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Expert Panel on Project 8 : Conservation of natural areas and of the genetic material they contain

Final Report

BIG THICKET NATIONAL PRESERVE
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Previous reports in this series:

1. *International Co-ordinating Council of the Programme on Man and the Biosphere. First session. Paris, 9-19 November, 1971.*

2. *Expert panel on the rôle of systems analysis and modelling approaches in the Man and the Biosphere Programme (MAB). Paris, 18-20 April, 1972.*

3. *Expert panel on Project 1: Ecological effects of increasing human activities on tropical and subtropical forest ecosystems. Paris, 16-18 May, 1972.*

4. *Expert panel on Project 12: Interactions between environmental transformations and genetic and demographic changes. Paris, 23-25 May, 1972.*

5. *Expert panel on Project 5: Ecological effects of human activities on the value and resources of lakes, marshes, rivers, deltas, estuaries and coastal zones. London, 19-22 September, 1972.*

6. *Expert panel on Project 3: Impact of human activities and land use practices on grazing lands: savanna, grassland (from temperate to arid areas), tundra. Montpellier, 2-7 October, 1972.*

7. *Expert panel on educational activities under the Man and Biosphere Programme (MAB). Paris, 5-8 December, 1972.*

8. *Expert panel on Project 6: Impact of human activities on mountain ecosystems. Salzburg, 29 January-4 February, 1973.*

9. *Expert panel on Project 13: Perception of environmental quality. Paris, 26-29 March, 1973.*

10. *International Co-ordinating Council of the Programme on Man and the Biosphere. Second session. Paris, 10-19 April, 1973.*

11. *Expert panel on Project 7: Ecology and rational use of island ecosystems. Paris, 26-28 June, 1973.*

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SYNOPSIS

The aim of this report is to generate concern and action for the conservation of natural areas and their valuable genetic resources. The social implications of nature conservation have a profound and manifold significance both for the present and the future. While attitudes and many of the needs of future generations cannot be reasonably predicted, we have a clear responsibility to "keep options open" and to prevent, to the best of our ability, the depletion or destruction of natural areas and of the genetic diversity of life.

Project 8 provides the focus for action on conservation problems within the MAB Programme. The Project is significant not only in itself, but also because of its logistic and conceptual relevance to other projects. This report provides recommendations on the scientific content of the project, and on the ways and means for its implementation, including the use of protected areas for baseline and other scientific studies, for serving as benchmarks for monitoring of changes in the structure and functioning of ecosystems, for the promotion of environmental education, for maintaining ecological stability, and for aesthetic and cultural reasons.

Adequate conservation should be provided for examples of all the biomes of the world, through the promotion of a world-wide network of representative significant ecosystems, or biosphere reserves. To provide an up-to-date assessment of those areas which are protected according to an accepted international standard a comprehensive inventory of world biomes and representative ecosystems is urgently needed. A classification should be prepared as soon as possible.

National Committees should be asked to prepare an inventory of the biomes, and important subdivisions of them, occurring in their countries, and to indicate for each the extent to which they are afforded protection. Assistance should be given, if requested, to any country participating in the programme, on the ways in which they might carry out such a survey.

Where significant gaps in international coverage are identified, countries in which such biomes occur are encouraged to take protective measures. It is also recommended that every country which has not already done so should prepare lists of rare and endangered plant and animal species within its boundaries and should take immediate steps to establish reserves or take other appropriate measures for their adequate conservation. Some guidelines for the selection and protection of these reserves are suggested.

For the conservation of genetic diversity, two categories of organisms included in Part B of Project 8 (as defined in MAB Report Series 1) are excluded from consideration: domesticated plants and animals, which are the subject of planning and activity under the auspices of FAO; and micro-organisms of direct application to science, technology, agriculture or medicine, since they are contained in many general or specialized culture collections which are expertly maintained, generally accessible, and catalogued on a world-wide scale.

Proposals on conservation measures (including survey, inventory, and reserve management) for wild species are based on a classification of these species and a "time scale of concern". The importance of the latter becomes evident when the purposes of conservation of higher plants and animals are considered in terms of the genetic material they represent. Species of no apparent or immediate economic usefulness should be conserved as a part of ecosystems, rather than receiving species-by-species attention. (Exceptions would include species of special public or scientific concern and certain migratory species). Ecosystem conservation with a long-term time scale is durable only if population structure and diversity of the species involved make it possible that adaptation to environmental change may continue.

The thrust of this MAB Project is threefold. It is of management or action nature; it includes ecosystem classifications and survey; and there is also an important research function. Information on the relations of population size, diversity, and survival is needed. Relevant studies indicate that suggestive information can be obtained using present-day methods of measurement of genetic variation. Thus studies which critically describe and investigate the dynamics of populations and communities occupying a natural environment over a long time period should be actively encouraged and supported. Such studies should be conducted in (but not restricted to) the proposed biosphere reserves as an important part of baseline studies. In addition to fundamental biological information, such studies will help in the development of an ecological predictive capability and will provide information directly relevant to the choice and management of reserved areas.

The need for increasing public awareness and support for conservation activities is emphasized. Recommendations are made concerning the use of protected areas for environmental education and for communicating MAB objectives.

It is recognized that further planning is necessary for several aspects of Project 8. While there is already much national and international experience to draw on, it is recommended that special groups be convened to accomplish the following:

1. Preparation of criteria and guidelines for the choice and establishment of biosphere reserves, embodying ecological and genetic principles of nature conservation.

2. Identification of those biomes, and subdivisions of them, for which representative samples are not already adequately protected.

3. Determination of criteria for selecting and establishing a network of baseline and monitoring stations in representative undisturbed biome areas, to serve as benchmarks or standards for assessing change.

4. Preparation of a general framework for various types of questionnaires which may be needed by National Committees to suit the specific circumstances and situations in their own countries.

5. *Development of plans for using existing protected sites and associated programmes for environmental education and to promote public awareness of MAB and its objectives.*

6. *Elaboration of research proposals on population structures in reserved areas and on the possible use of genetic change as an indicator of environmental change in baseline studies.*

Attention is drawn to the fact that a number of these activities are a central concern and important function of IUCN.

1. INTRODUCTION

At its first session in November 1971, the International Co-ordinating Council for the Man and the Biosphere (MAB) Programme recommended that a number of ad hoc panels of experts should be convened before the second session of the Council. These panels would elaborate the scientific content of projects proposed under the Programme and consider the approaches and plans of studies that might be recommended to National Committees for the implementation of these projects.

In the period between the first and second sessions of the Council (November 1971 to April 1973), eight expert panels were convened. The reports of these several panels have been published as MAB Report Series Nos. 2 to 9 inclusive. At its second session in April 1973 (see MAB Report Series No. 10) the Council decided to continue the process of elaboration by panels of experts of all the thirteen projects proposed under the Programme.

This document is the report of the panel of experts which met to consider MAB Project 8, entitled "Conservation of natural areas and of the genetic material they contain".

At the kind invitation of the International Union for the Conservation of Nature and Natural Resources the meeting was held at its headquarters in Morges, Switzerland, from 25 to 27 September 1973. The meeting of the panel was organized by Unesco, in collaboration with FAO and IUCN, and in consultation with ICSU. The composition of the panel is given in Annex 1 to this report. The panel elected Dr. E. Firouz (Iran) as its chairman.

This report will be submitted formally to the International Co-ordinating Council at its third session. It is circulated in advance for the information of MAB National Committees, with a view to assisting them in the planning of their participation in the Programme.

2. RATIONALE FOR THE CONSERVATION OF NATURAL AREAS AND OF THE GENETIC MATERIAL THEY CONTAIN

2.1 Background

The International Co-ordinating Council at its first session recognized that the establishment of reserves, protected and managed in various ways, is of importance to mankind through the role they can play in meeting scientific, economic, educational, cultural and recreational needs. Such areas are essential for studies of ecosystems of various kinds and of fundamental importance to the Programme. They represent baselines or standards against which change can be measured and the performance of other ecosystems judged. They represent a means for maintaining the gene pools of species of plants, animals and micro-organisms.

The Council also recognized that efforts to establish an adequate network of protected areas, while successful in some countries, had so far met with disappointing results on the global scale. In order to encourage and assist countries to establish and manage protected areas, and thereby to conserve the genetic material that these areas contain, this report attempts to expand on the justification for such action.

From the outset we wish to emphasize that mankind's increasing ability in controlling and manipulating various facets of the biosphere has given rise to a widespread belief that our continued existence on planet earth is independent of our life support system. Where such a belief prevails, there is little sympathy for protection of natural or semi-natural areas. On the other hand, where there is an appreciation of man's true relationship with nature, conservation has a greater chance of success. One of the main tasks of conservation must therefore be to instill into people everywhere an appreciation of the biosphere as a life-support system for man.

In order to generate concern and public support for action programmes it must be emphasized that nature conservation involves much more than setting aside scenic places for the enjoyment of man, important though this is. People must soon come to understand that there are sound and compelling reasons for conserving natural areas and the plants and animals they contain. In the balance lies nothing less than human well-being and probably even survival.

2.2 Scientific values

The slow progress in conservation may well have been due to the lack of a suitable scientific definition. Equating "wise use" of all the earth's resources with conservation fails unless what is wise is clearly defined. Defining wisdom in economic terms only can lead, and has led, to conservation disasters. What is needed is ecological wisdom in place of, or at least along with, economic wisdom. Elton (1958) described conservation as a "wise principle of coexistence between man and nature, even if it has to be a modified kind of nature". Recent work in the theory of ecosystem development, functioning and evolution, and studies of species diversity have provided the beginnings of a model against which this principle of coexistence between man and nature can be more wisely determined.

It has long been known that immature or early successional stages in the development of an ecosystem have higher net productivity for human needs than late successional or mature stages, in which net productivity tends to fall to near zero. Agriculture and forestry are based on this characteristic of ecosystems, although their origins were rooted in empirical discovery rather than theoretical insight. It is clear, therefore, than man must continue to maintain many ecosystems in immature stages in order to reap the benefits of high net productivity.

The desirability of maintaining some ecosystems in a mature state on the other hand does not seem to have been discovered empirically. It is here that theoretical insight comes to the fore and provides a scientific basis for their protection. Although their net productivity is low, mature ecosystems serve other functions important to man. They have been referred to

by Odum (1969) as "protective" ecosystems, in which, for example, there is: a high rate of CO_2/O_2 exchange; closed, or nearly closed, nutrient cycles; selection for quality rather than quantity of organisms; high ecological efficiency in terms of biomass supported per unit of energy flow; maximum information content and minimum rate of gain of entropy.

