PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

Conservation of Terrestrial Communities [and Discussion]

D. A. Ratcliffe, M. W. Holdgate and E. M. Nicholson

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Conservation of terrestrial communities

By D. A. Ratcliffe
Nature Conservancy Council, London

The U.K. contribution to this section of I.B.P. was led by the Nature Conservancy, first with a review of sites of national importance to biological conservation in Great Britain. Besides the existing 140 National Nature Reserves, 395 sites of equivalent importance (grade 1) have been identified, 111 of these being rated internationally important. Queen's University, Belfast, conducted a similar exercise for Northern Ireland.

Programmes of management research relating both to reserves and the wider countryside have included population studies of key vertebrates (e.g. red grouse, red deer, grey seals), studies of effects of mammalian herbivores on vegetation, and ecological investigations of plant communities and soils representing important semi-natural and natural habitats (e.g. coastland, woodland, grassland, wetland, moorland and mountain tundra). This has provided ecological insights for the manipulation and control of plant and animal species and communities important to nature conservation.

The Royal Society has supported surveys and other basic research on oceanic islands (e.g. Aldabra, St Helena), threatened world floras and faunas, and universities have contributed studies of endangered species such as the Nile crocodile and Asiatic lion.

Introduction

The work of the C.T. section of the I.B.P. has to be viewed against the objectives of the programme as a whole. The basic I.B.P. concern for close links between the advancement of science and the promotion of human welfare implied that the productivity studies were to be aimed at raising the carrying capacity of both land and water for human beings; or, in the terminology of the ecosystem model, at ensuring the optimal circulation of energy through man himself. This model, indeed, provides a basis for a conservation philosophy in that it envisages finite systems with ultimate limits to their growth. Human beings will benefit if these ecosystems are maintained in equilibria which stabilize at the highest possible level the availability of certain of their components as natural resources, for use as food or in other ways. The concern is with *maximum sustained yield* of the resources, an aim compatible only with conservation in the broad sense.

Conservation is thus concerned with maintenance of the essential ingredients of physical life, but it also extends to maintenance of attributes which nurture the mental life. Research into ecosystem dynamics not only promotes human welfare in a material sense; it is also a contribution to that continual enrichment of the intellectual endowment of mankind which we call basic science. Nature conservation in the broad sense deals with a still wider spectrum of human interest, from profound scientific discovery to simple aesthetic reward, all of which needs some part of the total environment set aside free from unlimited human exploitation.

I have made this somewhat elaborate analysis because sometimes I feel that the research scientist and the conservationist do not understand each other very well, and it seems necessary to emphasize the continuity between their work. This sense of separation may inevitably arise since the two proximate objectives, of intensified food production and nature conservation, so often emerge not as complementary but as antagonistic aspects of human welfare. While the conservation of terrestrial ecosystems is thus potentially divergent from ecosystem studies, the C.T. work of the I.B.P. was in fact conceived essentially as a parallel operation to safeguard scientific study areas throughout the world. It so happened that in the U.K., the Nature Conservancy (now the Nature Conservancy Council) programme for key site conservation, including management research, so closely measured up to I.B.P./C.T. requirements, that the subcommittee were happy to regard the Conservancy as the lead agency for U.K./C.T. work, endorsing their programme and adding their support to the proposed review of key sites, with the request that further consideration be given to the need for research and educational reserves.

Key site conservation in Great Britain

The *Nature Conservation Review*, to identify the sites of special biological importance to nature conservation in Great Britain was launched in 1966 and the results will be published in book form (Ratcliffe, in the Press). The *Review* followed accepted philosophy that nature conservation should centre around the safeguarding, through statutory scheduling and appropriate control and management, of a fairly large number of key areas adequately representing all major types of natural and semi-natural vegetation, with their characteristic assemblages of plants and animals, and habitat conditions, of climate, topography, rocks and soils, and biotic influences. This view had become a policy expressed in practice in the acquisition of a countryside series of National Nature Reserves (N.N.Rs), now numbering 140 and covering 114000 ha (283000 acres), by purchase, lease, or management agreements with owners. The *Review* thus involved a reappraisal of existing N.N.Rs, as well as a countryside survey to delineate other areas of national importance. It also took account of other categories of nature reserve and protected areas (e.g. National Trust land), and required assessment of all but the most highly developed land. In this formidable task, scientists of the Nature Conservancy drew on help from universities, research and specialist groups, and individual experts, and they had invaluable assistance from voluntary conservation bodies.

The selection of the key sites involves a three-stage process. First there is the recording of information on biota and habitat factors for defined areas, classified according to habitat/vegetational formation, i.e. coastlands; woodlands; lowland grasslands, heaths and scrub; open waters; peatlands; upland grasslands and heaths; and artificial ecosystems. Then there is the comparative evaluation of areas within the same formation, to identify according to accepted criteria of nature conservation value the best examples of particular nodal points within the field of variation, or to pick out any unique sites. The criteria themselves express the range of human concern which nature conservation aims to support, and involve the placing of value judgements on various neutral attributes, e.g. extent of site and size of populations; diversity of habitat, communities and species; 'naturalness' of vegetation and fauna; rarity of communities and species; fragility of habitat; 'typicalness' in representing widespread communities and species characteristic of major habitats; recorded history of a site; and potential value, when careful management is possible. In this way, it is possible to select series of the most important key areas for each formation. The third, and most difficult stage, is to choose from these lists a final array of sites, covering the whole range of formations, which can be recommended as the minimum needing protection, to satisfy the national interest. Weight has also been given to the international importance of sites, by using most of the above criteria on a continental or even global scale.

A four point scale of grading has been adopted. Grade 1 sites are of national and sometimes international importance. Grade 2 sites are also of national importance, but either duplicate the features of related grade 1 sites or are slightly lower in quality, and thus could provide alternatives for conservation. Grade 1 and 2 sites are collectively referred to as 'key sites'. The *Nature Conservation Review* lists 702 key sites covering roughly 8.7×10^3 km^2, comprising 395 in grade 1 (6.1×10^3 km^2) and 307 in grade 2 (2.6×10^3 km^2). Of the grade 1 sites, 111 are regarded as internationally important (1*). Each key site is described in detail, though available information on habitat, vegetation and fauna varies greatly in adequacy. There is also much background information about the range of ecological and geographical variation within each formation, and the selection of key sites in relation to this, together with a detailed exposition of rationale and methodology. The volume purports to describe the range of wildlife and habitat constituting the major nature conservation interest of Great Britain, and the choice of key sites which gives the best representation of this interest.

