micro-climate conducive to the insects' survival and this may mean greater diversity than in the rest of the resettlement area. Thirdly, there must be an adequate stock of colonists, of whatever stage. Where an insect can lay hundreds of eggs and conditions are favourable, fluctuations in numbers can be extremely rapid. If the species is to attain a peak within five years, can this be best achieved by liberating five, fifty or five hundred insects per acre?

REFERENCES

BARTLETT, C. 1918. Acanthocinus sedilis L. in N. Devon. Ent.mon.Mag., 54, 137-8.

BARTLETT, C. 1921. A note on Coleoptera in drift pine-logs. Ent.mon. Mag., 57, 15.

DE WORMS, C. G. M. 1965. An exotic Saturniid at Woking. Ent.Record, 77, 294.

DUFFEY, E. A. G. 1967. (In press).

ELLIS, E. A. 1950. The introduction of the Large Copper butterfly, Lycaena dispar batavus (Oberthür) at Wheatfen Broad, Norfolk. Trans.

FELTWELL, J. S. E. 1967. Bull.A.E.S., 26, 13-14.

FITTER, R.S.R. 1945. London's Natural History (Collins, London).

FORD, E. B. 1945. Butterflies (Collins, London).

FRENCH, R. A. 1964. Invasions of Britain by Lepidoptera in relation to wind trajectories. Proc.R.E.S. Series C, 29, 5.

GURNEY, G. H. 1927. Introduction of the Large Copper butterfly, Chrysophanus rutilus, in Norfolk. Trans.Norf.Norw.N.H.S., 12, 262-3.

GURNEY, G. H. 1928. The Large Copper butterfly, Chrysophanus rutilus. Trans.Norf.Norw.N.H.S., 12, 379.

HICKIN, N. E. 1959. Alien insects found alive in Britain. 7-8. Ent. Gaz., 10, 17-18.

LINDROTH, C. H. 1957. The faunal connections between Europe and North America. (New York and Stockholm).

MORISON, G. D. 1957. A review of glasshouse Thysanoptera. Trans.R.E.S., 109, 467-534.

NEWMAN, L. H. 1949. A re-introduction of Aporia crataegi in Kent. Entomologist, 82, 140.

NEWMAN, L. H. 1955. Nymphalis antiopa: migrant or stowaway? Entomologist, 88, 25-27.

NEWMAN, L. H. 1965. Return of the Black-veined White. Country Life, 137, 1073.

REVELL, R. J. 1965. The Rosy Marsh moth, Coenophila subrosea Stephens in Wales. Ent. Gazette, 16, 162.

SHAW, S. 1966. An Australian beetle in Coventry. Proc.Coventry & District N.H. & Sci.Soc., 3, 261-2.

WELCH, R. C. 1964. Pycnomerus fuliginosus Er. (Col., Colydidae) new to Britain. Ent.mon.Mag., 100, 57-60.

WRIGHT, A. E. 1945 . A Manx record of the Scotch Argus butterfly. Peregrine, 1, 8-9.

SUMMARY OF DISCUSSION

In the case of insect introductions it was said that the main point was to decide whether a species was in danger of becoming extinct. It was the fate of the species that really mattered. The speaker replied that some held the opinion that conservation should be concentrated more in the centre of the range of the species than on its edge, the point being that the conservation of a species on the edge of its range was usually more difficult than elsewhere. There was also the difficulty of defining what one meant by a species in this context.

It was suggested that it might be useful to build up a stock of a particular rare species under laboratory conditions and then at some stage in the future, reintroduce it to an area where the species had been known, or even to an area where it was becoming scarce.

Another contributor said that we all seem to be particularly sensitive about introductions at the species level and yet in another way we were aiding this by our declared policy of diversification of habitat which is written into most management plans. By modifying habitats in this way, we were helping to prepare the ground for the establishment of new plants and animals although we may disapprove in principle of the introduction of species. We should remember that at this stage of our knowledge, many changes are taking place on conservation areas because of our ignorance of the structure and functioning of complex ecosystems.

CONSERVATION AND THE COLLECTOR

D. A. Ratcliffe
Monks Wood Experimental Station

A basic question which we frequently meet but which conservationists often have difficulty in answering is "what is conservation good for?", or "why conserve wildlife?". Replies fall into three main groups: (1) those which emphasize economic utility; (2) those which try to make a case for the aesthetic needs of mankind, and (3) those which insist that wildlife should continue to exist in its own right. All three attitudes have validity, and you may argue that it is unnecessary or incorrect to separate them, but I am attempting here a scientific enquiry and think it right to break down a complex issue into component parts in order to achieve insight. I incline most strongly to the middle course of the three mentioned for I personally dislike the first as tending towards an essentially materialistic outlook and believe that economic aspects of conservation are not the primary concern of all conservationists. I tend to avoid the last - though not without sympathy - because of its fundamental philosophical difficulties.

My theme therefore lies along the line of conservation as a means of enriching the human way of life, in an intellectual or aesthetic sense, and by this, I mean giving a means of satisfaction and fulfilment to all with an interest in wildlife, from the person who finds this in simply looking at plants, birds and other creatures, to the research scientist who delights in unravelling the deeper intricacies of their lives, and is more concerned with biological processes. Beginning probably nearer the first, but sometimes developing into the second, there comes the collector, that is, the person who has a need to express the basic acquisitive urge so widely and innately present in mankind, and who does so by the assembling of a collection of specimens. The desirability of an organism as a collector's specimen is closely bound up with its intrinsic beauty, its variability (as a taxon) and its rarity - all three factors being closely related. As rarity tends to draw the collector's attention strongly, there is an immediate threat to the less common species, and collecting differs from many forms of predation in usually being highly selective and not density dependent.

Those who are aware of the potential dangers of collecting to wildlife have sought to control or even outlaw this activity by legislation. In Britain, laws have been passed which go well on the way to complete prohibition of the private collecting of birds' eggs and skins, and the taking of wild birds to keep in captivity. In Switzerland and Germany there are laws against the collecting of plants as well, but in Britain, all other creatures except game mammals and fish are unprotected by law, except on certain lands, such as National Trust properties and nature reserves, where they are protected under bye-laws. Attitudes are thus inconsistent: egg-collecting in this country tends to be portrayed by conservationists as an unethical and undesirable activity, while at the other extreme, there is a generally permissive view of lepidopterists who collect the country's rarest insects for no purpose other than the enrichment of private collections. While a schoolboy can be 'run-in' for taking the eggs of a blackbird, there is nothing except the law of trespass to prevent a greedy collector from raiding one of the few remaining colonies of Large Blues, trapping a Snowdonian Pine Marten or uprooting the rare alpine fern Woodsia on the northern mountains.

There would seem to be three approaches to the problem of the collector:

1. To legislate completely and severely against all unlicensed taking of natural history specimens for private collections. Laws could be passed but it would be unrealistic to expect anything more than limited enforcement, for special species, in special areas. I am here talking about the private collector. The need for licensed collection for scientific research is not in question, though the wholesale collection of biological specimens such as amphibians and reptiles for teaching purposes is obviously in need of appraisal and control. Private collecting leads to professional dealing but the latter is an effect rather than a cause.

2. To educate people and especially children, to an understanding that collecting of wildlife is an unethical activity, and that the collecting instinct should be sublimated into expression as photography, sound recording, observational recording, or simply tally listing - all of which can provide an adequate outlet, and nowadays are tending increasingly to replace the older style collecting.

3. To accept that collecting of wildlife is a normal human instinct, but to control and regulate its impact by a licensing system, with adequate protection for rarer species. This is the present approach to the shooting of wildfowl, which to me is neither more nor less civilized and ethical an activity than the taking of birds' eggs; it differs only in being much less selective for rarities.

Present practice in fact embraces all three approaches though with illogical separation in the case of the third according to emotive attitude towards the forms of wildlife involved. It is still "O.K." to collect most insects, bryophytes and lichens, provided that the scale is not overdone; it is becoming rather less respectable to collect native flowering plants and ferns in this country; and it is strictly taboo to lift a bird's egg from its nest. Possession of egg blow-pipe and drills is very nearly as incriminating as owning a set of burglar's tools. Yet, even in conservation circles, the similar question of collecting such organisms as mites, fleas, myxomycetes and freshwater algae would - I shall guess - be regarded as unworthy of serious discussion, if not actually frivolous. In other words, it all depends on the "popular appeal" of the organisms themselves.

Let us first examine the damage that private collecting has done amongst our wildlife. Taking the birds' egg and skin collector first; there are reasonable grounds for believing that these people contributed heavily towards the decline and extinction of the Osprey in Scotland between 1840 and 1920, though the part played by fishermen has never been revealed. They may also have hastened the end of the Sea Eagle though even protectionists are now admitting that more pervasive factors must have initiated the decline in this species. It may be true that the Welsh Kite would have gone under without the stringent protection given to the remnant which hung on after other factors had shattered the once flourishing countrywide population. But in the case of rare species such as the Hobby and Dotterel, it is clear that despite gloomy predictions for many years, the taking of literally hundreds of clutches of eggs of both birds in this country during the last fifty years has had no detectable effect on the size of the British breeding populations. True, they are both fringe species here, with large continental populations which could make up any deficit in replacements. Again, the Peregrine (another species which was forecast for extinction by many of the older writers) has shown a remarkable ability to maintain its numbers in the face of heavy collecting. From the records of the collectors themselves, it is clear that in the Lake District alone, several hundred clutches of eggs of this species were taken during the period 1900-1960, yet the population never varied more than fractionally during the whole of this time, remaining at 25 pairs plus or minus 3; and it was only after 1960 when decline set in, attributable to the contamination of the population by persistent pesticidal residues. Had the toxic chemical situation not arisen, the rock climber would probably by now be a more serious threat than the collector to the Peregrine population of this district.

I give this information not to white-wash egg collecting, but to try to restore a little balance to a subject heavily charged with emotion. I think the scale of egg-taking with some species has been truly deplorable and do not doubt that this activity could exterminate extreme rarities or prevent the establishment of new colonists. Again, some species are, through their habits, e.g. colonial nesting, inherently more at risk to collecting than others. What about the entomologists? Here I can only speak about lepidopterists, but the past ravages suffered by rarities such as the Purple Emperor, Large Blue, Northern Dart, Kentish Glory and Rannoch Sprawler are well known. But with insects, unless the habitat is limited or the habitats specialised, it is difficult to exterminate a species, as contact and capture have a fair measure of density dependence, and it is not easy to find the last few individuals. This is even more true of the less conspicuous insects and other invertebrates; with these, rarity is a relative measure only.

For both birds and insects, it would seem that the destruction of habitat is an infinitely bigger threat to survival than collecting on a scale known so far. Now for the botanists: plants have the great disadvantage compared with birds and, to a lesser extent, insects, of being relatively immobile, and their powers of recuperation are less. Rare plants are rare for the very reason that their powers of spread and competition are limited, under the prevailing conditions. When the population of a rare plant is reduced it may not readily recover, and if it is eradicated from a locality, it may not spread back there, at least not within a period of, say, a hundred years. The collecting of rare plants thus tends to result in a permanent depletion of their populations, or total extinction in certain localities. There are plenty of examples: the case of the Ladies' Slipper orchid is well known - eradicated one by one from all its other known localities, it was still, in 1966, being dug up in its publicised remaining station. Rare orchids in general are much threatened. The famous Killarney Fern was reduced from abundance to rarity in south west Ireland during the Victorian era of fern collecting, and is, I am told, still under threat from locals who sell rare plants for American exiles to take back home. During the same period, the rare mountain fern Woodsia ilvensis was totally eradicated in at least half of its few British stations, and I have myself watched the depletion of its equally rare relative W. alpina in two of its best known Scottish localities during the last ten years.

Without elaborating further, I will give my firm belief that, within their respective spheres, plant collectors have done far more damage than egg collectors to the wildlife of this country. It makes little difference that some of the worst offenders are those who take plants to grow rather than to stick on sheets of paper. Bryologists are not exempt from these strictures, either, and I have seen even eminent professionals behave with complete disregard for the damage they were doing.

This may seem an unhelpful analysis of the collector problem, but I shall now state some conclusions to be drawn from it.

1. There is a strong and increasing case for legislation to protect rare plants from collectors and gardeners. Yet, to guard against the occasional crank, secrecy in the case of localities for extreme rarities will have to be preserved into the foreseeable future.

2. The present attitude to the collecting of bird skins and eggs alienates a whole body of able ornithologists who have a contribution to make through their knowledge. A reasonable and rational approach here is more likely to achieve the end of protecting rarities. Present attitudes tend only to inflame the extremists on both sides and protectionists should realise that quite a lot of collecting of specially guarded eggs is done for no other reason than to score off the opposition!

3. The present permissive attitude to the collecting of certain organisms is not objectionable, but it is highly inconsistent. I believe that education about wildlife should be directed towards fostering modes of expression of the collecting "instinct" which do not involve taking and killing the living organism itself. The rights and wrongs of keeping live birds and animals in captivity is a still more difficult problem. Whether this educational process should involve the total banning of such collecting at all times, or whether such collecting of common organisms in early years is allowable as a developmental phase, is a problem for educational psychologists. Whatever the case, it will have to be based on a sound wildlife conservation ethic, and it will be a slower process than one would wish. Whilst realising that ideals are seldom if ever attainable in full, I believe that in this field, the goal should lie in the direction of achieving a more civilized attitude to wildlife and environment, and thus to life in general. And as we progress educationally, the original question, "what is conservation good for?" will be asked with decreasing frequency.

SUMMARY OF DISCUSSION
follows M. G. Morris' paper

INSECT COLLECTING WITH SPECIAL REFERENCE TO NATURE RESERVES

M. G. Morris
Monks Wood Experimental Station

It is obvious that an assessment of the problem of insect collecting can be made only in relation to the purposes of conservation. Some of these are to provide for the aesthetic and spiritual needs of the people. Why are insects collected? It is convenient to consider collecting under two headings which I shall call (1) scientific collecting and (2) "bug-hunting". The scientist - who may very often be an expert amateur - collects insects in the process of finding answers to problems in taxonomy, physiology, genetics, ecology and so on. As scientists ourselves, we probably approve in general of the reasons for the collecting of insects but we should note that research may not always be compatible with conservation. The bug-hunter however - who may occasionally be a professional scientist - collects insects because he gets pleasure from the formation of a collection of specimens. Some regard bug-hunting as, at best, an unfortunate survival from the nineteenth century while others consider it is a legitimate form of recreation.

It is of course, impossible to divide all collecting neatly into scientific collecting and bug-hunting. Nearly all collectors are a mixture of the two kinds, though most will be primarily one or the other.

A third kind of collecting may be distinguished, although it is really a variant of either scientific collecting or bug-hunting. This I call 'destructive collecting'. Destructive collecting may be regarded as any form of collecting which is detrimental to the interests of others. Assessment of whether collecting is destructive usually varies with the ideas on conservation which are held by the person judging the collector. Although basically the collecting of insects does not differ from the collecting of any other form of wildlife, there are several practical considerations which powerfully modify our attitude towards it. Most insects cannot be identified in the field and have to be killed before they can be determined. They do not stand still while they are photographed or drawn, as do plants. The reproductive potential of nearly all insects is much higher than that of mammals and birds and consequently natural mortality is also very much higher. Viable populations can exist in much smaller areas than is the case for larger animals. Most insects hide themselves away and are infrequently seen by the general naturalist, to whom in any case, they often have little aesthetic appeal.

So far I have spoken as if the problems of collecting do not differ from insect group to insect group. This is far from the case, and in fact, it is probably true to say that if it were not for lepidopterists, there would be no problem of collecting at all. This is because the majority of bug-hunters collect Lepidoptera which are often conspicuous and have a relatively high aesthetic appeal as well as having a commercial value. The average level of 'scientific competence' among lepidopterists is low compared with collectors of other insect groups (as a general rule mean scientific competence varies inversely with the popularity of a group).

What are these problems of collecting? As far as I can see, there are only two main objections; (1) collectors cause damage either directly to populations of insects, or indirectly to vegetation and 'habitats': (2) collectors project a bad image to the public, which should be increasingly educated in principles of conservation and appreciation of wildlife.

In the absence of any experimental evidence, it is difficult to evaluate the damage collectors cause to insect populations, though as Dr. Ratcliffe points out, this type of predation is not density-dependent and is directed towards the rarer species. This is because most collectors take a 'series' of each species and like to have at least as long a series of rarities as of common species. Uncommon species which are also variable and aesthetically pleasing are perhaps at greatest risk. Variability in a species often means that large numbers of specimens are taken where a dozen or so would have sufficed in the case of a constant form. Among reasonable well-documented extinctions of species in Britain, only two, the Large Copper, Lycaena dispar and the introduced Map butterfly, Araschnia levana have been commonly laid at the doors of collectors. In the case of the Large Copper the damage was done by local fenmen collecting larvae for sale rather than by the collectors in person. It is likely that reduction of the habitat was at least a contributory cause of the Large Copper's extinction, although this has been disputed. It is claimed that A. B. Farn was solely responsible for the extinction of the Map butterfly (the introduction of which that forthright collector opposed), but we have too little evidence to be sure.

Other extinctions (e.g. the Black-veined White, Aporia crataegi (L.)) and Mazarine Blue, Cyaniris semiargus (Rott.) were almost certainly due to climatic changes and not to collecting. Even in the case of the Large Blue, Maculinea arion (L.), collecting can only have been a contributory factor to the increasing rarity of the species, agricultural improvement destroying its habitat being the main cause. Yet few can doubt that the activities of collectors have helped in the decline of this species; while 'horror stories' of collecting such species as the Rose Plume, Eucnemidophorus rhododactylus (Schiff.) and some of those mentioned by Dr. Ratcliffe can leave one in little doubt of the destructiveness of some collectors.

The prevalence of techniques, such as light-trapping, is an additional problem as being potentially damaging to insect populations. However, the problem is really one of misuse of light traps rather than of their use. The killing of the whole night's catch is unnecessary and, to be fair, not usually done. The effects of anaesthetics are unknown, but may be deleterious to populations, though obviously better than outright killing.

Like all other users of the countryside, collectors indirectly damage wildlife by their activities. Unfortunately, destructiveness in collectors often comes to the fore when trees are beaten for larvae or bark stripped off for Coleoptera of lepidopterous pupae. On the other hand, one of our best field naturalists used to take hammer and tacks into the field with him to nail on pieces of bark which he removed to collect beetles. This problem seems to be one soluble by education and propaganda.

The bad image which collectors project to the less well informed and perhaps sentimental conservationist, is less easily put right. It is already difficult for the scientist to put over the ecological fact that culling of populations, particularly of species at the ends of food chains, is often necessary in the interests of the survival of a healthy stock. How much more difficult to persuade the sceptic that collecting, which is of no benefit to the species concerned, may be harmless!

I am aware that a third kind of objection to collecting exists; the ethical one. I have not included this because I am convinced that ethics are a purely personal affair. One person may believe that collecting and killing insects is wrong, but this remains a personal belief.

Having considered the objections to collecting, we may ask whether collecting serves any useful purpose. It does of course, meet the needs - or at least the desires - of the collector, surely an important point. Apart from that, we should have a much poorer knowledge of the fauna of the country, its composition, distribution and biology without collectors, even of the humble bug-hunting variety. In the Symposium on Invertebrates, I was able to summarize the representation of butterflies on statutory nature reserves by writing to Regional Officers for information. In most cases, the species were recorded by collectors. Collecting also provides material for scientific study. Apart from studies on living material, it is probably true to say however, that there already exists in museums more than adequate quantities of material for taxonomic study in all but the least well known groups and that the collection of material for such purposes in most cases is superfluous.

Sight records of Lepidoptera, especially butterflies, are often quoted as a possible substitute for collecting, as nearly all ornithological work is done on sight records. I am very dubious about this, even for our "well-known" butterflies. In my time I have been given so many 'sight records' which I simply cannot believe that I cannot think that they are at all reliable. It is true that sight records are usually given by people who do not habitually carry butterfly nets and are therefore the least familiar with the species. Photography of insects is an increasingly popular pastime but is likely to be confined to relatively few people because of the expense of equipment. It should, I think, be accepted that in general there is no obvious alternative to collecting insects, though the increase in 'insect-watching' (by analogy with bird-watching) might be encouraged. Most collectors breed insects, either from collected larvae and pupae or from the egg. Many release the unwanted stock and provided this is done in the place where the species were collected, this does not do any harm and may do some good.

The heyday of bug-hunting has passed; compared with the nineteenth and early twentieth centuries, there are many less demanding and more passive recreations than the spending of much time, often with too little profit, in the countryside, accumulating a collection. There are good and bad aspects to this trend. We have to ask ourselves, as conservationists, what are the trends which we would like to initiate or develop in the future.

Most important of all, we must examine collecting <u>ecologically</u>, for ecology is the basis of good conservation. In the past the problem of collecting has too often been examined in the light of sentiment, mistaken ideas or just downright prejudice. In the first place, we must admit in some people an aesthetic and acquisition need which finds its outlet in the collection of insects. We should seek to modify this urge by making bug-hunters aware of the need for conservation and by showing them the ways in which bug-hunting can be developed into a no less satisfying but scientifically more desirable pursuit. At the same time we should examine the effects of bug-hunting ecologically and formulate a policy in relation to what we find. We are badly in need of some experimental results on the effects on insect populations of bug-hunting. At East Malling Research Station, larvae of Blepharidopterus angulatus (Fall.) (a mirid bug) were collected by hand from apple trees over a considerable period of time without there being any detectable change in numbers compared with control trees.

One aspect of insect populations seems to be very infrequently put forward: that is, that they are a self-renewing resource which can be exploited. Provided that the level of abundance of the population is not altered, there is surely no objection to the collection of any particular species. In other words, insect populations can be considered as a crop, just like other animal species.

In the main I believe that conservation policy should be roughly the same inside reserves as outside them, and should be concerned with the situation in the countryside generally. I am not in the least suggesting that reserves should be managed so that bug-hunters can be free to collect large numbers of rarities. I am suggesting that the renewable natural resource of insect populations can be exploited by bug-hunters, while at the same time, the scientist can benefit by getting information of the primary survey kind.

I have often heard it suggested that the Conservancy should ban collecting on its reserves, or at least regulate it by tightening up the permit system. It will undoubtedly be necessary from time to time to ban collecting on certain reserves, or parts of reserves, and to prohibit the collecting of certain species. The use of reserves for more important purposes, such as research, and the need to be free of interference will necessitate this. But such a policy is very different from the uncritical total banning of collecting on reserves. This would be a negative attitude doing no good whatever to the Conservancy, which would stand to lose a good deal of information which it might otherwise obtain. I know that a lot of bug-hunters submit worthless reports, or no report at all, of their collecting activities in reserves but I am reasonably confident that this can be altered by education and influence. This has certainly happened in a large number of cases. In my view, a positive attitude of mutual help, mutual reliance and friendly criticism and advice is more likely to benefit both the bug-hunter and conservationist.

SUMMARY OF DISCUSSIONS

It was pointed out that the great majority of young people begin their interest in natural history by collecting eggs or butterflies and that it is important for young people to be able to handle things in order to develop a real interest in them. The question was asked how many participants in the Symposium had started their interest in biology by collecting some type of natural history material and by a show of hands, it was clear that very nearly everyone had done so. One speaker added a note of caution however, by saying that we must not give collecting the credit for generating the first interest in natural history, even though it may have been an important part in the subsequent development. He said that in his own case, he had always been interested in plants but he had never collected them. It was possible however, that the collecting of one type of organism may quickly lead to a longer and deeper interest in another natural history subject.

Another speaker said that realizing that the children had a natural urge to collect things, the Cambridgeshire Naturalists' Trust had prepared a list of common plants for circulation to schools which the Trust felt could be collected without danger to the species. Many young people who were now recruited to the Conservancy do not seem to have the same interest in natural history as older members of staff. Was this because they did not begin their natural history interest by collecting? Another speaker said that there were now more young bug-hunters than ever before.

Commenting on Dr. Ratcliffe's paper, it was said that although egg collecting had probably little effect on the number of birds, it should be borne in mind that the collecting of eggs of rare birds could be a very great handicap to people doing research. The Golden Eagle was quoted as an example.

The inconsistency of attitudes to collecting was discussed as a problem facing the conservationist. The Chairman said that legislation on this type of problem was dictated by public opinion, for example, the special protection given to birds. He felt that if the same attention had been given to plants and insects, they too would have had public support for protection.

Following the comment by the Chairman, it was said that because birds and mammals were the end of the food chain, they were far fewer in numbers and this was another reason why special consideration had to be given to their protection. Insects were much more numerous and so were subject to much higher predation and therefore the conservation problem was of a different type. Examples were quoted of insects which were apparently very local being collected over a long period of time without an apparent decline in numbers. However, some collectors set a very bad example to young people by exhibiting large numbers of rare species which they had taken. Attention was drawn to the fact that a wild flower protection bill had been drawn up and would be submitted to the House of Lords.

IS WILDFOWLING COMPATIBLE WITH CONSERVATION?

T. Huxley
The Nature Conservancy, Edinburgh

This is a huge subject: I have little time and I shall have to ride rough-shod over the facts. I shall begin with a short personal statement and a rather longer diversion on the philosophy of wildfowlers and wildfowl watchers. The reason for the personal statement is to stress that it was entirely because of my Conservancy job that I became involved in a wildfowling problem. I am not a wildfowler and am not particularly attracted to wildfowl. Although in my childhood I was forced to spend some rather uncomfortable hours watching Shelduck in Chichester Harbour, this was nearly the sum of my early connections with wildfowl and I did not consciously see a skein of wild geese until after I was twenty-five. When I did see one, it was an exciting experience, but the sight did not stimulate nostalgia nor re-awaken some deep-seated attachment of early childhood. Therefore, although, in this personal respect, I expect that I am not different to many Regional Officers, I and others like me are starting off from a very different emotional standpoint to those who have had a long personal history of interest and involvement in matters related to wildfowl and wildfowling: it is not difficult to think of examples! Whether the decisions of "involved" people are more or less wise I do not know. The point is simply that this long history of involvement can affect the intensity of feeling behind such decisions and this in its turn creates problems which are the hallmark of wildfowl conservation.

I have said that in my own case the sight of a skein of wild geese did not stimulate nostalgia. Nostalgia (from Nestos = return home + Algos = pain) is the pain felt due to absence from home. I think it is permissible in this context to equate "home" with "sense of security" or "comfort" and it is pertinent to quote Marshall McLuhan - a Canadian sociologist - at this point. In an interview broadcast a few months ago on the Third Programme he said: "Nostalgia for old environments is the only form of comfort which adults get in this life". The trouble with wildfowl - as an element in our old environments - is that they keep going away. So also, of course, do Cuckoos or for that matter, any migratory bird. But the characteristic thing about wildfowl which distinguishes them from many other migratory species, is that while they are in Britain (a) many of them do not breed and (b) we shoot them. Thus there is about their going away, a feeling of guilt in some and of blame in others.

Of course any feelings of guilt or blame may be irrational but I believe they exist and I think they may intensify the sense of expectation before the birds return and of relief when they do. In our increasingly insecure world of bombs and rushing life, the "old environment" returns to give comfort and security. If the return of the wild geese still has almost a religious significance for some people, I would not be surprised; as late as the eighteenth century, men were still disproving that wonderful myth about the Barnacle Goose. But in our modern sophisticated age the simple fact that the birds have returned is not enough to give complete comfort. We must also know how many have returned, compare the year's figure with that of the year before and if the numbers have dropped, rapidly take up positions with loaded pens. The farmers among us will, in this case, remain silent but if the numbers rise it is they who may rush to print. Comfort for the farmer is the absence of anything likely to diminish his crops. W. J. Eggeling made the same point in a 1963 lecture on conservation: "We take a harvest of the wild geese, which yield both food and sport; food and recreation for man. If we didn't, there might well be larger 'clanging battalions' but there would be equally loud outcries from the farming population".

How different is all this variety of attitude to that concerning game birds! I know pheasants can do agricultural damage and grouse moors may be deplored by some ecologists but on the whole, game birds are watched, bred, fed and shot by the same group of people and conflicts between them do not often arise (see Summary of Discussion). Except for a handful of scientists with a vested interest in being able to continue their research, there is no game-bird watching lobby as distinct from a game-bird shooting lobby. Furthermore, the game-bird sportsman is generally a man of parts; he may not own the land he shoots on, but his income is often not far below the man who does and sometimes it is well above it. This brings me to another point about wildfowling folk. By and large, wildfowlers belong to the lower income levels of society. Of course one can think of many exceptions to this generalization but on the whole I believe it to be true that most wildfowlers have been traditionally accustomed to getting their sport "on the cheap" and so wildfowling has tended to be the sport of those who could not afford more. For the foreshore - where most wildfowling occurs - has been a pleasantly debatable land and one generally did not need permission to go on it. Furthermore wildfowl are not owned in the sense that game-birds are. So here is the one area where John Bull's poorer cousin can give free rein to his hunting instincts and understandably he has resented the inhibiting intrusions of bird watchers. But for some wildfowlers the most irksome inhibition of all has come from within their own ranks. As incomes have risen and competition for renting a rough shoot has become more severe, increasing numbers of relatively leisured, articulate, organization men have moved into the field of the small time free man's traditional sport.

I shall now return briefly to the fact that most wildfowl are migratory species wintering in Britain and breeding elsewhere. There are several important points to be brought out here. Firstly the breeding grounds are mainly in remote, widely dispersed northern lands which makes difficulties for scientists studying wildfowl breeding biology. Secondly, if it is discovered that something is going wrong at the breeding grounds, for example, nuclear warhead trials or an increase in numbers of feral mink, there is very little we in Britain can do about it. Thirdly, even in winter, there is still a great deal of movement among wildfowl within Britain, and between Britain and the rest of Europe. If we could make a kind of time-lapse film from a camera in space we should discern a general movement south in autumn and a return movement in spring. A wide-angled lens would suggest a remarkable overall constancy of movement from one year to the next but if we zoomed in on particular localities we should discover irregularities of seasonal movement, for example, some flocks in some years not reaching as far south as in earlier or later years. Occasionally major changes would occur, possibly correlated with periods of severe cold weather, but on the whole it would be very difficult from our time-lapse film to distinguish detailed trends within periods of much less than ten years.

Of course, it is impossible to obtain such a film but we can and do in Britain, deploy men at strategic points on the ground to monitor such changes as can be seen in each observer's limited arc of vision and we can ring young and moulting birds at the breeding grounds and analyse the recoveries. Since 1947 an astonishing volume of reliable information has been compiled in Britain in this way. I have intentionally used the word "reliable" as a coat-trailer because I know there are some who, with justification, cast doubts on the accuracy of wildfowl counts in some situations. One must remember however, that the maximum number of wildfowl wintering in Britain is of the order of 1,200,000 (see Annex) and local errors tend to even out. Incidentally, we in the Conservancy should take a special interest in the results of the wildfowl counts scheme. Since 1954 the Wildfowl Trust has been responsible for this research and, in the period 1954 to 1964, the Trust has received substantial grants from the Conservancy*, a proportion of which has been devoted to running the counts.

Unfortunately few other European countries maintain a wildfowl-counting scheme of the accuracy of that in Britain and this is really why our time-lapse film cannot be made. Wildfowl research is an international problem and the need for international co-operation was stressed in the Recommendations of the First European Meeting on Wildfowl Conservation held at St. Andrews in October 1963. Until we know much more about wildfowl numbers in Europe, what changes occur from year to year and in what direction, it is very difficult to interpret the data obtained in Britain.

Nevertheless, you may wish to know something of what has been discovered about trends in wildfowl numbers in this country over the last twelve years. I could attempt to demonstrate this by showing you some of the excellent graphs prepared by Hugh Boyd and his co-workers and published in the Annual Reports of the Wildfowl Trust. To do this however, might suggest that I really know something about the subject! Instead I will read out phrases selected from the Nature Conservancy's Monograph No. 3 on the wildfowl of Great Britain (published in 1963). Thus:

Mute Swan:	Has increased; now stable.
Bean Goose:	Down on past years.
Pink-footed Goose:	Maximum numbers now about 60,000.
White-fronted Goose:	No change in maximum numbers in last 10 years.
Greylag Goose:	In 1962, 36,000 counted, probably the largest number to occur in Britain in the twentieth century.
Canada Goose:	Now probably more abundant than in 1953.
Shelduck:	Increased in abundance.
Teal:	Some appearance of upward trend, but since 1963, some evidence has accumulated to suggest that this may be due to gains from Europe where Teal may be decreasing possibly due to the Dutch Delta Scheme.

*See Annual Reports of Wildfowl Trust, 1954-64.

Mallard:	Slow increase in the period 1948 to 1962.
Wigeon:	No sustained trends in numbers between 1948 and 1962.
Eider:	An abundant and increasing coastal resident.
Pochard:	The population in the winters 1960 to 1962 was twice that of 1948 to 1951.
Tufted:	Marked increase from 1948 to 1957. Numbers have remained about level since then.

It appears therefore, that at the present time, numbers of most species of wildfowl wintering in Britain are not declining. Some species, such as Brent and Bean geese, may be getting fewer but in general, despite - or perhaps partly because of - some of the many changes which have occurred in the British level or have even slightly increased. Exactly why this is so is not known, but we may be certain that when enough is known to prepare balance sheets for each species, important causes will not be the same in all parts of the country. Some of the factors now being investigated are (i) changes in agriculture e.g. larger crops of barley and larger fields; (ii) the creation of new wetland habitats, e.g. gravel pits in southern England; (iii) changes in the European dispersal of wildfowl favouring Britain possible at the expense of countries in eastern Europe; (iv) efforts by wildfowling clubs to increase the breeding stock by artificial rearing; (v) legislation e.g. the Protection of Birds Act, 1954 and (vi) the creation of wildfowl refuges by statute or private agreement.

Here at last is my cue to return to the question posed in the title "Is wildfowling compatible with conservation?" If overall numbers of wildfowl wintering in Britain are not diminishing, then it might be expected to follow that the present level of mortality due to wildfowling is compatible with the maintenance of existing stocks also at the present level. I have to say "it might be expected to follow" because there is still a possibility that, in respect of some species, we may be shooting more than are replaced annually by natural increase of birds wintering in Britain i.e. British stocks are remaining level only because of immigration which, if it should be reduced because of depletion of stocks elsewhere, would reveal that mortality in Britain due to wildfowling had been too high.

The question is, however, "Is wildfowling compatible with conservation?" which leaves me, I'm afraid, with the difficult task of defining what is meant by conservation! It so happens that I have recently used this subject as a main lecturing theme, but this doesn't really help because my object has been to get people to understand that it is "only the exceptional writer on conservation whose use of the word is not self-contradictory or a mere camouflage whether deliberate or not, for the promotion of some special interest".* Perhaps the main objective should be qualified as follows: that where possible and subject to the more important need to provide human beings with full employment, good

*Herfindahl, D. C. in Burton I. and Kates, R. W. 1965. Readings in Resource Management and Conservation. Chicago Press. p.230.

housing, adequate food and a variety of recreational pursuits, wildfowl stocks should be maintained in enough places around the country to give reasonable opportunity for some people to watch wildfowl and some also to shoot them.

Note that it is not an obligatory object of wildfowl conservation to maintain stocks of all species at their present levels, nor do I think anyone, including the Nature Conservancy, is under an obligation to ensure that all ornithologists and wildfowlers can go on watching and shooting wildfowl to suit every parochial interest. Some of us, despite Marshall McLuhan's dictum, will have to find our sense of security without the comfort of old environments - although we shall, of course, continue to insist that our new environments are pleasant.

Note also that in my qualifying objective I accept wildfowling as a facet of wildfowl conservation and this is the second reason for saying "yes!" to the question in the title. To me, asking whether wildfowling is compatible with conservation is almost like asking whether slaughter houses are compatible with agriculture. I hold no special brief for wildfowl, as a class, that they should not be shot nor for wildfowlers, as a class, that they should cease their chosen pursuit. But obviously it is in the interest of wildfowlers that wildfowl should remain in places convenient for wildfowlers to shoot at them and in such numbers as to maintain from year to year a reasonable chance of a reasonable number of wildfowlers being able to shoot a reasonable number of birds. If wildfowlers stay happy it is my contention that non-gun toting ornithologists (good wildfowlers also enjoy just watching birds) should be satisfied too.

Thus far, I conclude, we have a type of problem solved by a minimum of general rules and a multiplicity of <u>ad hoc</u> choices each needing to be selected on local merit and a wary eye cast on the way things are going next door. This, in practice, is how wildfowl conservation has been managed in Britain in the last ten years and especially since 1954 when Mr. E. M. Nicholson first convened meetings of an informal advisory group which subsequently became the Wildfowl Conservation Committee. We owe a great deal to the labours of this Committee which, in the period 1961 to 1967, has considered and advised on 34 areas of wildfowl interest in 24 counties as well as receiving regular reports on sanctuaries at Bridgewater Bay, Caerlaverock, Humber, Lindisfarne, Southport, and Wyre-Lune.

At this point I might try to summarize some of the main events in the history of wildfowl conservation but I think you would rather I spoke specifically about Caerlaverock, proposed as a National Nature Reserve to conserve a saltmarsh habitat and to provide sanctuary for unspecified minimum number of Barnacle Geese. The management of controlled wildfowling was not in the original remit and this factor was introduced as much by the owner - who wanted to maintain the opportunity of shooting a reasonable share of wildfowl - as by those who wanted to protect Barnacles. Quite quickly everyone accepted the need for compromise and the only major source of disagreement was soon despatched by the owner himself establishing that, despite traditional beliefs he held the whip-hand. For Caerlaverock, in theory if not exactly in practice, is not an example of controlled shooting on foreshore (which is where matters so easily get out of hand). Rather it is an example of controlled shooting above H.W.M.O.S.T. where most of John Bull's poorer and more independent-minded cousins feel less at ease. Furthermore, at Caerlaverock, most of the pitfalls that have trapped the unwary elsewhere had been filled in by a few major enactments before the Reserve was declared. Byelaws made all shooting illegal except under permits issued by the Conservancy and the nature reserve agreement stated exactly where shooting should occur and who should advise the Conservancy on all matters relating to wildfowling. Thus the regional staff were left with the relatively simple task of devising an administrative system for issuing permits and for enforcing the conditions of their use. The only additional problem which they themselves created was so to construct the permit-issuing and returning system that lots of information could be reasonably obtained from it. Of course there were some outstanding difficulties and some which still occur and the advisory body set up by the N.R.A., the Caerlaverock Panel, has had to adopt a reasonably tough and consistent line. So also has the executive arm, modified by a clear directive to "please the customer". I will not bore you with exact details of how the system works. This has been amply described elsewhere;* it is enough that you should know that we have now issued some 4,000 permits and opened files on about 2,000 individual wildfowlers. The point which I wish to stress is that we attempted to execute our task rather as one might manage a theatre and we have tried to get the wildfowlers to share this approach and willingly accept - as one does in a theatre - certain limits on complete freedom of action. Perhaps most important of all, the Caerlaverock Panel has retained to itself the role of judge and chief adviser. Several times strong recommendations have come from "outside" which the Panel has turned down, for example, a limitation on the legally permissible range of species which may be shot under permit and a proposal to ban the use of decoys (as at Lindisfarne, where decoys for geese, but not duck, are prohibited), and we have always resisted proposals advocated solely on the grounds of uniformity with other controlled shoots unless they independently merited adoption at Caerlaverock. My only worry now is whether it will be possible to maintain our present standard of service. As the permit issuing system becomes more automatic, a spark of personal interest may cease to shine through. Perhaps this doesn't matter so long as the actors on stage continue to play their part and I have no qualms about the ushers, the Reserve Wardens; continual contact with people will keep their interests alive.

But what about the birds themselves, about 600 of which are killed each winter at Caerlaverock? What effect has this shooting on their number? In an internal paper the Conservancy has stated "The Humber Refuge, together with Caerlaverock, still forms the most important source of information available in this country on the problem of conserving wildfowl stocks within large areas where shooting pressures are heavy - and the experience thus gained is greatly increasing our capacity to assess the future of stocks of wildfowl with the support of shooting interests" (from WC/M/64/26 dated 12.10.64). It would be nice if this were strictly true but in reality we are a long way from being able to assess the effects of shooting on wildfowl stocks. At Caerlaverock there has not been any significance of the actual kill - and it brings me to my third reason for saying "yes" to the question posed by the title - is that in my experience most wildfowlers shoot very few wildfowl. At Caerlaverock and Bridgewater Bay N.N.R's, an average wildfowler shooting every day of the foreshore shooting season will only kill one bird every other day. But how one could convert these fragmentary statistics into, for example, numbers

*Huxley, T. 1964. Wildfowling at Caerlaverock National Nature Reserve, the first Seven Years. (2nd Edition). Roneo: The Nature Conservancy.

killed per square mile of coastline I do not know; at the present time at Caerlaverock - i.e. under controlled conditions - I doubt that it exceeds one bird per day per square mile and this number probably would not rise even if all controls were lifted. However, the fundamental reason for the inadequacy of our knowledge is not that the Conservancy's records are poor but that they represent such small areas over which birds may be killed. At Caerlaverock, for example, we know nothing about the kill over ground neighbouring the Reserve, especially on inland areas where, from other evidence (wing and tail returns), there is a suggestion that many of the birds roosting on the Reserve may be shot.

These statements may seem very vague and unscientific and some of you, knowing of the charts and tables published from returns at Aberlady Bay, Bridgewater Bay* and Caerlaverock - and soon to be supplemented by returns from Lindisfarne N.N.R. - may ask what is their value? Or to rephrase this question from the particular to the general, what is the value of controlled shooting?

To answer this I must first return to what I have already said about wildfowlers' spirit of independence. In some this rests on a point of principle so deep-seated that they will defend even those colleagues whose actions are not in the general interest. Thus it has been necessary to demonstrate that a certain loss of freedom in principle could lead in practice to a better enjoyment of wildfowling. This is primarily what has been demonstrated at Caerlaverock and the success of the Reserve may be measured by the steadily growing acceptance among wildfowlers of the idea that controlled wildfowling is a "good thing". Incidentally it is because of this educational factor that I advocate a permit system which allows the maximum number of individuals to get a shot. The 25 season-permits at Aberlady are issued on a dead men's shoes system which is easy to administer but has a low turnover and minimum educational effect. By contrast, half the 450 permit holders shooting at Caerlaverock each year are new to the Reserve. (At Bridgewater, the figure is about 10 per cent.).

Part of the reason for the increased acceptance of controlled wildfowling is that wildfowling is said to be better in areas subject to control. However much in principle one may admire an independent spirit, it can be a nuisance if it leads directly to a diminution of one's own pleasures - and the pleasures of wildfowling like most other forms of recreation, are complex. They are not to be measured solely by numbers of birds killed but may include physical discomfort, the excitement of seeing the quarry at close quarters and the opportunity of a kill even if a shot is never fired. A second value of controlled wildfowling is that it actually benefits the birds themselves - mainly by reducing disturbance at the roost. Some people consider disturbance is a more serious threat than actual kill. This is another subject about which we need to know much more. A third value of controlled wildfowling is that it can be a useful way to discover the requirements of an average wildfowler. I said something earlier about "a reasonable chance of a reasonable number of wildfowlers being able to shoot a reasonable number of birds". I am sure there have always been individual wildfowlers who have known their reasonable requirements but they seem not to have been documented in such a way as to be of use to managers of a controlled

*Morley, J. V. 1966. Wildfowling on the Huntspill Wall. Roneo: The Nature Conservancy.

wildfowling area. At Caerlaverock, after nearly ten years, we have begun to learn a little; for example, that shooting about one bird in a couple of days on a marsh to get to which one may have motored several hundred miles, may be an adequate prize for one's efforts.

Finally to answer the specific question about the value of shooting returns at Bridgewater Bay and elsewhere, their chief use, at present, is to stimulate all wildfowling associations to compile similar returns. Here again we are up against the freedom principle coupled with a suspicion that telling someone what you have shot today might reduce your chances of a shot tomorrow. At Caerlaverock we have gone out of our way to stress that admitting to what one has shot will not prejudice one's chance of another permit.

I hope you are now convinced that wildfowling is compatible with conservation. I believe it is (i) because as yet we have not good evidence to suggest that present mortality due to wildfowling is reducing wintering stocks; (ii) because I do not distinguish wildfowling from wildfowl conservation; and (iii) because the average British wildfowler shoots very few birds. One might argue that my first and last reasons come to the same thing and research may discover that this is so. Wildfowl numbers might go down for reasons unrelated to shooting pressure, or a lot more people might start shooting wildfowl - possibly upland where they may be easier to shoot. This might be undesirable for the wildfowl but I suspect that the first group to suffer real hardship would be the best types of wildfowler. You may thus conclude that the important question about wildfowling is not whether it is done but how it is done and where. Also in discussing the subject we must never speak of conservation and wildfowling interests as if they were in opposition.

Finally I must acknowledge that I have not attempted to answer the question "how should we conserve our wildfowl stocks?" Obviously conservation of wetland habitats and feeding grounds is going to be important but I think that the most difficult problem now, and always, will be to achieve unanimity of opinion as to whether all species should be conserved and at what population levels.

/Annex ....

Annex

TABLE OF WINTER MAXIMA OF WILDFOWL IN BRITAIN

Figures estimated from data in Wildfowl in Great Britain, 1963 Monographs of The Nature Conservancy, Number Three, H.M.S.O.

Mute Swans	18,000
Whooper Swans	2,000
Pinkfooted Geese	50,000)
Whitefronted Geese	8,000)
Greylag Geese	36,000)
Canada Geese	3,000)
Barnacle Geese	15,000)
Brent Geese	13,000)
Shelduck	50,000
Pintail	10,000
Teal	150,000
Mallard	500,000
Gadwall	2,000
Wigeon	250,000
Shoveler	6,000
Eider	34,000
Pochard	13,000
Tufted	30,000
Scaup	5,000
Scoter	10,000
Goldeneye	8,000
Total	1,213,000

SUMMARY OF DISCUSSION

It was pointed out that wildfowling was a very different problem to the shooting of game, from the conservation point of view. Wildfowlers were only interested in the birds which they wanted to shoot whereas the game preserver killed a variety of other birds and mammals because they were regarded as vermine. It was therefore much easier for the Conservancy to co-operate with wildfowlers and for both sides to make a constructive approach to conservation. In the case of game shooting, there were a number of other problems which were sometimes difficult to reconcile with conservation. It was also pointed out that, even in the case of wildfowling, its compatability with conservation was a relatively new concept and that not many years ago at Bridgewater Bay, it was considered unthinkable that the Conservancy should allow shooting at all on this particular coastal National Nature Reserve.

Another speaker said that wildfowlers were a section of the community who seemed ready to contribute towards their particular interest in a way which was not followed by other types of naturalists who thought that their activities should be quite free and unrestricted.

ARE RESEARCH ACTIVITIES ALWAYS COMPATIBLE WITH CONSERVATION?

E. A. Ellis
Wheatfen, Norfolk

Looking at the types of research activity carried out on our nature reserves in recent years, it cannot be doubted that in the long term, conservation must benefit from the knowledge acquired in this way. Indeed, most of the research has this end in view.

Nevertheless, each research project tends to be specialised and because of this there can be some risk of its having a damaging impact on a habitat or a plant and animal community, which may spark off a chain of events quite unforeseen by the individual specialist. To begin with, just the trampling of a path to and from the site being studied involves physical disturbance which may have long-term side effects. Such a track made over a marsh can open up the habitat for successful colonisation by sallow seedlings in May and June. The trampling of a belt of young reed shoots in April or early May may be followed by the rapid build-up of pathogenic fungi on the bruised plants, resulting in the death of reeds well beyond the line of the path itself. I have seen these things happen. No doubt many other examples could be found.

There is also the ever-present risk that the worker who makes visits to a site or a series of sites at regular intervals over a long period of time may be the unconscious bringer of invasive species from elsewhere. Seeds and insects are likely to be introduced in this way. What evidence I have, suggests that the marsh bug, Ischnodemus sabuleti colonised a small part of a Norfolk fen as a result of students coming directly to work at that spot after working in a habitat of this bug in another county. Within a few years, this insect was present in countless numbers on many hundreds of acres of fen and reedswamp in the Yare Valley. I also suspect that the cowslips on my lawn arrived as seed when a party of ecologists came over from cowslip country to work at Wheatfen one July when the plants would have been spilling ripe seed.

Such simple risks are well known and yet are mostly ignored, but they could at least be looked into more closely at times. Ideally I suppose, one should enter a nature reserve as one is expected to enter the Taj Mahal.

Then there is the risk of alien species being introduced purposely by a research worker. I am referring to instances in which plants are moved experimentally from one reserve to another for the legitimate purpose of finding out more about their adaptability as to local climate, pH, associated flora and fauna and so on. If such projects are to be given a blessing, the utmost care must be taken to see that they are under complete control. If bog plants from a Yorkshire moss were introduced to a Norfolk site and vice versa, there could be a risk of moss spores and insects of upland and lowland bogs being interchanged along with the phanerogams that are being studied. This could lead to the development of a highly complex and confusing situation in both habitats. I think one also has to be very careful about transplant experiments in relation to the conservation of local populations of species which may have peculiar genetic characteristics. Every nature reserve is a "gene bank" and it may be storing some rare treasure.

Lepidopterists who breed their insects in cages are familiar with the many parasites of caterpillars. Some of these are plurivorous, others specialise in attacking a single species, genus or family, as the case may be. Any risks of introducing putatively dangerous parasites should be calculated when outside stocks of Lepidoptera are placed on reserves. Similarly, care should be taken not to introduce lethal insect viruses 'in the field'.

In the past, light traps for sampling the moth fauna of particular habitats have sometimes been misused resulting in the destruction of large numbers of insects. I believe this risk is now usually obviated successfully by improved apparatus.

Grazing experiments are much in fashion and a good deal of valuable information has been obtained from some of them which can be made use of in the management of reserves. All the same, putting sheep and cattle on to some areas must be fraught with some very real risks at times, and I am sure that those who initiate this action do not always consider what are likely to be the consequences apart from getting rid of some dominant type of vegetation in favour of turf. Sometimes over-compaction of the soil may follow, or in soft ground the surface mat may be destroyed, leaving pulk holes. Animal dung and urine in excess may encourage vegetation changes not wholly desirable. Moreover, when animals are brought in periodically from outside, seeds are introduced in their dung from their last grazing area. Thus animals transported from Castor Hanglands to Woodwalton Fen and vice versa could effect exchanges in flora. In some instances, where nesting birds are involved, the introduction of grazing animals at certain periods may be harmful, although in other instances it may have a beneficial effect.

Woodland experiments involving the "gardening" of trees and shrubs, clearing undergrowth and litter, may increase the diversity of the flora and fauna in a particular habitat but at the same time develop a jumping-off place for some insect or fungus which may go on to have a more widespread effect in surrounding areas. When trees and bushes are cut down, possible wind effects should be considered in relation to adjacent areas. Blow-outs can develop on sandy ground after removal of sheltering vegetation; blow-outs of a different kind can develop in woods; moreover, the prevailing wind may sweep away flying insects from an isolated special habitat when shelter belts are removed. Sometimes, plants of various sizes are dug up for the study of root systems. This can affect local drainage, start blow-outs in light soils and so on. These points may seem trivial but they need to be thought about in relation to wider aspects of possible effects e.g. soil evolution and the interruption of ecological progression. Vegetation is burned off heaths and marshes to improve the habitats for certain birds or plants as the case may be. The experiments in such cases may have only one end in view, other consequences being ignored. Where large areas are involved, it must be fairly obvious that damage can be done, to insects such as grasshoppers, Lepidoptera and to indigenous reptiles such as lizards and snakes.

The deliberate raising or lowering of water tables for the purposes of experiment, unless very carefully localised, may prove injurious to some species. If a major interference results in a species becoming much scarcer, the scarcity may not be just temporary, because natural pressures may then prove too great for the species to survive in the absence of a proper reserve in the population. A decline initiated artificially can end in extermination.

I need hardly touch on the many possible side effects of conducting field experiments with pesticides and herbicides. Within the Conservancy I am sure that these highly necessary experiments are conducted with every care, but there may be risks which are best not taken on particular reserves and certainly the whole of the Conservancy's advisory services should be brought to bear when sites are being considered for carrying out such experiments.

In general, it seems to me that with the exercise of care and consideration in advance, whereby the specialist's project for an experiment is looked at from the conservation angle by those best qualified to judge, there should be little risk of scientists 'fouling their own nest' so to speak in the years ahead.

SUMMARY OF DISCUSSION

A participant said that there were certain types of research which were best done on land not within National Nature Reserves. In view of the many uses made of nature reserves, there was a strong case for owning land specifically for experiments where we could, if necessary, carry out experiments which may be harmful to wild life.

PUBLIC PRESSURES ON SOILS, PLANTS AND ANIMALS NEAR SKI LIFTS IN THE CAIRNGORMS

Adam Watson
Nature Conservancy Unit of Grouse and Moorland Ecology,
University of Aberdeen

INTRODUCTION

The Cairngorm region contains an area of high-arctic terrain unique in Britain, as well as being our largest National Nature Reserve in Britain. It was one of several outstanding Scottish areas chosen for potential National Parks in the late 1940s. Though till recently regarded as a wilderness almost untouched by man and likely to remain so because of its inaccessibility, it has now been developed considerably in certain areas.

Problems have arisen from a great increase of tourists following the building of roads, ski lifts and hotels. These various developments have hitherto been piecemeal and unco-ordinated. Damage occurred to the soils and vegetation during construction of the roads and lifts, and is still increasing due to human trampling and the passage of tractors. All this has led to more erosion which shows clearly on aerial photographs.

In addition, these developments have caused local eyesores on an attractive landscape, and some people fear that the unusual arcti-alpine plant communities and animal life may suffer. Planners and conservationists have been asked for advice, without having the necessary data on which to base firm recommendations. Since the area is of such outstanding public and scientific interest, such advice, which is urgently needed, must be realistic. Development should be preceded by research, although this has not so far happened, and the pace of development is now so fast that conservation interests are in danger of being swept aside because it is too late to do anything. It is a case where research and conservation interests must merge, and in 1967 the Nature Conservancy began a three-year research project on the problem in co-operation with the Universities at Aberdeen and Glasgow. It is a team project consisting of a botanist, a geomorphologist, and myself as zoologist. Landowners, ski-lift operators and other local organizations are co-operating. The Institute of Geological Sciences at Edinburgh has promised help, and the Geography Department at Glasgow University are interested because they are making a detailed large-scale recreation map of the Cairngorm area. Since our research project has just begun, there are no detailed results to report yet. This paper describes what has happened and outlines a proposed research programme.

WHAT HAS HAPPENED

Since 1945, many more people have visited the Cairngorms than before. Most are not mountaineers, who were always a small minority and whose numbers have not increased much. They climb mainly on the cleaner rock faces and tend to shun the soil-covered ledges that are good habitats for arctic-alpine plants. There has been no obvious erosion on or near the cliffs, such as has occurred in more popular climbing area like Glencoe or Snowdonia. The number of hill walkers has increased greatly since 1945 but the only obvious results on the Cairngorms are that some old paths have become slightly wider, new paths have appeared in some places where none previously existed, litter has increased and mountain bothies have been damaged (some have since been renovated by mountaineering clubs).

Very few skiers visited the Cairngorms before the late 1940s but an increase began around 1949 in Speyside due to the foresight of a few hotel keepers in offering special low rates and other attractions. However, this increase was very slow and even in 1955-56 there were few or no skiers at Aviemore at the New Year, which is now a peak period.

A rapid increase occurred in 1957-58 and has continued ever since. Its origin is uncertain and would make an interesting sociological study. Ski clubs from the main Scottish cities ran a number of small ski tows and huts, for instance around Glen Shee, and excursions by many buses became common at weekends. During the 1960s the number of independent ski clubs increased, rapidly spreading even to small rural Aberdeenshire towns such as Alford or Rosehearty, and shops selling ski equipment in Scotland proliferated from three or four up to scores, spreading even to the villages. The number of professional ski schools also greatly increased. By 1959-60 the tourist season for the Speyside hotels had greatly lengthened. The demand for better facilities, especially a new road and chair lift up Cairngorm, was so great that public as well as private money was put into a mountian road in 1961 and the Cairngorm Winter Sports Development Board was formed to construct and run the chair lifts and other facilities.

The new road was built from Loch Morlich at 1,000 feet up to a car park at 2,200 feet at the foot of Coire Cas with a large cafe at 2,500 feet (the White Lady Shieling), and a chair lift began operating on the White Lady ski run late in 1961. At Cairnwell, south of Braemar, a chair lift and cafe were built by the Glenshee Chairlift Company in 1962, based on the public road which already existed there. Several new tows have been built at both places since then and a new chair lift at Cairngorm connects the original car park with the White Lady Shieling 300 feet higher. Large new car parks, road improvements, cafes and toilets have also been made at Cairngorm and Cairnwell. Many hotels have greatly increased their accommodation, and the biggest new hotels in Scotland for decades have been built at Coylumbridge and at the Aviemore Centre in the last two years. The duration of the holiday season for Speyside hotels has virtually doubled since the early 1950s and the numbers of people using the lifts or tows increased tenfold during the three winters from 1962-63 to 1964-65.