It is necessary to recognize that the carrying capacity of the biosphere for man has been greatly increased by manipulation of ecosystems in the direction of increased net productivity. It can also be said that interspersion of managed land with land left in its natural state tends to maximize habitat diversity which, in turn, often results in an increased variety of fauna and added benefits for agriculture. Thus agriculture and forestry, when well practised, are compatible with ecological wisdom. But it is important to recognize that this process can go too far. Only ecological awareness and understanding can guide us to recognition of the importance of unmodified, protective ecosystems for the healthy functioning of the biosphere as a whole.

Protected areas may serve as benchmarks against which change can be measured. To serve this function, of course, baseline studies must first be completed, then a system of environmental monitoring will be required. Unmodified ecosystems (those which have not been significantly disturbed or altered by man), particularly those in mature, or climax stages, are likely to best fulfil this function; when undisturbed they change little, or not at all, with time and they contain a rich assortment of organisms, some of which may serve as indicator species because of unique susceptibility to particular pollutants or disturbance. There is also interest, in many countries, in establishing automated meteorological stations on protected areas that have a high probability of permanency. This interest stems from the fact that the areas surrounding many of the older stations have been so modified by increasing human activity that records are no longer comparable from one decade to the next.

It should be further noted that the modern study of ecosystem ecology is in its infancy. Both practical and theoretical aspects can be expected to flourish as additional attention is devoted to ecological studies.

Some of these studies can be done in laboratory situations, but the ultimate verification of ecological theory must come from well planned and well executed studies carried out in nature. Protected areas, both unmodified ecosystems and ecosystems variously altered by human activity, will thus play a key role in the future development of ecological science. This aspect of the scientific importance of protected areas is particularly relevant to other MAB projects, several of which envisage studies of particular ecosystem types or physiographic units.

An indication of recent advances in ecosystem research has been given by Reichle (1973) in discussing the accelerated rate of development of environmental biology and the insights recently gained on the functioning of whole environmental systems, largely through the IBP. He also demonstrated the existing capability of scientists to: 1) characterize the nutrient, energy and water metabolism of whole ecosystems; 2) explain the behaviour of ecosystems, through understanding the basic governing processes of the systems; 3) couple mechanistic processes together in systems models, which are capable of simulating the behaviour of the whole ecosystem; 4) derive generalities about the structure and dynamics of ecosystems, which permit extrapolation of knowledge to other environments. These recent advances, and the data which are now becoming available, will surely be important in dealing with the environmental challenges of the future.

Nature reserves are increasingly becoming the main sanctuaries for wild biota. The reduction of species diversity is depriving not only ourselves, but all future generations of living resources essential for the economic, environmental, cultural and scientific existence of man. This attrition, proceeding with increasing rapidity, may become irreversible within a mere generation or two. Whatever our own attitudes, our clear responsibility towards the future is, at the very least, to "keep options open" and to prevent, to the best of our ability, the depletion or destruction of the genetic diversity of life.

There is strong scientific justification for preservation of rare and endangered forms, because every species of living organism represents a store of information which is irrevocably lost if it becomes extinct. Such preservation is far better accomplished in the context of the entire ecosystem to which a species belongs than *in vacuo* in a zoo or a botanical garden. However, as Frankel (in press) has argued, what is at stake is not only the extinction of individual species, though the current rate of loss in many parts of the world is high and accelerating. This may not be without precedent in evolutionary history. But what is without precedent is the predictable destruction of habitats of what remains of the earth's natural and semi-natural communities and of most of the species they include. Without deliberate protection few of these communities will have a chance of survival; nor does the shrinkage of undisturbed habitats offer a promise of evolutionary replacement.

This is a situation outside past experience, a confrontation between man and other biota which in the short space of two or three human generations could imperil a large proportion of the wild species that now remain. Man would direct the evolution of biota that are of use to him, and the only ones retaining some evolutionary independence would be those he is unable to suppress.

Predictions about the future become increasingly uncertain as the pace of change increases. But it seems likely that cultural, technological, economic, and possibly biological man a century or two from now will differ more from us than we differ from the early agricultural settlers. Future man is more unknown and unpredictable than at any time in history. Hence at this point of decision-making, it may be our evolutionary responsibility to keep evolutionary options open as far as we can. This is a modest precept, but even so is as much as is at all likely to be socially acceptable at this time. It may grow into a evolutionary ethic if and when men come to regard other species as an essential part of their own existence. Perhaps our greatest difficulty stems from the contradictions of time scales: evolutionary time is compressed into historical time and made subject to decision-making on a socio-political time scale (see Table 1).

On a socio-political time scale, some people may object to the space and cost devoted to conserving particular ecosystems. Lifeboats in a ship are also costly in terms of space and money. Yet we pay the costs because we know that ship disasters do occur. We also know that we will need to use some of the genetic material maintained in protected ecosystems. This objection to the cost of conserving ecosystems will become less of a problem when the values of conserving these areas are more widely and effectively communicated to the public. In addition to the long term values of conserving these areas, there are also immediate and short term benefits. There are, for example, many species of plants and animals that are now being used to improve cultivated or domesticated species, or to strengthen them against new outbreaks of insects or disease. Thus, Ethiopian strains of sorghum rich in an essential protein-making chemical that other sorghums lack have been used in improving sorghum as a food. The continuing existence of these strains has thus been of great importance in meeting the need for more nutritions foods now, and it will become even more important because of the expanded needs of larger populations in the future. As knowledge grows and needs change, we are likely to have to return more and more to wild stocks to satisfy them.

TABLE 1 - The time scale of concern *

	PERIOD	OPERATOR	OBJECTIVE	TIME SCALE
Wildlife	to 8000 BC	hunter-gatherer	next meal	1 day
Domesticated plants	to 1850 AD	"primitive" or "traditional" peasant farmer	the next crop	1 year
	from 1850	plant breeder	the next variety	10 years
	from 1900	crop evolutionist	to broaden the genetic base	100 years
Wildlife		genetical conservationist	dynamic wildlife conservation	10.000 years
	today	politician	current public interest	next election

* from Frankel (in press).

2.3 Cultural, aesthetic, recreational and economic values

Aside from the points discussed thus far, there are many other subtle, yet important, reasons for the conservation of natural areas.

Consider the enormous consequences of rapid scientific and technological changes, communications, mass migrations from country to town, tourism, and many other influences upon individual equilibrium, community life and institutions and traditional values which require people to adapt more rapidly than ever before. In this unprecedented situation the parks and reserves of the world assume increasingly greater values as places of relative stability and peace. They provide a "sense of place" where people can feel they still have roots in their historical and natural heritage. Consider the vast numbers of people who live in large urban areas who get out to the countryside not just for relaxation and recreation, but because of strong feelings of kinship with nature and with the life of past generations which was more intimately in contact with nature.

The cultural values of protected areas seem to have received little recognition in the past, but since man and culture are inseparable, this is an aspect that should be stressed by MAB, particularly in view of related Unesco activities on the protection of the world's natural and cultural heritage.

An example or two should clarify this relationship. The early history of European settlement in North America, for instance, consisted of a struggle to subdue the wilderness and that attitude has come down almost to the present day. Now that much of the wilderness has disappeared, however, attitudes are changing and there is greater sympathy for attempts to preserve some of what is left. Clearly this is related in part to a felt need to preserve part of the theatre in which early historical events took place. In fact, full understanding of those events may only be possible against such a background.

An example of an even more intimate association of culture and conservation is provided by those reserves that make it possible to preserve a whole way of life - where man, in fact, is accepted as an integral part of the ecosystem receiving protection. Marsabit National Reserve in Kenya attempts to do

just that. A final example is perhaps best expressed in Zaire where there is a strong movement in artistic expression that finds its roots in the natural heritage of landscapes and wild plants and animals. The character and diversity of artistic expression thus depends directly on the character and diversity of natural communities.

All of these conservation activities discussed here have economic values, but their long-term benefits are sometimes difficult or impossible to measure in terms of economy. It is much easier to evaluate certain benefits of national parks and reserves to the economy of a particular region or country. These areas have economic importance primarily because they are attractive to tourists. This is no less true of areas such as Yellowstone and Banff in the developed world than it is of the magnificent parks and game reserves of developing countries in Africa or elsewhere. This should not be interpreted to mean that every protected area will or should generate economic activity. High density tourism, which produces economic wealth, could be quite inappropriate in an area reserved for research or for protection of a rare species or a unique or fragile habitat.

2.4 Educational values

The use of parks and reserves for education has become increasingly important. This use, wherever it is appropriate, should be given high priority, for it is clear that protected areas are affected by the treatment of the land, air, and water beyond their boundaries as well as by the attitudes and actions of people in and around them. Consider the future of marine parks and riverways affected by abuse of adjacent lands and also the future of many other ecosystems that cannot escape from the currents of air and water contaminated in some distant place. Establishing buffer zones around parks will help in many cases but even buffer zones are not sufficient unless people want to conserve quality in their total environment, and such an attitude can only be engendered through education.

Support should be given to the recommendations of the Second World Conference on National Parks that parks should be used to foster understanding of park values and to develop environmental awareness, and that facilities should be made available to youth groups to carry out environmental studies.

The wide-scale use of these protected areas by educational communities could have a great "multiplier" effect in communicating the need for nature conservation. The concept of the "total educational environment" and the values of getting students into environments outside the traditional classrooms are now widely recognized. Thus, it may well be that one of the most important values of networks of protected areas will be to assist man to understand his relationship with the natural environment. Promoting understanding of the MAB Programme is also an important objective. Dasmann (1972a) points out in reference to the MAB Programme that: "There seems to be no way of speeding these commitments except by public demand from within each nation, and this requires a growing level of public awareness not only of the problem but of the means and machinery required for its solution".

This is a critical point, for it is recognized that resources (trained personnel and funding) are currently inadequate to do the job that has to be done. This problem could be overcome through greater public support, and that support must be generated through carefully planned information and education programmes. Some recommendations regarding educational activities related to MAB Project No. 8 are given in Section 6 of this report.