Within the coastal formation, special emphasis has been given to the selection of the major estuaries, with their great complexes of intertidal flats and fringing salt marshes, and their internationally important concentrations of wildfowl and waders. These include notably Morecambe Bay, the Wash, the Solway Firth, the north Kent and Essex coasts flanking the Thames estuary, the Dee, Chichester and Langstone Harbours, and the Cromarty Firth. The main sand dune systems are all included, such as Scolt Head Island, Braunton Burrows, the Harlech dunes, Newborough Warren, Ainsdale, Torrs Warren, Tentsmuir, Culbin Sands, Sands of Forvie, Morrich Mor and Dunnet Links; and the oceanic variant, termed machair, in the Outer Hebrides is well represented. Three shingle beaches are of international importance, for their physiographic, as well as biological features – Dungeness, Chesil Beach and Orfordness. Botanically interesting examples of sea cliffs and small, oceanic islands have been identified, but internationally these coastal habitats are of the greatest importance for their huge concentrations of breeding seafowl, especially auks, kittiwakes, gannets and petrels. Significant fractions of the world population of some species occur on the British coasts, with the major stations including St Kilda, Westray, Hermaness, Noss, Clo Mor, Handa, Berriedale, Fowlsheugh, Ailsa Craig, Bass Rock, Bempton and the Pembrokeshire islands.

British woodlands are mostly highly fragmented and modified remnants of the original forest cover, but show a wide range of variation in dominant tree species, structure and associated communities of both plants and animals. The several series of woodland key sites reflect this field of variation, and are classified according to dominant tree species. To some extent these are climatic series, within which the types evolved under the strongly oceanic conditions of western Britain have a high international importance. Western oakwoods rich in ferns, bryophytes and lichens, and ashwoods are in this category, and are well represented. The New Forest, with its complex of oak and beechwoods, acidic heaths and valley mires, is one of the most important conservation areas in Britain, and vies with the pinewoods of Speyside and Deeside as the largest remaining tract of semi-natural forest. Other major types included in the national series are beechwoods in the Cotswolds and Chilterns; mixed deciduous woods of oak, ash, wych elm, birch and hazel in many districts; alderwoods in the Norfolk Broads and Scotland; birchwoods in the Highlands; and park woodlands with scattered over-mature trees,

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especially oak, in various districts. A few examples of more restricted types are recognized as grade 1 sites, such as yew wood; juniper and hazel scrub, and populations of rare *Sorbus* species.

Lowland grassland, heath and scrub covers a wide range of variation, but is essentially an anthropogenic complex, and mainly in England. The grasslands are typically on base-rich soils, and are disappearing rapidly through agricultural intensification. This is especially true of the once widespread chalk grasslands from Dorset to Yorkshire, which have mostly been converted from sheep pasture to arable or improved leys. Many of the remaining fragmented areas are rated grade 1, but the largest and best chalk grasslands still surviving are mostly under Ministry of Defence control, on Salisbury Plain, Wiltshire, and include the very fine Porton Down. Similarly, the unique complex of calcareous grassland to sandy heath known as Breckland in East Anglia is now reduced to scattered remnants except in the Stanford military training area of 65 km^2. Included with the Carboniferous limestone grasslands of northern England are fine examples of floristically-rich clint and grike 'pavement' and various karstic features. The grasslands or meadows, rich in forbs (i.e. non-grassy herbs), especially those cropped for hay, are another disappearing habitat type under modern agriculture, with heavy applications of fertilizer, ploughing and re-seeding, or conversion to arable. It is hoped that the best remaining examples have been identified but this is a widespread type difficult to survey. The acidic heaths belong especially to southern England, and are likewise much subject to development, including building. The best remaining areas are in Dorset, Hampshire, Surrey and East Anglia, though there are large areas transitional to upland types in Devon and Cornwall.

Open waters are divided first into lakes and rivers, and then classified according to other physical and chemical factors. Lowland, eutrophic lakes are rather uncommon, the best examples being in the Norfolk Broads, albeit of artificial origin as flooded mediaeval peat-diggings, and now much degraded by pollution. Other examples occur scattered over the agricultural lowlands, including the Cheshire–Shropshire plain (Rostherne Mere, Crose Mere), Yorkshire (Hornsea Mere), and Scotland (Loch Leven). In the north are smaller calcareous lakes on limestone, such as Malham Tarn, but the numerous northern and especially upland lakes are predominantly oligotrophic. A range of examples of this group has been identified in North Wales (Llyn Tegid, Llyn Idwal), the Lake District (Wastwater and mesotrophic Esthwaite Water) and Scotland (Cairngorm Lochs, Loch Laidon, Loch Morar, Loch Druidibeg and Loch Sionascaig). In coastal areas is a range of interesting lakes of eutrophic to brackish type, ranging from lagoons associated with sand dunes (Loch of Strathbeg, Aberdeenshire, and Hebridean machair lochs) and shingle (the Fleet, Chesil Beach and Slapton Ley, Devon) to lochs variably connected with the sea (Loch an Duin, Hebrides, Lochs Harray and Stenness, Orkney).

Rivers have been much less well surveyed but, notwithstanding the practical difficulties of safeguarding even short sections, a number of grade 1 examples has been named, covering the main variations. These range from eutrophic lowland types (River Great Eau, Lincolnshire; Shropshire Union Canal–Prees Branch; and River Tweed), chalk streams (River Avon and Moors River, southern England), limestone streams (Lathkill Dale, Derbyshire and Malham streams, Yorkshire) to oligotrophic rivers of the mountainous northern regions (Cairngorm rivers, including Spey and Dee, and Strontian River, Argyll). The River Wye, rising in the Welsh mountains and draining to the Severn estuary is included as a large, relatively unpolluted river increasing in chemical richness of water through its length before finally becoming brackish.

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Peatlands are grouped into six main classes of mire: valley, basin, raised, blanket, flood plain or open water transition, and soligenous. Raised and blanket mires are essentially oligotrophic, and basin mires mostly so, but the rest vary widely from oligotrophic to eutrophic. The first two classes are especially interesting on the international scale as major climatic types of peatland, and blanket mire is a feature particularly associated with the oceanic climate of Britain. Raised mires are relatively few and scattered, the best examples being Borth and Tregaron Bogs in South Wales, Glasson Moss and Wedholme Flow in Cumberland, and Flanders Moss in Stirlingshire. Blanket mires are extremely extensive in the uplands, and grade 1 examples have been selected in all the main hill districts from Dartmoor to Shetland. Many of the less disturbed and lower level blanket mires in western and northern Scotland show patterned surfaces of pools and hummocks, and a wide range of these interesting features is represented in the series. Valley and basin mires are mostly rather small and widely scattered, and a fairly large number is included. Soligenous mires occur mostly in the hills and are well represented on Upland grade 1 sites. The flood plain or open water transition mires (corresponding to the British usage of 'fen'), often occur in association with open waters, as in the Norfolk Broads and the Spey (Insh) Marshes, Inverness-shire, to give two especially important examples, one southern and eutrophic the other northern and oligotrophic.