PROPOSALS FOR CAIRNGORM DEVELOPMENT

A Technical Planning Group from the Scottish Development Department recently issued an illustrated book called Cairngorm Area (1967, H.M. Stationery Office, 40s.). This gives much information on the area and describes a plan for future development. The Group bear carefully in mind the need to preserve the attractive scenery of the area and to make sure that tourists do not unwittingly spoil what they come to see, and they have also laid down conditions for high standards of design and planning for all future developments. Briefly, their main urgent recommendations for ski-ing facilities (see map) are: (a) a spur road, chair lift, tows and chalet on Coire na Ciste at Cairngorm, a mile east of the present White Lady ski run; (b) a road up Glen Quoich or by Glen Lui to the very fine ski-ing on Beinn a' Bhuird, with chair lifts and tows; (c) widening of the Devil's Elbow road, and (d) a road through Glen Feshie. Less urgent developments which they recommend should come later are: (a) a road from Nethybridge to Cairngorm; (b) a road from Glen More to Creag and Leth Choin with lifts up the streams on the west side of Cairngorm; (c) a road from Tomintoul up Glen A'an by Loch Builg to meet the present road between Crathie and Garnshiel; (d) spur roads from the Loch Builg area on to Ben A'an with associated ski-ing developments there, and (e) a road through Glen Tilt. There are many less important proposals such as using Derry Lodge as an outdoor training centre, erecting new shelter huts or refuges, and other important proposals on forestry, land-use and employment which do not concern the ski-lift problem. A wardening service is proposed for public guidance and information, paid publicly and not subject to any sectional interests. Public guidance of this sort will also be invaluable for the ski-lift problem. The Group looked at other ski-ing areas at Carn Ban Mo-Sgoran Dubh, Brae Riach, and Glas Maol, but recommended no developments there. Other major snow-holding areas in the Cairngorms, such as Ben MacDhui-Cairngorm, Beinn Bhrotain and Carn an Tuirc were not described. Carrying out these recommendations will involve a big outlay of public money and so will depend on decisions by the Government and local authorities and also on the result of conflicting pressures from other organizations.

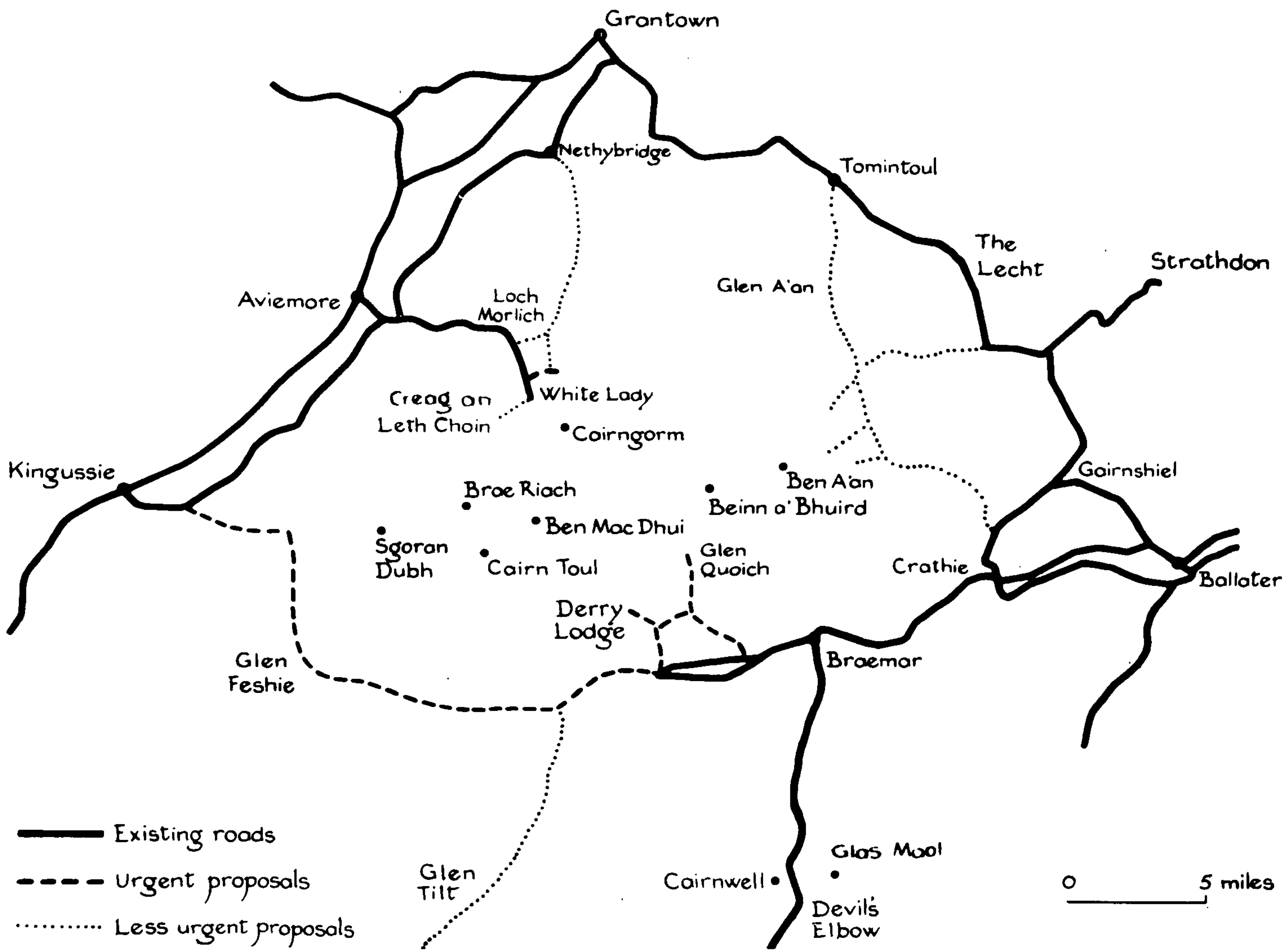
From the point of view of wildlife conservation, major threats exist to two outstanding areas given little or no prominence in Cairngorm Area: the Glas Maol hills and the Ben MacDhui plateau. The Group noted a few of the ski runs on the Glas Maol hills but thought the Cairnwell could absorb future increases. However, the poor snow-holding of the Cairnwell areas makes this seem improbable. Any further major increases at Cairnwell are likely to involve the Glas Maol hills which are part of the Caenlochan National Nature Reserve. All the present and proposed developments for Cairngorm are outside the Cairngorms National Nature Reserve, although they do result in many more people moving south from Cairngorm on to the Reserve itself. However, the present Cairngorm lift already brings skiers almost to the northern edge of the Reserve on the Cairngorm - Ben MacDhui plateau, which is the best snow-holding area in the Cairngorms and where large snow fields lie into May and June when the presently-used runs at Coire Cas or White Lady are broken or absent. There is already a view among many skiers and ski schools that these large snowfields should be developed, and even that a road should be built through Lairig Ghru instead of Glen Feshie, which would open up the large snow fields on Cairn Toul and in the Garbh Choire. These areas lie inside the Reserve and are of great conservation interest. Finally as conservationists we should be thinking about the developments on Beinn a' Bhuird and Ben A'an that are already proposed in the Technical Group's report. These are not in the Cairngorms National Nature Reserve, but the Quoich-Lui woods and the Beinn a' Bhuird-Ben A'an hills are Sites of Special Scientific Interest.

PRELIMINARY SURVEY

I did a preliminary survey in November 1966 - March 1967, having also made casual observations in earlier years.

Cairngorm

The main damage to vegetation and soils occurred during construction operations. Areas along the course of the chair lift, along roads and bulldozed banks, and around new buildings were and still are almost bare



Map of the Cairngorm region, showing existing roads, urgently needed new roads proposed in Cairngorm Area, and less urgent proposals for new roads. New ski-lifts are envisaged at Cairngorm, Beinn a' Bhuird and Ben A'an.

of vegetation. The Cairngorm Winter Sports Development Board have carried out some seeding experiments in co-operation with the North of Scotland College of Agriculture, using grass seeds and fertilizers protected by a film of bitumen. Grass has grown at all altitudes from 2,200-3,600 feet. The seeded areas were eroded and damaged in the 1966-67 winter, but in May 1967 the grass was already growing again. The gravel roads from the car park to the White Lady Sheiling and also further up Cairngorm were badly eroded in some places during the same winter and gravel has spread on to vegetation further down. There are also frequent signs of less severe erosion due to damage from skiers passing uphill on the ski tows when snow cover is thin, from skis cutting into vegetation along the ski-runs in similar conditions, and from people walking up to the summit of Cairngorm and elsewhere in a large area around White Lady and Coire Cas. The areas close around the buildings are an eyesore, covered with dirty gravel or sand and bare of vegetation because of trampling. Caterpillar tractors probably cause far more damage than people, when they move uphill, either with equipment or else to move snow. Erosion channels up to 6 inches deep were seen after a tractor had gone up a steep slope when the ground was soft during a thaw following hard frost.

The damage looks spectacular and severe to anyone who confines his activities to the chair lift and the subsequent walk up Cairngorm. However, in terms of the whole mountain of Cairngorm, the damage is so far minute and occurs only in the White Lady - Coire Cas - Cairngorm summit area. Even on this affected area, most of the ground still shows little damage. The problem is that this damage appears to be getting worse and is spreading year by year. In addition, the lift is taking many people to Cairngorm in summer. Most of them walk only to the summit or nearby, but increasing numbers walk south to the Ben MacDhui plateau. Apart from a great increase in litter and the appearance of new paths where none existed before, there are no obvious effects of these more adventurous walkers so far. However, the situation needs to be watched because the MacDhui plateau is the area of the Cairngorms that most closely resembles the high-arctic, and so is of outstanding interest.

Cairnwell

Again it is clear that the main damage occurred during construction operations. Compared with Cairngorm, far less damage occurred when the original chair lift up Cairnwell was built. The Cairnwell lift was built on a slope as steep as at Cairngorm, and although it rises to a lower altitude (2,850 feet compared with 3,600 feet) the damage at comparable heights at Cairngorm was worse. Also, recovery is negligible at Cairngorm but at Cairnwell is almost complete. Vegetation was damaged and much bare peat was exposed during construction of a ski tow east of the Cairnwell chair lift, but here also much of the vegetation has already recovered. The underlying rocks at Cairnwell are base-rich schists and quartzites, and small areas of limestone, as compared with very poor granite at Cairngorm. The faster recovery at Cairnwell may therefore be partly due to a more fertile and deeper soil than at Cairngorm. Particularly severe damage occurred in 1966 from caterpillar tractors dragging sledges with equipment for new huts and ski tows. We must hope that this new damage will also recover naturally. No attempt at seeding has been done at Cairnwell so far.

Beinn a' Bhuird

No ski-ing facilities yet exist. Upper Glen Quoich was one of the last large trackless glens in Scotland, has a very fine relic of the old

Caledonian pine forest, and is a Site of Special Scientific Interest. Over the last two years a rough road suitable for a Land Rover has been made from Mar Lodge up Glen Quoich; and the final section, which was completed in summer 1966, involved a spectacular series of zig zags leading finally to 3,600 feet on the plateau. One or two ski races have been held on Beinn a' Bhuird but there are no tows, lifts, or other facilities, and these are unlikely to develop without a good road and car park being built at public expense. There are no obvious signs of damage yet at Beinn a' Bhuird, other than those associated with the road and road banks.

OUTLINE OF PROPOSED RESEARCH

This will be done at Cairngorm, Cairnwell and Beinn a' Bhuird. All three places are fairly near each other and the advantage at Beinn a' Bhuird is that we will be able to study the future development there from the start, whereas at Cairngorm and Cairnwell there are no measurements from the period before the chair lifts were built. There is also a chair lift at Meall a' Bhuiridh in Glen Coe; this will be visited but the intention is to concentrate the team effort on the fairly compact group of places in the Cairngorms, which are all on or near areas of outstanding conservation interest.

Vegetation

Survey

Comparison of the vegetation near and far away from chair lifts is necessary because erosion and damage occur naturally at these altitudes due to severe rain, wind, solifluction and other conditions, and it is important to distinguish this from man-made damage. This is clearly a problem in sampling, and it will require a proper statistical approach. This comparison will be made by extensive surveys measuring the frequency and performance of different plant species, the percentage of bare ground and the proportion of the vegetation covered by soil or gravel. This will be done by our team, using simple short-cut methods such as visual estimates on large numbers of quadrats. In addition, Dr. C. H. Gimingham from the Botany Department at Aberdeen University has offered help from his M.Sc. class of students by providing a large amount of labour on a practical exercise that would also be instructive to them. The comparison will also be done by us more intensively at fixed sites on selected plant communities, to give a more precise check on the extensive work. All this work will be done on places where the traffic rate by people's feet, skis and caterpillar tractors is known (see work on People). It will then be possible to relate vegetation damage or recovery to known amounts of traffic.

Experiments

The main experiments will be trials of different plant species to find which are best for rehabilitation at different altitudes, and in different soil conditions (gravel, peat etc.). In some of these experiments we will use seeds alone, but others will involve a variety of ancillary methods that have proved useful for reclaiming deserts or gravel elsewhere (e.g. fertilisers, mulches with wood chips, seeds held in latex, netting or bitumen etc.). As part of this programme we study gravel and peat outwashes from floods of known age to find which pioneer species have colonized; and we will also survey areas subjected for much longer to human pressures, to find which species are resistant to trampling. A brief preliminary survey indicates that Rumex acetosella, Poa annua, Aira praecox, Polytrichum juniperinum and P. piliferum, and to a lesser extent Rubus chamaemorus are fairly resistant in hill country, though, of course, not all on the same kinds of soil. More work on this should tell us which species are likely to be best for rehabilitation experiments. These experiments will also use commercial seed mixtures, but unless these are very successful there may be a need to develop new mixtures suitable for mountain conditions.

We intend to put up small fenced enclosures to keep out people so that we can measure the recovery rate of the vegetation and the rate of change at places which are not yet badly affected but are likely to become so in future. It may be necessary to keep people off some damaged areas till recovery is complete, and this is a problem of publicity and guidance.

Experiments will also be done with known amounts of trampling, either by using people or an artificial trampling machine on small plots.

Geomorphology

Mr. A. Mather, Department of Geography, Aberdeen, is working near and also far away from the ski lifts on (a) areal and linear erosion of the soil and underlying material; (b) compaction of soil and snow; and (c) water run-off and drainage. Since soil movements and erosion also occur naturally by solifluction, rain and wind, the study will have to distinguish between natural processes and those due to human impact. These aspects are being studied in relation to construction features such as roads and bulldozed ski-ing channels, and in relation to a known amount of traffic by people and vehicles on some hillsides. The work on People (see below) is therefore an essential part of this programme, as it is for the work on vegetation. This geomorphological study may also prove to be of practical use for future civil engineering projects in mountainous terrain.

Animals

Counts will be done of ptarmigan, red grouse, dotterel and other hill birds on areas near and far from ski lifts, to see if their populations are affected, either directly by human disturbance or indirectly through damage to their habitat. The invertebrate fauna may also be studied.

A preliminary study of the effect of ski lifts on ptarmigan and red grouse since 1962 suggests that neither breeding stocks nor breeding success are affected, and in fact, both species have become tamer, paying little attention when skiers pass by. These results will be checked by more work but they already suggest that it is unlikely that grouse are affected by the continual presence of people e.g. in National Parks or other heavily-used hill areas.

People

It will be essential to compare what is happening to the vegetation, soils and animal life with known amounts of human traffic near and far away from the lifts. The project will involve everyone concerned measuring the location of people or vehicles, on every working visit.

The location of people can be plotted quickly and accurately using photography by polaroid camera, which would also show the location and extent of snow cover. Panoramic photographs with gridded overlays are another possible method. Location can be measured by spot observation at a given time, but if necessary, also by repeated observations to study changes within the day.

The aim is to find the carrying capacity, rates of damage, and recovery of different plant communities and soils in relation to known amounts of human traffic. From these data, it should be possible to predict what will happen in other areas from the numbers of people likely to be involved, and possibly to say different communities should be rested in some form of rotation.

The research on the location and numbers of people also raises the questions of why people come to these areas and what their needs are. These are beyond the capability of the present team, but questionnaire surveys on these aspects have already been carried out by the Department of Forestry and Natural Resources at Edinburgh University and by a Ph.D. student at the Geography Department in Glasgow University.

REMEDIES

Even if the present damaged areas can be rehabilitated, there will be a need to channel people's activities so that the damage does not occur in the same places all over again or elsewhere on new ski-ing grounds not yet developed. Well-defined paths marked by cairns, possibly with tarmac or concrete surfaces, may be needed to prevent the proliferation and erosion of paths. Obligatory return tickets on chair lifts for all summer visitors might help to prevent people coming downhill on many different routes. All roads should be surfaced with tarmac and equipped with good drains, including gravel roads which are at present not open to public cars but are used by vehicles at the chair lift. Above all, work with caterpillar tractors or bulldozers should be very carefully planned to cause the least damage, and helicopters should perhaps be considered for carrying materials. The use of tractors or bulldozers for moving snow on to ski runs also causes damage and should perhaps be confined to prepared tracks for getting up and downhill. For future developments, cable cars or other forms of transport may be possible alternatives to the more damaging roads and ski tows.

FUTURE DANGERS

Now that new hotels have greatly increased accommodation, the demand by the skiers for better facilities has risen and in press correspondence there have been serious criticisms of the ski lift operators. In trying to make facilities better they may therefore consider trying to improve the runs by methods used in ski-ing resorts abroad but not so far here, e.g. digging deep channels so that snow will drift more deeply and last longer into the summer, and bulldozing out rocks, peat haggs and heather to make way for smoother slopes with grass. Of course, these would be local problems on the ski runs and would probably not affect large areas.

More serious potential dangers in future for larger areas of ground and for other hills in the Cairngorms are:

(1) future research on the unique high-arctic terrain of the higher ground may be jeopardised and we do not yet know how important such research may be; (2) the threatened plant communities and the dotterel and other mountain birds are of interest to many naturalists; and (3) one of the last areas in Scotland still more than a few miles from a road may be spoiled as a wilderness area for the increasing minority who enjoy this, and the unique

high-arctic nature of the scene on the plateaux may also be spoiled. The reason for keeping a few of these areas for the enjoyment of these minorities is similar to that for preserving our art galleries which also provide enjoyment only for a minority.

Whatever the outcome of this research programme, we should think now exactly which areas should be kept free from possible developments in the future and why they should be; considering each part of the Cairngorms on the grounds of scientific interest, ski-ing potential, and outstanding value as landscape and wilderness. Landscape and wilderness value may not fall within the Nature Conservancy's original remit but any 1967 definition of conservation is unrealistic if it omits such aspects. Of course, more ski-ing areas must be provided. However, this should ideally result from a compromise between ski-ing interests and the interests of conservationists, climbers and walkers. A compromise might allow both sets of opposing interests most of what they need without putting any one interest in great jeopardy.

SUMMARY OF DISCUSSION

The Chairman said that the importance of the Cairngorms Nature Reserve should be emphasised and that it was rather striking that some fifteen or twenty years ago, it was regarded as one of the most inviolable areas in the country and yet now we see all sorts of new threats appearing. In connection with the construction of chair lifts, a participant asked whether the people making these in Scotland had taken note of the experience in the Alps where there is often very little disturbance to the ground vegetation.

The speaker said that he did not think they had taken note of continental experience and that one contractor may cause a good deal of damage whereas another may not. The instability of the soils in the Scottish Highlands was an important factor because there were no proper specifications for this type of work. Construction had to be done as economically as possible so that for instance, roads may be made without adequate drains and this could result in bad erosion effects.

In answer to a question of whether it was possible to assess numbers of people in relation to the amount of damage caused and so institute appropriate control measures, the speaker said that on present knowledge, it was difficult to lay down any sort of standard. For instance, 4,000 people a day on a snow-covered slope may not result in any significant damage whereas the passage of a tractor or bulldozer could result in a great deal of damage of the ground surface. One of the most vulnerable times was in the spring after a thaw had set in and in such cases, a small number of people could do a good deal of damage to the vegetation, and he emphasized the very slow rate of plant recolonization on these poor soils. He thought that generally speaking, a good snow cover was probably a good protection but that one could not exclude the possibility of some damage by the compaction of snow by large numbers of skiers moving over the surface.

The speaker was asked whether it would be possible to build an experimental ski lift where the actual effects of specific numbers of people could be measured, but he said that the capital investment for this sort of thing would be very high. He thought however, that they would have to map where people are at the time of the highest population density and that this could possibly be done by an aerial photograph.

HUMAN PRESSURE ON THE MOUNTAIN ENVIRONMENT OF SNOWDONIA

R. Goodier
The Nature Conservancy, Bangor

Introduction

The appearance of the countryside of Britain has been fashioned as much by man's influence as by non-human agencies. While the truth of this is obvious to all in the case of the English lowlands, in much of Wales the nature of the natural landscape is such as to render the effects of man's activities less evident and to cause them to reveal themselves in more subtle ways.

In the present account I intend to restrict myself to a consideration of the mountain environment of that part of North Wales which lies within the Snowdonia National Park. It is here that the mountain environment is found in its most developed form in southern Britain, and where the Nature Conservancy's main effort in the conservation of the mountain environment in Wales has been made. It is here also that the human pressures on the mountain environment occur in their most intense form in Wales, and probably in Britain.

It is, of course, much too early to write a comprehensive scientific account of the human pressures on Snowdonia and of their biotic effects and my aim is here rather to present a review of the subject and put before you some ideas on how the problems can be formulated and suggestions on how they may be studied. In the first place, I will attempt to outline the historic development of human pressures on the mountain environment. Secondly, I will review the present situation and deal briefly with how we intend to assess the intensities of pressures in relation to our special interests in the area. I will then consider how we might measure the effect of these pressures and, finally hazard a guess at some possible future trends.

The Development of Human Pressures in Snowdonia

There is much evidence to suggest that the mountain environment of Snowdonia has been much modified by man's influence for a great length of time. The comments of the English botanist Johnson (1639) on the generally monotonous grassy cover, furnishing grazing for sheep, of the Carneddau Mountains in the north of Snowdonia, indicate that at the beginning of the 17th century these mountains had much the same treeless appearance that they have today. However, the remains of birch trees embedded in peat, in some places up to 1,800 feet, indicate that the mountains were afforested up to at least this altitude at some period since the end of the Pleistocene glaciations. I am not aware of any carbon 14 dating of these birch remains from the Snowdonian mountain peats but in the case of the deposits examined by Godwin (1955) from Cwm Idwal at an altitude of 1,220 feet, O.D., birch remains indicating woodland cover on the site were abundant in zone VIIa, the "Atlantic" period of Blytt and Sernander, between about 5,000 and 3,000 years B.C. This was the period of the post glacial climatic optimum and it would therefore seem reasonable to assume that the forests reached their maximum altitudinal limit on mountains during this time or early in the succeeding drier, but still warm, sub-boreal period.

Although man, represented by a Neolithic culture, was present in North Wales by the beginning of the "Atlantic" period as shown by remains from Prestatyn and Aberffraw, these are coastal sites and it is not until the beginning of the sub-boreal period (Zone VIIb) that the Neolithic cultures associated with the Graig Llwyd axe factories on the northern flanks of the Carneddau represent a penetration into the mountain zone. Stone axes from this site have been dated to before 2,500 B.C. (Godwin 1964) so the development of these axe factory sites must have occurred early in the sub-boreal period. However, there is no evidence to suggest that the Neolithic cultures made any marked impact on the mountain environment as there is no indication of any local settlement. The abundance of Bronze Age remains on the flanks of several of the mountains, but particularly on the north flanks of the Carneddau between 1,250 and 1,500 feet indicate considerable human activity in the area by about 1,500 B.C. Unfortunately the pattern of Bronze Age settlement is not known though it is possible that some of the hut site remains from this area date from this time as Griffiths (1951) has shown that some of them are very similar in character to Early Bronze Age settlements on Dartmoor. Certainly by the time of the Roman Invasion and probably earlier in the Iron Age the flanks of the Snowdonian hills between about 800 and 1,500 feet were the site of much human settlement, in the form of both hill forts and unfortified settlements, which was on sufficient scale to have a marked effect on the montane ecosystem. Of the precise nature and extent of the effect in pre-Roman times we can only guess. It has been suggested that the Neolithic and Bronze Age cultures only made use of upland areas in a nomadic manner, visiting the montane zone of northern Caernarvonshire for stone axe material in the case of the Neolithic Graig Llwyd culture or for hunting and burial purposes in the case of the Bronze Age cultures. Even the later Iron Age B Celtic settlers seem to have been primarily pastoralists and hunters whose agricultural operations were little more than gardening (Bowen 1964). Nevertheless by Roman times much of the mountain environment must have been considerably modified by man's activities such as tree felling and burning and the grazing of his animals, towards the condition that we find today. Thus the tree limit had probably already been artificially depressed and the conversion of dwarf shrub communities to grassland commenced. As is well known the upland zones were also extensively used for ease of communication in pre-historic times and some mountain track-ways in Snowdonia have been shown to pre-date Bronze Age burial sites (Griffiths 1960).

The climatic deterioration of the sub-Atlantic period (Zone VIII) seems to have caused some lessening of human pressures on the mountain environment by post Roman times which are also characterized by a marked valley-ward environment of population (Fleure and Whitehouse 1916; Hughes 1940). Evidence presented by Seddon (1960) relating to the excavation at the dark age hill fort of Dinas Emrys suggests that by A.D. 500 there had been fairly extensive forest clearance in the neighbouring valley of Nant Gwynant.

It would seem unlikely that we shall be able to attribute any present-day features of the mountain environment of Snowdonia directly to the influence of pre-historic settlement as the influence of subsequent developments have probably, in most cases, over-ridden all that has gone before. It is in the dark ages and mediaeval period that the pattern of land-use characteristic of upland Wales developed, a pattern of isolated farmsteads (Y Tyddyn) with the seasonal movement of transhumance between the "old" or permanent home (Hendre) on low ground to the Summer upland dwelling (Hafod) which continued to the inclosure movement of the 18th century.

Even the early stages of this development have left their mark on the mountain landscape not only in the discernable outlines of old field systems but possibly also in long-lasting biotic effects on the plant communities as suggested by Hughes (1953).

The changes in the grazing economy from one of mainly cattle and goats to the dominance of sheep in the 18th century and subsequent development with the decline in transhumance consequent on inclosure has been reviewed by Roberts (1959) who also discusses the effects of the trend in the present century which has led to the decline in numbers of wethers in the flocks.

Throughout the mediaeval period and continuing until the present century, the main human influence on the mountain environment has been an indirect one through the medium of grazing animals. The earliest exception to this was the development of mining and quarrying which reached its height in the 19th century and has left many traces on the mountain landscape of North Wales notably in the form of quarry waste heaps and mine sites with localized heavy metal toxicity effects, the latter having had an interesting effect on the local flora.

In contrast to other upland areas the development of large sporting estates has never been a feature of the main mountain areas of Snowdonia, due possibly to the absence of deer and of suitable terrain for the development of grouse moors and to the pattern of land ownership.

When we think about contemporary human pressures on the mountain environment of Snowdonia, we find that, apart from the recent afforestation on the lower slopes, we are usually considering the effects of tourism and the use of the mountains for recreation and education. Before we look at the contemporary scene in more detail we must look at the early development of these modern trends which have led modern men to imitate the prehistoric settlers in treading the uplands as much for spiritual as for material purposes.

Perhaps we can excuse the 11th century traveller Giraldus Cambrensis the doubtful honour of being the first tourist as well as the early botanists whose aims were clearly defined and were not simply those of recreation. To Samuel Johnson the description of tourist can perhaps be applied and also to the zoologist Pennant whose account of his tours in Wales (1778) had many successors and must have done much to attract attention to the area. The increase in visitors to Snowdonia was an important feature of 19th century development in North Wales paralleling similar trends in the English Lake District.

Rock climbing and mountaineering for its own sake is a comparatively recent development, commencing at the beginning of the present century in North Wales but having a tremendously accelerated growth since the last war. Present-day recreational activities in the mountains cover a wide range from hill walking and rock climbing to canoeing, pony trekking and aqua-lung diving in the mountain lakes to fox-hunting and bird watching. Arising largely out of the evolution of mountaineering in Snowdonia a yet more recent development has been the establishment of many centres owned and managed by English Education Authorities for the purpose of enabling school children to enjoy the benefits of physical recreation and education in a mountain environment.

The Present Human Pressures on the Mountain Environment

The foregoing historical preamble has led us to a more detailed consideration of contemporary human pressures. It will enable us to see these in the context of a very long tradition of mountain usage which has "conditioned" the environment of North Wales more than any other mountain area in Britain.

Two factors during the present century have probably had a greater biotic effect on the mountain environment than any others. These are the change in grazing regimes and the development of extensive coniferous afforestation on the lower mountain slopes. However, our attention has already been focussed on the conservation problems relating to these factors for some time. We have already had a symposium on grazing and the place of sheep grazing in the mountain ecosystem of Snowdonia has been discussed by many writers and reviewed by Hughes (1958). The biotic effects of forestation clearly demand much attention but I think that the "public pressures" in the title of the present symposium refer to something else than major changes in land use. Thus the footpaths worn by Bronze Age hunters to their mountainside hunting and burial grounds and the erosion of rock surfaces by the passage of present-day climbers might qualify as public pressures but not the planting of Sitka spruce.

I shall therefore deal primarily with the pressures on the mountain environment caused by direct human use. For most practical purposes, this is recreational, educational and scientific use in descending order of "impact". It is also useful to consider these in relation to the Nature Conservancy's role in Snowdonia, both as a land manager and in the capacity of a provider of scientific advice. Considering first the role of manager of nature reserves within the Park, we need to know what form these human pressures take and what their biotic effect is. In addition we need to relate the two quantitatively so that we can predict the degree of "biotic effect" from a certain intensity of pressure.

In its advisory role the Conservancy's special function will be to answer enquiries relating to the latter category, i.e. what biotic effects can be related to specified pressures. The identification and mapping of pressures themselves is a task more allied to the role of the Park Authority as has recently been recognised by the Parks Commission in supporting the survey to be carried out by a team at the University College of North Wales. The survey of public pressures within the Park is likely to continue to be carried out by the Park Authority while the Nature Conservancy's role will be to provide information on the biotic effects of such pressures.

As managers and advisers, we cannot afford to wait until the survey of pressures is completed before commencing an investigation of biotic effects. In North Wales the Regional staff have found it necessary to do some preparatory work in this field, firstly to obtain a quick assessment of which parts of our mountain environment demand priority in our programme of investigation and secondly to develop methods for detailed human pressure survey of selected areas which will subsequently be used for the study of biotic effects. In the first instance we have used a combined subjective assessment of a number of observers using a simple scoring scheme in conjunction with a gridded map of the area. Scores relating to intensity of pressure are given in each map square for each type of pressure so that maps (Appendix I) can be produced showing the variation in intensity of pressure of various recreational activities.

For the more detailed assessment of pressures on particular areas we are investigating the use of gridded panoramic photographs, a technique originally developed for the study of the feral goats in the Snowdonia mountains. Using these panoramas and with the help of many observers we hope to build up a detailed picture of the pattern of uses to which certain important mountain areas are subject. In the first place these areas will be the mountain National Nature Reserves such as Cwm Idwal (Appendix 2) and Snowdon.

The Biotic Effects of Human Pressures on the Environment

Having gained insight into the pattern of public pressures we shall then hope to be in a position to assess how best to apply our resources in a study of the biotic effects of these pressures, bearing in mind our dual role of managers and advisors. In our Reserves we clearly need to know:-

1. What environmental changes are taking place as a result of existing public pressures;

2. What is the quantitative relationship between the changes and the pressures.

We must obtain information on the relative vulnerability to the different pressures of different elements in the mountain ecosystem so that we can manage or guide public access on the basis of a scientific assessment. In relation to a mountain reserve such as Cwm Idwal, three types of pressure urgently need investigation; that exerted by the ordinary visitor walking on the Reserve including those using the nature trail; that exerted by the mountaineer; and that exerted by camping. We know from casual observation that there has been a marked deterioration in the appearance of the habitat in the immediate vicinity of the public footpaths and we need to know more precisely what this deterioration is in biological terms and how far it extends on either side of the footpath. So far we have been working on the assumption that if we repair the footpaths, the majority of visitors will keep to them but we have yet to demonstrate this conclusively.

While the majority of visitors to the mountains keep to the well-worn paths, a proportion - mainly mountaineers or rock climbers - do not. The effect of rock climbing on cliffs where it is practised is quite marked but has not been the subject of any systematic study. In such an "intensive" activity, confined to relatively few cliffs, it is unlikely that any simple remedy could be found even if it were established that environmental degradation were taking place. However apart from the main problem of the removal of vegetation from cliffs there are other peripheral effects of climbing where some remedy might be found. For example the "ways down" round the side of cliffs often become more "degraded" than the cliffs themselves and another related problem is the increase in instability of screes due to climbers indulging in the sport of "scree running". Here again once the pressures and their effects are fully understood some solution by rotational treatment might be possible.

Camping has a marked local, apparently temporary, effect on the grassland of the Reserve but here again we do not know precisely what the effect is or how long it lasts, hence we do not have the necessary information to enable us to regulate camping within the Reserve on a scientific basis.

Studies on these sorts of problems within our own Reserves as well as leading to practical solutions of reserve management will also place us in a better position to answer such enquiries as might be asked by the National Park Authority. They might, for example, lead towards a set of acceptable criteria for amenity judgments, enabling stages of habitat deterioration to be defined having a relation to certain pressures. One would expect such criteria to be fairly imprecise in the first instance but at this stage of development any well formulated criteria are better than none. In the case of camping, it would be useful to have even a rough classification of the stages of sward deterioration under camping pressure so that some "acceptability level" could be defined and related to the number of tent/nights/annum for different sward types. The same type of approach could be adopted towards such places as picnic sites and car parks.

The design and execution of investigations of this kind necessitate close co-operation between regional conservation staff and the mountain grassland habitat team.

Future trends

Our approach to the problems of human pressures on the environment of Snowdonia must be conditioned by what we can forecast of future developments in the use of the mountain environment. Although we can forecast with considerable confidence that the pressures will increase we can only guess at the form they will take. It is important that we should begin to attempt to forecast trends even if our success at first is no greater than that obtained in most other fields of forward planning.

One aspect of this problem in Snowdonia is an attempt to forecast the type of balance that might eventually be attained between economic use of the mountain environment and recreational use (without implying that recreational use is necessarily uneconomic). This is a subject in which argument arouses strong emotions. On the one side it is sometimes stated that within a National Park recreational use must be paramount and, if necessary, supercede agricultural use and it is argued that the principles of democracy dictate that the enjoyment of the many outweigh the agricultural interests of the few. On the other side it is maintained that the residents of an area and those who derive a living from the mountain environment should decide its use. It is of course, unlikely that either of these arguments stated in an extreme form will prevail but the position of the balance of interests that is finally achieved will be of great importance not only in determining our future approach to environmental conservation but perhaps even more importantly, determining the political and sociological framework within which it is attempted.

Our approach to environmental conservation in the face of human pressures must be of course also conditioned by the type of environment that is required. Even if we know precisely what we want in the case of mountain nature reserves (by no means obvious from close scrutiny of many management plans) it is clearly not the case in other areas except where the choice is limited by some well-defined economic requirement such as grazing for sheep. Arising out of our experience on mountain reserves there is clearly tremendous scope for investigating the design of environments which will withstand human pressures in particular recreational environments. Cannot we, in effect, be creative ecologists in this particular field? Even if the environments thus produced can hardly be termed "natural" they could undoubtedly have considerable conservation potential.

If recreational use will eventually obtain priority in some parts of the mountain environment of Snowdonia we must have both the influence and the knowledge to promote our belief that the best environment for the pursuit of these recreational activities is one for which the management is based on a detailed knowledge of the mountain ecosystem and the way it responds to human pressures. Our experience has shown that in general the users of the mountain environment of Snowdonia are sympathetic to this approach. We must set about providing the basis of knowledge which can turn a sympathetic response into effective action.

REFERENCES

BOWEN, E. G. 1964. The Settlement Pattern of Wales in "Field Studies in the British Isles". edit. Steers. London.

FLEURE, C. F. & WHITEHOUSE, I. 1916. The early distribution and Valley-ward movement of population in South Britain. Arch.Camb. 16(6) 101-140.

GODWIN, H. 1955. Vegetational History at Cwm Idwal, a Welsh Plant Refuge. Svensk Bot.Tidskr. 49, 35-43.

GODWIN, H. 1964. In "Caernarvonshire", 3, Royal Commission on Ancient Monuments in Wales and Monmouthshire, cited "in litt".

GRIFFITHS, J. E. 1950. Early Settlements in Caernarvonshire. Arch.Camb., 101, 38-70.

GRIFFITHS, J. E. 1951. The Development of Native Homesteads in North Wales. Antiquity XXV.

HUGHES, R. E. 1940. Environment and Settlement in the commote of Arllechwedd Isaf. Trans.Caernarvonshire Hist.Soc., 2, 1-26.

HUGHES, R. E. 1953. Possible Human Historical Factors determining the distribution of Eriophorum latifolium in the North West Conway Valley. The Changing Flora of Britain (edit. Lousely) 40-45.

HUGHES, R. E. 1958. Sheep population and environment in Snowdonia (North Wales) J.Ecol., 46, 169-189.

JOHNSON, T. 1639. The Itinerary of a Botanist.

PENNANT, T. 1810. Tours in Wales. 3rd Edition. London.

ROBERTS, R. Alun. 1959. Ecology of Human Occupation and Land Use in Snowdonia. J.Ecol., 47.

SEDDON, B. 1960. Report on the Organic Deposits in the Pool at Dinas Emrys. Arch.Camb., 109, 72-77.

SUMMARY OF DISCUSSION

A participant said that quite small patches of interesting vegetation could easily be destroyed in the Cwm Idwal area of North Wales simply by picnic parties sitting on them. Could not the public be educated in such areas about the dangers of this sort? The speaker said that it should be possible to decide which types of vegetation could withstand the most intense public use so that one could say where camping should be allowed and where restriction on public access was necessary. He also thought that the recreational centres in Wales would be very willing to assist in making possible controlled experiments on effects of public activities. There was no reason why an experimental plot should not be selected in an area into which people could be directed so that changes in vegetation and soil structure could be accurately measured in relation to the type of use made of the area.

Appendix 1

THE NATURE CONSERVANCY

PRESSURES OF USE ON THE MOUNTAIN ENVIRONMENT OF SNOWDONIA

Preliminary Survey Based on Subjective Estimates

Section I Status Survey

a) Management by

1. Owner/occupier
2. Tenant
3. Common rights holders
4. State or public ownership

b) Scientific Interest

Use 4 intensity categories as follows:-

0 None
1 Significant but small (unscheduled sites)
2 Of local or regional interest (some S.S.S.I's)
3 Major (national) interest (all N.N.R's and P.N.N.R's and some S.S.S.I's within this category)

Enter figure in each square of the map which is used in conjunction with O.S. Sheet 107. Leave blank only those squares which you cannot assess.

Section II Use Survey

Separate map to be used for each of the following uses. (Use map in conjunction with O.S. 1 inch Sheet 107).

a) Economic land uses

1. Agriculture (grazing)
2. Forestry
3. Water storage
4. Other uses (quarrying etc.)

b) Recreational land uses etc.

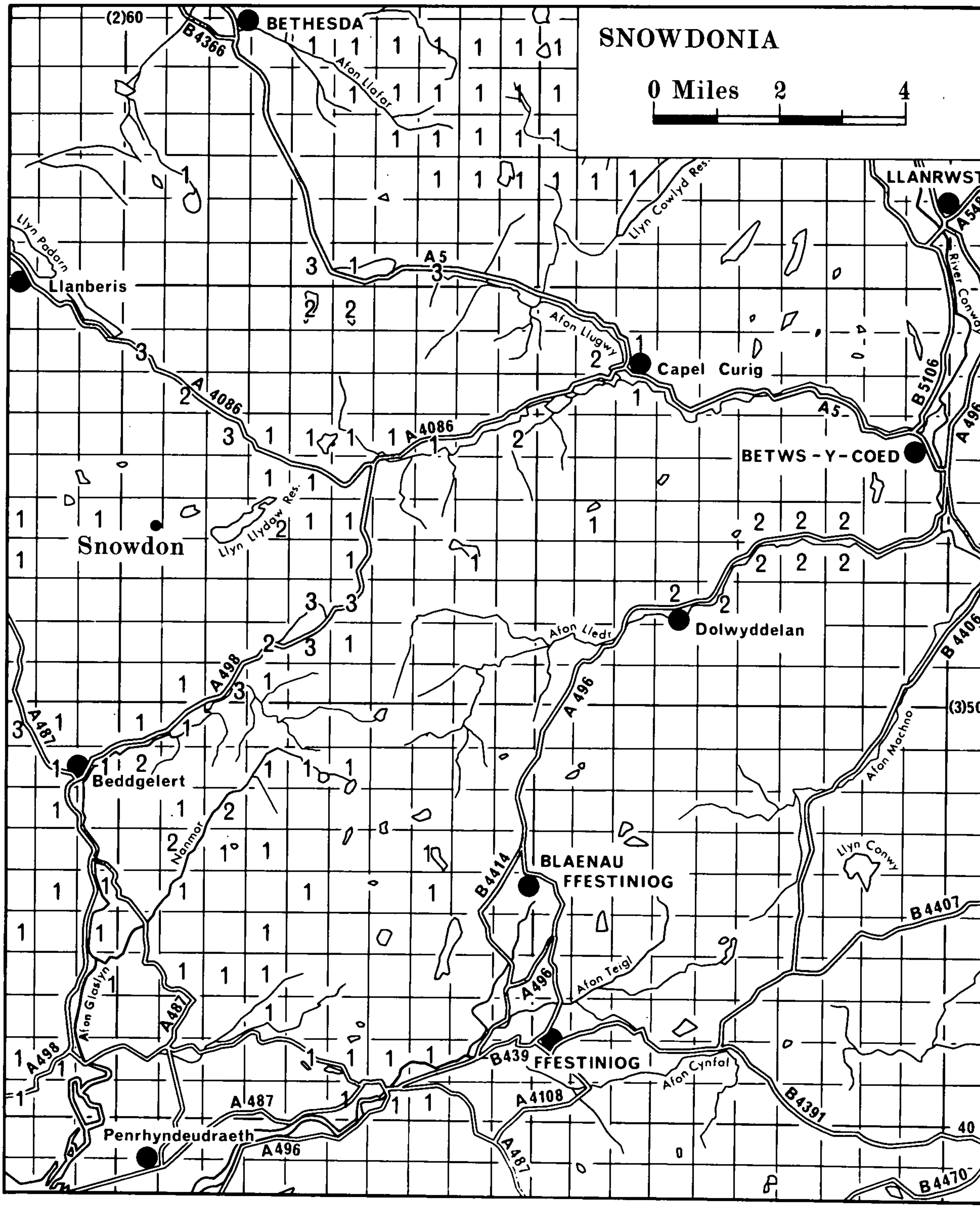
5. Walking
6. Rock climbing
7. Camping (tents)
8. Camping (caravans)
9. Fishing
10. Canoeing
11. Field Studies (educational)
12. Scientific research

Use 4 intensity categories (enter figure in each square)

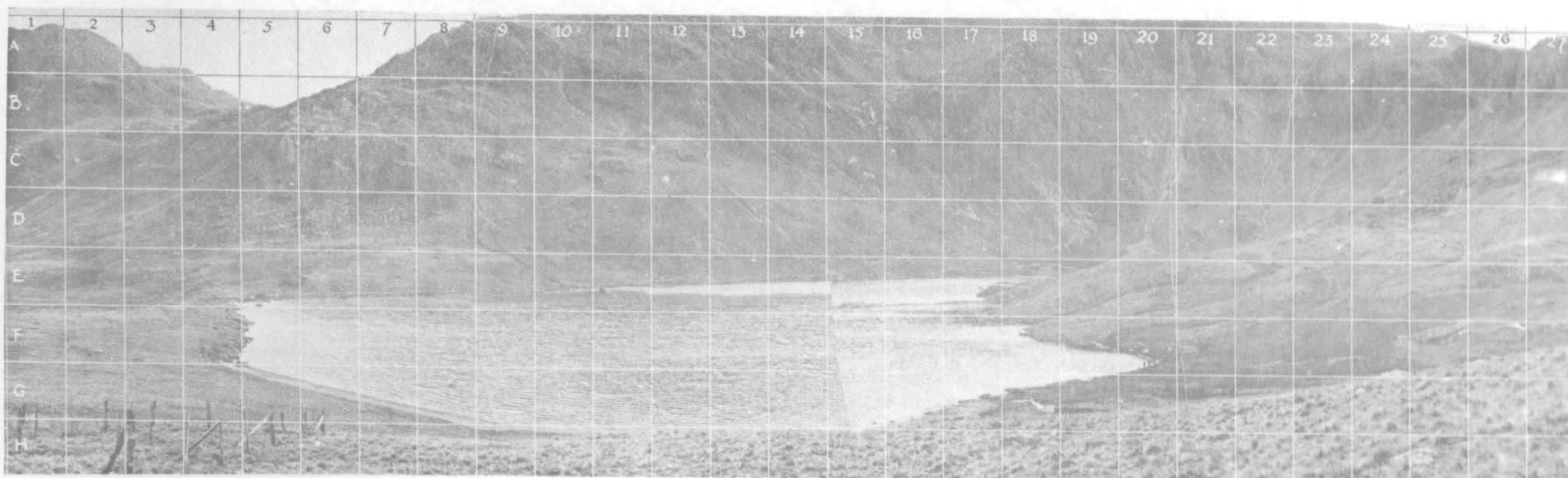
0 Not used
1 Light use
2 Moderate use
3 Heavy use

Leave blank only those squares which you cannot assess.

Camping Tents (Example)



Appendix 2


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
A
B
C
D
E
F
G
H

LAND USE PLANNING FOR WILDLIFE AND NATURAL RESOURCES IN THE NORTH-WEST HIGHLANDS

J. Morton Boyd
The Nature Conservancy, Edinburgh

INTRODUCTION

The North-West Highlands of Scotland (hereafter referred to as the North-West) is intractable country, poor in agriculture and forestry. Its wildlife resources in red deer, Cervus elephus and fisheries are of greater value, and it is a splendid scenic area with a growing tourist industry. The Lewisian gneiss, Torridonian sandstone and Cambrian quartzite which make up most of the country give a very poor basis for soil. Where the bedrock is not showing - a large proportion of the landscape is bare rock (Plates 1 and 3) - the ground is mostly covered with peat. On outcrops of Durness limestone in the Kishorn, Elphin, Inchnadamph (Plate 3) and Durness districts and on maritime soils along the coast, there is a local amelioration with fertile grasslands. These green oases and coastal niches support crofting agriculture and north-country Cheviot sheep, on the broad background of wet moorlands with Blackface sheep and red deer.

The topography is of coastal mountains, with sea lochs such as Loch Torridon and Loch Broom, carrying the mild maritime influence deep inland. The basement complex of gneiss is exposed over wide areas of bare undulating country (Plate 1), with the sandstone and quartzite occurring either as massive formations like Beinn Eighe (3,309 feet) and An Teallach (3,485 feet) or as spectacular outliers like Suilven (2,309 feet) and Stac Polly (2,009 feet). The coast is rocky with isolated ranges of sand dunes of which the most extensive are at Gairloch, Gruinards, Stoer, Sandwood Bay, Durness and Bettyhill. There are many short rapid rivers which run from a complex of oligotrophic lochs and hill burns and have fine fisheries of sea-trout, Salmo trutta and salmon, S.salar. The catches of these fish, both in bag nets on the coast and by angling on the rivers and lochs, together with sporting value of the fishery, make up to some extent for the poor agriculture and forest economy of the area.

The land-use history of the North-West followed the pattern common to Scottish Highlands as a whole, though the influence of the Vikings from about 1000 A.D. onwards was probably more strongly felt on the North-West seaboard than elsewhere; conversely sheep husbandry and commercial forest exploitation advancing from the South took longer to reach, and substantially change, the North-West than elsewhere. Charcoal layers in the peat of the old pine forest at Kinlochewe indicate a great forest fire in the 9th or 10th centuries (Durna & McVean 1959) at the time of the Viking conquest and suggest the earliest point in time when man began to change substantially the pristine environment of Wester Ross.

What the pristine North-West was like, we can only guess. In the present climatic period, the land has not been capable of supporting extensive pine or oak forest as is the case in other parts of the Scottish Highlands, but there is likely to have been birch forests somewhat similar to the present woodlands on the islands of Loch Sionascaig with pine and oak woods in well-drained areas on the slopes and floors of the glens (McVean 1957; McVean & Ratcliffe 1962). Bones of red deer, reindeer, Rangifer tarandus, brown bear, Ursus arctos, northern lynx, Lynx lynx, badger, Meles meles, otter, Lutra lutra, northern rat-vole, Microtus ratticeps, lemming, Dicrostony torquatus, arctic fox, Canis lagopus, red grouse, Lagopus scoticus and ptarmigan, Lagopus mutus have been found in limestone caves near Inchnadamph (Callander et al 1927); only five of the twelve animals cited still survive in the area. Other large species which once bred in the North-West were elk, Alces alces, wild boar, Sus scrofa, beaver, Castor fiber, great wild ox, Bos taurus primigenius, wolf, Canis lupus, white-tailed eagle, Haliaëtus albicilla and osprey, Pandion haliaëtus, (Ritchie 1920). This shows how rich the fauna of the North-West was from immediate post-glacial times until about 1000 A.D. and probably until considerably later.

Today little of this remains. There are of course, red and roe deer, Capreolus capreolus, wild cat, Felis sylvestris, fox, Vulpes vulpes, badger, pine marten, Martes martes, otter, golden eagle, Aquila chrysaetos, divers, Gavia spp., ptarmigan and greenshank, Tringa nebularia breeding. However, one can walk in summer over miles of the almost treeless North-West deer forests and see only the occasional meadow pipit, Anthus pratensis, stonechat, Saxicola torquata, wren Troglodytes troglodytes, common sandpiper, Tringa hypoleucos and mallard, Anas platyrhynchos.

The initial changes in the character of the country were probably caused by climatic amelioration but the destruction of the birch, oak and pine forest was greatly hastened by the continuous felling and burning of the vegetation by graziers. There was also the destructive grazing of the sheep which appeared in great numbers from the 17th century, when vast areas of oak forest at Letterewe were also felled for iron smelting. The destruction of the natural woodlands is still in train with severe burning and grazing regimes in the interests of sheep, red deer and grouse, but natural regeneration is probably greater now, in this land which does not lend itself to production forestry, than it has been for the last two centuries. The end of the forests has, however, meant the end of a habitat with the extinction or near-extinction of many plants and animals.

Ross-shire and Sutherland were traditionally the lands of Mackenzie, Macleod, Mackay and Murray bound by the laws of Scotland with allegiance to the Scottish crown. The clansmen probably hunted, fished and grazed small black cattle and primitive sheep within their own territories, looking to their chiefs for law giving and favour in return for loyal service. Deer forests were created during the mediaeval period for royal pleasure and later adopted by chiefs including those in the North-West, as a fashionable way in which to manage their lands. The end of the 1745 rebellion found the Highlands a much more peaceful place than before, and this provided sheep farmers from the south with the opportunity of becoming established with their flocks north of the Highland Line. Before 1745 the cattle : sheep ratio throughout the West Highlands was generally about unity; in 1911 it was about 1 : 20, in 1944 about 1 : 30 (Darling 1955) and now it is probably over this in those areas which still have livestock. Black (1964) reaffirmed what Darling stated in the 'West Highland Survey', that the poverty of the West Highlands would probably have been avoided if the sheep/cattle ratio had been maintained near unity. High rents were offered by the incoming sheep farmers and the impoverished Highland chiefs readily accepted them, often at the expense of their tenantry who found themselves and their livestock ousted from the glens. The first farm in Ross-shire was settled in 1782 and many others followed before 1800 (Darling & Boyd 1964).

The two main land-use formations of deer forest and sheep run have therefore been in the North-West since the late 18th century, sometimes acting in concert and sometimes in isolation, depending on the prosperity of the various estates into which the old clan lands had subsequently been partitioned. In other parts of the Highlands, forestry entered the field at the end of the 19th century, but the effect of this was slight in the North-West as a whole, with scattered plantations in the Westminster Estates in Sutherland and the Forestry Commission at North Strome, Achnashellach, Slattadale and Corrieshalloch (Plate 2). Throughout the 19th century, the growing popularity among the nouveaux riches from industrial Britain, of deer hunting and later of deer stalking, raised the sporting rentals of deer forests to such an extent that it was more profitable in some districts to provide deer facilities than to maintain a sheep stock; consequently the poorer sheep ground was returned to deer forest, and this applied to considerable tracts of the North-West where sheep farming has always been generally less profitable than elsewhere in the Highlands.

The deer forest development reached its peak about 1912 and has since declined; the two world wars put sheep and cattle back on the deer forests to boost national food supplies (Darling 1955, pp 132-133); and as estates have found it necessary to supplement income with a more broadly based policy of mixed land-use, in sheep, cattle, deer and occasionally forestry and grouse. Sheep and cattle properly herded, did not greatly impair the sporting value of the land though culls of stags were proportionately reduced. At Langwell in Caithness, for example, the introduction of 1,200 sheep resulted in the stag cull falling from 100 to 65 per annum (O'Dell & Walton 1962).

As the shifts from sheep to deer and back to sheep progressed throughout the last two centuries, the habitat has been changing with the modification of the vegetation by burning and heavy grazing. McVean and Ratcliffe (1962) mention the disappearance of *Calluna* from the Molinieto-Callunatum and Trichophereto-Callunatum drawing attention especially to a severe example at the source of the river Oykell on Ben More Assynt, where burning and grazing have almost eradicated the ericaceous stands, degraded the soil and vegetation, and caused peat erosion and the formation of worthless mixtures of *Trichophorum*, *Molinia* and *Calluna*.

Darling (1937) observed in the North-West that red deer were very mobile in response to changing weather, daily utilising pastures through an altitudinal range of about 2,000 feet, while sheep and cattle remained in one low-lying locality all day. The combined effects of climate, pasture change and the different behaviour of the animals are among the main factors which have made the North-West a much more favourable habitat for deer than sheep and cattle. Many of the forests in Wester Ross and West Sutherland are consequently now carrying small numbers of heavily subsidized livestock or have been completely cleared of them.

The human population of the North-West has been declining since about 1830 but the decline did not affect the entire area until about 1870 (O'Dell & Watson 1962). It still continues; between 1931 and 1951 the seven parishes in the area had lost between 11 and 35 per cent. of the 1931 population (Darling 1955). However, the pattern of occupation is changing with the gradual re-organization of crofting to give larger agricultural units, and the partitioning of some of the large estates into smaller units managed in a multiple way in sport, agriculture and occasionally in tourism, forestry and minerals. The spacious uninhabited country attracts people from the built-up areas of southern Britain and many of the small parcels of land, unoccupied crofts and off-shore islets are keenly sought as sites for summer cottages. The influx of motorborne tourists saturates the hotel, boarding house and caravan accommodation between June and August, with heavy tourist traffic in May and September, but little at other times of the year.

The local economy is now based mainly on agriculture and tourism. Gairloch, Ullapool, Lochinver and Khlochbervie are landing stages for large fisheries of herring, whitefish and prawns, but the boats are based outside the area and the economic benefit goes elsewhere. Local boats fish lobsters mostly in winter; transit losses have made the summer fishery unprofitable (Thomas 1958). Sporting rentals are high and most of the benefit goes to the conservation of the freshwater fisheries and deer forests, though there is also a great deal of local benefit for hoteliers and traders. There are severe limits to the expansion of agriculture and forestry, but the tourism is growing steadily and there is no indication as yet that the industry has reached its peak in the North-West.

CONSERVATION OF WILDLIFE

The present state of impoverishment of the North-West is the result of many centuries of non-conservative use of fundamentally poor land. Extraction of resources has been based on policies, common throughout the Highlands, of maximum production to the breaking point of agricultural economy, without respite or replacement. The North-West with a poorer endowment of mineral wealth and a wetter and windier climate than other areas, has suffered more from exhaustion of soils and pastures and concomitant agricultural collapse and depopulation.

This depression has also affected wildlife. Land-use in sheep and deer over these centuries has simplified the environment not only by the elimination of many species due to burning and grazing, but also by the ruthless slaughter of predators and perhaps in more recent times by the use of toxic chemicals in sheep-dips (Lockie & Ratcliffe 1964). Added to effects of land management, there were those of sportsmen and collectors. Ratcliffe in this Symposium has drawn attention to the serious effects which plant collectors have at sites of rare plants, of which there are many on the limestone outcrops in Wester Ross and Sutherland. There are first-hand accounts of the persecution of predatory birds and mammals at the hands of landowner, gamekeeper and collector given by Mackenzie (1924) and St. John (1884); some of these, notably the osprey and the polecat, <u>Putorius putorius</u> have not recovered, but others like golden eagle, wildcat, pine marten and badger are still present and apparently prospering.

Effective wildlife conservation in the North-West requires the control of grazing, fire and human disturbance in the widest possible range of habitats. To achieve this, the Nature Conservancy have completed a programme of acquisition of nine National Nature Reserves (N.N.R's) and two 'A' category Sites of Special Scientific Interest (S.S.I.(A)) as part of a national series (Table I and Figure I).

Wildlife conservation through nature reserve management is a complicated exercise in scientific and political administration, the results of which are often a compromise between conflicting interests. Before nature reserves are chosen careful survey is needed to ensure that they contain the desired complement of plants and animals, and this must be followed by: (i) the planned integration of wildlife conservation with other forms of land-use in the reserve or on its boundaries, and (ii) a continuous monitoring of the results of management and making of new prescriptions to maintain, for example, the highest possible level of habitat diversity.