3. CONSERVATION IN RELATION TO THE MAB PROGRAMME

Progress in conservation of natural areas and of the genetic material they contain has been uneven; however, it should be emphasized that, in many countries, it has been considerable. Accordingly, case histories that illustrate the kind of progress that has been made are given in Annex 2 of this report. Other examples could equally well have been cited, but the ones chosen illustrate that essentially the same ends can be achieved under vastly different conditions.

At the international level, considerable attention has been, and is being, given to this subject, as witnessed, for example, by the number of international conventions that have recently been prepared and opened for signature (e.g. Convention on Wetlands of International Importance, especially as Waterfowl Habitat; Convention for the Protection of the World Cultural and Natural Heritage; Convention on International Trade in Endangered Species of World Flora and Fauna). Conventions such as these are one tangible result of a whole series of long-term international initiatives on various aspects of conservation, some of which are mentioned in subsequent parts of this report. In addition, statements made on behalf of the international organizations represented at the panel meeting are given in Annex 3.

Within the MAB Programme, it is Project 8 that provides the focus for consideration of, and action on, conservation problems. The project will have far less value, however, if it is treated as an isolated component of the Programme. The project, though important in its own right, is also of major logistic and conceptual importance for the implementation of many other MAB projects, and will, in great part, succeed to the extent that its philosophy and substance is reflected in the planning and implementation of these other projects. This importance was recognized by the Council at its second session, in deciding that subject areas such as those included under the general heading of conservation in Project 8 should be incorporated as appropriate in the consideration by working groups of internationally coordinated activities within the framework of Projects 1, 3, 5 and 6.

All of the MAB projects, by their interdisciplinary nature and by their objectives of contributing totally to rational decision-making about the conservation and use of natural resources, will contribute to each other. Some of the expert panels for other projects have made specific suggestions and recommendations regarding Project 8. These and the related suggestions of this expert panel are given in Section 6.

As defined by the International Coordinating Council at its first session (MAB Report Series 1), Project 8 is comprised of two distinct but intimately related parts: A. Coordinated world-wide network of protected areas; and B. Conservation of animals and plants, including micro-organisms. These two aspects are developed further in the two succeeding sections of the report, which outline certain lines of action that are considered to be both desirable and feasible within the MAB Programme, given the objectives and scope of the Programme and the structures proposed or established for its implementation.

4. CRITERIA AND GUIDELINES FOR THE CONSERVATION OF REPRESENTATIVE ECOSYSTEMS

4.1 Classification and inventory

Any series of protected areas should not only include unmodified examples but also samples of different kinds and degrees of modifications produced by human use. To this end it is necessary to assess those biomes and subdivisions of which examples are already adequately safeguarded somewhere in the world against an inventory of all that should be protected if a comprehensive network is to be available for posterity.

Considerable progress has already been made by IUCN (1973a) in providing and continuing an up-to-date assessment of those areas which are protected according to an accepted international standard. Also, site information on a large number of both unprotected and protected areas of biological interest has been assembled within the framework of the IBP/CT Check Sheet Survey, which is being maintained and kept up-to-date at Monks Wood Experimental Station with the assistance of IUCN, and, in regard to inland waters, by Project Aqua (see Annexes 3 and 4). However, no comprehensive inventory of world biomes has yet been prepared against which success can be judged. This is required urgently.

> *The panel therefore recommends that a classification system should be prepared as soon as possible, based on Dasmann (1972b, 1973a, 1973b) and other pertinent works, to include all the biomes and biome subdivisions of the world.*

In order to stimulate interest and action to complete the conservation of a representative world network of biomes, National Committees should be asked to prepare for their countries an inventory of the biomes occurring in them and to indicate whether examples of each type are already afforded protection. This will enable an assessment to be made of the most significant gaps in the world network. This will only be possible as a result of a co-ordinated international effort.

The primary objective of such an international programme must be to ensure that adequate examples of all important and representative biome subdivisions are protected. National Committees may have to prepare detailed inventories of ecosystems of importance within the various biomes in their countries for identifying and conserving adequate representative samples of such ecosystems.

This preparation of inventories is an essential step towards the recognition of which communities are in need of conservation. Synthesis and organization of the collected information will be an important research aspect of National Committees. Assistance should be given, if requested, to any country participating in the programme, in carrying out such a survey.

In order to give more assistance to the National Committees for organizing surveys, a task force should be convened to consider these issues and to prepare the general framework for various types of questionnaires which may be used by National Committees.

4.2 Criteria for selection

Where significant gaps in international coverage are identified, countries in which these biomes occur should take steps to include examples of them as a contribution to the international effort in the context of their national programme for conservation action. In choosing proposed protected areas and selecting boundaries for them, the following criteria should be considered.

Any proposed protected area should be representative of a widespread biome or a main subdivision, and therefore valuable as a standard against which to judge the result of human use or modification elsewhere in that biome; alternatively, uniqueness may make an area worthy of conservation as the only example of its kind. Such a network of representative protected areas would, it is hoped, provide for the conservation of most species of the less conspicuous groups of plants and animals about which knowledge is still inadequate.

The minimum requirement for safeguarding each biome or biome subdivision should be adequate protection in Strict Natural Areas or Managed Natural Areas (for nomenclature of these categories see Dasmann, 1973b), the primary objective for which is nature conservation. The larger these are, the more valuable they will be for this purpose. Their value can be further enhanced if they can be surrounded by areas in which the natural ecosystems are managed as a resource, e.g. for recreation, game, grazing or production of forest produce. This arrangement of zones for different purposes will increase genetic diversity and promote gene flow.

Where forms of land-use destructive to natural communities are likely to take place in all areas other than those set aside and specially protected, or where uncontrolled exploitation or destruction of indigenous species is likely to take place wherever those species are not specially protected, the need for a carefully selected network of protected areas becomes most acute. Where public attitudes, population pressures and land-use practices are favourable to conservation of species and natural areas, the need for specially protected areas is less extreme; however, such areas are still required for perpetuation of biotic communities little influenced by human activities or maintained under specified management practices. Reserves are unlikely to continue to serve their designated purpose unless some degree of planning and control of land and resource use outside their boundaries can be accomplished.

Under conditions where only specially protected species and areas are likely to remain undisturbed, parks or reserves should ideally be large enough to include the home ranges of sufficient numbers of the mobile resident animal species to constitute viable populations of those species.

Although the difficulties of protecting highly mobile species are marked, such protection is necessary not only for the sake of the species itself but also for the aim of maintaining complete biotic communities and ecosystems. Protection of the vegetation component of such ecosystems is relatively easy compared to the protection of the faunal component. Where it is impossible to create very large

reserves, a series of smaller reserves, connected by travel corridors, may provide a workable alternative.

For migratory bird species or migratory marine species it is impossible to establish reserves large enough to protect the entire area of seasonal ranges and migration routes. However, such species may have critical areas, e.g. for breeding or feeding, in which protection becomes highly essential for their survival. Protected areas need to be established in such strategic locations along migratory routes and seasonal ranges, including safe nesting, breeding and feeding grounds. With marine species, critical areas will often lie in coastal areas (e.g. mangrove swamps, salt marshes, turtle-nesting beaches) or on islands (e.g. seal or sea-bird rookeries).

It is generally desirable to include examples of different biomes or biome subdivisions within one large protected area and to choose examples of biomes which are rich in species, contain concentrations of animals, include breeding, feeding or staging sites of migratory animals or possess relict flora and fauna. In some cases a variety of smaller and more scattered reserves may be required to preserve critical or important types of ecosystems or biota.

In addition, examples of the different kinds of human modification, or even degradation, of natural biomes should be included in protected areas as examples of semi-natural communities and the reserves of species they contain. These can be used to demonstrate the processes of natural recovery, but a small part of each should be kept in its modified or degraded state as a standard against which this recovery may be judged and demonstrated.

In many countries patterns of land use have developed under long periods of human occupation and use. These have produced their own characteristic flora and fauna and may form valuable corridors between more natural areas, e.g. hedges in the English farming landscape.

MAB Report Series No. 8 (Impact of Human Activities on Mountain Ecosystems) presented an interesting case study of the Alps and recommended a

research programme to help implement actions to protect the man/ecosystem relationships of these alpine ecosystems. The report described a prudent form of human exploitation in the Alps which has resulted in a varied and harmonious landscape associating "man-constructed" components (some remarkable habitats, fields, meadows) and the "natural" associations (forests and high altitude pastures). Samples of landscapes such as these, which often have great aesthetic value, should be maintained in a form of use which preserves their character and the genetic diversity they contain for as long as there is a desire to continue the pattern.

Other criteria for selection of preserved areas should include preservation of fragile areas, areas which if lost would require a long time for regeneration, and areas which would help in the preservation of rare and endangered flora and fauna.

> *When complete, a network of reserves will provide for the conservation of most species of endangered plants and animals. Meanwhile every country which has not already done so should prepare lists of rare and endangered species within its boundaries and should take immediate steps to establish reserves or take other appropriate measures for their conservation.*

4.3 Network of protected areas

A world-wide network of protected reserves is of great value for ecological research relating to rational use and conservation of the biosphere, and for improvement of the global relationship between man and environment. These values include: identifying and assessing ecosystem, biotic, and environmental changes; studying the structure, functioning, and dynamics of natural and artificial ecosystems; the relationships between ecosystems and the effects of man's developmental activities.

As a part of the United Nations Environment Programme (UNEP) it is important to measure both short- and long-term changes in ecosystems and flora

and fauna of the world resulting from both natural and man-caused environmental and biotic changes. To accomplish this, it is necessary to establish a network of baseline and monitoring stations in representative undisturbed biome areas to serve as benchmarks or standards to measure change. In addition, studies should be conducted in impact areas and other man-modified areas to determine sensitive and accumulator species which should be selected for monitoring. It is recommended that a task force be convened to determine criteria for selecting monitoring sites and methods using the list of pollutants and methodologies recommended by UNEP (1973) and advisory groups such as the SCOPE Commission on Environmental Monitoring and Assessment (Munn, 1973). Account should be taken also of IBP research sites for which extensive data already exist.

An important objective of the MAB research programme is to study basic processes in ecosystems and to understand how they function normally and under stress. The exact requirements of other MAB research projects cannot be determined until working groups have more precisely defined the projects, but it will undoubtedly require protected undisturbed natural areas with control areas and zoned areas which can be scientifically manipulated. This manipulated research may be destructive and may require use of fire, heavy grazing, timber cutting, denudation, silting, or over-fertilizing.