The mountains and moorlands, with their wide range of grasslands, heaths and wetlands, are by far the most extensive of the formations surveyed. They are formed predominantly of hard, acidic rock, giving base-deficient soils, so that calcareous or base-rich uplands are highly valued, especially for their much greater floristic richness. The higher mountains of England and Wales are managed mainly as sheep walk, and so have a range of biotic grasslands. More gently contoured moorlands in the same areas or elsewhere are, or were until recently, often managed as grouse moor, and are clad with dwarf shrub heath, mainly of *Calluna vulgaris* with *Vaccinium myrtillus*, which becomes converted to acidic grassland when heavily grazed and burned. Important areas of both sheep walk and grouse moor are represented in the Mountains of Snowdonia in North Wales; Moor House in the Northern Pennines; Skiddaw Forest in Lakeland; and Cairnsmore of Fleet in Galloway. The higher and less heavily grazed mountains in deer forest country of the Scottish Highlands have a much greater extent of montane vegetation of more or less natural character. The Cairngorms is the largest and most important high mountain massif in Britain, and above 750–900 m there are extensive areas of climatic climax vegetation with a pattern determined largely by the shifting balance between wind exposure and snow cover, under the influence of topography. With increasing distance towards the north and west in the Highlands there is pronounced altitudinal descent of vegetation zones with their characteristic flora and fauna. Areas have been chosen to represent this feature, as on Ward Hill in Orkney, Ronas Hill in Shetland and the Cape Wrath area in Sutherland.

The British mountains as a whole have pronounced oceanic features, although many of their vegetation types are closely parallel to those of the Scandinavian mountains. The Atlantic character of both the montane and sub-montane zones is important internationally, especially in massifs along the western seaboard, such as Rhum, Beinn Eighe, Beinn Dearg and Foinaven. On the whole the British mountains are floristically poor, but on the limited areas of calcareous upland there are the interesting Arctic-alpine plant refugia. That in Upper Teesdale on sugar limestone is one of the most famous, and there are other notable areas in the Pennines on Carboniferous limestone, such as Ingleborough and the Malham area. Snowdon, Helvellyn and the Moffat Hills have noteworthy montane floras in the more southerly mountain ranges,

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but are eclipsed by the mica-schist mountains of the central Highlands, notably Ben Lawers, Ben Lui and the Clova–Caenlochan area. In the far north of Scotland are small but important areas of dolomitic limestone and blown shell sand, with calcicolous montane vegetation, especially *Dryas octopetala* heath, at very low elevations.

The artificial ecosystems consist of a medley of habitats such as roadside and railway verges, canal and reservoir banks, hedges and ditches, ponds and old gravel workings, derelict mined areas, and waste or uncultivated land. Though important for their nature conservation interest in the aggregate, they have few particular examples of special importance and cannot be conserved on a key site basis.

The *Nature Conservation Review* brings together extensive ecological data about the nation's capital of wildlife and habitats, with a list of the most important sites, and a rationale for their selection. It thus provides a framework for national policy for safeguarding wildlife on a key site basis, and a guide for scientists, planners, landowners, administrators, politicians and others concerned with the planning, management and use of land.

The Nature Conservancy Council is engaged in exploring the possibilities for safeguarding as many as possible of the 702 key sites. All but a very few of the existing 140 N.N.Rs are confirmed as grade 1 in quality, and the N.C.C. will continue to negotiate for acquisition of the most threatened and important sites. The resources required for acquisition and subsequent management of all these 702 sites would, however, be extremely large. The N.C.C. is therefore in discussion with various parties, especially Government departments, who either own, manage or influence the management of the lands in questions, to achieve the maximum safeguards by means other than N.N.R. treatment. A large number of key sites, for example, are owned by the Crown Estate Commissioners, the Forestry Commission and Ministry of Defence and might, with little if any interference to the principal uses, be managed by them for nature conservation. In addition to influencing the use of land in the public domain, the N.C.C. is considering the contributions which might be made through Government on fiscal incentives and land use grants to encourage private owners to manage their land for its nature conservation interest. All key sites are being notified as Sites of Special Scientific Interest (S.S.S.Is), though this is little more than a planning device whereby nature conservation objections to proposed developments are considered in deciding whether or not planning consent is to be granted. Discussions are also proceeding with the voluntary conservation bodies who may be able to acquire or secure control of other key sites as reserves.

The voluntary bodies, notably the Society for Promotion of Nature Reserves, the Royal Society for Protection of Birds, and the National Trusts for England and Wales, and for Scotland, have between them established at least 850 reserves, totalling 374 km^2. They range from a smaller number of areas identified as key sites in the Nature Conservation Review to a majority which is of regional or only local importance. Many of these have been scheduled as Sites of Special Scientific Interest by the Nature Conservancy Council.

Key site conservation in Northern Ireland

With the appointment of the Northern Ireland Nature Reserves Committee on 15 August 1966 it became possible to implement a proposal, made in principle in 1965, to provide assistance under the I.B.P. with the development of a programme of nature conservation in the Province. On 15 June 1967 the Council of the Royal Society approved a grant of £750 to

R. E. Parker of Queen's University, Belfast (a member of both the U.K. I.B.P./C.T. sub-committee and the N.I., N.R.C.) for the evaluation of potential nature reserves in N.I. by visiting groups of experienced ecologists. In N.I. it had been decided already that reserve selection should be based on a survey of possible sites by habitat type and by the latter half of 1967 preliminary surveys of several habitat types had been completed. Visits were made in the summer of 1968 by the Woodland, Bogland and Coastal Groups, and in the summer of 1969 by the Grassland and Heath, and Freshwater Groups.

The work of the groups took the form of an examination, under local guidance, of a series of sites including those thought to be of particular scientific importance. Each group was accompanied by appropriate members of the N.R.C. and scientific officers of the N.I. Ministry of Development (the branch of Government then responsible). A conservation officer of An Foras Forbartha (Dublin) joined the groups visiting in 1968.

Comprehensive reports which included site descriptions, evaluations, conservation proposals, and suggestions for management were prepared and submitted. These reports were welcomed in N.I. and have become important working documents. To a considerable degree the visiting groups endorsed the tentative evaluations already made locally but the special knowledge of the visiting experts both in respect of their particular habitat type and its representation in reserves in G.B. led to many adjustments and greatly enhanced the reliability and weight of the final recommendations.

