IUCN

Eleventh Technical Meeting
Onzième Réunion Technique

Papers and Proceedings

Rapports et Procès-verbaux

NEW DELHI, INDIA

25-28 November 1969

VOLUME I

First and Second Sessions : Commission on Ecology

A. CONSERVATION IN LAND-USE PLANNING: SOIL AND WATER RESOURCES, ESPECIALLY IN MOUNTAIN REGIONS: WILDLIFE RESOURCES AND FORESTRY.

B. EFFECTS OF POLLUTION ON NATURAL ECOSYSTEMS

C. SOME ASPECTS OF WILDLIFE UTILIZATION AND MANAGEMENT

D. INTERNATIONAL BIOLOGICAL PROGRAMME: THE CT SURVEY OF UNDISTURBED OCEANIC ISLANDS: CURRENT RESEARCH IN INDIA AND ITS RELEVANCE TO CONSERVATION.

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Union Internationale
pour la Conservation de la Nature
et de ses Ressources

International Union
for Conservation of Nature
and Natural Resources

Morges, Switzerland, 1970

The International Union for Conservation of Nature and Natural Resources (IUCN) was founded in 1948 and has its headquarters in Morges, Switzerland; it is an independent international body whose membership comprises states, irrespective of their political and social systems, government departments and private institutions as well as international organisations. It represents those who are concerned at man's modification of the natural environment through the rapidity of urban and industrial development and the excessive exploitation of the earth's natural resources, upon which rest the foundations of his survival. IUCN's main purpose is to promote or support action which will ensure the perpetuation of wild nature and natural resources on a world-wide basis, not only for their intrinsic cultural or scientific values but also for the long-term economic and social welfare of mankind.

This objective can be achieved through active conservation programmes for the wise use of natural resources in areas where the flora and fauna are of particular importance and where the landscape is especially beautiful or striking, or of historical, cultural or scientific significance. IUCN believes that its aims can be achieved most effectively by international effort in cooperation with other international agencies such as UNESCO and FAO.

The World Wildlife Fund (WWF) is an international charitable foundation for saving the world's wildlife and wild places. It was established in 1961 under Swiss law and shares joint headquarters with the International Union for Conservation of Nature and Natural Resources (IUCN). Its aim is to support the conservation of nature in all its forms (landscape, soil, water, flora and fauna) by raising funds and allocating them to projects, by publicity, and the education of the general public and young people in particular. For all these activities it takes scientific and technical advice from IUCN.

Although WWF may occasionally conduct its own field operations, it tries as much as possible to work through competent specialists or local organisations.

Among WWF projects financial support for IUCN and for the International Council for Bird Preservation (ICBP) have highest priority, in order to enable these bodies to build up the vital scientific and technical basis for world conservation and specific projects. Other projects cover a very wide range from education, ecological studies and surveys, to the establishment and management of areas as national parks and reserves and emergency programmes for the safeguarding of animal and plant species threatened with extinction.

WWF's fund-raising and publicity activities are mainly carried out by National Appeals in a number of countries, and its international governing body is made up of prominent personalities in many fields.

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Volume I

First and Second Sessions: Commission on Ecology

A. Conservation in land-use planning: soil and water resources especially in mountain regions: wildlife resources and forestry.

B. Effects of pollution on natural ecosystems.

C. Some aspects of wildlife utilization and management.

D. International biological programme: the CT survey of undisturbed oceanic islands: current research in India and its relevance to conservation.

Edited by
Hugh F. I. Elliott

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Preface

The Ninth and Tenth Technical Meetings of IUCN held at Nairobi (1963) and Lucerne (1966), were concerned with identifying and assessing some of the more important ecological considerations affecting conservation of nature and natural resources in tropical and temperate regions, respectively. The Eleventh Technical Meeting, held at New Delhi on 25-28th November 1969, adopted a somewhat different approach. Although much of the material presented was appropriately drawn from experience of conservation problems and scientific research in southern Asia, the aim was to use this material, supplemented by a limited number of comparable studies from other parts of the world, to illustrate the activities and interests of each of the five Commissions on which IUCN relies for technical advice, the formulation of its policies and the promotion of its projects.

Thus, with the exception of the Commission on Legislation, whose specialised field of work does not lend itself to this kind of approach, each Commission undertook the organisation and supervision of a Session of the Technical Meeting. In addition, reflecting the close community of interests between IUCN and the International Biological Programme, a full Session of the Meeting was devoted to IBP activities and this was also organised by the Commission on Ecology by virtue of its special liaison responsibilities.

The Papers and Proceedings of the Eleventh Technical Meeting are, therefore, being published in five parts. Volume I contains those pertaining to the Commission on Ecology, including the IBP Session material; Volume II has been prepared by the Survival Service Commission; Volume III by the International Commission on National Parks; Volume IV by the Commission on Education and Volume V by the Commission on Landscape Planning.

Two points concerning the arrangement of material in the five volumes call for comment. First, certain of the topics dealt with in Volume I, under the heading of wildlife utilisation and management (e.g. 'the role of zoos') and also the problems concerned with the identification and conservation of undisturbed islands, are very much the concern of the Survival Service Commission and of its specialist groups. That they were nevertheless dealt with at the first two Sessions of the Technical Meeting, under the auspices of the Commission on Ecology, was mainly due to the large number of papers on endangered species presented for discussion at the Survival Service Commission's Session (see Vol.11). It is, however, also an indication of the interdependence of conservation of habitat and species survival, which closely links the work of the two Commissions.

Secondly, a novel feature of the Eleventh Technical Meeting was the presentation and discussion of the reports on what came to be known as the 'pre-Conference Study Tours'. These were in effect six short-term research projects, designed to provide an up to date assessment of a variety of conservation problems of current importance in the host country of India, but typifying problems which frequently come to IUCN's attention. The projects were made possible by the generous financial support of the Smithsonian Institution and were carried out during the week immediately preceding the General Assembly by small groups of experts, representing the appropriate Commissions, working in collaboration with their Indian counterparts, appointed by the Inspector-General of Forests, who were responsible for all the local arrangements. Two of the

studies were mainly concerned with endangered species, two with National Park development and management, and one each with problems of general ecological and landscape planning significance. The resulting reports were dealt with accordingly at various Sessions of the Technical Meeting, but for ease of reference and because, with one exception, the studies were sited in existing National Parks or equivalent reserves, it has been deemed convenient to include all the reports and summaries of the discussion on them in Volume III of the Proceedings.

Contents

General Introduction

As already mentioned in the Preface, responsibility for the organisation and supervision of the first two sessions of the Eleventh Technical Meeting of IUCN lay with its Commission on Ecology. Planning of the technical programme is customarily undertaken in consultation and agreement with the organising authorities of the host country and these sessions were designed to link up with the Keynote Addresses, delivered at the opening Plenary Session of the Tenth General Assembly on the theme of 'Environmental and Economic Values of Nature Conservation'. From this starting-point, the aim was to lead into a more detailed consideration of ecological aspects of some current conservation problems, selected for their interest and relevance to India and southern Asia generally. Reflecting the vast range of habitats represented in this region, from the highest mountains of the world to the most luxuriant tropical forest and arid deserts, the selection was inevitably somewhat diffuse and had the disadvantage that each topic could easily have occupied a full session, so that discussion had largely to be confined to brief question and comment and could seldom be developed to constructive conclusions. On the other hand, it ensured that material of very wide interest and appeal could be included, which will, it is to be hoped, be of value in the context of the UNESCO-sponsored 'MAB' programme now under development on the 'scientific basis for rational use and conservation of the resources of the biosphere'.

Thirty-six papers were submitted for the 'Ecology Commission's sessions', the majority by invitation and in time to be circulated in advance to participants, although a few late submissions were accepted because of their special interest or as filling important gaps. In thirteen cases, marked below with an asterisk, contributors were unfortunately prevented from attending the Meeting and presenting their Papers in person, and IUCN is much indebted to them for contributions which greatly enhanced the value of the documentation. They were introduced, in some cases, by appropriate representatives and, in others, summarised by the Secretary of the Commission.

The First Session, held on Tuesday 25 November 1969, was subdivided into three sections.

In *Section A,* over which the Chairman of the Commission on Ecology, Professor F. Bourliere (France), presided, four groups of Papers were presented, each group followed by a short period of discussion. In the first group, Poore (U.K.) and Chandras* (India) dealt with some of the broad scientific, economic and politico-social issues affecting the elaboration of a sound conservation policy; the next three papers, by Mirimanian (U.S.S.R.), Gulisashvili* (U.S.S.R.), and Berry (U.K.), concerned general and specific problems of mountain regions; papers by Ambasht (India) and Varshney (India) described some recent research on soil conservation and rehabilitation techniques; and the final group by Vulterin* (Czechoslovakia), Hejmadi and Qureshi (India), and Taber* and Scott* (U.S.A.), reviewed the relationship between forest and wildlife resources, with particular reference to nature conservation as an objective in the multiple use of forest lands. The Papers are grouped accordingly in these Proceedings and, after each group, the main points made in the discussions are summarised.

In *Section B,* for which Professor J. B. Cragg (Canada), Deputy-Chairman of the Commission on Ecology, took the chair, five papers were presented as a basis for considering some of the problems of environmental pollution, which are currently the cause of so much concern. As the Chairman pointed out in his opening remarks, the emphasis in four of these papers, by Moore (U.K.), Appleby (U.S.A.), Prestt* (U.K.), and Denisova*, Popova* and Pushkar* (U.S.S.R.), is largely on the incidence and effects of chemical contamination of aquatic ecosystems, including of course their soils, vegetation and animal life; the fifth paper, by Mani (India), dealt with some parallel aspects of air pollution. The Chairman in his introduction also expressed the hope that despite the limited coverage of an enormous subject, these papers and their discussion, might lead to reconsideration, further revision, if necessary, and more effective use of the valuable policy statement tabled at the Ninth General Assembly by the Committee on Ecological Effects of Chemical Controls of IUCN's Commission on Ecology. Although, in the event, a lively discussion had to be cut short because of lack of time, a revised version of the policy statement was

in fact included in the subsequent report of the Commission to the General Assembly and is reproduced in its Proceedings (IUCN Supplementary Paper No. 27).

For *Section C*, in which three topics relating to the utilization and management of wildlife resources were selected for attention, Mr. C. R. Gutermuth, Vice-President of the Wildlife Management Institute, Washington D.C, kindly took the chair. For the purposes of record in these Proceedings, it has been thought desirable that the sequence in which the Papers were actually presented at the meeting should be rearranged in a rather more logical order. Thus the first topic, based on contributions by Bannikov (U.S.S.R.), Spillett (U.S.A.), de Vos* (F.A.O.), Southwick (U.S.A.) and Siddiqi (India), and Kurt (Switzerland), is chiefly concerned with the problem of ensuring that exploitation of wild animals, particularly the large mammals, is properly controlled and placed on a sustainable basis. The next three papers, by Severinghaus (Taiwan), Galushin (U.N.E.S.C.O.) and Salim Ali (India), look at some of the special considerations applying to bird species as a result of the impact, economic and otherwise, exerted by their numbers, distribution and mobility. Leading on from this, the particular contribution of zoological parks and gardens to conservation, by facilitating the study and understanding of factors essential to good management, helping to insure the survival of stocks of species under threat and, above all, by promoting the interest and concern of the general public, is discussed in the contributions by Medway* (Malaysia), Wayre* (U.K.), David* (India), and Sankhala and Desai (India).

The first part of the Second Session of the Technical Meeting, on 26 November, was devoted to the presentation and discussion of four reports on Study Tours which had been carried out by groups of experts during the week preceding the General Assembly. As explained, however, in the Preface, for reasons of convenience and future reference the reports on all six Study Tours and an account of the discussions are placed together in Vol. 3 of these Proceedings.

Following the mid-morning interval, the Session was re-convened under the chairmanship of Professor B. R. Seshachar, of the Department of Zoology, Delhi University, Chairman of the Indian National Committee for the International Biological Programme. The aim of the Session, as Professor Seshachar explained in his introductory remarks, was to bring out and provide an opportunity for discussing the close community of interest between conservation and the IBP study of the biological basis of productivity and human welfare. A better understanding of the processes involved and of man's integral part in them was essential, if conservation was to be placed on a sound basis and to have any chance of fulfilling its purpose. The casual and unscientific approach which had sometimes characterised past efforts, was no longer appropriate. To illustrate this, the material to be presented in the present session fell into two sections, reviewing respectively the progress made in a major research project at the international level of very obvious conservation significance and, secondly, in a series of projects at a national level: these covered very detailed as well as more general studies at present being carried out in India under IBP auspices, which at first sight might seem to have little relevance but which could nevertheless each make its contribution to the solution of conservation problems.

In the first section, the Paper by Nicholson and Douglas (U.K.) examines the aims and objects of the survey of undisturbed oceanic islands organised by the Conservation of Terrestrial Communities (CT) section of IBP and hitherto concentrated on the Pacific Ocean. This is followed by a preliminary account of the situation in the islands of the eastern Indian Ocean by Snow* (U.K.). The discussion of these Papers dealt with the problems of extending and completing the work to give world coverage and, in particular, the responsibilities of IUCN, in following up the results and recommendations of the surveys, for promoting the establishment of International Supervision of islands classified as of prime importance for Science. Finally, as an example of a regional organisation, which could assist in this task and in carrying out the further research which will certainly be needed, a paper by Soemarwoto* (Indonesia) draws attention to the newly-established Center for Tropical Biology and Conservation in South-East Asia.

In the last part of the Session six papers relating to IBP research in India were presented, all of them contributed by Indian authors or, in two cases, by foreign scientists recently or currently working in India on sponsored research projects. The first three, by Misra, Murty, and Pandeya and Jayan (India) dealt with problems of productivity and

genetics, in vegetation types or specific plants, and the next two by Hodd* (U.K.) and Odend'hal (U.S.A.) examined the ecology and ecological impact of domestic cattle, the subject being introduced by Mr. Zafar Futehally as Convenor of the national CT Section. Each group of papers was followed by a short discussion, of which the main points are summarised. Unfortunately time once again precluded the formal presentation and discussion of the final contribution by Das* (India) on freshwater ecology and conservation, but as the Chairman remarked in closing the Session, it is to be hoped that the many points of interest in this and indeed all the Papers contributed will repay further study and be of value for future reference.

London. 15 May 1970

Hugh F. I. Elliott
Secretary
IUCN Commission on Ecology

SECTION A: CONSERVATION IN LAND-USE PLANNING: (i) General

Chairman: Prof. F. Boulière, Faculté de Médecine, 45 rue des Saints-Pères, Paris 6, France

The Role and Economic Justification of Conservation in Land-use Planning

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There are few now, especially in this audience, who would question that the renewable natural resources of the world should be conserved. This is the purpose of this Union, and the aim has been endorsed by the United Nations. It is also now widely recognised that the extent to which this can be done, the cost of doing it and the quality of the life of future generations depends overwhelmingly on establishing a sensible balance between population and resources. Shall we take these points as agreed? What are frequently glossed over and as frequently ignored are the internal strains and inconsistencies in the aim itself—the conservation of one natural resource can and often does complete with the conservation of another.

First let us examine what we mean by renewable natural resources. These usually are taken to include soil (and soil fertility), water, and populations of plants and animals; they are functionally connected to one another and have the capacity for increase under suitable conditions. Among the most important renewable natural resources are human ability and ingenuity and these are certainly increasing fast. Some of us may have doubts about another—the human sense of responsibility.

We can look at these resources of soil, water and living creatures in two ways—as a resource for man and as features having a value in their own right. Although there are many who hold strongly, as I do, that no living creature should be unnecessarily exterminated and that it is a degradation of human beings to exterminate them, I do not intend to pursue this line of argument here. Let us confine ourselves then to considering the value of these resources to man. What is it he requires of them? Space to live, food and drink, warmth, health and the conditions to enable him to enjoy his capacities to the full, both physically and mentally. I suggest that our target is a system in which, at any time, the resources of soil, water, plants and animals are organised to match as closely as possible the needs of the population. But both components of this system, the natural and the human, are always changing. The wants and requirements of societies in one stage of their evolution are very different from those in another. If we appreciate this we are led to what I consider to be the most important principle of conservation. Natural resources should be managed in such a way that the choice available to future generations should in no respect be less than the choice available now. Planning and management should be so arranged that nothing irreplaceable is destroyed.

Much literature on conservation emphasises two ideas, imbalance and irreplaceability, both of which require critical examination. Some ecological imbalance is, of course, natural—the delayed adjustment of ecosystems to climatic change, and the processes of recovery after volcanic eruptions, hurricanes, natural landslips and so on; but by far the greatest imbalance has been and is caused by man. This started in the neolithic phase of his development and has increased in intensity and scope ever since. One can visualise how great is the disequilibrium by thinking what would happen if man were to disappear from the face of the earth tomorrow. Some civilisations at some times have established transitory and local balances but the general picture is one of imbalance which now affects very nearly all of the globe. The extent of the imbalance anywhere can be judged quite simply by the amount of human effort that is required to maintain the status quo. An area of antarctic ice or of untouched Malaysian forest remains in balance without effort or cost; the organisation of a modern urban community requires enormous expenditure of human labour and resource to keep it running satisfactorily. Forest plantations and productive farms lie between these two extremes.

Is imbalance necessarily a bad thing? The general answer to this must I feel be 'no' if we believe in man's past achievements and future possibilities. Practically any imbalance can be corrected by suitable injections of money, effort and inventiveness; the history of civilisation could be defined as the creation and control of ecological imbalances. One must distinguish therefore between imbalances that are deliberate, contrived and controllable and those that are unintentional, and often ill-considered. The capacity to control should ideally precede interference with the ecosystem.

Imbalances which are irreversible are a different matter however; the extinction of a species, or part of the gene pool of a species, and the destruction of ecosystems which have evolved a complex structure of interrelationships are permanent losses which cannot be made good with any skills that we have yet developed or are likely to develop. We have a different kind of responsibility—a trusteeship—to conserve these for their possible future use and for the knowledge we may derive from them.

The three cardinal points in the management of renewable natural resources seem to me to be these:

(a) that we should at all times try to establish the best balance between human needs and the resources to satisfy them;

(b) that we should not introduce new serious imbalances into the system before we have the capacity to control them and have assessed the consequences of action;

(c) that we should keep a freedom of choice available for our successors by not destroying irretrievably any species or system.

The conservation of wildlife enters into all of these. Into the last by trying to ensure the survival of species and the protection of samples of ecosystems. Into the second because the maintenance of reasonable populations of wildlife are likely to act as a buffer to the more serious consequences of ill-considered change. And into the first because wildlife in its true and widest sense is an essential part of the resources available to man, being not only a manageable source of food in some circumstances, but an essential component of the ecological systems on which agriculture, forestry, and almost all human uses of the land or water depend. These three requirements are based on an appreciation that man is a rather special part of the ecological system to which he belongs; they can be considered as ecological principles for the wise use of natural resources.

The arguments developed above take what I believe to be a commonsense but far-seeing view of the situation but touch only indirectly and by implication on the economic justification for the conservation of natural resources. I should like to deal with this point explicitly.

Natural resources are often compared to capital and their unwise use to squandering and dissipation (which is, after all, the antonym of conservation)—the pursuit of the short term aim at the risk of losing permanent solvency and stability. The comparison is valid but is worth developing more deeply.

Few would now dispute the economic justification for conserving soil fertility and water, because there is a clear economic demand for the income from this capital—food and valuable raw materials from the one and water for domestic, agricultural and industrial use from the other. But investment in soil conservation works, for example, is frequently still confined to situations where the agricultural yield will give an immediate short term return on investment and, if this return is not forthcoming (at present market values) the necessary measures are not taken even when such neglect will lead to the irreversible deterioration of soil resources. This is happening now in many mountain catchments and in areas where marginal agriculture is practised. There is no doubt that the greatest increase in yield for money invested can be obtained on the most fertile soils, but concentration of investment on these is often accompanied by neglect in areas of lesser inherent productivity leading to a permanent loss of soil, vegetation cover and the natural characteristics that make a catchment effective in retention and release of water. Such a policy leads to a permanent loss of resource for the future and often makes necessary expensive engineering works and social programmes to correct its harmful effects. Thus, in spite of the fact that it is now universally recognised that there is every economic justification for the conservation of soil fertility and water, there are still instances

when both are allowed to be irreversibly harmed because the return on investment will be slow. These are surely fields in which injections of national and international finance by subsidy and aid are necessary and fully justified.

Convincing economic arguments can also be applied in the case of those biological resources which give an immediate yield either of food or of an economically valuable raw material. The most important of these are pastures, forests and those wild animals which can be managed as a source of food such as fish and some ungulates. The cardinal principle to be observed in all these situations is that the management should be organised to ensure a sustained yield based on the best available knowledge. There is always a tendency to overexploit; but this must be rigorously checked, by education and by national and international legislation. Exactly the same trends, however, can be detected here as in arable farming. Extensive forestry is being replaced by intensive plantation forestry for timber production, fish farming is increasing, and wild ungulates are being managed in corrals for meat production.

If these trends continue, as they are likely to do, it would appear that the economic justification for managing any biological resource extensively will become slimmer and slimmer; and, if we are concerned only with the economic value of these resources as food or industrial bulk raw materials, this would certainly seem to be the case.

But food and raw materials are not our only concern. The advances in standard of living which have accompanied the intensification of land use have also made people aware of the value of the resources of unspoilt country and of wild plants and animals which make such an important contribution to human health and well-being in an overcrowded world. As these become scarce, they begin to have a money value. The economic justification for retaining natural resources of wildlife and unspoilt landscape is becoming apparent and is already as important in East Africa as is the conservation of beautiful buildings and archeological remains in the Old World. As population grows and land use for food production intensifies, it is certain that the money value of these assets will increase both for local use and as the foundation of a flourishing tourist industry.

I earlier laid stress on so ordering land use that we leave a freedom of choice to future generations. The most far-sighted thinker would not have foreseen even one hundred years ago what the economic values of today would be. Is our crystal gazing likely to be any more accurate? Most economic forecasts for forests lay stress on the importance of quickly growing softwoods for production of bulk cellulose. Dawkins has advanced the view that, as chemical technology advances, trees will be replaced by other raw materials and that the use of forests will be for luxury produce and amenity. He may well be right.

Taking the longest view therefore the economic justification for conservation is that, by preserving samples of all natural systems and of genotypes, we retain the freedom to select the most appropriate raw materials for future use.

Economic arguments can, accordingly, be advanced for all elements of the conservation of natural resources although in some circumstances the return cannot be expected quickly and in others the investment may rather be looked upon as an insurance. If one looks at past developments and their effects, however, one sees that the use of ecological foresight would have prevented mistakes which are proving very expensive to rectify —the salinisation of irrigated land in Mesopotamia and the Indus valley, the American dustbowl and the introduction of the rabbit to Australia or the red deer to New Zealand.

If it were possible to manage land so that all natural resources were conserved together, our problems would melt away. But this is unfortunately not so. Intensive, productive agriculture retains and may increase soil fertility but destroys natural ecosystems; extensive forestry is compatible with game conservation, intensive forestry may not be. Where the population is small, land can be used in many ways at the same time but, as each use becomes more intense, so they become less compatible one with another and have to be separated. Sometimes the conflicts can be subtle. In one Mediterranean country the removal of goats in the mountain valleys led to a great and unexpected growth of plane (*Platanus orientalis*) valuable as timber and as an amenity. But the transpiration of these trees was much greater than the natural water loss of the stream beds. Villages lower down the valley began to suffer from water shortage and the supply of water to underground storage in the plains was cut down, storage which was used to irrigate valuable crops such as vines and citrus. The answer to this dilemma is not ecological but

economic and social. Two solutions are possible, both conservationist; which should be adopted?

Conservation, we see, is a matter of wise choice. But, as usual, implementation is more difficult than theorising and it is implementation that matters—something that those who attend conferences should constantly remember. How are we to make the best use of our natural resources while leaving them, perhaps altered but yet unimpaired, for the future? To have one's cake and eat it?

When one begins to consider the implementation of such a policy in any place, one realises that it can only be done by planning—and planning which is run through and permeated with a conservation ethos. The actual details of implementation depends greatly, of course, on the social and economic conditions of the country at the time.

First let us consider a country which has many of its resources of vegetation and soil intact, which is relatively rich and has a small but rapidly growing population. Here the choices are still open. The planning of land use can be so arranged that all requirements are met. if wise choices are made early: mineral development, where appropriate with plans for restoration, agriculture on the best soils, planned water storage and irrigation systems, economic forestry and catchment protection, national parks, suitably selected areas for the protection of ecosystems and plant and animal populations and gene pools, etc. All these elements are essential for a healthy land use. Early planning is essential because it is so easy to damage seriously one resource by inefficient or ill-chosen and temporary development for an unsuitable use: hill soils by inappropriate agriculture, the best alluvial soils by unwise irrigation; a valuable scenic and tourist resource by an oil terminal, or the only haunt of a rare species by a reservoir, both of which could have gone elsewhere.

The choice is open in this instance because the resources are intact and the pressure of need on them still allows time. There are parts of the world which are in this fortunate position but they are few; they should learn from the experience of others and use their good fortune to good advantage. In them there need be no competition for the conservation of different natural resources.