> *By these methods the functioning of ecosystems may be discovered and evaluated, including successional stages, regeneration times for recovery, productivity and carrying capacity, and methods for speeding change and recovery. Adjacent protected control areas are essential for these studies. The time scale of these experiments may be days or a century. With sufficient critical data on these experiments combined with a systems approach and mathematical modelling it is possible to develop an ecological predictive capability.*

5. THE CONSERVATION OF GENETIC DIVERSITY

5.1 Conservation versus genetic engineering

It appears that the ability to synthesize genes may soon be achieved, and the idea of creating a whole new organism is at least plausible. In terms of cost, measured either as money or as energy input, these alternatives are enormously more expensive than saving genes and species that already exist. As technological and scientific feats, the synthesis of genes and species may be compared to Sputnik and Apollo 8. This massive input of resources into space technology has added enormously to our understanding of earth, but has added few new physical resources to those already on earth. Similarly, gene and species synthesis may add biological understanding, but will probably not greatly contribute to earth's biological resources. One problem is that a new gene is not necessarily an adapted gene. And a brand new species, while it can perhaps successfully survive in a protected laboratory environment, is unlikely to fit harmoniously into a community of plants, animals, and micro-organisms which have evolved with each other and in earth's environment for many generations. Its likely fate is to die out quickly when put in contact and competition with native earth organisms. A much less likely, but frightening, alternative is that it will encounter no effective natural controls, and prove destructive to many earth's natives, including possibly man. Without gene and species conservation, risk of such an event is increased.

Can we then simply store organisms, like microfilm, until they may be again interesting or needed? The technology for this option is available, or perhaps soon will be available. For some organisms, storage in spores or seeds is already normal procedure, and technology needs only to extend the period of viability. The development of whole organisms from single cells maintained in cell or tissue culture is an accomplished feat for some species of plants, and may be possible for all species, including animals. There remains one serious objection. Evolution will be halted in such stored organisms. Species that fail to evolve may find themselves in trouble when again asked to exist in an environment that is likely to have significantly changed during the period of storage.

Can we maintain otherwise extinct species in zoos or botanical gardens? The problem here is that evolution will continue. After many generations, these token remnants of the original species will have adapted to, even to the point of becoming dependent on, the environment of the zoo or botanical garden.

> *The remaining, and apparently best, alternative appears to be the conservation of sufficient natural ecosystems so that a significant proportion of earth's plant and animal species can continue to exist and evolve surrounded by and in harmony with man's continuously changing civilization.*

5.2 Limitations

This report excludes the following categories which were included in Part B of Project 8 (First Session of Council):

a. Domesticated plants and animals, which are the subject of planning and activity under the auspices of FAO.

b. Micro-organisms of direct application to science, technology, agriculture or medicine. Such micro-organisms are contained in many general or specialized culture collections which are expertly maintained, generally accessible, and catalogued on a world-wide scale. The case for establishing further collections, including regional collections in developing countries, rests on the claim for regional use and availability rather than for the conservation of threatened genetic resources. This latter claim cannot be sustained in view of the ubiquity and the enormous variation of micro-organisms. Whatever justification a case for additional culture collections may be shown to possess, it would appear to be extraneous to the purposes of MAB.

5.3 Classification of wild species and time scale of concern

In conformity with MAB Project 8, the following classification of wild species is adopted:

A. Species of direct economic significance, including range, forest or drug plants, and game and other wild animal, including invertebrate, species exploited by man.

B. Wild species related to cultivated plants, and wild progenitors or relatives of domesticated animals.

C. Species of no known immediate economic use to man, though of ecological, aesthetic, social or scientific relevance.

D. Micro-organisms of no known immediate scientific, technological, agricultural or medical concern.

As indicated in section 2 of this report, activities which extend into the future inevitably have a time projection, be it a day, a year, a century, or "forever". In conservation, a time projection may be implicit, but the need for defining the "time scale of concern" becomes evident when the purposes of conservation of categories A-C (above) are considered in terms of the genetic resources they represent. The needs of the future are less predictable today than at any time in man's history. We cannot even be sure what kinds of plants or animals will be used in a mere century or two. Hence a notional time scale of concern for categories A and B could be of the order of decades or at most a century or two, rather than of millennia. Whereas the preservation of species of no ostensible economic use (category C) has no notional end point in time. The time scale of concern for nature conservation is infinite.

These differences have a very real significance in the planning of conservation measures for the three categories of higher plants and animals.

5.4 Wild species of direct economic importance (Category A)

Species of direct economic use - In many parts of the world, wild plant and animal species are of great economic importance in pasture or forest production,

for land reclamation and as sources of various useful products. In many instances introductions from elsewhere are used, hence a range of types adapted to a wide spectrum of ecological conditions is of the greatest importance for securing high levels of productivity. Great industries such as the pastoral industries of Australia and New Zealand, and forest and fish production in many parts of the world, are largely or wholly based on such introductions from other parts of the world. A reservoir of ecological and genetic diversity of such species is of the greatest importance for further improvement, and especially for the establishment of new industries in developing countries.

The biological unit in species establishment is at the level of the population, the ecotype, biotype, or provenance. The target of conservation is to secure the continuing existence of a broad range of genetically diverse populations reflecting the diversity of conditions in which the species occurs. Populations in areas of natural distribution may be expected to have a wide spectrum of genetic diversity. But agronomists, foresters and limnologists have also come to recognize the value of genetic adaptations which are acquired in countries of adoption. Mediterranean pasture plants were re-introduced to their region after half a century of natural selection under pastoral use in Australia; foresters use locally adapted provenances of introduced species as valuable sources of seed.

It is necessary to call attention to the wide variety of animal species that are of direct economic use to man. Many kinds of wild animals contribute to man's food supply, including most notably fishes, but also wild birds, mammals, reptiles and amphibia along with many invertebrates. Others produce furs, hides, plumes, etc., of direct economic value. In some countries wild life is a major source of animal protein in the diet. One of the principal problems in maintaining populations of these economically important species lies in control of exploitation and special attention needs to be given to ways of educating the public to the possibility and the necessity for managing those species to provide for a continuing yield of their products. One difficulty lies in the fact that, being wild animals, these species are often considered common property and therefore free for the taking by anyone.

The dramatic development and collapse of the largest fishery in the world, the *Anchovetta* fishery off the west coast of South America, focusses particular attention on conservation of aquatic resources. Of freshwater fishes, man may claim to have domesticated species of carp and their relatives, and presently is domesticating species of trout and *Tilapia* as well as certain inshore marine species like plaice and mullet. Invertebrates such as oysters, mussels and crustacea are likewise intensively farmed.

Considering the growing need for protein food, there is likely to be a considerable development of aquatic resources, and therefore a need for long-term conservation of genetic diversity for future breeding purposes.

Particular attention needs be given to the remaining wild populations of fish of those species which are now generally reared in hatcheries or fish farms and translocated into suitable aquatic habitats throughout the world (e.g. rainbow trout). Care must be taken to prevent interbreeding between wild and semi-domesticated varieties, to establish new breeding populations in suitable streams or lakes, and to protect the remaining original habitats from pollution or other forms of damage.

Far more important than the domesticated species are the great variety of wild fishes as direct or indirect sources of protein. In some areas, especially in the tropics of Africa, South America and Asia, genetic diversity is not only very great but evolution of new forms is probably taking place with remarkable rapidity - sometimes as a result of introductions by man to new environments.

Thus any plans for long-term conservation of genetic resources should include an adequate variety of aquatic habitats.

In general, these economically important wild plant and animal species, which may or may not be in early stages of domestication, should be treated on a species-by-species basis, with the needs and special problems of each case given careful attention. Two examples drawn from among California's forest tree species which illustrate alternative problems and suggest courses of action are found in Annex 2 of this report.

5.5 Wild species related to domesticated plants and animals (Category B)

Wild relatives of domesticated plants - Presumptive progenitors and other relatives of domesticates are increasingly used in the improvement of domesticated plants. They provide important historical links with the early origins of crops and are used in the study of the genetic and evolutionary relationships among the relatives of crop plants which are of actual or potential use in further crop improvement. The biological unit of concern is the individual within a population; variation not only within, but between populations is of direct relevance. Conservation of wild plant species in categories A and B must be considered in relation to their use, their distribution, and the nature and extent of the threat to their continuing existence. There is considerable diversity in all these respects. On the whole, pasture species are relatively secure, although overgrazing and cropping development have endangered some mediterranean species. On the other hand some important forest species are seriously endangered. Relatives of domesticates are similarly placed, with some groups such as the progenitors of several mediterranean and near-Eastern vegetable crops, or various wild fruits in Malaysia, in need of protection.

As in all wild species, conservation is best carried out *in situ*. Transfer from the natural to an adopted habitat for better protection is a makeshift, but it is better than complete loss which could eventuate through the destruction of habitats, a danger to which forest species are particularly exposed. Similarly, relatively simple measures of protection such as establishment of small reserved areas (however, see Annex 2, Number 5) or prevention of overgrazing, might salvage valuable genetic resources. Conservation measures for such species can be mercurial and adaptive, taking advantage of existing reserves, developing relatively simple protective measures or when unavoidable, setting up special reserves.

Wild species used by plant breeders can be readily preserved as seeds by standard procedures applied in the preservation of crop species. Representative population samples are collected in the field and lodged in a seed storage laboratory under conditions appropriate to the species. Seed preservation has the advantage

of ready accessibility, but regeneration of wild species when seed viability declines may present greater difficulties than in domesticates.

Wild relatives of domestic animals - Generally speaking the wild relatives of domestic animals are in a critical condition and the survival of many is seriously endangered. For example, the wild relatives of the horse, ass, cow, sheep, buffalo, goat, yak, are all either endangered as species or have endangered races. In many instances populations have been reduced by habitat destruction combined with excessive exploitation. In addition, interbreeding with domestic livestock including feral populations of domestic breeds is a threat to the genetic integrity of many wild populations.

Conservation of most wild populations is best carried out by protecting the species within its native habitat through establishment and strict protection of reserves. However, since many of these species are now confined to small remnant areas within their original range, there is the further need to establish new breeding populations through capture and transplantation of the wild stock to secure habitats ecologically similar to those already occupied. In certain cases breeding in zoos can help as a temporary measure preparatory to restocking natural areas.