Despite problems of several kinds, some of them peculiar to N.I., substantial progress has been made in the establishment of nature reserves and the notification of Areas of Scientific Interest (equivalent to S.S.S.Is). Up to 1 June 1975 some 19 National Nature Reserves had been established. Among these, woodland and bogland habitats predominate, with some coastal and geological sites. Several other coastal sites valued highly by the Coastal Group are in the care of the National Trust. Some 35 A.S.Is have been notified. These include examples from all of the main habitat types, with strong representation of freshwater and coastal types. Some of the A.S.Is are small and of very specific scientific interest but others, e.g. L. Neagh, Rathlin Island, and the North Antrim Coast are very extensive and include a whole series of important sites. It is confidently predicted that during the next two years 9 further reserves will be established; including several more important coastal sites together with some areas of woodland, heath and freshwater.

Management research

The safeguarding of key sites is only one arm of strategy for nature conservation. The other main approach is to influence use of the generality of land and water by the infusion of concern and knowledge about nature conservation into the planning, management and development of the natural environment. This involves the provision of advice to those especially concerned with land use, and education and legislation which foster a favourable climate of public opinion. But all these things must be based on adequate and accurate knowledge. The field is so vast that the fund of existing knowledge has continually to be augmented by new research, which is of three main kinds – survey, to record essential features at one point in time, monitoring to detect and measure change, and ecological studies in depth, to provide understanding of processes and relationships, especially those involving cause and effect. The Nature Conservancy has, since its inception, promoted a research programme to underwrite both its advisory functions and its executive responsibilities in managing reserves.

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Management of both communities and species depends essentially on ecological insight. In particular, it is important to know the natural dynamics relating to reproduction, growth and development, decline and death, in the vegetational component of ecosystems. Many British woodlands are characterized by an almost total lack of regeneration so that, although the existing trees are often healthy with many years still to live, these woods are potentially moribund. Unless the inhibiting factors can be identified and removed, at least temporarily or locally, such woods will eventually die out. Even artificial planting of new seedlings may be ineffective if conditions for growth are adverse. A good deal of attention has thus been given to problems of tree regeneration. It has been found that in many woods, especially of oak and birch, the stocking density of the trees themselves is too high, producing a degree of shade inhibitory to seedling growth. Regeneration is then dependent on opening up the canopy, either naturally or artificially (Kinnaird 1974). Fencing experiments in upland woods have shown that regeneration of most trees is prevented by heavy grazing pressure of large herbivores (sheep, deer and goats), which eat or trample the seedlings and saplings (Shaw 1968). Rotational fencing is a technique which provides for regeneration over a long period without having to remove grazing animals from the wood completely at any one time. Moor-burning is an integral part of upland management in many areas, and destroys seedlings and young trees. Conversely, in some areas, regeneration of Scots pine seems to be partly dependent on the coincidence of heather-burning with a good seed year, for the fire temporarily removes the pine seedling's main competitor. But in the cool, extremely humid climate of the western Highlands, moor-burning appears to produce virtually irreversible physical changes in the surface layer of the shallow peat soils, rendering them inhospitable to pine seedling growth. In such areas, it has been found necessary to resort to conventional artificial techniques of draining, fertilizing and seedling planting in order to obtain satisfactory regeneration of Scots pine. Considerable efforts have been made, using various techniques, to re-establish pine and other woodland at Beinn Eighe, Wester Ross, in particular.

By contrast, many of the grasslands and heaths of the lowlands are constantly tending to revert to the woodland from which they were derived, or at least to scrub as an intermediate stage. The interesting and important flora and fauna of the grasslands and heaths is thus fragile, especially since myxomatosis removed the natural control of woody seedlings by rabbits. There may also be adverse changes within grassland communities through shifting balance of competition between established species, notably for instance in the invasion of species-rich chalk swards by the dense, vigorously competitive grasses *Brachypodium pinnatum* and *Bromus erectus*. Experimentation has involved use of different techniques to resist these natural processes of succession. Flocks of sheep have been used on chalk grassland at Aston Rowant and Old Winchester Hill, to simulate the former beneficial management practice, but with varying treatments on different parts of the areas in order to determine the best régime in terms of grazing intensity. Cattle have been used similarly to help maintain Oolitic limestone grassland at Castor Hanglands and open damp meadow areas of Woodwalton Fen. Artificial cutting treatments have been applied, by using mechanical mowers, at Barton Hills, Knocking Hoe and Lullington Heath (see Wells 1971; Wells & Wells 1974).

The problems here have proved complex. Chalk grassland has been destroyed on a large scale chiefly because the sheep grazing on which it depended is no longer economic. Even when farmers are still prepared to run sheep or cattle on these grasslands, modern standards require supplementary feeding of animals, and this may lead to a build-up of nutrients in the ecosystem.

Research has shown that the floristic richness of these ancient grasslands is associated with deficiency of phosphorus and nitrogen in the calcareous soils, inhibiting the growth of robust grasses and forbs. When grazing animals increase instead of decreasing these nutrients, there is loss of botanical richness. The same applies when mown vegetation is left as litter, for it acts as a top dressing, and so has to be removed if deterioration of the sward is to be avoided (Green 1972*a*). Conservation research in this field thus ranges from the understanding of economic trends and constraints to the fundamentals of plant–soil relationships and competition (Green 1972*b*; Duffey 1974). In the uplands, the wide range of sub-montane dwarf shrub heaths and monocotyledonous communities, originally derived from forest, represents a biotic series determined by intensity of grazing in combination with moor burning. Heavy grazing suppresses shrubs of all kinds and tall forbs, and is generally believed to have been a major factor in the present restricted distribution of many Arctic-alpine plants. However, exclosure studies at Moor House suggest that certain montane species have evolved dwarf ecotypes adapted to heavy grazing, and that when this factor is eliminated, they are smothered out by the vigorous growth of grasses and sedges which results (Rawes 1975). These studies also demonstrate that the main grassland types formed under heavy sheep grazing are fairly stable when this factor is removed, though there are marked changes in balance between the dominant species. By manipulating the range of management options, i.e. the stocking density of grazing animals and the species, and the frequency of moor burning, it is thus possible to adjust the pattern of vegetation to give the optimum for a particular régime. Studies at Moor House of the production and utilization by sheep of *Calluna vulgaris* and *Eriophorum vaginatum* have suggested that if sheep farming is the main land use, increased sheep grazing will produce better summer feed; but if grouse shooting is given priority, either light grazing and no burning or burning without sheep grazing, are recommended (Rawes & Welch 1969; Rawes & Williams 1973). The retention of dwarf shrub heath, needed by red grouse and important for its rich fauna, depends on regulation of both grazing and burning and is incompatible with maximum exploitation of uplands as sheep walk.

In Snowdonia, there have been studies of the preferences of sheep for different upland plant community/soil types, and the effects of grazing as a differentiating factor within this range of vegetation. Sheep selectively graze the more nutritious swards on the better soils, reaching higher densities than on poorer ground. Complete exclusion of grazing results in a change from dominance of *Nardus stricta* to that of *Molinia caerulea* with greater prominence of *Ericaceae*, on podzolic soils. On base-rich brown earths, species-rich *Festuca ovina–Agrostis* spp. swards in exclosures tended to change to *Holcus lanatus–Festuca rubra* grassland with *Deschampsia caespitosa* (R. E. Hughes, unpublished).