A much more frequent situation, especially in the arid zone, is of an area which has been inhabited for a long time, where most cultivable soils are already cultivated, population is rising, resources of forests and grazing lands have been over-used and degraded and the main preoccupations are food and health. Here few options are available. All cultiable land must be cultivated to the full but every effort should be made to enable marginal land to recover its potential. This requires careful planning of land use, intensification of use on the better land and remedial action on the damaged land. Too often the first takes place but not the second—one brings a quick profit, the other does not.

The situation is different again in populous highly developed countries. The requirements have become more complex and the intensity of use greater. Planning is essential if the uses of the land are to match the needs of society, and, because these needs are so complex and varied, and the changes taking place so comprehensive and rapid, there must be a sensitive system to translate choice into action.

Although the priorities vary from time to time and society to society, it is only by basing the use of land on principles of conservation that the future can be assured; this can no longer be left to accidental development but must be done deliberately and of intent.

SUMMARY

Conservation of renewable natural resources—such as soil, water and populations of plants and animals—often involves competing interests. Ignoring, for the purposes of this Paper the value of such resources in their own right, their value for man suggests that the aim must be the establishment of a system in which resources and human needs are matched. But since both components are constantly evolving, the most important aim of conservation is to keep the options open, to manage resources in such a way that none is irretrievably destroyed. The three principles are to balance resources and needs, to refrain from introducing imbalances without the capacity to control them and to maintain freedom of choice in the utilization of resources.

Even when the economic justification for conservation is particularly obvious, as with soil fertility and water, it still too often happens that because returns from careful management may be slow, irreversible damage is allowed to occur. With biological resources the economic case for extensive management always tends to give way to that for intensive management. But maximum production of food and raw materials is not the only return needed by man and the valuations of today are not necessarily those of tomorrow. While this makes it all the more imperative to retain samples of all natural systems and genotypes, it does also mean increasing conflict between uses, so that conservation becomes a problem of wise choice. Such a choice can only be properly exercised through planning, which in turn takes full account of social and economic factors within the framework of the conservation ethos: the future use of land can no longer be left to accidental development but must be deliberately chosen.

RÉSUMÉ

La conservation des ressources naturelles renouvelables telles que le sol, l'eau, les populations animales et végétales, fait souvent intervenir des intérêts opposés. Si pour les besoins de l'article on ignore la valeur intrinsèque de ces ressources, leur valeur pour l'humanité révèle qu'il faut chercher à établir un système où ressources et besoins humains puissent s'accorder. Mais comme ces deux facteurs sont en constante évolution, l'objectif essentiel de la conservation doit être de garder ouvertes toutes les options possibles, d'aménager les ressources de telle façon qu'aucune ne soit irrémédiablement détruite. Les trois principes de la conservation sont d'équilibrer les resources et les besoins, d'empêcher l'apparition de déséquilibres sans qu'il soit possible de les contrôler et de maintenir la possibilité d'une liberté de choix dans l'utilisation des ressources.

Lá même où la justification économique de la conservation semble tout à fait évidente, comme dans le cas de l'eau et de la fertilité du sol, il arrive encore trop souvent, parce que les bénéfices d'un aménagement mesuré sont lents, que des dégâts irrémédiables se produisent. En ce qui concerne la mise en valeur économique des ressources biologiques, l'exploitation extensive tend toujours à céder le pas à une exploitation intensive. Mais la production maximum de produits alimentaires et de matières brutes n'est pas l'unique 'bénéfice' dont l'homme ait besoin et les valeurs d'aujourd'hui ne sont pas forcément celles de demain. S'il n'en paraît que plus impératif de conserver des échantillons de tous les systèmes et génotypes naturels, cela implique aussi un conflit croissant entre les diverses utilisations, de telle sorte que la conservation devient une question de choix rationnel. Ce choix ne peut s'exercer correctement qu'à l'aide de la planification qui, de son côté, tient compte de tous les facteurs sociaux et économiques dans le cadre du système de la conservation: l'utilisation future des terres ne doit plus être laissée aux soins du hasard, mais doit faire l'objet d'un choix voulu.

Section A (i)

Economic Considerations in Conservation Reform in India

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The present concern for the depletion of renewable natural resources like forest resources in India is more than quarter of a century old. Remarkably enough, it is devoid of the traditional values and institutions which made it more meaningful and subjective in the olden days. Speaking in particular terms, conservation in recent centuries was in great measure under religious and feudal influences which are loosening their hold on modern man and nothing equivalent seems to have replaced them.

On the contrary, the influence of socio-political changes coupled with increase in population pressure and consequential rise in demand on land and its products viz. food, wood, fodder, etc. naturally has had adverse effect on our forest wealth, thus generating the present concern even in the scientific world.

Since independence (1947), there has been no dearth of conceptual directives for conservation of natural resources in India. The special committee (1949) under the chairmanship of Prime Minister Nehru stated: 'The problem of conservation of soils and forests must be treated as a whole. For this purpose, the system of land utilization as it obtains at present requires the closest investigation. A land utilization survey should be conducted by a body of experts and land utilization maps prepared on the basis of information gathered. The position should be reviewed every ten years....'[2]

A REPETITIVE SITUATION

Since then even though a good deal of thought has been given to this problem at all levels viz. governments, private bodies and individuals, there has been a gross omission of action in the right direction. Even the preliminary steps like land-use studies remain to be completed. In the meanwhile, our resources have been subjected to successive over-exploitation and presently the condition of forest resources is much worse in comparison to their condition in 1949. Within the past two decades, there has been an all round erosion of soil and vegetation. There is a significant reduction in the benefits to the society from these resources; on the contrary, heavy outlays are involved in attempting to restore normalcy in their condition. For example, the processes of natural regeneration of the forests cannot be relied upon as before and forests have to be developed on an increasing scale through artificial plantations. Similarly, soil conservation programmes have to be implemented on extensive hilly tracts for the sake of preventing soil erosion and of regulating water supplies.

This involves large outlay, obviously difficult for a low-income country like ours to sustain. Today after two decades, it is found that mere pious wishes have not been able to achieve the desired advance. In simpler words, we are now trying again to make a beginning at a point not very far from where we started in 1949. Look at what has been stated (1965) by the Planning Commission in its first draft of the Fourth Five Year Plan:

> '... Our forests are capable of producing much more (some estimate it as 10 times more) than what they are doing now... There are considerable areas of waste lands, ravines, canal banks, road avenues, etc., which could profitably be planted up with

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[2] Report of the National Planning Committee; Soil Conservation and Afforestation Sub-Committee 1949, page 177.

useful species to meet the growing demand for wood and other products. ... The bio-aesthetic role of forests also deserves to be stressed. Under its purview will come the provision of cultural amenities such as scenic beauty, sport, recreation, scientific study and nature conservation. Nature conservation which includes the preservation of wild life and the pristine indigenous flora has, therefore, an important place in the management of the forests of any country.'

Very recently, also, in 1969 the Planning Commission has observed:

'Preservation of wild life is ultimately connected with the preservation of its habitat. .. The task of preserving our rich flora and fauna is one of growing urgency and complexity. ... A certain number of steps, both legislative and administrative, remain to be taken.'

Different functions of conservation i.e. whether in the form of products or services or both, are therefore achieved in a sort of a package deal. A proper vegetational cover serves the purpose of wood production, soil and water conservation, climatic amelioration and protection to wild life, tourism and so on.

As pointed out above, we are now in a situation when natural resources are in a more degraded condition than in 1949. *Demands* on the products and services of forests have steeply risen and so also the *costs* of conservation programmes. Fruits of a normal agricultural programme can be harvested within a year or two of its execution, of a forestry programme within a couple of decades, but it takes part or more of a century for a nature-conservation programme in its broader sense to fructify.

In such circumstances as presently obtain in India, it is evident that a systematic formulation of nature-conservation programmes demands a very high level of skill and competence, particularly in the matter of providing *now* for requirements of future generations.

CRITERIA FOR APPRAISAL OF FUTURE DEMANDS AND SUPPLIES

This leads us directly to the question of estimation of future demands and supplies. At the level of our present understanding, they be classified under the following types of commodities and services:

I. Domestic demands

(a) *Production,* say of (i) wood for pulp, paper, construction, furniture, fuel, etc.; (ii) grass and fodder; (iii) other minor products viz. gums, tan-stuffs, drug-plants, etc.; (iv) horticultural products.

(b) *Regulation*—through conservation of soil and water in hilly areas for (i) prevention of soil erosion in the catchment areas; (ii) control of floods, etc.; (iii) maintenance of water supplies to rivers and reservoirs, etc.

(c) *Climatic amelioration,* e.g. provision of shade along roads, canals, railways, residential areas and industrial establishments, particularly in arid areas (of peninsular India).

(d) *Recreation*—parks, gardens, etc., containing plants and animals of aesthetic and recreational value.

(e) *Protective,* e.g. wind belts and shelter belts around habitations and agricultural lands.

(f) *Education and scientific research*—creation and preservation of sites for developing the academic interest of students of schools and universities in topics concerning flora and fauna.

(g) *Defence*—for camouflage and survival in vulnerable areas with the help of tree growth capable of providing the right type of shelter and food, etc.

(h) *Hygiene*—conversion of polluted atmosphere of congested urban areas into oxygen-rich air as a result of the photosynthetic processes of plants.

(i) *Reclamation*—of problem areas like marshes, deserts, and eroded areas, etc.

(j) *Wildlife*—for food, tourism.

II. International demand

On wood, minor forest products, wildlife, tourism.

Necessary estimates and forecasts made in respect of forest products only

Look at the threatening situation shown by a comparison between estimates of requirements and supplies of major forest products in India (as prepared by Government of India experts):

		1960	1965	1970	1975
		(all figures in million tons)			
Requirements	Industrial wood	6	8	12	17
	Fuel wood	100	110	121	130
	Total wood	106	118	133	147
Supplies	Industrial wood	6	7	10	14
	Fuel wood	100	98	95	97
	Total wood	106	105	105	111
Net Shortage		–	13	28	36

One can imagine how difficult it is going to be in the near future the job of conserving forests and other resources dependent on them.

Negative trade balance in India in respect of forest products and their derivatives

Only a few of the above demands can be fulfilled by imports, but not the rest. Among imported commodities can be mentioned pulp and pulp-products like paper, rayon, etc., gums, tannins, etc., all of which in aggregate exceeded Rs. 237 millions in 1965-66, as against exports which were less than Rs. 155 million in the same year.[3] All other items (b to j in the classification above), which constitute important services to the society, have a highly domestic and at times only a localized significance.

The need to maintain balance between functions in multiple use of land

It is well realised that a combination of the above functions involves the application of a fine sense of analytical judgement, because such combinations are capable of multiplying success or failure. In the former case, they economize on costs, but in the latter wastages may be entailed. The mountainous regions in northern India and in the Western Ghats offer examples where a minimum level of forest cover must be retained to keep soil in position. Wherever soils get exposed beyond their tolerance, severe unrestorable erosion has been an inescapable consequence. Thus irrational land management in the past has inflicted heavy penalties on the present generation, in the form of floods, land slides and soil erosion. Similarly, ports in the Arabian Sea and in the Bay of Bengal have been heavily silted. These are cases where productive functions were harnessed at the cost of regulatory and protective functions, by virtue of disproportionate blending between them.

Persistence of aridity following successive cycles of destruction of vegetation in Peninsular India

Within the peninsular region, successive cycles of destruction of vegetation on account of invasions and wars have exposed extensive tracts to intolerable desiccation and have brought about desert conditions over a large area. Today, these regions have become problem regions possessive of inbuilt dampeners on economic growth. Here again, the natural vegetation has not been allowed to play its role of multilateral performance.

3 Forest Statistics Bulletin No. 3 issued in 1967 by the Central Forestry Commission of the Government of India.

Need for establishment of sanctuaries for protection of threatened species of plants and animals

On the whole, the natural vegetation has been so very severely disturbed that a number of species of plants and animals are leading a threatened life and are heading towards extinction. Exploratory studies carried out by us in this regard (only plants) reveal that the proportion of such disappearing species is far higher than what is usually expected and that, on top of it, much scientific and economic information on not only the threatened plants but also on the so-called known plants has not yet been collected and put on record. The question of establishing records of all such plants cannot be neglected any more. In India, for example, there are a number of zoos and sanctuaries for the protection of wild animals, but for the immobile kingdom of plants there are hardly any sanctuaries. They are overdue and their formation must be undertaken in a systematic manner. For this, it is strongly suggested that the whole vegetation may be classified into constituent types and a suitable number of plant-sanctuaries be formed and maintained in a proper manner, so that the present fear about the disappearing plants and animals and difficulties experienced in conducting studies of them, will be removed.

Urgent need for economic studies on alternatives in land uses

In contradiction to the above-mentioned advantages of forestry, we must judge the benefits of the alternative uses of the land involved in a given situation. In some cases, feasibility of blending some kinds of uses may also be examined. Detailed cost-benefit analysis of the feasible alternatives like forestry, pasture, forestry-cum-pasture, hill agriculture, agriculture-cum-forestry, agriculture-cum-pasture,forestry-cum-tourism and so on, are called for as early as possible. It must be emphatically stated here that the aforesaid types of analysis would pose two most difficult theoretico-empirical problems: (a) how to quantify the benefits of the preservation of flora and fauna and of recreation; (b) how to quantify losses due to erosion and other retrogressive factors such as forest fires, etc. To undertake a critical examination of these considerations seems to be required without any further delay.

Appraisal of regional demands

Reverting to the main question of assessment of future demands, it must be said that along with the qualitative and quantitative assessment, the need for accent on regional requirements and localization cannot be overlooked. For example, conservation measures for regulation of floods may be concentrated in the north-eastern region of India, whereas plant-cum-animal sanctuaries will have to be distributed in a representative manner all over the country. Catchment areas of various water reservoir projects deserve special treatment for conservation of soil and water, as against extensive swamps and marshes like, say, mangroves, where plants aided by some engineering works may be required to perform reclamatory functions.

Past neglect in the management of non-arable lands

Following this broad account of future demands on conservation programmes, let us turn our attention to the matrix i.e. the type of land with which a conservationist is concerned. They are essentially non-arable lands which are distributed all over the country and the imprudent treatment of which has given rise to some of the prominent conservation problems presently before us. Arable lands, on the other hand, are being intensively looked after by the agricultural administration and the rural populace, as a part of the food production drive, and there is hardly any scope and need for the conservationist to probe and meddle with them except in cases of marginal nature. There can be no doubt that non-arable lands in this country have been neglected grossly and consistently, and the few efforts made towards their development have proved almost futile. Consequently the gap between supply and demand of their products and services has widened steadily. Apart from demands which could be met with through imports, the rest have remained unfulfilled or only partially fulfilled and can naturally be expected to do so in future if the problem is not examined in a fundamental manner and in a dynamic and progressive way. Our preliminary examination of the problem reveals that no significant progress can be made in the development of such natural resources unless the situation is subjected to a proper combination of reform measures.

Conservation reform will help to meet the requirements of society

By Conservation Reform we mean the combination of measures which are commonly termed land reforms, consideration of institutional factors and so on. For this purpose, non-arable lands must be treated as a whole and not in a piecemeal and individual manner as has been done hitherto. There are economic reasons for this. Production of wood, other forest products and forage on a small scale has proved an uneconomic proposition. On the other hand, large-scale production has proved impractical due to the complex pattern of ownership of non-arable lands, which can be traced to historical reasons (like legislation, administration and traditional use of lands). A careful examination of land-reform measures implemented in India within the last two decades will reveal that they have been oriented not towards land-use in a *wholesome* manner but only towards increasing food-production.

We have observed in our reconnaissance that there is vast scope for immediate attention to be paid to this aspect. As against 728, 800 sq. km of area presently covered by forests in India, there is an additional 560,900 sq. km of area which could be properly considered for forestry utilisation. This large area has been declared by the Government of India to be potentially productive under agriculture *or* forestry. As it comprises mainly uncultivable wastelands and permanent fallows, the possibilities of utilizing these large tracts of land for forestry and allied purposes are better than for agriculture. But for one reason or another, this important aspect of land utilization has remained far in the background.

Problem of attitudes in the economic justification of conservation programmes

Something must be stated here about the present attitudes of the people and hence the outlook of the Government. In the words of Sagreiya 'the attitude of the people at large to forest is one of indifference and to forestry one ranging between antagonism and tolerance.... Today, those who live in or near the forest as a rule dislike the restraints and regulations imposed by the forester as they cannot see any justification for this.... Those who live away from the forest are in any way not interested in them much less in forestry'.[4] This expression contains statements of facts which cannot be overlooked by conservation planners. Significantly enough the word justification in the above extract implies an economic justification. Perhaps, something similar applies to the outlook of the government in a democratic set-up (i.e. where representatives are elected by the people).

Identification of conflicts

Conservation programmes, whether based on 'Van-mahotsava' (the festival of trees), farm-forestry, wildlife sanctuaries, preservation of flora and fauna and species threatened with extinction or otherwise, have bleak chances of success if formulated without cognizance of the above fundamental handicaps. Costs of establishment of road-side avenues or of scientific management of range lands have therefore risen sky high. The need for taking a serious note of the multiple conflicts involved in the execution or implementation of a conservation programme, cannot be overemphasized, especially when in actual operation neglect or even underassessment of such conflicts is likely to result in colossal waste if not dismal failures. *Indiscriminate* cutting of trees or grazing of cattle has been found respectively to lead to considerable shortfalls in the necessary production of wood and fodder. Fires are seen to cause incalculable damage to the natural resources concerned. The practice of shifting cultivation and irrational exercise of rights and privileges are additional prominent features which must be mentioned. A thorough enquiry into all such institutional factors brooks no delay if it is decided to pay serious attention to the problems of conservation.

Referring specifically to India, one must expect that consideration of *immediate needs* is likely to receive priority over that of more *distant needs*, a practice which has often proved to be in signal contrast to fundamental concepts of conservation. An additional conflict between personal and *social* costs or benefits aggravates the problem.

[4] 'Forests and Forestry in India' by K. P.Sagreiya (1967). Published by National Book Trust, New Delhi.

CONCLUSION

In the Indian situation, where development of natural resources, which seem to have been depleted in many quarters, is required to be attained through organized efforts involving large outlays in the near future, questions like why to conserve and to conserve what, how much, how and for how long, are of basic importance. It is often experienced that in trying to preserve everything, all is lost. In the face of population pressure and growing demands, it seems essential to implement conservation reforms embodying land-reform in non-arable lands and cognizance of all the institutional factors which have a strong influence on the situation. Significantly, a large part of non-arable land is already in charge of an elaborately organized forestry organization of long standing and experience. Neglect or mismanagement of the residual non-arable lands, which happen to be intricately linked with forest land, seems to be responsible for nullifying the good effects of present conservation programmes.

It is mainly due to the lop-sided concentration of our national activities on the acute problems of agricultural and industrial development that conservation needs which are even more basic in significance have remained grossly neglected. Now is the most opportune time to move towards meeting conservation demands through the necessary reform measures. Urgent concrete steps to follow up the declarations of 1949, 1967 and 1969 (as quoted at the beginning of this paper) are long awaited. The initiation of evenly distributed and soundly framed pilot projects, based on results of research, seems to be the most powerful means of making a beginning with progress towards the desired goal.

SUMMARY

Since 1949 a number of official pronouncements have been made on conservation and land use in India, with special reference to the role and proper management of forest land and of wild life resources and to the importance of maintaining habitat and vegetational cover.

A classification of the supply and demand situation relative to the various values of the countryside, and of forest land in particular, is presented and the conclusion is drawn that there is at present a serious imbalance, which is being accentuated by continuing disturbance or misuse of natural vegetation. In comparison with arable land, non-arable areas have been neglected. Although there are 728, 000 sq. km in this category under management as forest, a further 560, 000 sq. km, which could be better developed for forestry and allied purposes than for agriculture, have received little attention, due to lack of popular and governmental interest in areas not oriented towards food production or industry.

It is suggested that progress in the conservation and development of this complex of non-arable land is dependent on a wholly new approach, a 'conservation reform' which would combine comprehensive planning and essential land reform with a much greater research effort and understanding of existing areas of conflict and of the institutional factors responsible for the lack of success so far. This could lead to the establishment of a network of soundly based pilot projects as a first step in the concrete implementation of the declarations of policy quoted at the beginning of the paper.

RÉSUMÉ

Depuis 1949, un certain nombre de déclarations officielles ont porté sur la conservation et l'utilisation de la terre en Inde, et en particulier sur le rôle des terres afforestées et de la vie sauvage et leur gestion rationnelle ainsi que sur l'importance de la conservation de l'habitat et du couvert végétal.

L'auteur donne une liste des productions et des besoins relatifs aux divers éléments des zones rurales et des terres afforestées en particulier. Il en conclue qu'il y a actuellement un sérieux déséquilibre accentué par la perturbation continue de la végétation naturelle ou par une mauvaise utilisation de celle-ci. Les terres non-arables ont été négligées en faveur des terres arables. Bien que dans cette catégorie de terres non-arables 728. 000 km^2 soient exploités en forêts, il reste encore 560. 000 km^2 qui conviendraient mieux à la sylviculture et à des activités connexes qu'à l'agriculture, et dont

le gouvernement s'est peu occupé du fait que ces terres n'étaient orientées ni vers la production agricole ni vers l'industrie.

Il ne peut y avoir de progrès dans le cadre de la conservation et du développement de ce complexe de terres que si on adopte une attitude tout à fait nouvelle, une 'réforme orientée vers la conservation' qui allierait une planification d'ensemble et une réforme agraire profonde à un effort beaucoup plus poussé dans le domaine de la recherche et dans l'analyse des points de conflit et des facteurs institutionnels responsables jusqui'ici de l'échec des projets. Ceci pourrait susciter la création d'un système de projets-pilotes solidement assis, qui constitueraient la première étape d'une application concrète des déclarations gouvernementales mentionnées au début de l'article.

SECTION A (i): POINTS MADE IN DISCUSSION

Reference Dr Poore's suggestion that human civilisation is based on the creation and control of ecological imbalances, the difficulty is that much of the imbalance has not been controlled so that, due to unchecked feed-back from man's activities, ill-effects tend to persist. Despite apparent economic advantages from the system of imbalances, much more effort should therefore be made to re-establish equilibrium (Leyhausen, Germany).

What this means is that in the long run the economic value of conservation lies in the fact that man's own survival depends on it and it is this which has constantly to be emphasized (Southwick, U.S.A.).

The problem is that while a quantitative valuation of some aspects of conservation may be available, there is still no recognized way of assessing other values, and great scope and need for further research into this (R. C. Soni, India).

On the point of leaving the options open for future generations and assuming these options will essentially involve value judgements in the administrative and political processes of conservation, the present generation must of necessity make value decisions, some of which may involve transcendental or intangible elements, such as the valuation of wildlife, environmental quality and ecological principles, for and on behalf of future generations. It also has to be assumed that future generations will 'buy' or endorse these types of values (Henning, U.S.A.).

It is essential to distinguish between total equilibrium and local equilibrium. Control of the former is beyond our reach, so that any policy which might disturb it is most dangerous and to be avoided. But we cannot operate without generating local imbalances, so that the task is to work out in advance how to control them: it may be a question of subjective choice of what seems to be the wisest long-term view, based on the best public opinion available, since exact cost benefit analysis of economic and ethical values is often not yet possible (Poore, U.K.).

Reference Mr Chandras's criteria for appraising the future need and supply of resources, he referred under the heading of 'Reclamation' to problem areas of marshes, deserts and eroded areas. It is important to distinguish the first two of these, since they may in fact support fauna and flora resources of great scientific and even economic interest: hence the IUCN/IWRB 'Project MAR' for the conservation of wetlands because of the high value of the wildfowl and other wildlife populations which depend on them (Mörzer Bruyns, Netherlands).

Basic Elements of Soil Conservation in Mountains

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Soil, forest, vegetation, water and other natural resources of mountain regions are abundant, many-sided and very diverse, but not boundless. In keeping with the laws of nature these riches will continue to serve mankind as a source of welfare, only so long as man, taking proper account of the composite and complex mutual relationship of nature and human society, uses them wisely and rationally and refrains from violating the natural laws of these regions by exploitation which exceeds the capacity of their resources to sustain and restore themselves. The unity of nature and mankind, the complex relationships and interdependence between various components of nature, demand from man such measures and forms of utilization as will ensure that nature becomes richer and not poorer.

In the present widespread development of industry, national economy, science and technology, this consideration of the interrelationship between nature and man gives grounds for serious alarm in regard to the practical use of forests, soils, water and other resources of mountain regions in the USSR and other countries of the world. Forest resources in the Crimea, the Carpathians, the Caucasus, Armenia, Georgia, Azerbaijan, the Urals, Siberia and the Far East, as well as in the Middle Asian Republics, France, Italy, Spain, the Balkans, India Afghanistan, Africa and many other countries of the world, are being used in ways that are far from rational, often haphazardly and in some cases without taking any account of the biological peculiarities of forests and without observing the natural laws of mountain regions or the conditions for natural regeneration of the forests.

In areas near to lines of communication and industrial centres, felling of forests is frequently excessive and has resulted in specially great diminution of conifer woods (cedar, pine and mixed pine-spruce associations). Belts of forest protecting water supplies are damaged by clearing right down to river banks and sea shores. Forest destruction on slopes exceeding 30-35° makes future reafforestation particularly difficult. In general, the annual cutting down of forests greatly exceeds forest planting: figures for a 5 year period all over the world show that 25 million hectares of forest were felled but only 2. 65 million hectares were planted.