There are three main ways in which the Nature Conservancy can acquire reserves: purchase, lease or Nature Reserve Agreement (N.R.A.). It follows that, if the Conservancy own the land, they have much more freedom of action than is possible by either lease or N.R.A. and there is usually more freedom with a lease than with a N.R.A. Some reserves are partly owned or leased, and partly managed under an N.R.A. Some large reserves, like Inverpolly (Plate I) are managed under a group of N.R.A's with several private landowners. Table I gives some idea of the variety of arrangements and the varying degrees of freedom of action which the Conservancy has in the N.N.R's in the North-West. The fact that a reserve is managed under a N.R.A. does not necessarily mean that wildlife conservation is less effective than if owned by the Conservancy; much depends however, on the willingness of the landowner to accept wildlife conservation as part of his ownership responsibility.

/Table I......

TABLE I

List of National Nature Reserves in the Counties of Ross and Cromarty and Sutherland showing the acreages and details of ownership

Reserve	Area	Ownerships: Private	Public +	Conservancy	N.R.A's	Leases
Inverpolly	26,827	x	-	x	3	-
Beinn Eighe	10,507	x	-	x	1	-
Inchnadamph	3,200	x	-	-	1	-
Invernaver	1,363	x	-	-	2	-
Rassal Ashwood	202	x	-	-	1	-
Corrieshalloch Gorge	13	-	x	x	1	1
Allt nan Carnan Gorge	18	x	-	-	1	-
Strathy Bog	120	-	x	-	-	1
Mound Alderwoods	659	x	-	-	2	-
Letterewe Oakwoods	1,172	S.S.S.I.(A)*	-	-	-	-
Borralie	313	S.S.S.I.(A)*	-	-	-	-
Handa Island (RSPB)	830	x	-	-	RSBP	-

* Site of Special Scientific Interest (A Category)
+ Other than Nature Conservancy

This series of N.N.R's together with the reserve of the Royal Society for the Protection of Birds on Handa constitute the total acreage which has been set aside specifically for the conservation of wildlife in the North-West. There are also some 42 S.S.S.I's of geological, botanical and zoological interest which though not of "reserve" status, have been notified to the owners and the county councils under Section 23 of the National Parks and Access to the Countryside Act, 1949. Table 2 shows how this array of reserves covers the broad range of habitats.

It is one thing to create this series of reserves, but it is another to manage successfully within them the three main agencies of wildlife damage: fire, grazing and public disturbance. Reserves such as Beinn Eighe, which are owned by the Conservancy, are at present neither burned nor grazed by domesticated stock; in leased or N.R.A. reserves, the Conservancy co-operates with the owners to ensure that burning and grazing do not unduly damage the vegetation and fauna and experimental exclosures have been established to investigate the regeneration of heaths and woodlands in the absence of fire, livestock and deer grazing. Human disturbance is minimised with the posting of wardens, and to some extent by providing the public with an information service on conservation with interpretation devices such as nature trails and motor trails. Table 3 summarizes the management of the reserves in the North-West so far.

TABLE 2

Brief descriptions of the National Nature Reserves, S.S.S.I.(A) and R.S.P.B. Reserve in Ross and Cromarty and Sutherland.

Reserve	Description of Reserve
Inverpolly (Plate 1)	Range from sea-level to 2,786 feet, with coastal, moorland, birchwood and montane areas, marine and freshwater islands, crags, screes, bogs, lochs rivers and hill streams.
Beinn Eighe	Range from freshwater-loch level at 60 feet above sea level to 3,188 feet, with pine-birchwood, coniferous plantation, moorland and montane areas with calcareous localities, crags, screes, bogs, lochans, hill streams.
Inchnadamph (Plate 3)	Limestone crags, heaths and grasslands at about 750 feet above sea level with pavements, caves and "disappearing" streams and flushes.
Invernaver	Coastal sand dune, maritime grassland, estuaries and moorland to about 500 feet above sea level with extensive wind-blown sand.
Rassal Ashwood	Limestone woodland, heath and grassland with pavements, flushes and a gorge with basic rocks on one side and acid rocks on the other.
Corrieshalloch Gorge (Plate 2)	A deep box canyon woodland with wet, shaded crags and acid-rock conditions.
Allt nan Carnan Gorge	A gorge woodland with mixed basic and acid rock conditions.
Strathy Bog	Low altitude blanket bog at about 400 feet above sea level.
Mound Alderwoods	An alder woodland with swamp and open water just above sea level.
Letterewe Oakwoods (S.S.S.I.(A))	Oakwoods at about 200 feet above sea level, with brown earths, steep bracken-covered slopes, bog crag, moorland and loch shores.
Borralie (S.S.S.I.(A))	Blown shell sand and limestone bedrock near sea level covered by rich montane vegetation.
Handa Island (R.S.P.B. Reserve)	Vertical sea cliffs with large assemblies of sea-birds, rocky and sandy shore, moorland and fresh-water lochans.

TABLE 3

Nature Reserve Management in the North-West Highlands

N.N.R.	Wardens	Estate Workers	Fires	Grazing	Exclosures	Trails
Inverpolly	2	-	Limited	Sheep Cattle Deer	3	2
Beinn Eighe	1	1	None	Deer	9	2
Inchnadamph	1 Part-time	-	Limited	Sheep Cattle Deer	2	-
Invernaver	1 Part-time	-	Limited	Sheep Cattle	-	-
Rassal Ashwood	1* Part-time	-	Limited	Sheep Deer Cattle	1	-
Corrieshalloch Gorge	1+ Part-time	-	None	None	-	N.T.S.≠
Allt nan Carnan Gorge	1* Part-time	-	None	None	-	-
Strathy Bog	1 Part-time	-	None	Slight Sheep	-	-
Mound Alderwoods	Not yet + in post	-	Limited	Cattle	-	-
Letterewe Oakwoods (S.S.S.I.(A))	1* Part-time	-	Limited	Sheep Cattle Horses Goats	2	-
Borralie (S.S.S.I.(A))	None	-	None	Sheep	-	-
Handa Island (R.S.P.B.)	1 Part-time	-	Limited	Sheep	-	R.S.P.B.∅

∅ R.S.P.B. The Royal Society for the Protection of Birds have a hut on Handa.

* The Warden at Beinn Eighe also attends to these N.N.R's.

\+ The Wardens at Inverpolly also attend to these N.N.R's.

≠ N.T.S. National Trust for Scotland have a viewpoint at Corrieshalloch.

The acreage in reserves, however, is insignificant when compared with the total area in need of conservation in the North-West. Samples of a wide range of habitats are safeguarded, but this is only part of the mission in wildlife conservation; the lessons which are learnt in the reserves must be made widely known and come to influence the course of events in the North-West as a whole. The reserves are no more than demonstration areas in which the results of proper control of burning, grazing and disturbance can be displayed. The exclosures at Beinn Eighe and Rassal Ashwood, some of which have been standing for ten years, now show what can be achieved by eliminating grazing and burning for comparatively short periods and at the Loch Druidibeg Reserve in South Uist (just outside the area under discussion), there is an outstanding example of how stringent control of the public during the breeding season has resulted in the increase in numbers of the native grey lag goose, Anser anser.

Liaison between the staffs of the Conservancy and estates has been growing stronger through the years, with an improved flow of information in both directions and a better and wider understanding of the long-term effects of burning too often in large fires, overstocking of ground by running too many sheep or culling too few deer, and the legitamate role which predators must play in the make-up of the deer forest and sheep run. On this last point, Viscount Arbuthnott (1967) states: "The predator will never exterminate a species - that is just not the way of nature! Most landowners pride themselves on a liberal attitude towards the casual poacher who is simply taking one for the pot; why cannot at least the same attitude be accorded to the predator? Is scarcity to be our only standard of value of wildlife?".

The visits by representatives of the Royal Society for the Protection of Birds and the bounty scheme for the protection of the golden eagle and other rare birds, also contribute to improvement in status of these birds and the understanding in the minds of the landowner and estate staff, of their value to the locality and the country as a whole.

WILDLIFE AND LAND-USE

The long train of events which has led to the present-day impoverishment of the North-West starts from the birch-clad country with its bare ranges of mountains, in which there were only natural boundaries: the forest edge, the loch shore, the edge of the scree and so on down through the mosaics of macro- and micro-habitats of pristine forest, moorland, wetland and mountain top.

The arrival of man and the pageant of human land-use of the area has meant the successive superposition of political boundaries, most of which have been lines separating different types of land-use, or the same types done in different ways. These differences have resulted in the interruption of the natural ecological continua, with different semi-artificial habitats developing on each side of the boundary.

Darling (1937) showed that an old traditional deer forest such as that of Dundonnell was not a simple self-contained unit, but one which gave and received deer from neighbouring forests. The forests, more or less distinct ranges of mountains, were never accurately defined and formed the basis of the sporting estates, probably because they gave the superficial impression of being a satisfactory unit of sporting land. Few of the estates in their heyday ever circumscribed an entire unit of red deer such as occurs on the isles of Rhum and Jura though some contained more than one forest. Whitehead (1960) gives details of history, size, culls and deer data and records the great changes which have occurred in the

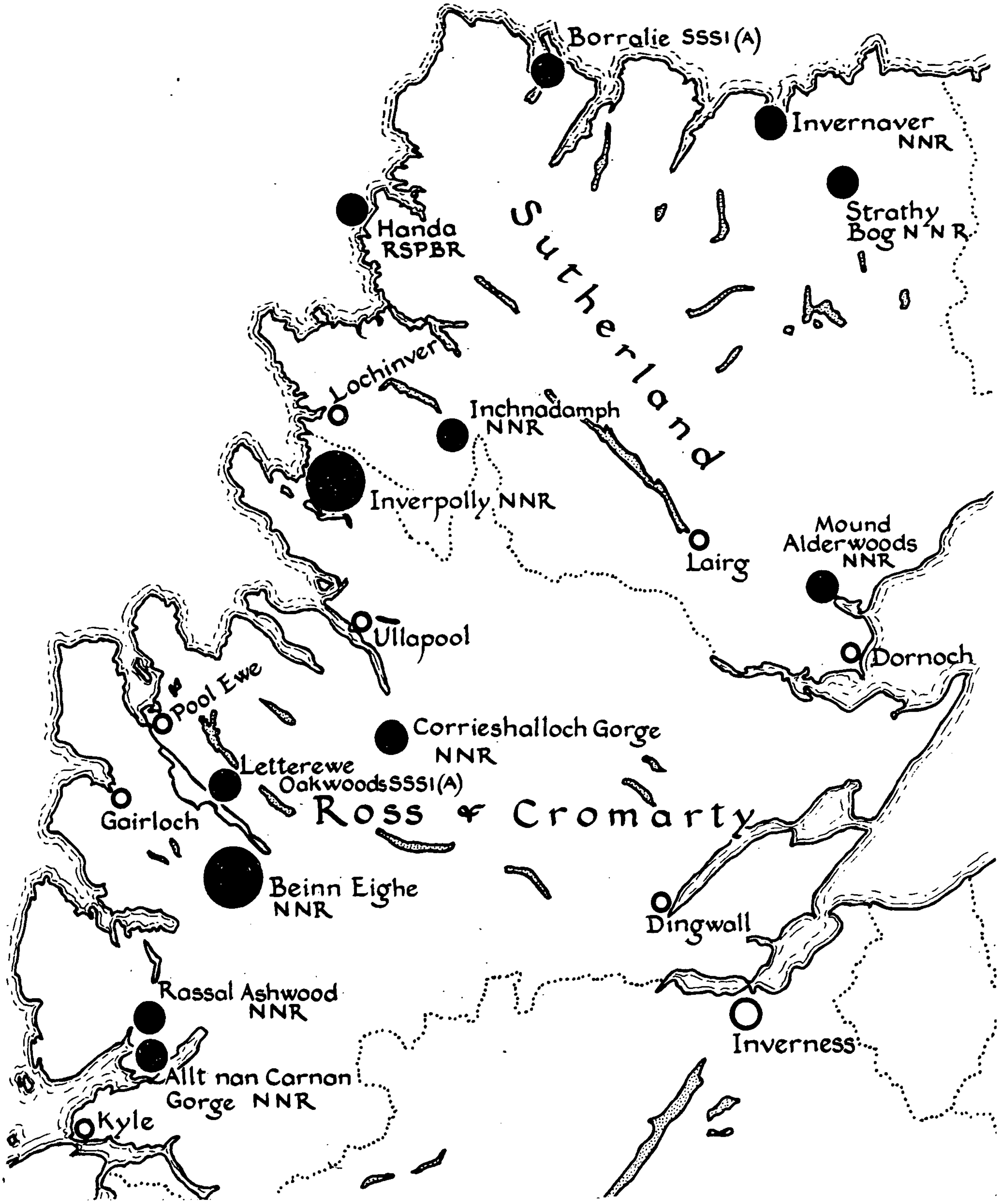


Fig. 1. The Counties of Ross and Cromarty and Sutherland showing the locations of Reserves, SSSI (A) and the main centres of population. The size of the discs does not relate to the size of the areas; Inverpolly and Beinn Eighe are shown larger because of the comparatively greater size of these Reserves to all others.

forests (or estates), with the progressive partitioning of the land, the introduction or withdrawal of sheep from part or all of the forest, the changing capability of estates to take the optimal crops of stags and hinds, and the changing use of the land by the deer themselves.

What applies to red deer also applies to other wildlife which do not respect political boundaries. Distributions of red and roe deer, fresh-water fish and so-called "pests" such as fox, badger, wildcat, otter, pine marten, raven, Corvus corax, hooded crow, C. corone cornix and others, cut across the boundaries. It is essential therefore that conservation of nature must also transcend the marches of the estates as a matter of joint rather than unilateral action among landowners. The conservation of the salmon, the golden eagle or the pine marten could be used as the basis of this discussion, but red deer is the outstanding wildlife resource of the North-West, and is given prominence in this paper. Tables 1 and 2 show that the Conservancy have, within their series of reserves in the North-West, two large areas of deer forest at Inverpolly (Plate 1) and Beinn Eighe (Figure 1) in which the problems of red deer and predator conservation can be studied.

The basis of the red deer problem in the Highlands is the super-position of an ever-changing mosaic of estates upon the mosaic of the deer ranges. Both of these mosaics are largely the work of man, since, although red deer are still regarded as wild animals, their distribution is to a large extent, governed by land-use. Estates and deer ranges are far from being complementary, and the progressive divergence of pattern between the ranges of the deer and the units in which they are managed, has resulted in widespread marauding by red deer on agricultural and forest lands and inefficient exploitation of deer resources (Red Deer Commission, 1966). The planning of sheep farming, timber afforestation and the partitioning of the deer forests into smaller units has seldom been preceded by a survey of deer and the distribution of the deer population taken into account.

There has been introduced in recent times the complications of hydro-electricity, recreation and subsidies for hill-land improvement, sheep and cattle. Whitehead (1960) points out that the disruption of the deer forests by the construction of the dams, aqueducts, roads and power stations is temporary, but the considerable loss of important lochside pastures by flooding, was bound to be harmful. Perhaps more important is the effect which hydro-electricity has on the economy of the estates; the opening-up of previously inaccessible country together with subsidy incentives, give wider opportunities in forestry, sheep farming and sport. Roads constructed for hydro-electricity and forestry, also give easier access to the mountains by rock climbers, hill walkers and occasionally also by motorists; this poses its own acute problems of fire danger and continuous disturbance of wildlife, including red deer.

If red deer are to be properly integrated into the planning of natural resources in the Highlands, landowners will require to know much more about the deer than has hitherto been the case. Management is becoming more sophisticated and there is a possible trend towards deer "ranching" with accurately determined and assiduously maintained stocking rates, of deer alone, and of deer with sheep and cattle. The Nature Conservancy's research on the Rhum nature reserve (just outside the area under discussion) is aimed at refining the comparatively crude techniques of the past and the production of a new code of management; in this it is hoped to describe the relationships between deer and pasture, and between deer and other livestock.

The new technology of deer management however, involves more accurate measurement of the population, with censuses, calf marking, selection of animals for culling based on meat production as well as on sporting trophies and, in many areas, heavier culls. On Rhum it has been possible to work out in detail the control of the hill-going public, to obtain the best results. Censuses are carried out in April, calf tagging in June, culling of stags in September-October and hinds in December-January; in all those months the island is kept comparatively undisturbed. On mainland ranges this cannot be done so easily and those who are planning recreation in the Highlands should bear in mind the basic needs of deer management not only during the autumn and winter when the deer are being shot, but also in the spring when they are being counted, and locally in mid-summer when calves are being caught.

All of these features are present in the make-up of the land-use/natural resource/public pressure complex of the North-West, and it is a matter of great urgency to effect some disentanglement of the main factors. In the section which follows an experimental land-use planning unit for the North-West will be described in which sheep, deer, forestry, agriculture, hydro-electricity and recreation are all represented. In this area the ecological implications of all these forms of land-use can be studied with reference to the North-West as a whole.

A LAND-USE PLANNING UNIT

In 1951 the Nature Conservancy purchased the Beinn Eighe Reserve (10,450 acres plus 57 acres added in 1962). This was part of the old Kinlochewe deer forest (62,000 acres) which is now partitioned in four smaller units. From the beginning, therefore, the reserve was only part of a very much larger deer forest and observations by the reserve wardens since 1951, indicate that Beinn Eighe is part of a different and larger unit of deer forest than old Kinlochewe. In winter, deer from Kinlochewe move westwards into the forests of Flowerdale (10,031 acres), Shieldaig (8,293 acres) and possibly also into Torridon (16,000 acres); the acreages are taken from Whitehead (1960).

The numbers of deer occupying any one of these blocks of country varied greatly according to season and weather; yet they are all managed independently with the usual neighbourly courtesies which in many areas can fall short of providing a basis for the joint planning of optimal exploitation of deer in the district. The general tendency - in many cases the rule - among forest owners, their agents and staff has been to remain uncommunicative about stocks of deer even in cases where it was obvious that two estates were sharing the same herds. The planning for sheep-farming, forestry and recreational schemes, has not generally been accompanied by prior consultation on the effects which these developments will have on deer, and vice versa. There is therefore a great need for improved intercommunication between the estates at both the planning and operational levels if the principles of conservation are to be achieved in the difficult, unyielding North-West. It is important therefore, to develop some means of breaking down barriers to local inter-communication and of estates planning and operating together for the common good. This is what the Nature Conservancy have been trying to achieve in the Beinne Eighe district.

An area, hereafter called "the unit" (Figure 2), covered by the old forests of Kinlochewe, Torridon, Flowerdale and Shieldaig is now sectioned into smaller estates. Two sections of old Kinlochewe - Kinlochewe Lodge

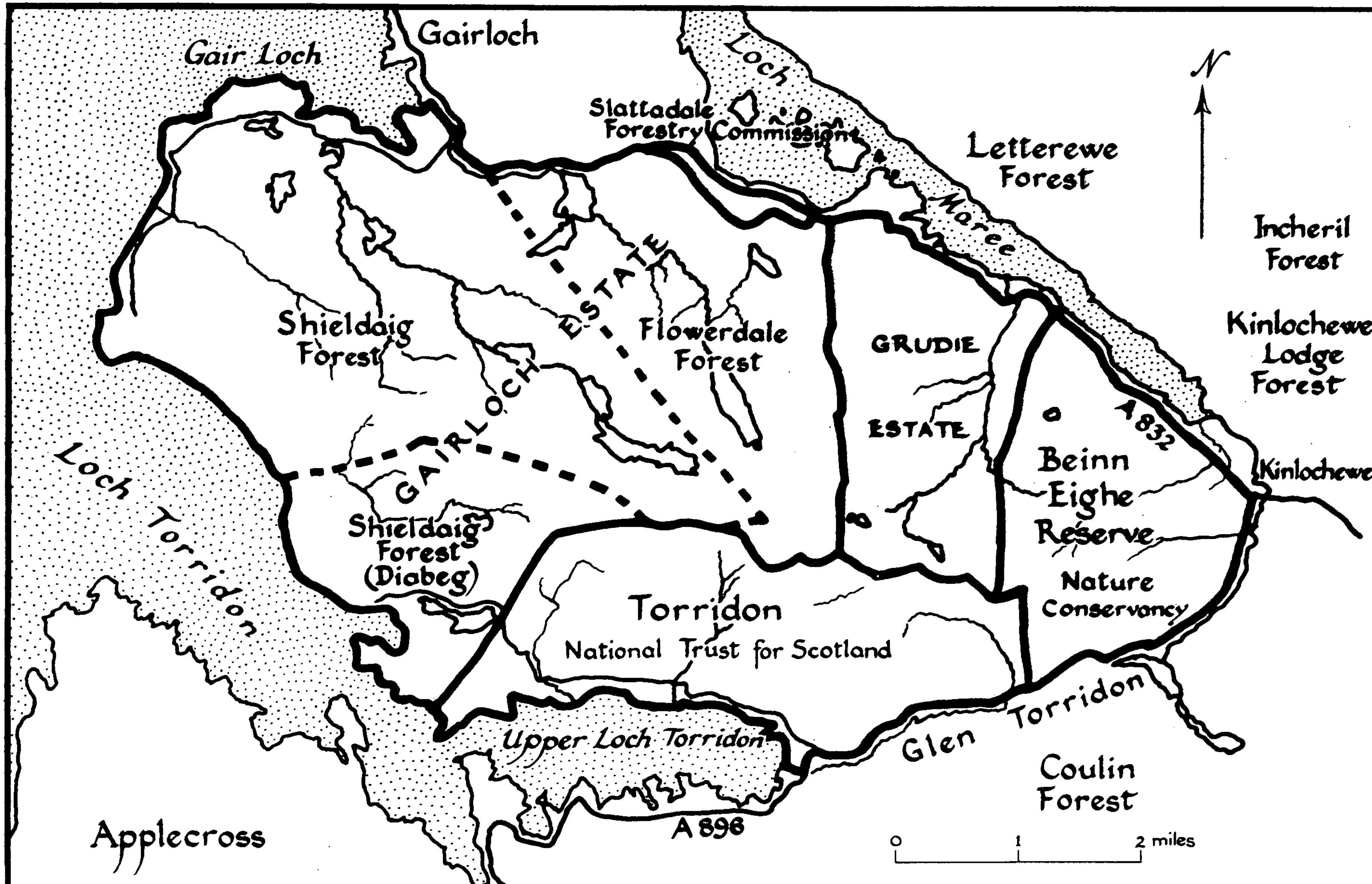


Fig. 2. Land use planning unit in the deer forests of Kinlochewe, Torridon, Flowerdale and Shieldaig in Wester Ross. The final boundary of the unit will probably include the shore strip of Loch Maree and the Loch Maree Islands.

forests and Incheril - lying to the north-east of the village are excluded from the unit, since the geographical and biological connections of this country with that to the west of Kinlochewe village, are not strong. There is, for example, little interchange of deer between the two, and little or no forestry or tourist development in Kinlochewe Lodge forest and Incheril. Similarly, there are no strong connections between the Coulin Forest to the east of Glen Torridon and the country to the west.

This block of country therefore, bounded by Loch Maree and the band of timber and sheep land between Loch Maree and Loch Shieldaig in the north, Glen Torridon in the east, Loch Torridon in the south and the open sea in the west, is a reasonably self-contained unit. The major ownership is as follows (Figure 2):

Gairloch Estate	-	private
Torridon	-	National Trust for Scotland
Beinn Eighe Reserve	-	Nature Conservancy
Grudie Estate	-	private
Slattadale Forest	-	Forestry Commission

The North of Scotland Hydro-Electricity Board have the Kerry River power station which takes all of its water from a catchment in the midst of the unit. The main streams of tourism to the fishing port of Gairloch are on the A832 from Inverness and the A896 from Skye; these roads converge on Kinlochewe village. The Ross and Cromarty County Council are improving roads in the district. The section between Shieldaig and Torridon villages was recently completed and a new double-carriageway road is planned between Kinlochewe and Gairloch. Work has already begun on this road which will run through some of the most attractive scenery in the North-West.

The unit contains a well-balanced group of interests covering the widest possible range of the resources of the North-West. Table 4 shows the approximate way in which each estate contributes to the exploitation pattern. Some may have a few sheep, cattle or plantations of conifers but these have been omitted to obtain the bold outline.

Sheep and timber do not contribute significantly to the economy of all the estates, though they are most important in Gairloch and Slattadale respectively. The most striking feature of Table 4 is the all-round sharing of deer (and other wildlife) and recreation, and it is upon these that the joint planning of land-use can be conveniently based. In the minds of some deer-forest owners, large-scale recreational developments are inimical to sport and the unit provides an opportunity of working out in detail the successful management of the land in deer and people.

/Table 4.....

TABLE 4

The major natural resources which have been utilized in the various estates which make up the Unit

Ground	Resources									
	Deer	Other Wild-life	Rec-rea-tion	Sheep	Timber	Cattle	Crof-ting Agr.	Fresh-water fish	Water Power	Educa-tion
Gairloch Estates	x	x	x	x	x	x	x	x	x	
Torridon N.T.S.	x	x	x	x		x	x			
Beinn Eighe Reserve	x	x	x		x					x
Grudie Estate	x	x	x	x				x		
Slattadale Forest	x	x			x					

The basis of joint planning in deer and recreation having been obtained, a start must be made on the ground. In this exercise it is vitally important that the initiative springs from the locality and carries with it from the beginning, the goodwill of the owners and their staffs. If such can be achieved on the <u>domestic</u> level without having to call upon help from outside, the closer will the unit come to satisfying the need for self-help in the communities of the North-West.

A beginning has, in fact, been made through the initiative of the reserve warden at Beinn Eighe who organized a count of the red deer in the unit in late March 1967. All the estates sent representatives to meetings before and after the census and twenty local people took part in the census. For the first time, the communal red deer resource shared by these estates has been measured. Both the act of measuring and data obtained show: (i) the high level of co-operation which can be achieved by local initiative alone; (ii) the numbers of stags, hinds and calves available; and (iii) the need for annual or twice-yearly counts to determine the optimal culls of stags and hinds for each estate.

What applies to red deer also applies to recreation. The National Trust for Scotland and the Nature Conservancy are now providing picnic sites, nature trails, information centres and a field station in the unit. This is the beginning of planned integration of recreation into the Torridon and Beinn Eighe hills with due respect to the other interests in the unit and particularly to the management of red deer and other wildlife.

SUMMARY

The soils, vegetation and animal populations of the North-West Highlands of Scotland, have long since passed the point of no return to the spectacular habitats of a thousand or more years ago. The impoverishment of wildlife still continues mainly through sheep grazing, burning of

the vegetation and human disturbance. A wide range of habitats have been included within ten reserves and two S.S.S.I. (A)'s. These reserves in themselves cannot substantially stem the widespread impoverishment of wildlife in the North-West, but can act as reservoirs of species and demonstration areas. These, together with liaison between the staffs of estates, the Conservancy and the Royal Society for the Protection of Birds, can bring about improvement in the status of many species.

Wildlife does not respect man-made boundaries. For example, the herd ranges of red deer are not complementary to the units (estates) in which they are managed. This is one of a root cause of damage to agriculture and forests by red deer. Similarly, so-called "pest" species which are tolerated on deer forests, will not be tolerated on neighbouring sheep runs or grouse moors. In the management of wildlife the political boundaries require to be reconciled with the distribution of wild animals. The new technology of deer management requires freedom from human disturbance at census, calf-tagging and culling periods and the planning of recreation in the North-West should take this into account.

In the old Kinlochewe, Torridon, Flowerdale and Shieldaig deer forests there is an outstanding opportunity for mixed land-use planning in red deer, recreation, forestry, freshwater fisheries and sheep farming. Included in this unit are two private estates, a property of the National Trust for Scotland, a National Nature Reserve, a State Forest and a hydro-electric scheme. The conservation of the resources of this area depends to a great extent on the goodwill of the various owners and their staffs and to planning and co-operation on the ground for the common good. A great deal of the initiative for co-operation in management of deer and recreation arises locally; the Nature Conservancy has already taken an initiative through their warden at Beinn Eighe in carrying out a deer census in the unit. The National Trust for Scotland, the Nature Conservancy, the Forestry Commission and the private landowners are now beginning to plan the integration of recreation into the district.

REFERENCES

ARBUTHNOTT, Viscount. 1967. Nature Conservation and landownership (111) Sport and recreation. Scot.Landowner, 127; 639-41.

BLACK, J. N. 1964. The ecology of land-use in Scotland. Trans.Bot.Soc. Edinb., 40, 1-12.

CALLANDER, J. G., CREE, J. E., & RITCHIE, J. 1927. Preliminary report on caves containing palaeolithic relics near Inchnadamph, Sutherland. Proc.Soc.Antiq.Scot., 61, 169-72.

DARLING, F. F. 1937. A Herd of Red Deer. Oxford.

DARLING, F. F. 1955. West Highland Survey. Oxford.

DARLING, F. F., & BOYD, J. M. 1964. The Highlands and Islands. London.

DURNO, S. E., & McVEAN, D. N. 1959. Forest History of the Beinn Eighe Nature Reserve. New Phytol., 58, 228-36.

McVEAN, D. N., & RATCLIFFE, D. A. 1962. Plant communities of the Scottish Highlands; a study of Scottish mountain, moorland and forest vegetation. Monograph of the Nature Conservancy, 1. London.

O'DELL, A. C., & WALTON, K. 1962. The Highlands and Islands of Scotland. London & Edinburgh.

RED DEER COMMISSION. 1966. Annual Report for 1965. Edinburgh.

RITCHIE, J. 1920. The Influence of Man on Animal Life in Scotland. Cambridge.

ST. JOHN, C. 1884. A Tour of Sutherland. Edinburgh.

THOMAS, J. H. 1958. The lobster and crab fisheries in Scotland. Mar.Res. Scot., 1958, 8. Edinburgh.

WHITEHEAD, G. K. 1960. The Deer Stalking Grounds of Great Britain and Ireland. London.

SUMMARY OF DISCUSSION

The speaker was asked what evidence there was for his comment that the public caused disturbance to deer stalking. He said that this came mainly from hill walkers and hiking parties and that his wardens had recorded a number of instances where deer stalking had been interfered with by such people. The discussion then turned to whether disturbance was in any way detrimental to the general habits and movements of the deer. Because people used distinct routes when crossing the hills, was it not possible that the deer would adjust themselves to this? Another point was that a general pattern of disturbance could be established in relation to where people go and that some measure of the interference with the movements and behaviour of deer could be measured. The speaker said that much of the western Highlands was not fully developed for recreational purposes so that one could expect, in the near future, a much greater degree of human interference. The effect of this on the deer could not be predicted but should be the subject of a further study. It was possible that some redistribution of the deer could be expected in relation to this.

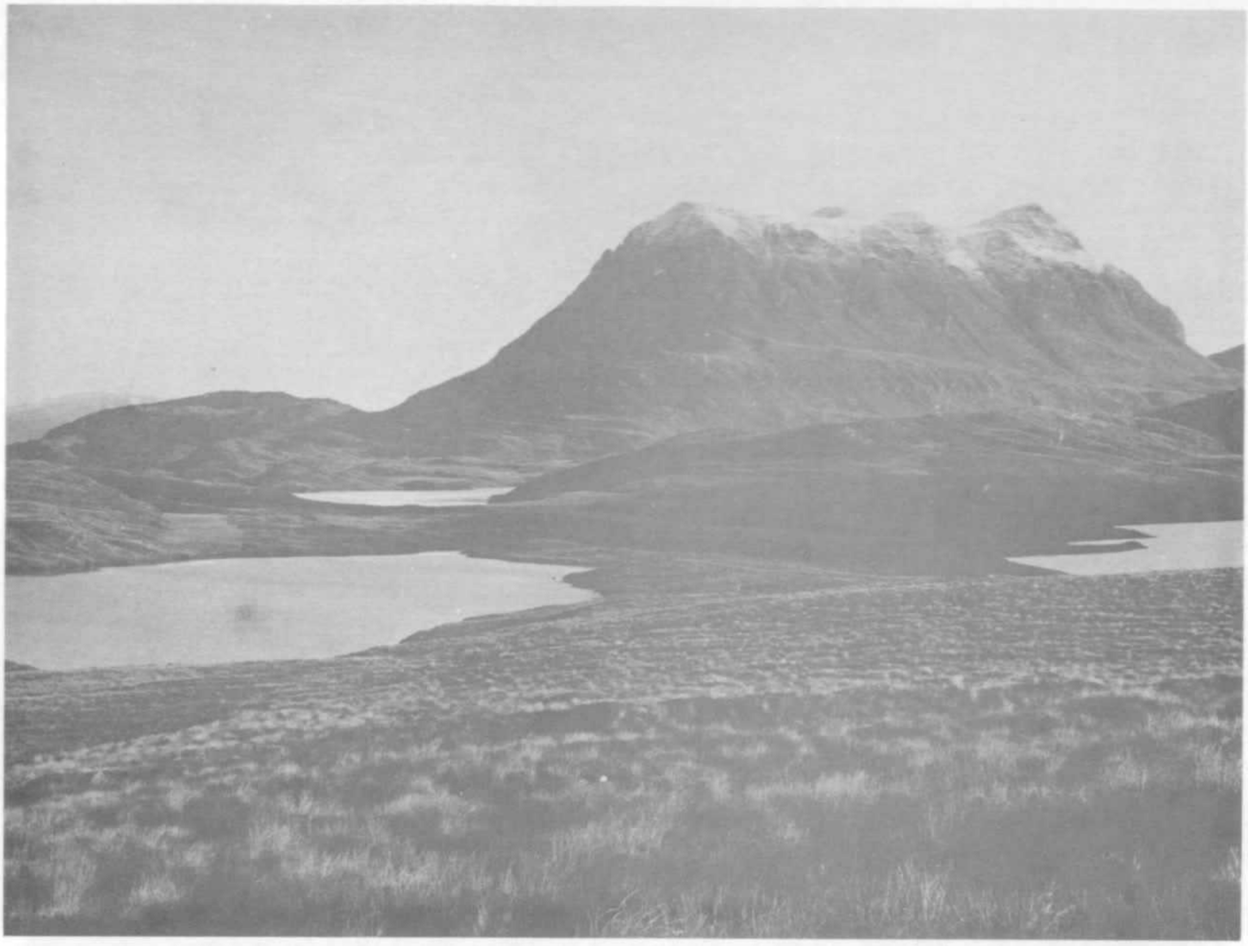


Plate 1

Photo: R. Tweddle

The Inverpolly National Nature Reserve (26,827 acres), Ross-shire is the largest reserve in the North-West Highlands of Scotland containing a wide variety of habitats from sea level to the summit of Cul More (2,786 ft.) which is seen here with a covering of snow on the summit ridge. In the foreground and middle distance there is the rolling country of Lewisian gneiss with grass and dwarf-shrub heaths characteristic of the North-West. The hollows are filled with small oligotrophic lochs and in the middle distance a glimpse of Loch Sionascaig is seen below Cul Mor.

Plate 2

Photo: J. K. St. Joseph

An aerial view of the Corrieshalloch Gorge National Nature Reserve (13 acres), Ross-shire looking westwards towards the farmlands at the head of Loch Broom. The area has been afforested by the Forestry Commission and is also a National Trust property. The main tourist routes can be seen on both sides of the Gorge with a private road running on the fringes of the forest at the right of the picture. Across the Gorge at its deepest point can be seen a footbridge which is an outstanding tourist attraction since it gives an excellent view of the box canyon and the Falls of Measach (150 feet).

Plate 3

Photo: J. K. St. Joseph

The Inchnadamph National Nature Reserve (3,200 acres), Sutherland seen in the middle distance with the prominent limestone escarpment of Stronchrubie Cliffs. At the end of Loch Assynt the hamlet of Inchnadamph can be seen with the ruin of Ardvreck Castle on the small peninsula in the foreground. This is an area of outstanding geological and biological interest centred on the outcrops of Durness limestone which can be seen in the left foreground and middle distance. The landuse of this area includes sheep and cattle farming, red deer and freshwater fisheries. The main tourist route A.835 threads its way through the area.

THE INFLUENCE OF FOREST PRACTICES ON WOODLAND NATURE RESERVES

A. Carlisle and A. H. F. Brown
Merlewood Research Station

For all his intelligence and technical skill, man is not a very far-seeing creature. All too often he sees only what he wants to see and shows great ingenuity at finding cogent reasons for doing what he wants to do. It is only when the results of his short-sightedness cause a disaster which threatens his physical or economic survival that he takes any positive action to take precautions against such a disaster happening again. Sometimes he is too late and the process of destruction or degeneration cannot be reversed. Since man learned to make fire, fell trees and till the land, his main concern has been to manipulate his environment for his own immediate needs for warmth, housing, food and security, with little thought for the long term results of these activities. While this attitude is understandable in primitive man, at our present level of civilization it is quite inexcusable. Even today, man is using his environment for the most part quite blindly, and he has little idea of the effects which will result from his activities.

The present paper reviews the effects of forest practices very briefly. The major topics of influences of forest practices upon erosion, the water cycle, the microclimate, and man's health are only mentioned in passing. Most of these have been discussed at length in the literature (Bennett 1939; Kittredge 1929, 1948; Vaychis 1958; Molchanov 1963; F.A.O. 1962; McComb 1966; Durk 1966; Storey 1966; Hughes 1949, 1950; Delfs 1955). The emphasis is on conservation problems (in their widest sense) raised in Britain and other countries of the north temperate zone by current practices in commercial forests and woodland reserves.

THE EFFECTS OF TREE ESTABLISHMENT

The planting of any tree cover, whether it is the afforestation of a previously treeless site or the replacement of a previous forest cover with different tree species, greatly alters the microclimate, the nutrient and water relations of the soil and vegetation, and the quantity and quality of the litter fall. The ancillary activities of draining and fencing also exercise their influences. The net result of these changes is a modification of the chemistry of the soil profile, the activity of soil organisms, the ground flora and fauna. Many of these changes may be superficially obvious but are not always easy to measure or interpret. There is a number of papers which describe ad hoc experiments on these influences (e.g. Zinke & Crocker 1962; Zinke 1962; Pokhiton 1958; Vaychis 1958; Ovington 1958a, b; Duchaufour & Bonneau 1961; Griffith et al 1930; Burrichter 1954; Fisher 1928; Crocker & Dickson 1957) but we still know surprisingly little about the effects of afforestation or changing from one tree species to another.

It is well known that different tree species tend to form different types of surface soil organic matter such as mull and mor (Handley 1954). We also know that leachates from freshly fallen litter of some tree species (e.g. *Pinus* spp.) mobilise iron more readily than others, and thereby increase the possibility of iron (and other cation) movement down the profile in the characteristic process of podsolisation, particularly on freely drained soils. Most vegetation litter produces leachates which mobilise iron (Lossaint 1959; Bloomfield 1953a and b, 1955, 1956, 1964;

King & Bloomfield 1966) and leaching of soil profiles and the weathering of minerals is an inevitable process in well drained immature soils in an oceanic climate such as we have in Britain. When however, this process is accelerated by changing the tree species, a podsol can form in a very short time on soils of low fertility. In the Lake District the soil beneath a group of 60 year old Scots pine planted in a long established oak wood on a brown earth of low nutrient status over slate has developed into a micropodsol. The development of deep podsols beneath Scots pine planted on the relatively infertile quartzose sands of the oak areas of the New Forest has been reported by Davies (1960). In the Lake District oak woodlands on siliceous sites, bracken, Pteridium aquilinum is invading many of the deeper soils beneath the more open parts of the canopy. On some of these sites there is a marked grey-white bleached horizon beneath the H layer. It is possible that a change in ground flora can also accelerate podsolisation.

The present tendency is to replace the oak woods on the less fertile soils with the more productive conifers. This is not the place to discuss the wisdom of this policy, but it is essential that we know what the ultimate effect of this practice will be upon soil fertility and site potential and how far these changes can be reversed. The expansion of conifer woodlands to meet the needs of the new chipboard and allied industries is inevitable and it is vital that their effects on the soil, flora and fauna are monitored. It will be most unwise to take refuge in the fact that some trees (e.g. Picea abies) can grow perfectly well on podsols on some soils for many rotations without any fall-off in production (Genssler 1959). It is implicit in the process of podsolisation that mobile nutrients such as the bases are leached down the profile and partly lost. These losses may be offset to some extent by income of nutrients in rainfall and mineral weathering, but on the poorer soils where the rainfall is not particularly high, there is likely to be a net loss of nutrients from the profile, and such loss is a diminution of the site potential. It may be argued that this loss can be made good by adding fertilizers, but quite apart from the expense, the effectiveness of this depends upon the ability of the soil to retain the nutrients, i.e. on its ion exchange capacity. Although we know a great deal about the process of podsolisation, we still know very little about its significance in terms of site potential.

The use of certain tree species on poor well drained soils can result, therefore, in soil deterioration, but the ameliorative properties of a forest cover, particularly of broadleaved species, are well known. Some trees, Douglas Fir, Pseudotsuga menziesii for example, are known to bring bases from lower down the soil profile up to the soil's surface where they can participate in the nutrient cycle (Duchaufour & Bonneau 1961; Barneschi 1966). Burrichter (1954) describes how oak and birch decrease the acidity of heath soils, improve the organic matter distribution in the profile and encourage the activity of soil micro-organisms. Romell (1957) found that the fertility of degraded pastures was restored if trees were allowed to invade and develop thickets for a few years. The role of birch as a soil improver is of direct concern in the management of woodland reserves. Many cases are known of birch improving soil fertility (Abaturov 1961; Dimbleby 1952b) but we still do not know how this operates. For some time it was thought the benefit to the soil was due to relatively high levels of mineral nutrients in birch leaves, but this is not necessarily the case (Nykvist 1961; Mork 1942). Nykvist (1961) points out that the soil improvement is due more to the complex relationships between birch leaf litter and the soil organisms, the beneficial effects of birch on the physical characteristics of the soil, and the influence of the roots. Dimbleby (1952a) emphasizes the ability of birch roots to exploit the soil and enrich upper horizons. It is often said, probably quite correctly, that hazel is a soil improver, but we do not know the process by which this improvement is effected. Any speculation on how these species improve the soil inevitably leads to the blank wall of our lack of knowledge of the processes of forest soils.

The possibility of upgrading degraded soils by changing the tree cover is demonstrated by the fact that when a podsol developed on an old agricultural site in America in 40-50 years after planting with Pinus, that particular soil was restored to its former state and recharged with nutrients in 30-50 years by planting mixed hardwoods such as oak and maple (Griffith et al 1930). This may not be possible on all soils, but the manipulation of the tree cover is a valuable tool in the large scale reclamation of derelict soils.

It is not possible to generalise about the influence of establishing trees upon the ground flora and fauna as this depends upon the site. Naturally a closing tree canopy will favour shade-bearing plants, and the lowering of the water table which often follows afforestation (either due to drainage or an increased transpiration) will favour plants tolerant of drier conditions. Such changes are being followed at Gisburn where pure and mixed tree stands have been planted. The influence on wild life is also complex and dependent upon local conditions. Afforestation of previously open ground affords shelter, particularly in the phase prior to canopy closure, for a wide range of fauna, and the introduction of new tree species provides new ecological niches. In a study of seasonal changes in populations of wild life in conifer plantations in Britain, Smith (1957) observed that spruce, Picea spp. plantations and mixtures containing spruce attracted rabbits and grouse in the winter and generally had greater numbers and diversity of birds than plantations of other conifer species. Deer frequented all plantations but had a strong preference for Pinus areas in the winter. Plantations of $>$10 acres had a high density and more variety of wild life than smaller areas. Until recently a high proportion of commercial plantations has been in the thicket or pole stage, a uniform condition that does not encourage diversity of fauna. This is however, only a phase and the large commercial plantations will be (indeed already are) one of the major reservoirs of wild life in Britain. The great increase in deer in Britain in the last decade is probably largely due to extending afforestation, most of which is coniferous.

One aspect of the influence of trees which has been neglected is the influence of tree canopies on aquatic habitats within woodlands. Many ponds and streams beneath trees are remarkable for their lack of wild life (Boudru 1937; Huet 1952). Huet (1952) found that a canopy of spruce, Picea abies destroyed the microfauna and microflora in rivers and reduced fish populations. This was not only due to light reduction as the effect extended some miles downstream. This raises the question as to whether or not tree leaf and litter leachates are toxic to water organisms. If this is the case it should be taken into account in reserve management where the pond fauna are of interest and in management of the extensive commercial plantations of conifers adjacent to rivers.

The changes in bird populations of newly planted forests at different stages in their development have been outlined by Campbell (1964). He points out that reduction of grazing by fencing encourages lush growth of ground vegetation which provides shelter for small birds. Vole populations sometimes increase considerably and attract predators such as the short-eared owl. When the canopy closes the bird population falls, but increases again when the wood is thinned. The pre-canopy closure encouragement of birds occurs whether the trees are conifers or broad-leaved species. The new conifer plantations are encouraging the ingress of redpoll, siskin and crossbill.

If the tree cover any large area is altered, for example to a monospecific conifer cover, most of the changes which take place in the flora and fauna can be reversed naturally if a certain degree of heterogeneity is maintained. It is generally realised that 'islands' of broad-leaved species in vast areas of conifers, or an intimate mixture of conifers and broad-leaved species, are valuable in maintaining the site potential. We do not know the degree of heterogeneity needed to maintain this potential. We need to know the size of broad-leaved groups and the proportion of broad-leaved trees in a mixture necessary to act as centres for repopulation with flora and fauna when the land use is changed. The desirability of mixed plantations compared with pure coniferous stands has been stressed in a recent review by Noirfalise (1967).

THE EFFECTS OF FELLING

The felling and extraction of any appreciable proportion of tree cover, whether as clear-felling, group felling or thinnings, has an immediate and often dramatic effect upon the microclimate. More rainfall and solar radiation reach the forest floor than before, wind can penetrate more easily, the insulating effect of the canopy upon the soil is removed or diminished, and the transpiring surface is temporarily reduced. In the case of thinnings these changes may only be temporary until the canopy closes. Felling and extraction also mean appreciable soil disturbance. The churned-up soil is more exposed to oxidation processes and may bring unweathered material from lower down the soil horizon into circulation. The net, and again possibly temporary, result of this is usually an increase in fertility, the 'assart effect' described by Romell (1957). The soil temperature increases in the summer following fellings (although the soil may be colder in winter) and there is an increased activity of the soil organisms with a surge of mineralisation of nitrogen. Nutrients are released and both the ground flora and remaining trees are able to take full advantage of the increase in available solar radiation. The shade bearing species in the ground flora will be dominated by the light demanders until the canopy closes again. This initial increase in the growth of the ground vegetation is well known, but we still know remarkably little about it in terms of plant succession and competition. Following felling there is often a marked increase in soil water content and possibly a rise in the water table. Again this may be temporary, but it could well affect the plant succession and even the success of the trees, particularly on poorly drained sites. In a Scots pine woodland on the fluvioglacial deposits of Deeside there used to be considerable quantities of Goodyera repens, Pyrola rotundifolia, P. minor and Trientalis europaea. A seeding felling was carried out and Deschampsia flexuosa is now dominant. The Trientalis is still present, but the Goodyera repens and Pyrola spp. have gone. This is one example of how opening the canopy can virtually eliminate relatively uncommon species. We hope that this is only a temporary loss.

When any plant material is removed from the site there is a loss of nutrients. The significance of this loss depends upon the soil type, the rate of mineral weathering and the income of nutrients in the rainfall. We know virtually nothing about the absolute quantities of nutrients entering the nutrient cycle of woodlands from weathering, but we do know a certain amount about the income in the rainfall. There is good evidence that in some cases the rainfall nutrients are able to replace most of the macro-nutrients such as N, P, K, Ca and Mg taken out in fellings. One example is oak high forest on a siliceous site in a high rainfall area in the Lake District (Carlisle et al 1966a). This is not always the case and in areas of low rainfall the nutrients in the precipitation may not be sufficient to replace these losses. The most likely loss is phosphorus which is present in rainfall in only small quantities. There is also some danger of a net nutrient loss on short rotation system such as coppice where there is removal every 12-15 years of young stem materials which have a relatively high proportion of nutrient rich bark. We are currently examining this possibility. The bark of some trees contains considerable quantities of nutrients. In an oakwood on a siliceous site for example (Carlisle et al 1966b), the bark contains 31 per cent. of the N; 25 per cent. P; 74 per cent. Ca and 35 per cent. Mg in the vegetation. Several instances have been seen of trees (e.g. Picea sitchensis) planted in bark waste, with a spectacular increase in height growth and needle size. If the timber is to be barked, the possibility of returning this bark to the site should be considered.

The object of a thinning or group clearing is to allow light to enter and to stimulate natural regeneration or planted trees and the growth of the older trees and possibly to increase diversity. Often however, the increase in the luxuriance of the flora tends to attract grazing animals and gives additional cover to small rodents. These effects can completely offset the advantage to the regeneration of the provision of extra light. In many woodlands an invasion of bracken, Pteridium aquilinium on deeper soils follows an opening of a canopy. Bracken takes up a great deal of potassium, phosphorus and magnesium, particularly the first (Carlisle et al 1966b) and on soils of relatively low fertility there is bound to be considerable competition for nutrients, as well as for water. The water soluble leachates of bracken have also been found to be toxic to young seedlings of spruce, Picea abies but less so to older plants (Torkildsen 1950). The possibility of this toxicity being part of the reason for tree regeneration failure on bracken sites, must be borne in mind.

When a group felling is made in a woodland, an interface is created between the treeless area and the tree-covered area. Garfitt (1966) pointed out that in a great many cases young trees on a treeless area adjacent to woodland are often much more vigorous near the edge of the forest than further away from it. If the clearing (or felling strip) is small or narrow, most of the young trees benefit from the proximity of the older stands. We do not know why it happens, although shelter is part of the reason. It is additional support for the advocates of small group fellings.

On shallow soils felling can lead to complete destruction of the ground vegetation. On an area of oak, ash, hazel (coppice with standards) on Carboniferous limestone pavement in the Furness area of Lancashire, the ground flora consisted mainly of bryophyte mats growing on a thin 0.5 inch (1.3 cm) thick layer of humus on the rocks. The soil was deeper in the grikes and here Mercurialis perennis and Rubus spp. dominated. The wood was heavily thinned and in two months the bryophyte cover and the associated humus on the rocks had completely disappeared, and the grike vegetation had greatly diminished. The loss of the humus and bryophytes appeared to be due to drying out of the thin humus and subsequent erosion. It indicates the need for opening the canopy cautiously on such sites if the ground flora is to be preserved. It will be of interest to see how rapidly this limestone ground flora is restored.

EFFECT OF COPPICING

Coppice woodland is of high conservation value and often contains a great variety of flora and fauna. There is little in the literature about the effects of this management system apart from the observation of Adamson (1911) in the oak/aspen/ash/hazel coppice woodlands of Cambridgeshire, and Salisbury's (1916) work on the oak-hornbeam woods of Hertfordshire in the second decade of this century. They found that before felling the soil beneath the coppice canopy was sparsely populated. After cutting, the temperature of the partly bare soil increased, and there was an invasion by light demanding species, thereby increasing the diversity. As the canopy closed, the shade bearers again dominated the ground flora. An outstanding feature of the coppice system is that the ground flora and forest floor are exposed to both shade and full daylight at short intervals i.e. at the frequency of the coppice rotation of 10-15 years. We still do not know a great deal about how the coppice cycle influences the flora, the fauna, or the soil in quantitative terms, and until we know more it will be difficult to manage these sites to the greatest advantage.

THE EFFECTS OF BURNING

In Britain controlled burning is used as a silvicultural tool to a certain extent for the disposal of slash, or the burning of rank heather prior to ploughing to avoid turf spring back. It is more widely used at the forest margins as muirburn for the improvement of hill pastures and has been responsible for the destruction of a great deal of marginal natural regeneration in the indigenous pinewoods, thereby preventing lateral spread of the trees (Steven & Carlisle 1959). Accidental fires have, of course, caused widespread destruction. Fires can be beneficial and there is good evidence (Steven & Carlisle 1959) that a great deal of the past successful regeneration of the indigenous Scots pine woods in Scotland has followed catastrophic fires, provided a few seed trees were left. In Scandinavia the burning of sites in the far north where the decomposition of mats of raw humus is very slow improved site quality (Spurr 1964).

The burning of woody vegetation (and the associated litter) has three main effects:-

(a) a loss of carbon, nitrogen and sulphur in gaseous form (Allen 1964; Alway & McMiller 1933);

(b) the production of ash containing soluble bases such as potassium, calcium and magnesium (Allen 1964; Fuller et al 1955; Finn 1943).

(c) the alteration of the physical structure of the soil, particularly in the properties of aggregates and the associated infiltration capacity in the surface horizons (Fuller et al 1955; Spurr 1964).

The losses of carbon, nitrogen and sulphur are to a certain extent replaced from the atmosphere by plant assimilation, nitrogen fixation and precipitation. The nitrogen loss could be serious if the N-fixing activity of the soils is low. The production of soluble bases can be beneficial to the trees provided the soil has the cation exchange capacity and base saturation deficit to keep the bases in the system. On freely drained soils of low exchange capacity there is a danger of loss by leaching (Finn 1943). The main change in the soil is the destruction of the organic matter at the surface, and the breakdown of soil aggregates, first by fire and then by the rain, followed by a clogging of the soil pores at the surface and reduction in infiltration capacity. On slopes this will result in an increase in surface run-off, and the surface erosion of the base rich ash on the surface. There are exceptions, and Tarrant (1956a, b) found that burning pine areas was not necessarily detrimental to the infiltration capacity. There is also some evidence that heat diminishes the ion exchange capacity of soil, at least in laboratory conditions (Rotini et al 1963). On some mineral soils, a heavy clay for example, the soil is baked hard and the micro-organisms are destroyed, and the effects appear at first to be very severe. Usually, however, the mineral soil recovers. The most severe destruction is where there is a great deal of organic matter, for example, coniferous woodlands with mor humus or afforested peat bogs. In this country there have been few instances so far of extensive catastrophic fires in forests on peat bogs but afforestation of these areas is increasing. In America and Canada, however, the burning of drained peat bogs after dry seasons has caused great destruction by removal of the soil. This is perhaps, something we have yet to contend with. Where a forest is growing on a thin layer of humus over rock, the destruction of this humus completely eliminates the soil leaving the bare rock. Very hot fires may burn off the organic horizons of the soil, but they do not influence the mineral soil temperature to any great depth e.g. at about one inch depth the soil will be at or below the boiling point of water, with the temperature decreasing rapidly further down, (Fuller et al 1955; Spurr 1964; Tarrant 1956a, b; Alway & Rost 1927; Alway & McMiller 1933; Finn 1943; Burns 1952; Fowells & Stephenson 1934).

It is impossible to generalise about the effects of fire on vegetation and the plant succession which follows. This depends upon the available seed, soil, climate, and many factors. There is, however, a tendency for species with light seeds to move in from the surrounding undamaged areas, and for an initial success of rhizomatous species and other species with perennial root systems, or species which need heat to break seed dormancy. In America, it was found that legumes tend to move in and help to offset nitrogen losses by their N-fixation properties (Spurr 1964).

Fire tends to favour, in many places, vegetation with foliage of low nutrient content, low palatability for the soil mesofauna and a tendency to slow litter decomposition. Examples are the Ericaceae and the effects of these combined with grazing and deforestation upon the soil have been discussed by Dimbleby (1962).

Fire is an important factor in the 'natural' selection of tree species, the species with relatively thick bark being able to withstand quite severe ground fires when thin barked species are destroyed. The classic example is the Californian Redwood which partly owes its longevity to its ability to withstand fires. In Britain the authors have observed fire exercising its selective powers both by species and age of tree. In rather open mixed oak and birch woods inflammable bracken, Pteridium aquilinum tends to invade and ground fires occur killing the birch and leaving the oak. This was seen at Glen Garry in Inverness-shire. The selection by age sometimes occurs in uneven aged pinewoods. At an age of about 20-50 years old, Scots pine usually have thick fissured basal bark while older trees often have thinner, eroded, plated bark. A severe ground fire sometimes kills the older trees (as well as the very young regeneration) and leaves the 20-50 years trees relatively undamaged (Steven & Carlisle 1959).

We still know very little about the effects of fire on the soil and its influence upon plant succession in British conditions. If we knew more about how to control burning and its effects on the vegetation and soil, it could be a valuable tool in the regeneration of the pinewoods. In the present state of our knowledge it would be folly to use it.

THE EFFECTS OF GRAZING

The evidence in the literature about the influence of grazing large herbivores upon the fertility of woodland soils is conflicting. On some sites grazing reduces soil fertility (Leaf 1958) and on others the manuring action of the animals increases the organic matter and available potassium in the upper soil horizons. The effect depends upon the type of animal, soil and grazing regime. There is one case of tree (Douglas Fir) increment being improved by grazing (Hedrick & Keniston 1966), but this may be a short-term effect. The physical effects are, however, clearer. Intensive grazing tends to break down surface mineral soil aggregates, reduce the surface pore space and decrease infiltration capacity and surface soil aeration. The activity of soil organisms is reduced, and there is a risk of increased surface run-off with associated erosion and flash flooding (Spurr 1964). These dangers are less where the mineral soil is covered in a thick layer of litter and humus, but unfortunately the best grazing is on soils with surface organic matter of the mull or moder type where risks of compaction are greatest.

Grazing herbivores naturally select the most palatable species and, as Spurr (1964) points out, this tends to leave unpalatable species which generally have a relatively low nutrient content. The litter of these plants does not readily decompose, and the activity of the soil organisms diminishes. The grazing also favours species which can tolerate it and this reduces the diversity of the ground flora. Where grazing is intense, a short, tight sward of grasses is produced and regeneration of trees has little chance to become established. There is the added risk of litter being easily blown off these sites, with a resultant loss of nutrients.