Work on moor-burning connects very closely with the P.T. section of the I.B.P., in that this is a major factor affecting nutrient circulation, the accumulation and decomposition of plant material. The ecosystems especially subject to fire in Britain are medium to dwarf shrub heaths in both lowlands and uplands, and ombrogenous bog surfaces. Burning of the vegetation and litter causes a sudden and substantial release of mineral nutrients to the soil surface, though there is some loss or redistribution in gaseous or solid matter in smoke. It has been alleged that on certain soils or peats of low exchange capacity and high acidity, these mobile nutrients may be lost through leaching at a greater rate than they are retained by the soil exchange complex, leading to a progressive loss of soil fertility through repeated burning over a long period. A contrasting view is that burning allows a more rapid circulation of major nutrients, since a smaller fraction remains locked up in the litter on average. The subject is still controversial, but recent studies of the atmospheric fall-out of nutrients in dust and rain show that this source of enrichment may compensate for losses through leaching, at least for certain elements (Allen 1968).

On lowland heaths, burning is important too in maintaining the open habitats required by certain organisms, e.g. reptiles, but uncontrolled fires can be extremely destructive, both in killing these creatures and in wiping out habitat. Recovery in animal populations occurs at varying rates, and for ant species has been studied over a ten year regeneration period (Brian, Mountford, Abbott & Vincent, in the Press). Studies by Chapman, Hibble & Rafarel (1975*a*, *b*) of production and litter accumulation of *Calluna* on lowland heaths are relevant as work bridging C.T. and P.T. programmes, since they bear upon the needs for management of these eco-systems.

The relationship between moor-burning and nutritive value of *Calluna vulgaris* is a good example of the way in which land use effects on vegetation then connect with dependent animal populations, in this case the red grouse *Lagopus lagopus*. A long-term study of the dynamics of red grouse populations in eastern Scotland has established that numbers, though subject to irregular fluctuations from year to year, are basically dependent on the carrying capacity of the moor in terms of the food value of *Calluna*, the staple item of diet. As with the large mammal herbivores, the nutritive quality of the fodder is closely related to base-status of the prevailing rocks and soils, and is highest on those rich in calcium carbonate, notwithstanding the traditional view of *Calluna* as a calcifuge species. The elements of greatest significance to the nutrition of the grouse appear to be phosphorus and nitrogen (Moss 1969). Numbers thus respond to the addition of conventional agricultural fertilizers to the moor (Miller, Watson & Jenkins 1970). Other factors being equal, however, a careful regime of rotational burning of the heather can maximize the carrying capacity of a moor by giving optimum area of nutrient-rich young *Calluna* at any one time. Vagaries of climate can result in sudden reduction of grouse numbers, e.g. prolonged winter frost during a period of little snow can kill extensive areas of heather through severe desiccation of the plants (Watson, Miller & Green 1966). It appears that the grouse are able to adjust their numbers to availability of food, by displacement of surplus birds from the territory-holding populations, and by spacing behaviour of the latter, though the exact mechanisms are still not fully understood. Numbers are also related to chick survival as influenced by some, as yet unknown, factors relating to nutrition of the females when eggs are laid (Watson 1967, 1970; Watson & Moss 1971). Studies of the Ptarmigan *Lagopus mutus* have shown that this species is a selective feeder, choosing the plant species and tissues of highest nutritional value (Moss 1968; Gardarsson & Moss 1970).

Studies of red deer *Cervus elaphus* populations, especially on the Hebridean island of Rhum, have shown that these animals preferentially select the richer swards and ignore the poorer ones, and that overall numbers depend primarily on the rock/soil qualities of the grazing range. This work has, however, been concerned with practical aspects of deer forest management, notably in the cropping of the herds themselves. On Rhum, it was found that culling annually at the rate of one sixth of the total population – a much higher rate than is practised on most deer forests – was a feasible proposition, provided the animals were carefully selected according to age-class, sex and body conditions (Lowe 1969). Recent trends suggest that the herd may not be able to sustain this high level of cropping indefinitely, and that adjustment to a lower rate may be required for a time. Further studies of the Rhum herd have provided much

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information on the relationships between age, sex, reproductive state and body condition (Mitchell *et al.* 1972). This is relevant to the two related management and conservation problems of carrying capacity and deer performance. On the remote Atlantic island group of St Kilda, the feral population of Soay sheep has been studied in depth (Jewell, Milner & Boyd 1974). These animals, which have no significant predators and are now unmanaged, rapidly build up in numbers and are subject to sudden 'crashes', giving marked fluctuations over a period of about five years. A main precipitating factor in these declines appears to be an adverse tipping of the delicate balance between summer provisioning in the body of the sheep against severe winter poverty. This depends to a great extent on the size of the population and weather conditions in the previous summer as well as in the winter when the crash actually occurs.

The Atlantic grey seal *Halichoerus grypus*, though an extremely local species on the global scale, has a fairly large population scattered around the northern and western coasts of Britain, with concentration on several major breeding stations, mainly on the rocky islands of the Farnes, the Orkney group, North Rona, and the Hebrides. Complaints of the predation by grey seals on salmon, especially involving injury to living fish and damage to nets, have led to culls of adults and pups at some of the breeding stations. On North Rona, however, a study involving marking of pups and adults is attempting to measure mortality rates and dispersal, as factors influencing predation (see Boyd & Campbell 1971). On the Farnes the increase in seal population has caused substantial soil erosion, posing a threat to important bird populations, and control of numbers here is necessary for nature conservation purposes.

While the winter wildfowl populations of the United Kingdom are of great international importance, the breeding populations are of much less significance. Loch Leven in Scotland is one of the most important sites for breeding wildfowl, especially for mallard *Anas platyrhynchos* and tufted duck *Aythya fuligula*, but studies of breeding success have shown that predation on eggs and young is so heavy that adult numbers must be maintained by an annual influx from other localities (Allison, Newton & Campbell 1974). Wildfowling is accepted as a legitimate sport, but has to be regulated at a level which prevents permanent depletion of the population. Large numbers of ducks and geese also provide competition with cattle and sheep grazing on saltings, and a problem successfully solved at Bridgwater Water, Somerset, is the reconciliation of wildfowling, grazing and wildfowl protection (Cadwalladr, Owen, Morley & Cook 1972).