On mountain slopes it is often the forest of greatest importance from the point of view of soil and water holding capacity, that is felled. Excessive or unskilled felling, combined with grazing of cattle in forests, may soon result in a situation where the self-restoring capacity of forests, their natural regeneration, can no longer operate and an undesired change takes place in the types of trees: the more valuable species disappear (pine, fir, pine-spruce associations and beech) and their place is taken by less valuable species (aspen, hornbeam, birch); in some cases also waterlogging of soils may be observed (the soils become boggy).

It has been established in the Armenian SSR that if the forest cover is thinned by 40-50%, its soil and water protective ability may well be lost. Our observations showed that in heavy rain, water can pass through such thinned forest with the same ease as through unforested areas, especially when the green cover of pastures above the forest has been destroyed by overgrazing by cattle and by cattle tracks. Transportation of timber by tractors and the bull-dozing of tree-trunks also contribute to destruction of young growth, inhibiting regeneration and heavily damaging soil cover. Further serious damage is caused when grassland inside forest areas is grazed or cut for hay, since with the grass the tree seedlings are bound to be eaten or removed and regeneration prevented.

When, as a result of these factors, the forest area has been greatly reduced, severe changes take place in the landscape, the water regime of the environment sharply deteriorates, the normal pattern of run-off is disrupted and a very dangerous phenomenon begins—erosion of the mountain slopes and destruction of soil fertility. It is due to the

great decrease of forests and their replacement by arable lands, the ploughing up and destroying of natural vegetation, burning of steppes, savannah and prairies, not to mention the uncontrolled tillage of mountain soils, absence of crop-rotation and other bad farming practices, that in the Carpathians, Crimea, Caucasus, Daghestan, Moldavia, Armenia, Georgia, Azerbaijan, Uzbekistan, Kazakhstan, Tadjikstan, the Far East and other mountain regions of the USSR, and also in most mountain regions of all the Continents in the world, hundreds of millions of hectares have undergone erosion. This is the greatest natural disaster, doing enormous damage to the national economy of mountain regions. Resulting directly from the uncontrolled activities of man, the process of erosion has caused us to lose that most valuable gift of nature, the soil, for which there is no substitute as a basis for the production of food, of raw materials for manufacture and of all the other fundamentals of human well-being.

Under the influence of rain and melting snow, the arable soil horizons are destroyed, and much more of the organic matter and nutrient materials are removed from the soil than can ever be easily reintroduced by artificial fertilizers.

Through erosion, the physical properties of soils are spoiled, they lose their water absorbing and holding capacity and drought grows. The fluids flowing from the mountain slopes carry down to the valleys great quantities of the solid materials which are essential for the production of bread, sugar, cotton, grapes, meat and wool, butter and potatoes, and make the slopes unfit for cultivation.

This is not the end of it. As a result of soil erosion and the changes in the water regime, gullies and ravines begin to form and the unimpeded water, pouring from the bare mountain slopes, gathers enormous strength and, carrying mud and stones, rushes down in flood, widening the gullies on the way, to damage or destroy hydro-electric installations, railways and highways, or to engulf fruit gardens and cultivation. Many reservoirs are filled with silt, water supplies with impurities, fish disappear, rivers overflow, landslides occur and ultimately the climate itself may change, become drier and in turn give rise to wind erosion; in short, the whole physical and biological balance may be irreversibly upset.

The amount of solid matter removed by water from mountain soils must run into hundreds of millions of tons. They contain great amount of organic matter, N, P_2O5, K_2O. It is important to note that as steepness of slope increases, so does the loss of solid matter. For instance, in one case studied, 37 m^3 of soil was carried from a 4°-6° slope, 52 m^3 from a 6°-8°, 75 m^3 from a 8°-10° and more than 100 m^3 from a 10°-12° slope. Even where the relief is uniform, the danger of erosion varies according to soil type and structure. For example, from black soil 8 tons of soluble material, from grey forest soil 14 tons and from podsolic soil 20 tons may be carried away, under identical conditions. Observations have confirmed the great amount of fertile soil and nutrients carried away in many of the great river basins and, for example, have shown losses of 2-3 tons per second in an area studied in the Carpathians and 4-5 tons per second in a similar area in the North Caucasus. It has been calculated that from the mountains of Armenia during the last few years up to 12 million tons of soil have been lost annually. Such a mass contains about 600 tons organic matter, including 48 tons of N, 26 tons of P_2O5 and 180 tons of K_2O. As a result of erosion, the USSR annually loses about 535 million tons of soil, containing about 1 million tons N, 0. 6 million tons P_2O5, 8 million tons K_2O and more than 12 million tons of organic matter altogether.

In the USA annually the loss amounts to about 3 billion tons, containing 43 million tons of N, P_2O5 and K_2O, 60 times more than the annual input of artificial fertilizers. The Mississippi river alone, as a result of erosion from the Rocky mountains, carries away some 200-300 million tons of soil, containing 62, 000 tons of P_2O5 and 1. 6 million tons of K_2O. The Amazon and Parana rivers carry away similar quantities from the slopes of the Andes and Brazilian plateau. No doubt, in India too, the Ganges from the Himalaya, the Bramaputra from Tibet, and the rivers flowing from the Deccan plateau, all annually remove tens of millions of tons of fertile soils. The Ganges alone is recorded as carrying 36-40 tons per hour. Many similar figures could be quoted for other great rivers in all parts of the world.

Reverting to damage caused by floods laden with mud and stones, an example occurred in 1948 in the Alushtian region of the Crimea, where, as a result of such floods, the Black

Sea coastline was extended by about 40 metres out into the sea. In the process, a large area of vineyards was covered with deposits of silt and sand.

Again in 1958 floods in the Crimea did much damage to soil and hydro-electric installations: large areas were also made unusable in the upper reaches of the Tisa and Dnestr rivers. Floods often occur in Daghestan, in the basin of Sulak, where considerable areas of arable lands have been covered by deposits of mud and stone, while at Alma Ata in Kazakhstan and Erevan in Armenia there have been several equally serious inundations. Formerly, these often brought rail traffic to a halt along the shores of the Black Sea and the railways of Transcaucasus still annually suffer immense damage from erosion and floods. In the Far East, a small river, the Suputinka, becomes a formidable raging torrent after heavy rain, capable of washing out and carrying away huge trees. As an illustration of the loss of national economy from accelerated erosion caused by floods, the Mississippi floods of 1927 are estimated to have done $300 million worth of damage, and the recent tragic flooding in Florence in Italy may be mentioned as well as the great floods in China, which have sometimes affected 16 provinces and many millions of people.

As an example of silting effects from erosion may be cited the Ak-Su reservoir in Daghestan, which was rendered useless in three years, although the dam was 13 m high. Again the Shterov reservoir in the Ukraine became 85% silted in 5 years and, in the same period, the Uad-Foda reservoir in Algeria accumulated 3 million tons of silt. Side effects of silting include obstruction to navigation, putting hydro-electric installations out of action and making irrigation more expensive.

Even where slopes are more gentle and erosion comparatively less obvious, the soils may become less fertile and crop-yields sharply decrease. This can be seen when erosion affects mountain meadows or alpine pastures, as has happened in the main cattle-breeding alpine areas of the USSR, where pastures have deteriorated both in productivity and in feed value. In many similar mountain regions of Europe and Asia overgrazing and the heavy erosion resulting from cattle tracks which have cut through the turf, have had very adverse effects on meadow soils, changing the nature of the vegetation, reducing productivity and even leading to desiccation.

According to our investigations in the mountainous conditions of Armenia, other factors contributing to the velocity and degree of soil erosion and of destruction of soil fertility are type of soil and parent rock, downhill as opposed to contour ploughing or cultivation, the actual steepness, extent, exposure and surface structure of slopes, quantity and intensity of rainfall, the melting of snow and so on.

Next, mention should be made of effects on mountain soils of industrial activities, such as the mining of building materials, coal and ores, and also the various kinds of construction work, which so easily turn beautiful mountain landscapes into scenes of scars, excavations and spoil-heaps. Thus in many cases, roadbuilding, power line construction and other improvements and developments have been allowed to destroy vegetative cover and contribute to erosion and the decline of soil fertility. In this connection, we are now faced with a new problem in the rehabilitation of land which has been spoilt or destroyed by industry.

Finally, the decrease of mountain forests, ploughing of pasture and grasslands and deterioration of the water regime all bring about profound changes in environment for the wild fauna. This leads in turn to lower production of game and fewer of the birds which are the friends of man by controlling pests in forest, garden and field.

As the situation I have described in this paper is common and widespread in all mountain areas, all countries and peoples of the world must give serious thought to what to do. In the Soviet republics during the decade 1952-1962, all the governments promulgated special laws on nature conservation and the rational use of soil, forest, water and other natural resources. In keeping with these laws and other decisions of the governments, our scientific institutions and experimental stations have extended their research and organized scientific conferences, while in all the republics nature conservation societies and similar scientific organizations have been established.

In 1968, for example, at Erevan in the Armenian SSR, one such conference, devoted to the problems of conservation of the nature of mountain regions of the USSR, was organized. It began by considering the control of mountain soil erosion and protection of soil fertility, and the problem of bringing about a fundamental change in the farming of mountain

slopes in the direction of cattle-breeding and meat, milk, wool, hides and skins production, together with bee-keeping, hunting and fruit growing. The conference then went on to call for the organization of a unified service to coordinate and govern all nature conservation activities such as the establishment of scientific institutions and laboratories, enlargement of reserves, and teaching of principles of nature conservation in schools and universities.

Our scientific institutions worked out and suggested to the farmers a wide range of measures to control soil erosion and promote rational utilization of mountain soil resources, including: planting of forest belts, afforestation of slopes, stabilising the sides of ravines, gullies and river-banks with trees and shrubs, more rational exploitation of forests (with a more careful felling policy), sowing of annual grasses on slopes, crop rotation, contour tillage, strip cropping, terracing and banking of slopes, deep cultivation and furrowing, fire-breaks, various kinds of fallow, pasture improvement and rotation, application of fertilizers, snow-gathering and control of snow-melting, control of run-off by levelling, construction of proper cattle tracks, construction of stone walls, wood dams, stone overfalls, aqueducts, straightening of river-beds and other hydrological installations. In short the aim has been to develop the rational organization of land use and the selection of the appropriate anti-erosion measures for the various soil conditions, in keeping with local natural and economic factors.

The application of the above-mentioned measures in several mountain republics and regions of the USSR have shown that they can in practice achieve success in the control of soil erosion, safeguarding of soil fertility and the conservation of forests, vegetation, water resources, wildlife and beautiful landscapes of mountain regions. It seems that they could do so equally well in the mountain regions of other countries in the world, taking of course due account of their pecularities and national economics. The fight against the same terrible and gradually increasing scourge of soil erosion affecting the economy of mountain regions demands the greatest attention.

In this situation, it is the suggestion of the Soviet delegation to this XIth Technical Meeting that, for the purpose of coordinating activities, exchange of information on scientific and practical achievements and cooperative efforts in the fight against destruction of the mountain landscapes (soils, forests, water resources, fauna and so on), a special committee on the protection of the mountain regions of the world should be set up within the Ecology Commission of IUCN. It is believed that this could make a very important contribution to active protection of mountain soils and soil fertility in the interests of all countries and peoples and the welfare of all mankind.

SUMMARY

Due to the sharp decrease of forests, ploughing up of natural vegetation and haphazard cultivation of mountain soils in the USSR and other countries of all the Continents, wide areas, totalling hundreds of millions of hectares, have undergone erosion. Flood waters flowing swiftly from mountains as a result of erosion have caused enormous damage to national economies, including the silting up of rivers and reservoirs. Mountain soils have annually lost great amounts of solid matter, containing N, P_2O5, K_2O and many organic constituents. In montane conditions, the velocity and degree of soil erosion and of destruction of soil fertility depend on the type of soils and parent rock, the steepness and extent of relief, the exposure and surface pattern of slopes, quantity of rainfall and so on.

Following upon decisions of the Soviet Government, scientific Institutions in the USSR have worked out and suggested a wide range of measures to control soil erosion and promote rational utilization of the mountain soils including: afforestation of slopes, stabilising of ravines, sowing of annual grasses, crop rotation, contour cultivation, strip cropping, deep furrowing and terracing. It is believed that such measures for conservation of mountain soils are equally applicable to mountain regions of other countries in the world.

For the purpose of coordinating activities and the international effort to prevent destruction of mountain soils and other resources, it is suggested that a special committee on protection of the mountain regions of the world should be set up within the framework of the IUCN Commission on Ecology.

RÉSUMÉ

Sous l'effet de la forte diminution des forêts, de l'arrachage de la végétation naturelle et de la mise en culture irrationnelle des sols de montagne en URSS et dans d'autres pays, de vastes espaces couvrant des centaines de milliers d'hectares ont été soumis à l'érosion. Les cours d'eau en crues descendant en torrents des montagnes par suite de l'érosion ont causé de lourds dommages, dont l'envasement des rivières et des réservoirs, aux économies nationales. Les sols de montagne ont perdu chaque année d'importantes quantités de matériaux contenant du N, P_2O_5, K_2O et plusieurs éléments organiques. En montagne, la rapidité et le taux d'érosion du sol dépendent du type du sol et de la roche-mère, de l'inclinaison et de l'importance du relief, de l'exposition et de la structure superficielle des pentes, de la pluviosité, etc.

A la suite de décisions prises par le gouvernement soviétique, des établissements scientifiques d'URSS ont élaboré et suggéré toute une série de mesures afin de lutter contre l'érosion du sol et de promouvoir une utilisation rationnelle des sols de montagne; parmi ces mesures, on peut citer: afforestation des pentes, stabilisation du ravinement, semis de graminées annuelles, assolement, labour des contours, cultures en rubans, sous-solage et terrassements. On pense que ces mesures de protection des sols de montagne sont également valables pour les zones montagneuses dans d'autres pays du globe.

Dans le but de coordonner sur le plan international les activités et les efforts visant à empêcher la destruction des sols de montagne et d'autres ressources, il est suggéré de créer un comité spécial pour la protection des régions montagneuses dans le monde, dans le cadre de la Commission d'Ecologie de l'UICN.

Section A (ii)

Basic Elements of Conservation of Mountain Forests

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Mountain forests all over the world are a main source of wood for timber and fuel, but at the same time have an extremely important function in water control and protection. Mountain ecosystems usually comprise three natural zones: the forest zone occupying the lower, middle and upper parts of the mountain flanks; the high-level zone with its alpine vegetation; and the highest zone, known as the niveal, with its glaciers. The role of these three principal zones in the formation of climate, as well as of the water regime of mountain countries, is rather different. The niveal and alpine zones are characterized by the harsh influence they exert on the countries' climate. It is in these zones that cold air masses are formed and flow downwards; but when they mix with the warm air under the forest canopy, they themselves become warm and lose their harsher properties. Similarly, the winds arising in the alpine zone are modified as they reach the forest zone, while avalanches, which may occur both in the cold and warm seasons in the niveal and alpine zones, are very often shattered when they arrive at the forest zone. Indeed avalanches can be blocked not only by trees, but also by shrubs such as rhododendron.

From ancient times in the Pyrenees, in Switzerland and in Tyrol, a ban was put by folk custom upon the felling of forests which gave protection from avalanches. In the Pyrenees such forests were called 'bedates', and in the Alps 'Bannvealder' (E.Reclue, 1872). Thus of all the natural zones characteristic of mountain systems, the forest zone with its plant cover plays the greatest protective role in relation to climate. Its plants also have an equally important significance for the hydrology of mountain countries. The rivers of these countries are mainly dependent on water from precipitation, though in alpine zones glacial supplies make a contribution through the melting of ice and snow. However, because of the relatively small area of glaciers and the fact that they melt only during warm months (June-August), their role in feeding rivers is not specially important. For their main sources of supply, mountain rivers must, therefore, depend on precipitation in the alpine and forest zones, whether this is distributed by useful subsoil flow or by more harmful surface run-off.

In relation to water flow the significance of the two zones, alpine and forest, is quite different. The alpine zone is characterized by mountain meadow soils with a fine-grained structure and low index of non-capillary porosity, which make for low permeability. Moreover, in winter these soils usually freeze and this further impedes the penetration of melted snow water in spring. These peculiarities of the alpine zone's meadow soils are the main reason for their low water-control potential.

It should therefore be stressed that clear-felling of forest cover near the border with the alpine zone leads both to disturbance of their protective functions in relation to climate and avalanches and to the loss of their water-regulating function. Five or ten years after deforestation, forest soils in these areas near the alpine zone, lose their nutty structure and acquire a fine-grained structure under the influence of secondary alpine plant cover; at the same time their physical properties deteriorate, non-capillary porosity sharply decreases and in winter the soils freeze in the same way as soils under primary alpine plant cover, and lose their permeability.

It is for the above reason that conservation of forests near the boundary of the alpine zone in mountains is so important and indeed essential if they are to keep their functions both of water-regulation and of acting as a barrier against the flow of cold air and winds. Apart from this, the role of the forest zone in the hydrology of mountain countries is extremely great, for the following reasons. First, mountain forest soils, and especially the brown soils peculiar to moderate altitudes (in the Alps, Pyrenees, Carpathians, the Crimea, the Caucasus and the Urals, for example) are characterized by well-pronounced

nutty structure and good indices of physical properties and water permeability. The data for forest brown soils of the Caucasus can serve as an example:

Soil depth	Porosity of soil, per cent			Water permeability, the height of water column, penetrating in 1 min., in centimetres
	Total	Capillary	Non-capillary	
0-10	65.6	51.6	14.0	0.4
40-50	48.5	42.2	6.3	0.15

High non-capillary porosity, equal to 14% in the upper water-receiving horizon of soil, provides high water permeability, 0. 4 cm per minute.

Another reason for the water-regulating function of mountain forests is that the soil under trees does not freeze, so that in spring melted snow-water easily penetrates. Furthermore, the duration of snow-melting under the forest canopy tends to be much greater than in an area without forest: recent studies in Georgia have shown that although in mountains the snow under the forest canopy begins to melt earlier than in unforested areas, the actual duration of melting is consistently longer. This lengthy and gradual melting of snow in forests favours soakage of melted snow water deep into the soil.

The third reason why mountain forests help to maintain the water regime is that, as established by Landermilk, the ground litter is able to act as a filter, allowing the rain and snow water to pass through and thus facilitating soakage deep into the soil. It is this water which feeds and maintains the permanent flow of springs, which in turn maintain the dry season level of mountain rivers, without which irrigation and hydro-electric installations could not continue to operate. From the above considerations it is clear that the safeguarding of the protective functions of mountain forests in relation to climate and the water regime is rather important for the economy of the countries concerned, but it is only possible when the forests are properly maintained and used. What is it that destroys the useful functions of mountain forests? Studies carried out by Engler (Switzerland), Hirota (Japan), Dubakh (USSR) and others, have proved that loss of the water-regulatory properties of forests follows clearing. The work of Burger, Nemich and Kvapil, Gulisashvili and Stratonovich has further shown that the principal reason for this phenomenon is the deterioration of the soil's physical properties, especially the decrease of non-capillary porosity, after clear-felling. This decrease of non-capillary porosity adversely affects the water permeability of forest soil by a factor of 4-5. In addition, deterioration is accentuated by the disappearance of ground litter after clearing, which results in water running off without being filtered and the particles suspended in the turbid flow blocking the pores in the soil, and causing a further great decrease in permeability.

Again, after clear-felling the soil is more liable to freeze, which hampers permeability, while the faster melting of snow cover on bare slopes means that less water sinks in and there is more run off. As the latter increases, various harmful effects are bound to follow, such as soil erosion, creation of ravines, silt, and the drying up of springs and lowering of the dry season level of rivers.

All this makes it obvious that clear-felling should not be permitted in mountain forests. But unfortunately, it has also to be recognized that water-controlling functions are destroyed by selective deforestation, if they are too intensive. Studies of water flow, physical properties of soils and permeability in areas where selective deforestation has been carried out with various degrees of intensity, and studies over long periods of river levels in river basins in which the forest has been cut out with various degrees of intensity, have shown that for the forest to retain its water controlling capacity, the stand density of tree cover must not be reduced by more than 50 per cent. If clearing exceeds this figure the deterioration in the soil's physical properties and permeability is very nearly equal to what takes place after clear-felling. For example, in the beech forests of the Main Caucasian range, after too intensive selective felling, the water permeability of soil deteriorated 4-5 times, the flow of springs decreased and the regime of the rivers changed greatly—higher river levels in spring and much lower levels in summer and

winter. In short, too intensive selective felling caused just the same adverse consequences as clear felling. The conclusion to be drawn is that intensive selective deforestation which results in a stand density lower than 0. 5, should be prohibited just as much as total clearing.

The better is the soil, the more marked is the deterioration in soil conditions and the loss of water-regulating functions. Black ash structureless soils change but slightly after clear-felling or intensive selective felling, although the disappearance of ground litter, freezing of soil and fast melting of snow have some effect on water-regulating functions. But a much more marked deterioration after total or partial clearing is to be observed in the brown forest soils with a good nutty structure.

Apart from clearing and cropping or selective clearing, mention should be made of the loss of water-regulating capacity which follows when trees and ground litter are destroyed by fire or, again, through uncontrolled intensive grazing by cattle, which destroys the soil structure and decreases non-capillary porosity. The water-regulating function of mountain forests can also deteriorate through temporary agricultural use, especially in the 6th-7th year after cultivation has been abandoned.

What kind of economy then should be applied in mountain forest areas, to ensure the best development of the protective and water-regulating capacity of the forest? Clearly, proper land use is a rather important aspect of the problem. Unfortunately, as we know, primary cultivation of such areas usually involves excessive clearing. Such improper cultivation of mountain forest land has taken place in many countries. As Bernard has remarked, all transitions from primary mountain forest to a regime of economic exploitation have hitherto led merely to the destruction of the forests! It is quite essential that when forest areas are opened for exploitation, the stand density be maintained at not less than 70% of the original density. Only if this rule is observed, will the water-controlling and protective functions of mountain forest areas be retained. Another important point is that a proper system of clearing is followed, which has a reasonable prospect of allowing these useful functions to be maintained or even improved. As already mentioned, all the studies undertaken point to the abandonment of total clearing and of too intensive selective felling and suggest that only gradual group-selective and selective cutting will preserve the beneficial functions of these areas.

The problem has been studied at the Tbilisi Forest Institute in the spruce and spruce/fir stands of the Trialeti Range of the Minor Caucasus. Observations on the liability of the soil to freeze, the accumulation and melting of snow, the physical properties of soil and its permeability, and the extent to which precipitation is distributed between run-off and subsurface flow, were carried out in areas subjected to gradual group-selective and selective clearing, with the following results: the most favourable conditions for subsoil flow are created in stands in which felling is strictly selective and in keeping with the principle of restricting the yield to the amount of annual increase. This ensures against soil freezing, and promotes gradual melting of snow, permanence of ground litter to act as a filter, favourable indices of the physical properties and permeability of the soil, minimum run-off and increased subsurface flow.

To achieve these results, felling is restricted to selected groups in spruce, spruce/fir and beech stands over areas of not more than 15-20 m in diameter. Where the diameter of clearings is increased to 25-30 m, some deterioration takes place, though this deterioration only lasts until the clearings are closed by regrowth. A few years after the clearings are covered by this regeneration, the water-regulating capacity of the forest is fully restored. On this system, clearing is limited to between a quarter and a third of the area and the rest remains under closed forest, and it seems that it may be recognized as the system most appropriate and applicable for forests which have a water-holding and protective significance.

Slighty different results were obtained when the same problem was studied in forest areas subjected to progressive coupes. Deterioration of the water-regulating capacity of the cropped areas was observed as each was opened up, but not to the same degree as in totally cleared areas. This deterioration is especially pronounced in the case of felling on slopes with poor soils, where the regrowth is characterized by low intensity; even with the use of the method of gradual clearing over a regeneration period of about 10-15 years, the regrowth height by the end of this period does not exceed about 1 to 1. 5

metres, the regrowth itself is often quite thin, does not make a closed canopy and poorly performs its water-holding and protective functions.

Taking into account the results obtained under these different cropping systems, there seems to be no doubt that the selective and group-selective methods should be recognized as the most beneficial, while progressive felling systems should be considered as the least desirable. This accounts for the fact that in a number of republics, such as Georgia, first-grade forests, namely the forests of water-holding and protective importance, progressive felling of beech, spruce and fir stocks, the regrowth of which is initially very slow, has been replaced by selective and group-selective felling. Where special conditions apply or in the case of species such as oak, pine and larch, which grow faster and are more enduring, there has been no change.

In recent literature, there is much discussion of the best methods of exploiting forest which has water-holding and protective functions. The attempt to define the optimum age for felling such forest on the basis of technical or quantitative exploitability is not altogether rational. Of course, these points should be considered when deciding on the best age for felling, but if we keep in mind that the principal function of these forests is water-regulation and protection, it appears obviously necessary to define the age at which the stands of various species perform these functions most efficiently and beyond which the performance of these functions deteriorates. This question was studied by long-term observations on the experimental plots in the Trialeti range spruce and fir forests. The plots were sited in stands of trees of various ages, including those which had reached a medium state of maturity and were capable of exploitation, and the observations covered all factors relating to water balance, precipitation, evaporation, run off and subsurface flow, as well as water loss through transpiration.