If grazing is excluded from a previously grazed site, a more luxuriant and diverse ground flora usually develops within a few years if there is enough light. Regeneration of trees is not always as successful as one expects in these areas, possibly due to increased competition and the increase in small mammals. We know less about how long it takes for reversion to the pre-grazed condition (if ever).

If the policy of grazing in woodlands is adopted, it is essential that these effects are studied so that the grazing regime can be manipulated to ensure that it is not to the permanent, irreversible detriment of the site. A great deal of past destruction of woodland in Britain and elsewhere can be attributed to grazing (Ellenberg 1954; Pearsall 1934; Dimbleby 1962). It is hoped that we shall leave a better legacy.

THE LEGACY OF THE PAST

There is good evidence that a great many of the upland soils of Britain began to deteriorate about Bronze Age times when the activities of man (deforestation, burning and grazing) began to make an appreciable impact. The large areas of heaths with heavily leached podsols, acid humus and low fertility are the end product of centuries of land misuse (Dimbleby 1962, 1965). From the 16th to 18th century, the forests in Britain were being devastated repeatedly to produce charcoal. In 1613, for example, 180,000 tons of iron were smelted per annum in Britain (Fell 1908) and this would require about 3.6 million tons of trees for the charcoal or 90 million hoppus feet. This is four times the current annual fellings of the Forestry Commission in Britain. The timber drain was tremendous and was concentrated in the iron industry centres such as in the Lake District, the Sussex Weald and the Severn Valley. By the early 18th century the southern Lake District was almost treeless apart from scrub (Fell 1908); it is not surprising that the oak woods of this locality are degenerate.

Some of the infertile soils are reclaimable by manipulation of the tree cover; others may be beyond redemption. To quote Dimbleby (1962): "We must recognize that our bank account of soil fertility is heavily overdrawn and only some form of repayment stands between us and bankruptcy. It is a debt that has been incurred for us by many previous generations, but if we wish to preserve the land, let alone use it, we must make some effort to discharge this debt .....".

This view is supported by the report of the Sixth World Forestry Congress Technical Committee on Forest Influences (W.F.C. 1966) which states: "The Congress recognized that forests have a distinct effect on soil characteristics and formation .... there is an urgent need for further intensified research in this field, especially where natural forests are replaced by monocultures of exotic species".

This applies just as much to the flora and fauna as to the soil. An understanding of the influences of forest practices and other forms of land use is not just an academic exercise; it is a condition for human survival.

SUMMARY

The effects upon the soil, flora and fauna of planting different types of tree cover and replacing the indigenous broad-leaved woodlands with conifers are discussed.

Soils can be degraded by a tree cover tending to accelerate podsolisation or improved by trees which lift nutrients from lower to upper horizons and stimulate soil micro-organism activity. The lack of knowledge of the processes involved prevents the most effective use of trees as a tool for reclamation of large areas of degraded soils and maintenance of fertility of marginal soils. For economic reasons the increase of coniferous plantations on relatively infertile soils is inevitable, but it is essential that the associated changes in soil, flora and fauna should be monitored. A major problem is what proportion and pattern of indigenous tree species should be included within large areas of conifers to maintain the biological potential of the site.

Increases in soil fertility following felling are frequently temporary. Subsequent increases in the ground flora may lead to increased competition and small mammal populations which may offset the advantage of the additional light to the young trees. Extraction of forest produce means a loss of nutrients. These may be replaced by rainfall and weathering in a long rotation system. Under a short rotation system such as coppice there could be a net nutrient loss.

The burning of slash or vegetation prior to ploughing as well as accidental fires, results in carbon, nitrogen and sulphur losses which can largely be replaced by assimilation, N-fixation and rainfall except on soils of low N-fixing ability. Ash rich in soluble bases is produced which may be valuable to plants, but on steep slopes the ash may be lost by surface erosion. Fire decreases soil infiltration capacity, thereby increasing dangers of flash flooding and erosion. Organic soils can be completely destroyed by fire.

Woodland grazing generally results in a decline in soil fertility, infiltration capacity and aeration. Unpalatable species tend to be left and these produce litter which is not readily decomposed and tends to

accumulate. Large areas of degraded soils in Britain are due to indiscriminate use in the past. The investigation of the effects of forest practices and other forms of land use is vital if we are to leave a better legacy.

REFERENCES

ABATUROV, Y. D. 1961. The effect of pine and birch forests on soils of the southern Urals. Pochvovedeniye, 6, 47-54.

ADAMSON, R. S. 1911. An ecological study of a Cambridgeshire woodland. J. Linn. Soc. (Botany), 40, 339-87.

ALLEN, S. E. 1964. Chemical aspects of heather burning. J.appl.Ecol., 1, 347-67.

ALWAY, F. J. & ROST, C. O. 1927. Effect of forest fires upon the composition and productivity of the soil. Proc. 1st Int. Congr. Soil Sci. 1927, 3, 546-76.

ALWAY, F. J. & McMILLER, P. R. 1933. Inter-relationships of soil and forest cover on Star Island, Minnesota. Soil Sci., 36, 281-94.

BARNESCHI, L. 1966. Researches on the pedological influence of Douglas fir. 6th Wld. For. Congr. Madrid. C.T. 9/2.

BENNETT, H. H. 1939. Soil conservation. New York and London.

BLOOMFIELD, C. 1953a. A study of podsolisation. I. The mobilization of iron and aluminium by Scots pine needles. J. Soil Sci. 4, 5-16.

BLOOMFIELD, C. 1953b. A study of podsolisation. II. The mobilization of iron and aluminium by the leaves and bark of Agathis australis (Kauri). J. Soil Sci., 4, 17-23.

BLOOMFIELD, C. 1955. Leaf leachates as a factor in pedogenesis. J.Sci. Fd.Agric., 11, 641-51.

BLOOMFIELD, C. 1956. The solution-reduction of ferric oxide by aqueous leaf extracts. The role of certain constituents of the extracts. Proc. 6th Int. Congr. Soil Sci. 11.4, 427-32.

BLOOMFIELD, C. 1964. Organic matter and soil dynamics. Proc. 11th Easter Sch.agric.Sci.Univ.Nott., 257-66.

BOUDRU, M. 1937. Le boisement des fagnes et ses conséquences au point de vue piscicole. Pêche et Pisciculture, 48, 98-101, 122-5.

BURNS, P. Y. 1952. Effect of fire on forest soils in the pine barren region of New Jersey. Bull.Sch.For.Yale Univ., 57.

BURRICHTER, E. 1954. Regeneration von Heide - Podsolboden und die Entwicklung des Bodenkeimgehaltes in Abhangigkeit von der Bewaldung. Z.Pfl.Ernähr.Düng.Bodenk., 67, 150-63.

CAMPBELL, B. 1964. Birds and woodlands. Leafl.For.Commn. 47, 1-24.

CARLISLE, A., BROWN, A. H. F. & WHITE, E. J. 1966a. Nutrient cycles in a semi-natural oak, Quercus petraea woodland in a high rainfall area in north-western Britain. 6th Wld.For.Congr.Madrid. C.T. 3/36, 1-9.

CARLISLE, A., BROWN, A. H. F. & WHITE, E. J. 1966b. The organic matter and nutrient elements in the precipitation beneath a sessile oak, Quercus petraea canopy. J. Ecol., 59, 87-98.

CROCKER, R. L. & DICKSON, B. A. 1957. Soil development on the recessional moraines of the Herbert and Mendenhall glaciers, south eastern Alaska. J. Ecol., 45, 16.

DAVIES, R. I. 1960. Soil profile development under individual tree species. Welsh Soils Discussion Group, 1, 9-10.

DELFS, J. 1955. Die Neiderschlagszurückhaltung im Walde. Mitt. Arbkreis. Wald Wass., 2, 1-54.

DIMBLEBY, G. W. 1952a. The root sap of birch. Pl. Soil., 4, 141-53.

DIMBLEBY, G. W. 1952b. Soil regeneration on the north east Yorkshire moors. J. Ecol., 40, 331-41.

DIMBLEBY, G. W. 1962. The development of British heathlands and their soils. Oxford.

DIMBLEBY, G. W. 1965. Soils and vegetation history. Proc. N. Engl. Soils Disc. Grp., 2, 31-3.

DUCHAUFOUR, P. & BONNEAU, 1961. Evolution of soil of deciduous forest of terra fusca under plantations of Pseudotsuga douglasii about thirty years old. Revue for.Fr., 12, 793-9.

DURK, P. 1966. The influence of forest on the health of man. 6th Wld. For.Congr. Madrid C.T. 9/1.

ELLENBERG, H. 1954. Steppenheide und Waldweide. Erdkunde, 8, 188-94.

F.A.O. 1962. Forest influences. F.A.O. for.Forest Prod.Stud., 15.

FELL, A. 1908. The early iron industry of Furness and district. Ulverston.

FINN, R. F. 1943. The leaching of some plant nutrients following the burning of forest litter. Black Roack Forest Pap. 1, 128-34.

FISHER, R. T. 1928. Soil changes and silviculture in the Harvard Forest. Ecology, 9, 1-6.

FOWELLS, H. A. & STEPHENSON, R. E. 1934. The effect of burning on forest soils. Soil Sci. 38, 175-81.

FULLER, W. H., SHANNON, S. & BURGESS, P. S. 1955. Effect of burning on certain forest soils of northern Arizona. Forest Sci. 1, 44-50.

GARFITT, J. E. 1966. The edge effect. Forestry, 39, 189-90.

GENSSLER, H. 1959. Veränderungen von Boden und Vegetation nach generationsweisem Fichtenanbau. Thesis. Forstliche Fakultät, University of Göttingen.

GRIFFITH, B. G., HARTWELL, E. W. & SHAW, T. E. 1930. The evolution of soils as affected by the old field white pine - mixed hardwood succession in Central New England. Bull. Harv. Forest, 15, 1-82.

HANDLEY, W. R. C. 1954. Mull and mor formation in relation to forest soils. Bull. For. Commn. Lond. 23.

HEDRICK, D. W. & KENISTON, R. F. 1966. Grazing and Douglas fir growth in the Oregon white-oak type. J. For., 64, 734-8.

HUET, M. 1952. Nocivité des boisements en épiceas, Picea excelsa Link pour certains cour d'eau de l'Ardènne Belge. Bull.Soc.r.for.Belg., 59, 321-8.

HUGHES, J. F. 1949, 1950. The influence of forests on climate and water supply. For. Abstr., 11, 145-53, 283-92.

KING, H. G. C. & BLOOMFIELD, C. 1966. The reaction between water-soluble tree leaf constituents and ferric oxide in relation to podsolisation. J. Sci. Fd. Agric., 17, 39-43.

KITTREDGE, J. 1929. The importance of time and rate of change in forest soil investigations. Proc.Int.Congr.For.Expt.Stns. Stockholm, 479-84.

KITTREDGE, J. 1948. Forest influences. New York, Toronto and London.

LOSSAINT, P. 1959. Étude experimentale de la mobilisation du fer des sols sous l'influences des litières forestières. Thesis. University of Strasbourg.

LEAF, A. L. 1958. Effects of grazing on fertility of farm woodland soils in southern Wisconsin. J. For., 56, 138-9.

McCOMB, A. L. 1966. Forest influences. 6th Wld. For. Congr. Madrid. C.T. 9/NS/1.

MALCHANOV, A. A. 1963. The hydrological role of the forest. I.P.S. Transl. 870. Jerusalem.

MORK, E. 1942. Om strøfallet i vare skoger. Meddr. Skogsforsvaes., 29, 297-365.

NOIRFALISE, A. 1967. Forest management; ecological consequences of the intensive cultivation of resinous trees in the deciduous zone of temperate Europe. Council of Europe Publication Exp/Nat (66) 74, 1-18.

NYKVIST, N. 1961. Björken som markförbattrare. En jämförelse mellan björkförna och granforna. Svenska SkogsvFor Tidskr 3, 227-38.

OVINGTON, J. D. 1958a. Studies of the development of woodland conditions under different trees. 6. Soil sodium, potassium and phosphorus. J. Ecol., 46, 127-42.

OVINGTON, J. D. 1958b. Studies of the development of woodland conditions under different trees. 7. Soil clacium and magnesium. J. Ecol., 46, 391-405.

PEARSALL, W. H. 1934. Woodland destruction in northern Britain. Naturalist, Lond. 25-28.

POKHITON, P. P. 1958. The effect of various trees species on the soil. (Translation). Soviet Soil Sci. 630-4.

ROMELL, L. G. 1957. Soil activation. Proc.6th Tech.Meet.int.Un.Conserv. Nat.nat.Resour. 1956, 171-4.

ROMELL, L. G. 1957. Man-made 'nature' in northern lands. Proc. 6th Tech. Meet. int.Un.Conserv.Nat.nat.Resour. 1956, 51-3.

ROTINI, O. T., LOTTI, G. & BALDACCHI, 1963. Studies in the changes occurring in soils and clays heated at 50°C and 100°C. Agrochimica, 7, 289-95.

SALISBURY, E. J. 1916. The oak-hornbeam woods of Hertfordshire. I and II. J. Ecol., 4, 83-117.

SMITH, R. L. 1957. An evaluation of conifer plantations as a wildlife habitat. Diss.Abstr., 17, 465-6.

SPURR, S. H. 1964. Forest ecology. New York.

STEVEN, H. M. & CARLISLE, A. 1959. The native pinewoods of Scotland. Edinburgh.

STOREY, H. C. 1966. Forest ecological influences on climate, soil, water resources and man. 6th Wld.For.Congr.Madrid. C.T. 9/5.

TARRANT, R. F. 1956a. Changes in some physical soil properties after a prescribed burn in young ponderosa pine. J.For., 54, 439-41.

TARRANT, R. F. 1956b. Effects of slash burning on some physical soil properties. For.Sci., 2, 233-53.

TORKILDSEN, G. B. 1950. Om årsakene til granens dårlige gjenvekst i einstapedbestand. Blyttia, 160-4.

VAYCHIS, M. V. 1958. Influence of European larch on changes in sod-podsolic soils (Translation). Soviet Soil Sci. 480-7.

WORLD FORESTRY CONGRESS, MADRID 1966. Report of technical commission 9 (Forest influences). I.F.T.C. 9, 1-3.

ZINKE, P. J. & CROCKER, R. L. 1962. The influence of giant sequoia on soil properties. For.Sci., 8, 1-11.

ZINKE, P. J. 1962. The pattern of influence of individual forest trees on soil properties. Ecology, 43, 130-3.

SUMMARY OF DISCUSSION

In answer to a question about the contribution made by the droppings of insects to the nutrients in the ecosystem, it was said that much was dissolved by rainwater and although this source of nutrients influences the circulation in the system, it did not affect the total nutrients. The nutrients available in wind-blown dust were also referred to and it was said that much of the dust was caught by the canopy and washed off by rain.

THE HISTORY AND EFFECTS OF COPPICING AS A WOODLAND PRACTICE

O. Rackham
Botany School, University of Cambridge

Coppice, with or without standards, is a very ancient and widespread form of woodland management both in England and on the continent (e.g. Troup 1928). In this country it has greatly declined in the last few decades, although it is still a living tradition in such areas as Cranborne Chase. The subject of this paper is a small area to the west of Cambridge, in which commercial coppicing is extinct although the practice has been revived experimentally on a small scale. Many of the former coppice-woods, although abandoned, survive reasonably undamaged; a field survey of these woods, together with information from historical documents and from an early ecological study, makes it possible to reach some conclusions about the effects on the ecosystem of a long-continued method of management.

The area concerned (Fig. 1) contains about 25 ancient woods on the boulder clay; these are shown on the Ordnance Survey 1st ed. (1835) and on earlier parish and estate maps where available*. More recent woods and those on other substrata are not considered. In three instances (Hardwick, Hayley and Longstowe Home Woods) a combination of documentary and archaeological evidence enables us to establish, with some confidence, a continuous history of woodland on the site since the 13th century; Hayley, indeed, is probably alluded to in Domesday Book. Specific evidence earlier than about 1600 for the continuity of the other woods is at present lacking; but strong circumstantial evidence that many of them go back to the middle ages is provided by an analysis of the Hundred Rolls (<u>Rotuli Hundredorum</u> 1818), a detailed, though imperfectly preserved, national survey carried out in 1279. This records, inter alia, the extent (though not the location) of the woodland in each parish. Of the Cambridgeshire parishes which lie wholly or mainly on the boulder clay in this area and for which the complete entry exists, 11 out of 17 contained woodland in 1279; with only one exception these are the parishes which contain ancient woodland at the present day. Furthermore, there is a very strong correlation between the <u>areas</u> of wood in those parishes which had woods in 1279 and the corresponding areas at the present day (allowance being made where necessary for known and documented additions and subtractions). These correlations make it unlikely that there have been any major changes in the location of woods since the 13th century, but field study shows that some of them have encroached on adjacent arable or former habitations, as seen by ridge-and-furrow, earthworks etc. Such additions (of which those dating from the 19th and 20th centuries are shown in Fig. 1) are usually quite small, but a few woods (such as Buff and Madingley) have only a small core which does not show signs of clearance.

*The earliest maps so far discovered are the Boxworth Estate Map (1650) which shows the Boxworth Woods and Overhall Grove, and the Gamlingay Estate Map (1601) which shows Gamlingay Wood and corners of Potton and Cockayne Hatley Woods.

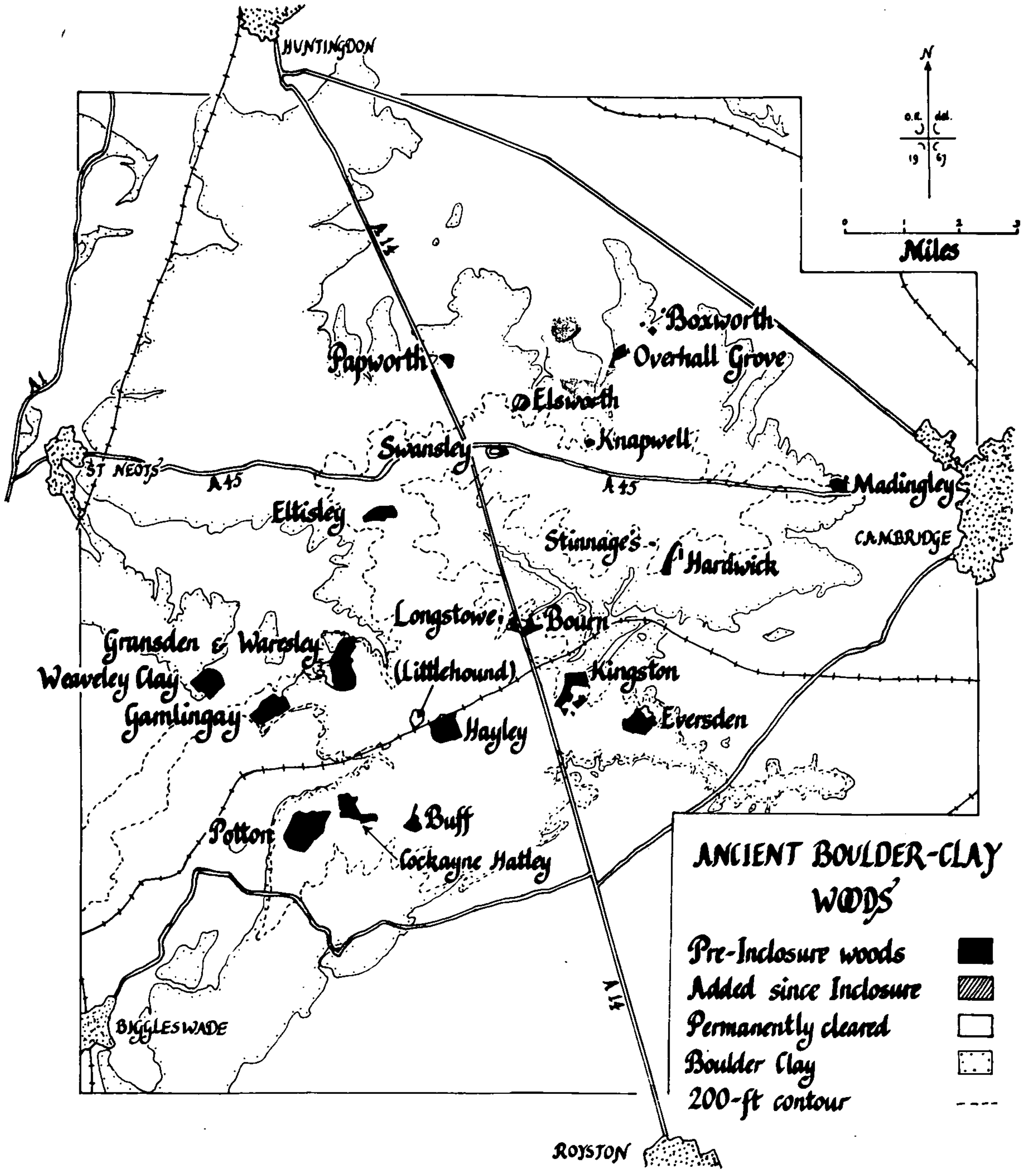


Figure 1. Location and extent of the ancient woods on the boulder-clay of west Cambridgeshire and the adjoining counties.

The Great Chalky Boulder-clay on which the woods lie is up to 200 feet thick (Sparks & West 1965) and forms a gently undulating plateau with flat hill-tops. The soils are badly drained, shallow, difficult to plough and moreover deficient in phosphate. Nonetheless, it is clear from Domesday Book that by the Norman Conquest almost the entire district had been converted to farmland and the area of woodland (Darby 1950) cannot have been much greater than the 2 per cent. which the ancient woods now cover, and could even have been less. Throughout the middle ages, the district supported a large population (Smith 1965) which presumably depended on this 2 per cent. of woodland for most of its requirement of fuel, fencing, and building timber. Timber was even sent out of the district, as shown by the Hardwick Estate Papers. Consequently, although part of the ancient woodlands may well be primary in the sense that there has been nothing but woodland on the site in historic times, their present state is certainly the result of centuries of intensive management.

These woods have at present a three-storeyed structure with trees of the following types:

1. Standards, mainly oak, Quercus robur, sometimes with ash, Fraxinus excelsior and maple, Acer campestre.

2. Large coppice, consisting of ash and maple. The ash is usually cut on a stool about 2 to 3 feet high (the height varies from wood to wood) and the maple near the ground. The poles are large and seldom number more than 8 per stool. Large ash stools are very characteristic of the old woods.

3. Small coppice, consisting of hazel, Corylus avellana and hawthorn, mainly Crataegus oxyacanthoides.

Woods with this structure are frequent in lowland England ranging at least from Monks Wood, Huntingdonshire, to Asham Wood, east Somerset. Elms are frequent but their place in the woodland structure and management is at present little understood; they seem to have increased greatly in the last hundred years.

HISTORY OF COPPICING

Coppicing is a very ancient practice. There are several references to silua minuta in Domesday Book, particularly in Huntingdonshire; this presumably means a simple coppice without standards. The earliest detailed record of coppice with standards in the district is for Hardwick Wood. We know from the Old Coucher Book of Ely, a survey of the Bishop of Ely's estates carried out in 1251 (date established by Miller (1951)), that coppicing and hurdle-making went on in Hardwick Wood at that time. The account rolls and other documents of the manor from about 1340 onwards are preserved in Pembroke College, Cambridge (Hardwick Estate Papers) and enable us to reconstruct the medieval system of management. Hardwick, unfortunately, is not altogether a typical wood: at that time it was very small, about 20 acres, and at present (and probably also in the middle ages, as suggested by the records) it has very little large coppice. Hayley Wood, like Hardwick, belonged to the Bishops of Ely, and (together with the long-extinct Littlehound Wood) is referred to in similar terms in the Old Coucher Book which mentions that the manorial tenants had substantial rights to coppice material, but - alas - the main body of documents relating to it cannot now be traced, though we have scattered and tantalizing allusions to coppicing* and sales of timber from it in other sources.

A fairly complete series of annual accounts exists for the manor of Hardwick in the later middle ages, and the entries relating to the wood are summarized in Fig. 2. Management was evidently very irregular both as regards the coppice and the standards. The latter are not recorded as having been felled in small quantities from time to time whenever there was a demand for heavy timber in the village. Instead, in 8 years around 1380, at least 500 oaks were cut down and sent away to the Bishop's estates in the Isle of Ely, apparently for farm improvement projects. Although the density of oaks can easily exceed 30 to the acre, this cannot have been far short of a clear felling and it is 70 years before we hear of any more oaks being felled. There is no more constancy in the annual sales of coppice, which range from $8\frac{1}{2}$ acres in one year (over a third of the wood) to none in three successive years. The coppicing cycle was certainly short. The average annual sale in the 14th century was about $3\frac{1}{2}$ acres, giving a rotation of 6-7 years**. Indeed, around 1370, at least 25 acres were cut in five years, so that some of the wood was probably cut twice in that period. These figures probably do not take account of coppice cut by certain villagers who had common rights in the wood, which would add $1\frac{3}{4}$ acres to the annual cut, reducing the rotation to perhaps only four years***.

* In 1411-12, a year in which no coppice was sold in Hardwick, a payment is recorded for coppice cut "in bosco domini de Heylee" (Hardwick Estate Papers).

** These calculations are based on the area of $21\frac{1}{2}$ acres given for the wood in the Old Coucher Book which is the only direct statement of its size in the middle ages. Its greatest possible area (in terms of modern acres) was 28 acres; this is defined by parish boundaries on three sides and a field (explicitly described in the Old Coucher Book) on the fourth. Its least possible area was 18 acres; this excludes three clearings (made at some time prior to 1600) which formerly existed on the west side of the wood. It has seemed best to accept the medieval measurement as it stands; this reduces the likelihood of certain errors which may arise when medieval measurements are compared with modern (for instance, from variations in the size of the acre, or from an apparently consistent tendency of medieval surveyors to underestimate the areas of woods).

***The annual coppice right is defined in the Old Coucher Book as "unum fasculum clausture" (one bundle of fencing, i.e. material for making hurdles). By the 16th century, <u>v. infra</u> it is referred to as "one Ringe of Woode" enjoyed by each of "ffowerteene Copieholders", the "Ringe" being laid down as 1/8 acre, for which a nominal 8d. was paid.

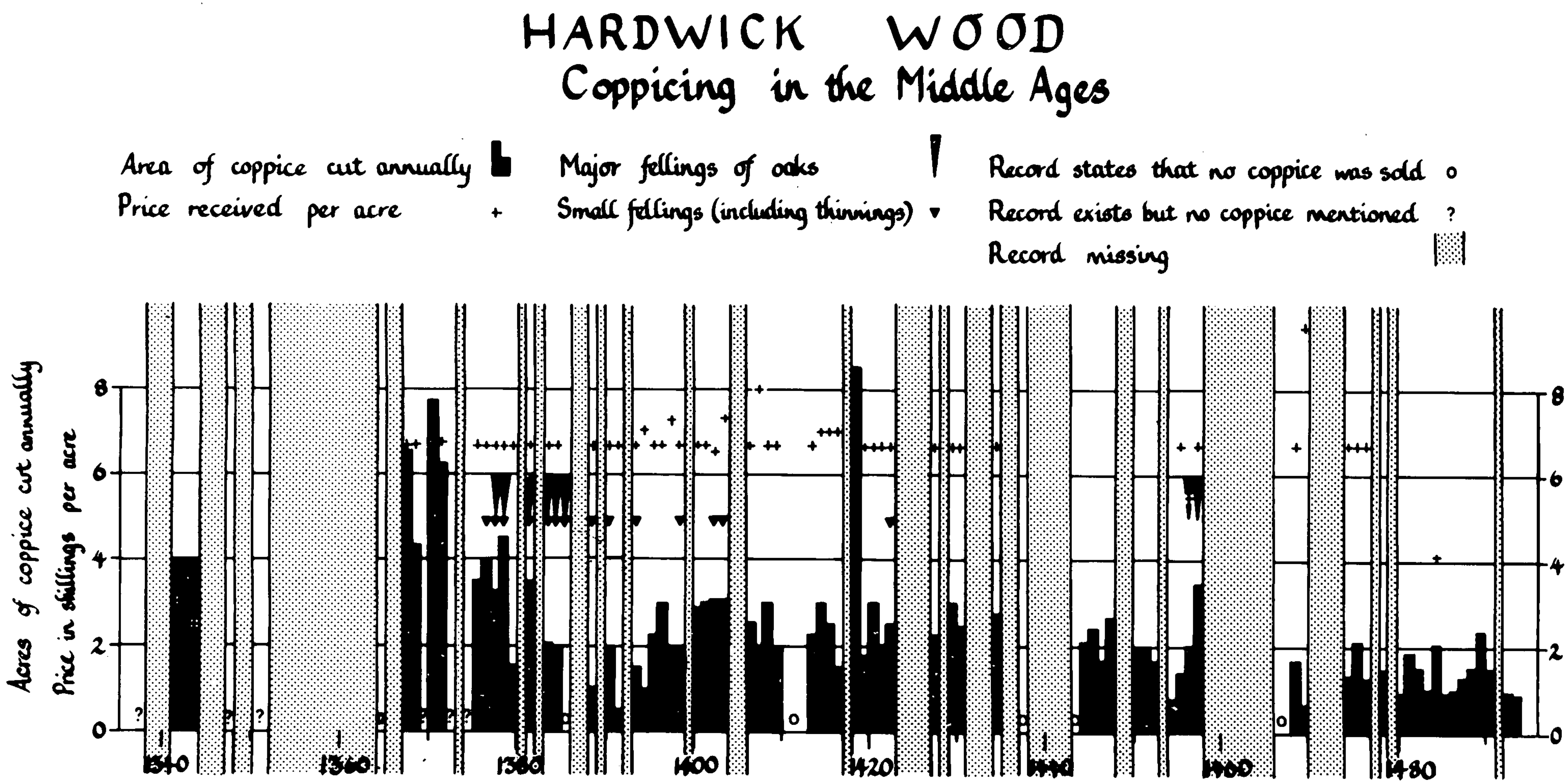


Figure 2. Quantities of coppice sold yearly from Hardwick Wood during the latter middle ages. The price received per acre and the years in which oaks were felled, are added. The information is derived from the annual accounts of the manor, of which the wood formed only a small part, so that the missing records do not necessarily imply that no coppice was sold in those years. The existence of a record in which no coppice is mentioned probably does imply that no income was received from this source.

During the 15th century, the annual sale was gradually reduced to an average of $1\frac{1}{2}$ acres, giving a maximum rotation of around 14 years or (if, as is more likely, we have to add the commoners' coppice) 6-7 years.

Few of the Hardwick records of the early 16th century can be traced. For the latter part, we are fortunate enough to have a well-documented lawsuit. In 1587 the villagers took proceedings in the Court of Exchequer against one Sir Francis Hynde of Madingley who, they claimed, "by collor of a pretensed graunt" of the wood, had "cutt down spoyled and Carryed awaye the most parte of the same wood their growinge", and had tried to deprive the plaintiffs of their immemorial coppice rights*. The court adopted the recommendation of a Royal Commission of Inquiry which had attempted to discover what the commoners' rights were. The wood was to be coppiced on a seven-year rotation, each of the 14 commoners having 1/8 acre annually, "the staddles (i.e. standards) to the Lord alwaies reserved". This settlement was continued well into the 17th century; the 7-year rotation gave the commoners the right to coppice most of the wood, but the Hardwick Estate Papers contain entries for small amounts of coppice sold outside the manor. Standard timber was also sold, apparently in small quantities frequently rather than by an occasional clear felling. From 1660 onwards the records become scanty, but the coppice rights continued to be claimed, and their holders were compensated at the parliamentary inclosure of 1837.

Hardwick Wood, as we have seen consists almost entirely of standards and small coppice. There is very little historical evidence on the cutting of large coppice. A rotation of 14 years is frequently assumed, and the modern coppicing plans for Buff and Hayley Woods are based on it, but there is a lack of evidence that it ever was the procedure in this area. Gooch (1811) says that in the boulder-clay woods of east Cambridgeshire the coppice was cut at 12-13 years. Adamson (1912) speaks of a rotation of about 18 years in Gamlingay Wood in his day and the very scanty stump evidence for Hayley suggests about 17 years; but it would be unwise to put much weight on figures from the end of the time of economic coppicing, as the rotation may well have been lengthened as the practice became uneconomic. One would expect the ash and maple to have a longer optimum rotation than the hazel and there is no reason why they should all have been cut at the same time.

The purpose of the Hardwick coppice rights is said to have been to provide the commoners with fuel and fencing. These were probably the main uses of small coppice though much must have been used in building** and thatching. Large coppice poles must have been used for

* It should perhaps be mentioned that the second stage of the Madingley Hall building bears the date 1589 (Pevsner 1954).

**Wattle and daub is the usual material for the panels of frame buildings in the district until c. 1600 or later.

fencing stakes and the frames of buildings as well as for tools and farm implements. The reasons for the decline of coppicing lie partly in the introduction of alternative materials. Its final extinction probably comes from the fact that it is a skilled and underpaid craft which men will not take up. Furthermore, although there is a revival of demand for coppice products (such as hurdles and pea-sticks), the replacement of horses by tractors has made it difficult and expensive to extract anything from these very wet woods. It appears from ring-counts that Hayley was last fully coppiced in the 1890's though some cutting was done in the early 1920's. Small areas of Potton Wood have been coppiced commercially in the last few years.

EFFECTS OF COPPICING ON THE ENVIRONMENT

Microclimate

Most ecological writers on coppicing (e.g. Adamson 1912, Tansley 1939) refer to the great increase of light on the woodland floor after cutting and the gradual decrease as the coppice grows up again. This alternation is held to be a main factor in the characteristic flora of boulder-clay woods with a high proportion of species which, although shade-tolerant, respond quickly to increased light. The effects on light will not be discussed further here: although they can easily be seen in qualitative terms, a complete quantitative analysis would be extremely difficult to carry out. The problems of making useful measurements of light in woods are discussed by Coombe (1957, 1966), Evans & Coombe (1959), Anderson (1964) and Evans (1966). Briefly, one has to take into account not only changes in the total light but also variation over the day and over the year, the proportion which comes as direct sunlight as against diffuse light and the spectral composition. These variables will depend on the density and species composition of the canopy as well as the coppice.

After about 30 years a neglected coppice wood such as Hayley starts to open out again. This can be seen by comparing Hayley with Eversden which was clear-felled in 1941 and then left (Nature Reserves 1965). This will be referred to later.

Besides light, coppicing affects the temperature and humidity of the air, and also wind. A study of these factors has recently begun in Hayley. A difficulty is that important effects on plants may well come, not from changes in the average microclimate, but from short periods of extremes. Humidity for instance fluctuates during the day in an irregular manner which probably results from gusts of wind bringing down eddies of drier air from above into the lower layers of the wood. Another factor which might be changed by coppicing is the incidence of combinations of intense radiation from a sun-fleck, high humidity, and low wind. In these circumstances a leaf can overheat by several degrees (Fig. 3). At some stages in the coppicing cycle, such combinations could lead to damage to the ground vegetation from high temperatures or excessive transpiration, especially with the shade forms of leaves.

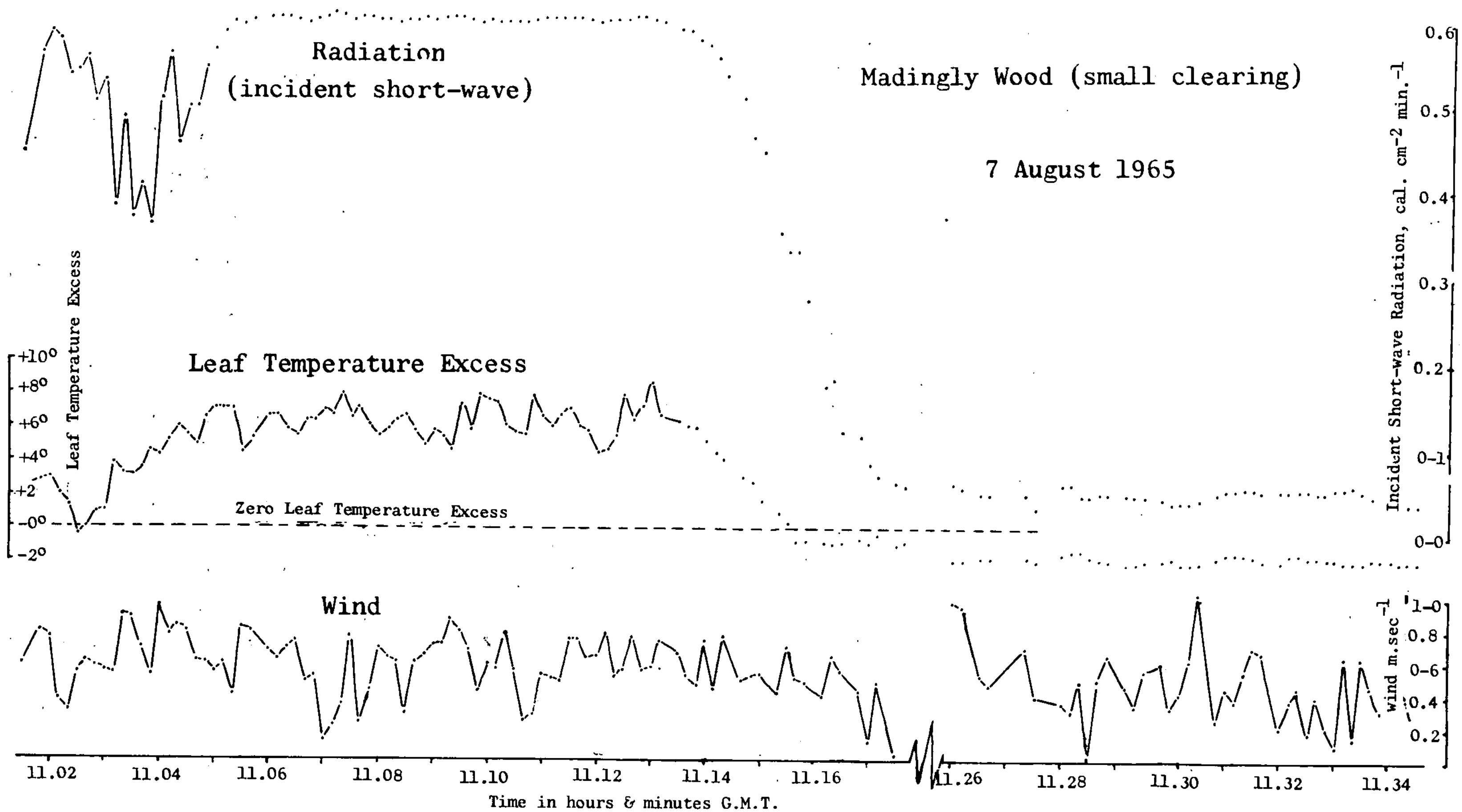


Figure 3. Variation with time of excess of leaf temperature over air temperature, incident short-wave radiation (i.e. visible light plus near-infra-red radiation up to 3 wavelength), and wind. Measured on <u>Impatiens parviflora</u> in Madingley Wood. The first part of the record shows the effects of a large sunfleck in which the leaf went as high as 9°C above air temperature during brief lulls in the wind; measurements made in shade some 10 minutes later are given for comparison to show that in "normal" circumstances the leaf temperature is fairly steady at around 2°C <u>below</u> air temperature.

There is a lag on the graph of some 45 sec. between changes in leaf temperature excess and the corresponding changes in radiation. This is because the radiometer could not be put in exactly the same place as the leaf, and it happened that at this time of day the shadow of an object in the tree canopy passed over the leaf 45 sec. before reaching the radiometer.

Lines joining points in the graph have been inserted for convenience whenever a variable is fluctuating, and have no significance.

Details of instruments, and a physiological analysis of the phenomenon will be published elsewhere.

Soil

Effects on the soil, unlike those on the microclimate, can be cumulative as well as cyclic.

Coppicing operations, especially in a wet winter, damage the soil structure of these woods by trampling and puddling of the clay. Most of the woods have very wet areas which are responsible in part for the continued existence of the woods by making the sites difficult to convert into farmland; this condition could well have been aggravated by centuries of treading by men and horses.

During the modern coppicing in Hayley Wood, it has been necessary to burn large quantities of unsaleable material. The effects of bonfires, though local, persist for several years; in the past they were probably unimportant because every scrap of material was used or given to the poor*.

Perhaps the most important cumulative effect of coppicing, however, is the depletion of nutrients, especially phosphate which is in short supply in boulder-clay soils. One of the main ecological functions of man in boulder-clay areas is as a collector of phosphate, which he gathers together by farming operations from the countryside as a whole and stores in small areas such as farmyards, rubbish tips, back gardens, and churchyards. Coppicing is no exception to this process. The main species involved, ash and hazel, have a higher phosphate content than any other woodland trees (Ebermayer 1882); the coppice was cut young when the proportion of twigs and bark, which have a higher phosphate content than timber, was high; and the whole of the material was removed so that little or none of this phosphate can have found its way back to the soil. As there is apparently no means of replenishing significant quantities of this phosphate except by weathering of the boulder-clay itself, it is possible that the present shortage of phosphate in these woods and the corresponding infrequency of phosphate-demanding plants in their ground flora may result in part from long-continued coppicing. It is hoped in the next few months to gain precise information on the size of this effect, but a few very rough figures will now be presented in order to show that it is worth investigating. The total phosphate content (as P_2O_5) in the top foot (this being roughly the rooting depth in the wetter

*The Hardwick Estate Papers record that, when oaks were being felled in the 14th Century, considerable sums were received "pro loppio & chippio".

parts of these woods) of woodland soil is at present about 5,000 lb $acre^{-1}$*. The annual accumulation of phosphate by short-rotation coppice is of the order of 4 lb $acre^{-1}$**. Hence the phosphate now remaining within reach of the plant community, assuming that the non-available fraction became available at a sufficient rate, would be completely exhausted by further coppicing in rather more than a millennium. Since coppicing has in fact gone on for at least 700 years and probably longer, it is very likely that noticeable depletion has already occurred in this way and possible that the flora has been changed thereby.

EFFECTS OF COPPICING ON THE GROUND VEGETATION

Evidence for the immediate effects of coppicing on the ground vegetation in these woods comes from three sources:

1. The published account of Gamlingay Wood by Adamson (1912) which includes its behaviour under long-rotation coppicing.

2. The experimental coppicing of Buff Wood by Cambridge University Botanical Garden at the rate of 3-4 acres every other year since 1955. This departs from the traditional practice in that the coppice is cut in the summer (instead of the winter) and left to rot on the site.

3. The experimental coppicing of Hayley Wood by the Cambridgeshire and Isle of Ely Naturalists' Trust at the rate of one acre annually since 1964. The work is done in approximately the traditional way except that much of the material is piled up and burnt.

The results of the Hayley coppicing, for which rather fuller information is available, will be summarized and compared with what is known from other sources.

The ground vegetation of these woods has been intensively studied by Adamson and later workers. In the case of Hayley, its geographical

* This figure is based on analyses for Gamlingay Wood (Adamson 1912) and for Hayley and Buff Woods (unpublished figures kindly supplied by C. D. Pigott).

**This is based on production figures for a possible comparable coppice near Bury St. Edmund's (Forestry Commission 1956), and on the phosphate content of hazel and ash in north east France (Henry 1908). Leaves are of course omitted.

HAYLEY WOOD: GROUND VEGETATION IN 1966

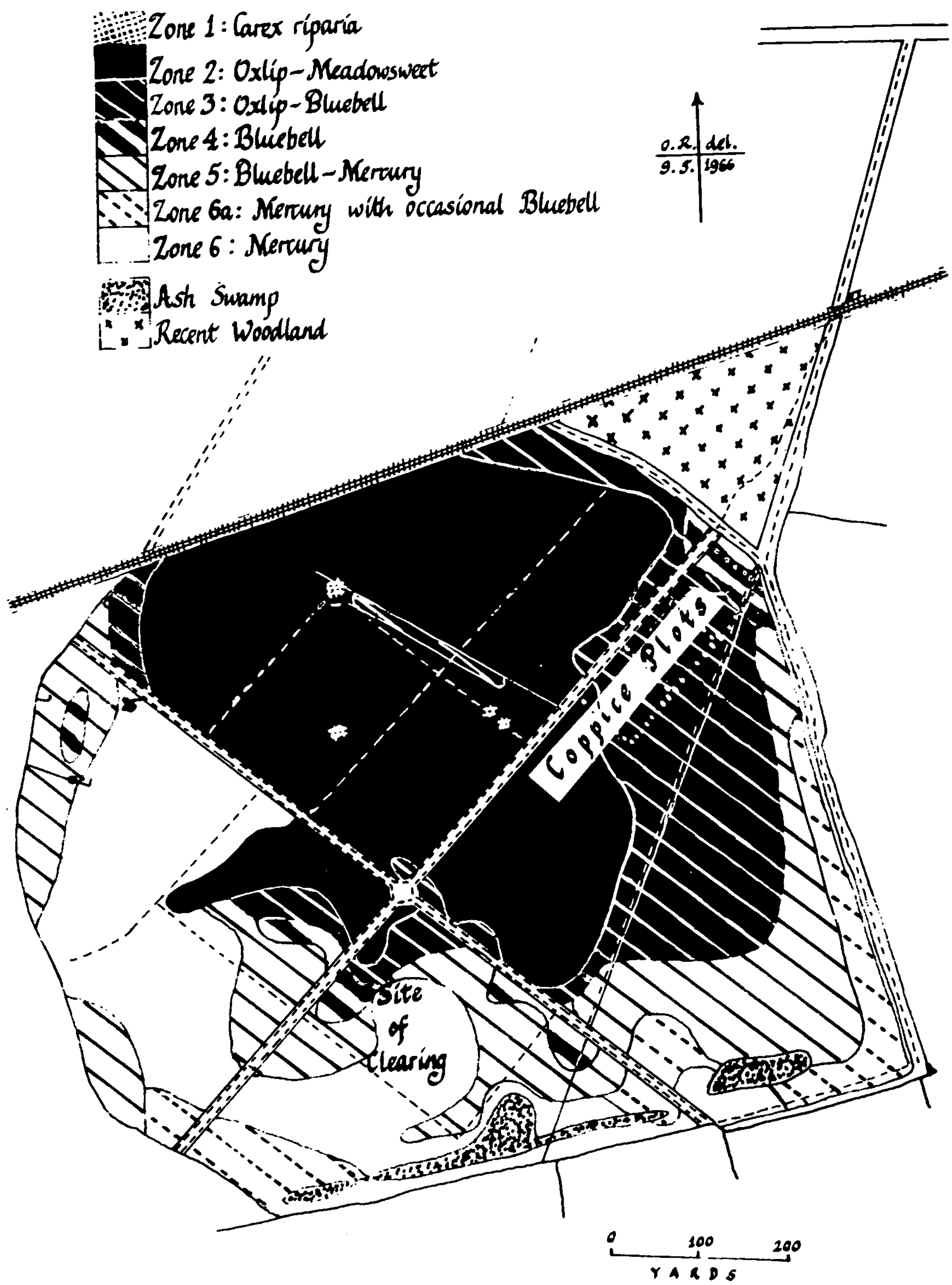


Figure 4. Distribution of the main ground vegetation types in Hayley Wood. The zones are given in terms of their commonest dominants, and are often modified in response to varying shade and other factors.

A more complete description will be published in the forthcoming Guide to Hayley Wood.

distribution is particularly elegant and can be described in terms of a zonation (Fig. 4). Zone 2, which occupies the middle and north, is on an almost level plateau and has the ground cover dominated by the oxlip, Primula elatior, in the more densely shaded parts; where the shade is less, oxlips are abundant but the dominant is the meadowsweet, Filipendula ulmaria. Zone 6 which occupies a sloping fringe is a continuous carpet of dog's mercury, Mercurialis perennis, and is poor in other species. The intermediate zones contain varying proportions of bluebells, Endymion nonscriptus, and other species, Zone 3 being the richest. Similar zones are found in most of the other woods; in some, such as Buff and Gamlingay, Zone 3 is characterized by primroses, Primula vulgaris. The zones are determined mainly by the degree and duration of waterlogging (Pigott & Martin 1964).

The coppice plots were laid down adjacent to one another, starting in Zone 3 and proceeding into Zone 2. The early stages in a mercury area can be studied in a permanent clearing in Zone 6 which has been gradually extended since it was begun in 1965.

The immediate damage is most serious for mercury which immediately and almost completely disappeared after clearing. This is probably because of excessive trampling. In 70 years since the last coppicing and on a well-drained site, the ash had grown to sizeable trees, and it was necessary for logs weighing up to half a ton to be man-handled by inexperienced workers. After a normal rotation, the damage would be much less, expecially with skilled workers, and it is likely that enough mercury would be left to re-establish a continuous carpet. Adamson says of mercury areas: "after cutting Rubus caesius tends to over-run the area for a time", and this shows signs of happening in Hayley.

In the oxlip zones, coppicing does less immediate damage, especially as the volume of timber involved is much less. The oxlip itself is a very resistant plant - at Eltisley Wood it has even survived clear-felling and replanting - and even in a wet winter the reduction in the density of plants, though noticeable, is not large. Bluebells usually emerge towards the end of the annual coppicing operation and thus escape the worst of the treading and are not greatly reduced.

Attention has often been drawn to the appearance, in the first two years after coppicing, of ruderal species from outside the wood on the bare ground among existing vegetation. For instance, Ray (1660) refers to Chenopodium polyspermum "in Kingston wood after it had been new felled". Several such plants have been seen in Hayley. In the wet coppice, Anagallis arvensis and the inevitable Chamaenerion angustifolium appeared, together with the unexpected Oxalis acetosella (a very rare plant in the district). An interesting phenomenon is the appearance of rings of Cirsium arvense from seed around bonfire sites.

Apart from these other effects, the most obvious effect of coppicing, according to the literature, and indeed the main reason for reviving the practice in the management of woodland reserves, is the increase in the small herbs which is said to take place in the second and third years as a result, we are told, of the sudden increase of light. This has to some extent been borne out at Hayley. Such plants as the oxlip, bluebell and Ajuga reptans, which flower before the tree canopy is complete in the spring but go on photosynthesizing afterwards, have increased in numbers and in cover. The increase has not been a dramatic one. The reason is probably the great increase in tall herbs which is appreciable even in the first year, very marked in the second, and continues into the third year. Some of these are species already there such as Filipendula ulmaria and Cirsium palustre. Others, such as Arctium and Epilobium hirsutum probably became established from seed in the first year. After three years, they form a very impressive stand indeed, with Cirsium palustre reaching 9 feet high. There is often a dense under-storey of Juncus inflexus which comes up very abundantly from seed (of unknown origin) in the first and second years, together with Rubus caesius. For the oxlip and its associates, therefore, the summer shade of the coppice is replaced by a canopy of tall herbs whose dead remains may provide shade in the spring as well. This is probably also the main reason why coppicing makes no apparent difference to the suppressed ash saplings which are exceedingly numerous in uncut coppice.

These results are quite at variance with those described by Adamson at Gamlingay in which cutting was apparently followed by a greater increase in the vernal herbs and a much smaller increase in the tall herbs. The sequence at Buff Wood (insofar as information is available) has followed the Gamlingay pattern. In the permanent clearing in Hayley, the elimination of mercury has not been followed by the establishment of tall herbs, and there has been a marked increase in oxlips (which were already present in small numbers, but suffer severely from shading by mercury, as shown by Pigott & Martin (1964)).

Coppicing on the plateau in Hayley, therefore, has resulted in a community resembling a tall fen, instead of the expected stand of short herbs. It is too early to give definite reasons for this, but the two unusual factors in the situation are: (i) the wetness of the site; (ii) the cutting of a long over-mature coppice in which the canopy had opened out. These two factors apparently combined to produce a scattered, though quite large, population of light-demanding fen plants, such as Filipendula, in the uncoppiced wood. When the coppice was felled, these species were already there and could occupy the site within two years. In woods such as Eversden, which have been coppiced within the last 30 years, the density of tall herbs is much lower than in Hayley; if, as in Hardwick Wood, the site is also better-drained, the density is even less. In Buff Wood and the mercury areas of Hayley, the site appears to be too well-drained to support fen vegetation, while in Gamlingay in Adamson's time, the last coppicing was probably too recent for the canopy to have opened.

The balance between tall and short herbs will probably be shifted in favour of the latter as the regenerating coppice canopy closes in again. It may be that at least one coppicing cycle is needed before the ground-vegetation sequence returns to what it was in the days of regular coppicing.

ACKNOWLEDGEMENTS

I am most grateful to the County Archivists at Cambridge and Huntingdon, to those in charge of archives at Downing, Gonville and Caius, and Pembroke Colleges, and to the Keeper of the Ely Diocesan Registry Archives, who have kindly allowed me to use douments in their care. I also wish to thank land-owners who have permitted me to do field work in their woods.

I am indebted to many people for discussions and advice or for help in field work. I would mention particularly Mr. G. H. Rackham, who first suggested the historical side of this investigation, and also Dr. M. D. Hooper, Dr. M. H. Martin, Mr. W. H. Palmer, Professor C. D. Pigott, Dr. S. M. Walters, Dr. A. S. Watt, and Miss J. F. Wilson, all of whom have given help in some aspect of the work.

REFERENCES

Manuscript

Boxworth Estate Map: The Plott or Description of Boxworth in Cambrigsheire, being pt of the demeanes of the Lady Ann Cutts . . . by Mattheu: Haywarde: (1650). Huntingdon County Record Office.

Gamlingay Estate Map: The description of the mannor of the Mertonage and the Mannor of Avenelles . . . in the parishe of Gamlingay . . . 1601. Merton College Oxford, Record 6/17. (Photostat in Cambridge Univ. Lib.).

Hardwick Estate Papers: (Account rolls, correspondence, and legal and other documents in the possession of Pembroke College Cambridge. 14th-19th centuries).

Old Coucher Book of Ely: Liber de Inquisicionibus maneriorum episcopatus Elyensis factus tempore Hugonis Elyensis Episcopi Anno consecracionis sue vicesimo primo (1251). (The original is untraceable. Several MSS copies and fragments exist; the most reliable text is probably that of the early 14th century copy in Gonville & Caius College Cambridge - MS 485/489.)

Published Sources

ADAMSON, R. S. 1912. An ecological study of a Cambridgeshire woodland. J.Linn.Soc.(Bot.), 40, 339-387, Pl. 12-17.

ANDERSON, M. C. 1964. Studies of the woodland light climate. I. The photographic computation of light conditions. J. Ecol., 52, 27-41.

COOMBE, D. E. 1957. The spectral composition of shade light in woodlands. J.Ecol., 45, 823-830.

COOMBE, D. E. 1966. The seasonal light climate and plant growth in a Cambridgeshire wood. In 'Light as an ecological factor', ed. R. Bainbridge, G. C. Evans, O. Rackman, 148-166. Oxford, Blackwell Sci.Pubs.

DARBY, H. C. 1950. Domesday woodlands. Econ.Hist.Rev. 2nd ser., 3, 21-43.

EBERMAYER, E. 1882. Physiologische Chemie der Pflanzen. I. Die Bestandtheile der Pflanzen. Berlin, Springer.

EVANS, G. C. 1966. Model and measurement in the study of woodland light climates. In 'Light as an ecological factor' (see Coombe 1966) above), 53-76.

EVANS, G. C. & COOMBE, D. E. 1959. Hemispherical and woodland canopy photography and the light climate. J.Ecol., 47, 103-113.

FORESTRY COMMISSION 1956. Utilization of hazel coppice. Forestry Commission Bull., 27, London, H.M.S.O.

GOOCH, W. 1811. General view of the agriculture of the county of Cambridge. London.

HENRY, E. 1908. Les sols forestiers. Paris, Berger-Levrault.

MILLER, E. 1951. The abbey and bishopric of Ely. Cambridge Univ. Press.

NATURE RESERVES AND SITES OF SPECIAL SCIENTIFIC INTEREST 1965. Survey Report. Cambridge; Cambs & Isle of Ely County Council.

PEVSNER, N. 1954. The buildings of England: Cambridgeshire. London, Penguin.

PIGOTT, C. D. & MARTIN, M. H. 1964. Hayley Wood. Nature in Cambs., 7, 23-26.

RAY, J. 1660. Catalogus plantarum circa Cantabrigiam nascentium. Cantabrigiae.

ROTULI HUNDREDORUM temp.Hen. III & Edw. I in Turr' Lond' et in Curia Receptae Saccarij Westm. asservati. Vol. II (1818). London.

SMITH, C. T. 1965. The Cambridge region: settlement & population. In The Cambridge Region, ed. J. A. Steers, 133-162.

SPARKS, B. W. & WEST, R. G. 1965. The relief and drift deposits. Ibid., 18-40.

TANSLEY, A. G. 1939. The British Islands and their vegetation. Cambridge Univ. Press.

TROUP, R. S. 1928. Silvicultural systems. Oxford, Clarendon.

SUMMARY OF DISCUSSION

A participant suggested that the coppicing treatment used at the present time in Monks Wood did not restore the type of conditions maintained under the regular commercial coppicing which was practised years ago. The management which we practise today in some woodland nature reserves may result in a modified type of flora and fauna.

A comment was also made on the competitive relationships between plants in coppiced areas and that little information on this seemed to be available. Was the differential effect on the flora of different coppicing cycles known and would it be possible to predict what would happen on the basis of available knowledge of plant behaviour?