A classic example of a threatened species in Britain is the Large Copper butterfly *Lycaena dispar*, reintroduced after earlier extinction to Woodwalton Fen N.N.R. in Huntingdonshire, and there maintaining a precarious existence. Research here aims at gaining insights into insect biology-habitat relationships which will allow manipulation of the vegetation and water table favourable to natural survival of the butterfly. Results so far have not solved this problem, and may point to a basic difficulty, that the extent of suitable habitat is below the minimum size which can sustain this fragile, relict population; or that the optimum habitat no longer exists in this much modified island remnant of the original Fenland (Duffey 1968).

Certain unstable habitats are prone to erosion which may be exacerbated by human activity and may lead to losses in both economic value of land and nature conservation interest. Sand dunes are liable to blow-outs, causing loss of vegetation and sometimes serious wind-blow of sand. Blanket bogs in many areas are subject to wind and water erosion along gullies which ramify and gradually cut back into the peat mass, causing its dissection and leading eventually to sheet erosion and complete denudation of the sterile underlying mineral substrata. In steep mountain country, heavy grazing and burning have caused a good deal of scree formation, involving soil erosion, and the process continues in many areas. Various studies have aimed at checking the physical processes of erosion and stabilizing the bared surfaces again under a cover of vegetation. These have had variable success, and sometimes stabilization depends on the addition of nutrients to promote plant growth. On eroded Pennine blanket peat, A. J. P. Gore (unpublished) found that digging and fertilizing fostered a healthy growth of several common moorland species and willow *Salix caprea*. This is related to another important ecological problem studied by the University of Wales at Swansea, the stabilization and rehabilitation of derelict mineral spoil heaps. A study was made of ecological factors inhibiting the revegetation of about 500 ha of bare wasteland (one of the largest in U.K.) immediately north of Swansea, South Wales, and left derelict following intensive nineteenth century metal-smelting activities. A large part of the land had been covered with deposits of mixed smelter wastes containing copper, zinc, lead and iron which were highly toxic to plant growth and very deficient in N, P and K. Successful sowings of commercial strains of agricultural grasses were made by adding inexpensive amendments to the spoils, e.g. N, P and K fertilizer, lime and organic matter (domestic refuse or sewage sludge). Metal-tolerant genotypes of grass collected from old mine sites were also successfully established by using N, P and K additions and minimal amounts of organic matter. Some 25 ha of trees were planted in the degraded soils surrounding the waste after treatment with ground mineral phosphate and granite dust. Coniferous species, especially *Pinus contorta*, were particularly successful. An educational programme was developed to avoid the very high risks of fire and vandalism. This was so successful that no fences were needed for the plantation. Both trees and to a lesser extent grass still flourish, 10–13 years after establishment, with little or no maintenance (Street & Goodman 1967; Goodman, Pitcairn & Gemmell 1973).

Pollution and pesticides have posed many problems for wildlife, but advice to Government based on a major research programme has resulted in better regulation of the more harmful toxic chemicals in the environment, and in reduction of adverse effects. Management research has attempted to use herbicides to manipulate communities by suppressing invasive species. It was found that the application of a mixture of 2,4-D and 2,4,5-T effectively controlled stump regrowth of *Crataegus monogyna* in chalk grassland, without harmful effects to the surrounding soil fauna (Moore 1968). Aquatic herbicides can be used to control the species balance in open water bodies, e.g. paraquat controlled *Elodea canadensis* without serious effects on aquatic fauna; casualties of fish and invertebrates were attributable to oxygen depletion resulting from breakdown of vegetation, rather than to toxicity of the compound (Way, Newman, Moore & Knaggs 1971).

Overseas projects

Some of the U.K. contributions have involved projects overseas, and these vary from surveys to process and autecological studies. They were funded by the Royal Society.

An expedition to the islands of St Helena was mounted by N. R. Kerr, C. Hill and P. Messent, to conduct a survey and appraisal of conservation problems (unpublished report). A survey of the important endemic flora showed that several species have increased substantially in population during recent years, while most others appear safe from extinction, and only two or three are in urgent need of protection. A programme of conservation by propagation and protection of the more fragile species was initiated and should continue. A varied collection of seeds, fruits, seedlings, cuttings and living ferns was distributed to the Universities of Cambridge

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and Leeds, to Kew and Wisley Gardens, and to the Public Gardens on St Helena. A collection of insects and other small fauna, and a collection of dried plants were all submitted to the British Museum (Natural History). Suggestions for appropriate Nature Reserves were sympathetically received and will be further considered by the island Government. Considerable interest was aroused amongst the island's inhabitants in the scientific importance of the native flora, and the need for its conservation, but a major threat to the indigenous flora is the uncontrolled spread of *Phormium tenax*, and financial help may be needed to achieve control.

In another type of survey, covering the whole world, R. Melville in the Royal Botanic Gardens, Kew, has prepared *Red Data Books* for the threatened species of flowering plants and gymnosperms. These are essentially compilations of information sheets, one for each species, and in loose-leaf format to assist addition and revision, for all plants known to be declining and threatened in some degree. Five categories of rarity are used, ranging from presumed extinction to indeterminate when information is too vague. The second category, 'endangered', gives the greatest concern, for these species are unlikely to survive without remedial action. The data sheets provide the taxonomic background for each species, information on ecology and biology relevant to conservation of the plant, its scientific and potential economic value, and notes on cultivation. Present and past distribution, and reasons for decline – when known – are given. Protective measures already taken are summarized, including legislation and occurrence in Reserves, and there are suggestions for conservation requirements and action. Special factors such as an export trade in a species, or the need for secrecy, are indicated. The intention is to stimulate corrective action and to generate concern and responsibility for threatened species. A similar project, on compilation of an index to the rare endemic vascular plants of Europe (I.R.E.P.) was undertaken by S. M. Walters of the Cambridge Botanic Garden using the Flora Europaea Organization as a basis (the scheme is described in a paper published in 1971 in *Boissiera*, **19**, 87–89). This project is still proceeding, as the manuscript for the as yet unpublished volumes of *Flora Europaea* become available for abstracting. Since December 1974 the I.R.E.P. project has been united with a much larger scheme of joint interest to the Council of Europe and to the newly-formed European Regional Group of the Threatened Plants Committee of the I.U.C.N., of which Dr Walters is Chairman. Lists of all threatened European vascular plants are now being prepared and processed at the Kew Headquarters, and a network of experts in the different countries, many of which are the Flora Europaea I.R.E.P. collaborators, is being used to compile and check each country list. The scheme has developed successfully and, by tackling the rare endemic element first, an effective start has been made on a complex and urgent problem. It is confidently expected that money will be found to support this expanding work from Council of Europe, I.U.C.N. and other sources.