The result of the five-year study was to establish that the older the stand, the better is its water-holding and protective capacity. However, these functions are performed most effectively by stands of trees of mixed ages. So it seems that it is not the age of a stand that is important, but the over-all age structure, so that forest with trees of varying ages perform the water-regulating and protective function better than stands of a uniform age. This once more proves the necessity for 2 system of selective felling in mountain forests, which will create a stock of trees of various age groups. There is no doubt, therefore, that the best way to conserve mountain forests and to make use of their favourable functions is through suitable and proper management and utilization of the natural resources they provide.

SUMMARY

Of the three natural zones in mountains, forest, alpine and niveal, the forest zone has many useful functions from the point of view of man, including the power to modify or give shelter from cold air masses or winds descending from the two higher zones and to break up and block avalanches. But its most important function is to protect and control the water regime.

Rivers depend for existence mainly on rainfall, whether received directly from run-off or by subsoil flow; the flow from glaciers and snowfields is comparatively unimportant, as it lasts for only a few warm months of the year. Soils of the alpine zone tend to be fine-grained and impermeable so this gives special significance to the upper margin of the forest zone which, due to the structure of the soil, the gradual melting of snow and the fact that the ground is less prone to freeze under tree cover, and to the filtering action of the ground litter, is able to absorb the run off from the alpine zone as well as local precipitation and snow-melt.

If the forest is clear felled or allowed to be seriously damaged by fire, grazing or cultivation, the special properties of forest soils and tree cover are lost and the water-retaining and regulating capacity disappears. The result is a diminution of springs which feed the rivers, greater fluctuation in river levels and silting from turbid run-off. Selective felling of forest, if too intense, can also produce similar results. Experiments have shown that, if the beneficial properties of mountain forest are to be retained, the density of the tree cover must not be reduced by more than 50%, preferably only by 30%, and that a system of group-selective felling, extraction of patches not exceeding 15-30 m in dia-

meter, is preferable to progressive felling, since it ensures that the regenerated forest will consist of trees of varying ages, which is more efficient from the water-regulation point of view than stands of uniform age.

RÉSUMÉ

Des trois zones naturelles des montagnes, les zones forestière, alpine et nivéale, la première joue pour l'homme un rôle important, ayant entre autres le pouvoir de modifier ou d'arrêter les masses d'air froid ou les vents qui viennent des étages supérieurs ainsi que de morceler et de bloquer les avalanches. Mais le rôle le plus important de cet étage consiste à règler le régime des eaux.

L'existence des rivières dépend essentiellement de la pluie qu'elles reçoivent, soit directement par ruissellement soit par résurgence des eaux souterraines; la fonte des glaciers et des névés ne contribue que peu à alimenter les rivières, étant donné qu'elle ne dure que pendant les quelques mois chauds de l'année. Les sols de l'étage alpin ont une structure granulométrique plutôt fine et sont imperméables; ceci confère une importance particulière à la zone supérieure de l'étage forestier qui, du fait de la structure de sol, de la fonte progressive des neiges, de l'action filtrante de la litière du sol et du fait que le sol a moins tendance à geler sous le couvert de la forêt, est à même d'absorber le ruissellement des eaux de l'étage alpin ainsi que les précipitations locales et les eaux de la fonte des neiges.

Quand la forêt est coupée à blanc ou très détériorée par le feu, le pâturage ou la mise en culture, les caractéristiques propres aux sols de forêts et au couvert végétal sont supprimées et le pouvoir de régulation et de rétention d'eau disparaît. Il en résulte une diminution des sources qui alimentent les rivières, des variations plus importantes du niveau des cours d'eau et un envasement progressif dû aux matières en suspension dans les eaux de ruissellement. Des coupes sélectives trop radicales peuvent également produire les mêmes résultats. Des expériences ont montré que pour conserver le caractère utile des forêts de montagne, il convient de ne pas réduire de plus de 50%—et de préférence de 30% seulement—la densité du couvert des arbres; de même, il est préférable d'adopter un système d'abattage de groupes d'arbres par taches n'excédant pas 15-30 mètres de diamètre plutôt que des coupes progressives, car ceci permet d'obtenir un peuplement forestier régénéré d'âge varié, ce qui du point de vue de la régulation des eaux est plus efficace que des peuplements d'âge uniforme.

Section A (ii)

Introducing his paper on *'Some Recent Studies of Ecological Effects of Montane Water Storage in the United Kingdom*', Dr J. Berry said:-

'My Paper deals with some recent studies on ecological effects of water storage in the United Kingdom and particularly in the Scottish Highlands. In this vast sub-continent of India, with the highest mountains in the world and with some of the greatest rivers, it may seem ridiculous to consider impoundments in my small country; but the United Kingdom and, particularly in this context, the Highlands of Scotland can be regarded as a research laboratory where techniques can be studied and data be obtained, some of which can be of general application throughout the world. Thus a dam only 70 feet high in Scotland seems to me to have parallels in its ecological problems with those of the Idikki dam, now being constructed in Kerala, about 700 feet high and creating a lake with a surface area of some 24 square miles.

In recent years, pumped storage of water has been adopted in the United Kingdom and in other countries. In pumped storage schemes surplus off-peak electric power, (available from thermal, including nuclear power stations, which must continue a steady output of electricity even at night or at weekends when it is not required for regular use) can be used to pump up water to a high level reservoir from which it can be released very rapidly to produce large quantities of electricity for 'peak load demand'. As a result, relatively enormous flows of water may be discharged into watercourses and lakes which have never before received such flows. This procedure requires reappraisal of the ecological consequences in the areas affected by such schemes.

I have referred to two aspects that are of special concern in my own country of Scotland. These are, first, conservation and development of freshwater fisheries in high level reservoirs, most of which are naturally deep, cold and oligotrophic, and secondly, use of such reservoirs and lakes for public recreation and tourism. The two aspects overlap, for angling is a growing recreational and tourist attraction, especially for trout and other fish which are also valuable for food. In India I have found surprisingly close parallels between conservation problems of some races of Mahseer with those of the northern Salmonidae.

In regard to my references to recreation, may I endorse the point made by Mr Dewar W. Goode in his paper on land use in Australia (Vol. 5 of these Proceedings), that 'Open air recreation is now becoming one of the most urgent needs of man'. Mr Goode's remarks on multiple use and conservation of '.. dams and watering places' show that recreational problems of open waters now under study in the United Kingdom, in Kashmir and elsewhere, are indeed world-wide.

I stress '.. that indirect ecological consequences of human recreational use can be far-reaching' and I suggest '.. that in such aspects of reservoir use the I.U.C.N. helpfully might become involved'. Professor Mirimanian's proposal (see p. 28 above) to refer to the Ecology Commission the special problems of conservation in the mountain regions of the world might be the best way to implement this suggestion regarding the effects of recreation.

In conclusion, I commend to the I.U.C.N. the need for coordinated and comparable studies of impoundment ecology in widely differing environments if we are to achieve the best economic multiple use of lakes and reservoirs, including their use for human recreation combined with conservation of wild life.

Some Recent Studies of Ecological Effects of Montane Water Storage in the United Kingdom

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1. MULTIPLE USE OF NATURAL RESOURCES

The IUCN, from its inception, has sustained the principle of integrated multiple use, so far as possible, of all natural resources. Problems of Hydro-Electric Development and Nature Protection were considered at the Union's General Assembly and Technical Meeting at Caracas in 1952. The 550 pages of proceedings and papers of the Caracas meeting indicated a desire on the part of a majority to strive towards 'practical means of harmonising policies which may at first sight, and in the views of extremists, appear to be irreconcilable' (Lord Hurcomb). Particularly in small, densely populated countries, such as the United Kingdom, coordinated development for maximum use of all natural resources is now accepted as an essential policy. In many cases, however, it may be a matter of difficulty and of controversy to decide the best economic balance between competing development projects for specific localities. A wise decision requires study and appraisal of the long-term ecological effects.

In the United Kingdom, as in many other countries throughout the world, new projects for water storage are receiving urgent attention. Clamant demands for additional water supplies are increasing, for domestic use and for industry, for irrigation and for power. Coastal barrage schemes, refilling of depleted underground sources, notably in porous strata and in the chalk, and other methods of storage are under investigation: but high-level storage reservoirs in mountain regions remain of major importance.

Different countries and differing climatic zones pose their own ecological and economic problems: but some studies of water impoundment ecology are of general application, although individual species of flora and fauna may differ greatly from arctic to equator.

The following notes on recent ecological studies in the United Kingdom, particularly for fish conservation, in waters used for montane storage, may be relevant to studies on the ecology of quite different species in other countries.

2. MONTANE WATER-STORAGE IN THE UNITED KINGDOM

The Hydro-Electric Development (Scotland) Act, of 1943, created a world precedent in requiring the North of Scotland Hydro-Electric Board, established by that Act, whose primary purpose was development of water power, to have regard to the conservation of other natural resources which might be adversely affected by storage and use of water, specifically scenic beauty and 'fisheries and the stock of fish in any waters'.

Most of the montane water storage schemes in the United Kingdom are in the Scottish Highlands. No part of Scotland is more than 80 km (50 miles) from the sea and there are no extensive high plateaux or summer snow fields. Consequently rivers tend to have small natural catchments and rapid run-offs, with winter flood flows as much as 300 times the dry weather flows, and these may be only one-fifteenth of the annual average flows. For water storage, many small catchments have been tapped and their waters diverted by tunnels and aqueducts to large reservoirs. Advantage has been taken of these proceedings to study effects of diverting alkaline water to a previously acid catchment, and vice versa. Briefly, it is beneficial in general to impound water from a calciferous catchment in a formerly acid valley: but the gradient of the surrounding land, the duration and range of reservoir fluctuation, with associated leaching of soil nutrients, and other factors make assessments of local ecology essential for each case.

In recent years, development of pumped storage schemes has added to the importance of high level reservoirs. Surplus off-peak energy from thermal (including nuclear) power stations is used to pump up water which can then be released rapidly to supply peak-load

demands for electricity. Hitherto, water flows in British hydro-electric schemes, and small catchment developments in many other countries, have been low in comparison with those on big continental rivers. Now the quick discharges of water from pumped storage reservoirs, with consequent rapid fluctuations of level in such reservoirs and in the rivers and in some cases the lakes to which they discharge, are demanding reappraisal of conservation procedures and experimentation with new techniques.

Two Scottish pumped-storage schemes illustrate the scale of such operations and the ecological changes which they may produce within relatively small areas. The 400 mega-watt Cruachan Scheme, in Argyll, was a prototype for the reversible pump-turbines now used in similar developments. It has an operating head of some 365 metres (1,200 ft.). The upper reservoir, made in a steep-sided mountain corrie, is normally filled by pump-ing at night and at weekends, when the demand for electricity from the grid is light. The reservoir is drawn down over the week to meet the peak demand for electricity. The upper-reservoir has an operating range in water level of 29 metres (95 ft); the lower reservoir is a lake, Loch Awe, with a surface area of some 40 square kilometres (15 square miles). The level of Loch Awe is controlled by a barrage and the river from the loch is under maintained flow. The Foyers Scheme, to be constructed in Inverness-shire, has for its upper reservoir two lakes, joined by a dam made 70 years ago, with shallow margins on a plateau. The lower reservoir is a lake, Loch Ness, 37 kilometres (23 miles) in length. The mean natural inflow to Loch Ness is 71 cumecs (2, 600 cusecs),yet pumping and discharge may cause a daily fluctuation in the level of Loch Ness at the outflow weir, 21 km (13 miles) away, of about 7. 5 cms (3 inches).

This requires installation of new control sluices at the existing fixed crest outflow weir so that the fluctuation in Loch Ness, particularly in times of drought, will not be reflected in the River Ness, flowing from the Loch. It also requires small-mesh fish screens on the pump intakes, for the intake to the pumps will be equivalent to a river discharge attractive to down-stream migrant fish, and especially the very valuable salmon smolts.

3. CONSERVATION OF FISH

3. (i) Passes and fishways

Conservation of fish, and notably of migratory species, continues to be the main ecological problem of water impoundment in many countries. Study and research is being directed to improved fish-passes (fishways), fish screens and counting devices, and to hatcheries and rearing ponds, compensating for inundation of natural breeding and feeding streams and shallows—a characteristic of many reservoirs in mountain regions being their steep sides and resultant oligotrophic nature.

The first fish pass to enable salmon to surmount a mill weir, was constructed on the River Teith in Scotland about 1830. For some Scottish hydro-electric dams, a pool type of pass was designed with submerged orifices between the pools in the form of pipes, in-clined at an angle of 20° to the horizontal, discharging into spoon-shaped depressions. The arrangement helps to dissipate the water-flow energy without turbulence. This type of pass proved suitable for fish which will swim in rapid water but which may be unwilling to jump. A fish pass on the principle of a canal lock, first proposed by P. D. Malloch, was developed by J. H. T.Borland of Kilmarnock, Scotland in the late 1940's. The Borland fish pass can lift fish, with a minimum expenditure of energy on their part in swimming, and is suitable for high dams. At Ardnacrusha on the River Shannon, in the Irish Republic, a Borland type pass in the form of a vertical, cylindrical shaft, 4. 6 metres (15 ft.) in dia-meter and 34. 5 metres (113ft) high is operating with sucess. The River Orrin dam in the north of Scotland, which impounds water to a level of 41 metres (135 ft) above the river bed has four separate but coordinated inclined Borland fish-locks which maintain access for fish to and from the reservoir, although there can be a variation in reservoir level of more than 21 metres (70 ft).

3. (ii) Screens

Methods of excluding or deflecting fish from aqueducts and other water-ways in which they are not wanted continue to receive intensive study. Small-mesh mechanical screens and methods of cleaning them of debris are under investigation and sizes and design of

intake are the subject of individual hydraulic model test to ensure the most satisfactory distribution of flow. The North of Scotland Hydro-Electric Board's Research Laboratory has been conducting (May 1969) sustained swimming tests with batches of fish in a flume to find the critical water velocity which may tire them and hold them against a mesh screen where they may die. The equipment provides for the maintenance of a flow of water in a channel at a selected velocity. The fish are prevented from escaping upstream by an electric screen; another electric field keeps then in the central part of the water where the flow is substantially uniform. Cameras take pictures of the fish in the flume, in relation to the screen, at regular intervals and their behaviour has been recorded on motion film.

Tests of electric and other types of non-mechanical fish screens and deflectors and of fish counters, also continue as a part of wider studies of fish ecology and behaviour in impounded or controlled waters. W.G. Hartley, and a team under aegis of the U.K. Natural Environment Research Council, are (May-June 1969) conducting experiments to control fish in a low-conductivity mountain river, the Meig, in north Scotland. The Meig has a conductivity of 24 microsiemens at 20°C. The variable parameters are voltage, pulse length and cycling speed and the screen system is constructed to allow each section to be tested in reversed directions to eliminate bias resulting from natural fish distribution. By firing the electrodes of a transverse line sequentially, a field can be made to sweep across in a series of waves and fish approaching the line are turned aside.

3. (iii) Automatic recording

The electronic counting device which is now installed to record the passage of fish at many of the Scottish hydro-electric dams was designed by N. G. Lethlean, the Hydro-Electric Board's research engineer until 1965. It depends upon changes in the electrical resistance of the water when a fish swims past the counter's electrodes. The counters record on automatic digit meters the numbers of upgoing and downgoing fish and also divide the upgoing fish by size. In addition to automatic counting, the apparatus has sockets to which an underwater camera can be connected to photograph each fish and to register on a chart-recorder the time of day of its passage.

Increasing use of these sophisticated new techniques for recording automatically the movements and behaviour of fish and of other animals is being combined with more detailed studies of changes in the physical environment resulting from different water storage procedures. A clearer picture is thus emerging of ecological effects of water impoundment on the vertebrate fauna, which in turn assists faunal conservation.

4. FLORA AND INVERTEBRATE FAUNA OF RESERVOIRS

Detailed coordinated studies of flora and fauna in a controlled lake are being made in Loch Leven, Kinross, Scotland, the site of a main IBP/PF project. The surface area is 13. 5 sq. km (5.2 sq. miles). The water level is artificially controlled by sluices and fluctuations of about 1 metre (3. 3 ft.) in water height occur. The sandy shore line slopes very gradually and large areas of the littoral are exposed when the water is low. Transects have been set up by P. S. Maitland of the Nature Conservancy, from the shore to deep water along which regular samples are taken for quantitative and qualitative analyses of the invertebrate fauna. During 1968, when the water level dropped, burrowing species—chironomids, particularly *Strictochironomus* sp., and nematodes—survived for several days in the exposed areas. On reflooding, recolonisation by Chironomidae, Naididae and *Micronecta* was rapid.

Eutrophication is outside the scope of this paper. It should be noted, however, that the micro-flora and occasional algal blooms in Loch Leven are being intensively studied in this context. The Regional Water Board have set up a pilot filtration plant to investigate the type of treatment required to make such water of potable quality and to study the separate stages of water treatment using flexible but efficiently controlled equipment. Processes under investigation include microstraining, sedimentation and filtration and the use of polyelectrolytes. In the adjoining country of Perth, the Central Scotland Water Development Board have other interesting water treatment equipment in use in their Loch Turret public supply scheme. Batteries of aero-hydraulic guns are installed in the

reservoir at depths of about 35 metres (115 ft.) to prevent stratification which can lead to stagnant conditions in the lower layers of impounded water. This is a matter of ecological importance when water has to be taken from near bottom of a deep reservoir to maintain a flow in a natural river. Aero-hydraulic guns are also in use in two other reservoirs in the same public supply area, in Upper and Lower Glen Devon, at depths between 30 and 40 metres (100-130 ft.).

4. (i) Marginal planting

The ecological effects of fluctuations in reservoir level have been intensively studied for many years and an extensive literature is available dealing specifically with many aspects. Marginal planting of reservoirs is one aspect now under further investigation. In England, the Water Resources Board is financing a programme under Professor A. D. Bradshaw of the Hartley Botanical Laboratories, University of Liverpool.

More or less violent fluctuations in reservoir water levels result in the exposure of barren rims round the reservoir during times of drawdown. The inability of most plant species to colonize this zone seems to depend on susceptibility to either flooding or wave action, or both. In Britain the problem is now one of aesthetic appearance rather than margin stability. The Liverpool programme, conducted by C.Gill, is directed towards finding plant species, or associations of species, able to tolerate the flooding regimes operative in reservoirs.

It seems likely that associations of such species as *Alnus glulinosa* and *Salix cinerea* can tolerate flooding sufficiently to enable them to be planted in groups below top water level in some reservoirs thereby breaking up a stark high water line. Such tree species promise to be more suitable for upland reservoirs; tolerant sward-forming herbaceous species such as *Littorella uniflora* may be appropriate for less exposed reservoir fringes. Wholesale planting of the problem zone using littoral species like *Glyceria maxima,* which could threaten water quality, cannot be considered for public supply reservoirs. Based on reservoir case studies coupled with vegetation surveys, the Liverpool programme deals with the broad ecology of certain promising species and is supported by detailed investigations of new means of propagation, root growth in waterlogged conditions, and field performance of these species.

5. WILDFOWL

Marginal planting and maintenance of aquatic vegetation in reservoirs is of importance for wildfowl conservation. The International Wildfowl Research Bureau is giving attention to the matter. In Britain, the conservation requirements for wildfowl in reservoirs are (1969) specifically under consideration by the Wildfowl Conservation Committee of the Nature Conservancy, for whom detailed studies are being made by the Wildfowl Trust and by the Wildfowlers' Association of Great Britain and Ireland. In large lake-reservoirs, such as Lough Neagh in Northern Ireland. which has a surface area of 390 sq. km (150 sq. miles), the great majority of wildfowl are concentrated within 550 metres (600 yds.) of the shore. Reservoirs with much smaller surface area and with islands are therefore preferable for wildfowl, but deep oligotrophic waters have little value except, in some cases, as roosts. Drawdown exposing a broad muddy foreshore is aesthetically undesirable for tourism, but may be an attraction as a feeding ground for wading birds. The effects of drawdown depend upon the flora and invertebrate fauna; these are under study (as already mentioned) at Loch Leven and elsewhere. A clause in the English Water Resources Act of 1963 requires consideration of wild life conservation. To resolve problems in this field, since 1967, assessors from the Water Resources Board and the Sports Council have been appointed to attend meetings of the Wildfowl Conservation Committee. That Committee has overlapping membership and close liaison with the Freshwater Sub-Committee of the Natural Environment Research Council.

Success in developing a lake or reservoir as a wildfowl refuge may require attention to indirect consequences. Complaints of damage to agriculture by geese have resulted when the roost attraction of the water surface and open shore exceeded the available natural feeding. In routing power lines, a special hazard of bird strike may deserve consideration. Observation on a possible route for a new transmission line showed that it

might cross what, in 1968, was a regular flight and feeding area for wild geese and swans in central Scotland. On several occasions in the autumn of 1968, large flocks were noted flying in that locality even in mist and in the semi-darkness of early morning and late evening. Photographs taken at dawn in November, 1968, showed several hundred Whooper Swans (*Cygnus cygnus*) and many thousands of geese, mostly Pinkfooted *(Anser brachyrhynchus)* and Greylag (*Anser anser*), flighting at about pylon height and feeding on fields in the area. Observations suggested that a deviation of the power line route could miss the wildfowl flyway between the feeding area and the controlled lake on which the wildflowl were roosting, thereby avoiding a possible risk of killing swans and geese in fog, with an associated chance of flash-over on a strike by such large and heavy birds which fly habitually in big flocks. Further observations will be required in the autumn and winter of 1969-70.

6. DEER

Some mention should be made of continuing studies on the effects of impoundments and aqueducts in restricting the wandering of deer and other nomadic herbivores. Steep-sided open aqueducts may cause death of deer and other grazing animals by drowning, if they attempt to cross when the aqueducts are partly frozen and snow-covered. Deaths may also result if deer cannot reach shelter and grazing on low ground when sudden storms with snow drive them from high and exposed mountain sections of their natural range. Piped aqueducts have the advantages that there is no risk of drowning, but big pipes, too, can obstruct movements of deer. Provision of occasional crossing places for deer at big aqueducts in mountain country is thus desirable to enable the deer to move rapidly from bare and exposed high ground to more sheltered valleys. Deer, and notably Red Deer (*Cervus elaphus*), have shown reluctance to cross bridges or to go through narrow pass-ways under aqueduct pipes; they may be more ready to do so if the crossing places are of substantial dimensions and are sited on a habitual deer route.

A sudden early blizzard in the autumn of 1968 provided an opportunity to observe Red Deer movements in the vicinity of a high-level piped aqueduct in north Scotland. For about 2. 4 km. (1½ miles) the aqueduct pipe crosses an access for deer between high montane pasture and valley grazing below. Tracks in the snow showed that deer from the moorland above the pipe had passed it in large numbers. They crossed not only over the pipe, where a ramp some 4. 5 metres (15 ft.) wide had been made over it with soil and vegetation, but also went under the pipe where it crossed a gulley on piers. At that point the pipe was about 3 metres (10 ft.) above the ground level. This was only an isolated observation, but it showed that in that particular locality, deer would readily cross or go under an aqueduct pipe, although the total length of the obstruction was small in relation to the wide extent of the open range.

7. HUMAN RECREATION

Conservation of fish for angling, of wildfowl and of deer illustrate increasing attention now being given to species in which there is a growing tourist interest. Modern social trends are resulting in the deliberate management of reservoirs for recreation as one of the multiple uses to which many open waters may be put. The extent to which reservoirs can be used for bathing, boating, sailing, water-skiing and other forms of public enjoyment depends largely upon the regime dictated by the reservoir's primary purpose, especially the frequency and extent of drawdowns at times when use for human recreation may be sought. In this context good landscaping, amenity planting with trees and shrubs as well as with herbaceous and marginal plants, becomes important. It must be appreciated, however, that indirect ecological consequences of human recreational use can be far-reaching. This is a matter to which the British Nature Conservancy has been giving consideration. It has been suggested that it may be in such aspects of reservoir use that the IUCN most helpfully might become involved.

8. CONCLUSION

In conclusion, the point should be stressed that while some generalisations about the ecological effects of water storage can be made, each particular case requires special study of local conditions. There appears to be a growing need for coordinated and comparable studies of impoundment ecology in widely differing environments, and particularly in tropical countries, if projects for montane water storage are to be developed with best economic multiple use, including the conservation of wild life.

SUMMARY

High-level water storage reservoirs are required increasingly in many countries. The impoundments, diversion aqueducts and ancillary works may have adverse ecological consequencies, but these may be mitigated or avoided by planning from the outset to ensure maximum conservation of other natural resources. In the United Kingdom, and in the Irish Republic, the need to make best use of all potentially self-renewing natural resources, especially in the highland zones, has led to continuing studies of long-term ecological effects of water storage. Mention of some recent British studies may assist conservation in different environments in other countries.

Conservation of fish, notably of migratory or nomadic species, continues to be a main ecological problem of water impoundment. Intensive studies are in progress to develop ways of enabling fish to ascend and descend past high dams; for screening of waterways in which fish are unwanted; and for new hatching, rearing and feeding methods to compensate for loss of natural breeding and feeding areas by inundation or by water abstraction.

Use of sophisticated new techniques for recording automatically the movements and behaviour of fish, and of other animals, is being combined with more detailed studies of changes in the physical environment associated with different water storage procedures. As a result, a clearer picture is emerging of the effects of impoundments on vertebrate fauna.