SOME ASPECTS OF THE SCIENTIFIC INTEREST AND MANAGEMENT OF SCRUB ON NATURE RESERVES

K. Williamson
British Trust for Ornithology

'Scrub' has become the botanical counterpart of 'vermin'; it is usually regarded as something to be got rid of at all costs. One of the major tasks of Conservation Corps squads appears to be 'scrub clearance' on nature reserves and one cannot help feeling that the operation is often carried out in complete ignorance of the value of this feature of the habitat as a refuge for birds. Many reasons have been given for this crusade; frequently they are biased towards botanical interests and they are not always relevant to conservation.

I am currently studying the breeding bird community on a 200 acre reach of the Ivinghoe Hills Buckinghamshire, part of the 4,000 acres Ashridge Estate owned by the National Trust. In recent years, consequent upon the cessation of grazing and the severe reduction in rabbit activity, the slopes of these 800-foot hills (a spur of the Chilterns) have become covered to a varying extent with scrub composed mainly of Hawthorn, Crataegus monogyna; Elder, Sambucus nigra; and Dog-rose, Rosa canina, with scattered Whitebeam, Sorbus aria; Oak, Quercus sp. and patches of Gorse, Ulex europaeus. The local committee of the National Trust recently insisted upon the wholesale clearance of about 10 acres of hillside merely because the tenant farmer had been lax in carrying out this condition of his lease. Further clearance is contemplated, partly to satisfy botanical interests but mainly on grounds of public amenity. The Hawthorn scrub, it is claimed, encourages the growth of Upright Brome Grass, Bromus erectus and suppresses the orchids and the foodplants of interesting chalk grassland butterflies; it spoils the panorama (apparently, to judge by notices displayed, an agricultural landscape is preferred); it discourages public access - or, if it does not, then it ladders the ladies' stockings!

The case against the wholesale destruction of scrub, here as elsewhere, is largely an ornithological one - and birds, except for some of the rarer species, are often overlooked by the conservation movement when devising management plans.

There are of course, innumerable types of scrubland, but wherever scrub occurs, it appears to support a rich and diverse bird community, varying in species composition from one type to another, but often with interesting species present at a relatively high density. This much is obvious from a number of surveys which have been carried out in various parts of the country since 1964 as part of the Common Birds Census organized by the British Trust for Ornithology, with Nature Conservancy support. As an example, I give in Tables I and II details of the bird-communities occupying two widely different types of scrub, namely the Ivinghoe Hills (mentioned above) and the Gibraltar Point L.N.R. near Skegness, Lincolnshire, where the dominant cover is Sea-buckthorn, Hippophae rhamnoides and Elder on coastal dunes. In the last column of the tables a density figure for arable land, based on the results of 130 different census 'plots' - mainly in the English lowlands - is given for comparison: the first figure represents the upper limit attained by a majority of the plots, while the one in parentheses represents the upper limit reached on occasional, exceptional, farms.

The densities of Whitethroat, Dunnock and Reed Bunting (here in a relatively dry environment) at Gibraltar Point are far in excess of those found on any other survey yet carried out under the Common Birds Census (for fuller details, see Williamson 1967). Much the same applies to the Willow Warbler on the Ivinghoe Hills, and the Linnet in both areas. Also a feature of both is the very high density of the Meadow Pipit, a species which occurs only infrequently on agricultural land other than reclaimed coastal marsh and rough upland grazings, and which is extremely local in its distribution in the English lowlands. The striking abundance of the Meadow Pipit among the scrub of the Ivinghoe and nearby hills invests this habitat with very considerable importance from the ornithologist's point of view, particularly as its numbers decline rapidly even a few miles farther west in the Chiltern Hills. The abundance of the Yellowhammer and the good representation of such relatively scarce species as Whinchat, Grasshopper Warbler and Lesser Whitethroat are also noteworthy (see species maps 1-6). Red-backed Shrikes, Lanius collurio nested formerly and the Quail, Coturnix coturnix is present in some years. The chief aim of the present study of the density and distribution of the scrub and so recommend a policy for management. The results of the census in 1966, carried out by mapping song-registration and other evidence of territory-holding, reveal some interesting features. The Meadow Pipit, for example, is more tolerant of the moderately dense thorn bushes on the hill slopes than is the Skylark, which prefers the more open aspect of the hill tops (maps 1 and 2). Both are absent from the vigorous development of Hawthorn, Oak, Elder, Gorse and other shrubs on the clay-with-flints cap of Steps Hill; a small area which looks as though it will ultimately achieve an oak wood climax, and which it would be of considerable ecological interest to leave untouched. Willow Warbler and Yellowhammer (maps 3 and 4) have a similar distribution throughout the scrub (the latter requiring the larger territory) though only the former will tolerate the extremely vigorous growth on the clay-with-flints cap. This also attracts the Garden Warbler and several woodland species such as Blackcap and Chiffchaff.

In considering the generally lower densities of the same species on agricultural land which occupies some 80 per cent. of the English countryside, one might comment that the slow but progressive reduction of the linear scrub of field hedgerows and ditch-side vegetation high-lights the importance to bird-life of scrubland refuges of the type discussed above. At the B.T.O. we are keeping a register of hedgerow reduction in connection with repeat bird-census surveys on a number of farmland 'plots' scattered widely throughout England and Wales. During the last three years 40 such plots totalling 8,500 acres have lost a total of 14.2 miles of hedgerow - which means that this feature of the countryside is disappearing at a fairly steady rate of one yard per acre per year. I will not go further into this problem (since it is the subject of Dr. Moore's talk) except to ask, since agricultural needs demand the continuance of this process, what conservationists can do to redress the balance.

It is possible that some gain will be achieved in rural areas from the closure of small branch railway lines in various parts of the country since these, together with disused canal cuttings, very quickly develop a rich scrub formation. Since much of their length is at a different level from the surrounding fields, either embanked or in cuttings, they are not likely to be incorporated into adjoining agricultural land, and would make ideal nature reserves. The Common Birds Census, which is becoming increasingly conservation-minded, is turning its attention to detailed studies of disused railway lines to find out which bird species are particularly attracted to this relatively recent development.

In the same way the environs of disused sand and gravel pits have a high potential as bird refuges. It is interesting to note that a 12 acre reserve of the Bucks., Berks. and Oxon Naturalists' Trust, on the site of former gravel workings, accommodates some 40 species at a density of about 10 pairs to the acre. Other types of industrial waste ground could be equally important in this context, particularly as they are likely to increase the bird-life within urban and suburban zones. Such refuges would add variety to town bird-life since suburban parks and gardens (a controlled form of scrub) are somewhat restricted as to species, although the density of Blackbird, Song Thrush, Dunnock, Robin and Chaffinch is high, and the Greenfinch is better represented in this man-made habitat than in any other.

The B.T.O. Populations Section is also actively collaborating with the Forestry Commission, in a small wood in the Gade Valley, Hertfordshire set aside for this purpose, in a census programme aimed at determining how far the maintenance of 'islands' of scrub in areas clear-felled for the economic planting of conifer crops will retain bird-species which would otherwise disappear. Preliminary study suggests that such 'islands' should be at least an acre in extent, should have an irregular outline, and a tiered structure culminating in a few tall trees to provide canopy for Blackcap and Chiffchaff, and song posts for Tree Pipit. Studies are also being carried out in a Chilterns beech-wood to find out how forest management, particularly in relation to natural and artificial regeneration, affects the bird community.

Scrub is a stage in the succession towards a woodland climax of one kind or another and is in consequence, a dynamic condition which demands careful management if it is to retain the richest assortment of birds. We need to know how to manage it, whether by careful thinning, or clearance of small areas phased over a number of years. One of the difficulties is that scrub is as attractive to rubbish as it is to wildlife; old bicycles, bedsteads, prams and (not least in importance) the plastic and metal containers of farm chemicals. This problem is most acute in urban and suburban zones, particularly with old gravel pits and disused railway lines; in the long term it can be overcome only through education.

A pre-requisite of good management is to know what birds and other creatures the scrub contains and supports. No clearance, partial or complete, should even be comtemplated without preliminary census studies. In its diverse forms scrub is an important habitat whose amenity value is increasing year by year as a result of the growing pressures on the wildlife environment. The need to design well-balanced programmes that will take care of the fauna and flora in such situations is an urgent challenge to conservation interests at the present time.

REFERENCES

BRITISH TRUST FOR ORNITHOLOGY 1967. Common Birds Census 'Instructions'.

WILLIAMSON, K. 1967. A bird community of accreting sand dunes and saltmarsh. Brit.Birds, 60, 145-57.

/Table I ....

TABLE I

IVINGHOE HILLS NEAR TRING, BUCKINGHAMSHIRE

(Chalk grassland with Hawthorn, Elder, Dog-rose, Gorse, etc: 36 species, about 540 pairs on 200 acre sample 'plot')

Main Species	No of Pairs	Dominance (per cent)	Density (pairs per 100 hectares)	Density on arable land (see text)
WILLOW WARBLER Phylloscopus trochilus	75	14	92	11 (16)
LINNET Carduelis cannabina	67+	13	82	22 (37)
SKYLARK Alauda arvensis	46))		57	22 (64)
MEADOW PIPIT Anthus pratensis	43))	8	53	8 (23)
DUNNOCK Prunella modularis	40))		49	49
WHITETHROAT Sylvia communis	38))	7	47	20 (35)
YELLOWHAMMER Emberiza citrinella	37))		46	18 (36)
BLACKBIRD Turdus merula	35	6	43	50 (65)
SONG THRUSH Turdus philomelos	18	3	22	20 (32)
CHAFFINCH Fringilla coelebs	13))		16	40 (57)
ROBIN Erithacus rubecula	12))		15	30 (55)
TURTLE DOVE Streptopelia turtur	10))		12	4 (9)
HOUSE SPARROW Passer domesticus	10))		12	?
WOOD PIGEON Columba palumbus	8		10	?
GRASSHOPPER WARBLER Locustella naevia	8		10	(3)
LESSER WHITEHTROAT Sylvia curruca	7		9	5 (8)
GOLDFINCH Carduelis carduelis	7		9	8 (13)

TABLE II

GIBRALTAR POINT N.R., NEAR SKEGNESS, LINCOLNSHIRE

(Dunes with dense Sea-buckthorn and Elder flanking shore and saltmarsh: 36 species, about 540 pairs on 200 acre sample 'plot')

Main Species	No of Pairs	Dominance (per cent)	Density (pairs per 100 hectares)	Density on arable land
WHITETHROAT *Sylvia communis*	94	16	117	20 (35)
DUNNOCK *Prunella modularis*	76)	13	94	49
REED BUNTING *Emberiza schoeniclus*	75)		93	10 (24)
SKYLARK *Alauda arvensis*	65)	11	81	22 (64)
LINNET *Carduelis cannabina*	60+)		74+	22 (37)
BLACKBIRD *Turdus merula*	28)	5	34	50 (65)
MEADOW PIPIT *Anthus pratensis*	26)		32	8 (23)
SEDGE WARBLER *Acrocephalus schoenobaenus*	20)	3	25	9 (27)
PHEASANT *Phasianus colchicus*	18)		22	6
WOODPIGEON *Columba palumbus*	13)	2	16	?
TURTLE DOVE *Streptopelia turtur*	12)		15	4 (9)
SONG THRUSH *Turdus philomelos*	11)		14	20 (32)
YELLOWHAMMER *Emberiza citrinella*	9		11	18 (36)

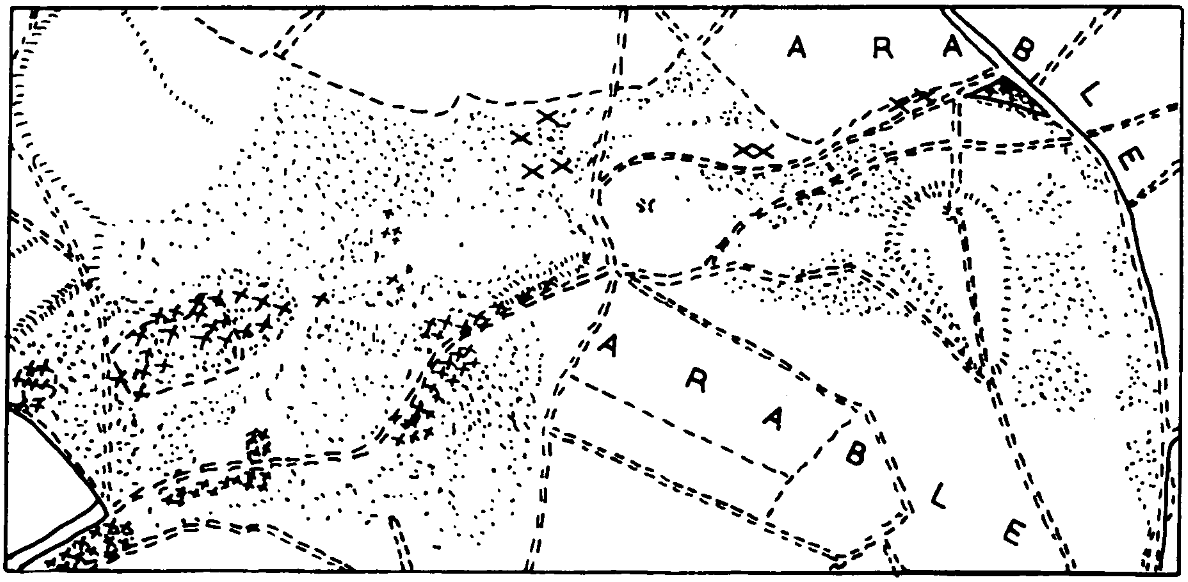
SUMMARY OF DISCUSSION

A comment was made that it was a widely held view among landscape architects that scrub was a less desirable type of vegetation than, for instance, wooded or grassy hillsides. This attitude seemed to be derived from what was thought to be good for amenity purposes. It was also said that scrub often created a pest control problem for conservationists because land owners who may be sympathetic to wildlife sometimes found that they were under pressure to clear scrub in order to get rid of rabbits and other pests. It was pointed out by another member that the butterflies of chalk downs fed mostly on herbaceous plants and that the introduction of scrub with its consequent boost in the bird population may be detrimental to the resident species.

On the question of management of chalk scrub, the speaker was asked whether it was worth maintaining for ornithological reasons, scattered bushes rather than an extensive scrub cover. There were no strong botanical reasons for this but if it were desirable for bird life, presumably it could be maintained. The speaker thought however, that there was no special advantage in having scattered bushes as a scrub cover for birds.

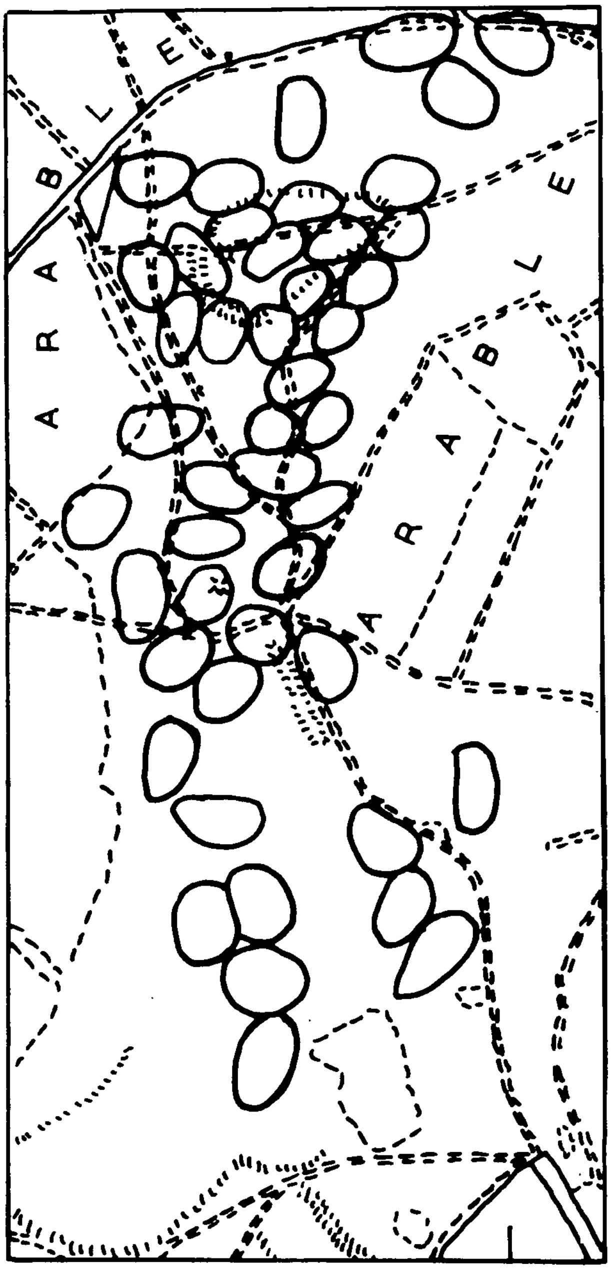
Fig. 1. Invinghoe and Steps Hills, Buckinghamshire. The stippling indicates the distribution and density of hawthorn scrub on the slopes. Areas with trees 15 ft. or more tall are marked xx.

FIGURE I



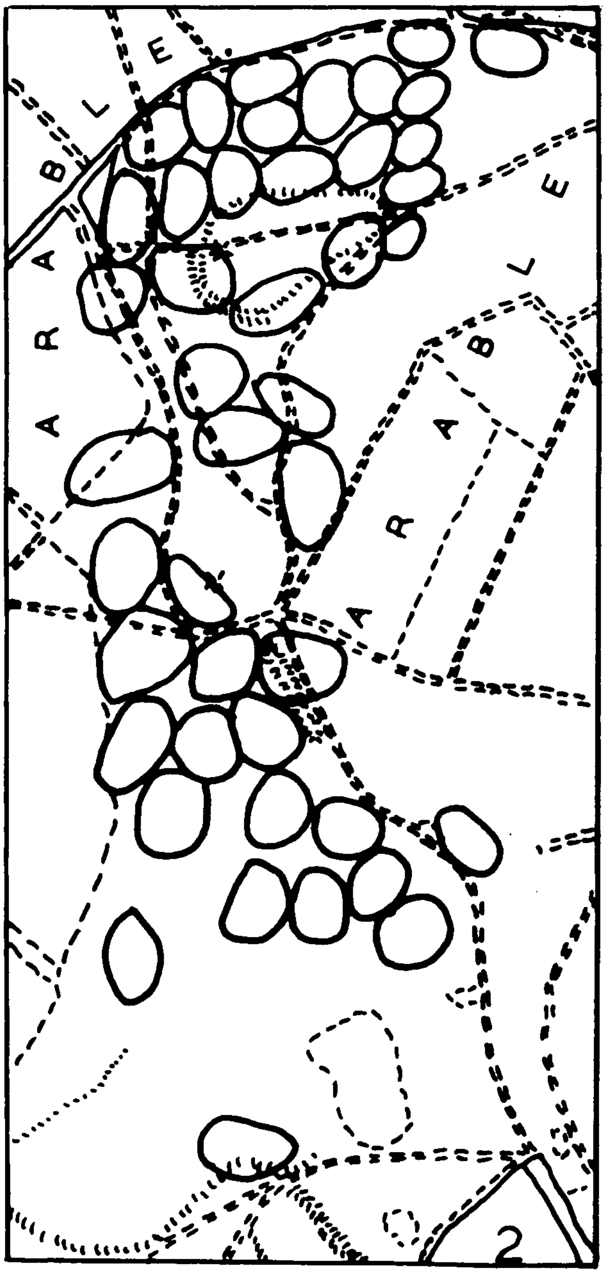
Figs. 2 - 7. Species distribution maps showing approximate limits of bird territories: 2, Skylark c.46 pairs; 3, Meadow Pipit c.43 pairs; 4, Willow Warbler c.75 pairs; 5, Yellow-hammer c.37 pairs, with peripheral Corn Bunting song-posts shown in black; 6, Whitethroat c.38 pairs, with Lesser Whitethroat, 7 pairs, shaded; 7, Grasshopper Warbler, 8 pairs, and Whinchat, 4 pairs (plus 2 extralimital), shaded.

FIGURE 2



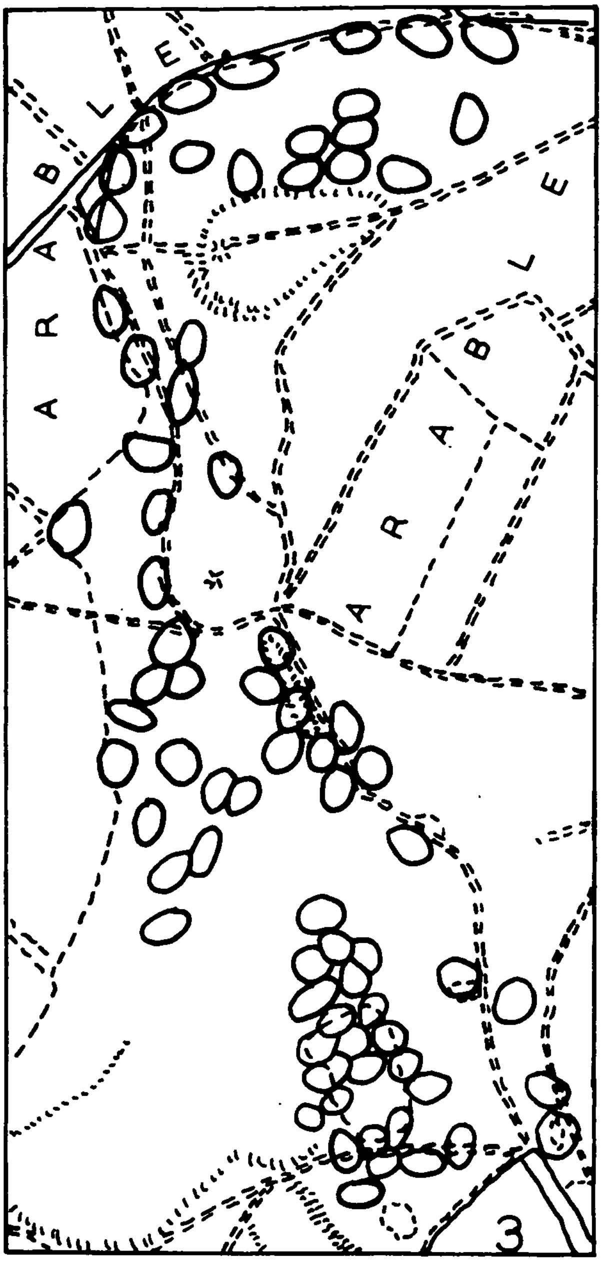
Skylark 46 pairs

FIGURE 3



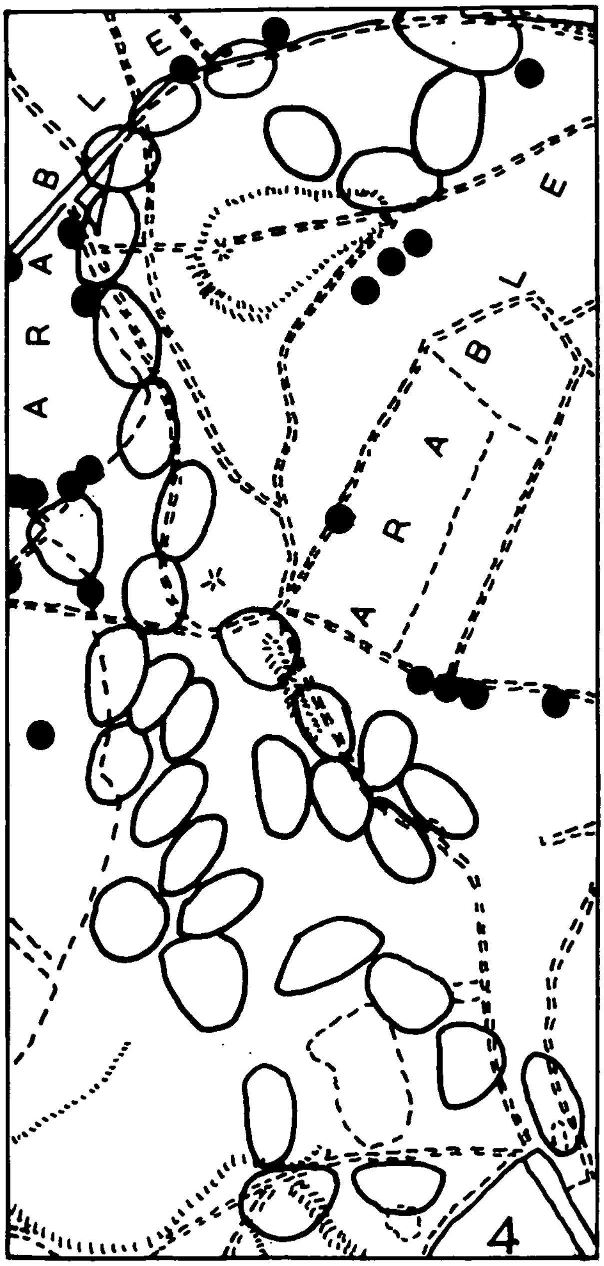
Meadow Pipit 43 pairs

FIGURE 4



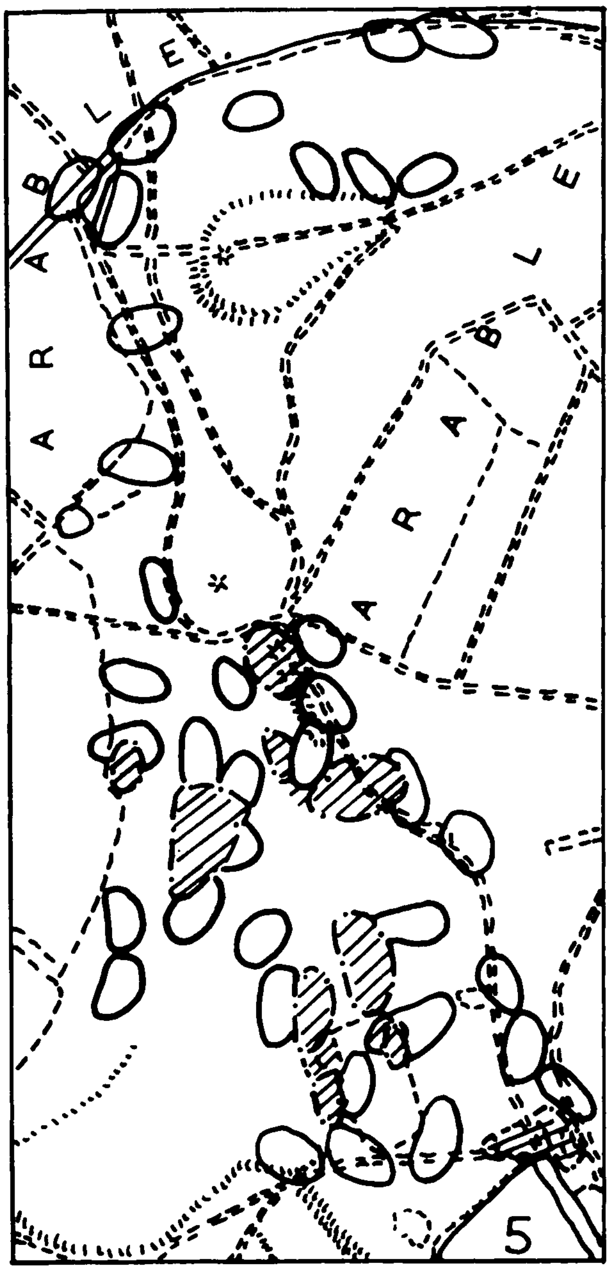
Willow Warbler 75 pairs

FIGURE 5



Yellowhammer 37 pairs
Cornbunting peripheral

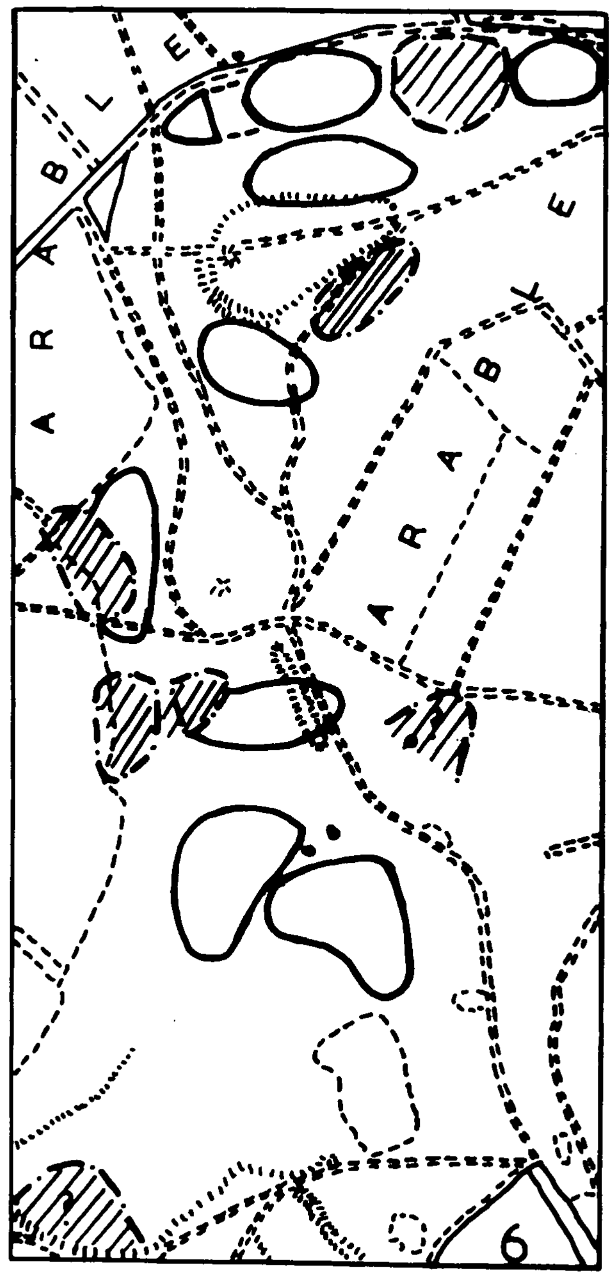
FIGURE 6



Whitethroat 38 pairs ——

Lesser Whitethroat 7 pairs –·–·

FIGURE 7



Grasshopper Warbler 8 pairs ——

Whinchat –·–·–· 4 pairs

THE HEDGEROW AS A CHANGING WILDLIFE HABITAT

N. W. Moore
Monks Wood Experimental Station

INTRODUCTION

In presenting this paper I should like to acknowledge the help of my colleagues Dr. M. Hooper, Dr. B. Davis and Mr. E. Pollard, who contributed to much of the work I shall be describing. I shall be speaking on their behalf as well as my own. The substance of this talk is in Moore, N. W., Hooper, M. D. & Davis B. N. K. (1967).

I shall discuss the agricultural habitat, which is one in which the effects of Man are so much taken for granted that we know extraordinarily little about them.

The Toxic Chemicals and Wildlife Division is primarily concerned with conservation outside nature reserves. We feel that it is essential for the Conservancy to be concerned with farmland because it is much the largest general habitat type in Great Britain (Fig. 1), and because we cannot rely on nature reserves alone to support the variety of life which the Nature Conservancy was formed to conserve. Also, for most people it is far more important to be able to see wildlife on their doorstep than in remote areas visited occasionally on holiday. In saying this I do not want to give the impression that I think that conservation on reserves is unimportant - of course it is essential, but I do think that we should also emphasize the complementary need to conserve wildlife outside them.

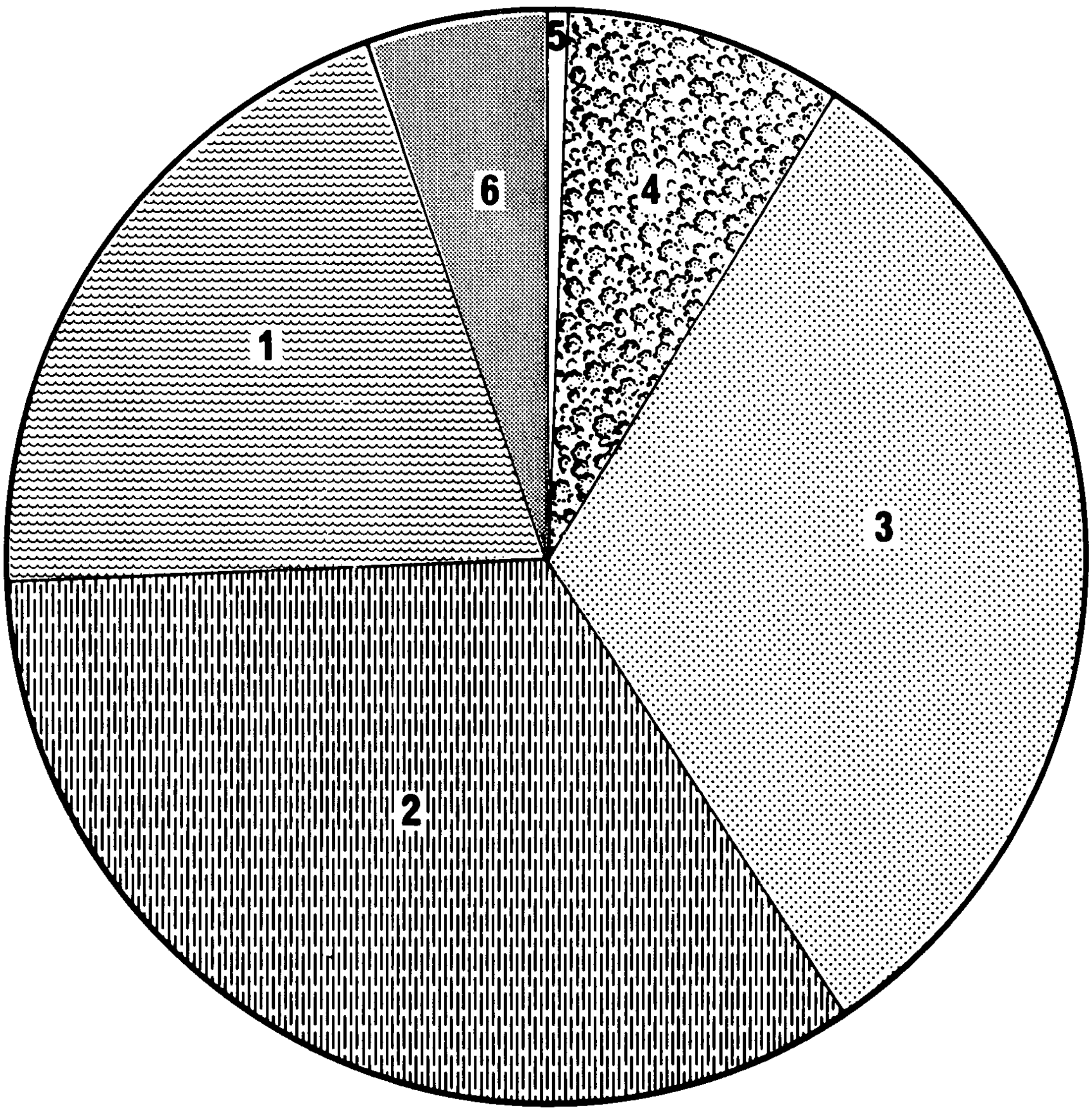
THE LOSS OF HEDGEROWS

In agricultural land wildlife is based largely on the hedgerows. Locke (1962) estimated that there were 616,000 miles of hedgerows in Great Britain. If we take two yards as the average width of hedgerow we have 448,000 acres of this habitat, that is about twice the total acreage of our National Nature Reserves.

Dr. Hooper has found that during the last twenty years about seventy per cent. of the hedge mileage in a sample area near Monks Wood, was destroyed. Other studies made elsewhere in Britain show that hedge destruction is going on everywhere although it is particularly severe in the East Midlands. A study of aerial photographs of randomly selected areas in six counties showed the following loss of miles of hedge per hundred acres between 1946 and 1963:

Cornwall	0.03
Shropshire	0.07
Oxfordshire	0.1

LAND USE IN GREAT BRITAIN   FIGURE 1.



1. Arable ---------------------------┐
2. Grass ----------------------------┘--- Farmland
3. Moorland
4. Woodland
5. Nature Reserves
6. Urban Land

Data from Prof. Dudley Stamp 1962 and other sources

Norfolk	0.1
Devon	0.28
Huntingdonshire	0.53

Devon, unlike Huntingdonshire, is still rich in hedgerows because its initial mileage was exceptionally great.

Conservationists are thus faced with a situation in which an important and widely distributed habitat is rapidly disappearing. I doubt whether any other ecological event of the last twenty years has been as important as the increasing destruction of hedgerows and hedgerow timber. These have been characteristic of our landscape for centuries, especially since the 18th century. Important questions have to be asked.

1. What are we losing?

2. Why are we losing it?

3. Can, or should we try to stop it?

   (the answer to this question largely depends on finding out whether hedges are valuable economically.)

4. Given that we have hedges, what types are most valuable for the conservation of wildlife? In other words how should we manage them?

WHAT ARE WE LOSING?

What is a hedge in biological terms? There are many types but all consist primarily of a line of woody plants with bands of field layer plants on either side. Frequently there is a ditch and/or a bank. The hedge has many of the characteristics of the edge of a deciduous wood.

A very superficial study of hedges shows that they enable woodland species to live in open country, which but for the hedges would not support woodland species at all. Considering that Britain was mainly woodland for hundreds of years it is not surprising that much of our fauna is a woodland one. For example, of the 40 or so species of birds found on farmland only about 6 can exist in open country which has no woods and/or hedges. Two years ago I made a brief study of birds of Laxton, the Nottinghamshire parish which is still farmed on the medieval three field system. I found only five species, Skylark, Red-legged Partridge, Partridge, Lapwing and Reed Bunting. It is obvious that if one does away with hedges one greatly reduces species diversity (i.e. numbers of species per unit area; see discussion) as far as birds are concerned. Mr. E. Pollard has found that the carabid beetles in the hedges near Monks Wood are also found in the wood itself. Again we would lose woodland species in open land if we destroyed the hedges. In country like the Weald, where there are many woods the loss of hedges might be relatively unimportant, but in much of East Anglia and the Midlands, where there are relatively few woods, the large scale reduction of hedges would have a very considerable effect on the flora and fauna.

WHY ARE WE LOSING HEDGEROWS?

Clearly this is a question of economics. First we should consider a hedge from the farmer's point of view. It is primarily a living fence which also may give shelter for stock. It is also a boundary mark; in general parish boundary hedges are the most ancient; many date back to Saxon times. During the last two or three decades farming has become almost universally mechanised and labour costs have risen considerably. Hedges are expensive to maintain. They take up much land which could produce food; small fields are very difficult to cultivate with large machines. Therefore unless there are good reasons to the contrary the modern farmer will always get rid of hedges if he can. Yet not bothering to take them out. They are also positively conserved for game preservation and hunting. Our survey showed that most of the well kept hedges occurred in fox hunting districts and in areas with wealthy landowners. In other localities hedges are conserved to prevent erosion of light soils. It is often forgotten that spectacular erosion can occur in this country, e.g. in the Fens and Breckland. Hedges are conserved in order to give shelter to stock, although the trend to keep animals in buildings and to bring food to them will reduce the value of hedge for this purpose. Finally hedges, especially those near farmsteads are conserved for aesthetic reasons.

It is interesting to note that one can get a government grant to remove a hedge and also one to plant a hedge.

CAN WE, OR SHOULD WE TRY TO STOP THE DECLINE OF THE HEDGE?

Conservationists value hedges for the wildlife they support and so would be glad if hedges were found to be valuable economically. Whether or not they are preserved will depend mainly on their economic rather than on their conservation value. That is:

1. If the economic value of their beneficial species are proved to outweigh the damage done by their pest species.

2. If hedges were found to reduce erosion on ordinary soils.

So far there is little evidence on which one can draw up a balance sheet for the pros and cons of hedges. If there was an obvious short term economic advantage in retaining them I think we would have seen more evidence of hedge planting in those districts in which there have never been hedges or which have been without them for a long time. It is obviously extremely difficult to study the effects of hedges on long-term erosion. The first requirements in tackling both problems is to get many more facts that we have to date. In particular we need to know much more about the flora and fauna of hedges and the extent to which pests and beneficial species move into adjoining crops. Some of our work at Monks Wood should assist the agricultural departments in their studies on this subject.

THE MANAGEMENT OF HEDGES FOR WILDLIFE CONSERVATION

The Nature Conservancy is increasingly asked to advise on agricultural management problems relating to wildlife. For example, we have been asked to what extent small copses at the corner of fields are adequate substitutes for hedges. We have been asked what types of hedge and what types of management are best for birds. We have started studies on the last two problems; the results of our initial survey are given in Moore, Hooper and Davis (1967). They suggest that when the same management types are compared, hawthorn hedges contain richer fauna and higher densities of birds than do elm hedges. This may be correlated with the fact that hawthorn comes into leaf earlier than elm. Clipped hedges appear to be better for birds than layed ones. Much the best type of hedge for birds is an unmanaged one with thick outgrowths at its base. This confirms casual observations which show that bad farming often favours wildlife. It is our job to see how we can get as much wildlife as possible under the difficult ecological situation of good farming. None of us should underestimate the difficulties.

CONCLUSIONS

First steps have been taken to measure an event of great conservation importance in Britain - the destruction of the hedgerow. We have also begun to assess the conservation value of different types of hedge so that we can advise on the management of those that remain from the wildlife point of view. Some of our work should help to assess the economic value of hedges and their fauna.

No attempt has been made to study the effects of hedge destruction on public pressure on farmland. It is obvious that most footpaths are used far less today than they were when only a small proportion of the population owned cars. In Eastern England the change from pasture to arable has also made walking in the countryside more difficult and may well have reduced public pressure on it. By destroying shelter and the attractiveness of the countryside, the destruction of hedges has conceivably reduced public pressure on agricultural land yet further. We have no facts with which to prove or disprove such speculations.

REFERENCES

STAMP, D. L. 1962. The land of Britain. Its use and misuse. 3rd Ed. Longman. London.

LOCKE, G. M. 1962. A sample survey of field and other boundaries in Great Britain. Quart. J. Forestry 56, 137-44.

MOORE, N. W., HOOPER, M. D. & DAVIS, B. N. K. 1967. Hedges. 1. Introduction and Reconnaissance studies. J. appl. Ecol. 4, 201-220.

SUMMARY OF DISCUSSION

It was pointed out that the absence of permanent pasture in the winter may affect some resident hedgerow birds. In some parts of Scotland, headlands and permanent pasture had disappeared so that there were no feeding areas for woodland birds in the winter.

There was evidence that different types of scrub varied in richness of fauna so that one type might have a higher "quality" than another for conservation purposes. For example a gorse scrub was richer than a hawthorn scrub in numbers of birds and possibly the mixed scrub found in some chalk areas had its own ornithological characteristics. Did one find the same effect in hedgerows? The speaker said that this was so and that work in his Division had shown that a pure elm hedge was less rich in bird life than a hawthorn hedge, and that a hedge of mixed scrub species which is commonest in the west and south is probably the richest in bird numbers.

The speaker was asked whether the destruction of many hedgerows so that only small stretches of hedge were left, resulted in an increase in the density of the birds in the surviving fragments. He replied that although there was little factual evidence at present, it did look as if this occurred to some extent.

Reference was also made to the Game Research Association's booklet on the maintenance of a farming landscape for game. Could not the same principle be adopted for wild birds? The speaker said that in some parts of the country it was likely that bigger and bolder patterns of shelter belts would develop but he did not feel that these represented a suitable alternative to hedgerows because effective shelter belts had little scrub and so supported few scrub species.

On the question of species diversity in different hedge types, the speaker said that this was worked out in terms of number of species per length of hedge and was rather different from the usual method of measuring diversity which was number of species in relation to number of individuals.

HUMAN IMPACT ON THE FAUNA, FLORA AND NATURAL FEATURES OF GIBRALTAR POINT

J. M. Schofield
The Nature Conservancy, Norwich

INTRODUCTION

Gibraltar Point lies on the Lindsey coast, at the entrance to the Wash about 1½ miles south of Skegness holiday resort. The reserve is about 2½ to 3 miles long, averages about ½ mile in width and extends to approximately 1,300 acres. It consists of a sandy, shingle and muddy foreshore (670+ acres), sand-dunes (280+ acres) and saltmarsh (200+ acres), all in varying stages of development. There is also an area of approximately 41 acres of fresh-water marsh and other grassland. The coast south of Skegness is in the process of accretion with sand-dune ridges being formed in lines roughly parallel to the coastline. The area is owned by the Lindsey County Council and Skegness Urban District Council and managed on their behalf by the Lincolnshire Trust for Nature Conservation. Non-scientific aspects of management are supervised by a joint Management Committee which has representatives of the County Council, Skegness Urban District Council, the Trust, and the Conservancy. Fig. 1.

PUBLIC ACCESS AND USAGE

Public access to the reserve is unrestricted although bye-laws are in force ensuring a high degree of protection to the area. A public road (Gibraltar Road) runs from Skegness and joins the north-west corner of the reserve some 2½ miles from the town centre. It follows the western boundary of the reserve and terminates at the South car-park which has a capacity for some 100 cars. There are two other car-parks; the North (50 cars) and Middle (30 cars). Cars are also parked alongside the road and this adds a further 35 cars to the total capacity. An additional 155 cars may be parked on a dried-out lagoon north of the reserve itself.

From the north and south car-parks, there are two track-ways leading across the saltmarsh and dunes to the beach, a distance of approximately ½ mile, known as Mill Pond Road and South Marsh Road respectively. The Trust's policy has always been to seek the co-operation of the many visitors and to try and pass on to them by various means, information on the main features of the reserve. The methods involved include tours of guided parties and individuals by the resident warden and voluntary wardens, pictorial notice boards, nature trails and more recently, the Information Centre. The Field Research Station, which was recently extended by the Lindsey County Council at a cost of £12,000 now provides facilities for both research and educational purposes. The Station contains laboratories, display room, lecture/recreation room and accommodation for thirty students with the usual services.

REASON FOR SURVEY

In order to try and assess the effects of the public, students and research workers on the natural features, plant, and animal life, it is necessary that detailed investigations should take place over a period of time. In 1965 the Conservancy awarded a contract to the Trust to carry out studies on this problem. An extension of six months was subsequently given. The Trust appointed Mr. Barrie Wilkinson to take charge of the survey.

Some of the results obtained are outlined as follows:

VOLUME AND FREQUENCY OF PUBLIC PRESSURE

During the first season (1965) only one traffic counter was available, the type commonly used for road census work. It was located at the northern end of the reserve across Gibraltar Road where, from June to October 1963, 41,000 cars visited the reserve. During 1966 an additional traffic counter was installed just before the entrance to the South car-park. The total figures, over the period April to October, showed that slightly over 50,500 cars visited the reserve and of these, 76 per cent. visited the South car-park and 24 per cent. were distributed between the North and Middle car-parks and alongside the road. These accurate figures clarified a confusion which had apparently arisen during 1965 when an estimate, based on counts carried out during two periods of five and eight days, led us to believe that only 33 per cent. used the South car-park and 67 per cent. the North and Middle car-parks and roadside. During 1965, six counts were made of the number of people per car providing a mean of 3.12 people/car. During 1966 when 22 counts were made, the ratio of people/car was estimated to be 3.06.

The number of people visiting the reserve can thus be calculated as being:

1965	123,000 people
1966	151,000 people

The relationship between the numbers of people who visited the reserve and the prevailing weather conditions is shown below:

	1965 (June-September)		1966 (April-October)	
	Cars	People	Cars	People
Average Sunday	550	1,650	505	1,515
Fine Sunday	700	2,100	542	1,626
Cool/wet Sunday	465	1,400	344	1,032

During weekdays the numbers were considerably less than at weekends or Bank Holidays. In 1953 it was estimated that 200 people visited the area on a fine Sunday and less than 100 during weekday.

SOURCE OF PEOPLE AND MOTIVES

250 interviews during 1965 showed that 11 per cent. of the people interviewed were permanent residents of Skegness. The main catchment areas for the remaining 89 per cent. were Nottingham, Leicester and

Sheffield, the Midlands area and Birmingham, in that order. It is believed that these people reflected the varying proportions which stayed for a day or longer in Skegness itself. It is interesting to note that 40 per cent. of those interviewed were new to the reserve whilst the relatively high figure of 60 per cent. had been there on more than one occasion. It was difficult to ascertain various people's motives for visiting, but the vast majority came because of the beach, because there was more open space than Skegness, because of the 'wildness' of the area, etc. Only a minority came for the natural history interest of the reserve.

MOVEMENTS OF PEOPLE

On eight occasions during 1965 and on thirty-three occasions during 1966, observations were made on the behaviour of people in the South car-park. The results are summarized in the chart below:

	1965	1966	Mean
No. cars visiting South car-park (on basis of 75%/25%)	30,750	37,825	-
Cars which left immediately	18.3%	16.9%	17.15%
People in or near to their cars	63.4%	38.0%	42.7%
People using South Marsh Road	23.7%	42.5%	39.0%
People using Field Station Road	12.9%	19.5%	18.3%
People who looked at Information Centre	20.3%	35.6%	34.2%
People who looked at map of reserve	5.3%	?	?
People who looked at pictorial notice boards	1.25%	?	?

	1965	1966
No. of people who:		
1. Used the South Marsh Road	7,458	35,624
2. Looked at Information Centre	6,388	31,185

The 1965 figures are not reliable because of the low numbers estimated for cars (and so people) who visited the South car-park

Two transistorized 'people counters' have been installed on the Mill Pond Road and South Marsh Road and it is hoped that these will give accurate counts of the numbers of people using these roads.

Where the South Marsh Road meets the East Dunes there is a further 200 yards walk to the outer dunes and beach. This stretch was once marked by a conspicuous gash in the dune vegetation and the tendency was for it to get wider as the public tended to use the edge of the track. A sleeper track has now been laid and is much appreciated because a large percentage of those using the South Marsh Road consist of family parties with children and prams. The building of the sleeper track was commenced in 1961 and at the sides of the oldest part, the gash has completely healed.

The sleeper track ends at the top of the outer dunes where people fan out on to the beach area and where most wear and tear is concentrated. Careful observations are continually necessary to ensure an early warning in the event of a blow-out developing. Although the dominant vegetation of Marram and Sand-couch tends only to get flattened it recovers during the periods when public usage is minimal.

DISTRIBUTION OF PEOPLE WITHIN THE RESERVE

The distribution of people at known peak periods was plotted on large-scale maps and these showed that the highest density on the beaches occurred in the region of the two road outfalls to the extent that 90 per cent. remained within 200 yards of either side of them. The balance of 10 per cent. found their way into the more distant areas of the reserve. A large proportion of those on the beach were to be found in the dune system; this was especially marked on the more windy days when shelter from the wind was considered more desirable than the attractions of the open beach.

LITTER

In Car Parks

On the South park there are seven litter bags, three on the Middle park and four on the North park. On the parking areas there is no large litter problem, for example, paper bags, bottles, newspapers etc. There is however some slight problem of small litter in these areas such as toffee papers, silver wrapping paper etc.

On Beaches

Two bags are sited at the South Marsh Road outfall. Here, in areas habitually used for picnic spots, there is a large litter problem which could be solved by providing increased numbers of collecting bags at a greater frequency.

INFORMATION CENTRE

Over 31,00 people visited the Information Centre during 1966 and of these, 2,757 bought a Nature Trail leaflet at 6d. each. Together with the sale of post-cards, the actual receipts during 1966 amounted to £96. It is estimated that 3.3 per cent. of the visitors to the South car-park bought a Nature Trail leaflet, but the number who actually see the leaflet is probably three times greater; on the basis of 1 Trail/car and 3 people/car.

NOTICE BOARDS

These certainly achieve their main aims and objects but it is difficult to quantify the numbers of people who look and learn from them. The effect of well designed notices may be illustrated by the following example. Eight years ago a great many people picked Sea-lavender from alongside the South Marsh Road when the plant is in flower, but now the plant flowers right up to the edge of the track.

EFFECTS ON PLANT AND ANIMAL LIFE

The final results of experiments to measure quantitatively the effects of feet on the various habitats represented on the reserve are not yet available. Interim figures indicate that 7,500 people/season walking off a concrete path and on to the mature saltmarsh cause complete loss of the vegetation cover. A similar density walking over yellow dunes completely eliminates Marram, Sea-couch and Prickly Saltwort and results in considerable dune erosion. If protection is then afforded to these eroded areas, recovery of plant life is complete within about four years. On a grey-dune system, approximately 3,500 to 4,500 people cause local exposure of soil and sand.

The reserve is noted for its shore-nesting birds, Little Tern and Ringed Plover. It has been recorded that a maximum of 250 people walk in the vicinity of one of the two Little Tern breeding colonies during a fine Sunday in the nesting season. Prior to protection in 1965, this level of disturbance was sufficient to prevent any degree of breeding success, believed to be the result of inadvertent trampling on eggs and chicks. A single wire fence enclosing ten acres was erected with suitable notices on the northern part of East Dunes. This preventative measure was successful in that it deterred access to all but 15 per cent. of the public in that area. Of this percentage, only two people actually attempted to look for eggs.

Whatever degree of control over public disturbance was achieved the colony suffered from predation by foxes and only two chicks out of a total of seventeen nests were fledged successfully. Ringed Plovers also suffered from predation rather than disturbance, and only twelve chicks out of eighteen nests were reared.

In 1966 two enclosures were erected and successfully prevented people from causing disturbance to the breeding birds. These studies are continuing and the effectiveness of different types of notices are being evaluated.

TENTATIVE CONCLUSIONS

1. Public usage has increased tenfold since 1953.

2. Localization and canalization of cars and people has restricted the amount of damage and disturbance to a very considerable degree.

3. The prediction of peak periods of pressure has enabled the wardening services, both full-time and voluntary, to be used to far greater effect.

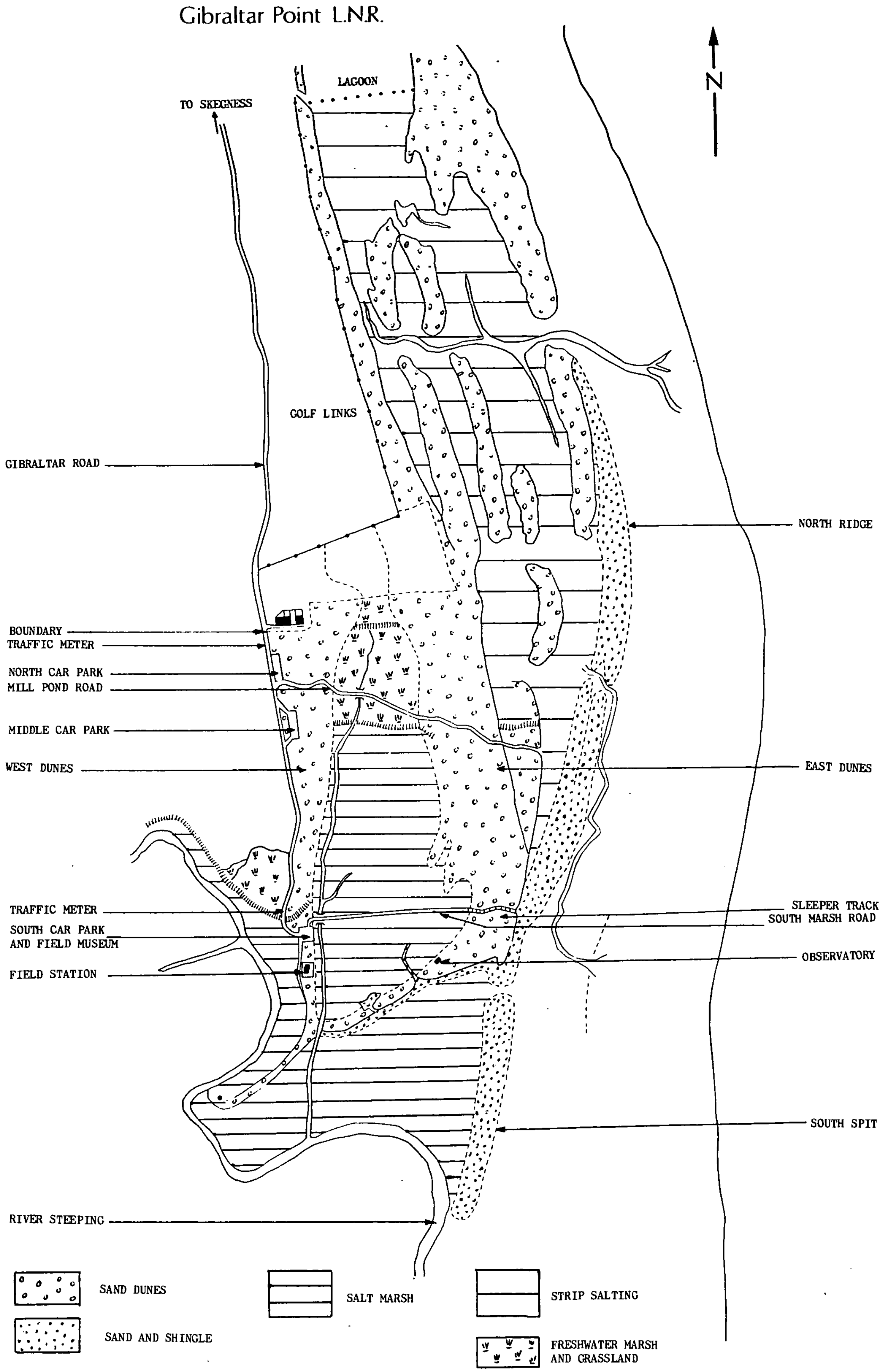
4. The measures taken to cater for the public are appreciated by them.

5. The visitors make good use of the Information Centre and the services it provides and derive a great deal of value from them.