The East African big-game reservations are among the most important nature conservation areas in the world, but are giving serious problems of management. In the Murchison Falls National Park, Uganda, D. H. N. Spence and A. Angus of the University of St Andrews (unpublished report), have made a study of grassland management in relation to grazing and burning. Because of increase in human population and subsistence agriculture around the boundaries of the Park, concentrations of elephants and fires have caused rapid replacement of forest by uniform grassland, followed by deterioration of the latter. Cropping of elephants and controlled burning are being used as management techniques to resist these adverse changes, but have to be planned according to detailed information about the relative importance of grazing and fire in certain vegetation types. Exclosure plots were therefore established and subjected over several years to controlled burning, or total protection, in the presence or absence of large grazing mammals. The results show that strict exclusion of burning from the *Terminalia–Combretum* woodlands, as part of a wider fire control programme, will result in very rapid improvement in diversity and size of woody vegetation. In these woodlands, increase in 'woody legumes' and other woody species would be even more rapid if grazing were also excluded. The *Setaria–Sporobolus* grasslands will only improve in cover and in number of woody species if grazing is excluded. In spite of fairly heavy cropping of elephant and hippopotamus at the beginning of the experiments, on the area in which the plots are situated, there has been little change in the cover and composition of the grazed, unenclosed, grassland plots.

Within the Murchison Park, the Nile crocodile *Crocodylus niloticus* is a threatened species, largely because of illegal poaching of the animals for their highly valued skins. H. Cott of Cambridge University (unpublished report) has conducted a study of the ecology and status of the species, to provide advice on its conservation. The Nile crocodile has shown serious decline during the last 25 years, and within the Park has been reduced to a fraction of its former numbers. The poaching impact can be solved by increased Ranger protection and is a matter of resource allocation, but another serious problem is disturbance by launch parties of tourists. This drives off the mother crocodiles from their eggs and young, and exposes these to heavy predation from monitors, baboons and large predatory birds, especially Maribou Storks. The tourist problem could easily be solved by close-season restrictions on launch visits to certain beaches, and predation reduced by control of the main predators. As a further, positive, conservation measure, the establishment of a predator-proof hatchery for crocodile eggs is proposed.

With support from Royal Society Leverhulme Scholarships and other sources, P. W. B. Joslin and K. T. B. Hodd have made a study of the conservation of the Asiatic lion *Panthera leo persica* (unpublished reports). This once widespread subspecies is now confined to the Gir Forest of Gujarat State in India, where a sanctuary of 1265 km^2 has been established in this area of predominantly dry mixed deciduous forest and monsoon climate. Population counts of 285 lions in 1963 and 177 in 1968 are considered to reflect a real decrease, and there is concern that this shall not continue. Agricultural encroachment around the edges and along valleys in the sanctuary is gradually reducing the lion habitat. This is especially serious when it involves crops such as sugar cane and groundnuts, from which prey animals become excluded. The Gir Forest is managed for commercial timber production, but there is competition through the penetration of domestic grazing stock, especially cattle. These domestic herbivores prevent tree regeneration and so may slowly cause a loss of the cover needed by the lions, but they are at least as good a source of food as the now greatly reduced wild ungulates. However, other associated human competition includes cropping large amounts of fodder within the sanctuary and so reducing carrying capacity for domestic prey; grazing large numbers of adult bullocks which lions seldom tackle; and also the frequent driving of lions from domestic prey which they have just killed. It was felt that conservation measures should include suitable control of these adverse factors to prevent further deterioration, allied to development of the already strong tourist interest in the area and improved compensation to graziers for loss of stock. As long as forestry remains a primary concern, with control of grazing to allow tree regeneration, the habitat will be maintained.

Funds from the Royal Society's Parliamentary Grant-in-aid for the I.B.P. have contributed in a modest way to the development of conservation research on the island of Aldabra in the

Indian Ocean, which has been a major relevant interest of the Royal Society during the period of the Programme. Aldabra came to the Society's attention in 1966 at a time when the Ministry of Defence was considering the construction of an air staging post on the atoll. A preliminary reconnaissance in that year established that the atoll had escaped disturbance by man, because of its inhospitable environment, lack of soil for cultivation and absence of guano deposits, and that its ecosystem was of great biological interest. On the basis of this information the Royal Society presented arguments for the preservation of Aldabra for scientific research and in 1967 launched a series of expeditions to gather what information they could before the proposed military development began. In the event, the proposal for an air staging-post was dropped in November 1967, but the scientific expeditions continued. An account of this scientific work was given at a Discussion Meeting in the Royal Society in 1969, and subsequently published (Westall & Stoddart 1971, see also Stoddart & Yonge 1971). Construction of a small research station began in October 1969 and this has served as a base for continuing multidisciplinary research under the guidance of the Society's Aldabra Research Committee. In 1970 the Government of the British Indian Ocean Territory took powers under a new Protection and Preservation of Wild Life Ordinance to safeguard the fauna and flora of the atoll. In the following year the lease of Aldabra was formally transferred to the Royal Society.

Appraisal

The U.K./C.T. projects have mostly run to completion, though some have become extended or developed in different directions as the natural consequence to recognition of other needs and problems. As a whole they have made a considerable contribution to the conservation of terrestrial ecosystems. It cannot, however, be said that there was close integration between the various contributing bodies or individuals. The Nature Conservancy contributions were part of an on-going programme of conservation evaluation surveys and conservation research, which happened to fit closely into the I.B.P. philosophy. They had a good deal of internal integration, but little if any connection with other projects. Certain staff responsible for the Conservancy's Nature Conservation Review gave advice in the field to those concerned with the parallel survey and selection of key sites for nature conservation in Northern Ireland, and Royal Society support was also politically valuable in promoting this Ulster programme. The overseas projects funded by the Royal Society were a careful selection covering a wide field of interest, but appeared to function in almost total independence. This does not in any way detract from the success of the individual projects, and there are perhaps fairly strict limits to the possibilities for coordination of projects of the kinds involved. Probably the most significant advantage stemming from the aegis of the I.B.P. in this field was the provision of funds for overseas projects which would not otherwise have been available, and the boost given to the conservation programme in Northern Ireland.

I am grateful to all those project leaders who have contributed appraisals of the outcome of their work to this brief review. Where appropriate, reference is made to those involved through relevant publications; in the case of unpublished work (including reports to the I.B.P.), the individuals are named. Dr R. W. J. Keay kindly wrote the section on Aldabra. The number of people involved in the Nature Conservation Review is too large for inclusion here, but full acknowledgement to the many staff of the former Nature Conservancy, and others, will be

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made in the published work. My thanks are due besides to Professor A. R. Clapham, F.R.S., Dr M. W. Holdgate, Miss N. A. Bonnar, Miss Gina Douglas, Miss S. M. Penny, Mr M. J. Rush, Miss M. Fullwood and Mrs R. Bulsara for guidance and factual help in the compilation of this report.