Nomadic herbivores must be able to move rapidly from exposed parts of their range when sudden storms drive them to seek shelter and grazing in sheltered valleys. Deer may be drowned in open aqueducts or obstructed by large pipes and other works; they may be reluctant to cross bridges or to use narrow passways, but crossing places for deer can be effective if of adequate dimensions and sited on habitual deer routes.

Reservoirs may be of value as wildfowl refuges. In this context, marginal and sub-marginal planting of vegetation can have importance. Planting of shore lines also serves to minimise erosion and for scenic amenity. The season, extent and rapidity of reservoir drawdown and of water-level fluctuations, and wave action, may be critical factors in selecting plant species for reservoirs. Amenity planting in and round reservoirs is of importance when they are to be used for human recreation. Social trends are leading to increasing use of reservoirs for that purpose, but the indirect ecological consequences of human recreational use require consideration.

Coordinated studies of different types of impoundment, in districts differing widely in climate, rock and soil, flora and fauna, permit some generalisations to be made about probable ecological results of proposals for water storage. Each individual case, however, requires study. There appears to be a need for more ecological investigation, in widely differing environments, if water storage projects are to be developed with best economic multiple use, including the conservation of wild life.

RÉSUMÉ

Dans de nombreux pays il devient nécessaire de créer un nombre toujours croissant de lacs-réservoirs en altitude. Les lacs de captage, les aqueducs de dérivation et autres aménagements accessoires peuvent avoir du point de vue écologique des conséquences négatives qu'il est toutefois possible de limiter ou même d'éviter en établissant de prime abord un plan qui assure un maximum de protection aux autres ressources naturelles.

En Grande-Bretagne et en République d'Irlande, la nécessité de tirer le meilleur parti de toutes les ressources naturelles spontanées, en particulier dans les régions situées en altitude, a conduit à poursuivre des études sur les effets écologiques à longue échéance des retenues d'eau. Certaines études britanniques récentes pourrent apporter une contribution utile aux problèmes de conservation dans des milieux différents dans d'autres pays.

La conservation du poisson, notamment d'espèces migratrices ou nomades, continue d'être un des problèmes écologiques majeurs posés par les retenues d'eau. On effectue actuellement des études très poussées sur les possibilités de faire passer aux poissons des barrages élevés (échelles à poissons), de leur barrer par un système de treillis l'accès des voies d'eau où ils sont indésirables et enfin de trouver de nouvelles méthodes d'ensemencement, d'alevinage et d'alimentation afin de compenser la disparition des zones naturelles d'élevage et d'alimentation par inondation ou exondation.

On utilise de nouvelles techniques très complexes permettant d'enregistrer automatiquement les déplacements et le comportement des poissons et d'autres animaux et on effectue parallèlement des études approfondies sur les modifications du milieu physique sous l'influence de divers modes de retenue d'eau. Ceci permet d'obtenir une idée plus nette des effects de l'endiguement sur la faune des vertébrés.

Les herbivores nomades doivent être en mesure de quitter rapidement les secteurs exposés de leur territoire lorsque de soudains orages les obligent à chercher refuge et nourriture dans des vallées protégées. Les cerfs et daims risquent de se noyer dans des canalisations ouvertes ou d'être arrêtés par de grosses conduites d'eau et autres installations. Ils peuvent répugner à traverser des ponts ou des passerelles trop étroites. Toutefois, l'aménagement de passages suffisamment larges, placés sur les parcours habituels de ces animaux pourrait donner de bons résultats.

Les lacs-réservoirs peuvent servir de refuge à toute sorte de gibier d'eau. Dans ce contexte, la plantation d'arbustes et de buissons le long du réservoir et au bord de l'eau présente un intérêt certain et permet en outre de réduire l'érosion et d'embellir le paysage. Le choix des végétaux à planter le long des réservoirs peut dépendre de facteurs tels que la période, l'importance et les vitesses d'abaissement du plan d'eau et de variation du niveau des eaux ainsi que de l'action des vagues. L'embellissement des rives et du réservoir par des plantations présente une grande importance lorsque le lac est utilisé à des fins récréatives.

La tendance actuelle est à l'utilisation croissante des lacs de retenue comme zones de loisirs et de détente, mais ceci a toutefois sur le plan écologique des répercussions indirectes qu'il conviendrait d'examiner. Des études coordennées portant sur divers types de retenues d'eau dans des régions différant largement par leur climat, leurs roches, leur sol, leur flore et la faune permettent de faire quelques généralisations sur les résultats écologiques probables de divers projects de réserves d'eau. Chaque cas devra toutefois faire l'objet d'une étude particulière. Il semble nécessaire d'effectuer des recherches écologiques plus poussées dans des milieux très différents afin de pouvoir réaliser des projets de lacs-réservoirs qui tiennent compte de toutes les possibilités économiques, y compris de la sauvegarde de la faune naturelle.

SECTION A (ii): POINTS MADE IN DISCUSSION

Supporting Professor Mirimanian's proposal for a technical committee of IUCN to deal with ecological aspects of the conservation of mountain regions, I would suggest that a main aim of such a committee should be to produce an authoritative booklet on mountain forest protection and management: little research on this has been done in other parts of the world such as South-east Asia (Hunter Han-ting Eu, Taiwan).

The results of experiments by the U.S. Forest Service at Fraser, Colorado, concerning the role of high altitude forests on run-off following snowfall, would be worth comparing with those reported by Dr Gulisashvili, which in some respects appear not to be fully in agreement (Nicholson, U.K.).

Personal experience with rivers of northern India suggests that a significant proportion, perhaps 25-30%, of their water comes from snow-melt, though it is of course seasonal, concentrated in this case in March/April. The important point is the timing, how it fits in with the pattern of supplies from subsoil sources, rather than the length of the period (Bhadwar, India).

Concerning the value for wildlife of reservoirs in mountain regions, especially when they are subject to sharp fluctuations of level as described by Dr Berry, crucial factors appear to be the problem of the most suitable vegetation to establish on the reservoir banks (Mörzer Bruyns, Netherlands) and the risk that when water levels are low large animals may slip in and get drowned as has happened with elephants at Periyar (Futehally, India).

More research preferably on a global basis is needed on the question of marginal planting: for example, the capacity of *Phragmites* to maintain itself in the margins of some reservoirs in Turkey, where there is a big seasonal variation, could well repay further study. Danger to animals which depend on reservoirs such as Periyar is clearly connected with the gradient and soil characteristics of the banks, though disturbance of the animals when drinking may be a factor (Berry, U.K.)

The study being made by the Department of Botany in the University of Liverpool of the best ways of using native species to conceal the effects of drawdown in reservoirs, was mentioned by Dr. Berry, and it is worth adding that the possibility is being investigated of breeding plants adjusted to these conditions (Poore, U.K.)

Conservation of Soil through Plant Cover on Certain Alluvial Slopes in India

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INTRODUCTION

The Gangetic plains in the Northern India have been under human habitation since very ancient times. Gradually much of the original climax forest was cleared for the purpose of agriculture. In recent decades there has been a sharp rise in population and the demand on limited land has become very high and complex. Consequently all lands that could be cultivated have been brought under the plough. Many sloping habitats that could not sustain the erosive forces prevailing in certain periods of the year, in absence of extensive and permanent plant cover, have become useless due to formation of undulations, gullies and bare rock. The Ganga river banks and those of its tributaries, despite being mostly on a slope, have been cultivated for crops, because of the high fertility of soil and insistent demands of the very dense population. At some places around the confluence of the Varuna and Ganga rivers at Rajghat (Varanasi), erosion has resulted in the formation of ravines and gorges, although at lower elevations visited by floods, erosion is often compensated by silting with fresh alluvium.

Varanasi (25°1' lat. 83°1'E long.) occupies almost a central place in the Gangetic plains. Most of the average annual rainfall of 1100 mm falls in the months of July, August and September. Sloping alluvium at many places along the river gets eroded on account of rapid run off, forming small and large gullies. Some of the old alluvial soils on higher elevations, as at Rajghat, have, however, been recently protected with barbed wire and the ravines are now under dense tree and shrub growth. But along the river Ganga on lower slopes where agriculture is practised, forests cannot be planted for conservation of soil, due partly to economic reasons and partly to the recurring ravages of inundation in certain years of high floods. The fresh alluvial deposits are extremely fertile and yield a rich harvest of wheat, barley, gram and other pulses, so that reconciling the stabilization of soil with the demands of agriculture presents a real problem to the conservationist.

The author has tried to find out a suitable conservation method after detailed field and experimental investigations, that could be practised with advantage for a continuous and sustained yield of food grains on the one hand and protection of soil against rain and run off on the other. With this aim in view the ecology of the river bank at Varanasi was first studied (Ambasht 1968). Some of the more characteristic uncultivated species that grew naturally on eroded areas or which could grow on such areas easily were selected for a detailed study of their performance on sloping soils and their effectiveness in binding or conserving the soil against the erosive forces of torrential rainfall and run off. Some of the species selected for detailed investigations from this point of view and discussed below are *Cynodon dactylon, Saccharum munja, Cyperus rotundus, Alhagi camelorum* and *Euphorbia hirta.*

DESIGN AND PURPOSE OF THE EXPERIMENTAL WORK (FIG. 1)

Two plots, each 15 m long and sloping at an angle of 30°, were prepared out of alluvial soils. These were divided into smaller plots of 3 m in length for the purpose of planting individual species separately. One of the plots was kept bare as a control. At the base of slopes, cement channels were prepared to receive the run-off of each sub-plot in separate compartments. Arrangements for periodic washing and flushing the reservoirs were also made. Two species of grass, a sedge, and a few species of weed were planted

Fig. 1 Sloping plots under the cover of different plant species and a bare plot. In the reservoirs water and soil runoff from each plot is collected separately.

in separate blocks, indivual plants being spaced at 15 cm. In course of time, when the plots were fully covered with fully grown plants, the set was ready for taking readings to calculate the conservation value of different species. The water and soil carried off in each heavy shower from each plot was collected in the respective reservoirs. The soils were collected, air dried and weighed. Similarly, each plot was subjected to identical showering with water artificially.

The weight of soil eroded from the bare plot was much higher than that from vegetated plots, so that plant cover certainly conserved some soil. The quantity of soil washed from vegetated plots varied, showing that different species of plant conserved the soil to different extents. In order to further assess the role of the aerial and subterranean parts of plants separately, the stems were clipped close to the ground and the run off and collection of soil was repeated as before.

The quality of erosion, from the viewpoint of particle size, was also determined by mechanical analysis of soil samples taken from the original plot, from the run-off soil and from the eroded surface left behind. Further, certain physical and chemical conditions of the eroded soils, whether left unprotected and bare or under the cover of some plant species, were also analysed, to assess the relative effect of plant cover on the soil conditions.

RESULTS OF THE EXPERIMENT

Conservation value

A formula has been devised to calculate the conservation value of the various herbaceous species based on weight of soil washed from plant-covered and bare plots of equal area under otherwise identical conditions:

$$CV = 100 - \left(\frac{Swp}{Swo} \times 100\right)$$

where CV = conservation value, Swp = weight of soil washed from plant covered plot and Swo = weight of soil washed from bare plot. Conservation value in fact represents the percentage of soil that is checked from getting eroded by the cover of a particular plant species and which would otherwise have been washed away if the plot had been left bare. On this basis, it was found that *Cynodon dactylon* conserves between 89 and 97. 5%

of which subterranean parts account for 76%. *Saccharum munja* conserves between 92 and 96%. A sedge *Cyperus rolundus*, which is a perennial, propagating through tubers (Ambasht 1964), conserves 81-92% and its subterranean parts check erosion up to 66. 2%. Dicotyledonous weeds, native to sloping river bank soils, like *Alhagi camelorum*, with extensive deep roots and rhizomes (Ambasht 1963), conserve 30-35% and on clipping of aerial stem the value falls to 10. 5%. *Euphorbia hirta*, a small herb, conserves up to a maximum of 12. 2%.

TABLE 1 - CONSERVATION VALUE OF DIFFERENT SPECIES

Agencies of erosion	Cynodon dactylon	Saccharum munja	Cyperus rotundus	Alhagi camelorum	Euphorbia hirta
Rainfall	89.4	92.0	81.9	30.0	6.0
Artificial showering	97.5	96.4	92.9	30.2	10.0
ditto	94.2	92.5	90.9	35.2	12.2
ditto (with stem clipped)	76.5	92.0	66.2	10.5	8.5

Mechanical quality of eroded soils

It was found that finer components like clay and silt are eroded in greater proportion, leaving the eroded soil predominantly sandy and the deposited soil richer in clay and silt. The plots were originally 57% sand (56% fine sand) and the rest shared almost equally between clay (20.5%) and silt (21.5%). After the erosion experiment, the surface soil left behind on the bare plot had an increased sand percentage of 77.2%, whereas silt and clay were reduced to 14. 5%, 8. 7% respectively. The deposited soil had 44.3% sand, 24% silt and 29.4% clay (Fig. 2).

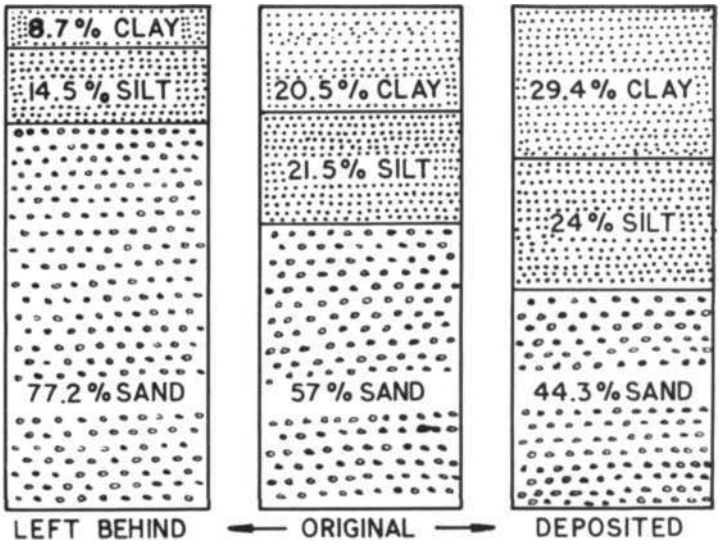

Fig. 2 Mechanical composition of sloping plot soils with respect to erosion

Other physical and chemical properties

Porosity, organic matter, nitrate and carbonate contents were determined on the bare plot and vegetated plots under a grass, a sedge and a weed, respectively, and it was found that slightly higher values are obtained in respect of all these soil qualities in vegetated plots, except that under *Alhagi camelorum* porosity is slightly less (see Table 2).

TABLE 2 - SOME PHYSICAL AND CHEMICAL PROPERTIES OF SOIL ON BARE AND VEGETATED PLOTS

Plot condition	Porosity %	Organic matter %	Nitrate %	Calcium carbonate %
Bare plot	58	1.25	1.8	0.9
Cynodon dactylon	60	1.9	1.9	1.6
Cyperus rotundus	62	2.5	2.0	1.25
Alhagi camelorum	57	1.4	2.0	1.0

RECOMMENDATIONS

On the basis of this investigation, it is recommended that fertile tracts along river banks in Northern India should be retained under intensive cultivation of agricultural crops but that on areas susceptible to erosion, *Saccharum munja, Cynodon dactylon* and, possibly, *Cyperus rotundus* should be planted in regular strips for conserving the soil. All these three species were found to withstand partial submergence in water of four to six months duration, but only the first two survived a dry hot summer.

ACKNOWLEDGEMENT

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REFERENCES

Ambasht, R.S. 1963. Ecological studies on *Alhagi camelorum* Fisch. *Trop. Ecol.* 4: 72-82.

Ambasht, R. S. 1964. Ecology of the underground parts of *Cyperus rotundus* L. *Trop. Ecol.* 5: 67-74.

Ambasht, R.S. 1968. Ecology of a river bank. Proc. Symp. Recent Advances in Tropical Ecology. 466-470.

SUMMARY

In the Gangetic plains in North India, human population is exceedingly dense and man's demand on land is heavy. Consequently, sloping lands along the river Ganga are also under the plough, even where erosion of soil is fast and disastrous. These alluvial soils cannot be put under protective forest cover as they are extremely fertile and yield good and badly needed agricultural crops. The paper describes an experiment to assess the kind and extent of erosion and the percentage of erosion that could be checked by different local herbaceous plants. It was found that the soil is selectively eroded of its finer components like clay and silt in greater proportions.

Conservation value (CV), i.e. the percentage of soil protected from getting eroded due to plant cover was determined for certain characteristic species. Two grasses—*Saccharum munja* and *Cynodon dactylon* and a sedge—*Cyperus rotundus*—are found to conserve up to 97. 5%, 94. 4% and 92.9% of the soil. Local weeds like *Alhagi camelorum* and *Euphorbia*

hirta are comparatively ineffective, CV being 32% and 12% respectively. Even after grazing (simulated experimentally by clipping), subterranean parts of *Cynodon dactylon* conserve 76% and *Cyperus rotundus* 90%. It was also found that under plant cover, the porosity, organic matter, nitrate and carbonate contents were usually higher than in bare eroded plots.

It is therefore recommended that on marginal lands between agricultural holdings or better at regular intervals, strips of land along sloping river banks should be kept under the cover of *Saccharum munja, Cynodon dactylon* and *Cyperus rotundus,* the first two being preferred as able to withstand a dry hot summer.

RÉSUMÉ

Dans les plaines du Gange au nord de l'Inde, la population est extrêment dense et les exigences de l'homme à l'égard du sol s'avèrent très lourdes. De ce fait, les terres en pente qui bordent le fleuve sont mises en culture, même là où l'érosion du sol est active et désastreuse. Ces sols d'origine alluviale ne peuvent être afforestés, car ils sont très fertiles et donnent de bonnes récoltes dont on n'a que trop besoin. Le présent article décrit un essai réalisé dans le but de déterminer le type et l'importance de l'érosion ainsi que le pourcentage d'érosion qui pourrait être supprimé par l'emploi de diverses plantes herbacées locales. On a constaté que le sol subissait une érosion sélective intéressant surtout ses constituants les plus fins tels que les argiles et les limons.

On a déterminé la valeur conservatrice (conservation value = CV) de certaines espèces caractéristiques, c'est à dire le pourcentage de sol protégé contre l'érosion par le couvert végétal. On a pu constater que deux graminées–*Saccharum munja* et *Cynodon dactylon*- et un carex—*Cyperus rotundus*–retiennent respectivement jusqu'à 97.5%, 94.4% et 92.9% du sol. Des adventices locales telles que *Alhagi camelorum* et *Ephorbia hirta* sont relativement peu efficaces, leur valeur conservatrice étant respectivement de 32% et 12%. Même après pâturage (simulé dans l'essai par une tonte artificielle), les parties souterraines de *Cynodon dactylon* conservent 76% de CV et celles de *Cyperus rotundus* 90%. On a également trouvé que sous un couvert végétal, la porosité, les teneurs en matière organique, en nitrates et en carbonates sont en général plus élevées que dans des parcelles érodées découvertes.

Par conséquent, il est conseillé d'instaurer sur les terres marginales entre les parcelles agricoles ou mieux encore à des intervalles réguliers tout au long des berges en pente des bandes de terre plantées de *Saccharum munja, Cynodon dactylon* et *Cyperus rotundus,* les deux premières espèces étant préférées pour leur résistence aux étés chauds et secs.

Section A (iii)

Effects of Reafforestation on Saline and Alkaline Tracts of Northern India

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INTRODUCTION

In India vast areas are lying barren on account of saline and alkaline soil conditions. These areas suffer from a high salt and/or sodium problem, have very sparse vegetation and are of little or no economic value. The barren, saline alkaline areas are locally called *usar* or *reh* and are widespread in the northern plains of India. In Uttar Pradesh alone about 3 million acres (Raychaudhuri *et al.*, 1963) are lying as uncultivable waste on account of high salt or alkali conditions. The acreage of salt-affected soils has greatly increased after the introduction of canal irrigation in the alluvial plains of the country. Areas neighbouring canals are fast becoming unproductive due to the excessive accumulation of water soluble salts in surface soil (Agrawal and Gupta, 1968). In 1938 (Usar Land Reclamation Committee, U.P.),the total area of the *usar* land in Uttar Pradesh was estimated about 2. 2 million acres but in a recent survey made in 1967, the acreage of salt affected land has increased to 3.1 million acres. It shows that there is approximately 50% increase within a period of less than 20 years (Raychaudhuri *et al.*, 1963).

The problem of unproductive *usar* lands was recognised by Dr Leather as early as 1876 and since then soils of these areas have been studied in great detail by various workers (Agrawal and Gupta, 1968). A number of methods have been suggested for reclamation of these salt affected soils which can be grouped in the following four categories:

1. leaching or washing out water soluble salts by water;
2. growing suitable salt resistant crops in rotation;
3. applying chemicals, such as gypsum, calcium chloride, etc. to the soil;
4. green manuring and the addition of enough organic matter.

All the above categories of methods are rather expensive and need expert technical know-how which is seldom available. Thus they present a serious hurdle in adopting any one of these methods for reclamation. In many cases methods recommended for reclamation are based on the data obtained from pot experiments or on the basis of small experimental plots. Findings of these experiments, though very helpful, cannot be extended to field conditions without making suitable modifications.

A saline alkaline tract of 210 acres which was lying barren for a very long time at Aligarh (Uttar Pradesh) was enclosed in 1954 by the U.P. Forest Department. In this area *Prosopis juliflora, Dalbergia sissoo, Acacia* spp. were sown and seedlings of *Azadirachta indica, Tamarix dioica, Albizzia lebbek* and *Terminalia glabra* were planted.

Grazing and felling was completely prevented after enclosure was complete. During the past 15 years, this area has developed into a semi-open forest dominated by *Prosopis juliflora* and *Acacia* spp. The physiognomy and other measurable attributes of this area are altogether different from the adjoining land outside the fencing which is reminiscent of the original saline alkaline waste land before the enclosure was established. The unenclosed area represents the condition which the whole area must have shown if the enclosure had not been established. Thus this locality provides a suitable opportunity to study the effect of afforestation on saline alkaline waste land of U.P., the result of which is discussed in detail below.

THE STUDY AREA

Location and History of the Area

The Sussait Forest Block is situated on the Aligarh-Hathras Road at a distance of 10 miles from Aligarh. This area has a highly saline and alkaline alluvial soil. Prior to 1954, this area was lying as a waste land and was grazed indiscriminately.

This tract of land was acquired by the U.P. Forest Department and about 210 acres of uncultivable waste land was fenced with barbed wire. The enclosed area was completely protected from grazing, trampling and felling. After completely enclosing the area, trenches of 5' × 2' × 1½ dimension were dug and along the ridges of these trenches seeds of *Acacia spp., Prosopis juliflora* and *Dalbergia sissoo* were broadcast. Within a couple of years, many seedlings established themselves and the protection from grazing and trampling helped to reclothe the area with herbaceous vegetation. Encouraged by this initial success, the Forest Department planted a few important trees, such as *Albizzia lebbek, Tamarix dioica, Terminalia glabra* and *Pongamia glabra.* Under the protection accorded by the U.P. Forest Department, this area has slowly developed into a semi-closed forest with many open grassy patches in between the thickets of *Prosopis juliflora.*

Sussait Forest Block presents a great contrast from the neighbouring land which is a part of the original saline alkaline waste land. The physiognomy of the area changes dramatically as one approaches the fenced boundary of the Forest Block (see Figs. 1-6).

Climate

The climate of this area is characterized by the monsoon which exhibits the typical seasonal fluctuation of weather already described for the upper Gangetic Plain (Varshney, 1967). The climatic elements, viz. rainfall, temperature, relative humidity and wind, show typical changes amounting to three distinct seasons.

The average annual rainfall is about 784 mm of which about 80-90 per cent is received during the wet months of August, September and October. The remaining months are dry except for light showers.

The month of October is a transitional period from the rainy to the winter or cold season, which extends from November to the middle of February and is characterized by low temperature and dry weather. The month of March marks the transition from the cold season to the dry summer season, which lasts from April to the middle of June. During this period, hot winds locally called 'loo' blow until the advent of monsoon, while a crust of salt is deposited on the soil due to the capillary rise of water and its evaporation from the soil surface.

Method of study

Soil samples for analysis were collected during the summer of 1969, both from the Sassait Forest Block and also from the adjoining waste land outside the enclosure. Random samples of surface soils 1 -4" in depth were collected from ten spots inside the forest enclosure and from the neighbouring waste land. The samples were collected in polythene bags and brought to the laboratory for further processing.

Saturated soil pastes were prepared and saturation extracts were obtained by electrical vacuum pump. A portion of saturated paste was used for estimating saturation percentage. Electrical conductivity, pH, Ca^{++} + Mg^{++} and sodium content of the saturation extract were determined following the methods given in USDA handbook No. 60 (1954). SAR values were also calculated according to the formula given in the same publication. Organic carbon was determined by Walkly and Black's method (*see* Piper, 1942).