The paper is a progress report and the results given form only a small part of the final document which will be prepared at the end of the 1967 season. In particular, a far greater amount of information will be available on the particular aspects of human impact on plant and animal life.

In the preparation of this paper, I would like to acknowledge the tremendous help from all those concerned with the exercise, in particular B. Wilkinson, A. E. Smith and M. Ball.

FIGURE 1


Gibraltar Point L.N.R.
LAGOON
TO SKEGNESS
N
GOLF LINKS
GIBRALTAR ROAD
NORTH RIDGE
BOUNDARY
TRAFFIC METER
NORTH CAR PARK
MILL POND ROAD
MIDDLE CAR PARK
WEST DUNES
EAST DUNES
TRAFFIC METER
SOUTH CAR PARK
AND FIELD MUSEUM
FIELD STATION
SLEEPER TRACK
SOUTH MARSH ROAD
OBSERVATORY
SOUTH SPIT
RIVER STEEPING
SAND DUNES
SALT MARSH
STRIP SALTING
SAND AND SHINGLE
FRESHWATER MARSH
AND GRASSLAND

AN ASSESSMENT OF DUNE INVERTEBRATE FAUNAS IN HABITATS VULNERABLE TO PUBLIC DISTURBANCE

Eric Duffey
Monks Wood Experimental Station

There are about 32 dune systems of major conservation importance in Great Britain, covering some 37,000 acres. Their position by the sea make them a natural focus for public recreational activity and consequently it may be difficult to control access to those which are nature reserves. The main management problem however, is not to stop public use but to regulate it so that the visitor does not feel there is significant loss of freedom and at the same time the fauna and flora are adequately safeguarded.

Whether this ideal arrangement can be achieved we have yet to see, but it is clear that dune areas are being used by more and more people each year and that in many cases considerable physical damage results. Three years ago a group of arachnologists and myself began to look for a suitable dune area on which to do an invertebrate survey and we found that the range of animal habitat types was low on those where public pressure was intense. We tried to find a relatively unspoilt system where there was a chronological sequence of vegetation units from the foreshore to completely stabilised formations on the landward side. These may not exist for natural reasons, either because of physiographical development or subsequent erosion. In the latter case all the early stages in the dune formation may be absent as the sea cuts back the shoreline.

A number of sites were examined in the neighbourhood of Swansea and the Gower in Glamorgan. The most important are those at Oxwich, Whiteford Burrows, Llangennith and Kenfig. The last of these is the most extensive and was probably the richest in wildlife before the development of the Margam Steel Works. At Llangennith, we found that the dune meadow part of the system was occupied by caravans and campers during the summer and that between this area and the shore considerable secondary erosion was taking place as a result of public disturbance. At Oxwich National Nature Reserve where the dune system has become very popular with holiday-makers during the last 15 years, the breaking up of the vegetation, followed by sand movement, had extended the yellow dune stage inland over a considerable area. A vegetation map which is currently being prepared by the Botany Department of University College of Swansea indicates significant changes in the plant cover compared with a similar map made 10 years ago, due to public use (Mr. G. T. Goodman pers.comm.). The Rosa pimpinellifolia L. and Geranium sanguineum L. association which is characteristic of the older stabilised dune areas has been largely replaced by Ammophila and Rubus spp. Whiteford Burrows National Nature Reserve however, is relatively inaccessible to the public because it can be reached only on foot and there we found the best undisturbed series of dune habitats. Parts of the area are grazed by ponies but this is not damaging the vegetation cover and a considerable proportion of the stabilised dunes were planted, in the past, with conifers. Details are described in the Whiteford National Nature Reserve Management Plan (White 1967).

THE FAUNA OF DUNE SYSTEMS

Although it is well known that the fauna of coastal dunes includes many species peculiar to this type of maritime habitat, much of the published information consists of notes or of species lists, some very comprehensive, but with no ecological analysis. Elton (1966) refers to the main studies of sand-dune animals and comments that the work of Diver on Studland Heath is the only British example of an analytical survey. Only a small part of this work, on grasshopper populations, has however, been published (Diver & Diver 1933). Published observations on dune faunas usually describe the animals peculiar to "drift sand" or "marram dunes" but reference is seldom made to other components in the complex series of dune habitats.

Our surveys attempted to make an assessment of the diversity of animal communities on dune systems and enable some comparison to be made of the number of species and individuals between one habitat and another. Plant ecologists have described the chronological sequence of vegetation types, beginning on the foreshore and moving inland. Generally accepted terms are "strand line" for plants growing on the narrow zone of drift-material deposited by the upper reaches of the tide; "embryo or fore-dunes" on the seaward side of the main system and usually vegetated by _Agropyron junceiforme_ or _Elymus arenarius_; "yellow or white dunes" for the actively growing dune ridge vegetated almost exclusively by _Ammophila arenaria_ but with a good deal of mobile sand; "late yellow dune" for the more mixed vegetation on the landward side of the main dune ridge and "fixed dune" for the various types of closed vegetation where _Ammophila_ is absent or if present, no longer dominant. In addition dune slacks may be present where the seasonally fluctuating water table is at or above ground level at certain times of the year.

Using these terms as a basis we wished to devise a simple system of describing animal habitats which covered as wide a variety of formations as possible and could be used by survey teams on different dune systems. It was also important that the units could be easily recognized by the non-professional, or zoologists with little botanical knowledge. Certain marginal or transitional zones which might be important to the botanist but less so to the zoologist may not be adequately covered but for the most part these are probably not significant from the point of view of the main animal communities. The animal habitat zones selected were as follows: (Fig. 1).

1. Drift-line. The accumulation of dead organic material, usually marine algae but sometimes with _Spartina_, together with driftwood and other debris. The formation, composition and position on the foreshore varies according to weather and season. This habitat has no living plants unlike the "strand-line" of the botanist.

2. Fore-dune. This name is preferred to "embryo-dune" because it describes the position of the zone on the seaward side of the main dune formation. Low dunes usually less than one metre in height; may be 100 m. or more in width as at Blakeney Point, Norfolk, and Tentsmuir, Fife but usually a relatively narrow zone of 2-5 m. Floristically poor and typically dominated by the grass _Agrophyron junceiforme_ or in a few cases _Elymus arenarius_.

3. Yellow Dune. The main Marram (_Ammophila_) zone. The vegetation is usually tussocky with wide areas of mobile sand. This zone is often very extensive and may spread inland if heavy public use breaks up the fixed dune vegetation cover.

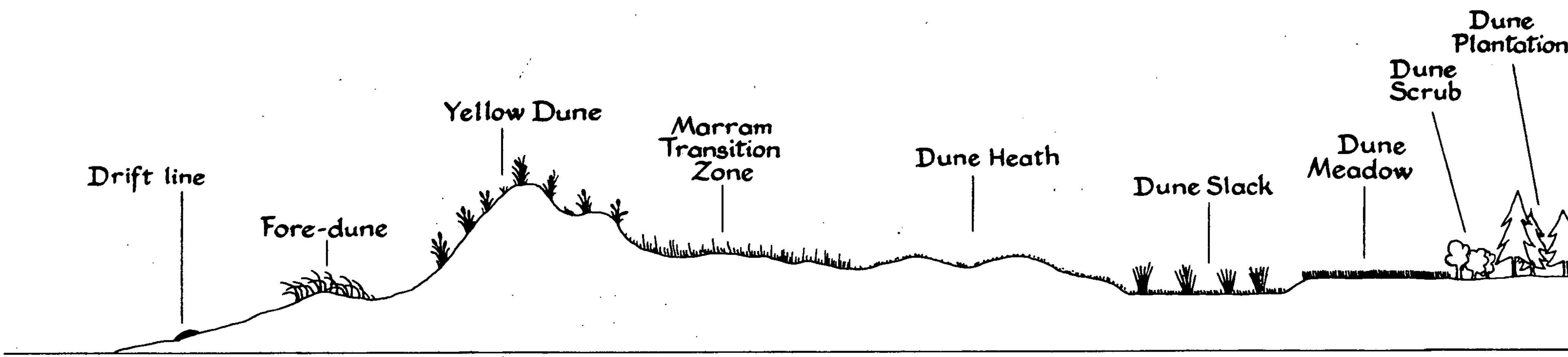


Fig. 1. Diagramatic representation of animal habitats on a dune system.

4. Marram Transition zone. This name describes the later yellow dune stage where Marram, although widespread, is losing vigour so that it is usually not tussocky and few plants flower. A considerable number of other plant species including some mosses and lichens are found, but the vegetation is still open with 20 to 30 per cent. bare ground. (A mosaic of Open-Ground and Field Type Formations, Elton & Miller 1954).

5. Dune Heath. This name includes the "grey dune" formation (Tansley 1939) originally given to the leached base-poor fixed dune having a predominantly lichen cover together with other fixed dunes where the vegetation consists of mosses or low prostrate herbs such as Thymus. Vegetation height does not normally exceed about 10 cm (the Open-Ground Formation, Elton & Miller 1954).

6. Dune Slack. A fresh-water or brackish marsh vegetation in seasonally water-logged ground. Includes the prostrate growth form of Salix repens and tall plants such as Juncus spp.

7. Dune Meadow. This name is used to describe a closed vegetation cover of the Field Type, usually exceeding 15 cm in height (if not grazed) and in which Marram is absent or insignificant. It may consist of a grass sward or of other tall herbaceous plants. At Tentsmuir a mixture of grasses and heather was included in this zone.

To these should be added two habitats which were not studied during our survey: 8. Dune Scrub, e.g. Sea Buckthorn, Hippophae rhamnoides and 9. Dune Plantations. These are usually of conifers but not in all cases.

The idealised profile in Fig. 1 does not imply that the chronological sequence is as indicated nor that the selected animal habitat zones always have clear boundaries. The variation in vegetation cover on a large dune system may be very complex, particularly in the Marram Transition zone and Dune Meadow, so that some areas cannot easily be assigned to any one of the nine categories. The behaviour of Marram is often upredictable and in some localities it may extend far inland and be a common plant in the Dune Meadow area. On some dune formations Calluna heath develops on the oldest fixed dunes and this might be regarded as a separate unit or a subdivision of 7. (Dune Meadow). There is no need however, for confusion between a fresh-water marsh and a dune slack, both of which may occur. Saltmarshes are not included in this system although some may share common plants with dune slacks and a well-formed drift-line is usually found. Additional minor habitats may have to be added according to complexity of the system as, for example, the Salix repens dunes of west coast formations, which usually develop around the dune slacks.

No accurate measure has been made of the proportion of a dune area which would be included in the 9 animal habitat categories described, but estimatesat Whiteford, Tentsmuir and Scolt Head suggest that not more than about 8 per cent. would fall outside.

METHODS

The survey team usually consisted of 10 zoologists, of which 8 were arachnologists collecting mainly spiders and harvestment, while 2 others collected beetles, bugs and woodlice. In 1965 a botanist accompanied the party and plant lists were made in the animal habitats. The team worked for one week in July 1964 and September 1965 at Whiteford Burrows National Nature Reserve, one week in June 1966 at Tentsmuir National Nature Reserve and will do a further week in April 1967 at Whiteford. The object of each week's work was to collect for a specified period of time, usually units of a $\frac{1}{2}$ hour or 1 hour in the 7 main habitats trying as far as possible to devote the same amount of time to each. At the end of the week between 72 and 132 hours collecting had been done with an average of 19% hours per habitat.

The team included both amateur and professional zoologists and each member had to learn to recognize the 7 habitat zones in the field. With some initial practice each year before collecting began, this exercise did not prove difficult. Apart from this the only self-discipline asked of members was accurate time-keeping and the need to collect everything, even if one species proved to be abundant. Each survey week produced between 100 and 145 species of spiders and between 1,500 and 3,500 specimens.

The most abundant species at Tentsmuir in June 1966 was Hypomma bituberculatum which totalled 510 specimens; one adult every 2.2 minutes for 19 hours collecting in the Fore-dunes where it was most common.

RESULTS

In Fig. 2 the mean number of spiders collected per hour is illustrated for Whiteford in September 1965 and Tentsmuir in June 1966. The total number of species of spiders collected in each habitat is also shown. At Whiteford the same type of histogram profile was recorded in July 1964 although fewer specimens were taken. The Tentsmuir results were unusual in recording the highest numbers of spiders in the Fore-Dunes (a temporary effect due to the maturing of Hypomma bituberculatum) and the very high species totals in the Dune Slacks and Dune Meadow. The latter is ungrazed at Tentsmuir and includes patches of heather.

At Whiteford there was a rapid rise in the number of species from the Drift-line, where there are small numbers of specialized species, to a much higher total in the Yellow Dunes or Marram Transition dunes. The numbers of specimens taken per hour also increases rapidly in the same way but falls in the Marram Transition zone, Dune Heath and Dune Slacks rising to a higher total of species and individuals in the Dune Meadow. Seasonal changes are also important. At Whiteford more specimens were taken on the Dune Heath and Yellow Dunes in September than in July but the species totals did not vary very much.

In Table 1, 42 of the more common dune species are listed together with the total number taken in each habitat. Each total is adjusted to an average of 19 hours collecting. Inspection of the Table shows that each habitat zone has its own characteristic group of species and this is, in general, maintained through different seasons. Some species however, may be equally common in two adjacent or separated habitats.

/Figure 2 .....

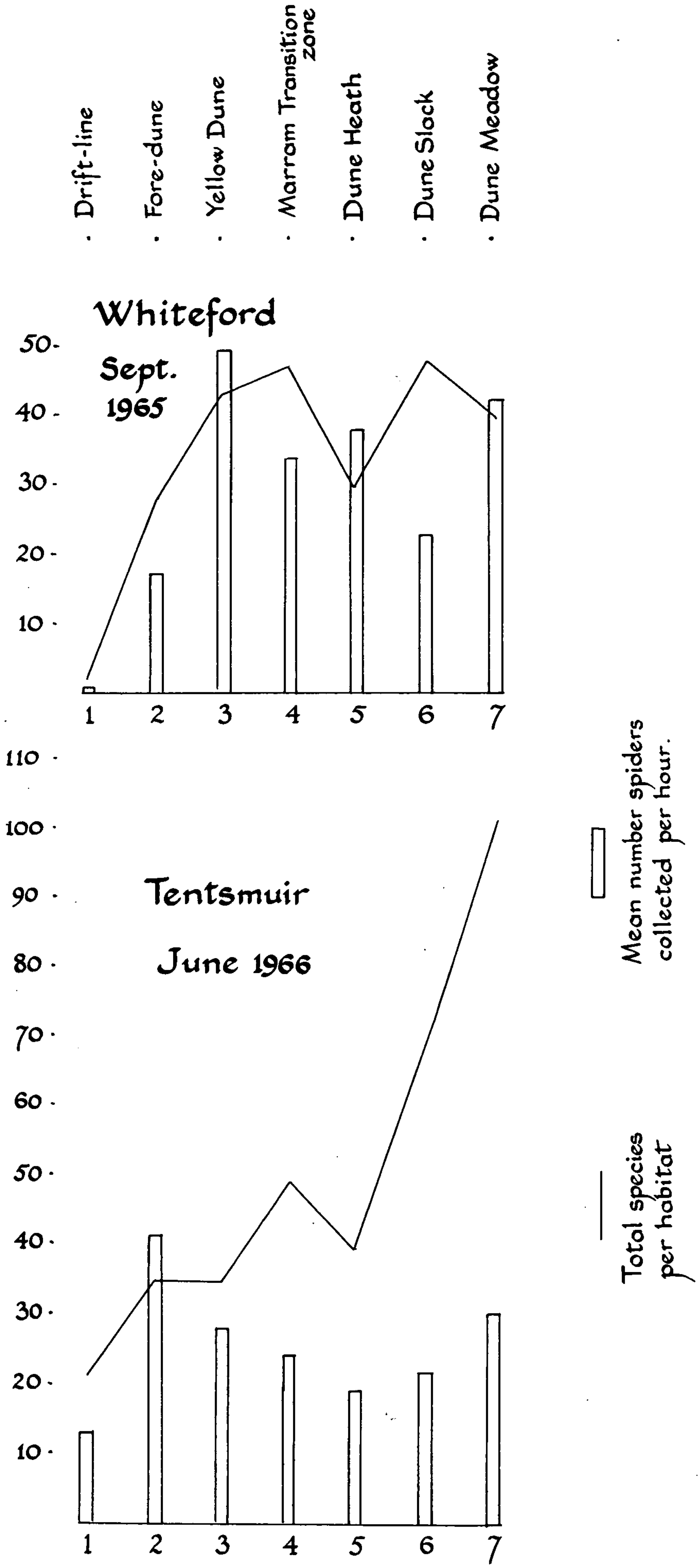


Fig. 2. Total of species recorded for each habitat and mean number of spiders collected per hour.

TABLE I

NUMBERS OF COMMON SPIDERS AVERAGED TO 19 HOURS COLLECTING, AT WHITEFORD (W) AND TENTSMUIR (T)
PEAK NUMBERS UNDERLINED

	Drift Line	Fore Dune	Yellow Dune	Marram Transi-tional Zone	Dune Heath	Dune Slack	Dune Slack Juncus Tussocks	Dune Meadow	Month	Site
Silometopus ambiguus	26.6								June	T
Erigone arctica	88.3	25.0							June	T
Porrhomma pygmaeum	18.5	12.3		1.4		9.2		14.3	June	T
Erigone atra	39.0	70.7	5.3	-	6.2	1.9		8.7	July	W
Oedothorax fuscus	10.3	39.0	1.8	-		3.7		2.2	July	W
Oedothorax fuscus		34.0							Sept	W
Lepthyphantes tenuis	2.0	51.2	15.1	-	3.1	5.6		15.2	July	W
Lepthyphantes tenuis		100.6	124.8	11.3		10.5			Sept	W
Lepthyphantes tenuis	16.4	101.4	12.2	1.7		2.9		0.5	June	T
Hypomma bituberculatum	22.6	510.1	335.2	28.2	1.0	47.8		6.6	June	T
Hypomma bituberculatum						14.0			Sept	W
Arctosa perita	2.0	10.9	7.3	1.7					June	T
Arctosa perita	8.2	29.3	14.2	-				8.7	July	W
Arctosa perita		1.3	20.8	9.0	13.0				Sept	W
Theridion bimaculatum		43.9	43.4	-		5.6		21.7	July	W
Theridion bimaculatum		6.3	148.2	17.0		14.0		79.6	Sept	W
Tibellus oblongus	2.0	9.4	30.4	16.6		3.9		2.8	June	T
Tibellus oblongus		1.3							Sept	W
Tibellus maritimus						2.0			June	T
Tibellus maritimus		14.6	12.4	-				23.8	July	W
Tibellus maritimus				2.3					Sept	W
Tibellus spp. (immature)			45.2	-				49.8	July	W
Tibellus spp. (immature)		8.8	301.6	126.6	1.9	3.5		4.9	Sept	W
Synageles venator			4.3	-				4.3	July	W
Synageles venator			28.6	5.7					Sept	W
Xerolycosa miniata		1.5	7.3	8.3	14.0	2.9		0.6	June	T
Xerolycosa miniata			28.4	-	6.2			17.3	July	W
Xerolycosa miniata				27.1	18.6				Sept	W
Clubiona phragmitis		2.4	7.1	-					July	W
Clubiona phragmitis		10.1	28.6	1.1				3.3	Sept	W
Clubiona neglecta			3.7	19.9	1.0	5.9		3.3	June	T
Clubiona neglecta				4.5		1.2			Sept	W
Clubiona spp. (immature)			11.5	-	9.4	9.3		10.8	July	W
Clubiona spp. (immature)			36.4	9.5	13.0	13.9		30.8	Sept	W
Agroeca proxima		1.3	2.6	12.4		3.5		3.3	Sept	W
Agroeca inopina		10.1	15.6	76.9		1.2		3.3	Sept	W
Agroeca spp. (immature)			4.3	-				45.5	July	W
Agroeca spp. (immature)				32.8				3.3	Sept	W
Stemonyphantes lineatus			4.7	31.6	9.0	3.0		2.2	June	T
Stemonyphantes lineatus			5.2	17.0	1.9	7.0		8.1	Sept	W
Peponocranium ludicrum		1.6	9.8	82.1	30.0	4.9		36.8	June	T
Lycosa nigriceps			7.3	34.9	2.0	6.8		7.1	June	T
Lycosa monticola			1.2	11.6	65.0	18.5		0.5	June	T
Lycosa monticola				5.7	76.1				Sept	W
Zelotes electus				10.0	14.0			0.6	June	T
Zelotes electus			1.3	17.0	70.6	4.7			Sept	W
Argenna subnigra		7.3		-	10.9				July	W
Argenna subnigra			1.3		29.7			4.9	Sept	W
Typhocrestus digitatus			7.6	4.1					June	T
Typhocrestus digitatus				19.2	76.1	1.2			Sept	W
Prospotheca monoceros				2.3	9.3	1.2		4.9	Sept	W
Styloctetor romanus		3.8	6.5	3.4	115.1				Sept	W
Pocadicnemis pumila		1.7	3.5	3.4	1.0	8.8		38.0	June	T
Araneus redii			9.1	17.0	7.4	23.3		120.3	Sept	W
Singa pygmaea				3.4		18.6		53.6	Sept	W
Lycosa pullata				3.3	17.0	31.2		30.8	June	T
Lycosa pullata						7.0		22.8	Sept	W
Troxochrus scabricula			2.7	-				41.2	July	W
Theridion ovatum	2.0		8.9	-	9.4	3.7		184.2	July	W
Maso sundevalli			10.6	-		5.6		17.3	July	W
Lepthyphantes ericaeus	4.1	4.7	13.4	6.6	1.0	9.8		22.0	June	T
Metopobactrus prominulus	2.0	1.6				3.9		17.0	June	T
Micrargus herbigradus				1.7		2.9		12.1	June	T
Oedothorax gibbosus						2.9		20.3	June	T
Oedothorax retusus	2.0	1.6	2.4			26.3		3.8	June	T
Centromerita concinna				4.5	1.9	23.3		11.4	Sept	W
Trichopterna thorelli			1.3			30.2		8.2	June	T
Drassodes spp. (immature)				-		11.1	6.6	17.3	July	W
Drassodes lapidosus			1.3	10.2	1.9	15.1	97.5	8.1	Sept	W
Gongylidiellum vivum	2.0	4.7	2.4	0.8	4.0	41.0		40.6	June	T
Gongylidiellum vivum						2.3	17.6	3.3	Sept	W

Only a few species are almost exclusively coastal in distribution in this country. Of these Erigone arctica is most abundant in the Drift-line, Arctosa perita in the Fore- and Yellow Dunes, Xerolycosa miniata in the Yellow Dunes, Marram Transition zone and Dune Heath and Zelotes electus, Argenna subnigra and Styloctetor romanus in the Dune Heath. The fauna of the Dune Meadow and Dune Slack end of the series was relatively rich but for the most part it includes widespread species which may be found in grassland areas inland. The Whiteford Drift-line fauna largely disappears in September when this habitat decomposes or is covered by blown sand. Some of the spiders may overwinter elsewhere, perhaps as eggs or young, but there is evidence that other invertebrates may move into the Fore- or Yellow Dunes. The carabid beetle, Eurynebria complanata moves up into the into the vegetated dunes in the autumn and Armadillidium album, another exclusive Drift-line species may burrow into the sand until the reforming of a drift-line in the winter or spring.

The list includes a number of very common and widespread species which occur in many different inland habitats. On a coastal dune system however, they appear to be clearly zoned so that useful information on their ecological preferences can be obtained. Examples include:

Erigone atra	Typhocrestus digitatus
Lepthyphantes tenuis	Pocadicnemis pumila
Theridion bimaculatum	Centromerita concinna
Stemonyphantes lineatus	Lycosa pullata

Peponocranium ludicrum

Another group of species shows two peaks in numbers with the secondary peak in a very different dune habitat. For example Porrhomma pygmaeus, Theridion bimaculatum, Hypomma bituberculatum, Lepthyphantes tenuis and Lepthyphantes ericaeus have a main peak in the Fore/Yellow Dune area and a subsidiary one in the Dune Meadow or Dune Slack. Two of these (H. bituberculatum and P. pygmaeum) together with Synageles venator, Clubiona phragmitis and Thanatus striatus are typically associated with wet places on inland sites, particularly fens. This curious behaviour on coastal formations is not understood but it may be determined partly by the vegetation structure and the milder maritime climate.

In some species the immature stages appear to have different habitat preferences compared with the adults. The adults of the two Agroeca spp. were most numerous in the Marram Transition zone but in July the young were more frequent in the Dune Meadow. The two common Clubiona spp. were most numerous in one case in the Yellow Dunes and in the other in the Marram Transition zone. Immature spiders of these species were more widely distributed and equally common in the Dune Meadow and Dune Slack.

The small components of the dune animal habitats may sometimes be of special importance either for structural reasons e.g. Theridion saxatile on the sttep sides of the Salix repens dunes or because of microclimatic differences. Two examples of the latter can be quoted. In July at Whiteford, immature Drassodes spp. were equally common in the Dune Meadow and Dune Slack with 18.9 per cent. of the numbers taken, occurring in the

Juncus acutus tussocks of the slacks. In September after a period of dry weather 72.7 per cent. of the total specimens were taken in the Juncus tussocks. Similarly in June at Tentsmuir Gongylidiellum vivum was widely distributed but with highest numbers in the Dune Meadow and Dune Slack. In September at Whiteford about 75 per cent. of this species was taken in the Juncus tussocks. In these cases the higher humidity of the thick tussock formation provided a refuge for those species sensitive to desiccation. The same appears to hold for some species of woodlouse. In September at Whiteford Porcellio scaber was widely distributed from the Yellow Dunes to the Dune Meadow but 81 per cent. of the specimens of Philoscia muscorum and 61 per cent. of Armadillidium vulgare were taken in the Juncus tussocks of the Dune Slacks.

Not only do the described habitats have different faunas but there is movement from one to another in relation to climatic conditions, seasons of the year and stage in the life-cycle. It is important therefore that a mosaic of different habitats should be maintained throughout the dune system. The greater uniformity imposed by disturbance will mean a loss of the habitats required by certain species with narrow ecological tolerances and is also likely to affect the numbers of other species requiring a range of habitat conditions for survival.

Ecological survey on all dune systems likely to be affected by public use is not possible because not enough staff with special knowledge are available. Periodic survey on a few important sites might be possible however, and these could act as standards for predicting the changes which might occur on other dune areas where public use is intense. The preparation of vegetation maps every few years using ground survey data and aerial photographs would be particularly valuable. The view is expressed that the most useful results from invertebrate surveys are obtained by a properly organized team of specialists all working together to an agreed plan; the main object of such work should be ecological analysis rather than the preparation of species lists.

ACKNOWLEDGEMENTS

The survey work described was only made possible by the willing cooperation of members of the British Spider Study Group and my colleagues, Dr. M. Morris and P. Harding at Monks Wood Experimental Station. I am also very grateful for the financial help provided by Peter Walters-Davies, Regional Officer for South Wales and Miss N. Gordon, Regional Officer for North and Central Scotland.

REFERENCES

DIVER, C. & DIVER, P. 1933. Contributions towards a survey of the plants and animals of South Haven Peninsula, Studland Heath, Dorset. III Orthoptera. J.Anim.Ecol., 2: 36-39.

ELTON, C. S. 1966. The Pattern of Animal Communities. London.

ELTON, C. S. & MILLER, R. S. 1954. The Ecological Survey of Animal Communities with a practical system of classifying habitats by structural characters. J.Ecol., 42: 460-96.

TANSLEY, A. G. 1939. The British Isles and their Vegetation. Cambridge.

WHITE, D. A. 1967. Whiteford National Nature Reserve Management Plan. The Nature Conservancy.

SUMMARY OF DISCUSSION

A participant commented on the dune systems which he had studied in the Hebrides. These sites were all grazed and he found that the numbers and distribution of earthworms, beetles and harvestmen were influenced by the grazing pattern and numbers of cow pats. On Tiree, the faunas of the grazed and ungrazed dune grassland, although very different, were of equal quality contrary to what the speaker had suggested was the case for inland grassland areas.

THE BIOLOGICAL IMPLICATIONS OF ESTUARINE BARRAGES

M. J. Hudson
The Nature Conservancy, Shrewsbury

INTRODUCTION

Man has had, until recently, a limited impact upon estuaries, which have retained many of their habitats in a more or less natural condition, and these are frequently extensive and remote from centres of human activity. They include a wide range of habitats, some of which are among the most fertile in the world, and these features combine to create condition which are attractive to large concentrations of animal and plant life. In terms of primary production some estuaries produce 10-25 gms. dry matter per square metre per day.

The particular features of estuaries maintain a flow of biological energy at rates often much greater than in either sea or fresh water.

These are:

a) Tidal action which promotes a rapid circulation of nutrients and food and aids in the rapid removal of metabolic waste products.

b) A diversity of plant species and life forms which provides a continuous photosynthetic carpet despite variable physical conditions. Three major types of primary producers maintain high rates of gross production:

   1) phytoplankton

   2) benthic microflora - algae living on rocks, mud, etc.

   3) large attached plants - seaweeds, eelgrass, emergent marshgrasses.

c) An estuary forms an efficient nutrient trap where physical factors such as differences in salinity bring about vertical as well as horizontal mixing and biological factors such as the presence of colonial molluscs maintain a cyclical flow of nutrients particularly phosphorus, e.g. mussels which are important for this reason in spite of the fact that they constitute only a small part of the total biomass.

d) A year round succession of "crops" even in high latitudes, giving a high rate of primary production.

e) Close contact between autotrophic and heterotrophic layers, so that in short food chains there is a large source of available energy, relatively little having been lost in transfer from primary producers (autotrophs).

While the physiography of the estuary is constantly changing, the changes for the most part are gradual and, though the vegetation and animal life undergoes a continuous succession, the processes of accretion and erosion combine in such a way as to create conditions which bring about a measure of stability.

The estuarine environment is also constantly changing for, not only is there a perpetually changing pattern of immersion and exposure, but also variation in the salinity of the water, with its inherent problems of osmoregulation and tolerance of turbidity.

In consequence a specially adapted fauna and flora has evolved which is capable of withstanding these conditions.

Estuaries frequently support four main types of habitat - rocky shores, sandy beaches and dunes, inter-tidal mud flat and saltmarsh, and before discussing the implications of barrages it is necessary to consider briefly the communities which are found in the last two of these which are the ones most likely to be affected by the construction of barrages.

The most extensive habitat is the inter-tidal mud flat. Most of this is largely free from vegetation save for Ulva, Enteromorpha and Zostera.

Though the fauna of the mud, muddy sand and sand is limited in species, the individuals of the dominant species are exceedingly numerous. Estimates in the Dee Estuary by Stopford (1953) showed that the small snail Hydrobia ulvae occurred in numbers up to 12,500 per square metre in muddy inshore regions. Other organisms such as Sabella and Macoma may be equally numerous and contribute to a rich supply of food upon which the waders and several species of duck are largely dependent.

The saltmarsh is normally densely clothed by vegetation, at least in its upper levels, but the range of species is somewhat restricted, and forms a strict zonation. The animal populations are also rather restricted in species diversity, and they vary with each stage in the vegetation succession. This habitat probably is of more value as resting and nesting cover for wildfowl and waders than for food.

The range and variety of the flora covering the dunes and its associated fauna, like that of saltmarshes, increases with increasing distance from the sea, so that even if the lower dunes are submerged the loss in terms of numbers of species will not be particularly serious. However, some species are characteristic of the lower zones and may be rare or absent in the more advanced dune communities as has been shown by Dr. Duffey in his paper on Dune Invertebrate Faunas.

It is into this situation that it is proposed to insert barrages which upon their completion immediately prevent the further mingling of river and sea water and create, from an area subject to a continuous daily cycle of changes in water and food supply, protection and exposure, one where conditions would tend to be relatively constant.

Littoral communities of the estuary would inevitably be destroyed, and other organisms would be under selective pressure from competitors better adapted to the new conditions.

After an initial period of leaching out lasting perhaps five years or so, a fresh water area is created behind the barrage separated abruptly from the salt water beyond, the zone of gradual transition having been destroyed. In the case of the Ijsselmeer the salinity fell from 5.56‰ cl' in 1932 to between 0.5 and 0.16‰ cl' in 1937.

The bottom of the estuarine reservoir would probably support only Chironomid midges, tubificids and other oligochaetes for a period of two to four years. During this period the reservoir would be open to colonisation both from its inflows and airborne sources, the nature of the water in the inflow streams determining the ultimate productivity. Sewage, non-toxic industrial wastes and leached fertilisers will tend to increase the potential productivity of the water and in part compensate for the loss of tidal action which formerly brought about the rapid circulation of nutrients.

However, if the reservoir is fairly deep, summer stratification would be inevitable with a severely de-oxygenated hypolimnion. There would be a tendency for herbicides, insecticides and toxic industrial wastes to accumulate behind the barrage with unpredictable effects both on bottom fauna and fisheries.

Areas of water not greater than 10 ft. in depth are likely to become covered by rooted plants and the cessation of tidal changes in water level would probably encourage the growth of marginal vegetation. In bays and inlets where silt would tend to accumulate rapidly common reed, Phragmites communis would be likely to establish itself, and would almost certainly be succeeded by a fresh-water hydrosere, which would progressively encroach upon the reservoir. Large areas of reed or reed grass, Phalaris arundinacea would offer considerable attraction to birds presenting habitat conditions similar to those of the Norfolk Broads and might encourage typical marshland species.

An extensive growth of vegetation would encourage a rich invertebrate fauna including insects and crustacea. Among the former, Chironomids might be produced in very large numbers during the first few years after establishment of the reservoir. In the Ijsselmeer Chironomids were a serious nuisance after the closing off of the Zuider Zee in 1932 until the colonisation by fish, particularly ruffe, Acerina vulgaris took place in numbers sufficient to control the midge larvae.

Once a relatively stable biological system has established itself, the primary production of the shallow lake formed by the barrage would probably fall, and figures between 3-10 gms. dry matter/sq. metre/day would then apply, but will depend on the nature of the water flowing into it and the depth - shallow waters being more fertile than deeper ones.

The construction of a barrage creates serious problems for migrating game fish and fish passes would be essential to permit passage to and from the sea, and it would be necessary also to minimise pollution of the reservoir. It is likely that the reservoir itself would be colonised by fish; the actual species depending on the populations in the local rivers. Brown trout, Salmo trutta might invade in appropriate areas, but as silting and weed growth increased, conditions would become more suitable for coarse fish and perch, Perca fluviatilis, roach, Rutilis rutilis and rudd, Scardinius erythrophthalmus, tench, Tinca tinca, and bream, Abramis brama, and pike, Esox lucius which would increase at the expense of trout. Eels, Anguilla anguilla would certainly be quick to colonise. At the Ijsselmeer in Holland, the production of fish from the water, though reduced in volume, increased from 12 to 20 million kg. per year, without any new species being introduced.

The construction of an estuarine barrage would inevitably result in a considerable reduction in the extent of sand and mud available as feeding areas to wading birds, and the populations of these species would certainly decline locally. On the other hand the reservoir would probably provide a large feeding area suitable for duck, which might be expected to increase and would in any case find the water attractive for roosting.

Although silt would tend to settle more rapidly within the confines of the barrage, the quantity brought in by the inflowing river, will inevitably be deposited within a much smaller area.

Thus suspended silt would severely reduce penetration of light, and so restrict the growth of planktonic algae and rooted plants. Moreover, recirculation following summer stratification would discharge enormous quantities of freshly settled silt back into the upper layers of the water, and this would restrict the autumnal burst of plankton production which would normally occur at this time.

Silting would, in any case, be a serious management problem, and frequent dredging operations would be necessary.

For the duration of stratification, however, planktonic Blue Green Algae, e.g. Aphanizomenon flos-aquae, would presumably be in a favourable situation, and heavy blooms might be anticipated, since these occurred in the Brielle Meuse following its damming off in 1950.

Interference with the pattern of tidal streams would probably result in considerable accretion of material on the seaward side of the barrage and consequent formation of saltmarsh but depending on the topography of the coastline scour might be sufficient to prevent this.

With many barrages having been proposed for the purpose of water storage it is conceivable that a substantial drawdown might occur in periods of heavy demand, and that this would result in considerable interference to submerged vegetation and to fish populations. The exposed mud would, however, offer feeding areas suitable for wading birds and this could be valuable if the drawdown coincided with autumn passage.

CONCLUSION

There are thus a considerable number of biological problems which arise when estuaries are dammed off by barrages. In this country we have relatively little experience on which to base forecasts of the probable results and it is vital that adequate scientific investigation should precede the setting up of the barrage and monitor its consequences.

As has been implied, there is much that can be learned from the experiences of other nations, particularly those of the Netherlands.

From a biological point of view the construction of estuarine barrages involves the scientist in consideration of a profit and loss account. The diversity of habitats each with specialised communities determined by a multiplicity of factors found in most estuaries is superceded by a single habitat in which the various communities are largely determined by a single factor - namely, water depth. The animals and plants of the estuary are replaced by organisms better suited to conditions within the lake formed by the barrage.

One of the most conspicuous features of estuaries is the wealth and variety of its birdlife. The most numerous species are waders, which in some estuaries may occur in tens or even hundreds of thousands. These birds either over-winter in Britain or stop off on passage on their way from breeding grounds in arctic and subarctic regions to wintering grounds in the southern hemisphere. Estuaries such as the Dee and Solway and certain other coastal areas such as the Wash are thus most important areas on these migration routes and may well be vital to the conservation of these species. At a time when barrages are being considered for the Dee, Morecambe Bay and the Solway, and several other estuaries, there is cause for grave concern for the conservation of these species. This concern prompted the International Wildfowl Research Bureau to draw the matter formally to the attention of the Nature Conservancy at the Second European Meeting on Wildfowl Conservation.

Undoubtedly waders will be adversely affected by barrage schemes but ducks and marsh birds may be expected to profit from them.

The closing off of an estuary produces a system out of equilibrium for a few years and may have adverse or unforeseen side effects such as the mass invasion of _Salvinia_ and _Eichornia_ in tropical reservoirs. However, these phenomena are largely temporary and should disappear once a new steady state is reached. These bursts of production are particularly associated with the formation of reservoirs in river valleys and result from the abnormally high nutrient level present initially in the water when land is first inundated.

As recorded above, fish production from the Ijsselmeer was large after completion of the dam across the Zuider Zee and good growth rates of fish initially have been recorded elsewhere. Once equilibrium has been attained growth rates tend to fall off.

There are therefore many biological considerations which must be taken into account when considering whether the needs of the human population are best served by the destruction of highly productive estuarine ecosystems.

In conclusion I would like to offer a quotation for your consideration. The late Aldo Leopold, the great American Conservationist, has said man has difficulty in understanding organic function in any system he has not built himself. Hence, he will permit the destructive tampering with the landscape by the rankest amateurs even though he would not permit an amateur to tinker with his expensive watch.

I am grateful to Professor W. R. Kershaw and Dr. M. Pugh Thomas of Salford University, Dr. E. M. Burrows of Liverpool University and Mr. H. Gilson, Director of Freshwater Biological Association, for the opportunity to discuss with them the implications of the Dee Barrage and to Mr. Colin Reynolds and Mr. P. H. Oswald for their helpful comments on earlier drafts of this paper.

REFERENCES

DUFFEY, E. 1967. An Assessment of Dune Invertebrate Faunas in Habitats Vulnerable to Public Disturbance. Third Scientific Staff Symposium.

GILSON, H. C. 1966. The Biological Implications of the Proposed Barrages Across Morecambe Bay and the Solway Firth in "Man-Made Lakes". Institute of Biology and Academic Press. London and New York.

KERSHAW, W. E. & PUGH THOMAS, M. Report on Zoological Implications of Barrage proposals in the Dee Estuary. Unpublished.

LITTLE, E. C. S. 1966. The Invasion of Man-Made Lakes by Plants in "Man-Made Lakes". Institute of Biology and Academic Press. London and New York.

ODUM, E. P. 1963. Ecology. Holt, Reinhart and Winston, New York. 152 pp.

STOPFORD, S. M. 1953. An Ecological Survey of the Cheshire foreshore of the Dee Estuary. J. Anim. Ecol. 20, 103-122.

VAAS, K. F. 1966. Lakes in Dutch Reclamation Schemes in "Man-Made Lakes", Institute of Biology and Academic Press. London and New York.

SUMMARY OF DISCUSSION

The Chairman thought that one of the important effects of the creation of estuarine barrages was the replacement of the diurnal tidal regime of drawdown by an annual regime of drawdown. This would mean that the banks exposed when the water levels were low would be baked in the sun and this would have a very profound effect on the animal life in the sand and mud. A drawdown of 16 feet had been estimated in the Morecambe Bay study.

The creation of exposed mud flats was a very unaesthetic part of the effect of barrages making the area unpleasant for residents. The speaker said however, that in the case of the Dee estuary, many people who at the present time have a view of the saltmarsh would in the future look over extensive fresh water because it was intended that permanent lakes should be created in certain places for recreational purposes.

In the case of the Dee estuary there would be greater access to North Wales just as the Severn Bridge had made an easy link with South Wales. This had lead to a greater flow of traffic and access to areas in South Wales.

A participant said that although there had been quite a lot of discussion about the effects on the wildlife within the area flooded by a barrage, one should not overlook the possibility that there may be profound effects outside the barrage area. In the case of the Wash scheme for instance, there seemed a possibility of a new sort of scour being created along this part of the east coast, and that it had even been hinted that the resulting erosion might, in the course of time, remove Scolt Head and Blakeney Point Nature Reserves. One should also bear in mind the changing pattern of human movement in the Wash area because there seemed little doubt that a Wash barrage would also be accompanied by a new major road system.

VISITOR PRESSURE AT WYE AND CRUNDALE DOWNS N.N.R.

E. C. Hammond
Warden/Naturalist, Kent

INTRODUCTION

There are two sides to every equation and while this Staff Symposium is primarily concerned with the biotic effects of public pressure, I would suggest that in order to assess these effects, we must be able to evaluate and quantify the causative agent, namely the visitor. I emphasise this side of the problem as we are not often in the position of obtaining such data from other sources; Dr. A. Watson has indicated that such information when available is often not sufficiently accurate for our purposes. Indeed in most situations which concern us in the South East Region, there is no quantitative evidence and subjective evidence is at the best, sparse. While I will agree that subjective assessments are better than no values we must treat such data with extreme caution. For example in 1964, I asked three of the Honarary Wardens at Wye and Crundale Downs National Nature Reserve to estimate the numbers of visitors during the same half hour period. Their results were in the range of 40 to 50 people, in fact the actual number was 72, showing a 30 to 40 per cent. error.

Today I will describe the research in progress at the Wye and Crundale Downs N.N.R. in relation to visitor numbers, outlining the methodology involved and briefly summarize the results I have obtained.

LOCATION AND DESCRIPTION OF THE RESERVE

The reserve lies on the scarp face of the chalk escarpment of the North Downs about four miles north east of Ashford, and approximately ten miles from Canterbury to the east, Folkstone and the Channel coast to the south, and Faversham and north Kent coast to the north. The main London to Dover A.20 road passes within four miles of it and is easily visible from this road where it byepasses Ashford. It is a small reserve of only 123 acres almost equally divided into woodland and grassland, with its boundaries being in the main formed by good 'C' class roads at the top and bottom of the scarp.

By virtue of its accessability by road and the excellent vantage point it affords for views from the top of the scarp over a large tract of the Weald of Kent and the English Channel in the vicinity of Dungeness, coupled with the almost complete lack of any similar situation in this part of Kent, it attracts considerable interest from visitors.

Prior to the acquisition of the Reserve in 1961 by the Nature Conservancy the previous owner had allowed reasonably free access (in the main by default) by the general public for walking and picnicking, which is in keeping with the general attitude of most Kent landowners.

Since the 1950's the number of car-borne visitors has increased considerably so that in 1964 a zonation policy was introduced in an effort to marry the conflicting demands of the public for recreation with the prime function of conserving the habitats. This policy allows visitors free access without permits over parts of the top of the scarp and includes the major viewpoint "Millstone Point". At this time Ashford's population was under 30,000 but was scheduled for London overspill development to 60,000 plus by the 1980's; consequently it was decided that there was a need to investigate the number and pattern of usage by visitors.

POSSIBLE SURVEY METHODS

There are two main approaches which for the sake of convenience I have classified into manual and automatic.

(a) MANUAL

(i) Simple estimation of visitors

(ii) Counting total numbers of visitors per unit area

(iii) Plotting visitor numbers and positions on to a map (distribution maps)

(iv) Asking visitors specific questions

Dependent upon the quality and quantity of manpower available the method and sample size can be varied.

(b) AUTOMATIC

(i) Mechanical switch operating a counter

(ii) Proximity switch, operating a counter

(iii) Photocell-operating a counter

(iv) Car counters as used for traffic surveys

(v) Time lapse photography

These require limited manpower and can provide detailed data of visitor numbers over a long period of time. However they all are subject to technical limitations: methods (b) (i)-(iv) all require visitor canalisation; (b) (iv) is in addition partially dependent upon manual methods in assessing numbers of people per vehicle, while (b) (v) is only practical for suitable terrain.

SURVEY METHODS USED AT WYE

In 1964 when the survey was started there was no reliable published data on "passive recreation" with the exception of J. Wager's survey of Berkhampstead Common in Hertfordshire. In the absence of any quantitative evidence why the majority of visitors come to the Reserve, it was decided to initiate a questionnaire type survey involving interviewing visitors at peak pressure times so that we could orientate future management, publicity and wardening on a realistic basis.

A questionnaire was designed to obtain the following data: (in the light of experience gained during 1964, it was modified with the assistance of Mr. T. Burton of Wye College, Kent).

1. Distance travelled from home to reach the reserve - (radial, not road miles). Home being defined as the town or village from which the visitor and/or party had travelled on the survey day. In the event of a party containing two elements, i.e. a family resident in Canterbury plus visiting friends or relatives from London, the party was treated as coming from Canterbury.

2. Reason for visit - (scientific study, scenery, picnic). Scientific study applies to visitors carrying out a serious study and includes amateur natural history interests. In many cases, visitors came for a picnic <u>and</u> the scenery therefore when expressing the results for this question, the total percentages may exceed 100 per cent.

3. Frequency of visit.

   Initially it has been hoped to obtain an indication of the frequency of visits by visitors. However this proved extremely difficult and it was finally found most practical to assess this question in terms of "first visit" and the rest who visit to lesser or greater degree.

4. Knowledge that the area was a National Nature Reserve, prior to arrival.

   This gives an indication of the general state of the local knowledge about the Nature Conservancy and the effect of publicity via reserve leaflets and word of mouth.

5. Composition of visiting groups - (family party: adults only, children only).

   A family party is defined as one or more adults together with a child or children - although it could be possible for a grandparent or relative to be accompanying the child/children. In practice this is considered to be a negligible number of cases.

   An adult is defined as a person of 17 years or more, as this is the minimum legal age for driving a car.

Initial subjective assessments indicated that peak visitor numbers occurred between 1400-1700 hours on Sundays and Bank Holidays: consequently the majority of surveys took place during this period owing to the limited available manpower.

AUTOMATIC COUNTER

In 1965 in an effort to obtain an estimate of the total number of visitors to the reserve during the summer months, i.e. May to August, one of the two stiles which are used by the majority of visitors was modified so that pressure on the lowest bar activated an electro-mechanical counter.

/Table 1 ......

TABLE I

Summary of Results 1964-1966

		1964	1965	1966
1.	Numbers of visitors interviewed	1,271	719	513 (A)
2.	Distance travelled (radial miles)			
	Under 5 miles		22.7%	29.8%
	5-10 miles	See	21.6%	19.5%
	10-15 miles		21.7%	17.7%
	15-20 miles	Note	6.9%	15.8%
	20-25 miles		11.4%	13.3%
	Over 25 miles	(B)	6.4%	3.9%
	Inaccurate information*		9.3%	
3.	Reason for visit			
	Scientific study	2%	2.5%	Not Surveyed
	Scenery	98%	98.3%	
	Picnic	34%	29.8%	
4.	Frequency of visit			
	First visit	See Note (C)	44.2%	40.4%
	Came in last two years and/or this year		55.8%	59.6%
5.	Knowledge that area was an N.N.R. prior to arrival	42.5%	48.7%	56%
6.	Composition of visiting groups			
	Family party	62%	61.6%	54.7%
	Adults only	37.5%	37.8%	44.5%
	Children only	0.5%	0.6%	0.8%

(A) Single all day survey only on 28.8.66. - all visitors interviewed between 1000-1800 hours.

(B) The distance travelled was estimated by the visitors as under or over 10 miles. Results were as follows:

under 10 miles	57%
over 10 miles	43%

*On 16th May 1965, the interviewer used a 1964 questionnaire card in error; consequently the distances are estimated as under/over 10 miles and are not accurate radial mileage.

TABLE I (cont.)

However, it was found that this method was unreliable as visitors were often uncertain of the distance from home, while valuable data on points of origin were lost. Therefore in 1965 and 1966 the actual point of origin was recorded by the interviewer.

(C) Visitors were asked if they were "infrequent visitors", i.e. less than 6 times per year, or "frequent visitors", i.e. over 6 times per year. Results:

"Infrequent visitors"	72%
"Frequent visitors"	28%

Due to the inability of visitors to answer this question correctly plus the fact that "infrequent visitors" includes first-ever visitors it was altered in 1965 and 1966 to indicate the numbers of new visitors, i.e. "first visit".

AUTOMATIC COUNTER 1965 RESULTS

During the period 22nd May to 30th August it gave a calibrated reading of 4,795 visitors. In view of the second stile which receives approximately equal use, while all the other possible entry points only attract limited use, it is considered that the value given by the automatic counter X2 gave the best known approximation to the total number of visitors for the period i.e. approximately 10,000.

It was found that during this period by reference to the counter, we had interviewed approximately 8 per cent. of our total visitors.

DISCUSSION OF RESULTS

With reference to the Table I there are several obvious but nevertheless interesting results:

(a) Over 60 per cent. of all our visitors come from a drainage basin of 15 miles or less radius from the reserve. While a detailed breakdown of the 1965 and 1966 figures indicate that 20 per cent. come from the Ashford Urban District Council area, i.e. Ashford, Kennington and Willesborough.

(b) The 1964 and 1965 results provide ample evidence that the prime factor which influences visitors to come to the reserve at weekends is the magnificent view. However, it should be emphasized that the figures for "scientific study" is certainly artificially low as such visitors are not encouraged to use the reserve at weekends while organized parties can normally only visit the reserve during the week.

(c) There is a remarkably high incidence of "first-time" visitors, although it would appear to be slightly decreasing.

(d) It is heartening to see an improvement in the numbers of visitors who know that the area is a nature reserve. This is no doubt the result of several factors including press coverage of events on the reserve, active wardening by honorary wardens and reserve staff at weekends, good notice boards coupled with the introduction in 1965 of a cheap, simple give-away leaflet. Since the leaflet was introduced, we have given away over 6,000 and to date have found less than 20 discarded on the reserve or the adjacent road.

(e) The high proportion of family parties is to be expected showing the car-borne family weekend activity of a trip to the country and/or coast. The introduction of a self-guiding nature trail in 1965 has helped to interest children and parents alike.

The findings of the surveys has recently proved of value to the Region in assessing the effects of the proposed development of Ashford from the present figure of 30,000 to 150,000 plus on the Conservancy's interests in the area.

We were able to provide quantitative evidence to the Kent County Council which indicated that in 1965 and 1966 approximately 7 per cent. of Ashford's population visited the reserve. Assuming that the present percentage of 7 per cent. which demand this type of passive recreation facility remains constant, the proposed development would mean a total of 10,500 or 8,500 additional visitors from Ashford alone, i.e. nearly double the present total number of visitors.

The present visitor level of 10,000 plus per year is achieved without any proper car parking facilities and no doubt would be greatly increased, especially on fine Sundays, if car parks were provided. However, despite the resilience of chalk grassland to trampling, the present visitor is effecting changes to the flora on some parts of the open access zone. It is therefore doubtful if the present system could absorb the increase of the amount calculated above without causing management problems and damaging the prime function of the reserve.

SUMMARY OF DISCUSSION

In answer to a question asking for more details of the biotic effects of the public pressures described at Wye and Crundale, the speaker said that no quantitative observations had been made although their active team of Honorary Wardens were making many observational records.

Another participant said that he could not see that the use of this particular reserve would increase appreciably because the car parking facilities seemed to be very limited and most of the public reached it by car.

In reply it was said that the parking facilities were only used at peak capacity for limited periods such as weekends, Bank holidays etc., and that there seemed to be some possibility that this peak period would be greatly extended into other days. If this happened then the use made of the reserve could increase very appreciably.

CHANGES IN CHALK GRASSLAND CAUSED BY GALLOPING

F. H. Perring
Monks Wood Experimental Station

INTRODUCTION

This work was done mainly in 1955 and 1956 by A. O. Chater and myself on behalf of the Jockey Club who were concerned with the condition of parts of their race courses and gallops and were seeking advice on any changes of management which might reduce the wear on the sward.

The methods we adopted and particularly the analysis of the results were coloured by the fact that they had to be understood by officials of the Jockey Club which does not include many trained ecologists. However I make no excuse for presenting the results in the same simple form; it seems to me that if one of the objectives of this Symposium is to find methods of measuring the effects of biotic pressure on the environment, there may be merit in simple methods of measurement for an organization which has so many areas to administer.

GRAZING AND TRAMPLING

The domestic grazing mammal as a biotic factor affects the sward in three ways: mowing, treading and defaecating. The effects of these are by no means evenly spread over the sward: the 'mowing' is selective, the treading is concentrated around entrances or by scratching posts, and the defaecating may be similarly concentrated at particular 'resting' places. It is thus generally difficult to separate the effects of these three elements in normal comparative grazing experiments. As far as our problem can be related to the effect of human pressure on grassland reserve areas, it is treading alone which is of the greatest significance. Thus areas in which we can study the grazing animal as a treading machine only may be of particular interest, especially if this treading can be measured quantitatively. These conditions do prevail on the race courses and gallops of Newmarket Heath.

NEWMARKET HEATH

At the present day the Heaths around Newmarket administered by the Jockey Club cover over 2,000 acres and lie in an area 5 miles long and 1½ miles wide, partly in Cambridgeshire, partly in Suffolk. They represent a relic of the extensive sheep heath walk which was continuous south-westwards to Royston Heath and beyond into the Chilterns until the Enclosure Acts of about 1800.

SOILS

The underlying parent material is the Middle Chalk but in this area it is overlain by a thin layer of drift. Hodge and Seale (1966) recognize two soil series on the Heath: the Moulton and the Newmarket. They differ basically in the depth of the drift which consists of chalk fragments, flints, non-calcareous sand and loam. In the Moulton Series, the chalk may be over 2' below the surface and there is usually a well-marked B horizon: in the Newmarket Series, the B horizon is absent and the parent material is about 1' below the surface.

A typical profile (after Hodge and Seale, 1966):

0-8"	A	Very dark greyish brown, stoneless, friable sandy loam pH 7.6 $CaCO_3$11%
8-12"	A/C	Dark greyish brown friable loam containing abundant hard round chalk fragments up to 2" across pH 7.9 $CaCO_3$62%
12"+	C	White chalk rubble with occasional flints

The parts of the Heath to which I shall be referring in this paper all lie on the soils of the Newmarket Series or on the boundary between the two series.

The Jockey Club does not generally approve of soil pits being dug in large numbers on the Heath so that Chater and I confined our investigations to augering at every site to discover the depth of C horizon. In the ecological situation I am describing the soil variation is very small and can, with an exception I shall mention later, be regarded as uniform.

TOPOGRAPHY

The immediate prospect of Newmarket Heath, especially on the Cambridge or race course side is one of extreme flatness. On the Bury side though, there are two gallops with sufficient incline to warrant the name Hill - Long Hill and Warren Hill - but those of you who have climbed to the summit of Peas Hill or Market Hill in Cambridge will not be alarmed at the severity of these Newmarket Hills. Neither of the two areas I shall be dealing with in detail, the race course side of the Limekilns, have slopes which exceed 5^{o}. My experience on chalk grassland elsewhere suggests that slopes of this gentleness have no measurable effect upon the composition of the sward.

GRAZING

Until about 50 years ago the Heath was grazed by flocks of sheep - a tradition of centuries on these sheep heath walks, but, since the First World War, shepherded flocks have become almost extinct in this part of Eastern England. On Newmarket Heath the sheep have been replaced by Gang Mowers and these, towed by rubber-wheeled tractors keep the sward at an almost uniform length of 4" (10 cms). Variations in cutting in different parts of the Heath are not significant.

OTHER FORMS OF MANAGEMENT

1. Fertilisers. The sward of Newmarket Heath is regarded with great reverence by the Jockey Club and owners alike - any suggestions for the

addition of fertilisers are received with horror. Treatment on a wide scale would in any case not be economic. The only material added to the sward in large quantities is peat. The main area for this is between the Dykes where the sward is reserved for summer gallops.

2. Watering. Watering points have been put in over the last five furlongs of the July Course in the last three years, and the effects of watering are now being watched. None was added to any of the areas I shall be dealing with before analyses were made.

3. Weed-killers are not used.

4. Ploughing. There is no evidence from aerial photographs, soil analysis, the composition of the sward or local history that the major part of the Heath has ever been ploughed. Certain fringing areas were ploughed during the Second World War: there is no difficulty in finding their limits today.