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Discussion

Dr M. W. Holdgate (*Institute of Terrestrial Ecology* (*N.E.R.C.*), 68 *Hills Road, Cambridge*)

Dr Ratcliffe's paper is an eloquent description of the kind of national programme of work on conservation that we might, with hindsight, design today as a contribution to an I.B.P. beginning tomorrow. Historically, what really happened was a good deal less coherent than his paper implies.

Early in the I.B.P. the international C.T. committee decided to organize a world-wide survey of sites considered important for conservation, especially because of their use for scientific study, employing a standard check sheet or proforma. We encountered severe problems. First there was a circularity in the argument. If the check sheet survey was to help select a world series of nature reserves it would clearly need to be related to a definition of the dimensions of variation in world biotopes. Such a definition of the field of variation could have come objectively from a first stage of global random, or stratified random, sampling, but this would have been daunting in the scale of the effort required. Conversely, to use the check sheet survey only to document known or accessible sites which were considered representative of particular biotopes – that is to begin with a subjective selection – and then hope to use this subjective sample to assess the adequacy of the world conservation effort, was clearly a questionable procedure. Add to that the problem of choosing parameters for the check sheet that would reasonably define any area in the world, of any size and vegetation, and the difficulties are obvious. The international C.T. check sheet survey provided some useful data and a useful methodological exemplar, but I do not myself believe that we succeeded – except perhaps as a solemn warning.

However, there was valuable 'spin-off' from the international C.T. in that it stimulated countries to do their own national surveys. Dr Worthington tells me that in Canada the C.T. check sheet was used in such a survey and proved a valuable tool. In Britain we had advanced beyond the point of primary survey. We already had a National Nature Reserve series. Any survey we undertook would need to go into greater biological detail than was appropriate for the global C.T. exercise. But we were doubtful about the representativeness of the British

National Nature Reserves as samples of our national ecology, and feared that there might be important areas about which we knew nothing and which would be lost through development before we realized their existence. Hence the Nature Conservation Review Dr Ratcliffe has described.

This review was not planned as a contribution to I.B.P. The National C.T. subcommittee played no significant part in its design. It did not use the check sheet. It was produced internally by officers of the Nature Conservancy to discharge that organization's formal duties. It only came into the list of our I.B.P. activities in 1972 about four years after it began as an operational project. It is easy to criticize, with hindsight, its design: today we could undoubtedly make the initial sampling and site characterization more objective and given the results a statistical validity the procedures we devised in 1968 could not attain. But for all that I agree with Dr Ratcliffe that the review stands first in importance among the national conservation studies in Britain in the past 25 years, and he, as its scientific assessor and coordinator, deserves full credit for it. And I think we were right to add it, retrospectively, to our I.B.P. list, to promote international communication of information about the approach and results of the kind of study we may hope that every country will eventually undertake.

The other arm of conservation is, as Dr Ratcliffe says, the management of habitats and species that have been safeguarded. This received less attention from international C.T. – partly because the management procedures for any area commonly have to be designed specifically for local circumstances. In the U.K. C.T. programme I share Dr Ratcliffe's judgement that we did not begin anything new at home simply because of the I.B.P. We hoisted the flag over a large amount of existing and relevant Nature Conservancy Research. In the National Reports to S.C.I.B.P. we were quite explicit about it, explaining that we offered this work as an example and a contribution to methods that might be used internationally. I would defend this action. The I.B.P. was about communication of information as well as about the initiation of new research. But we should perhaps discuss the wisdom of this listing of on-going research in future programmes. Should we be more selective? Should we separate the new projects, designed for the programme and coordinated within it more clearly from the on-going projects listed for information and not coodinated by the programme?

Finally, Dr Ratcliffe has referred to overseas projects in which U.K. scientists took part. Conservationists would probably agree that it is in developing countries that the world's priorities for conservation lie. A handful of collaborative I.B.P. overseas projects, which were not designed following guidance from international I.B.P. C.T. (although welcomed by it), and which owed more in concept to I.U.C.N. than I.B.P., undoubtedly helped conservation. With hindsight we should have put more effort into bilateral projects on a more coordinated basis – but we would have needed much more money. None the less these projects and the existence of conservation as a theme within an international scientific programme may have helped it gain acceptance in the developing countries where the projects were located. Is this so? Perhaps someone who took part can tell us.

Conservation fitted in the I.B.P. because it is one use of biological systems for human welfare. I think we underestimated the suspicion with which developing country authorities viewed its rich country, protectionist overtones. We found dedicated naturalists striving against the odds in many countries, but I am not convinced that the I.B.P. revolutionized thinking or conservation practice there at government level. However, I do believe it helped in the process of conversion: it certainly did not hinder. And I suggest that what the U.K. can be seen to have done in the I.B.P. is to provide a demonstration of how to survey and select key sites and undertake research on their management, which will be a valuable guide to scientists in other countries when they come to make parallel national efforts – as ultimately, we may hope and expect they will.

E. M. Nicholson (13 *Upper Cheyne Row, London S.W.3*)

Our subject here is the United Kingdom Contribution to the International Biological Programme, with special reference to the C.T. Section. Dr Ratcliffe has rightly stressed the dichotomy between the productivity and the conservation aspects of the I.B.P., and has stressed that the research scientist and the conservationist do not understand one another very well. Here he has touched on the central difficulty against which the C.T. Section had to struggle, too often in vain.

While Dr Ratcliffe has kept strictly within our remit, Dr Holdgate has offered some personal comments on the work of the International C.T. Committee, of which he was a member and I was Convener. In these, I am not sure that I can follow him. I would suggest that it would be best to await the publication of Professor Clapham's volume of appraisal of the C.T. results in the international I.B.P. series before attempting to prejudge these very complex issues, in which scientific, organizational, financial, cultural and other aspects were inextricably mixed up.

There is one point at which the U.K. and the international programmes meet, and that is in their historical origins, going back to Sir Arthur Tansley and other pioneer ecologists. The Nature Conservation Review, launched in 1966, had several progenitors during the 1940s and 1950s and these were equally the progenitors of the International C.T. Programme, in shaping which the British approach as it had evolved up to around 1963 played a dominant role. While it is factually correct to say that the Nature Conservancy's recent Nature Conservation Review formed no part of the I.B.P./C.T. Programme, it was framed largely by the same people at the same time for a similar object; and therefore basically formed part of a single effort to enhance the ecological content of practical conservation. Moreover, the International C.T. office was, throughout its existence, located within the Nature Conservancy's headquarters building, and its organizing staff remained in intimate contact with the Conservancy's leading figures. The timing, however, worked out unfortunately, in that the work done on British sites did not become even partially available for use in the C.T. Survey until a very late stage. The most important U.K. contribution during the C.T. Programme was accordingly in terms of the management experimentation and research described by Dr Ratcliffe, and this undoubtedly played an influential role in the development of conservation programmes in a number of other countries. Here again, however, it is too early to draw any sound conclusions.