Results of soil analysis

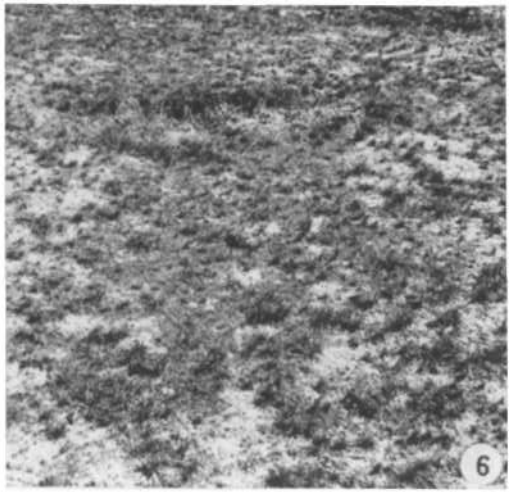
Table No. 1 shows that chemical characteristics of the soils of Sussait Forest Block are markedly different from those of the adjoining waste area. The electrical conductivity, sodium content and pH of the saturation extracts of the forest soils are substantially low in comparison. Similarly the amount of organic matter is very high in the forest soils as compared with the waste land. According to the USDA salinity scale (USDA Handbook


1


2


3


4



1. Saline alkaline soil outside the forest enclosure.

2. Photograph showing the Forest Block and outside waste. Note the change in the physiognomy.

3. A thicket of *Prosopis juliflora.*

4. Forest floor showing the accumulated fruits of *Prosopis juliflora.*

5. Forest Block showing grassy areas.

6. A closeup of a grassy pocket in the Forest Block.

TABLE 1 CHARACTERISTICS OF SOILS FOREST BLOCK AND NEIGHBOURING WASTE LAND

Soil Sample No.	pH		Saturation percentage		Electrical conductivity Mmhos/cm		Ca^{++} + Mg^{++} meq/l		Na^{+} meq/l	SAR	Organic matter	
	O	E	O	E	O	E	O	E	O	O	O	E
1	10.6	7.6	32.5	24.5	1.8	52	52	18	32	20.6	0.7	2.25
2	10.4	8.2	37.8	21.6	2.1	37	6	14	28	15.9	0.9	1.89
3	10.4	8.0	32.8	20.9	1.8	46	7	20	32	10.6	0.8	2.1
4	9.6	8.5	36.4	22.7	1.9	52	6	18	28	10.3	0.7	1.73
5	8.9	7.9	31.2	20.8	2.7	38	8	14	23	7.0	0.8	1.8
6	9.8	8.4	29.7	23.8	1.8	28	6	21	24	12.0	0.12	1.7
7	9.7	7.9	28.6	27.5	3.4	42	5	15	32	20.5	0.09	1.8
8	10.9	8.0	31.4	23.5	2.2	25	6	12	30	16.4	0.08	1.6
9	10.6	7.6	30.0	24.2	1.7	39	6	15	28	19.5	0.14	1.38
10	10.5	7.4	31.5	20.4	2.1	45	8	14	38	10.0	0.10	1.72

O: Waste land outside the enclosure.

E: Soil of the Forest Enclosure.

No. 60), a salinity problem starts only if the electrical conductivity of the saturation extract exceeds 4 mhos per cm. The electrical conductivity of the Sussait Forest Block is below 4 mhos per cm; thus the soils of the Forest Block have no salinity problem. The high amount of organic matter and their neutral pH indicate suitability for plant growth and good fertility. It is important to realize that these favourable features of the forest soils are mainly due to the enclosure and protection provided by the Forest Department. In absence of this protection, the soils of this forest block would have been in no way different from the soils of the adjoining areas outside the protective fencing. The data suggest that vegetation plays a very vital role not only in protecting the land from the hazards of erosion but is also highly efficient in reclaiming the salt and sodium affected areas.

While the author was surveying the area he observed an equally drastic change between the fauna of the forest and that of the adjoining *usar* land. Inside the forest block, one cannot miss the flocks of peacock, chatter of house sparrows and weaver birds, and actively dashing rabbits and rodents. All these animals are very conspicuous by their absence in the neighbouring areas.

DISCUSSION

Saline alkaline tracts can provide much needed extra acreage for growing crops if they can be successfully reclaimed within a reasonable time and at a reasonable cost. Repeated attempts have been made by various workers to reclaim salt affected areas with partial success. Still others have suggested a variety of techniques for reclamation based on laboratory experiments. The suggested methods could be conveniently grouped into four main categories: 1. Mechanical, 2. Agronomic, 3. Chemical, and 4. Green manuring. Dhar and Mukerji (1936) think that molasses which contain 2% calcium and 60-70% carbohydrate can reclaim the salt affected areas. Molasses upon decomposition release large amounts of organic acids and carbon dioxide which neutralises the alkali in the soil and improves the soil tilth. Growing of *Sesbenia aculeata* (dhaincha) as a green manure crop has been reported to have beneficial effects on salt affected soils (Agrawal, 1957).

A major drawback to all these methods is that they cannot be applied over large areas on account of the prohibitive cost of the operation. In order to deal with large areas such as are met within India, the reclamation method must be simple and capable of adoption without technical or sophisticated knowledge. Reafforestation of saline areas is one such method which satisfies the necessary requirements and appears most suitable under Indian conditions. Planting of *Prosopis juliflora* and complete protection from all biotic disturbances has been very successful in Sussait Forest Block.

The establishment of vegetation on salt affected areas will help to restore the ecological balance of these areas. The period of 10-15 years needed for reclamation is brief in comparison with the long periods for which such land has been out of use. It is important to realise that during the period of reclamation, the economic value of the area under treatment increases steadily. The amount of timber produced during this period will more than compensate for the initial expenditure.

It can be seen from Table 1 that organic matter has substantially accumulated in the soil. This organic increment will ameliorate the soil conditions and encourage proper development of soil biota which will lead to the restoration of the broken threads of the food web in the salt affected areas.

The vegetation cover will provide protection, habitat and food for a variety of animals and the over-all development will help to re-establish the normal functioning of biogeochemical cycles. The significant improvement in the soil characteristics and inescapable change in the fauna of the Sussait Forest Block provides a good example through which one can anticipate a solution of the problem of saline alkaline soils.

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I wish to thank Professor B. M. Johri F.N.I., Head of the Department of Botany, University of Delhi, for laboratory facilities and to the Divisional Forest Officer, Vrajbhumi Forest Division, Agra, for providing valuable historical information about Sussait Forest Block, Aligarh Range, Aligarh, U.P. My thanks are also due to Drs S. C. Gupta and K. G. Mukerji for helpful discussion.

REFERENCES

Agrawal, R.R. 1957. Alkali soil can be reclaimed. *Indian Forester* **7:** 6-8.

Agrawal, R. R. and R. N. Gupta. 1968. Saline-Alkali Soils in India. ICAR, New Delhi.

Dhar, N. R. and S. K. Mukerji. 1936. Available nitrogen in tropical soils. *J.Indian Chem. Soc.* **13:** 23-24.

Piper, C.S. 1950. Soil and Plant Analysis. University of Adelaide, Australia.

Raychaudhuri, S. P. 1966. Land and Soil. National Book Trust, New Delhi.

Raychaudhuri, S. P.; Agrawal, R.R.; Dutta Biswas, N.R.; Gupta, S. P. and Thomas, P. K. 1963. Soils of India. ICAR, New Delhi.

Usar Land Reclamation Committee, U.P. Report 1938-39 1: 118. Superintendent, Printing and Stationery, Allahabad.

U.S. Salinity Laboratory (Staff) 1954. Diagnosis and Improvement of Saline and Alkaline Soils. USDA Handbook No. 60.

Varshney,C.K. 1967. Seasonal aspects of the wall vegetation of Varanasi. *Trop. Ecol.* **8:** 22-29.

SUMMARY

In India vast areas are lying as unproductive waste land on account of the problem of high salt and alkali conditions. A number of methods have been suggested to reclaim these wastelands for agricultural use. These methods, though effective, cannot be applied in the field without considerable further research and, moreover, demand heavy economic in-

volvement and technical expertise. As an example of a possible alternative method, the effect of reafforestation in Sussait Forest Block, Aligarh Range, Aligarh, U.P., which was an uncultivable waste till 1954, is examined. 210 acres of land were enclosed by the U.P. Forest Department and reafforested by sowing *Prosopis juliflora, Dalbergia sissoo, Acacia* spp., *Azadirachta indica, Tamarix dioica, Albizzia lebbek* and *Terminalia glabra.* The soil characteristics of the Forest Block show that it is now free from the salinity problem, whereas the neighbouring land outside the enclosure remains highly saline alkaline. The planting of salt resistant trees and complete protection from biotic disturbances are responsible for the difference in the soil characteristics of the Forest Block and adjoining waste area. The data presented in this paper strongly suggest that reafforestation of unproductive saline alkali soils can prove very valuable as a reclamation measure without demanding heavy expenditure and technical supervision.

RÉSUMÉ

En Inde, de vastes étendues de terres demeurent à l'état de friches en raison de leur forte teneur en sels et en alcalis. Un certain nombre de méthodes ont été proposées afin de les amender et de les mettre en culture; mais, bien qu'efficaces, ces méthodes ne peuvent être appliquées dans la pratique sans des études plus approfondies et de plus elles s'avèrent très onéreuses et nécessitent des connaissances techniques poussées. L'auteur analyse ici les effets du reboisement dans le secteur forestier de Sussait (région d'Aligarh, Aligarh, U.P.) qui, jusqu'à 1954, était une friche inexploitable, à titre d'exemple d'une méthode possible de mise en valeur. Un terrain de 84 hectares a été enclos par les soins du département forestier U.P. et reboisé par semis des essences suivantes: *Prosopis juliflora, Dalbergia sissoo, Acacia* spp., *Azadirachta indica, Tamarix dioica, Albizzia lebbek* et *Terminalia glabra.* L'analyse du sol du secteur forestier montre que les problèmes de salinité ont disparu, alors que les sols situés en dehors de l'enclos sont encore fortement alcalino-salins. Ces différances de propriétés des sols viennent de ce que le secteur forestier a été reboisé avec des espèces résistantes au sel et protégé contre toute forme d'exploitation. Les données fournies par ce rapport montrent très clairement que l'afforestation des sols alcalino-salins infertiles peut constituer une méthode efficace d'amélioration des sols sans nécessiter de frais importants ni de grandes connaissances techniques.

SECTION A (iii): POINTS MADE IN DISCUSSION

An important question to consider is what actually happens to the salt in areas which are re-afforested. Table I of Dr Varshney's paper indicates the higher percentage of organic matter in soils of these areas and this may block or absorb salinity, but surely if the land is ever brought under cultivation again, the salts will inevitably be released into the top soil layer, so that rehabilitation is only temporary (Kuenen, Netherlands).

This will always be a problem, but the fact is that soil structure in the enclosed areas quite quickly improves and acquires a better absorption capacity, and it may become capable of at least intermittent productivity. On the other hand, outside the enclosures primary productivity is almost nil—small patches of grass not much more than 15 cm in diameter at 50 or 60 metre intervals (Varshney, India).

The explanation is surely that a calcareous layer tends to be formed according to soil type and climatic influences at varying depths from 4 feet to as much as 10 feet, through which no leaching of salt can take place, whereas when trees are established the roots can and do break through this layer (Soni, India).

The fact that salinity is more frequent in the west of Uttar Pradesh might suggest that it is partly the effect of the proximity of the desertic climate and soils of Rajasthan (K. K. Tiwari, India).

The latter suggestion seems to be disproved by the fact that there is no consistent gradient in salinity from west to east. More probably one of the main causes of salinization is misuse of irrigation water due to technical ignorance and inexperience on the part of so many of the cultivators (Varshney, India).

With reference to Dr Ambasht's experiments with riverbank protection, the difficulty is that if any palatable plants are used they have to be protected against livestock by fencing, which is very expensive. In some cases, for example on the Brahmaputra, bamboo planting seems to be quite effective against erosion (Ranjit Sinh, India).

Unfortunately, bamboo is not very resistant where large variations in water level between monsoon and dry season occur. One way or another, however, the fact has to be faced that if erosion is to be checked some sacrifice of agricultural land and of pasture for cattle and small stock is essential (Ambasht, India).

This of course involves breaking down long established traditions and is a difficult socio-economic problem (Soni, India).

Forest Reserves in Relation to Nature Conservation and to their Scientific Value

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The growing intensity of social and economic life continually increases demands on the supply of raw materials. This demand concerns all material resources, including forests. But it is a very superficial view which appraises only the productivity of a forest in terms of timber and considers this of primary concern. Forests are the most differentiated form of vegetative life and therfore extremely complex; furthermore, owing to this, their significance and function are many-sided and must not be appraised and evaluated from too one-sided a view.

In addition to the timber production, forests have several other just as important functions, as for instance in relation to water economy, soil preservation, climate, health, recreation and aesthetic interest. All these functions, which are very often considered as secondary, are nevertheless just as important as timber production. It is suggested that their combined value is four times higher than that of the timber produced.

It is also known that the forest, as the most complex biocenosis, is governed by certain natural laws on which everything it produces for man is qualitatively and quantitatively dependent, including the quantity and quality of timber and the costs involved in the exploitation of this raw material. Successful forest economy calls, therefore, for knowledge and recognition of these laws and their consequences, for only through this can the future production of the material required, such as timber, be ensured.

Such knowledge and recognition can be acquired only by comparative study and so—particularly under the intense economic pressures of the present day—we must have at our disposal a complete network of control areas, where it is possible to observe and study spontaneous natural processes and use the experience gained for the best possible development of a rational forest economy.

Generally, there are very few forests untouched by human interference; we could hardly expect to find today in Central Europe any primeval forest, as for instance the well-known Boubin or Zofin forests in Czechoslovakia, had it not been for the action of certain educated and provident individuals in the past in ensuring the protection and preservation of the last remnants of such forests.

Their motivation had not only a romantic basis, the feeling that forests of this kind would soon be known only by historical description, but also one of very serious professional and scientific interest.

Exploitation of forests had gone so far that it amounted almost to an actual violation of nature, foresters having been led astray by the desire to obtain the largest possible quantities of spruce and pine in order to meet demands in the technical field. Hence came about the monoculture plantation policy, which had little regard for the suitability of natural conditions for the trees selected for cultivation, for the enduring success of the effort made or for the deterioration of productive capacity of the soil.

Foresters tried to vindicate their attitude by mathematical formulas and by asserting that their aim was 'a forest of sustained yield', but tended to forget a number of 'trifles', which in the event have given rise to serious problems, such as soil deterioration and loss of water-holding capacity, adverse changes in the forest ecosystem and microclimate, and several more. These factors having been neglected in the first instance, led ultimately to a decrease in timber production, the yield per hectare becoming lower than originally calculated.

Investigation into the causes of this failure of monoculture cultivation has brought about the recognition that it is necessary to accept and respect nature's laws and that, in keeping with them, it is better to exploit natural resources within the limits necessary to preserve a proper balance between individual natural factors. The situation can in fact only be remedied through the study and understanding of natural forest, which of all vegetational associations provides the most significant example of a living entity. The development of a forest depending on ecological relationships and the phytocenological environment can provide the basic information about the multilateral factors governing natural processes, which are applicable to a whole region. Knowledge of them must not be ignored and it is essential that it should be applied even in conditions of an intensive economic development of forestry and agriculture.

Where a forest's natural character has been increasingly modified by economic exploitation and hence disturbance, the possibility of investigating the relationship between the forest and surrounding country becomes progressively inferior to that offered by natural forest. In Czechoslovakia, the forest land is well distributed at all altitudes and the policy is to set aside reservations where samples of natural forest of each important type are protected. These provide forestry research scientists with sites for numerous experiments, in which all the very diverse factors and their influence on the forest can be kept under observation.

Such research activities, which have the vital aim of strengthening the country's economy and maintaining irreplaceable economic and cultural values, need to be put on the basis of a single, unified project.

The structure and mineral contents of soils in Czechoslovakia are very varied. The relief is diverse and comprises many different zones of vegetation and altitude, so that forest types are equally varied. Their study therefore had always to be related to the natural conditions of each site, to a classification of the different types and growth factors. These investigations provided a rough orientation of the diversity of environmental conditions and laid the foundation for the selection of the forestry operation and management goals. The general approach aims at accelerating the restoration of the optimum structure of wood plant types and at preventing the continuing deterioration both of production and of natural conditions in economic forests.

Such an approach necessitated the establishment of a network of areas quite unaffected—or only partly affected—by economic interference, where it would be possible to study the living picture and the influence of individual biocenoses in a natural environment. These conditions are to be found in natural reservations, which are excluded from ordinary economic development and can thus serve as natural laboratories and key-points for ascertaining the normal relations between the individual natural components of a given type of environment.

The environment of a particular region forms an entity, in which flora and fauna individually and in their communities constitute the natural components, regardless of whether they do or do not confer any benefit, direct or indirect, on man. The components are dependent not merely on soil and climate, but also on each other, i.e. are interdependent and interacting, as they exist in a fixed community relationship. If any factor causes disturbance of the balance, that is of the natural relations in the given community, it evokes changes, which may be adverse to the interests of man and to his economy.

The need for ensuring preservation of samples of the 'minimum-disturbed nature', as laid down by the International Biological Programme, calls for the reservation and protection of a representative series of all stable vegetation types in proportion to the extent to which they are typical in the pattern of a regional unit and so in proportion to the extent of the areas they occupy and to their importance for the forest economy.

There is often no alternative but to give up the idea of finding areas which would meet the 'primeval forest' condition and, instead, to aim at relatively maximum preservation of natural conditions in the biocenosis pattern of a particular type. We are therefore often concerned with what Ellenberg (1962) called forest habitats 'conditionally' near to their natural state, in which the best policy will be to design and apply measures which make possible or promote the restoration of the natural state of the biocenosis.

Even in some long established reservations and in primeval forests, some degree of deliberate management will be necessary. Until the recent industrial and technological

upsurge, inaccessibility of an area for economic exploitation as a rule sufficiently guaranteed a natural untouched state. But this presumption ceases to be valid in present conditions, when air pollution from industry can significantly alter the climate of entire regions, when the zoocenosis and also the phytocenosis are affected by applications of chemicals and when large areas are afflicted by what we vaguely call 'disrupting of natural balance'. All this results in the paradox that preservation of nature requires removal of disturbance but at the same time extensive and costly intervention.

The kind of intervention required in Reserves where the forest was formerly exploited but has not been substantially damaged would be one that is exclusively oriented to the promotion and advancement of changes of biocenosis, which would bring about a return to a state similar to what we imagine existed before human interference. Such interventions, applied gradually over a period cannot be classed as economic, as they are not being done with the aim of making the productivity of the forest more profitable. They are therefore not suited to control by the authorities responsible for forestry management or economics, but should be designed and controlled by scientists concerned with nature conservation and only put into operation after thorough and comprehensive research.

Much of the scientific value of Reserves lies in their permanence. This involves two things: the preservation of remnants of undisturbed nature, which do not exist anywhere else in the whole world, and the continuing possibility of scientific studies which can be carried out nowhere else. Full value—from the view-point of natural science and forestry —can be obtained only from economically undeveloped Reserves, as these are the only ones where it is possible to study interrelations in the geobiocenosis, without any interference. In cases where it becomes necessary after all for such a reserve to be subjected to development and modification, the only justification is that this should be done with the aim of direct research into the effects. For this reason also such reserves should, as far as possible, be used for special educational purposes.

We must not regard a reserve as merely a memorial to a set of values which cannot be retrieved, but rather as an essential part of a general area in which the biocenoses are closely related to and originated from it and need to be investigated and studied in detail. The future of regional ecology should be directed towards learning to create biologically balanced biocenoses in place of monocultures. The network of forest and other nature reserves should therefore include examples, which in the light of what we know of the genesis of biocenoses can provide information on the most stable complex in a given regional situation. This invests nature conservation with a new functional role.

In the forest reserves of each of these regional units, it is possible to study in a proper and long-term way the dependence of the various associations on diverse conditions of climate and soil in relation to the influence of minerals and the form of the ground surface. Present economic forests have after all been derived from the old mixed growths which are typical of the natural forest cover. The soil conditions under the latter remain more or less in the natural state, unmodified by man to any great extent, and the character of the vegetation corresponds to the natural development of the whole biocenosis, so that a comparison can be made between the productivity of natural and economically developed areas. It also gives an opportunity of solving the problems of the water regime (such as the rate of run-off or retention) of the natural forest in relation to particular ecological conditions. This knowledge is of immense value to the forester in the management of economic forests situated in conditions similar to those of the reserves. In the same way the Pedologist can compare long-term soil development and life in natural growth with results obtained in artificial plantation, while the ecologist and the phytologist can evaluate natural changes in the flora due to natural causes in comparison with those caused by technology.

Where forest reserves extend over a major area, changes in phytocenosis and zoocenosis and development or transformation of the forest constituents furnish important microclimatic indices, which enable us to predict and appraise similar changes in the whole neighbouring environment. It is important to remember, also, that natural forests have been formed by natural selection and are likely to contain ecologically valuable ecotypes and communities, which may be able to provide highly significant genetic material suitable for utilisation in the surrounding areas of forest developed for economic purposes.

The gradual decay of individual trees causes natural thinning and the fallen giants show

the effects of the disrupting processes of fungi. The life of the forest is maintained by the natural regeneration of the individual species of woody plants, in which process there is no human interference. This gives further opportunities in a reserve for the study of the spatial structure of the forest and the age stratification of growth in relation to the trunk size increase. Long-term observations in the proportions of individual species can even throw light on changes which may take centuries to complete. Forest reserves are therefore exceedingly important both for the study not only of relations of flora to the environment but also of regional ecology and biology. The lessons that can be learned are valuable not only to the forester but also to all biologists and ecologists.

In the interests of a modern forest economy, it is essential within any forest area to create a net-work of scientifically selected reserves, which are fully representative of the characteristic natural features of relief, soil, minerals, flora and fauna.

These reserves should also include all the kinds of growth and association which are most typical in a given set of conditions; for example in Czechoslovakia they would cover all important natural forest communities and their zonal variants, including mountain and Scots pinewoods and mixed oak forest, coniferous and deciduous forest, communities of the drier soils of wooded grassland and the alders and other specialised species of peatland. Neither must we exclude samples of forest communities growing on rock or gravel and, at the opposite extreme, those of the most fertile lowland soil.

Forest reserves should also be used for the protection of stands of all rare and notable woody plants and all rare communities of the flora and fauna and may, in addition, also include regions of particular geological and geomorphological interest, the preservation of which is also important. But the aim should always be to protect not just individual species or communities, but the biocenosis as a whole and all the conditions underlying this biocenosis, and to make possible its continuing evolution. Brief reference should also be made to the problem of the adequate protection of reserves not only against destructive winds and gales, but also against effects of changes and transformations arising in neighbouring economic forests, which needs constant care and attention.

The first foundation for such a programme has already been laid down in Czechoslovakia, where research scientists are studying forest ecosystems, acquiring new knowledge to verify the validity of their findings and conclusions in relation to economic forestry, and seeking generally to improve the contribution of these protected areas to the aim and purpose of their establishment, the cultural progress of mankind.

CONCLUSIONS

It is hoped that this paper has shown that forest reserves, although often smaller in area than national parks and other regional reservations, have undoubtedly an enormous and up till now unappreciated importance for science. Being relatively undisturbed, they can provide the natural laboratories and key-points for the study of mutual relations between the individual components of nature in every type of environment.

The first objective of the network of natural forest reserves should be to serve the needs of research scientists, in the fields both of forestry and natural history, the results of whose work should be collected and made available by the authorities responsible for the management of the reserve. In this way the reserves will make a direct contribution to science, scientific training and the attainment of general educational goals, and, at the same time, provide valuable support for wise development, thus taking their proper place both as a cultural and an economic necessity.

The importance of this to the interests of the scientific community, to all who are concerned with conservation and indeed to the general public, suggests that IUCN might well consider establishing a special committee on forest reservations, which would seek to coordinate and control the use of these areas for the purposes discussed in this paper.

SUMMARY

Forest reserves, although often smaller in extent than national parks and some other preserved areas, have enormous and till now unappreciated importance both for science and practical application.

These reserves are natural laboratories and key-points for understanding the mutual relations between individual components of nature, undisturbed by human interference. They facilitate the study of spontaneous natural processes and of the development of each of the components and their complexes. They also give opportunities of comparing biocenoses, especially natural forests with economically exploited forests, for example in respect of soil development and formation, water economy, the growth of individual woody plants and forest growth structure generally, including spatial pattern and age differentiation, and development and succession of flora and fauna communities.

The network of nature reserves should therefore include the best examples of all significant natural forest communities and their regional variants. Thus established it can serve the purposes of scientific research in the field of forestry and natural science, both theoretical and practical, and be kept under permanent observation. Besides promoting scientific progress, it will provide for visual training in and teaching of natural sciences, an essential objective of general education, and will also make a positive economic contribution, so becoming both a cultural and economic necessity.

In conclusion, it is suggested that from the points of view of science, conservation and the public interest, IUCN should have a special committee on forest reserves, for the better coordination and control of these aims and objects.

RÉSUMÉ

Les réserves forestières, d'une étendue souvent moindre que celle des parcs nationaux ou d'autres zones protégées, présentent une très grande importance, insoupçonnée jusqu' ici, du point de vue scientifique et pratique.