THE RACE COURSES AND GALLOPS

The Gallops. These areas of the Heath are used for training. They are used in rotation and an attempt is made to ensure that no part of the Heath is used more often than once in three years. The open gallops are marked by lines of firs (or furze) which are stuck in at 50 yard intervals. They are moved at the discretion of the groundsman when he considers the gallops are too worn to stand further use. Exceptions to this general pattern are found in one or two places, notably on the Limekilns, to which I shall refer in detail, where there is a single permanent 'Long Gallop' down the centre, and one round the outside of the 'Round Gallop'.

The Race Courses. There are two race courses on Newmarket Heath. The part used for racing is a maximum of $2\frac{1}{4}$ miles long. They have a common origin on the Beacon Course but they divide on the west side of the Devil's Dyke, The July Course running parallel to the Dyke on the west side, the Rowley Mile proceeding through the Running Gap and then swinging south-east to give the straight mile on which the Thousand and Two Thousand Guineas are run towards the end of April. The Rowley Mile is used exclusively in the Spring and Autumn, the July Course in the Summer. The Beacon Course, common to both, is used at all Race Meetings, but because short races are frequent and long races rare, the Beacon Course is used much less than the Grand Stand end of either course.

Of the 24 Race Days in 1966, 16 were on the Rowley Mile, 8 on the July Course, so that the former has twice as much use as the latter. A quantitative estimate of the use can be obtained from the Race Cards issued for each day of racing. At Newmarket these give the length of the race, the number of runners and there is a sketch map of the 'route'. The figures for 1966 are given in Table I.

/Table I ......

TABLE I

	$2\frac{1}{4}$m	2m	$1\frac{3}{4}$m	$1\frac{1}{2}$m	$1\frac{1}{4}$m	1m1f	1m	7f	6f	5f
Beacon Course	38	142	218	377	-	-	-	-	-	-
Rowley Mile				218	291	336	625	872	1091	1358
July Course						159	277	384	553	608

This shows that use of the courses is relatively light at all distances over 1 mile from the Finishing Post. With the exception of the Beacon Course between $1\frac{1}{2}$ and $1\frac{1}{4}$ miles none of this part of the course is galloped by more than 300 horses, as against 1358 over the last 5 furlongs of the Rowley Mile.

THE EFFECTS OF INCREASING USE ON THE RACE COURSES AND GALLOPS

In setting the ecological scene I hope I have shown that the most important variable on Newmarket Heath is the galloping. The effects of increasing use can be demonstrated by reference to two sets of results, one on the Race Course side, one on the Limekilns.

The method of sampling the sward was in all cases the same. A square plot of approximately 50 square metres was laid out parallel to the line of cutting and the line of galloping. Within this plot 20 random quadrats of 10 x 10 cm were thrown: the percentage cover of the flowering plants and bryophytes found in each quadrat were estimated and scored on a scale of:

1 = 0-20%

2 = 20-40%

3 = 40-60%

4 = 60-80%

5 = 80-100%

Thus a maximum score would be 100. Other species found in the 50 square metre plot but not in the quadrats, were recorded as present.

Race Course Side. On this side 5 'use' categories were recognized: light, light to medium, medium, heavy and very heavy.

Light. Only areas in which galloping never occurred or was very rare e.g. the race course over $1\frac{1}{2}$ miles from the finish, or the outside edge of the race course between the course and the gallops. Max. 200 horses/annum.

Light to Medium. Areas galloped for training once in three years.

TABLE II

SPECIES	1 Light						2 Light Medium				3 Medium				4 Heavy		5 Very Heavy		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Euphrasia sp. - Eyebright	1																		
Polygala vulgaris - Milkwort	1																		
Hippocrepis comosa - Horse-shoe Vetch	12																		
Thymus drucei - Thyme	6		1																
Carex flacca - Carnation-grass	4		7																
Medicago lupulina - Black Medick			+																
Campanula rotundifolia - Harebell	1		+																
Carex caryophyllea - Spring Sedge	8		8	1															
Astragalus danicus - Purple Milk-vetch				2	2														
Asperula cynanchica - Squinancy Wort	1	2		3	1														
Onobrychis viciifolia - Sainfoin		1	6	4	2														
Helianthemum chamaecistus - Rockrose	15	1				1													
Filipendula vulgaris - Dropwort	+	+		+	+	+													
Helictotrichon pratense - Meadow Oat	3		9				4												
Scabiosa columbaria - Small Scabious	1						+	+											
Vicia cracca - Tufted Vetch	1	15				9			+	+									
Thalictrum minus - Meadow Rue		+												+					
Helictotrichon pubescens - Hairy Oat	2													1					
Pimpinella saxifraga - Burnet Saxifrage	1	4		3		2			1	+		1	+	+	+				
Briza media - Quaking Grass	2	+	8	5	4			+			+					2			
Brachypodium pinnatum - Tor Grass		2												1					
Linum catharticum - Purging Flax	1		3														+		
Festuca ovina - Sheep's Fescue	5	19	44	33	25		51	19	+	+	+	3			3	1			
Koeleria gracilis - Crested Hair-grass	20	17	17	22	21	20	1	3	15	13	15	15	9	8	6	12	2		
Lotus corniculatus - Birdsfoot-trefoil	3	7	21	13	10	2	8	12	3	6	1	1	1	1			1		
Poterium sanguisorba - Salad Burnet	4	9	11	21	6	+		3			1	2	1	+	1	4	1		
Zerna erecta - Upright Brome	48	26	46	23	28	46	27	35	31	26	21	19	13	8	2	9	12	14	5
Festuca rubra - Red Fescue	24	58		41	52	41	26	33	30	24	17	17	56	52	28	25	34	34	15
Achillea millefolium - Yarrow	2	2	1	1	3	2	6	7	3	1	16	7	+	3	19	9	1	1	+
Trisetum flavescens - Golden Oat Grass		6			2	1			6	19	+	1	1	1	2	1	2		10
Cerastium vulgatum - Mouse-ear Chickweed									+	1			1	3		+			1
Rumex acetosa - Sorrel										+									
Bromus mollis - Lop-grass																			2
% Heath Species	92	86	91	86	80	80	89	65	63	58	54	51	48	47	39	38	36	32	25
Poa pratensis - Smooth stalked Meadow grass	2	8		7	2	6	3	7	9	6	7	2	13	10	12	7	3	4	1
Trifolium repens - Wild White Clover		2	7	4	18	1	3	15	8	9	5	15	16	20	14	16	1	1	4
Dactylis glomerata - Cock's-foot		5		2	2	6	4	9	9	7	7	8	6	3	4	7	7	12	5
Phleum nodosum - Cat's-tail		1	2	1	6	8		16	13	10	5	22	20	15	20	27	9	14	2
Trifolium pratense - Red Clover		+	5	1	+			5	+	+	+		+		+		21	8	10
Lolium perenne - Rye-grass		1			2	1		1	1	+	12	7	3	5	5	2	21	23	50
Holcus lanatus - Yorkshire Fog						+					3		1	4	+				4
Agrostis stolonifera - Fiorin	1							3	2	20	24	11	34	35	30	43	17	25	9
Trifolium dubium - Lesser Yellow Trefoil								1									+		
Cynosurus cristatus - Crested Dog's-tail	1																4	1	5
% Pasture Species	1	9	7	6	14	14	7	30	26	33	40	40	48	50	51	55	54	55	66
Primula veris - Cowslip	3			5	1								+	+					
Cirsium acaule - Cauline Thistle	5	4	4	3	1	4			+	5	+	4	+	1	+	1			
Plantago media - Hoary Plantain	2	+					+	+	5	+	1	2	2	+	+	+			
Ranunculus bulbosus - Bulbous Buttercup	4	2		5	4	1	1		1	2		1			3	1	+		
Centaurea nigra - Knapweed		+		6	6	6		+	4	+	2	1	+	+	4	+			
Succisa pratensis - Devil's Bit				1									3	+					
Centaurea scabiosa - Greater Knapweed								2								+			
Agrimonia eupatoria - Agrimony								+			+								
Knautia arvensis - Field Scabious								1											
Senecio jacobaea - Ragwort									+										
Ononis repens - Restharrow										7									
Daucus carota - Wild Carrot														1					
% Broad Leaved Heath Species	7	4	2	8	6	6	1	2	6	8	2	4	2	2	4	1	1	0	0
Plantago lanceolata - Ribwort Plantain		1					3	3	2	2	+	2	+	1	6	6			
Leontondon hispidus - Rough Hawkbit		1							1	+	+	+	1		1	+			
Tragopogon pratensis - Jack-go-to-bed-at-noon							+												
Veronica chamaedrys - Germander Speedwell							1				2								
Taraxacum officinale - Dandelion								1	3	2	+	5	1		2	3			
Potentilla reptans - Creeping Cinquefoil								2			3				+	1	+	2	9
Crepis capillaris - Smooth Hawk's-beard													+				+		+
Bellis perennis - Daisy																	3		1
Convolvulus arvensis - Bellbine																	+	1	2
% Broad Leaved Pasture Species	0	1	0	0	0	0	3	3	4	3	4	5	2	1	6	6	3	2	9
Total % Broad Leaved Species	7	5	2	8	6	6	4	5	10	11	6	9	4	3	10	7	4	2	9
Bare Ground %									1								6	11	
Number of Species	31	30	19	26	25	20	16	25	25	26	26	22	26	26	24	24	23	13	19
Site Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19

Medium. The last five furlongs of the July course, or about five furlongs from the finish of the Rowley Mile.

Heavy. Finish of the Rowley Mile which is uphill from the Bushes, and is galloped in Spring and Autumn. About 1350 horses/annum.

Very heavy. The area of the Rowley Mile Paddock. Walked over by every horse for every race, with the addition of owner, trainer, friends, jockey, stable lads etc.

The broad pattern of change can be seen from Table II.

If we compare the extremes it can be seen that there is a change from a typical East Anglian chalk grassland sward with many species to a grassland which is not at all typical of the chalk and is extremely poor in species.

The following species appear to be most sensitive: Asperula cynanchica, Astragalus danicus, Campanula rotundifolia, Carex caryophyllea, Carex flacca, Euphrasia sp., Helianthemum chamaecistus, Hippocrepis comosa, Medicago lupulina, Onobrychis viciifolia, Polygala vulgaris, Thymus drucei.

The short list of more resistant species includes: Achillea millefolium, Festuca ovina, Festuca rubra, Koeleria gracilis, Lotus corniculatus, Poterium sanguisorba, Trisetum flavescens, Zerna erecta, most of which decline in abundance with increased use.

Pasture species which appear in the sward with increasing use include: Agrostis stolonifera, Bellis perennis, Convolvulus arvensis, Crepis capillaris, Cynosurus cristatus, Holcus lanatus, Potentilla reptans, Taraxacum officinale and Veronica chamaedrys.

The resistant species which appear throughout the Heath grassland but increase in abundance with use include: Dactylis glomerata, Lolium perenne, Phleum nodosum and Trifolium pratense.

In order to present these data in summary form for the Jockey Club the species of the sward were divided into four groups based on experience on the chalk elsewhere in East Anglia.

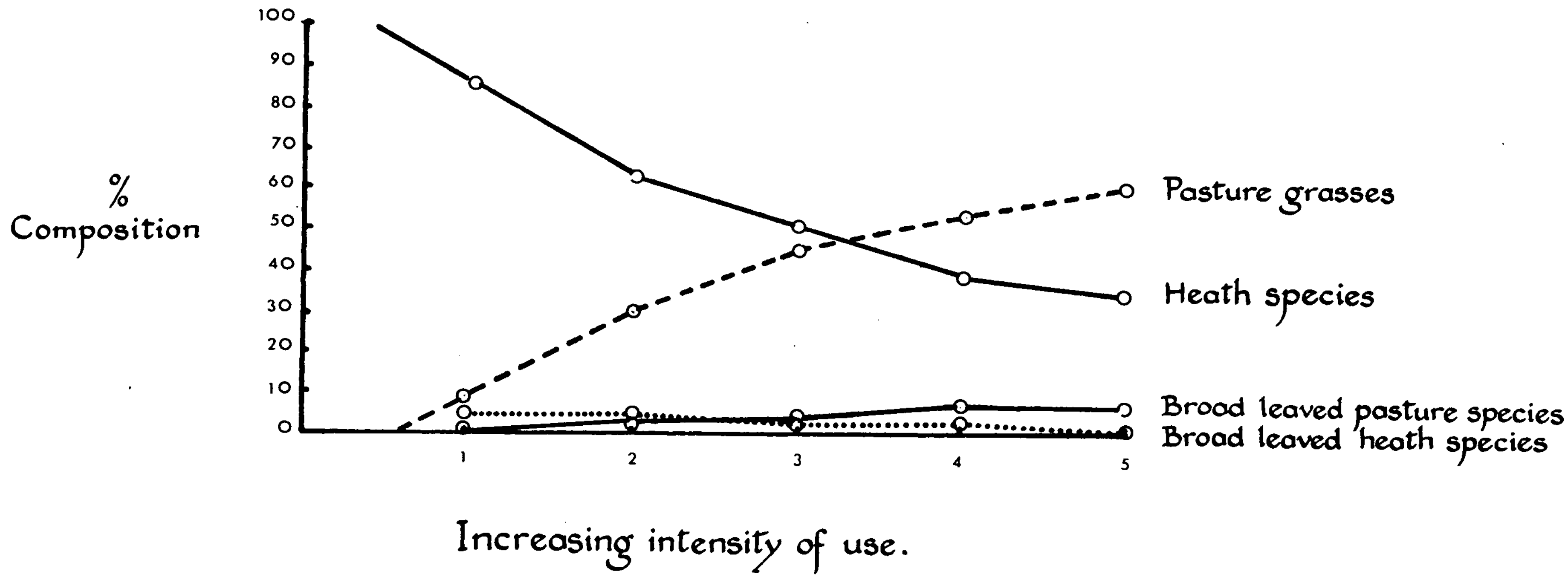
(a) Heath species. Species which are always in association with undisturbed chalk grassland.

(b) Pasture species. Species characteristic of swards other than chalk grassland, though they may appear in small quantity within it.

(c) Broad-leaved Heath species. These species react in the same way as group (a) but were separated as of particular importance to the Jockey Club.

(d) Broad-leaved Pasture species. Similar to group (b) but separated for the same reason as those in (c) above.

Fig. i


% Composition
100
90
80
70
60
50
40
30
20
10
0
1
2
3
4
5
Pasture grasses
Heath species
Broad leaved pasture species
Broad leaved heath species
Increasing intensity of use.

The percentage of each group in each sward was calculated and showed that over the range of wear investigated there was a fall in the percentage of heath species from 92 per cent. to 25 per cent. a rise in pasture species from 1 per cent. to 66 per cent. Broad-leaved heath species fell from 8 per cent. to 0 per cent., whilst broad-leaved pasture species rose from 0 per cent. to 9 per cent. These are the extreme values: however, if the figures for the results from the sites in the five 'wear' classes are lumped we arrive at the graph Fig. i. The actual data are given in Table III.

TABLE III

Intensity of Use	Light 1	Light-Medium 2	Medium 3	Heavy 4	Very Heavy 5
% Heath Species	86	62	50	38.5	33
% Pasture species	8.5	29.5	44.5	53	58
% Broad-leaved Heath species	5.5	5.5	2.5	2.5	0
% Broad-leaved Pasture species	0	3.5	3	6	5
% Bare ground	0	0	0	0	4

The number of sites studied on the race course itself are not adequate for any detailed analysis at this stage. The graph Fig. ii shows a fall from 99 per cent. heath species with 38 horses/annum to 55 per cent. heath species with 1358 horses/annum. On both courses the figures for the area round the winning posts are lower than the line. On both courses there is a climb to the finish and it is likely that the combination of a sprint to the finish and the rising ground accentuate the wear caused by the flying hooves.

LIMEKILNS

The Limekilns is a wedge-shaped piece of grassland lying to the east of Newmarket between the Norwich and Bury roads, with the point of the wedge towards the town. It is one mile long and at its broadest end, 800 yards wide. It is used for training gallops between May and October.

The most important feature of the area is this wedge shape. All galloping starts from the Bury end and a minimum 'gallop' would be about 5 furlongs. Thus we made two sample strips right across the Limekilns at 8 furlongs and 5 furlongs from the Newmarket end. Now as all the horses are running over both strips but the training ground is narrower at 5 furlongs (520 yards) than at 8 furlongs (800 yards) there must be an increasing intensity of use proportional to the different widths at these distances, i.e. $100 \times \frac{800}{520} = 154$ per cent. over 50 per cent. more wear at 5 furlongs than at 8 furlongs.

The comparison between the composition of the sward of these two strips can be seen by looking at Fig. iii. There are several features of interest:

1. (a) The constantly higher percentage of pasture species at 5 furlongs.
   (b) The generally (but not always) higher percentage of heath species at 8 furlongs.

2. The effect of soil depth. The deeper the soil in general the greater the percentage of pasture species. Thus when there is a combination of deeper soils and heavier galloping as in sites 9 and 10 (5 furlongs) compared with 13 and 14 (8 furlongs) there is a rise in percentage cover from 17 to 35 per cent. On the other hand when the soils at 5 furlongs (sites 4, 5 and 6) are shallower than those at 8 furlongs (sites 17, 18 and 19) this tends to minimize differences due to galloping and the sward at 5 and 8 furlongs is very similar.

3. The effect of constant use. In three sites on each strip the sward is in use every year as against every 2 or 3 years on the rest of the Limekilns. These sites are characterized by the very low value for heath species and high value of pasture species.

4. The effect of a shelter belt. This runs along the south side of the Limekilns. This keeps the early morning sun off the sward, particularly the round gallop and yet this gallop is open early in the day from 7 a.m. whereas the rest is not open until 9 a.m. This combination of slower drying and early galloping probably accounts for the very high values of pasture species compared with the same gallop on the north side.

5. The rate of recovery. This can be seen from the gallops at 8 furlongs on the north side of the Limekilns, where the percentage of Heath species in the swards rises with the length of time since galloping ceased, see Table IV. These observations were however not made in the same sample area at various time intervals but on adjacent plots the recent history of which was known.

TABLE IV

	3 months	12 months	15 months	24 months	36 months
% Heath Species (8 furlongs)	81	82	84	87	88

This is in fact an increase of 6 per cent. in heath species in the first 24 months after galloping. It is interesting to compare the results from two sites on the Race Course side used for training gallops which were sampled in 1964 and 1966 almost exactly 24 months later (Table V).

TABLE V

	Plot 3	Plot 4
1964	81.5	91.4
1966	86.9	93.7
Change	+ 5.4	+ 2.3

% Heath Species in Relation to Use

Fig. ii

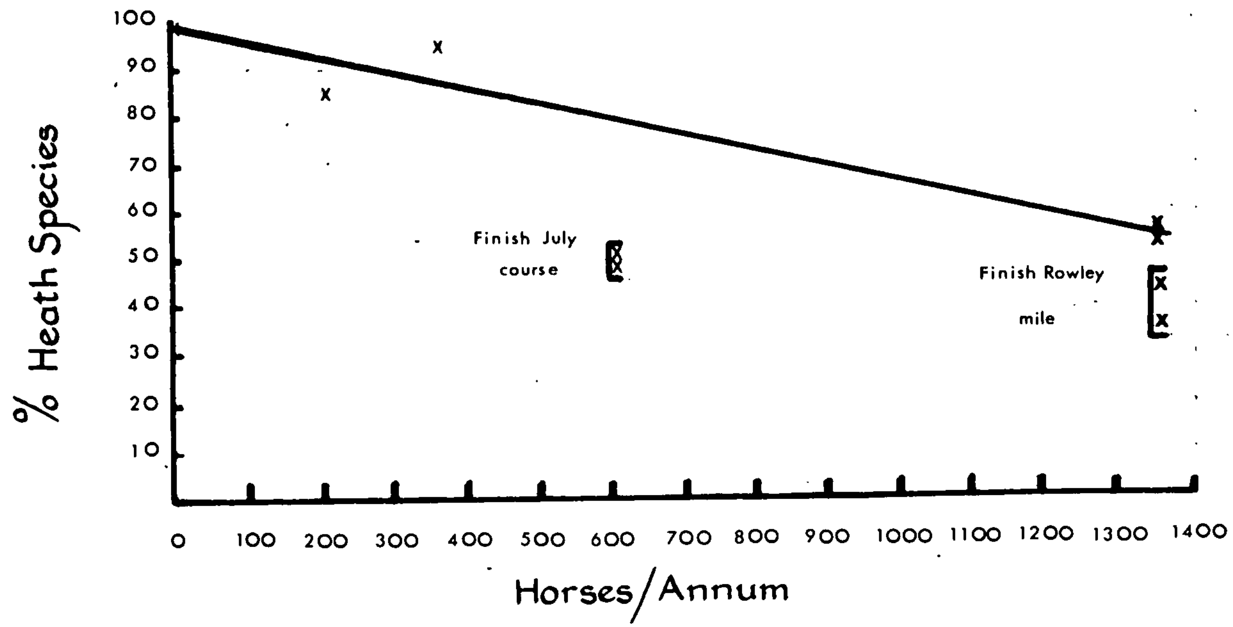
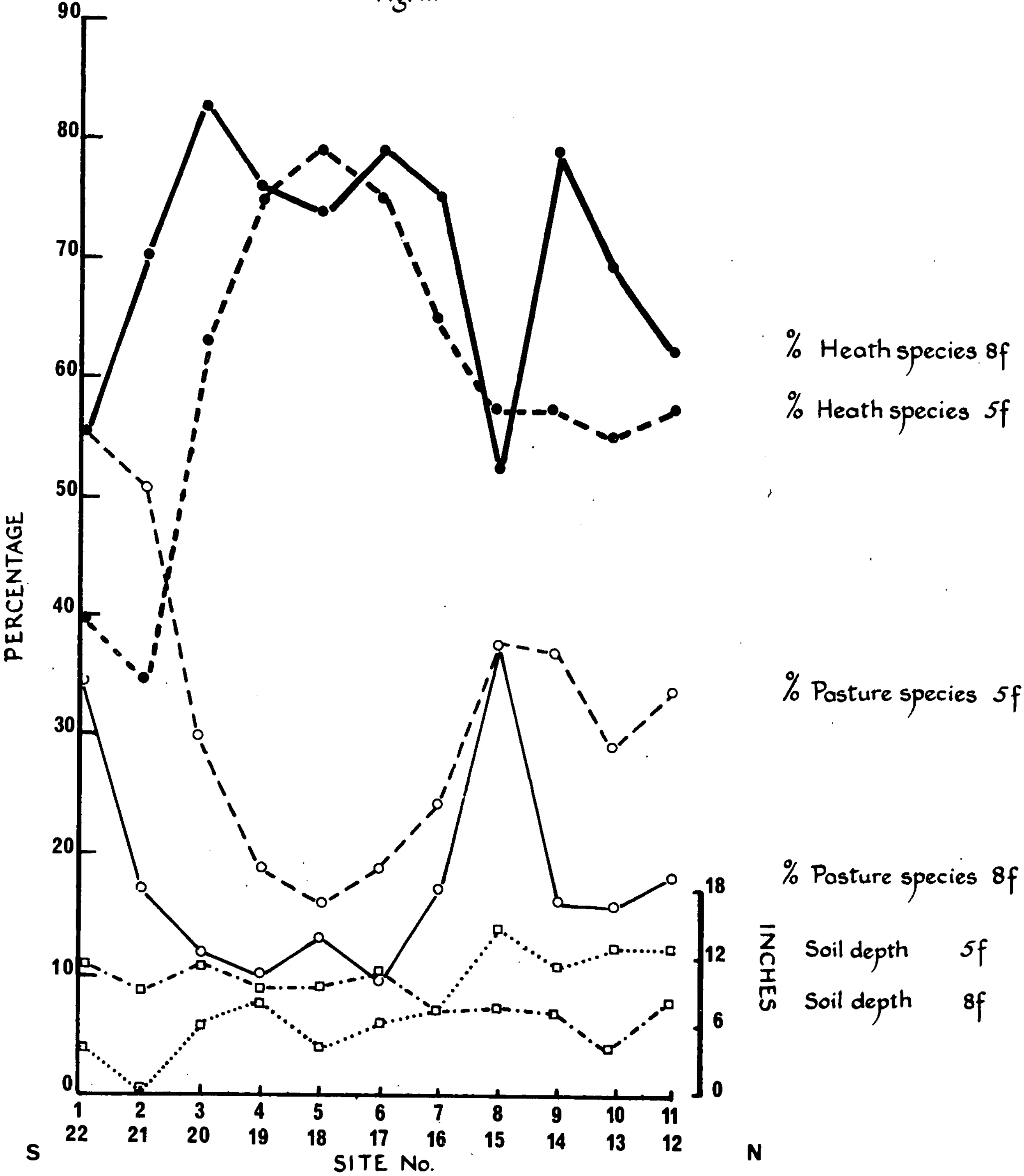


Fig. iii



90
80
70
60
50
40
30
20
10
0
PERCENTAGE
18
12
6
0
INCHES
1
22
2
21
3
20
4
19
5
18
6
17
7
16
8
15
9
14
10
13
11
12
S
N
SITE No.
% Heath species 8f
% Heath species 5f
% Pasture species 5f
% Pasture species 8f
Soil depth 5f
Soil depth 8f

Over the range 80-90 per cent. species the recovery seems to be about 3 per cent. per annum. Over 90 per cent. the recovery is somewhat slower.

I must apologize for the incompleteness of this paper. It is a by-product of other work and I realised in writing it up for this Symposium that many more analyses would be required to substantiate some of the tentative conclusions I have drawn. However, I hope I have demonstrated that there may be some value in using a single figure to represent the balance of the sward and in taking advantage of man-made experiments which may have been going on for a very long period to give us clues as to the type of effects we may expect from trampling on grassland habitats.

REFERENCES

HODGE, C. A. H. & SEALE, R. S. 1966. The Soils of the District around Cambridge. Harpenden.

PULSATILLA VULGARIS AND CHANGING LAND USE

T. C. E. Wells
Monks Wood Experimental Station

INTRODUCTION

The Pasque Flower, Pulsatilla vulgaris, has for long attracted the attention of botanists and naturalists, partly because of its beauty and partly because of its rarity and pattern of distribution in the British Isles.

In England, Pulsatilla vulgaris is confined to calcareous soils. It occurs on the chalk in Berkshire, Buckinghamshire, Bedfordshire, Hertfordshire, Cambridgeshire and on the oolitic limestone in Northamptonshire, Rutland, Lincolnshire and Gloucestershire. In earlier times and up to the end of the nineteenth century, Pulsatilla was also found on the Magnesian limestone in Yorkshire, but the plant became extinct on that formation in about 1860. Unlike many other characteristic species of chalk and limestone grasslands, Pulsatilla has never been found on the Carboniferous limestone, nor in calcareous dune systems.

The common feature of the habitat of Pulsatilla in England and on the continent of Europe is the highly calcareous nature of the soil which at 15 sites examined in England was expressed as a pH of 7.0 - 8.2, a calcium carbonate content of more than 50 per cent. in the upper 3 inches of soil and at more than half of the sites, an organic matter content of more than 8 per cent.

In 1966, as part of a more general study of chalk grassland, a survey was begun of Pulsatilla sites in England with the object of characterizing the habitat in terms of floristics and to estimate the quantity of Pulsatilla which was present at each site. It became apparent in the course of this survey that Pulsatilla was less widespread at the present time than it had been in the past and this stimulated the collection of evidence for its decline. Pulsatilla is an ideal plant for this sort of study because it is easily recognized in the field and errors due to misidentification would be absent. It also occurred in some quantity on the Barton Hills in Bedfordshire, where studies on the effects of grazing and the absence of grazing on the chalk flora had been in progress since 1963.

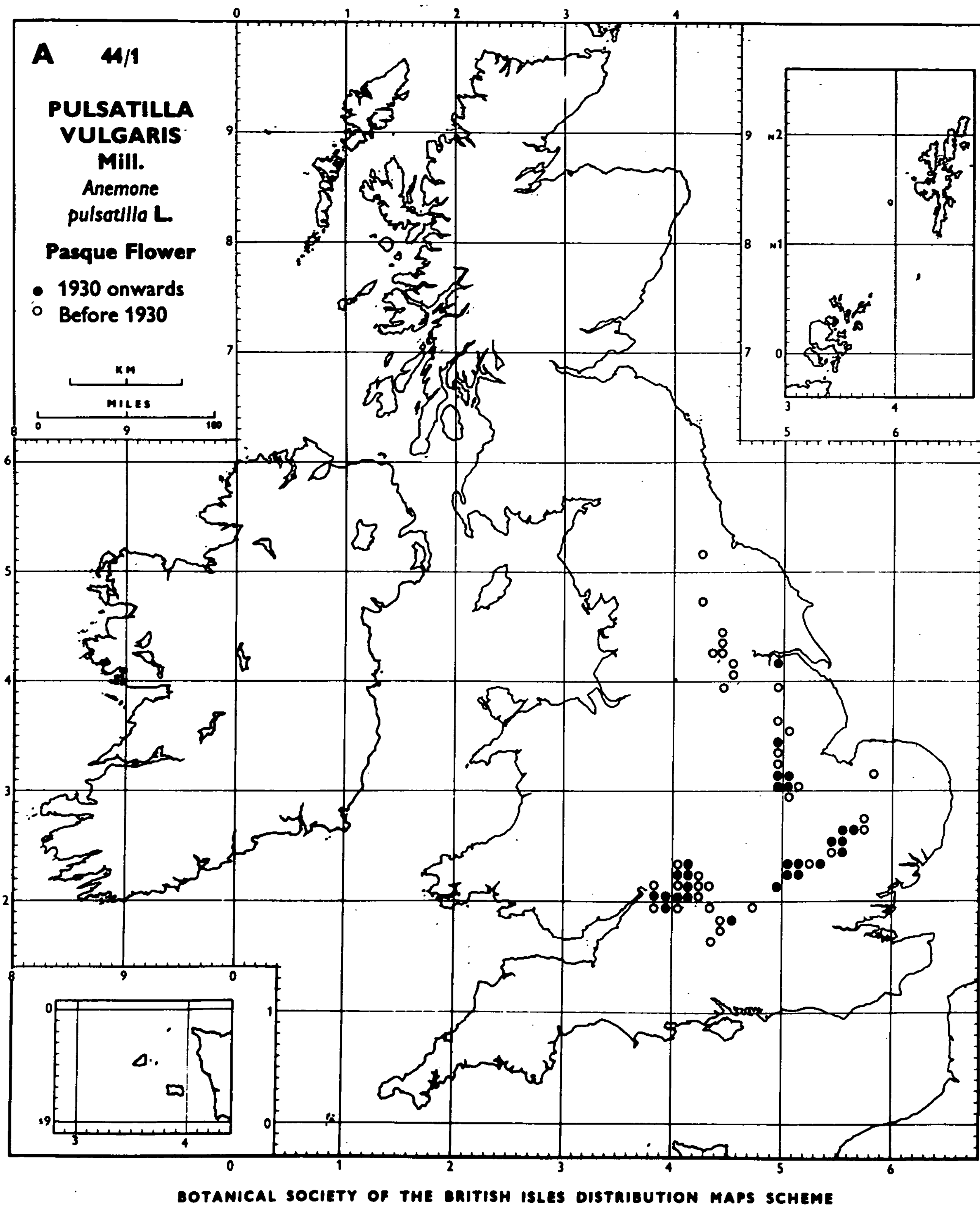
Two questions were asked:

(a) What types of land-use were associated with the elimination of Pulsatilla from sites where it had been recorded in the past?

(b) Under what habitat conditions did Pulsatilla exist and what were the characteristics of the vegetation and habitat in which the plant was most abundant at the present time?

SOURCE OF RECORDS

The distribution map of Pulsatilla vulgaris in the Atlas of the British Flora (Perring and Walters 1962) was used for establishing the


A 44/1
PULSATILLA VULGARIS Mill.
Anemone pulsatilla L.
Pasque Flower
● 1930 onwards
○ Before 1930
KM
MILES
BOTANICAL SOCIETY OF THE BRITISH ISLES DISTRIBUTION MAPS SCHEME

locality of Pulsatilla records. The Atlas showed 27 10 km. square with records post-1930, and 35 10 km. squares with Pulsatilla recorded in them before 1930, but not recorded since that date (Fig. 1). Dr. Perring kindly gave access to his individual site record cards from which the Atlas was produced and attempts were made to trace the actual sites of the records and to determine when Pulsatilla was last recorded from each site. In addition, attempts were made to find evidence of the land-use at the date when Pulsatilla was last recorded using the following sources:

(a) The works of the agricultural writers of the 19th century;

(b) the dates of Parliamentary Enclosure for parishes in which Pulsatilla grew (Slater 1907);

(c) old Floras;

(d) members of the Botanical Society of the British Isles who knew certain regions well and who were particularly well acquainted with the history of Pulsatilla sites.

Certain difficulties have to be overcome when using historical data which may be ambiguous, particularly when no dates are given for a record, but in all instances, the latest date possible was given for a site, even though it was suspected, because of other evidence, that the plant may have become extinct earlier.

EXTINCTION OF PULSATILLA VULGARIS

There are many possible explanations for the decline or extinction of Pulsatilla vulgaris which, excluding changes in climatic conditions, may be grouped for convenience under two headings. These are:

Destruction of the Habitat

i Ploughing

ii Mining and quarrying

iii Building

iv Road-making

v Excessive grazing

vi Digging up of plants

Changes in Habitat Conditions other than the Destruction of the Turf

This includes changes in the height and floristic composition of the grassland following the removal of the grazing animal, invasion by scrub and fire.

(a) Destruction of the Habitat

Table I shows the period in which the last record of Pulsatilla was made at 37 sites studied in this survey and from which it is assumed the plant is now extinct. Details of the sites are given in Appendix 1.

TABLE I

1800	1800-25	1825-50	1850-75	1875-1900	Date unknown but before 1900	Post 1900	Total
10	3	9	7	4	4	0	37

In some cases there is only circumstantial evidence that at 23 of the 37 sites examined, ploughing destroyed the habitat. At 2 sites building was responsible for the destruction of the habitat. At 5 sites either quarrying and/or building caused extinction. At 7 localities I was either unable to locate the site accurately or there was no evidence of ploughing, building, or quarrying having been responsible for the elimination of Pulsatilla. The key to the destruction of the habitat would appear to be the Enclosure Acts which not only rationalised the holding of land but also enabled by apportionment, the ploughing of lands which previously were common grazings and had never been ploughed. The period of most active enclosure by Act of Parliament was 1750-1850 within which 60 to 70 per cent. of the Pulsatilla sites investigated in this study were ploughed. It may also be significant that corn prices were high at the time of the Napoleonic Wars and there was good reason to plough land which under normal circumstances, would have remained under permanent grass.

There are references in the literature to support the view that ploughing of downland was the main cause of the extinction of Pulsatilla from many sites. In a few instances, the author of a local flora recorded this event, e.g. (Druce 1886) in the Flora of Oxford writes "The Burford locality is now brought under cultivation and the plant is now extinct". Perhaps the most informative remark concerning the destruction of downland is made by Babington (1860) in The Flora of Cambridgeshire in which he writes, "Until with a beautiful coating of turf, profusely decorated with Anemone pulsatilla, Astragalus hypoglottis and other interesting plants. It is now converted to arable land, and its peculiar plants mostly confined to small waste spots by roadsides, pits and the very few banks which are too steep for the splough. Thus many species which were formerly abundant have become rare, so rare so to have caused an unjust suspicion of their not being really natives to arise in the minds of some modern botanists".

References to the destruction of downland by ploughing are to be found in the works of the agricultural writers of the 19th century, but only in a few cases are details given, the writers being mainly concerned with methods of improving the arable land and the breeding of better live-stock e.g. Bravendar (1850) in a prize essay on the farming of Gloucestershire writes (p.132) "Nearly the whole of the Downs is now broken up and produces moderate crops with paring and burning, and a liberal use of artificial manures". The method of reclaiming downland by paring and burning is recommended by many agricultural writers of that period as the best way of improving downland. This was usually done by a labourer pulling a "breast plough" which skimmed off the upper 2 to 3 inches of turf, piling the turf into heaps and burning it, the ashes being scattered on the land. This rather harsh and seemingly wasteful operation destroyed even those plants with underground rootstocks such as Pulsatilla. Similarly, Clarke (1851) writing on the farming of Lincolnshire says (p.330) "The chalk wolds .... were, in the middle of the last century (1750), a succession of rabbit warrens from south to north. Fifty years ago that had been so improved that many thousands of acres of open fields were sub-divided by enclosures and the four-field system of cropping had established itself over the lands". The destruction of Lincoln Heath from which several records of Pulsatilla were made in the 19th century is referred to by Clarke (1851) (p.340): "There is no grassland upon the Heath, every part of it, with the exception of a few woodlands, is under cultivation, abounding with spacious, well-constructed farm buildings, strong well-fed working horses and immense folds of sheep: the barren sheep walk and warren have been clothed in fruitfulness .....".

Other doumentary evidence for the destruction of downland during the period of Parliamentary enclosure is to be found in a series of prize essays concerning the farming of individual counties by Read (1854, 1855), Bennett (1857), Ruegg (1854) and Spearing (1860).

(b) Change in Habitat Conditions other than the Destruction of Turf

The common factor linking the 27 sites in England where Pulsatilla is to be found at the present time is a physical factor which has prevented the ploughing of the site. Some localities which are Iron Age Camp sites defensive ditches (e.g. Devil's Dyke) have escaped destruction because farmers have not considered it worthwhile to bulldoze a large earth bank in order to gain a small increase in their arable acreage. In old limestone quarry workings such as Barnack Hills and Holes, the stony nature of the ground and the uneven terrain have rendered the area unsuitable for agriculture. Where the plant survives in open chalk or limestone grassland, the steepness of the slope has prevented ploughing.

At all of these sites there have been periods when grazing by sheep and rabbits has been intense and the vegetation short. At other times, particularly during periods of agricultural depression, grazing by sheep has ceased and coarse vegetation in which Bromus erectus and Brachypodium pinnatum have been the dominants, has developed. At other sites periodic burning to destroy the litter produced by grasses has been practised. Despite these changes in habitat conditions, I have been unable to find any site where Pulsatilla has become extinct because of a change in the management of the vegetation.

The tenacity of Pulsatilla under a variety of habitat conditions is best illustrated by considering in detail the land-use of one site, the Barton Hills in Bedfordshire.

There is abundant evidence in the form of strip lynchets, Celtic Field Systems, Iron Age Forts, Roman villas, etc. in the Luton/Barton area (Whittington 1962) to indicate that the land in the vicinity of the Barton Hills had been cultivated, probably since the Bronze Age, but there is no evidence of ploughing on the Barton Hills themselves. The steepness of the slopes (some are more than 25^{o}) has probably prevented ploughing and they have been used for grazing domestic livestock for many centuries. A pre-enclosure map of 1778 clearly shows the Barton Hills as "common pasture" with the same acreage as at the present time. After enclosure in 1814, the Hills were allotted to the Rector for tithes and used as sheep pasture. A specimen of Pulsatilla from the Barton Hills collected by Miss Foster in 1841, in the Herbarium, British Museum, is the first specimen from the Barton Hills. A specimen collected from Ravensburgh

Castle by Thos. Blow in 1873 is annotated "on the Hills neaby, locally plentiful". From 1814 until about 1922, the Hills were grazed by rabbits and Dorset Horn sheep. Following the depression in agriculture after the 1914-18 war, sheep farming became unprofitable and the Hills were not used for agricultural purposes. Although rabbits were plentiful in this period and a full-time rabbit catcher made a good living in Barton, Bromus erectus grew to about 2 feet in height and invasion by hawthorn scrub was considerable. This is clearly shown in a photograph taken in 1924 by H. Meyer of Letchworth of part of a hill known as "Plum Pudding Hill" which at the present time is a short ($\frac{1}{2}$") turf containing many Pulsatilla plants.

From 1932-34 about 100 sheep grazed on 108 acres of the Hills but from 1934-45 rabbits were the only grazing animal. Bromus ereotus became dominant and produced a thick sward until 1954. On Easter Monday 1954, the dense litter of Bromus erectus was burnt, scrub was cleared by hand and the stumps treated with herbicide and from then until the present time, Border Leicester X Cheviot sheep have grazed the Barton Hills at about three sheep per acre for nine months in each year. The turf is now less than 1" in height with an open structure and the Hills support a rich and characteristic chalk flora.

Pulsatilla was recorded in 1952 from four south to south-west facing slopes on the Barton Hills by Miss Meyer of Letchworth who kindly allowed me access to her map. In 1964, 1965, 1966 and 1967 I found the plant at all four sites in slightly greater quantity than was recorded in 1952. Pulsatilla has been shown to have survived:

1. 100 years of sheep grazing (density unknown);

2. 13 years of very heavy sheep grazing (3 per acre);

3. 22 years of competition from Bromus erectus and hawthorn;

4. Burning at a time when it was producing its leaves and flowers.

Annual counts of Pulsatilla vulgaris from 1963-67 within a sheep and rabbit-proof exclosure erected on the Barton Hills in May 1963 illustrates the response of this species to changing habitat conditions (Table II).

TABLE II

Behaviour of Pulsatilla vulgaris 1963-67 within an exclosure 150' x 40', Barton Hills, Beds.

	1963	1964	1965	1966	1967
Total no. of plants	6	138	469	612	849
% of plants in flower	100	65.3	61.7	9.3	10.8

In 1963 the Hills were heavily grazed by sheep and when the exclosure was erected the vegetation was a uniform $\frac{1}{4}$" high and only 6 plants in flower were found. In successive years, the number of plants increased greatly and examination of the rootstocks of some of these plants showed that they were old plants and not young seedlings producing leaves for the first time. Although many of these plants produced only 3 to 4 small leaves, about 60 per cent. flowered in 1964 and 1965 but there was a great reduction in flowering in 1966 and 1967 which was associated with an increase in the height of the Bromus erectus dominant sward to 10" to 12". Competition from Bromus reduced the amount of light reaching the base of the sward in which Pulsatilla grew, resulting in etiolated plants which remained vegetative. However, it has been observed at other sites that Pulsatilla can survive in this condition for many years: on the Barton Hills, these adverse conditions prevailed from 1924-1954 yet the plant flowered freely when the herbage was grazed from 1954 onwards. Similar increases in the number of plants in flower have been noted by the Berks., Bucks. and Oxon Naturalists' Trust in an exclosure at Aston Upthorpe Downs in Berkshire. A survey of extant sites of Pulsatilla with details of the vegetation and soils will be published elsewhere.

SUMMARY AND CONCLUSIONS

1. Destruction of the habitat, particularly by ploughing following Parliamentary enclosure has been responsible for the extinction of Pulsatilla vulgaris from old sites. Building, quarrying, mining and road-making have been contributory factors.

2. There is no evidence that a change in habitat conditions other than destruction has caused the extinction of Pulsatilla from any other site.

3. Pulsatilla is able to survive in grazed and ungrazed grasslands, but its ability to flower decreases when the height of the sward exceeds about 9" to 10". However, the plant survives in a vegetative state under these conditions and flowers when competition is removed.

ACKNOWLEDGEMENTS

It is a pleasure to acknowledge the help of members of the Botanical Society of the British Isles, particularly Miss J. Gibbons, Miss K. Rob, Mr. E. Lousley, Mr. J. Chandler, Dr. H. Bowen and Dr. J. Dony who provided records and information on individual sites. Dr. F. H. Perring kindly permitted access to his individual record cards and Dr. M. D. Hooper made many useful suggestions regarding the interpretation of the historical data.

REFERENCES

BABINGTON, C. C. 1860. Flora of Cambridgeshire, London.

BENNETT, W. 1857. Farming of Bedfordshire. J.R.agric.Soc., 18, 1-29.

BRAVENDAR, J. 1850. Farming of Gloucestershire. J.R.agric.Soc., 11, 116-177.

CLARKE, J. A. 1851. Farming of Lincolnshire. J.R.agric.Soc., 12, 259-414.

DRUCE, G. C. 1886. Flora of Oxfordshire. London.

PERRING, F. H. & WALTERS, S. M. 1962. Atlas of the British Flora. London.

READ, C. S. 1854. On the Farming of Oxfordshire. J.R.agric.Soc., 15, 189-236.

READ, C. S. 1855. Report on the Farming of Buckinghamshire. J.R.agric. Soc., 16, 269-322.

RUEGG, L. H. 1854. Farming of Dorsetshire. J.R.agric.Soc., 15, 389-454.

SLATER, G. 1907. The English Peasantry and Enclosure. London.

SPEARING, J. B. 1860. On the Agriculture of Berkshire. J.R.agric.Soc., 21, 1-46.

WHITTINGTON, G. 1962. The distribution of Strip Lynchets. Trans.Inst. Br.Geogr.Publ.No. 31, 115-130.

/Appendix I ......

OLD RECORDS OF PULSATILLA VULGARIS FROM AREAS IN WHICH THE PLANT IS NOW EXTINCT

Site	Grid Refer.	Source of Record	Last Record	Probable cause of extinction
Piercebridge, Yorks.	(45)21	Baker 1863	1863	Ploughed
North Stainley, Yorks.	(44)27	Slater 1879	1879	"
Aberford, Yorks.	(44)44	Lees 1888	1835	"
Kippax, Yorks.	(44)42	" "	1724	Building or quarrying
Kippax, Yorks.	(44)42	" "	1746	Building or quarrying
Brotherton, Yorks.	(44)42	" "	1869	Building and/ or quarrying
Park Hills, Yorks.	(44)32	" "	1765	Building
Pigburn Leys, Yorks.	(44)50	" "	1760	Building or quarrying
Darrington Leys, Yorks.	(44)51	" "	1840	Ploughed
Smeaton Cragg, Yorks.	(44)51	" "	1870	Building and/ or quarrying
Scawsby Leys, Yorks.	(44)50	" "	1798	Ploughed
East of Rotherham, Yorks.	(43)49	" "	1825	Building
East of Rotherham, Yorks.	(43)99	" "	1825	?
Lincoln Heath, Lincs.	(43)96	Miss J. Gibbons 1955	1848	Ploughed
Lincoln Heath, Lincs.	(43)96	Miss J. Gibbons 1955	1848	"
Ropsley Heath, Lincs.	(43)93	J. Cragg	1790	"
Colsterworth, Lincs.	(43)92	A. R. Horwood & C. W. F. Noel (1933)	1800	"
Ashby-de-la-Launde, Lincs.	(53)05	Rev. J. Dodsworth	1807	"
Casterton Magna, Rutland.	(53)00	A. R. Horwood & C. W. F. Noel (1933)	?	?
Stibbington, Hunts.	(52)90	G. C. Druce 1926	?	?
Sparte & Tulip Hills, Norfolk.	(53)81	W. A. Nicholson 1914	?	Ploughed
Saxham Bury, Suffolk.	(52)76	W. M. Hind 1889	1774	"
West of Icklingham, Suffolk.	(52)77	W. M. Hind 1889	1774	"
Ickleton, near Saffron Walden.	(52)44	G. S. Gibson 1850	1850	"
Ashwell, Cambs.	(52)23	H. Fordham 1840	1840	"
Watlington, Oxon.	(41)79	G. C. Druce 1897	?	"
Wickham & Kirtbury, Berks.	(41)37	G. C. Druce 1897	1897	"
East Isley Down, Berks.	(41)58	W. Hewett, H.B.M.	1839	"
Hamstead Norris, Berks.	(41)47	Bishop Mitchinson	1865	"
Cerney Downs, Gloucester.	(41)07	H. J. Riddelsdell et al 1948	1847	"
Colesbourne, Gloucester	(42)01	H. J. Riddelsdell et al 1948	1869	"
Hyath Pits, Evesham, Gloucs.	(42)03	H. J. Riddelsdell et al 1948	1874	?
Burford Downs, Oxon.	(42)21	G. C. Druce 1886	1794	Ploughed
Lyneham Camp, Oxon.	(42)22	G. C. Druce 1886	1849	"
Cornbury Park, Oxon.	(42)31	G. C. Druce 1886	1746	?
Abbotswood, Gloucester.	(32)81	H. J. Riddelsdell et al	1847	?
Scar Hill, Gloucester	(32)80	H. J. Riddelsdell et al	1851	?

SUMMARY OF DISCUSSION

The speaker was asked under what conditions *Pulsatilla vulgaris* reproduces by seed. In reply the speaker said that seedlings had never been found under natural conditions although in the laboratory there was 30 to 40 per cent. germination of wild seed. The questioner said that mineral soil was of considerable importance for the establishment of seedlings of many plants and that in this connection, the activity of moles was important.

The speaker said that under conditions of heavy grazing, there was usually a good deal of bare ground so one might expect to find seedlings but he had never done so.

THE INFLUENCE OF MANAGEMENT ON THE FLORA OF ROADSIDE VERGES

J. M. Way
Monks Wood Experimental Station

Roadside verges are taken for granted as a part of the countryside and their significance is not generally appreciated. Together with hedges they are now assuming an importance that did not exist before the Second World War but unlike hedges, they are increasing in extent.

Roadside verges serve a number of utilitarian purposes from the carrying of essential services such as gas and electricity, to the provision of parking and picnic places. They are used legitimately or otherwise for the dumping of materials. Essentially they provide a buffer zone between the road itself and the adjoining land. Because they are continually being made up, ditched, dumped upon, passed over by vehicles and farm machinery, they represent in general a disturbed, rough-grassland type of habitat with or without scrub encroachment. In addition they are managed by highway authorities, generally County Councils, in the interests of the maintenance and safety of the carriageway. These activities often lead to a diversity of vegetation types, and habitats for animals, which is increased by the presence of hedges, ditches woods, and banks which may adjoin the verges themselves. It is not possible to view the different habitats represented in isolation - thus from the edge of the road metal back to the highway boundary one may commonly find first a 'crushed' zone 6"-12" wide, then a 'managed' zone, which may or may not include a footpath, an 'unmanaged' zone, a ditch and finally a hedge or wall. Although when talking about verges one is generally understood to refer to the grassland strip, no such distinction can be made ecologically.

The increasing importance of roadside verges in the conservation of wildlife depends upon a number of factors. As the suitability of agricultural land for wildlife in some parts of Britain decreases, notably in the intensive arable districts of eastern England, wild plants and animals become more dependent on those areas of land that are not cultivated. In Addition, many areas of common land, heath, moor and the forms of uncultivated land are continually being encroached upon and their character changed so that although significant areas do still exist, they are nevertheless decreasing. On the other hand, it has been calculated as a rough approximation that there are 515,000 acres of road in England and Wales (Stamp 1962); one third of this might be reckoned to be roadside verge giving an area of 171,000 acres. This acreage is increasing. In 1964 it was more than three times the total acreage of National Nature Reserves in England and Wales.

It cannot be said that verges have the same sort of wildlife interest that nature reserves have, nor indeed that all verges have any particular wildlife interest at all. However, they do serve a need in the conservation of wildlife which nature reserves cannot fulfill. This is because roadside verges occur all over the country on different soils at varying altitudes and in a range of climates. Their continuity is especially important because they can be used as "highways" along which wild animals and plants can spread from one place to another. Railway verges, canal and river banks have similar characteristics and the same importance.

The value of roadside verges for wildlife is reflected in the diversity of plants and animals that can be found in different parts of the country, not only casually associated with them, but actually breeding on them. Apart from a number of rare plants of various restricted habitats, most species of British plants can be found growing on roadside verges. At least 300 species of plants are commonly associated with roadside verges in lowland England. Of different groups of animals 20 out of 50 British land mammals, 6 out of 6 reptiles, 40 out of 200 birds, 25 out of 60 butterflies, 8 out of 17 bumblebees have been known to breed on roadside verges or in their associated hedges and ditches.

Different forms of management of the vegetation are necessary for a variety of good or less good reasons and reference should be made to the importance of roadside verges as a source of weed propagules for the infestation of neighbouring land. Very often pressure is put on Highway Authorities to 'clean up' roadside verges because a neighbouring farmer regards them as a source of weeds. Very few of the plants that grow on roadside verges are weeds of agricultural land, and it is doubtful whether their contribution to the weeds of neighbouring fields is of any significance compared to the populations already existing there. A number of plants of verges, especially the Umbellifers, are incorrectly described as weeds: it has to be admitted that there is a small number of plants of which the worst are Creeping Thistle, Cirsium arvense and Couch Grass, Agropyron repens that are common on verges and which present a serious agricultural problem. Where these very difficult weeds are present there is no doubt that steps should be taken to reduce their populations. However, the great majority of other agricultural weed species are characteristic of disturbed conditions and are only minor constituents of established verges, though of course, they are usually among the first colonisers of new verges. In addition the majority are easily controlled by modern herbicides and any influx from verges are dealt with at the same time as the weed plants already present in the fields.

The main question, however is "what end result do we want from the management of verges?". Clearly our answer to this is going to affect our judgment of the effects of modern methods of management. Do we want lawn-like, uniform swards, of pure grass vegetation; do we want colour together with variety of structure and so of habitat? Do we want places that are tidy or are we prepared to recognise that nature is untidy by suburban standards, and that many species of interesting animals are associated with plants, such as Nettle or Thistle, that are considered aesthetically undesirable? Is the purpose of conservation to preserve wildlife for man's enjoyment only or is it to protect from man's interference as wide a range of plant and animal species as possible?

Verge management techniques in use today may be mechanical or chemical. Hand cutting of verges is no longer widely practised except in some villages and western counties. In 1964 a brief questionnaire was sent to the 46 County Surveyors in England and 45 replies were received. 17 counties used chemicals of the auxin or growth-inhibitor type on motorways, trunk roads, "A" roads or on particularly inaccessible places. However, of the 17 only 5 used chemicals on a large mileage of verge. The impression was formed which was reinforced later, that many County Surveyors were not keen on chemical sprays because of the expense, uncertainty of action under different weather conditions, the necessity of using trained labour and adverse public opinion. However, many of the counties who replied were using total weedkillers, generally triazines, ureas or dipyridyls on footpaths, in drainage grips and in a band 6"-12" wide along the edge of the carriageway itself. This type of chemical management appears to be increasing. Provided the chemicals used for this purpose are non-toxic to animals and do not 'creep' there seems to be no wildlife objections to them.

A number of different types of machine are in use but the most commonly used ones in the country generally are either the ordinary hay mower of the flail. From a vegetational point of view the hay mower cuts 3"-4" above the soil leaving the cut vegetation in swathes, whilst the flail is able to cut very close to the ground, sometimes creating bare patches and leaves the cut vegetation in the form of a fine mulch.

The effect of chemical sprays on vegetation can be very severe; for example, 2,4-D and 2,4,5-T will drastically reduce the dicotyledonous flora of a verge so that after three successive seasons of use, most of the common species are eliminated. Those which survive are usually the most resistant species so that the use of sprays may select persistent agricultural weeds such as Cleavers, Galium aparine, Polygonum spp. and Mayweeds. Other species that are not very effectively controlled are tall-growing Umbellifers such as Anthriscus sylvestris and Heracleum sphondylium, which it is often necessary to control for road safety reasons. Balme (1956) found that in some instances Anthriscus actually increased, perhaps as a result of reduced competition from Nettles which were killed. However, the growth form of Anthriscus and Heracleum would also have been an important factor in their survival.

The growth-inhibitor chemical, Maleic Hydrazide (M.H.), tends to have a greater effect on grasses than on dicotyledons. Yemm and Willis (1962) have found that the use of MH over a period of four seasons reduced the growth of tufted grasses such as Dactylis glomerata and Arrhenatherum elatius. In their place rhizomatous grasses, in particular Poa pratensis and Festuca rubra were encouraged. There was a marked suppression of growth in all grasses and almost complete suppression of flowering. For some reason Anthriscus and Heracleum were affected by MH, and indications of similar effects have been seen in our own experiments. At the end of ten years Yemm and Willis (1966) found that the vegetation in the plots where MH had been applied continuously was dominated by Poa pratensis with many low growing dicotyledonous plants such as Plantago major, P. lanceolata, Galium cruciata, Veronica persica, Stellaria media and Cirsium arvense. When MH and 2,4-D, had been used together over ten years, Poa pratensis was encouraged and dicotyledonous plants were almost eliminated. If a uniform grass sward was required this type of treatment would achieve it. These results only refer to spring application of the chemicals without subsequent cutting treatments. Considerable differences in the effects of chemical application can be obtained by changing the rates of application and the weight of chemical applied, by spraying earlier or later, more frequently or by subsequent cutting. In experiments in Huntingdonshire and Cambridgeshire (Monks Wood Annual Report 1960-65, p.74., p.75 Table 1), height measurements of the vegetation were taken from April to September at monthly intervals. At the Cambridgeshire site the unmanaged vegetation grew to a peak neight of about 24" by June and then "settled down" progressively over the remainder of the season. Where 2,4-D alone was applied, a similar pattern emerged. The application of MH resulted in the suppression of the vegetation until late June but afterwards there was some growth up to 15" by mid August, with subsequent "settling". When 2,4-D was applied and the vegetation subsequently cut in late June, the height was similar to that of the controls until it was cut, after which it did not exceed 12" for the remainder of the season. When MH was applied and the vegetation subsequently cut in late June the vegetation never exceeded 12". It is of interest to note that when the effects of the MH 'wore off' about late June, there was some recovery of growth, but when the 2,4-D or MH plots were mechanically cut back at this time there was no apparent regrowth. Essentially similar results were obtained at the Huntingdonshire site.