Proposals for action

(i) Plants

a. Surveys: A survey of endangered genetic resources of domesticated plants was initiated by FAO and IBP and the first report published in 1973 (Frankel, 1973). A corresponding systematic survey of endangered wild plant species of use to man is also needed, especially for forest species. This survey would require a much greater effort. However, much valuable information already exists and could be obtained from ecologists, taxonomists, crop specialists, foresters, plant explorers, etc., which could be assembled and kept up-to-date.

b. Organization: A programme is required to encourage acquisition and wide dissemination of information; to provide information and advice on technical and, where appropriate, legal measures of conservation; and to encourage, support and co-ordinate national and international activities.

(ii) Animals

a. Continuing survey and inventory to monitor the status of wild populations and their habitats.

b. Establishment and protection of reserves suitable for perpetuation of wild species including removal of domestic animals from those areas.

c. Management of reserves to restore habitats that have been damaged by past misuse.

d. Translocation of animals from restricted areas of abundance to establish new breeding populations within other suitable reserves.

To accomplish these actions, international assistance will be needed to train personnel and to furnish facilities necessary for the protection and management of reserves and of animal populations.

(iii) Participation by MAB

Such a programme is foreshadowed in part B of MAB Project 8. The protective measures outlined have a good deal in common with those required for species and communities in category C, and in many instances would be included with them. However, considering that the genetic resources which species in categories A and B represent are utilized in agriculture and forestry, and that some of the needed information and participation would come from experts in agriculture and forestry, it is important that FAO be closely associated with

this programme and that full advantage be taken of the expertise assembled in the respective FAO panels.

5.6 Species of no apparent or immediate economic usefulness (Category C)

This section deals with genetic considerations in nature conservation, rather than with the preservation of wild gene pools for man's use. However, there is no clear dividing line, since natural gene pools are likely to be increasingly important in human activities. One example must suffice. Under the impact of population growth, of technological innovation, or of cultural and educational progress towards a greater appreciation of natural environments, landscape redevelopment for recreational and other purposes may assume considerable importance. Any such developments would require gene pools far exceeding the genetic resources of commercial suppliers or of botanical and zoological gardens, and the gene pools of natural communities would become important resources.

With some exceptions of special public or scientific concern, species in this category of no apparent or immediate economic usefulness will be conserved as a part of conserved ecosystems, rather than receiving special species-by-species attention. When considering a candidate location for inclusion in the system of designated and protected reserved areas, two major criteria should be satisfied. First, it must be a definable ecosystem containing either a representative or a unique biotic community made up of a diversity of interacting wild species. Second, it should be of a size and shape to contain sufficient numbers of individuals of sufficient genetic diversity so that long-term survival and evolution of one or more populations of most or all species in the ecosystem is possible. It must be fully realized that nature conservation is practicable and lasting only within communities adapted to their environment and adaptable to environmental change, in a state of continuing adaptation and evolution.

It is known that genetic variation is substantial in most natural populations, and at least part of it is adaptive. We need to know the minimum population size which is likely to yield a required level of variation.

Subpopulation structure, inter-population variation and gene flow are further parameters which affect variation and adaptation in long-term conservation. It is not only genetic variation between individuals but genetic differences between populations - the way in which a species gene pool is apportioned and patterned among component populations - which affords flexibility for evolutionary persistence.

One aim of conservation is to safeguard as many existing species and varieties of species as possible. However, there are natural and economic limits to conservation, and completeness of coverage is less realistic and relevant than the biological soundness of systems of conservation, whatever biota they are designed to protect. If extinction of a protected species occurs at some time in the future, it should be due to natural evolutionary causes, and not to an inadequate reserve.

Finally, human impact on reserved areas, unless widespread and severe, should not interfere so seriously with the population structure of the great majority of species in a reserved area as to have genetic consequences. The essence is to keep the impact in reasonable bounds. Infringement of ecological and genetic integrity must be balanced against long-term security of tenure: conservation is, and is likely to remain, uncertainly poised at the will of any generation, community or government. Moderate access for our dominant human species may result in exchanging a bearable loss in biological integrity for a gain in size, diversity and security of reserved areas.

5.7 Micro-organisms of no direct application in science, technology, medicine or agriculture (category D)

The chief characteristics of micro-organisms are their ubiquity, enormous diversity, and vast population size (which is itself a considerable source of variation). Conservation measures for the protection of higher

organisms generally automatically protect the associated microflora and fauna. As has already been discussed, micro-organisms of known concern to man are maintained in a multiplicity of culture collections, and actual or foreseeable needs for extensions can be met in the same manner. There is no apparent justification for the inclusion in MAB of conservation measures for micro-organisms beyond those extended to them as important members of ecosystems.

5.8 Research proposals

Information on the relations of population size and diversity on one hand, survival on the other, is scant indeed, but relevant studies indicate that suggestive information can be obtained using present-day methods of measurement of genetic variation. There are few studies completed or in progress except in lakes and the sea that critically describe and investigate the dynamics of populations and communities occupying a natural environment over a long period of time. Reserved areas provide a research facility where such studies can be initiated with confidence that they can be continued in such an environment. Besides the fundamental biological information to be obtained from such studies, they will provide information directly relevant to the establishment and management of reserved areas. It is proposed that MAB not only welcomes such studies on reserved areas, but actively encourages, initiates, and supports such studies.

Such studies should be conducted in (but not restricted to) the proposed biosphere reserves as an important part of baseline studies. Selection of species suitable for population biological studies should play a part in the selection of biosphere reserves. Parameters to be considered include length of life cycle, size (space requirement), density, behaviour, breeding system, vagility, species to be selected being both suitable for population studies and representative of different forms of life. Such studies would yield information on the rate of survival and the biology of adaptative processes of key species, but would also serve as sensitive indicators of environmental change.

Establishment of permanent nature reserves cannot await the acquisition of information on the population biology of even a small number of key species, desirable though this would be. It was recommended in Section 4 that a group should be convened to develop guidelines to assist the National Committees in organizing surveys. In addition, guidelines should be formulated, embodying ecological and genetic principles of nature conservation, to give practical assistance in establishing reserves intended to serve as long-term sanctuaries. This should be an immediate task for MAB.

6. RELATIONS WITH OTHER MAB PROJECTS AND ACTIVITIES

A number of panels convened under the MAB Programme have commented on possible links and ramifications of MAB Project 8 with other projects and activities under the Programme. Some of the relevant suggestions made by other panels in this respect are given, and where appropriate elaborated, in the following paragraphs.

6.1 Research on undisturbed ecosystems

MAB Projects 1 to 7 inclusive are, in general terms, concerned with the impacts and ecological effects of human activities on different types of ecosystems or physiographic units. Given this emphasis on man, several panels have commented on the need for further study of ecosystems which are, and have been, under a minimum of influence by man.

Thus, the panel on Project 5 (MAB Report Series No. 5, p. 33) considered that in order to understand the effects of intense use on inland waters, "it may be necessary to undertake complementary studies on "natural" systems, little affected by man. Comparison of the results from water bodies subjected to various degrees of stress or loading should result in generalizations on system functioning in these various situations".

The panel on Project 6 (MAB Report Series No. 8, p. 38) considered that the essential profound understanding of the ecology of the mountain environment requires, as a basis, the study of ecosystems which have been minimally modified by man's activities. In some of the mountain ranges under consideration these may be very rare, especially at the lower altitudes, and this gives special value to comparative studies between different mountain areas, particularly within the same bioclimatic zone. Once the characteristics of these natural environments have been established it will then become possible to better define the effects of man's impacts on mountain environments. In each important mountain region, therefore, examples of the most typical biotope should be defined and reserved for scientific and cultural purposes. Identification of mountain areas of importance for conservation and for long-term

co-operative research is required to ensure preservation of a comparative ecosystem base.

As a final example mention might be made of the panel on Project 7 (MAB Report Series 11, p. 9), which gave some attention to the question of uninhabited islands, particularly with reference to those included in the "Islands for Science" project of IUCN. The panel recalled that the emphasis in the MAB Programme is on man, but that an ininhabited island is nevertheless a part of man's environment, even if those having concern for it all live at distance. Furthermore, uninhabited islands situated among inhabited islands provide an invaluable baseline for the assessment of ecological changes in the latter.

These comments underline the importance of protected unmodified areas as basic logistic resources for much of the research to be undertaken within the Programme, and provide a starting point for the development of links between MAB Project 8 and other projects.

6.2 Genetic and demographic changes

The panel on MAB Project 12, concerned with interactions between environmental transformations and genetic and demographic changes, made the following statement and suggestion in regard to Project 8.

"This project (Project 8) is concerned with the conservation of natural areas and plant and animal gene pools, and raises a rather special issue with regard to human communities. There are a number of population groups who have maintained themselves for many generations as hunter-gatherers, or simple agriculturalists, in conditions of marked adversity. Their mode of life, their small numbers and their culture, have endowed them with a certain degree of distinctiveness in genetic composition. The persistence of most of these groups in Africa, India, South East Asia, South America and Australasia is now under great threat.

In line with the general aims of Project 8, the panel feels that it would be appropriate to consider not only the need to attend to the welfare of these people - and the more intensive study of their population characteristics and their knowledge of the management of the environment - but also to consider their freedom to preserve their traditional mode of life and genetic heritage".

Further consideration should be given to the relation of this controversial problem area to the research to be undertaken within the MAB Programme.

6.3 Perception of environmental quality

One of the possible entries to the study of perception of environmental quality, as outlined by the panel on MAB Project 13 (MAB Report Series No. 9), is analysis of the perception of national parks and other relatively unmodified natural environments. The problem is stated as follows: "Protection of the natural environment through enlightened management of its resources and through the establishment of reserves and national parks is of great importance to mankind. However, efforts to accomplish this goal meet, and have met, with limited success. One reason for the difficulties encountered appears to lie in the differing perceptions of the value and importance of natural environments by people of different cultures, socio-economic groups, and roles in society. This research activity will examine perception of, and attitudes toward, natural environments as represented by national parks or other protected areas."
The objective of the research recommended under this theme is: "to conduct cross-cultural comparisons of perception of a range of national and local values held concerning relatively unmodified natural environments, such as those represented in national parks or similar protected areas, with a view to finding means for more effective conservation of such environments, while satisfying the demands of those groups who occupy or make use of them". As such, this research theme has strong and explicit links with the concerns of MAB Project 8. This proposal should be expanded to include studies of the effectiveness of various educational and interpretive methods that are intended to increase or change national park users perceptions of the values and importance of these areas.