Ces réserves constituent en quelque sorte des laboratoires naturels et des positions clefs pour l'étude et al compréhension des interrelations entre les divers éléments de la nature non soumis à l'action de l'homme. Elles facilitent l'étude de processus naturels spontanés et du développement de chacune de leurs composantes et de leurs complexes. Elles permettent également de comparer diverses biocénoses, en particulier des forêts naturelles à des forêts exploitées, par exemple en ce qui concerne la formation et l'évolution du sol, l'économie hydrique, la croissance de plantes ligneuses isolées et la structure de la croissance d'une forêt dans son ensemble, la distribution spatiale et la différenciation d'âge des arbres ainsi que le développement et la succession des communautés animales et végétales.

Le système de réserves naturelles devrait done comporter les meilleurs exemples de toute communauté forestière naturelle importante et de leurs variantes régionales. Etabli de cette façon, il pourra servir aux recherches scientifiques dans les domaines de la sylviculture et des sciences naturelles. De plus, ces réserves pourront servir d'illustration vivante à l'enseignement des sciences naturelles, ce qui est un des objectifs essentiel de l'enseignement général et apporteront également une contribution positive dans le domaine économique, devenant ainsi une nécessité à la fois économique et culturelle.

En conclusion, il semble souhaitable, dans l'intérêt de la science et du public, que l'UICN crée un comité spécial pour les réserves forestières, afin d'assurer une meilleure coordination et un meilleur contrôle de ces objectifs.

Section A (iv)

Multi-purpose use (Nature Protection) in Production and Protection Forestry

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INTRODUCTION

A complex biological entity like a forest, by its very nature, composition and location, has to be of multiple utility to the people for whose perpetual benefit it has to be judiciously managed and conserved eternally. With increasing population and heavy demand for diverse produce from forests, the need for increasing production from limited forest land by measures including intensive forestry is obvious, but this has to be accomplished with due safeguards for nature protection and the conservation of natural resources. This is already ensured under scientific forest management, as forestry and conservation go hand in glove because both aim at the same objectives.

THE CONCEPT OF MULTIPLE USE IN RELATION TO FOREST MANAGEMENT AND NATURE CONSERVATION

While 'conservation' is defined as 'the rational use of earth's resources to achieve the highest quality of living for mankind' (IUCN), 'forestry' is defined as 'the scientific management of forests for continuous production of goods and services' (Soc. Amer. For.). 'Intensive forestry' which aims at optimum utilisation of the productive potential of forests is defined as 'the practice of forestry so as to obtain the maximum in volume and quality of products per unit area, through the application of the best techniques of silviculture and management' (Central. For. Com.). The concept of 'Multiple Use of Forest Lands', as advocated by the Fifth World Forestry Congress, 1960, envisages the 'management of forest in a manner that will conserve the basic land resource, while yielding a high level of production in the five major uses—wood, water, forage, recreation and wild life—for the benefit of the greatest number of people in the long run'. In all four terms, viz. Conservation, Forestry, Intensive Forestry and Multiple Use of Forest Lands, the basic ingredient is the objective of maximum benefit to people in perpetuity without jeopardizing land resources. This is already implicit and practised in scientific management. Thus, in other words, scientific forestry takes care of, and, in fact, caters fully for the polyvalent role of forests according to national requirements, in consonance with the principle of conserving the nature and natural resources of the ecosystem. This polyvalent role can be illustrated by forestry practice in India with its wide range of geophysical patterns, flora and fauna, the diverse use of forests and heavy demand for various forest products and the fact that the protective role is as important as the productive. With increasing industrialisation and urbanisation, the bioaesthetic and recreational aspects of forests and other vegetation are receiving greater attention the world over. The protection of catchments of many multi-purpose river-valley projects, and the heavy pressure on forest for grazing of village cattle, are other factors of importance in Indian Forestry. The revised National Forest Policy of India, enunciated in 1952, was based on six paramount needs of the country of which the one for evolving a system of balanced and complementary land-use was significant in directing that each type of land was allotted to that form of use under which it would produce most and deteriorate least.

THE PRODUCTIVE ROLE OF FORESTS

(i) Essential requirements of man

The productive or material benefits from forests are usually more readily appreciated than protective owing to the direct use of numerous forest products in meeting the daily requirements of man viz. fuelwood, construction wood, other forms of timber, forage and grazing, agricultural implements, nutting and thatching material and numerous other items of wood and plant products, including medicinal plants and essential oils. For industrial development the role of the forests becomes even greater in the national economy, as wood is the basic raw material for many important industries like pulp and paper, rayon, plywood and other articles of processed wood, matches, mining, packaging and other wood working and saw-milling industries, as also in meeting large requirements of essential services such as railways, posts and telegraphs, defence and road systems.

This role of forests is more vital in an over-populated country like India with agriculture as the principal occupation and where industrialisation and other developmental activities are being vigorously pursued. The forests occupy only 75. 3 million ha out of a total land area of 327m. ha, forming about 23% of the area as against 48. 5% under agriculture. Though forests are distributed throughout the length and breadth of the country, their distribution is neither uniform nor equi-productive due to wide variations in climatic and edaphic conditions apart from biotic influences. The productivity zones vary from very low to relatively highly productive, the latter category being however very much restricted. Out of the 75 million ha of forests, nearly 65. 3m. ha are classified as productive, while 10m. ha are solely managed for their protective role in hilly and mountainous regions and the catchments of river valley projects. Further, out of the 65. 3m. ha of productive forests, merchantable forests account for only about 59m. ha.

(ii) The Forest Resource

In terms of composition, the proportion of India's forests which are coniferous and broad-leaved is not evenly balanced, the former being only about 6% and the latter nearly 94% of the forest land. The bulk of the forests, therefore, contain a multiplicity of broad-leaved species in varying proportions and of differing utility. Some of the most important and well known species are sal (*Shorea robusta*), teak (*Tectona grandis*), sissoo (*Dalbergia sissoo*), khair (*Acacia catechu*), rosewood (*Dalbergia latifolia*), Indian laurel (*Terminalia tomentosa*), benteak (*Lagerstroemia lanceolata*), sandal (*Santalum album*), gurjan (*Dipterocarpus* spp.), toon (*Cedrela toona*), gamari (*Gmelina arborea*) and poon (*Calophyllum tomentosum*). In the coniferous forests, the most important are chir (*Pinus roxburghii*), deodar (*Cedrus deodara*), kail (*Pinus wallichiana*), the fir *Abies pindrow* and the spruce *Picea smythiana.*

Ecologically the forests cover a wide variety of types on account of the diversity of climatic and geophysical patterns. The forests have been classified into 16 major climatic types, the principal broad groups being the Tropical, Montane Subtropical, Montane Temperate and Alpine. The flora ranges naturally from alpine to tropical and from xerophytic to the luxuriant evergreen tropical rain forests and lofty temperate coniferous vegetation.

A feature of Indian forestry is the State ownership of nearly all the forests, private forests forming a nominal 1. 7% of the forest area. Another important factor is that forests provide grazing for about 11% of the enormous cattle population of the country i.e. 336 millions, which is nearly 1/5th of the world's cattle population (1961).

(iii) Industrial requirements

One of the most important productive roles which forests in India are called upon to play is in meeting the large demands of forest-based industries whose development is essential for the overall economic development of the country. The total growing stock of the forests, as estimated in 1964-65, was of the order of 1442 million m^3 with an average growing stock of 32 m^3/ha. The average increment of merchantable forests is 0. 5 m^3 per ha though the potential productivity is nine times as much. The bulk of the production is fuelwood (about 14 million m^3), while that of industrial wood is about 8 million

m^3 from recorded and unrecorded sources. Although the production of industrial wood has increased nearly 2½ times since independence and is at present close to balancing the current demand, future requirements are estimated to be as high as 14 million m^3 by 1970, 32 million m^3 by 1980 and 50 million m^3 by 1985. The per capita consumption of industrial wood in India at present is about 0.02 m^3 only and this is going to rise steeply with over-all national development and the consequent rise in standard of living. Amongst the industrial woods, the most pressing demand at present is for pulpwood which is expected to be multiplied 23 times in the next fifteen years.

The important forest industries in India at present are the paper and pulp (production 0. 625m. tons), newsprint (31000 tons), rayon pulp (56900 tons), strawboard (65000 tons), fibreboard (19100 tons), particle board (8100 tons), plywood (28000 tons), and matches (8323 million gross boxes). Their growth, necessitated on account of increasing population and essential economic development, will depend to a large extent on the capacity of forests to supply the raw material. Although an area of about 9, 000, 000 ha has been planted during the first three plans to meet the growing requirement for industrial wood, the gap between supply and demand is likely to widen and will be 10 million m^3 in 1975 and 19 million m^3 in 1985, thus pointing to the increasing importance of forests and their development. This is proposed to be met to a large extent by increased tempo of plantation, more efficient logging methods and equipment, improvement of degraded forests and rational and complete utilization of all forest produce, particularly lesser-known species. A major break-through is the utilization of mixed hardwoods for pulping.

(iv) **Nature Protection and Conservation in Intensive Forestry**

In all these activities directed towards increasing production from limited forest land, the conservation of nature and natural resources including fauna and flora is ensured under scientific management of forests, the fundamental principle of which is the maintenance and improvement of the productivity of the site. Even in case of plantation forestry which involves clear-felling and planting, there should be no apprehension of disturbing the biological balance if the concept of forest as a dynamic ecosystem is recognised. Firstly, such plantations are small in proportion to natural forests and do not result in any significant change in the ecosystem as a whole which continues to be managed as natural forest. At present, man-made forests in India cover only about 1. 4 million ha which is hardly 1. 7% of the total forest area. Secondly, the recovery of indigenous flora is amazingly rapid under tropical and sub-tropical conditions: within a short time the typical local ground cover and understorey plants reappear, even under monocultures, following the opening up of the canopy thinnings and cultural operations carried out at regular intervals in the plantations. Further, profuse grass and herbaceous vegetation appears in the cleared fire-protection belts around plantations, which attract herbivorous fauna from adjacent forests. It is therefore no surprise that the population of chital *A. axis* has been observed to have increased in the eucalyptus plantations of the U.P. *terai.* Other fauna are also attracted to these plantations as they provide welcome open spaces in the midst of continuous natural forest. In addition to these factors, preservation of indigenous fauna and flora is ensured by establishment of game sanctuaries, national parks and nature reserves. Representative vegetation is also preserved in Preservation Plots established in various forest types of India where outstanding specimens of different species are scheduled as Protected Trees.

(v) **Requirements of fuelwood**

Fuelwood forms the principal demand of both urban and rural populations and far outweighs the consumption of other types of wood. Of the total energy consumed in India, nearly 40% is derived by burning wood, 9% from cattle dung and about 12% from vegetable waste. The total consumption of fuelwood is nearly 100 million tons, out of which forests produce about 14 million tons and the rest comes from lands outside forests. On account of the increasing demand for fuelwood, the country's forests and woodlands will continue to bear largely the burden of supplying fuel requirements, but need to be supplemented by creation of village and farm woodland on an increasing scale.

(vi) **Contribution to Food Production**

Apart from the influence of forests on the protection of agricultural land from floods, soil erosion, accelerated run-off and desiccation, an increasingly important contribution

of forest land to food production has been the large scale *taungya* (agri-silviculture) plantations designed to augment production of industrial and other wood. Under such agri-silviculture, the forest crop is raised in conjunction with an agricultural crop which is grown for the first two or three years. In the State of U.P. alone, nearly 10, 000 ha are leased out annually for food grain production under the *taungya* system.

(vii) **Minor forest products**

Although termed 'minor', these are of great utility and financial value and are of considerable importance commercially. They include kutch, resin, fatty and essential oils, tans, dyes, medicinal plants, *bidi* leaves, fibres and flosses, bamboos, grasses, canes, honey, hides and skins and wild life. A number of these products are used in important industries and the total production of minor forest produce in India is of the order of Rs. 158 millions as against Rs. 585 millions from major forest products. In terms of exports, minor forest products excel major forest products. During 1967-68, the value of exports of the former was Rs. 125 millions against Rs. 75 millions of the latter.

(viii) **Contribution to National Economy**

The financial contribution of forests to the economy of the country is not insignificant. The income from forestry is about 220 crores out of a total national income of 16, 692 crores, while revenue from forests is of the order of 98 crores out of a total national revenue of 4010 crores. Revenue from forests during 1966-67 was 2. 44% of the national revenue. In addition, forestry plays an important role in the foreign trade of the country and accounts for nearly 1.7% of total exports.

PROTECTIVE ROLE OF FORESTS

The protective role of forests has since long been recognised though some of its intangible aspects are not always easily perceptible. Various forest influences have been under intensive investigation in many countries, forming the basis of action-oriented programmes.

The direct effects of forest cover result from the tree canopy and the shrubby vegetation, by which the ground is shielded from direct exposure to the sun, rain and wind. The flow of air currents is retarded by the physical obstruction of the canopy. Leaf litter and humus tend to accumulate to form a beneficial spongy layer which has a high absorptive capacity for water and protects the soil from the force of rainwater, which is already reduced through interception by the canopy. This absorptive capacity, along with the channels and cavities formed by the root systems of vegetation, increases infiltration.

The moderating influences of forest cover on temperature is due to its effect on factors such as solar radiation, wind, humidity, soil temperature, interception of precipitation and evapo-transpiration. Vegetation, particularly multi-tiered, has a marked effect on micro-climate in and around forests. Though claims that forests affect local rainfall substantially are open to question, it is generally recognised that forests tend to increase rainfall (i) to a slight and possibly measurable extent by their orographical effect, (ii) to a variable but significant extent by bringing about occult precipitation through condensation of moisture in the form of dew and mist and (iii) to a substantial extent by causing, under certain conditions, instability rains. The influence of forest cover on water supply, soil stability and the stream flow regime depends on several factors, surface conditions, which are readily modified by land use practices, being one of the most important. Destruction of vegetative cover exposes the protective humus layer to rapid disintegration and to the impact of rain and wind. Progressive deterioration of the micro-flora and micro-fauna, loss of root systems and progressive compaction of soil, tend to increase surface runoff and decrease water infiltration. The surface runoff in turn, lowers the soil porosity. This cycle tends to bring in a condition of low infiltration and storage capacity in the watershed, excessive runoff, high floods during rains and dry stream beds otherwise.

While the influence of forests on the water regime is most marked in hilly tracts, their effect in breaking the force of winds and arresting wind erosion is marked in the drier

plains. Forest cover in the form of windbreaks or shelterbelts mitigates the desiccating action of wind and directly benefits the intervening agricultural crops.

The role of forests in soil and moisture conservation has been repeatedly emphasized. Forests afford protection against all forms of erosion except the geological processes. Though the role of grasses in arresting soil erosion as compared to forests is debatable, the efficiency of forests particulary in hilly tracts is certainly more reliable. Afforestation combined with suitable engineering measures gives the best results in soil and moisture conservation programmes.

The protective aspect of forestry has an overwhelming impact on land economy under the Indian conditions. The area under forest ranges from the almost barren to the fully stocked, with topography ranging from mountain slope to plain. Nearly 78 million ha form the watersheds of important river systems, whose continued utility depends upon adequate protection through vegetative cover at strategic places.

(i) **River valley projects**

In a developing economy, water resources have come to be regarded as essential for meeting the demands of irrigation and hydroelectric projects. In India large water storage projects have been undertaken and the total water storage capacity planned is about 185000 million cubic metres. Out of the projects completed up to and including the third five year plan, an irrigation potential of 17. 40 million ha at a cost of over Rs. 13, 000 million had already been created. The continued utility of these projects depends upon the rate of siltation and their economy is basically dependent on the protective functions of vegetative cover in the watersheds.

Surveys undertaken in the catchments have shown that the rate of siltation in some of the major projects is rather high. It has been shown that nearly 20% of catchment areas is affected by serious erosion and forms the major source of silt load. The necessity of intensive soil conservation measures in these catchments is demonstrated by the actual results achieved under schemes already undertaken. For example, in the Machkund project, the average silt inflow per annum has been progressively reduced to about 0. 623 million cubic meters as against 1. 25 million cubic meters prior to treatment. Similarly observations in Damodar Valley from 1959 to 1966 indicated that the total silt discharge in cubic metres per sq. km, has been reduced from 1062 to 219 as a result of intensive protective works including afforestation.

(ii) **Ground water resources**

These, which are so essential for providing for the minor irrigation and water needs of the community, depend to a great extent on recharging which is related to the vegetation cover in the catchments.

(iii) **Rehabilitation of degraded forests, wastelands and ravines**

There are considerable tracts of poorly stocked forests, or forests in a state of degradation due to various biotic factors,—wastelands and ravines which require rehabilitation both in the interest of protection as well as production. The area of wastelands in the country is about 50 million ha, of which ravines cover 2. 36 million ha, and a sizeable proportion of this falls within the forest estate of the country.

(iv) **Shelterbelts and windbreaks**

The protection of agricultural lands in arid tracts from desiccation by wind and the advance of shifting sands, is essential in maintaining or even increasing productivity from agricultural lands. Shelterbelts and windbreaks are now considered to have a definite influence on modifying adverse climatic effects. Similarly in the protection of canal banks, plantations, which in addition to checking erosion can serve the fuel and small timber needs of the local population, have a definite place and need to be maintained along old canal systems and created where new canals are opened

CONCLUSION

As will be evident from the foregoing discussion, both the productive and the protective roles of forest are important to the country's well being and development. In fact they are complementary, but where protection aspects are of overriding importance such as protection of mountain slopes and catchments, conservation of soil and moisture, and reducing the siltation of the reservoirs, they must be given precedence. This has also been adopted as a basic principle in the formulation of forestry development schemes in the Fourth Plan.

FORAGE AND GRAZING

The problem of grazing and provision of forage and fodder for the cattle is an inseparable part of the village economy in India, and is socio-economically indispensable. The cattle population in India is very large (336 million according to the 1961 census, which is almost one fifth of the total world population). In India about 11. 5% of the cattle population depends upon forest grazing. The pressure of grazing in accessible forests is greater than other areas and the forests have to cater for both grazing and fodder.

In the National Forest Policy of 1952, the subject of forest grazing and supply of fodder to the villagers has been given due consideration. Though the policy recognised forest grazing as one of the four vital needs to be catered for by forest resources, it emphasises the need for controlling grazing particularly in Protection forests. The grazing and provision of fodder for cattle has, therefore, to be included as one aspect of mutliple land use, taking maximum care to ensure other goods and services from forests.

BIO-AESTHETIC AND RECREATIONAL ROLE OF FORESTS AND PRESERVATION OF FLORA AND FAUNA

The public use of forest land is increasing rapidly all over the world, due to urbanisation and the greater need for recreation. Amenities such as scenic beauty, sport, recreation, scientific study, nature conservation, including the wild life which the forests sustain, make the role of forest resources truly multi-purpose. Nature conservation, therefore, is an integral part of the management of forests. There are nearly 500 species of mammals, 2100 of birds and 30, 000 of insects in the forests of India and their conservation is intimately associated with the preservation of their habitat. At present India has six national parks, 126 sanctuaries, 22 zoological gardens and two zoological parks and it is proposed to make provision for a considerably larger number in future development plans.

REFERENCES

Brooks, C. F. P. (1927).—The Influences of forests on rainfall. *Empire Forestry Journal*, Vol. VI, 1927.

Central Forestry Commission, Govt. of India (1969).—*Forest Statistics. Bull.* Nos. 6 & 8.

F.A.O. Rome (1962).—Proceedings of the Fifth World Forestry Congress, U.S.A., 1962.

I.U.C.N. Morges, Switzerland (1968).-This is IUCN.

Kulkarhi, D. H. and Qureshi, I. M. (1968).—Grazing and Range Management in India. Ninth Commonwealth Forestry Conference.

Qureshi, I. M. and Dabral, B. G. (1963-64).—Evapo-transpiration and infiltration, factors contributing towards flood control measures in forested watersheds. Northern Forest Rangers College Magazine, Dehra Dun.

Ranganathan, C. R. (1949).—Protective functions of Forestry. Proceedings of the United Nations Scientific Conference on the Conservation and Utilisation of Resources.

Society of American Foresters, Washington, D.C. (1950). Forestry Terminology.

U.S. Department of Agriculture (1940).—Influence of vegetation and watershed treatment on run-off, silting and stream flow. Publication No. 397, 1940.

Wilm, H.G. (1956).—The effect of forest cover on water supplies. Proceedings 12th Congress International Union of Forest Research Organisations, Oxford.

Nature Conservation as a Supplementary Objective of Protective and Productive Forestry

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Nature conservation, for purposes of this discussion, is the preservation of natural populations of plants and animals in natural communities. It is well served in those parks or natural areas which have this objective as a primary purpose, and is poorly served in the cultivation of wild animals in zoos or wild plants in arboreta. Somewhere between, presumably, are the extensive areas of forest land which still clothe the globe. These, even if of native species, are subject to major human uses other than a perpetuation of all the natural biota. The potentialities of nature conservation as a supplementary objective in various sorts of forest utilization is the subject of this review.

Natural forest systems, of course, differ widely in diversity. Some contain hundreds of species of dominant vegetation and animals, while others are subjected to a major control by only a few species. The potential diversity of a forest is largely a function of the variation of the environment; variation in bedrock, soil, microclimate, as these things are controlled by altitude, aspect, slope, microrelief, etc. But diversity of habitat is not sufficient for biotic variety unless there is a diversity of organisms to take advantage of the potential. The actual richness of the biota of any particular forest area, then, depends upon the potential diversity plus the success which organisms have enjoyed in filling the various ecological niches: that is—in realizing the habitat potential which the site provides.

When an environment is relatively stable over a long period of time, there is an opportunity for adaptation through natural selection of genetic advantages. Highly adapted organisms are highly efficient so long as the conditions to which they are adapted continue to prevail. In contrast, when the environment is relatively unstable the fittest organisms tend to be those with a broad ecological tolerance. These are adaptable species, able to cope with environmental change.

These differences, among different species, in the amplitude of their ecological adaptability, are reflected in biotic survival or extinction when forest habitats are subject to disturbance.

The natural forest is, of course, subject to disturbance—natural disturbance. Some sorts of disturbance are frequent, even annual. These would include annual flooding, the periodic, i.e. falling of over-mature trees, or, on a longer periodicity, the undercutting of river banks or the outbreak of lightning-caused fires following drought. Even the actions of animals, in rooting or grazing on the forest floor may be considered disturbance of a sort. Man, also, may occur in the natural forest. If he does no more than frighten or kill some animals, or trample or pluck certain plants, his ecological effect is on a par with any other large mammal.

It is when man first becomes a unique ecological force within the forest that we can speak of the exploited forest, since at this stage man uses his peculiarly human abilities to disrupt the forest system, with little or no consideration beyond the satisfaction of immediate need. Man increases the effect of certain natural disturbances, particularly the frequency of fire in temperate forests. And man adds new ecological events, such as herding domestic livestock in the temperate forest and practising slash-burn agriculture in the tropics.

As human populations increase, man exerts ever more ecological pressure on the forest, not only through fire, grazing and shifting agriculture, but the removal of wood for firewood or charcoal, and, more locally, to satisfy his needs for timber, mine-props, smelter fuel and the like. Man's heavy predation on game may well diminish the food base for native predators. The ultimate ecological change, beyond the scope of this re-

port, comes when man destroys the forest and replaces it with some different biotic community.

The extent of these man-caused changes in the exploited forest depends on the interplay of man-caused events and the ability of the forest to regenerate following disturbance.

When the forest is intensively used for fuel and grazing there are ecological changes favouring a pioneer biota, and often a compaction of the soil surface reducing moisture penetration, with resultant increased run-off and reduced soil moisture and ground water, springs, and summer Streamflow. In addition, there may be direct competition for food between domestic and wild herbivores. Under intensive use, litter may be removed to provide bedding for domestic animals. This was recognized as the cause of a substantial loss of nutrient elements from the forest system as early as 1876 (Ebermayer, 1876). Most such ecological effects, however, have been noted and evaluated much more recently, if at all. Such changes have destroyed wholesale the former forest biotas in much of the Mediterranean region and the Near East, and are currently causing a steady shrinkage, for example, in those of India (Schaller. 1967).

With the spread of agriculture, extensive forests are broken up into smaller units, making all the forest products, including game, more accessible to man, and hence more heavily exploited. This sort of fragmentation of habitat led directly, in medieval Europe, to the extermination of the aurochs and the near-extermination of the forest bison. Today it is the basic cause of the loss, or near loss, of the lemurs of Madagascar (Fisher, Simon and Vincent, 1969), to cite one example among many.

These activities of man, in using the forest for his immediate needs, without regard for the perpetuation of the forest or its fauna, are still widespread. They are, in fact, a characteristic of much of Asia, Central and South America, and Africa. And as human populations increase and the amount of mechanical power available to man increases, these exploitative pressures grow stronger.

It is only where some measure of human security from hunger and discomfort has been reached that what we shall term *forest husbandry* is possible. This typically has two sequential phases, the protection or custodial, and the managerial or production.

1. *The custodial or protection stage* comes about as the full swing of the pendulum away from exploitation. While certain types of forest exploitation progressed to the establishment of other systems, agricultural or urban, for example, much forest area was left in altered form which was, for various reasons, some aesthetic, some materialistic, some sentimental, some scientific, regarded as highly undesirable. So efforts are made to eliminate the disruption of exploitation and to afford 'protection'.

These forests are usually protected from fire and often as well from disease, insect attack, heavy browsing by wild animals and other controllable events which are thought to interfere with a maximum of plant cover.