The influence of the different types of machine used in mechanical control depends very much on the height, frequency and timing of cuts. In contrast with the use of translocated herbicides, the life form of the plants is a deciding factor in their survival when machines are used. Geophytes with their buds below ground will have the greatest advantage. Effects on Hemicrypotphytes, which have their buds at ground level, will depend largely on the time of year at which the cuts are made. Phanerophytes and Chamaephytes, having buds above soil level will be selected against. Those plants that depend on seed for dispersal will be selected against compared to those that can propagate vegetatively. In our experiments we measured heights of the vegetation for the different cutting treatments in the same way as for the chemical treatments. At the Cambridgeshire site where the plots were cut five times, the height of the vegetation never exceeded 12". Where they were cut twice, in May and August, there was recovery of growth gradually after the May cut but none after the August cut. When the vegetation was cut once in June there was considerable recovery in July to a height of 15" with a subsequent decline. When there was only one cut, in July, there was still some recovery in August. The most interesting result from these measurements was the considerable influence throughout the growing season of a cut in May. This suggests that it would be possible for a County Surveyor to cut his verges in May and leave most of them alone during the peak flowering season - June, July and August - making a final cut in late August or early September. It is of interest to note that all treatment methods resulted in the vegetation being shorter than the controls at the beginning of the next season.

The management of roadside verges is an increasingly expensive and not very welcome part of the Road Engineers work programme. In some countries, notably America and Canada, the authorities have taken the easy option and have resorted to extensive chemical spraying programmes. Their aim is a uniform grass sward and visitors to America remark on its lack of interest. As labour and machinery become increasingly more expensive in the United Kingdom, Highway Authorities in this country may follow suit. If it is agreed that roadside and railway verges, river and canal banks are of importance in the conservation of wildlife, then there are four major lines of work that need to be done with some urgency. In relation to the conservation value of verges we need:

1. Country-wide surveys to find out what plants and animals are associated with, or increasingly dependent on, verges;

2. Local surveys to relate the population and associations of plants and animals found on verges, to the populations and associations in surrounding areas;

In relation to the management of verges we need to:

3. Discover the effects or likely effects of present-day practices on the fauna and flora of verges;

4. Start experimental work to help us plan the management practices of the future. If the Conservancy does not undertake this work there is no other body able to do so. Consequently management practices will develop in an *ad hoc* way. In particular, conservation interests may go by default.

REFERENCES

BALME, Olive E. 1956. Conclusions of experiments on the effects of the selective weedkiller 2,4-D on the vegetation of roadside verges. Proc. 3rd Br.Weed Control Conf., 771-777.

STAMP, L. D. 1962. The land of Britain. Its use and misuse. Longams, Green & Co., London.

WILLIS, A. J. & YEMM, E. W. 1966. Spraying of roadside verges: long-term effects of 2,4-D and Maleic hydrazide. Proc. 8th Br.Weed Control Conf., 505-510.

YEMM, E. W. & WILLIS, A. J. 1962. The effects of Maleic hydrazide and 2,4-Dichlorophenoxyacetic acid on roadside vegetation. Weed Res., 2, 24-40.

SUMMARY OF DISCUSSION

The speaker was asked whether cutting treatment had any effect on the botanical composition of the roadside sward. He replied that he had no information on this so far because his experiment had only been going for two years. A member commented on the procedure which is now followed in some 14 to 15 counties whereby the local authorities mark roadside verges of special floristic interest so that such areas receive the appropriate sort of management and are not damaged. This followed a very unfortunate occasion in 1960 when delegates to the first Naturalists' Trust Conference visited a chalk site in Lincolnshire just after it had been sprayed and the interesting plants destroyed.

The comment was made that although one hears a great many complaints about toxic chemicals on roadside vegetation, one seldom hears criticisms of the modern and very destructive methods of mechanical cutting. Some of the methods being developed at present would appear to be as bad, if not worse, than the use of toxic chemicals.

THE BASIC ELEMENTS IN PLANNING FOR RECREATION

T. L. Burton
Centre for Urban and Regional Studies
The University of Birmingham

In this paper I wish to change the emphasis which our discussions have taken during the past two days. Yesterday we heard a great deal about the specific biotic effects, such as erosion, arising from pressures made by specific sections or groups of the public, such as wildfowlers and collectors, upon (generally speaking) specific areas of the environment, such as mountain areas, woodlands and hedgerows. All of the specific groups that have been considered have four main characteristics: they usually contain relatively small numbers of people; these people are enthusiastic and deeply involved; they are organised; and they are, in the broad sense of the term, politically vociferous. This paper is concerned largely with the pressures that arise from the general public; that is, from large numbers of people who are only marginally involved in their pursuits; who are, generally, unorganised; and who are, politically speaking, relatively non-vocal. It deals not with the biotic effects of the pressures which they generate, but with the basic elements that make up these pressures. In short, it is a discussion of planning for recreation, from the viewpoint of a social scientist.

Recreation is not an easily defined, homogeneous entity. It covers a range of pursuits - active and passive, competitive and non-competitive, organised and unorganised. If, therefore, a comprehensive study is to be made of recreation within this country, or any part of it, it is immediately apparent that a systematic classification must be made of the many pursuits that fall within its purview.

Before any classification can be made, however, it is essential that its purpose should be clearly defined. For there are a number of possible classifications, none of which will be suitable for all purposes: J. B. Cullingworth has put it very clearly: "the usefulness of any particular classification will depend upon the purpose for which it is required ..... no one classification will suffice for all purposes and ..... classifications are not mutually exclusive". It is necessary, therefore, firstly, to define the purposes for which the present classification is required.

This purpose is to provide a classification which will serve as a basis for the project, Planning for Recreation in the West Midlands, which we are to undertake at the University of Birmingham. The terms of reference of this project are fivefold:-

1. What facilities are presently available for public recreation within the West Midlands region; where are they located; and who provides them?

2. What are the needs of the local population (and visitors to the region) at the present time; and how are they likely to change in the future?

3. What conflicts (and complements) within recreation and between recreation and other pursuits arise in the use of existing facilities?

4. Given projections about future levels of desired participation, what extra facilities will be required; who will provide them; and where will they be provided.

5. What will be the effects of changes in the available supplies of facilities upon the demands for them?

The first of these issues is concerned with the assessment of SUPPLIES; the second with DEMANDS; and the last three with DEMAND AND SUPPLY RELATIONSHIPS. These three elements, therefore, constitute the basic framework for the present classification, (Appendix 1).

RECREATION DEMANDS

A consideration of recreation demands is an essential part of any study of Planning for Recreation because of the impact which they have upon the use of land and other resources. This impact is felt in two main ways; firstly, through the demands of participants in recreation pursuits and, secondly, through the demands of spectators. This paper is concerned, primarily, with the demands of participants. The impact which these demands make upon land and other resources has three dimensions - quantitative, temporal and spatial. This gives rise to a threefold classification of participation:-

1. By types of pursuits.
2. By timing of pursuits.
3. By location of pursuits.

1. Types of Pursuits

There are three main types of recreation pursuits:-

a) Cultural Pursuits: that is, attendances at theatres, museums and art galleries and, more particularly, participation in amateur plays, concerts and exhibitions.

b) Sports and Physical Recreations: that is, participation in such traditional team games as football, cricket and hockey and, also, in the (relatively) newer pursuits like golf and water skiing.

c) Informal Pursuits: that is, walking, driving for pleasure, camping, taking picnics and informal nature studies.

Cultural pursuits make demands upon specific facilities, usually indoors. Sports and physical recreations make demands upon specific facilities both indoors and outdoors, and, usually, upon well-defined types and areas of land. Informal pursuits make less specific demands, particularly in terms of areal requirements.

2. Timing

The classification of pursuits by the time of the day, week or year at which they take place is particularly important in relation to the possibilities for the multipurpose use of facilities; that is, the use of the same facilities for different pursuits at different times. There are two major classifications:-

a) Seasonal or All Year

b) Overnight or Daily

The classification into seasonal pursuits and those which take place throughout the year is, of course, directly related to the point made above - namely, the possible multipurpose use of resources. The classification into overnight and daily recreation is important in terms of the facilities required. Overnight recreationists will require accommodation for their stay. Participants in daily recreation pursuits, of course, will not. Daily recreation is not, however, a single classification. It can be subdivided into three groups; full-day, part-day and evening. These three categories are of major significance in relation to the classification of pursuits by location which follows.

3. Location

The classification of demands according to their location is closely related to the classification according to their timing, since the length of time available for participation, especially for daily pursuits, will determine, in some measure, the distance which people can afford to travel in order to participate and, hence, the location in which pursuits will take place. This location is not solely a function of time and distance, however, since there will also be, in some cases, difficulties arising from the availability of unique facilities which are fixed in location. This is a problem which needs further discussion in the context of recreation supplies, but the factors outlined above suggest that demands may be classified according to location under three broad headings:-

a) Local demands: that is, demands which are concentrated upon an area within a radius of, say, 5-10 miles of the participant's place of residence. These will often be pursuits which are classified as part-day and evening by timing.

b) Regional demands: that is, those falling upon an area within a radius of, say, about 25 miles or an hour's travel or some time-distance factor equivalent to these. These will often coincide with pursuits classified as full-day by timing.

c) National demands: that is, demands upon which there appears to be no time-distance limitation.

The relative significance of a classification of demands based upon location compared with those based upon types of pursuits and timing is, perhaps, quite small, but it would still appear to be of considerable importance in the context of the provision of new facilities.

4. Factors Affecting Demands

Finally, an investigation of recreation demands cannot be complete without an examination of the relative importance of the various social and economic factors which affect the levels of participation in recreation pursuits; such as population, real incomes, available leisure time and standards of education. Moreover, such an examination is essential if any attempt is to be made to project future levels of participation in various pursuits.

RECREATION SUPPLIES

A study of recreation supplies has two aspects; firstly, an assessment of the facilities that are available for recreation pursuits and, secondly, an investigation of the agencies that provide these facilities.

a) Facilities

The classifications of recreation facilities should be directly related to the classification of demands, since facilities are designed to cater for demands. This means that the proposed classification of facilities must be considered in the light of the classification of participation by types of pursuits, timing and location which has just been determined. The classification of pursuits by timing has no complement in terms of facilities, but the classifications by types of pursuits and location give rise to the consideration of types of facilities and their location, as possible groupings.

The classification of facilities by location has two aspects:-

1. User-Orientated

2. Resource-Based

User-oriented facilities are those whose location is determined primarily by the location of their potential users. These will obviously be facilities which are capable of being provided almost anywhere. They will make provision, in large measure, for "local" and "regional" demands. Resource-based facilities, on the other hand, are those whose location is determined primarily by the fixed location of the major resources included in them. Thus, for example, National Parks and Areas of Outstanding Natural Beauty are based upon areas of unique landscape which are fixed in location. Resource-based facilities can make provision for many of the "national" demands discussed in the previous section.

The classification of facilities by type also has two aspects:-

1. Single Use facilities

2. Multipurpose facilities

Single use facilities consist of accommodation for overnight recreationists and specific facilities for individual pursuits, such as football pitches, golf courses and riding stables. Multipurpose facilities can be used for recreation pursuits and other purposes, such as nature reserves, or for a number of different recreation pursuits, such as sports halls and flooded gravel pits.

b) Agencies

The agencies that provide facilities for recreation are of two kinds:-

1. Public Agencies

2. Private Agencies

Public agencies consist of three kinds - local, county and ad hoc authorities. Local authorities, such as urban district councils, often provide such facilities as parks and swimming baths, while county authorities provide picnic spaces and car parks at scenic viewpoints. Ad hoc authorities, such as the National Parks Commission, the Nature Conservancy, the Forestry Commission and the Waterways Board often provide a whole range of facilities. Private agencies are of two kinds - clubs and organisations and commercial firms.

DEMAND AND SUPPLY RELATIONSHIPS

The study of demand and supply relationships has two aspects:-

1. Quantitative Relationships

2. Conflicts and Complements in the Use of Facilities

Quantitative Relationships involve a statistical analysis of existing surpluses and shortfalls of recreational facilities within any particular study area in relation to the known demands in that area.

Conflicts and complements in the use of resources for recreation can be considered from two viewpoints; firstly, in the context of aesthetic values, involving an assessment of the relationships between recreation, conservation and amenity; and secondly, in the context of the allocation of resources among different recreation pursuits and between recreation and other activities.

CONCLUSION

Coming to this problem from very different starting positions, we arrive at the same point: the relationship between conservation and recreation. I have tried to show how the problem of conservation fits into the larger problem of planning for recreation; just as, from the viewpoint of most of you here, the problem of recreation is only a small part of the much larger problem of the conservation of the natural environment. But what is meant by conservation?

I was disappointed that no attempt was made yesterday, at the beginning of the symposium, to define the term "conservation" and to show its relationship to the various kinds of public pressures, recreational, industrial and so on, that are made upon the environment. At a recent seminar on the subject of "Regional Planning", held at the University of Birmingham, the question of "Planning for Recreation" arose. You can imagine my reaction when one graduate student commented: "Of course, I'm on the opposite side to you. I'm a conservationist". This remark struck me deeply because, to my mind, the two words "conservation" and "planning" are inseparable. Conservation involves planning - planning how best to manage land and water resources to achieve a satisfactory allocation of them between competing uses; and planning involves conservation - the conservation of what is best among existing land and water resources and buildings, in relation to new competing pressures. I have spent some considerable time impressing upon planners, particularly social and economic planners, the need to consider conservation (and amenity) in their procedures. May I now take this opportunity to impress upon conservationists that planning is not a dirty word, but an essential element in conservation work.

SUMMARY OF DISCUSSION

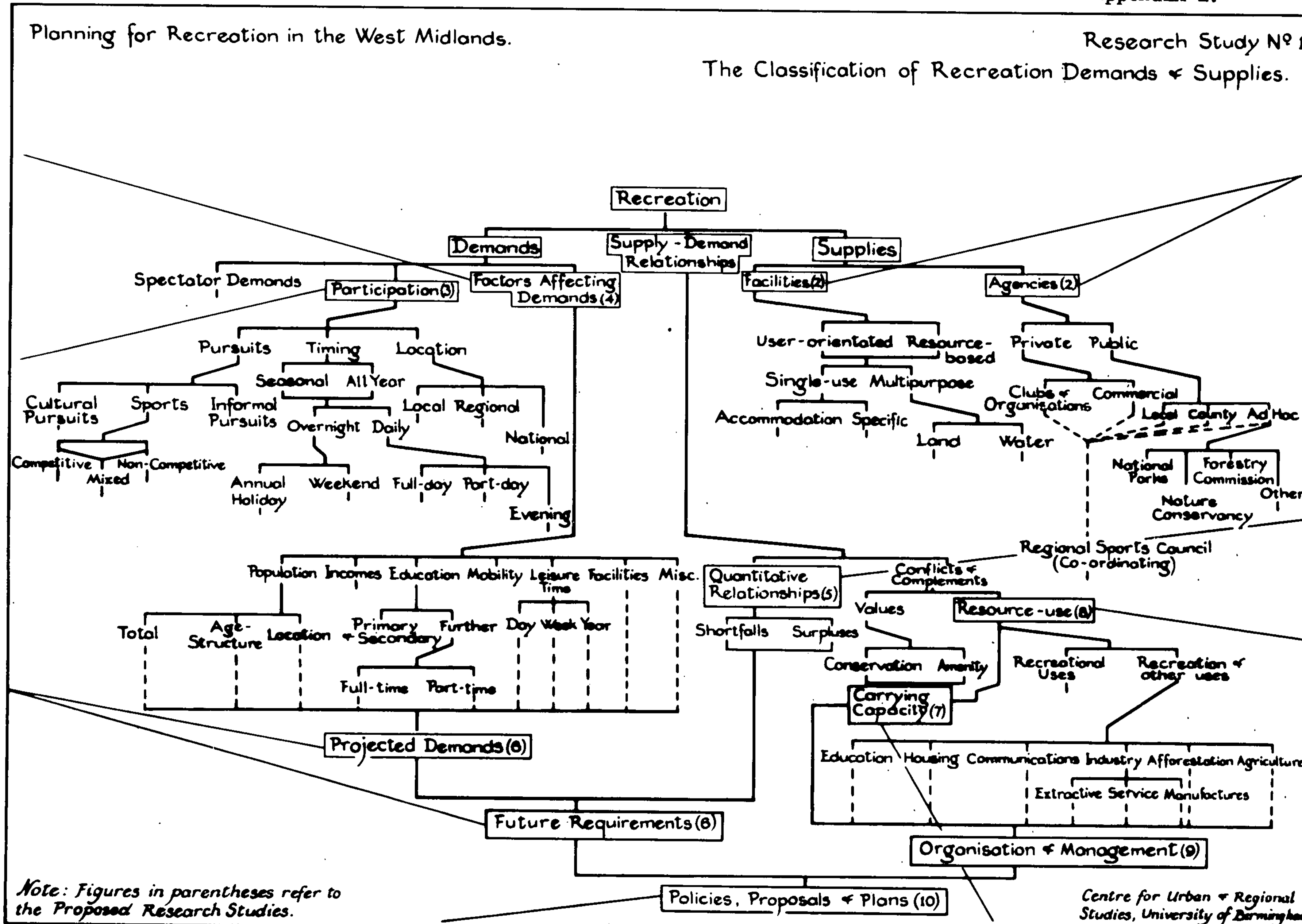
A questioner referred to the function of the Sports Councils. He said that they were making an assessment of the public demand for recreational facilities and that the Nature Conservancy should keep in touch with them in order to be aware of the type of demands on the countryside which will come from such bodies. He said that three sorts of activities were recognised: (1) indoor sports, (2) outdoor sports, e.g. football pitches, and (3) users of the countryside. The third would include walking, bird-watching, boating etc. The speaker said that the dividing line between indoor and outdoor activities was no longer very clear because quite a number could be performed either outdoors or indoors.

The speaker was asked whether the concept of the wilderness area was practicable and viable in this country. He thought that it was only practicable on a very limited scale, even in the Highlands of Scotland, and that communications were so extensive in this country that we do not, at the present time, have a real wilderness area and were not likely to have in the future. The pattern of public activities was such that the concept of an area in which car access was not permitted and where there was no organized recreation, was something which was not really practicable.

Another questioner commented that a wilderness area might be any piece of land which was more than a few yards from a roadside, if it did not happen to be used by the public. The speaker said that it depended on what one means by a wilderness area and also whether such areas were likely to survive.

A Scottish participant said that an examination of a map of the Highlands shows that there were very few large roadless areas left and he felt that we should make a positive effort to keep roads out of the few remaining remote areas left in the Highlands. The speaker said that although this was ideally a good thing, he thought that in almost every case, some sort of compromise would have to be made because an environment includes people and their needs had to be met.

Appendix 1.



After Burton 1967.

PUBLIC PRESSURES ON NATURE RESERVES AND S.S.S.I's NEAR LARGE URBAN AREAS IN SURREY

F. L. Reynolds and J. Sankey
Surrey Naturalists' Trust, and Juniper Hall Field Centre

In Surrey some 29 of the 33 biological S.S.S.I's are to be found on areas designated as public open spaces. There are over 26,000 acres of open spaces in Surrey accessible to the public; these are divided approximately in the proportion of 6,000 acres of chalk woodland and erst-while grasslands with the balance consisting of heath.

The appeal of these areas to the general public as well as those interested in wildlife, lies principally in those portions which are still open. Such portions of the chalk as have not been planted up, have during the past twenty years been invaded by thorn and dogwood to such an extent that there are but a few areas left of the original sward. Some of the sandy heaths supported stands of Scots pine which were felled in the First World War and have regenerated so fast that it is now little exaggeration to say that there are few open spaces left which are not doomed to become woodland within twenty years.

Box Hill is one of the most popular open spaces and others including the highly interesting Thursley Common, have sectors where there is much public presure. Newlands Corner, the second most popular open space, has retained some interest in spite of the heavy pressures, but it is not an S.S.S.I.

The main problem in the conservation of these open spaces of Surrey lies in the rapid regeneration of scrub and seedling pine when grazing pressures or burning are reduced. Such regeneration is responsible for the loss of some interesting habitats.

Except for a single paper cited later, no research has been done on the use of Surrey open spaces by the Public; but since the places most frequented are close to main routes, it is probable that the findings of Burton & Wibberley (1965) apply to long distance travellers at least. The pattern of local use appears different.

BOX HILL

This is a National Trust property scheduled as an S.S.S.I. of about 1,000 acres of which 600 are mixed woodland and the balance is chalk scrub and grassland. The principal feature is the scarp rising some 400 feet above the river Mole and the minor road along the crest is the main attraction for visitors. There may be 2,000 cars in this area at a time. The London-Dorking south coast main road passes at the foot of the scarp where there is another car park and nearby a railway station. The whole area is a most popular rendezvous for all types of holidaymaker, some of whom look upon it as a traditional site where the countryside can be used or misused at will.

Box Hill has considerable natural history interest. The locality has been studied and recorded for a long period and is well known to naturalists; it is used by schools and colleges from London for field work. The Juniper Hall Field Centre is established nearby and uses Box Hill as its principal study area. No quantitative studies have so far been made either to record the increasing human pressures, or the decrease of interesting species of plants and animals. In fact, no experiments involving fixed apparatus can be undertaken, since any trap, peg or marker is promptly interfered with.

From general impressions it seems that the visitors include a considerable proportion of those who remain close to their cars but a larger proportion than that indicated by Burton & Wibberley (1965) walk over the whole area and many of these are interested in the flora and fauna in varying degrees. It is noticeable that bad weather at the coast (e.g. sea fogs) increases numbers at Box Hill.

With a staff of three, management is centred principally upon the human interests. It is mostly occupied in keeping the area clear of litter, repairing acts of vandalism and in a lesser degree, with woodland conservation.

With recent establishment of car parks and with two cafes, the human pressures are concentrated to some extent; other areas have gained accordingly. But management still includes the burning of dead grass on the steep slopes in the early spring, while other flatter areas are cut by machine. Both these activities have reduced the variety and interest of the sward, though it does check the advance of scrub.

As elsewhere on the Downs, the last twenty years have seen a marked increase in hawthorn/dogwood scrub. Voluntary conservation workers have done some clearance but numbers are not sufficient to make any great impression. No sheep grazing is possible owing to lack of fences and presence of uncontrolled dogs. Many paths and certain areas of the grassland are kept open by human passage but the variety of the sward has lessened; there is a good deal of flower picking and even the taking of damaging amounts of foliage from young trees. It is noticeable that the grass on the steeper scarps has more variety but the spread of Tor grass, Brachypodium pinnatum (probably due to burning) gives cause for concern. There is also heavy and increasing wear and tear due to collecting, much inspired by education and in spite of appeals to the contrary. In the course of studies at Juniper Hall, the following have been particularly noted:

Roman Snail, Helix pomatia. In early 1950's it was common after a warm shower to find up to 40 specimens crushed on a certain section of the road by passing cars. Now it is not easy to find a single snail near this stretch of road, and even away from the main tracks, numbers have decreased in the last decade.

Chalkhill Blue butterfly, Lysandra coridon. Up to 1956 the colony was of sufficient strength for Juniper Hall students to do an annual Lincoln Index population count which gave number of between 300 and 500. The population has diminished considerably and in 1966 few individuals were seen.

Adonis Blue butterfly, L. bellargus. The small colony, which appeared to be thriving in 1949, has now disappeared.

In passing, it may be noted that other colonies on the North Downs are not so affected, though there is perhaps a tendency to diminish. It is considered that the reduction is due to the combined effect of collecting and excessive trampling of the sward.

Disturbance of birds however, is not so noticeable. Small birds continue to nest probably because of the increasing scrub infestation, and deer and fox are seen from time to time as well as rarer and migratory birds, e.g. buzzard. It is not thought that there is any great change in the population of small mammals. Rabbits are not now numerous and are kept under control; while the best badger colony has been reduced, others have gained correspondingly.

However, in spite of so much damage, the area remains one of outstanding interest, and of great potential educational value. Lack of finance is the main factor impeding conservation, coupled with a strong feeling by a section of the general public that they have every right to enjoy themselves and in so doing disregard the effects of their actions.

SHEEPLEAS

This chalk area consists of some 300 acres including mature beechwood, some scrub and about 40 acres of grassland, nearly all of which has been recovered within the last seven years from solid scrub cover, and is now kept open by mechanical cutting. It is owned by the Surrey County Council. There is an interesting variety of habitat arising from past use; the chalk flora is rich and the entomology promises well. A recent M.Sc. thesis by Miss A. Kelly (1966) studied the history of land-use and the categories of visitors using the area. The Surrey Trust has suggested a management scheme to the owners in order to conserve the natural history interests without losing sight of the County Council's original management plan which is largely based on forestry practice. Miss Kelly shows that nearly all the visitors move away from the car parks and that there is a high proportion of local users from within five miles. In this, the area is similar to some of the other open spaces but quite different from popular sites. There are a certain number of horsemen using well-defined paths which are rendered useless for those on foot in wet weather. In the open, visitors keep the grass short in one area traditionally used for picnics and games; similarly the main paths are worn to short turf. Otherwise the effects of visitors are confined to normal disturbance, particularly by dogs, together with flower picking which is a growing threat to certain more obvious species.

The County Council management has resulted in the clearance of much of the shrub layer in the woodlands as well as nearly all the dead wood. Mechanical cutting of the grasslands resulted in the destruction of the spring flush of vegetation, but this is now being remedied and a timetable has been evolved to avoid constant destruction of the same species from year to year. Efforts are being made to enlist active support from members of the local amenity society but without much success so far.

NEWLANDS CORNER

This site, which is probably the second most popular open space in the county, is another chalk scarp of some 300 acres just to the east of Guildford on the main east/west road. Up to three years ago nearly the whole of the area was heavily overgrown, much with high scrub, and cars were parked at random. The County Council has taken over management, constructed an enclosed hard standing for cars, and cleared a sweep of some fifty acres of the southern slope of the Downs. While there is a proportion of visitors who remain close to the car park, similar to those at Box Hill, perhaps half do walk more than a quarter of a mile, and a good proportion use the paths reaching out over the whole area. These paths remain as short grass kept down by human pressures. The freshly cleared open space is flailed but it is too early to say how this will affect the sward and the biology of the area generally. In spite of the pressures over many years, Nightingales as well as Chalkhill and Adonis Blue butterflies are reported to have survived so far.

It may be said of this site that it is the public interest which has resulted in the reopening of the grasslands and amenity societies have brought pressure to bear politically with a view to conserving the property on ecological lines. But the cost of keeping even a small portion of the grasslands open is so great that without the expenditure of public funds, the whole site would rapidly lose its biological interest. As such it would become the target for other development plans, such as golf courses and playing fields.

THURSLEY S.S.S.I.

This consists of a group of heathland commons of unusual interest which the Surrey Trust are anxious to establish as a Nature Reserve. It covers some 1,000 acres, including a fair proportion of deciduous woodland and number of lakes. A full time warden is maintained by the Trust. One small lake beside the Elstead road, the Moat Pond, is specially popular with the owners of electronically controlled model yachts, and families with small children who use the lakeside as a substitute beach for bathing and digging in the sand. Main pressures are in the spring and autumn and visitors are thought to come from places 5 to 25 miles distant. 600 acres of the S.S.S.I. are subject to an Access Agreement under the 1925 Act with some useful bye-laws. The Trust look upon the portion of the Moat Pond, which they manage, as a suitable area upon which to concentrate the human pressures. This is successful as was shown at Whitsuntide 1966 when in three hours walking, no one was found more than 200 yards from the Moat Pond, though there were 150 cars mostly within 15 yards of the water's edge. These pressures in the immediate vicinity of the pond have resulted in a serious loss of vegetational cover, coupled with the constant accumulation of litter. Marsh St. Johns Wort, <u>Hypericum elodes</u> which is local in the south, still grows freely, though attempts are made each year by the yachting enthusiasts to destroy it. When the pond is deserted, Tufted Duck, <u>Aythya fuligula</u> feed on it and still nest in the nearby heath, while a Common Scoter, <u>Melanitta nigra</u> spent a week there in the winter of 1965/66.

Some 250 acres of the S.S.S.I. are used by the Army for exercises at platoon level but no tracked vehicles are employed. Such exercises have been continuously carried out over this area and much of the surrounding heathland for well over twenty-five years. The present fauna, including several species of nesting birds which are unusual in the county, appear to have learned to tolerate this particular form of disturbance. These exercises seem to cause more fires than other human agencies, but it has to be borne in mind that fire is the main agency nowadays responsible for keeping the remaining areas of heathland open. It should be noted in passing that practically the whole of this heath was bare of vegetation by 1945 as the result of use by tracked vehicles. Attempts have been made to drain some wet portions under Defence Department control and the water levels were threatened in the West Bog, an important area for research and education.

A forestry plan has just been inaugurated on one section but this has been deliberately planned to avoid interference with nature conservation. Since it includes the provision of fire breaks, it seems likely to be generally beneficial.

Rabbit control by the Agricultural Department has caused the break-up of extensive stands of gorse, Ulex europaeus; not only were these a harbour for foxes, but they were also part of the habitat frequented by the Dartford Warbler, Sylvia undata until the collapse of 1963. Again the badgers have deserted their setts, driven out it is thought by measures intended against rabbits. In addition, rabbit control includes driving part of the heathland with dogs and guns. This causes violent disturbance if not actual loss of pheasants and hares as well as rabbits. Poachers from London suburbs have been troublesome but recent shooting regulations seem to have discouraged them.

Visits by educational establishments are very welcome and some 25 schools and colleges were recorded in 1966. However, pressures caused by large classes at certain wet sites are beginning to cause concern.

Beyond a few published records and with the marked exception of recent contributions by three entomologists, the Trust has received very little assistance from the many naturalists, professional and amateur, who use the S.S.S.I.

FRENSHAM COMMON

This is another heathland with a large and popular pond. It is probably the most extensive area of Calluna heath left in the county, but the biological interest is not so rich as at Thursley. The pond attracts very considerable numbers (of the order of 500) of cars at a fine weekend. There is a sailing club situated outside the S.S.S.I. and in addition a large number of the visitors use the water's edge as a substitute seashore. The heavy wear has resulted in the loss of vegetation wherever vehicles have access to the water's edge. Management by the local Rural District Council has been largely confined to organizing a car park and reduction of litter. As a result, during most of the year, the 150 yards to the water's edge is practically a desert of loose sand. Further away the heath remains in good condition and unworn except for the paths. The Smooth snake, Coronella austriaca austriaca and Sand lizard, Lacerta agilis agilis are still recorded, and informed opinion suggests that the ornithological interests are not greatly reduced. It is not possible to estimate the condition of the entomology since so little quantitative data exists but the impression is that this also has degenerated but little.

CHOBHAM COMMON

This is another extensive area of heathland on Tertiary sands. Regeneration of seedling pine is noticeably less than most other open spaces; it is thought that this is due to a greater incidence of fire. One of the principal features is the number of valley bogs. Visitors are principally concerned with flying model aeroplanes, though there is a large and popular riding school which is dependent on the common for room to move freely. Generally local feeling is a compound of exasperation and despair at the litter and noise which it is beyond their power to control.

There has been little management over the past years but the County Council are in process of taking over from a private holder of the Lordship of the Manor. The army have long used the area for exercises and some sectors were bared by the tracks of heavy vehicles, but are now recovering.

Again it seems that fire, coupled with military use has been responsible for keeping the area open and such species as have survived are able to tolerate these conditions. There are a number of particularly interesting entomological communities, mostly centred on the wet valleys and adjacent dry Calluna covered ridges. It is thought that the interest has persisted because the area is extensive and sufficiently varied to allow for the burned areas to be recolonized from other portions not so affected. At least one area, Gracious Pond, has deteriorated considerably since it passed from the ownership of the late H. F. Witherby but this is possibly due more to the natural processes of succession on an area of wet heath than any human agency.

CONCLUSIONS

A considerable proportion of the visitors to these open spaces can be classed as either traditional or casual, travelling from a distance of 5 to 25 miles. They are concentrated at the well known sites - Box Hill and Newlands Corner - arriving by private car and public transport, generally for the purpose of picnicking and random wandering. They tend to do considerable damage, principally by wear and tear, vandalism and flower picking, together with scattering varying amounts of litter. There are also those who concentrate particularly at the edge of any easily accessible pond. But, and especially at the less popular sites, there are equally large numbers who do not appear to conform to Burton & Wibberley (1965) in that they definitely penetrate throughout the open spaces, either walking or riding, and often accompanied by dogs. Except for disturbance and some flower picking, these people do less harm. Because they are politically vocal, they can be helpful when alterations in management policy are required of public owners. There are also those, of both professional and amateur status, who are interested in the biology of the areas. They are valuable helpers and their records are of the greatest assistance, but it is felt that much more active work is required of them if successful management regimes are to be worked out for the conservation of these sites. Of the pressures noted, those which may be classified as direct and commonly found are the wear and destruction of vegetation, compaction of soil, damage to trees and verges. There is some vandalism such as uprooting newly planted trees, destroying notices on the most popular sites, taking of markers from experiments and trials, litter accumulation, disturbance of ground mammals by dogs, bird nesting and flower picking. Car parks and easily accessible stretches of water are useful in concentrating these activities and freeing other portions of the property from their effects.

Of the indirect pressures, lack of control of dogs has made grazing of the grasslands impossible, thereby inhibiting the maintenance of a normal sward and also greatly increasing the cost of keeping any grassland free of scrub.

Management by local authority up to the present has tended to follow forestry techniques with consequent destruction of the shrub layer in woodland, elimination of dead and fallen timber and excessive drainage. On open spaces, clearing of grassland by mechanical means is creating a new type of sward with its own characteristics. Rabbit control has intensified the scrub infestation problems and caused additional disturbance with some destruction of habitats. Drainage is a constant threat to the few wet areas which survive and the heathlands are particularly susceptible.

Use by the Army has modified the heathlands in a number of ways but as these have been applied continuously for many years, a type of plagio-climax has been achieved. This provides certain interesting habitats, particularly the open heath and bare sandy areas which cannot be easily maintained by other means.

There are indications that use for education and research will have to be carefully controlled as it becomes more frequent. A particular danger occurs in those cases where interest is aroused by the popular press but without a caution urging visitors not to pick flowers and collect. This is undoubtedly depleting the S.S.S.I. of many species. There are the positive advantages that will accrue however from the recording programmes now being made, as well as the occasional thesis or paper on specialized aspects of these sites.

Thus but for public interest and political pressures in the past, few of Surrey's S.S.S.I's would have retained their biological interest. Many Commons and open spaces would have been developed long since. Similarly, we are dependent on public support in future for the survival of these sites in their present form. To achieve this, comparatively unrestricted use by the public must be allowed. It is believed that there are suitable management techniques which will maintain the wildlife interest. It is important however, that sites which may now be regarded as of secondary importance, should be carefully managed so that they remain available to replace those where conservation proves unavailing against mounting pressures.

Invasion by scrub and seedling pine, coupled with over-drainage of wet land, are the principal threats to the habitats which S.S.S.I. status is designed to conserve. Direct human pressures have their effects and at present it is realized that this state may not continue long.

SUMMARY OF DISCUSSION

In reply to a question, the speaker said that the use of sheep grazing as a management tool was not possible in Surrey because of the number of dogs using open spaces. This resulted in a difficult public relations problem because so many people who were sympathetic to conservation also liked to exercise dogs on wildlife areas. The speaker agreed that in a populous area such as Surrey, educational nature reserves were especially important and perhaps more use should be made of them to inform the public of the case for conservation. There were something like 26,000 acres of uncommitted land in Surrey to which the public had access and although this was a very good state of affairs, it made the problem of selection and management much more difficult. There were also increasing pressures from the general public who were attracted to these areas.

HAMPSHIRE PUBLIC OPEN SPACES AND WILD LIFE CONSERVATION

G. Barker
Warden/Naturalist, Old Winchester Hill N.N.R.

In Hampshire, as elsewhere in the south of England, there is a great demand on land for forestry, agriculture, industrial and urban development. With an increase in population there is also a demand for areas of open countryside in which people can picnic and stroll at will. Among the areas of land under pressure for development are sites which the Conservancy has statutory obligations to protect - National Nature Reserves, or to notify to Local Authorities - Sites of Special Scientific Interest. I work in a county where the County Council is very sympathetic towards our views. The Council is also well aware of its responsibility for providing public open spaces and has bought about 2,000 acres of countryside to be used as open space. It is our view in the South Region that in many instances, recreational use of the sort made of these sites is not harmful to their plant and animal communities and as a demonstration of this point of view we supported the County Land Agent when he wanted to buy as a Public Open Space three sites in which we were interested, totalling over 800 acres of land. The subsequent management of these sites is in the hands of a committee which is, in turn, advised by a panel on which the Conservancy is represented by the Regional Officer.

The Hampshire Public Open Spaces can be grouped in three categories. First, those which are largely tarmac, concrete or holiday beach. Secondly, those which are too small for multipurpose use, from 1 to 20 acres. Thirdly, large areas from 20 to 600 acres. Our interests are in the third category.

The kinds of habitat represented are:-

1. Downland
2. Deciduous woodland
3. Coniferous woodland
4. Heathland
5. Marshland
6. Open water

First I would like to mention the effect of recreational use on plant life, taking each habitat in turn. Where the last two groups occur on Public Open Spaces, people do not affect the plants except around the edge of ponds; especially where fishing is allowed. The four remaining relatively dry habitats may have their plant communities affected in a variety of ways by the visitors. The most important is trampling and here I include the effects resulting from driving cars on to the site.

On downland, at a low level of use, trampling has little or no effect, even on individual plants. At a moderate level of use the soil is compressed with injury to the plant roots and the plants themselves are almost literally worn away until the area takes on the appearance of a lawn.

If the intensity of use is raised further, the plants are destroyed, the soil exposed and erosion is an inevitable consequence. On every downland site investigated, the three levels of intensity of use were represented. Where people were channelled along a path or over a stile there was severe damage to the turf. Lawns were created where cars were parked on grassland or where the concentration of picnickers was very high. Generally the major part of each site was virtually unaffected by trampling. We have so far failed to establish the actual numbers of people required to walk over grassland to bring about these changes. We know that this number will vary from site to site, according to soil type, slope, frequency of frost and amount of rain. We also know that there is a very wide range of tolerance on open downland.

This is certainly not true of the woodland on the Downs. In deciduous woods the ground flora is easily damaged by trampling. On Old Winchester Hill National Nature Reserve, a single party of 50 people wore a distinct track through Dogs Mercury which lasted from June until the autumn. Damage to the ground flora in woodland is mitigated by the fact that people tend to keep to paths to a greater extent than they do on open grassland. If a path exists it may get heavy use whilst areas a yard either side remain untouched. It follows that paths through ecologically valuable woodland need careful planning because the creation of a path will mean the total elimination of the ground vegetation in a very short space of time. In Yew woods the damage is less since there is no ground flora but the erosion round the trees is greatly increased. Surface rubble in an unused Yew wood was found to have an average downhill movement of 2 inches a year and in an adjacent wood where the public were allowed, the average movement was 12 inches a year.

The use made of open grassland is usually different from that of woodland. Children will play in either, but adults will generally try to keep children near them in woodland while allowing them to run at will over grassland. Most of the picnicking and family games take place on the open grassland giving such areas a relatively uniform level of use if all areas are equally accessible. Where use is heavy, public activities simulate mowing. The woodland edge, where it adjoins the road or grassland, may be used as a public lavatory if no toilet facilities are provided. The increased nitrogen content of the soil in such areas may eventually cause a change in the flora.

Either in deciduous woodland or on open downland it appears that any damage caused by trampling can be rectified over the course of one to two years by ensuring that a different area is used for that period. I have applied this technique to paths by re-routing them when the damage to the plants is marked. After two years, they are scarcely distinguishable from the surrounding areas.

On heathland sites the destruction of the ground vegetation may lead to the very rapid soil erosion or a radical alteration in the soil structure. Trampling on sandy heaths seems to break up the soil rather than to compress it. Even if a path is re-routed the original plant cover will take a very long time to re-establish itself. As in woodland with a vigorous ground flora, people tend to keep quite strictly to paths over heathland. The damage done by re-routing a path is probably greater than that done by accepting the total elimination of the vegetation along the original paths. On Yately Common it was clear that the formation of wide sandy paths was not entirely detrimental to the habitat since the colonies of sand digging Hymenoptera with their associated parasites were concentrated along the edges of these paths.

In the coniferous woodland on the edges of Iping Common there was no obvious effect of public access except on the conspicuous nests of the ant, Formica rufa. These were subject to physical disturbance ranging from prodding to burning.

I have records for some downland and heathland areas which go back ten years or more. On Yately Common the County Council has cleared away the Gorse and bracken from a 2 to 3 acre plot around an old waterfilled gravel pit. This is a popular spot where people can park their cars and picnic. The grassy patch created attracts rabbit-grazing and in turn their dung provides food for the Three Horned Dor beetle, Typhaeus typhaeus, whose population is particularly high in this area.

Old Winchester Hill, a downland N.N.R. has provided some interesting evidence about the effect of the public on certain mammals and birds. Since the construction of car parks with litter bins, there has been an annual movement of brown rats, Rattus norvegicus in the summer from a chalk pit filled with farm refuse to the food sources in these car parks. The total distance covered by the rats is a quarter to half a mile. This invasion, although it involves only 50 or 60 animals could have detrimental effects on the small mammal population along this edge of the reserve. Less serious perhaps, is the arrival of a large summer population of House Sparrows. Until the car parks were built, the sparrows were rarely seen; about 50 stay from about May until November. Like the rats, they feed from the litter bins.

On Old Winchester Hill too we have strong evidence that the behaviour of one group of badgers has been altered by the presence of large numbers of noisey people in the vicinity of the main sett. In the summer they emerge nearly two hours later in the evening than any others in the neighbourhood. In 1963 the presence of people near the car parks until late at night is thought to have prevented the badgers from reaching their feeding area.

Some birds, for instance sparrows, have clearly benefited from the presence of people. Rooks, robins, chaffinches and tits have all been seen picking up the fragments of food left by visitors. On the other hand it is noticeable that the thorn bushes in the disturbed parts of Old Winchester Hill are not used as nesting sites and that the whole of the five-acre strip where the public congregate is avoided during the day by all birds except the pheasant, which even nests alongside the paths. In the early morning however, this five-acre strip is one of the most crowded feeding areas for birds on the whole reserve. The effect here certainly seems to be an alteration in behaviour among the existing species rather than an alteration in the actual species composition of the community.

Perhaps more important than the effect of people on Public Open Spaces is the effect of management. The County Land Agent is well aware that the demand for open space is great, yet he is also aware of the problems facing the Conservancy in southern England and the possibility that indiscriminate use of any open area of land by the public may not only destroy the essential quality of the habitat which the Conservancy wishes to preserve, but also the attraction of the site to the public.

It is clear that in some instances the Conservancy's aims in management may be similar to those of the County Council in the interests of the general public. This has worked in practice, where Old Winchester Hill N.N.R. also serves as a Public Open Space and the County Council property at Butser Hill acts as a nature reserve. The actual management of the two sites is virtually identical except that the public are kept away from the most interesting areas on Butser Hill. We regard the larger open spaces in the county as sites to be managed in the same way as open access reserves but would like to mention here that not all the areas owned by the county are open to the public. Those that are not, mainly woodland sites, are comparable to restricted access reserves.

Finally, and perhaps most important in the long term, the county authorities are not restricting their interest in wildlife conservation to their Public Open Spaces. Over the past two years we have been working with the Planning Officer to divide the whole county into zones based on their present wildlife interest. The conservation zones will be borne in mind in future development plans for the county. We are also trying to define policies for the land-use in these zones, where that is practicable. The Public Open Spaces receive special treatment to enhance their value to the public and to the ecologist. Now the countryside around them is also being treated in such a way that conservation interests are being given general consideration. The realization by a County Council that isolated sites meet only part of the needs of the ecologist and the public is an important advance in the thinking of a Local Authority.

GENERAL DISCUSSION

Comments on the Symposium Papers by
J. G. Skellam, Head of Biometrics Section,
The Nature Conservancy, London.

It will be seen from the programme that the summing-up will be carried out by the meeting in general discussion. Your Chairman will, however, exercise his privilege - perhaps even abuse it - by making observations on certain specific points which have sprung to mind in the course of the Symposium.

First, there is the question of whether conservation is an art or a science. If it is an art, the papers we have heard are indeed a valuable contribution to the subject. If it is a science, there are certain serious methodological criticisms which can be made to many of them. The most outstanding of these is the well-known logical fallacy of "post hoc ergo propter hoc". There is no foundation for believing that if one state of affairs or event follows another in time the second event is necessarily caused by the first, yet this kind of reasoning seems to pervade almost the whole of conservation thinking. It is of course, essential to look for correlations and coincidences because coincidences are the starting points from which hypotheses are suggested to the mind, but these are only working hypotheses and do not in themselves constitute established scientific knowledge.

It is not easy to find a common theme that runs through the papers, so common that it is independent of the particular species and independent of the particular habitats. One thing, however, is apparent, a deep awareness by those who practise the art of conservation of the need for a philosophy which is in harmony with fundamental scientific knowledge. The basic tenets of conservation thinking are conditioned ultimately by the extent of the conservationist's appreciation and understanding of the essential properties of complex dynamic systems of ecological type, and in particular by his attitude to questions of stability, diversity and control. Conservation measures can never achieve objects which lie outside the realms of ecological possibility, no more than the devices of mediaeval alchemists could achieve ends beyond the possibilities of chemical combination. In particular, ecological systems cannot be guided towards arbitrarily chosen states or conditions and perpetuated there, but only towards those states which ecosystems are capable of realizing or manifesting by reason of their intrinsic dynamic properties.

Consider, to begin with, one of the simplest conceivable physical systems, that of a fixed mass of gas to which the familiar ideal-gas equation ($P V = R T$) applies. This relationship can be expressed alternatively in the more general abstract form, $F(P,V,T) = 0$, where P,V,T are the variables, and F symbolizes the functional relationship which connects them, the constant R being implicit or absorbed in F. The state of the system symbolized by the vector (P,V,T) is determined when any two of the three variables are held fixed; otherwise it is indeterminate. In the customary language of physical science, the system would be said to have two degrees of freedom, one less than the number of variables.

By contrast ecological systems are extremely complex with numerous variables and an extraordinarily high number of degrees of freedom. It is therefore not possible, by controlling only a few of the variables, to determine the rest arbitrarily, and this is precisely what many conservationists seem to be hoping to do.

If, for simplicity of exposition, we consider an ecosystem in abstract as having species components (X,Y,Z.....) including human visitors (H), edaphic components (N,P,K.....), microclimatic or meteorological components (R,W,L.....) and being subject to management factors or conservation measures (M_1, M_2, ...), then at time t the system may be described in terms of the magnitudes of its component features as a vector or matrix in essentially the same way that the Biological Records Centre records descriptions in vector form on punch cards. Symbolically, such a vector could be expressed as follows:

$$(x,y,z,\ldots\ldots, n,p,k,\ldots\ldots, r,w,l,\ldots\ldots, m_1, m_2,\ldots\ldots, t),$$

where a small letter is used to denote the magnitude or value on a scale of the corresponding component or factor. The system would be subject to contraints symbolized for example by $F\ (x,y,z,\ldots\ldots) = 0$.

Certain species (e.g. X) may not be represented (i.e. $x = 0$) and in a closed or insulated system would remain so. In an open system such species could be introduced but may or may not persist. It may or may not be possible to raise the specific diversity to an arbitrarily chosen pre-assigned level. When a system moves to a state which hardly changes with the passage of time (except for seasonal periodicity) such a state might be called 'stationary' and if, moreover, after moderate disturbance the system invariably returns to that state, such a state might be called stable. A system which is in a stationary state is not necessarily in a stable state, as is illustrated for example by the orbit of the earth round the sun. The degree of sensitivity to disturbance is another important characteristic by which ecosystems might differ. Ecosystems are always liable to temporary or permanent impoverishment through extinction, and even when extinction is not involved, it is conceivable that ecosystems might nevertheless possess several alternative stationary or stable states. Ecosystems may perhaps never even approach states which are truly stationary in all aspects but only in respect of the more influential species dominants, and might even display a perpetual flux in composition in respect of the more subordinate elements. Unfortunately, we know far too little about the problems of reversibility and cyclical change and the effects of low and high diversity on the dynamic properties of ecosystems. As long however, as our ignorance of the general abstract properties of complex dynamic systems of ecological type persists, and the views of conservationists on these basic issues remain traditional, intuitive or speculative, there can be no secure scientific foundation to justify conservation practices, attitudes and ways of thinking.

The interpretation of the simplest survey or controlled experiment is affected by our conception of the dynamics of the system. For example, two management treatments may have different effects. But if the system is not in equilibrium, the difference might not be as important as it may appear at first sight, for the two treatments, like catalysts, may not in fact differ substantially in their effect on the ultimate state of the system but only in their effect on the rate at which the equilibrium state is approached.

The essential difference between the conservationist and the ecologist is that the ecologist in his purely scientific capacity is not really concerned with attaching value to the composition of the system he studies but only in elucidating its structure and dynamics. It is preferable for a sensitive soul not to contemplate the aesthetic aspects of food chains and other cruelties in nature but to seek protection in scientific detachment. It is for the conservationist to state precisely what he is aiming at, and it is a matter for scientific research to estimate the effects of various proposed conservation measures and to determine whether or not the system moves, or is even capable of moving, in the direction hoped for by the conservationist.

Now I find that conservationists do not agree over the composition of the systems which they wish to see established. One says "I would like to see lots of birds", and another says "But what would happen to the butterflies?"; one may want scrub, the other grassland. Even to get started there must be reasonably good agreement on the major features which are aimed at. The number of species combinations exhibited by all conceivable states is virtually infinite, yet it is interesting to note that whenever a new combination appears to be realizable, someone attaches special value to it. If the flora and fauna of this country had remained almost unchanged since mesolithic times, causing many to think that conservation is unnecessary, there would surely be someone who would ask to create here "some of that interesting chalk grassland such as can be found on the continental mainland". It was clear today, for example, that the unusual communities which had developed in southern England under the action of military operations were themselves of very considerable intrinsic ecological interest. Indeed it can be argued that practically any species combination which possesses a reasonable degree of stability and self-perpetuation is worthy of ecological study. (Mr. Skellam then invited comments from the floor.)

The first contributor to the discussion made the comment that it was generally agreed that we wished to preserve as many variables as possible in the wildlife complex of our reserves so that we were concerned primarily with species and habitat diversity. Although this was our general aim, it did not mean that we sought to maintain maximum diversity in all cases and on all areas. It was pointed out that we often had to deal with situations which were unstable ecologically and that management really meant maintaining this degree of instability in order to conserve the most interesting features. The importance of ecological history was also emphasized, particularly in relation to the contribution on woodlands.

Mr. Skellam said that ecological systems were so complex that it would be wrong to believe that there was any sort of computer solution to the types of problems facing the conservationist. The point was also made that the conservationist was trying to do different things in different parts of the world and that possibly our objectives would have to be adjusted as changes in land-use took place and new things became desirable or were required in the public interest. Elsewhere in the world, however, we were trying to preserve low species diversity in contrast to what was usually the aim in this country. Oceanic islands were quoted as an example. These isolated features in large oceanic areas often supported a few species of particular interest (e.g. endemics) which frequently occurred in large numbers.

Probably there would never be a static conservation object which was generally applicable for all time because human influences are constantly changing. As human society evolved, our aims in what we regard as important, interesting or enjoyable in conservation would also change. It was generally agreed in the discussion that the variable, time, was probably one of the most important and continuing features of Mr. Skellam's equation. The fundamental aspect of a world conservation policy must be that the greatest range of species diversity and ecosystems should be preserved. Unless there was agreement on this, it would be difficult to go to the next stage where we would select the actual areas for preservation.

A member commented on the importance of afforestation as a form of land-use which was modifying our countryside and on which research was required. It was suggested that the Scientific Policy Committee and the Forestry and Woodlands Committee of the Natural Environment Research Council should be asked to bear this in mind. In reply it was said that there was close co-operation between the Forestry Commission and the Nature Conservancy whose chairmen met regularly and that a scientific officer was being appointed to Merlewood to work on the development of new ecosystems in large plantations.

A member asked for clarification on the function of National Nature Reserves. He said that he was not sure from what had been said in the programme whether nature reserves were meant for wildlife or for people and he asked how much emphasis the Conservancy should give to both of these aspects of nature reserve use?

In reply it was said that the National Parks Commission (and subsequently the Countryside Commission) would be working on the research aspects of measuring human impact because this was a problem of concern to them in their planning. The Countryside Commission Bill for Scotland was in draft and had been seen by the Nature Conservancy but the Countryside Commission Bill for England had not yet reached the first draft stage and the contents were as yet unknown. However, the Nature Conservancy will almost certainly be expected to advise the Countryside Commission on ecological matters concerned with the management of natural and semi-natural vegetation while the Commission will probably take on the responsibility for research on social science issues in countryside planning. They would be looking particularly at the demands for recreational use of the countryside. The Nature Conservancy, the Forestry Commission and the Countryside Commission, would in the future, be the three big government land managers and obviously they would have to work closely together to ensure that their duties were fully discharged.

These three organisations, for example will have to work together to ensure that priorities for land-use were agreed. On conservation areas where recreation is acceptable as a secondary use, advice would be sought from the Countryside Commission by the Conservancy. Similarly where conservation was a secondary use to recreation, then the Countryside Commission would consult the Nature Conservancy over aspects of management. All this however was in the formative stage and had not been worked out in any detail. A participant said that planners would soon be asking the conservationists for precise figures of the carrying capacity of different sorts of country used by the public. He gave as an example, Michael Dower's study in Donegal. However, he felt that there was no such thing as a precise estimate of carrying capacity because any number of people, even very few, would have some effect on the land they were using and it depended so much on the type of activity. He thought that it was really a question of how much change we were prepared to tolerate in the ecosystem as a result of public use. We must devise some standards which we thought were tolerable for environmental capacity to absorb public use and this was obviously going to be different on National Nature Reserves and on public open spaces. We must balance the equation: number of people permitted to use an area in relation to the effects brought about by those people.

Several members referred to what seemed to be some confusion over the policy of the Nature Conservancy on the use made of National Nature Reserves. One member said that he was surprised at the suggestion that appeared to have been made in one of the papers that more nature reserves should be used as public open spaces. This he thought would introduce a new factor in the management problems and great changes might result.

In reply a participant said that the Nature Conservancy's policy was that human access was desirable in so far as this was compatible with the primary objects of conservation. Most of us would think it very odd for any National Nature Reserve not to have the conservation of wildlife as its first priority in relation to other uses. While of course it was true that National Nature Reserves were there primarily because society wanted them, their use in providing for human pleasure was a specialised one arising from their wildlife diversity and interest, and they existed to serve a relatively narrow section of the total need of the community. The whole object of the community in establishing reserves would be frustrated by an attempt at catering for all the other possible forms of outdoor recreation on these special sites.

A Warden of a National Nature Reserve said that he felt alternative areas should be provided for public recreation and he favoured the concept of the Country Park because he did not think that in practice, effective compromises between recreation on the one hand and research and conservation on the other would often be possible on National Nature Reserves.

Another speaker referred to the strong feeling among some members of the public that publicly owned land should be made available to anyone who wished to use it and said that it was sometimes difficult for visitors to see that their activities were in any way detrimental to wildlife conservation. In cases where there was already established public use on land made into a nature reserve, it was very difficult to interfere with it. The conservationist was in a difficult position because he was forced to apply a value judgment when using scientific knowledge about a particular area. He had to say that because such and such is present on the area, therefore this or that activity could not be permitted. To many people this was unscientific because value judgments often seemed difficult to defend on strictly scientific grounds. It was essential that where the conservationist had to oppose other public activities, the scientific case should be very strong.

Other speakers said that the Conservancy's prime function was to conserve wildlife and that it should not make excuses for this. There was bound to be an increasing pressure on nature reserves because of an increasing population, greater leisure and greater mobility, but the Conservancy, as spokesman for a special section of the community, must draw the line somewhere. It could not go on and on compromising where its statutory duties were involved. An example was given of the demand which is made for car parks near nature reserves and then once these were established, for larger and larger car parks and if this was allowed to go on, obviously considerable damage could be done to the reserve. Unless some brake could be applied in the process, in time the Naturalists' Trusts' reserves, where there was no obligation whatsoever to admit the public, would be quieter places and consequently there would be fewer difficulties for research workers than on National Nature Reserves.

Other speakers said that this Symposium had shown how great the need was for research on nature reserves, both on ecosystem management and on the measurement of the biotic effect of public use. It was therefore all the more important that we should ensure that this research can take place and that we should not hesitate to control access where this proved necessary.

A member said that he would like to know the views of the Symposium on the responsibilities of the Conservancy in relation to the study of human impact effects. Mr. Hammond had shown in his study that a good deal of work had been done on the catchment area of public movement, their motivation, from where and how they came and the distance travelled to reach the Wye and Crundale nature reserve. This, the speaker thought, was the type of problem requiring the expertise of the qualified Social Scientist and that the Conservancy's responsibilities as a biological organisation began as soon as a member of the public set foot on the reserve. What the visitor did on the reserve, how often he did it, and how many people were concerned with the activity, were obviously things that we needed to study closely. He thought that it would be wrong for the Conservancy to embark on extensive work in the field of social science when there were no staff professionally trained to do this and in any case, it would appear to be the responsibility of other authorities. Other members supported this point of view and it was also said that the root problem to this question was the manpower resources of the Conservancy. The Nature Conservancy now had over 250,000 acres of land within its nature reserves but its scientific staff had not grown proportionately. Some public authorities with land management responsibilities had a relatively far larger staff available for work.

Other members said however, that the Nature Conservancy must concern itself with social science studies in relation to conservation because no-one else was available to do this work at the present time. The motivation of public activity was a problem the organisation must handle until it could be passed on to someone else.