In addition to the proposed interviews and studies of tourists who visit the parks, the studies should include school groups which participate in park programmes. The studies should attempt to determine how users' perceptions change with different educational experiences in the park environment.

Attention should also be drawn to the conclusion of the panel on Project 13, that it (Project 13) will mainly succeed according to the degree that a perception approach can be incorporated into, and reflected in, the other projects. Similar criteria might usefully apply to Project 8.

6.4 Educational activities

One of the general objectives of MAB is to promote environmental education in its broadest sense and to increase public support for conservation programmes. Thus support should be given to the suggestion of the expert panel on Education (MAB Report Series No. 7) that:

"The stations and sites associated with MAB research should become permanent places for demonstration and popularization of environmental subjects. These stations and sites could be used to promote environmental awareness through visual demonstrations, and for presenting to specialists pilot studies which would help in the orientation of their future work".

National parks, reserves, regional and international centres and museums should work with educational systems to develop programmes to help to interpret the MAB Programme. Systems of national and international environmental study areas should be developed in parks and reserves to serve as models for educational communities to use in studies of human use and modification of the environment. Some countries have made considerable progress in this area, and the development of an international model for training teachers and natural resource managers should now be considered by Unesco and other interested bodies.

The resources of Unesco should be fully used to provide the necessary background materials to be used in MAB interpretive and education programmes. This is in accord with the recommendation of the Education Panel that:

"Unesco, within its activities under the theme of Man and the Environment or as otherwise appropriate:

- "Develop the capacity to respond to requests from governments, MAB National Committees and other recognized bodies for materials on environmental education for use by secondary and college students. This development might also include the capability to produce appropriate materials (case histories, films, etc.) for use by decision makers.

- Promote the development of information flows which would deal with varied aspects of environmental education. An example might be the proposed IUCN Digest of International Environmental Education which with resources from appropriate organizations might serve as such a vehicle".

In relation to the above, it is noted that recommendation No. 16 adopted by the Second World Conference on National Parks, proposed that an international periodical be published as a medium for exchange of information on national parks operation and management. The panel suggests that the ways and means of assisting the implementation of this recommendation be explored by Unesco and other international organizations.

To assist in the task of engendering greater public awareness of conservation problems, it is recommended that existing resources, especially those at Unesco and at the sites which can be associated with the MAB Programme, be fully used for environmental education. A small group of experts should be assembled to develop plans for using Unesco's programmes and existing national parks and programmes to popularize and interpret MAB and its objectives as an example, a series of exhibits on biotic regions, biosphere reserves and the

world network of national parks could help to generate public interest and support for conservation of some of the major segments of the world's biota now in danger of being lost.

Whenever new reserves are created the educational function should be considered essential to their management and protection, and this function should be included in planning criteria. Statements on interpretive or educational services provided by parks or reserves should be included in the summary and separate sheets of the "World Directory of National Parks and Other Protected Areas".

ANNEX 1

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ANNEX 2

CASE EXAMPLES AND SITUATIONS

As noted in Section 3 of this report, while efforts at protecting representative ecosystems have been only partially successful on the global scale, considerable progress has been made in a number of countries. The four case histories that follow illustrate how essentially the same ends can be achieved under vastly different conditions and different original stimuli. A final example illustrates some of the problems and alternative courses of action involved in the conservation of economically important wild species.

1. Galapagos: multiple benefits accruing from a primary conservation objective

Since the scientific discovery of Galapagos by Charles Darwin in 1835, these islands have been considered as a natural laboratory and the showcase of evolution. This situation results from the particular insular conditions under which a limited number of original stocks evolved into highly specialized plants and animals strictly endemic to the Galapagos. They constitute a unique community which offers many opportunities for scientific investigation in various fields, notably ecological adaptation, speciation and evolution.

This natural heritage has been threatened with extinction consequent to human action, including introduction of feral animals and exotic plants which have become pests. Galapagos birds, such as flightless cormorants and penguins, and reptiles, especially giant terrestrial tortoises, were on the verge of extinction when the Republic of Ecuador took the first measures to protect them. In 1968 the Government of Ecuador established a national park over the whole archipelago, with the exception of settled areas, and strictly protected the endemic species. Simultaneously a programme of investigation was launched by the Charles Darwin Foundation and its Research Station, which was established in the islands in 1959. Due to the efficient actions of the Ecuadorian authorities and the collaboration of the international scientific community, a unique natural heritage has been preserved for the benefit of science and will provide clues for a better knowledge of some fundamental problems of biology.

The original motivation for protecting the Galapagos Islands was certainly scientific, but many others can be advanced. These islands, which are an essential part of the natural heritage of Ecuador, have also offered many opportunities for education at all levels, including courses for Ecuadorian Park managers and guards, a trend likely to continue. On the other hand, the unique fauna of giant reptiles, seals and spectacular birds living in scenic habitats now attracts an increasing number of tourists, both foreign and Ecuadorian. A well managed tourist industry, preserving its own basis, is an economic resource for the local inhabitants as well as for Ecuador, and thus constitutes a source of wealth much more important than any alternative development, including agri-

culture or cattle-raising. The latter activities would inevitably result in destruction of the unique fauna of the islands while producing dubious benefits because of the basically unfavourable geological and climatic conditions.

Perhaps the most significant result has been mobilization of international scientific and conservation support for the concept of preserving the Galapagos as a magnificent heritage for all mankind. Ecuadorians have willingly joined in the effort, and as a result resources are continually being supplied that are leading toward conservation of the islands for their universal scientific and educational values while providing economic benefits to Ecuador from activities that are compatible with the primary conservation objective. Thus the Galapagos Islands show how a natural asset of inestimable value for science can also be a source of welfare for man when preserved in its original condition for the benefit of science and education.

2. Iran: wildlife conservation as a stimulus for a network of protected areas

The creation of the protected areas and parks system in Iran had its impetus in the concern for the depletion of wildlife populations and the deterioration of their habitats. Today Iran has 46 protected areas and parks aggregating to a total area of over 7,000,000 hectares. The majority of these reserves were created in 1967 following approval of an Act directly related to wildlife conservation. In March 1972, having assumed ever-widening duties in the field of conservation, the Department of Environmental Conservation was designated the responsible agency concerned with the environment in the broadest sense.

One cannot dissociate wildlife conservation from the general subject of natural resource conservation. In assessing the achievements of the wildlife conservation programme in Iran we have witnessed the recovery of entire ecosystems and now appreciate the extent to which proper management can restore areas to a productive environment for wildlife and mankind alike.

As understanding of the interrelationship between wildlife species and their environment has increased, emphasis has been shifted from protection of individual species toward protection of the various types of ecosystems to be found in the country. Those reserves most recently acquired have greatly increased the diversity of Iran's network of protected areas, which now includes, for example, fine stands of coastal mangroves, tamarisk, pistachio, almond and juniper, desert, steppe and temperate rainforest. Particularly heartening is the inclusion of a wide range of wetland ecosystems in a nationwide network of waterfowl reserves and wildfowl refuges.

In recognition of the international spirit kindled for the protection and enhancement of our "one earth" the Shahanshah of Iran announced at the 1971 Ramsar Conference on Wetlands that Iran was prepared to place an ecosystem of global importance in joint trust with an appropriate international agency to

conserve and administer for the benefit of all mankind. To this end Iran has selected and approved an area, called the Arjan International Reserve, which comprises 191,000 hectares of some of the richest ecosystems in Iran and includes fresh and salt-water wetlands as well as the eastern extension of the Zagros oak forests.

It is hoped that this precedent will help raise to an international status the concept of ecosystem conservation through the establishment of a world-wide network of protected areas.

3. Kenya: promotion of public understanding of protected areas as a valid and economic form of land use

The natural resources of Kenya, its wildlife and variety of natural ecosystems, are well known throughout the world, but the fine example that the Kenya Government has set in conserving these outstanding resources is not so well known. The resources now protected range from marine environments to mountain ecosystems. Abundant wildlife, coral reefs, a rich assortment of vegetation types (such as desert grasslands, woodland savannas, rain forests, heath and alpine meadows) as well as snow- and ice-capped peaks are included in Kenya's extensive system of national parks and reserves.

Fortunately, representative samples of most of the naturally occurring ecosystems are now protected within the system. To acquire and protect some of the remaining important ecosystems Kenya is now seeking assistance from international sources. Expert assistance is being sought to identify and study the remaining areas which should be protected.

The task of acquiring and conserving lands in Kenya today is not as easy as it was in the past, when most of the lands which are now parks were unsuitable for human settlement because of tsetse fly or drought. Some of the areas which should be protected now are inhabited and difficult to acquire, yet progress is being made. Recently an area of over 14,500 hectares of grassland, riverine forest and dry forest was added to the famous Lake Nakuru National Park in the Rift Valley. This area includes one of the country's finest stands of *Euphorbia*. This was done with the assistance of the World Wildlife Fund.

This acquisition programme has been possible because of increased public understanding and support for parks and reserves as a valid and economic form of land use. This understanding has come about largely through an education programme conducted by the National Parks and the National Museums of Kenya. In this programme National Parks are being used by Kenyans. In these undisturbed surroundings they are acquiring an appreciation for the consequences of their own manipulations of the environment.

A Youth Corps, generally known as the "Wildlife Clubs of Kenya", has over 500 chapters in schools, in teacher training colleges, and in the Army. The movement enjoys such privileges as subsidized transportation to and from the parks

and reserves and free entry. One successful cost saving device is the use of volunteer assistance. In Nairobi National Park, volunteer "Honorary Park Wardens" assist the permanent staff in educational activities. The intensified conservation education programme in Kenya has been effective in reducing the number of poaching incidents; thus it has paid off in this respect too.

The work of the College of African Wildlife Management, Mweka, near Moshi, Tanzania, should be mentioned in this connexion. With the help of aid programmes, international organizations and local resources, students from several African countries have been given specialized training in wildlife management and conservation. Graduates of this school are now doing valuable work in parks and reserves in some twelve countries in Africa. A similar school has been established in Garoua, Cameroon, to serve the French-speaking countries of West Africa.

This account of the success of conservation efforts in Kenya does not intend to imply that the job is done; for example, there are increasing pressures and competing uses for the land caused by growing populations in several regions of Kenya. However, it has been a good beginning and it could well serve as a model for other countries.

4. Canada: survey and inventory as a basis for legislation on protection of natural areas

Canada combines features of over-development in its industrial heartland with those of underdevelopment in its far-flung northern territories. It is not surprising, therefore, that setting aside protected areas has proceeded at an uneven pace. Canada has one of the oldest migratory bird sanctuaries in North America, if not the world (Last Mountain Lake, Saskatchewan), and one of the first National Parks (Banff, established in 1887). During the first decades of this century additional large National Parks were established, mainly in the west, and some important Provincial Parks were designated in the central provinces of Ontario and Quebec. From about 1930 for a period of about 40 years very little was accomplished. There were no significant nationally protected areas in such major physiographic regions as the Precambrian Shield, the grasslands and the mainland tundra. The latter two are still unrepresented although several large new National Parks have been created in the last five years.

It was against this period of some 35 years of slow progress in conservation of natural areas that IBP/CT began its work in the mid-1960's. It was immediately clear to the National CT Committee that coverage of protected areas was very uneven. The Committee, therefore, deliberately set out to catalogue the kinds of ecosystems, with variants, that occurred, to evaluate which ones were already protected, and then to locate examples of the remainder and work toward their protection. An extensive list of candidate areas was drawn up, most of which were visited by field parties which prepared an IBP Check Sheet for each one investigated. Recommendations have now gone to governments (Federal or Provincial) which, when fully acted on, will result in a national network of Ecological Reserves representative of the variety of ecosystems in the country.

In most provinces the protection so far afforded IBP areas is somewhat tenuous. Some have no real status in law whereas others have been declared under authority of a Minister given power to act under an existing piece of legislation such as a game act or a parks act. In one province, British Columbia, the legislature passed an Ecological Reserves Act that provides especially for establishment, management and, where necessary, disestablishment of ecological reserves. Reserves so established have a high degree of security and it is now hoped that other provinces will emulate British Columbia.

Whatever success Canada has had, therefore, is attributable to a planned programme starting with a survey of what existed, proceeding through a process of inventory to find and to fill gaps, and terminating in an attempt to get legal entrenchment for areas selected to be Ecological Reserves.

5. U.S.A.: conservation problems of two economically important tree species in California

As noted in Section 5 of this report, the conservation of economically important wild plant and animal species should be treated on a species-by-species basis, with attention being given to the needs and problems of each individual species. The status of two tree species in California can be used for illustration of some of the problems and courses of action involved in the conservation of economically important wild species.

Douglas-fir (*Pseudotsuga menziesii*) is a widespread species of major commercial importance on the north coast of California, and plantations of this California coastal provenance are among the most successful exotic forest plantings in several countries. The Redwood National Park and several State Parks provide protected ecosystems including native Douglas-fir of this important provenance.

Most species within these reserves are not of economic importance, and thus will be adequately protected. But the reserves are surrounded by actively managed, commercially cut Douglas-fir forest. Present practice frequently includes aerially seeding Douglas-fir following logging. These seeds are commonly not of California coastal origin (and records show that many such exotic-origin Douglas-fir seeds were dropped on land that was later included in the Redwood National Park). Even if this practice stops, it will soon be common practice to reforest with genetically selected trees, which will be increasingly unlike the natives each generation that domestication of Douglas-fir proceeds.

The problem is that the "native" Douglas-fir of this important primitive provenance in the park reserves will be repeatedly exposed to clouds of pollen from the vast surrounding commercial forest, made up of both exotic and domesticated Douglas-fir. The offspring of the "natives" will be increasingly contaminated by genes from these surrounding forests, and the native gene pool will be compromised and finally lost. Thus, gene samples of some economically important species will have to be preserved *ex situ*, in some other place, if extensive man-caused genetic modification of the native stands occurs in the species range.

By contrast, native Monterey pine (*Pinus radiata*) occurs in only five small populations, three on the coast of California and two on offshore Mexican islands. While it is presently the most planted tree species in the world, it is not commercially exploited for timber in or near its native range. Thus, *in situ* preservation of these interesting and important gene pools appears to be possible.

In fact, one of the island populations is going extinct due to goat overpopulation, and two of the mainland populations are urbanized and receiving extensive amenity plantings of young Monterey pine. The source of these plantings is frequently New Zealand seed, which is partially domesticated and largely originated in the third mainland stand. Possible action programmes for *in situ* conservation would include goat exclosures on the island, and a publicity campaign to restrict amenity plantings to truly local trees in order to preserve the integrities of the mainland gene pools. Alternatively, an *ex situ* conservation of gene samples of all five populations might be cheaper and more effective.

ANNEX 3

RELATIONS WITH THE ACTIVITIES AND PROGRAMMES OF INTERNATIONAL ORGANIZATIONS

Many aspects of the work and expertise of international organizations collaborating in the MAB Programme are reflected in various sections of this report. In addition, statements made on behalf of those international organizations represented at the panel meeting are given below.

1. United Nations Environment Programme (UNEP)

The problems discussed and the actions envisioned could be carried out in co-operation with the United Nations Environment Programme (UNEP) since the decisions of the Governing Council, made at its first session, include:

- the promotion of the protection and conservation of plants and animals, especially rare or endangered species;
- the identification and conservation of unique natural sites and especially representative samples of natural ecosystems;
- the support to regional and national institutions in developing countries for promoting the collection, evaluation and conservation of gene pools of plants and animals and for maintaining genetic diversity for the future use of mankind.

2. Food and Agriculture Organization (FAO)

The general features of FAO's association with the MAB Programme were stated at the second session of the MAB Co-ordinating Council (see MAB Report Series No. 10). In relation to MAB Project 8, the following points should be mentioned.

The conservation of domesticated gene pools of economic plants and animals is subject to programmes under the auspices of FAO, with support from UNEP. There is no apparent need here for the participation of MAB.

Wild plant species used directly in agriculture, or as breeding material in plant breeding, seem to be for the greater part reasonably secure. However, there are significant exceptions, and in these instances there is an urgent need for information and protective action. Their conservation, while of some concern to FAO, has not been covered by a specific programme activity. Considering that protective measures would be akin to those required for other wild species, the initiative and co-ordination could well be provided by MAB, in close co-operation

with FAO. Action needed includes a survey of endangered wild species, and a co-ordinating programme to encourage and support national and international action programmes.

Forest species, though for the most part wild species, are a direct concern of FAO, and a specific sub-programme of the organization is concerned with the exploration, conservation and utilization of forest gene resources. However, little is envisaged in this FAO programme as regards *in situ* conservation and co-operative activities in this field with Unesco and IUCN, within the framework of MAB Project 8, would be welcome.

Wild animal species related to domesticates are of potential value as breeding material. Conservation of wild gene pools in the form of semen and, potentially, of ova is an active interest of FAO. Long-term conservation of natural populations should wherever possible be conducted in the native habitats and this is a specific form of community conservation. Here again co-operation between FAO and MAB may be fruitful.

3. International Council of Scientific Unions (ICSU)

Recent ICSU activities that relate to this MAB project mainly concern work undertaken within the International Biological Programme, as follows.

(i) IBP/CT: Terrestrial Conservation Section

IBP/CT Check Sheet Survey. The Check Sheet survey of IBP Areas using the Mark VII Check Sheet began in 1967 after considerable discussion and field trials. The Check Sheet is a questionnaire designed to collect information on National Parks and equivalent reserves and other natural areas in such a way that the returns can be machine processed. Over 3000 Check Sheets have been returned to the Data Centre to date and these results are being analysed for publication in the IBP Synthesis Series under the editorship of Professor A.R. Clapham. Relevant background publications include the "Guide to the Check Sheet" (Peterken, 1967) and the "CT Progress Report" (Nicholson and Douglas, 1971).

Survey of Pacific Oceanic Islands. Following the 11th Pacific Science Congress in Tokyo in 1966, the CT Section was asked to undertake a survey of Pacific Islands. A Technical meeting on Conservation of Pacific Islands took place in Koror and Guam in November 1968 for which a preliminary listing of islands was prepared, and a "Draft Check List of Pacific Oceanic Islands" has been published (Douglas, 1969).

Project TELMA. TELMA was begun at an international technical meeting held at Attingham Park, U.K., in June 1967. The objects of Project TELMA are the preparation of a world list of peatland sites of international significance to science and the promotion of their conservation as well as the encouragement

of communication and collaboration among scientists investigating peatlands. A preliminary draft of the TELMA Handbook was published in Nicholson and Douglas (1971).

Ecological field stations. A survey of biological field stations was initiated by CT in 1965 in association with the development of the Check Sheet survey. The project was discussed further in 1969 with the development of the biome basis of PT studies and a further survey was undertaken in 1970, resulting in the "Working List of Ecological Field Stations" which was presented to the IVth General Assembly of IBP in Rome in 1970. Following a resolution of the General Assembly, the results were handed over to IUCN for further action.

National CT Projects. A total of 43 countries participated in IBP/CT through national conservation projects related both to the Check Sheet Survey and other conservation surveys. Of the 276 projects initiated at national level, 185 have proved to be viable and the majority of these have been completed. Reports and publications resulting from these projects are available at the CT Data Bank and have been indexed and cross-referenced for use with the Check Sheet and in CT synthesis activities.

(ii) IBP/PF: Freshwater Productivity Section

Project Aqua. This project is an attempt to register "those aquatic sites throughout the world which, in the interests of science and posterity, should be given some kind of conservation status... the ultimate aim is international recognition of an agreed list and national action in conservation". Project Aqua was initiated in 1959 and the PF Section of the IBP has been responsible for collating the list since 1964. In 1969 a provisional edition was issued and distributed worldwide. The first definitive edition was published in 1971 as part of the IBP Handbook Series (Luther and Rzoska, 1971).

(iii) IBP/PM: Marine Productivity Section

Projects "Aquamarina" or "Thalassa". A list of marine areas, similar in concept to Project Aqua, has been in mind for a number of years but, apart from a number of suggestions, no systematic work has been done by PM.

(iv) IBP/UM: Use and Management Section

Plant gene pools. This theme of Section UM has been particularly active and has been responsible for publication of the important IBP Handbook on "Genetic Resources in Plants" (Frankel and Bennett, 1970). A survey of areas and species of primitive cultivated plants was undertaken as a joint IBP/FAO operation and the results were presented at a Technical Conference in March 1973. An IBP synthesis volume is in course of preparation under the editorship of Sir Otto Frankel and Prof. J.G. Hawkes.

4. International Union for the Conservation of Nature and Natural Resources (IUCN)

The activities proposed for the MAB Programme in relation to the conservation of natural areas and of the genetic material they contain are of direct interest to IUCN and relate closely to the core of IUCN's ongoing programme, reference to aspects of which are made in various parts of this report.

IUCN, in co-operation with the World Wildlife Fund, is engaged in projects related to: (1) the classification of natural regions; (2) the preparation of lists and directories of protected areas throughout the world and of endangered species of plants and animals; (3) the examination of the distribution of protected areas to determine the adequacy of conservation in relation to the world's biotic regions and endangered species; (4) action to promote and assist with the establishment of new national parks and reserves; (5) action to increase the protection provided for existing parks and reserves; and (6) action to provide protection for threatened species. In relation to these activities, IUCN also assists in maintaining and operating the Monks Wood IBP/CT Data Centre in co-operation with the relevant authorities in the United Kingdom.

IUCN was one of the sponsors of the Second World Conference on National Parks, held in Wyoming, U.S.A., in September 1972. This conference devoted considerable attention to problems which relate, directly or indirectly, to the concerns of the MAB Programme, including scientific research, park planning and management, wildlife and resources management, staff development and training, park interpretation, environmental education, international assistance programmes, analyses of past and current developments, and projections into the future. The proceedings and recommendations of the Conference are due to be published in early 1974.

IUCN will hope to continue active collaboration with Unesco and with the National Committees of MAB to promote the activities recommended by the panel of experts, in the light of subsequent considerations and decisions by the International Co-ordinating Council of MAB.

ANNEX 4

DATA COLLECTION AND HANDLING FOR CONSERVATION ACTION

1. Background

The IBP/CT Check Sheet survey was initiated to help fulfil the aims of the Section, as published in its Handbook (Nicholson, 1968) and the Guide to the Check Sheet (Peterken, 1967). At the time of its issue the Check Sheet was regarded as an internationally approved document for the collection of data of immediate relevance to the needs of conservation programmes. It had undergone successive revisions and field trials resulting in a questionnaire of 11 pages, which was issued with an accompanying guide. Mark VII was regarded as a practical compromise to give a document that could be completed reasonably easily by surveyors, and yet which gave site and community data at a level useful in the context of both international and national appraisals.

Over 13,000 Check Sheets were distributed throughout the world. The normal procedure was to organize the survey through the IBP National Committee or, where one did not exist, through a national organizer who agreed to act in this capacity. Early responses to requests for data were encouraging and the impression from correspondence was that a good coverage would be achieved, including areas from which the information was most needed. The proportion of Check Sheets returned from those issued is roughly a quarter; some 3,000 from 13,000. Of those returned some 700 were not fully completed; over half of these because of deviations from the Mark VII version of the Check Sheet, or because of a consistent limitation to a reduced number of questions. The remainder of the 700 have incomplete or unreliable entries, especially for the vegetation section and as such are not considered suitable for the full range of synthesis studies. Nevertheless, the information that does appear in them is still of value as a basis for site description. Of those fully completed the most consistent and reliable are those handled directly by National Committees with a large input of man hours, e.g. Canada, Japan, Netherlands. Returns from countries with poorly developed conservation programmes had a low standard of completion in general, and the density of sampling was also low.

The problem encountered early in the survey was mainly concerned with getting a good coverage of data from some countries, which could then be summarized and the results investigated. Early trials of data processing methods for this purpose were restricted to simple punched card systems, operated on the machinery in the Biological Records Centre, at Monks Wood Experimental Station (U.K.). As the flow of data quickened however it became clear that the potential for analysis would be greatly increased if a more sophisticated data retrieval system could be used. It was also apparent that the bulk of data to be expected would justify this move.

2. Development of data processing

The functions that a data base would be required to fulfil for IBP/CT were considered, and these are summarized below:

1) To establish a standard site description in some detail for sites of interest to conservation, whether reserved areas or unprotected.

2) To build up community inventories to help assess the extent to which major ecosystems are protected in reserved areas, and to help identify gaps in the series.

3) To provide the basis for a widely available data retrieval system capable of servicing enquiries which might involve all possible correlations of the data.

4) To provide for the reproduction of Check Sheets in whole or part in response to such enquiries, to be capable of transfer as a complete data base to other centres, and to form the nucleus of a permanent documentation system.

These considerations led to the development of a computer based system handling all the material entered into Check Sheets. The data base was designed and programmed by a consultant to the project and has remained unaltered except in detail. The advantages of the system are that it enables detailed analysis to be carried out, and allows maximum use to be made of the data. The types of enquiry that can be made vary from the simple recognition of sites with a particular feature, or combination of features, to analyses of Check Sheets in association with data collected independently, e.g. climate, productivity. The data base is described in some detail by Radford and Pankhurst (1973).

The provision of these facilities has involved a great deal of effort in data preparation and processing. For the purposes of detailed studies such as those proposed by IBP/CT, linked to the continuing operation of a data base along the same lines, the processing system is without doubt a very useful tool and would justify its continued operation, subject to certain conditions. The principal of these, however, is that the current need is for flexibility to handle information of a diverse nature in an attempt to develop an integrated documentation system. The present data base could be modified to provide this flexibility but only slowly, at high cost and subject to the usual inconveniences of dependence upon outside services, whereas a high degree of control is required. The essential for any efficient data base is stability both in its operating system and in the nature of data being handled. This is particularly important for purpose designed computer systems, such as the one in operation, where costs are kept to a minimum since change is accommodated more slowly and at greater expense than for less sophisticated systems.

The present opportunity to review the whole question of data collection and handling should not be limited in its scope, therefore, by the relative inflexibility of the present system, but should rather consider how a greater potential for flexibility can be achieved.

3. The present situation

A backlog of unprocessed data still exists despite the preoccupation of Monks Wood staff for more than two years with data processing. The current policy is to process those Check Sheets which give the best coverage in terms of sampling density or biological diversity, as a basis for the IBP synthesis studies.

The information so far processed is under review and has been assessed with regard to its reliability for different types of treatment. The plan for the major CT synthesis volume is outlined briefly below:

1) To investigate the coverage of the Check Sheet survey in terms of sampling density and the representation of plant communities, rare species and types of human impact in particular.

2) To place in perspective the advantages and short-comings of the Check Sheet type of approach to biological survey.

3) To appraise the methods of specification and classification adopted for the Check Sheet and to consider alternative methods.

4) To make recommendations arising from the results of the survey concerning the practical lines for development of such a system, in modified form where necessary.

4. Future developments

The foregoing presents some of the aspects which should be considered as affecting future developments in data collection and handling for conservation action. Of fundamental importance is the need to define precise objectives, to collect together such data as will meet those objectives, and to handle it in a fashion that will produce the summaries and analyses required as efficiently as possible.

In defining objectives there is an immediate division between drawing together such information as already exists, in the form of published and unpublished site lists, project reports, surveys and related material, and continuing the active collection of data from areas about which little is already known. Once the immediate task of dealing with existing material has been started, and it is in a form that will allow comparative studies at a general level, the need for further information can be better assessed. This should help to avoid repetitive requests

for information and also make better use of what is already at hand. Future development should be aimed at providing a means for the synthesis of material at a level that allows global coverage, but with provision to handle greater detail when necessary.

In both cases the aims of the documentation system to handle the data are similar and may be tentatively proposed as:

1) To help assess the extent of adequate protection of ecosystems or biotic units in reserved areas.

2) To help identify gaps in both knowledge and protection of ecosystems and selected species.

3) To focus attention upon sites of possible interest to conservation, where they contain examples of ecosystems or species not known to be represented in adequately protected sites.

4) To build up descriptions of sites of interest to conservation, leading ultimately to a better appreciation of their basic ecological features in the context of the full range of those features.

To meet these needs indicates the following ideals in a data processing system:

1) Flexibility of application.

2) Simplicity of operation.

3) Ease of updating.

4) Ease of interpretation of results.

5) Provision to handle a large amount of data.

The following requirements are ancillary but nevertheless have considerable influence on the operation of the system:

1) Independence of outside services.

2) Adequate service to users.

3) Efficiency and comparatively low cost.

A computer based documentation system such as that run by IBP/CT scores badly in flexibility of application, simplicity of operation and independence. It scores rather low for updating and cost, but high for interpretation, flexibility of data manipulation, and general user service.

A documentation system based on conventional office files and punched card files is to be very carefully considered as a practical alternative to a computer data base. It would be flexible in its range of applications, relatively simple to operate and update, inexpensive, and largely independent of outside services. Such a system would score low, however, for flexibility of data manipulation and output presentation. These disadvantages can be minimized by the fact that with specific objectives in view and less information than is given in the Check Sheet, the data can be organized to provide answers to a number of key question types which cover the major uses for which the data are collected. Such questions would be those framed around the primary objectives of the data base.

The aims and scope of the documentation system indicate that a modular approach to data handling would be the most useful. The basic modules would be those common to most sources of information, but each could be modified to handle data received in a non-standard form. This would ensure that entries from the various lists of important sites could be brought together in a way that does not involve distortion in the interest of standardization, but puts different descriptive systems side by side for comparison and evaluation on their own merits. The basic modules would include topics such as location, administration, vegetation, characteristic fauna, etc. Each could be modified or expanded to suit a particular project. For example, sites described in Project Aqua will merit an expanded module on hydrology, whereas information derived from a project on tropical rain forests would require special provision for vegetation classification and description.

The above comments refer in particular to information already in existence. For the treatment of data collected in continuing survey work the situation is easier in that there is an opportunity to use *a priori* classifications at the outset and consideration must be given to the extent that this is possible and desirable. For vegetation, the system proposed for use is the modified Unesco classification, linked to biotic units (Dasmann, 1972b; IUCN, 1973b; Unesco, 1973). Classifications for landform, climate, etc. could be included to cover those components of the ecosystems under study chosen for sampling and description.

The IBP/CT Check Sheet survey has pioneered the development of data collection and handling in the form of an organized survey asking for general ecological information. Operating concurrently have been a number of other projects each dealing with specific aspects of biological interest. The present situation is one in which there is need of directed effort to bring together data of importance to conservation action, and to rationalize the further collection of data.

It is essential that the documentation system chosen to help fulfil the aims decided upon for future development should be able to accomplish the task of both synthesis and analysis of data at a level and in a fashion that is practical within the limits of the staff and budget commitment.

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