As the vegetation changes under this protection, the watershed quality of the forest changes. That is, it becomes more capable of absorbing rain and snow-melt water, thus reducing flooding and erosion (Colman, 1953). For this reason, forests whose primary function it is to cover watersheds are the most common sort of protection forests.

The protection of forests, as long as only man-caused and not natural events are controlled, tends to permit them to revert to their natural state. Such protection, therefore, is favorable for nature conservation.

Unfortunately, in the process of guarding against man-caused disturbance, non-man-caused or 'natural' disturbance is frequently also controlled. This results in unnaturalness of another type—perhaps less objectionable in some ways, but, conceivably, no better for nature conservation. In eliminating man-caused fire, for example, we frequently alter the periodicity of lightning fires as well. This may cause an 'unnatural' imbalance between organisms and alter populations as dramatically as the man-caused fire we rush to control.

Protection, then, may exclude some of the natural events which contributed to the heterogeneity of the forest habitat, and to this extent protection can keep the forest from developing its full potential complement of ecological niches. Thus it has been found that the stands of red pine (*Pinus resinosa*) in the Great Lakes Region of North America can-

not be preserved if fire is completely eliminated. There has also been doubt in ecological circles regarding the perpetuation of the stands of redwood (*Sequoia sempervirens*) without disturbance.

The protection forest, in spite of these limitations, is usually an improvement, in terms of the objectives of nature conservation, over forests subject to exploitive use. As the protected forest reverts towards its pre-man state, mobile organisms can once more colonize it. Less mobile ones, however, will need to be reintroduced by man if they are to once again make up a part of the biota. For example, the wapiti (*Cervus canadensis*), which was once widely exterminated throughout the forests of western North America, was almost as widely and successfully reintroduced during the days of protective forestry.

It is evident that the needs of man and of nature conservation will be served in some forests by the protective phase alone, particularly if such husbandry is well conceived and executed. However, the systems resulting from protection alone will not satisfy all of man's requirements of the forests. Most forests are managed for some specific product or products and the manipulation of the system goes beyond protection from disturbances. Such forests we will term *production* forests. Purposes of management may be singular, such as maximizing the yield of one particular type of wood, or plural, where wood production, water production, game production and aesthetic values are combined.

The objectives of forest management, singular or plural, should reflect the philosophy and desires of the owners, whether they be public or private agencies. Whatever these may be, the biological and ecological principles necessary to successful manipulation aimed at attaining these objectives are the same in all circumstances. It is in his manipulation of ecological phenomena that the forester attains the desired ends. In most production forests today, the primary objective is the wood yield, and the forest vegetation is modified to produce a rather narrow range of the species, ages, and shapes of trees that are considered most desirable for certain uses. This, frequently, embraces only a part of the diversity that might be found naturally on an area.

There are several types of forestry operations which can be reviewed briefly in the light of their impact upon natural systems. Silvicultural operations are frequently divided into two broad groups; the *intermediate cuttings* which are designed to mold an existing stand of forest trees in a desired direction and the reproduction methods which are designed to harvest one crop of trees and make way for a succeeding generation. These have varying effects upon the natural system. *Thinnings,* for example, reduce the density of young stands of trees. Such reduction in density, made for the primary purpose of stimulating the growth of the remaining trees, may at the same time completely change the beneath-canopy environment. Normally, under a young stand of conifers whether it be of natural or artificial origin, light levels are so low and root competition so severe that few other plants can exist. Thus, while the young conifer stand may provide acceptable protective cover for animals, it provides little in the way of food and other necessities. Thinning speeds up the natural process of population reduction and may bring about a diversity of biota in a young stand that would not naturally occur for several decades. *Pruning* which removes the lower branches of the crown to provide knot-free wood may have very much the same effect in raising and lightening the canopy and providing a more hospitable environment for other organisms beneath the canopy. On the other hand, *sanitation cuttings,* which remove trees of potential danger as foci of disease or insect epidemics, may guard the system against a devastating natural disturbance, but at the same time remove trees which may be potential nesting sites or food supply for certain animals such as squirrels or woodpeckers. Similarly *improvement cuttings,* which are designed to remove trees of undesirable form or species for a particular wood product, may remove components of the stand which are of very considerable ecological importance to other flora and fauna in the natural system. Obviously, the use of insecticides, herbicides, or silvicides to control one part of the system may effect other parts of the system directly.

Reproduction methods embrace a range of degrees of tree removal from single tree selection to clear-cutting entire stands. This is within the natural spread of diversity, since in climax forests one mature tree at a time may die or an entire stand may be destroyed by fire, insects, disease or similar phenomenon. At the same time man's methods of regenerating a forest may not entirely parallel processes which achieve the same end in nature.

One of the most extreme departures from natural circumstances is the clearing of

entire forests, scarification or burning to prevent competition from non-tree plants and the regularly spaced planting of commercially desirable species. Under these conditions the practice of silviculture closely approximates agricultural husbandry. At the same time, we must not be too quick to condemn such practices because the outcome may not be very different from that naturally occurring after frequent fire or similar disturbance.

Where the preferred commercial species is not native, but introduced, an additional step away from natural conditions has been taken. The problem of exotic species, whether plant of animal, is a serious one in terms of nature conservation. The world is full of examples of exotics that have, for all practical purposes, made certain natural systems impossible to reproduce. The question, though, is too broad to be elaborated upon here. Suffice it to say that exotic trees, while obviously of substantial ecological importance where they flourish, can be controlled, if need arises, much more easily than many other exotic organisms.

Equally serious, perhaps, is the wood-oriented forester's preoccupation with what is termed 'full stocking'. Under these conditions, any growing space that is not occupied by the 'right' kind of tree is considered wasted. The natural forest rarely has such conditions obtaining over any but very small areas. Openings in the tree canopy are common and provide that diversity of habitat which is required by many species of plants and animals.

The narrow-spectrum forest manager is forever planting trees in these forest openings, trees which grow at least well enough to shade out much of the understory. The result is an impoverishment of the native flora and fauna.

Extreme examples of forest homogenization may be seen in Central Europe, where the native mixed deciduous-coniferous forest has been largely replaced by plantations of Norway Spruce (*Picea abies*) and, on sandier sites, Scots pine (*Pinus silvestris*). These forests were originally preserved from the incursions of agriculture as hunting grounds for the nobility, and so their native fauna was to some extent husbanded. With the shift in forest composition as a result of the emphasis on spruce and pine for wood production, there was increasing difficulty in maintaining the game, since its habitat was being altered more and more radically. The larger species of mammals could persist only where artificial food was provided. The present biota of such a forest are a pale reflection of the native biota and the basic reason is habitat change. Because of the slow growth of dominant forest plant species, it is not easy to reverse such changes.

Over recent years, there has been a broadening of forest management objectives. Where once the prime element in managerial decision was wood production, more and more demands and opportunities for goods and services from the forest are evident as time goes on. The watershed quality of the forest, its recreational possibilities, its aesthetic appearance, its suitability as habitat for certain animal species are all increasingly important, especially in industrialized countries. It is in response to this increasing diversity of management objectives that the United States Forest Service, for example, now speaks of *multiple-use* forestry. Further, an increasing amount of ecological information is being obtained on the effects of one sort of manipulation on other values: the effects of logging roads on watershed quality, erosion, siltation and landscape aesthetics; the effects of prescribed burning on wildlife habitat and on air pollution and the effect of insecticides on aquatic invertebrates—are common examples.

As an outcome of the increase in knowledge, and the broadening of objectives in forest husbandry, there is an ever-increasing awareness of the possibilities of integration of many different objectives within a single forest. Manipulation of different sorts on different sites can maximize different objectives within a single plan. At our present early stages of sophistication, we can perhaps but dimly comprehend what the possibilities are. But a few crude ideas come quickly to mind.

Every forest is somewhat heterogeneous in its substrate and microclimate. Within this variety, certain sites or locations have a very high growth potential for desirable species of timber trees. Such sites will well repay a heavy investment of certain types of manipulation, such as planting, thinning, pruning, and perhaps fertilization.

Other sites, because of altitude and exposure, are critical seasonal ranges for native un-

gulates. Their quality in this respect could be increased by such practices as certain types of forest cutting, selective use of herbicides, or fertilization.

Still other sites, by virtue of their characteristics, would be poor for timber production or ungulate winter range, but well suited for maintenance in a near-climax state to provide habitat for the peculiar climax biota, to insure a dry-season stream-flow and provide for human recreation.

Such considerations lead us to believe that the ends of nature conservation can potentially be served in production forestry. The extent to which this potential is realized will depend in each particular instance on the recognition of definite ecological aims, an understanding of the manipulative processes through which these aims may be achieved, an adoption of these aims as among the recognized objectives of husbandry and an integration of these aims in the other objectives of husbandry in the management of the forest.

The application of these concepts to nature conservation is not entirely visionary, by any means. The example of the rare Kirtland's Warbler (*Dendroica kirtlandi*) is a case in point. This bird breeds in the Lower Peninsular of Michigan (U.S.A.) in young forests of the native jackpine (*Pinus banksiana*) preferably in thickets of trees between 6 and 18 feet in height, occurring in areas at least 80 acres in extent. Specifically the birds seem to require thickets of pine-branches near the ground for successful reproduction (Mayfield, 1960). To encourage this species, a substantial area is now being manipulated, mainly through controlled burning, specifically to increase and maintain this vital element in the warbler habitat (Fisher, Simon, and Vincent, 1969). Properly designed patterns of harvesting and planting could probably achieve the same ends.

Nature conservation lies within the biologically feasible range of objectives of forest husbandry. The degree to which it will emerge as part of the managerial goal lies in the realm of social decision.

REFERENCES

Colman, Edward A. 1953. Vegetation and Watershed Managment. New York Ronald Press. XV. 412 pp. illus.

Ebermayer, E. 1876. Die gesammte Lehre der Waldstreu mit Rücksicht auf die chemische Statik des Waldbaues, Resultate der forstlichen Versuchstationen. Bayerns. XII. 116 pp. Julius Springer, Berlin.

Fisher, James, Noel Simon and Jack Vincent. 1969. Wildlife in Danger. The Viking Press. 368 pp.illus.

Mayfield, Harold. 1960. The Kirtland's Warbler. Bull. 40 of the Cranbrook Institute of Science, Bloomfield Hills, Mich. XV. 242 pp. illus.

Schaller. George B.1967. The Deer and the Tiger. Univ. of Chicago. Press. 370 pp.illus.

SUMMARY

Success in nature conservation is related to the extent that the original natural biota is maintained in its full diversity.

Natural forests maintain original biota which may be quite diverse or quite simple, depending largely on the stability of the environment—a more stable environment encouraging evolutionary species-diversification through natural selection. Organisms which are highly adapted genetically are less well able to tolerate ecological change than those which are highly adaptable. The tropical forest is especially rich in the former sort.

Man may be part of the natural forest. More often he is an ecological dominant. In the exploitative phase of man's use, nature conservation suffers through such pressures on the habitat as frequent fires, heavy livestock use, excessive wood-cutting, and replacement of forest vegetation by cultivated plants. Where the level of human security permits, the exploitative is replaced by the *protective* phase of forestry. Under protection the biome

rebuilds toward its 'natural' state. Nature conservation, then, is a feasible supplementary objective of *protective forestry.*

Protective forestry is frequently followed by forest husbandry, first with limited or narrow objectives, gradually broadening in the spectrum of objectives sought in the managerial strategy. Forest husbandry with narrow objectives—chiefly wood production-fails to maintain the full natural biota because of habitat changes connected with management for a forest of a few commercially desirable tree species, densely stocked, and of only young, vigorous individuals. This is the present tendency in *production* forests. However, as the spectrum of objectives in forest husbandry becomes broader, values related to nature conservation tend to become managerial goals more frequently. Given ecological knowledge which may be applied within the framework of forest husbandry, and the recognition that the aims of nature conservation are to a large extent compatible with other forest management aims, nature conservation as a supplementary objective of productive forestry becomes increasingly feasible.

Résumé

La réussite des projets de conservation de la nature dépend de la mesure dans laquelle l'écosystème natural original peut conserver toute sa diversité.

Les forêts naturelles conservent un écosystème original extrêment varié ou très simple suivant le degré de stabilité du milieu naturel—un milieu plus stable favorisant la diversification des espèces par sélection naturelle. Les organismes hautement spécialisés du point de vue génétique sont moins aptes à supporter des variations écologiques que des organismes très adaptables. La forêt tropicale comporte nombre particulièrement élevé de types hautement spécialisés.

L'homme peut être une composante de la forêt naturelle, mais il représente le plus souvent une dominante écologique. Au cours de la phase d'exploitation, l'homme impose au milieu naturel des pressions importantes telles que des incendies fréquents, le surpâturage par le bétail, l'abattage excessif des arbres et le remplacement des forêts par des cultures. Là où le niveau de prospérité de l'homme le permet, la phase d'exploitation est remplacée par une phase de *protection* de la forêt. Protégé, l'écosystème tend à retrouver son état 'naturel'. A ce stade, la conservation de la nature peut parfaitement s'intégrer aux objectifs d'une *sylviculture protectrice.*

La phase de protection de la forêt est fréquemment suivie d'une phase de mise en valeur rationnelle, qui d'abord des objectifs limitées ou étroits, pour rechercher ensuite peu à peu une gamme de possibilités plus étendue et plus variée. Un type de mise en valeur des forêts qui ne poursuivrait qu'un seul but—essentiellement la production de bois—ne peut assurer le maintien de l'intégrité d'un écosystème natural, ceci en raison de la transformation de l'habitat sous l'effet de la plantation de quelques essences d'intérêt commercial en peuplements denses, ne comportant que des individus jeunes et vigoureux. On observe actuellement cette tendance dans les forêts de *production.* Toutefois, à mesure que les objectifs de mise en valeur des forêts s'élargissent, les valeurs de conservation tendent à être plus fréquemment intégrées dans les plans d'exploitation. Comme la gestion forestière repose de plus en plus sur des connaissances écologiques et qu'il est démontré que les objectifs de la conservation sont loin de s'opposer à ceux de la sylviculture, la conservation de la nature semble, dans ces circonstances, pouvoir devenir un objectif supplémentaire de la mise en valeur des forêts de production.

SECTION A (iv): POINTS MADE IN DISCUSSION

It has to be recognized that certain types of intensive forestry, e.g. rubber plantations, can never be reconciled with other uses such as recreation and wildlife conservation. But from the latter point of view, the situation can usually be ameliorated in planning the pattern of plantation (Poore, U.K.).

The suggestion in our paper that some animal species are adapting themselves to plantations, notably of exotics such as eucalyptus, is derived from observations made on frequent visits rather than from any specific detailed studies (Qureshi, India).

The difficulty is that it is usually considered uneconomic to intersperse plantations, for example of sal or teak, with areas of mixed forest which is essential for maintaining wildlife (Ranjit Sinh, India).

Although afforestation is considered the best means of watershed control, especially in hilly country, there are circumstances, depending on environment, the economic situation, the degree of devastation and so on, which may call for other measures in addition to afforestation, for example the use of efficiently managed grasslands, planned farming and engineering works. Much more research is needed into the multitude of problems involved and co-ordination, at both the national and international level, of research, experimental work, control measures and documentary sources of information and guidance, is highly important. The latter could perhaps be achieved if an international organisation such as IUCN were to circulate a carefully designed questionnaire on water catchment management, carry out an analysis of the data collected and make the results of such an analysis generally available (Salverda, Netherlands).

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The Ecological Impact of Pollution

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INTRODUCTION

Local pollution has always existed; even before the advent of man poisonous gases from volcanoes and oil seepages killed organisms locally. However, the problem today is new, without precedent in the past: life on the earth is increasingly threatened by man-made pollution. The present situation has been caused by man's rapid population increase and by rapid industrialisation in many parts of the world. Industry has not only increased the amount of chemicals already present, for example SO_2, CO_2 and radioactive substances. but has produced totally new chemicals, for example most pesticides and polychlorinated biphenyls; living organisms are now having to adjust to these substances for the first time in their evolutionary history. I shall illustrate the ecological nature of the pollution problem, which exists today, by examining one type of pollutant—the persistent organochlorine insecticides.

ORGANOCHLORINE INSECTICIDES

The persistent organochlorine insecticides—DDT, TDE (=DDD), aldrin, dieldrin, heptachlor, BHC and toxaphene, and other related substances—are used extensively in preventive medicine, agriculture, horticulture, forestry and industry. Thanks to refined methods of chemical analysis it is now possible to measure residues of these substances at very low concentrations. Surveys have shown that residues of organochlorine insecticides and their metabolites now occur throughout the world, not only in soils, plants and animals in sprayed localities but also in fish and seabirds from the Atlantic, Pacific and Antarctic oceans, despite the fact that these compounds have very low solubilities in water (Moore and Tatton 1965, Sladen *et al* 1966, George and Frear 1966, Tatton and Ruzicka 1967). They have also been detected in rainwater (Wheatley and Hardmen 1965). DDT and BHC were first used on a large scale in the late 1940's; so, all life on the earth has been confronted with a variety of chemically related but entirely new environmental contaminants within the last thirty years. The residues found in animals range from extremely low ones which almost certainly have no toxicological significance to those which are indicative of acute poisoning. Many organisms in Europe and North America contain residue levels in between these extremes: only by doing extensive toxicological work in the laboratory and population studies in the field can their biological significance be determined.

Organochlorine insecticides like other pesticides are not specific poisons; therefore whenever they are applied they are bound to affect organisms other than the pests against which they are used. However, organisms vary greatly in their sensitivity to the same compound, for example, endosulfan is less toxic than DDT to bees but enormously more toxic than DDT to fish (the LD50 for the bees in 70 mg/kg, the TLm—24 hours for the fish is 0. 00002 ppm). Even quite closely related species differ in their sensitivity to the same compound (Grolleau and Giban 1966). No organism lives in isolation: each is part of a number of different ecosystems whose operations are usually little understood; therefore whenever a pesticide is applied to a crop not only does it have toxic effects which differ from species to species, but also indirect ecological effects on food supply, and on prey/predator and competitive relationships (Moore 1967). The net effect of the application of a pesticide on an ecosystem results from the interaction of numerous population changes of these kinds within it. Owing to the great complexity of each situation it is extremely difficult to predict effects on any one species. However, pesticides,

like other pollutants, tend to reduce species diversity, and cause population increases in resistant species. The effects of a pesticide are likely to be more prolonged and more far-reaching when that pesticide is persistent because it continues to act on populations for a long time after application—in some cases significant activity occurs years later.

As we have seen already, persistent pesticides spread out from the areas where they were applied into the biosphere and so become environmental contaminants. Very few studies have been made on the biological effects of organochlorine insecticides on whole species. Most of the work has been on terrestrial birds of prey, in which residue levels of organochlorine insecticides are on average much higher than in other organisms (Moore and Walker 1964). This is due to the accumulation of organochlorine insecticides in their prey which in turn results from their considerable solubility in fat. There is now very good evidence that the uprecedented declines of the Peregrine *(Falco peregrinus*) and other birds of prey in the Nothern Hemisphere during the last thirty years have been caused principally by a combination of acute and sub-lethal effects of organochlorine insecticides, principally by dieldrin and DDT respectively (Hickey 1969).

Recently much has been learned about the sub-lethal effects of organochlorine insecticides on birds. A decline in eggshell weight has been observed in those species which contain most organochlorine insecticide both in the United Kingdom and in the U.S.A. The declines started at about the time that DDT was introduced into widespread use (Ratcliffe 1967, Hickey and Anderson 1968). Laboratory studies have shown that DDT and its metabolites can cause changes in eggshell weight. Possible mechanisms are suggested by the fact that the metabolism of steroid hormones is affected by DDT and dieldrin and by the fact that DDT has pronounced effects on the thyroid gland at doses as low as 1/lOth of the lowest lethal dose recorded in the experiment (Peakall 1967, Jefferies in press).

EFFECTS OF ORGANOCHLORINE INSECTICIDES ON AQUATIC SYSTEMS

All too little is known about the effects of organochlorine insecticides on aquatic systems but a few examples will be summarised briefly to illustrate some special features of the problem. Organochlorine insecticides are mainly applied deliberately to freshwater in order to control vectors of disease and nuisance insects, and to control insect pests of rice. The use of TDE, which is also a metabolite of DDT, to control midges in Clear Lake, California, resulted in the fish obtaining large residues. One of the principal fish predators in the Lake, the Western Grebe (*Aechmophorus occidentalis*), was virtually exterminated by eating the contaminated fish (Hunt and Bischoff 1960). Thus the use of an insecticide, chosen because of its low toxicity to birds, caused severe damage to a bird species as the result of accumulation of the insecticide in its prey. The use of dieldrin, a much more toxic compound, to control rice pests can result in large-scale casualties to fish in paddy fields (Rudd and Genelly in 1956). Thus efforts to increase carbohydrate production can cause an important loss of protein for local human populations.

In temperate regions organochlorine insecticides are applied to freshwater less frequently; therefore it is noteworthy that in these areas residues are found in freshwater organisms and also in marine ones from the surrounding coasts. For example, in Britain, where very little organochlorine insecticides are applied to freshwater, the fish-feeding Herons (*Ardea cinerea*) contain on average more organochlorine residues than any other bird species in Britian (Prestt 1969). Also, all the eggs of British seabirds which have been analysed during the last five years in a study undertaken to monitor changes in environmental contamination by these chemicals, have contained residues of one or more of them. The total organochlorine insecticide residue in British seabird eggs is generally within the range 0. 5 to 3. 4 ppm (Moore and Tatton 1965). There is increasing evidence to suggest that the source of this contamination is principally industrial effluent, the use of dieldrin sheep-dip (now banned) and the disposal of agricultural effluents, and does not result from leaching from the soil after normal application. Changes in eggshell thickness, such as those mentioned above, have been noted in Herring Gulls (*Larus argentatus*) in the U.S.A., Shags (*Phalacrocorax aristotelis*) and Herons (*Ardea cinerea*) in Britain; this implies that organochlorine insecticides are already having sub-lethal effects on aquatic birds although there is no evidence to suggest that this is yet affecting the populations of these species adversely (Hickey and Anderson 1968, Ratcliffe in press, Prestt 1969). Nevertheless, if the levels of marine contamination of rivers and the sea were

raised by an order of magnitude, effects on seabirds would be serious. This has occurred in at least one case: there is good evidence that industrial effluent containing dieldrin, endrin and telodrln from a pesticide factory on the Rhine was the cause of the catastrophic decline of Sandwich Terns (*Sterna sandvicensis*) on a small island in the Wadden Sea, over 160 km away. Subsequent measures were taken to reduce the effluent from the factory and the tern colony has recovered (Koeman 1967, and personal communication). Very recently the Rhine became polluted with endosulfan between Mannheim and Koblenz; as a result an estimated 40 million fish died along 250 miles of river in Germany and the Netherlands (The Times 25. 6. 69). Dead terns and fish may be easily observed but severe casualties can occur to invertebrates, including those essential for maintaining stocks of fish, without anyone being aware of them; if, in the cases mentioned above, pollution was enough to kill vertebrates, it is almost certain that many Crustacea were seriously affected by these accidents, because Crustacea are particularly susceptible to organochlorine insecticides. It is very likely that populations of Crustacea and other sensitive organisms already may be affected by 'normal' contamination recorded on the North Sea coasts.

CONCLUSIONS BASED ON CONSIDERATION OF PESTICIDE CONTAMINATION

The work done on organochlorine insecticides shows that the release of persistent toxic substances into the environment is likely to affect living organisms over large areas of the earth's surface. Owing to the complexity of both ecosystems and the effects of chemicals it is extremely difficult to predict the results of such contamination. It must be expected that all persistent toxic substances are likely to have profound effects if they are used on a large scale; that relatively few effects have been recorded so far is probably due to lack of observations.

The work on pesticides shows that contamination of the environment is due both to the correct use and to the misuse of persistent chemicals. Much of it is caused by deliberate or accidental misuse, for example by farmers washing out spraying machinery in watercourses and by dumping used containers in them, and as a result of moth-proofing factories and pesticide factories allowing effluent containing pesticide to escape into rivers. Misuse can be greatly reduced by effective legislation and education. However, even if correctly used, these substances will be moved by wind and water currents from the areas of application, especially when they are applied from aircraft. Contamination resulting from proper use can only be controlled by replacing persistent compounds by less persistent substances. During the last few years much progress has been made in reducing the use of persistent organochlorine insecticides in countries in the temperate zones of the Northern Hemisphere—total or partial bans on these compounds are already in effect in nine nations.

The endosulfan incident on the Rhine showed that the fish in one country could be affected by contamination in another. A total ban on DDT has been declared recently in Sweden to determine the extent to which Swedish soils and water are affected by DDT coming from other countries by wind and water. It is becoming increasingly obvious that effective control of pesticide contamination depends upon international action. Since the 8th Technical Meeting of the IUCN in Warsaw in 1960, considerable progress has been made in the international field. Members of the IUCN Committee on Ecological Effects of Chemical Controls, which was set up as a result of the Warsaw meeting, facilitate the flow of information on pesticide effects between different countries, and have taken part in studies and discussions with relevant international agencies, notably WHO, FAO, OECD and the Council of Europe. Work on environmental contamination by pesticides has had the important effect of drawing attention to pollution problems in general. The United Nations is becoming more aware of pollution problems and an increasing number of states are taking practical steps to reduce environmental contamination.

OTHER POLLUTANTS

Pesticides are toxic chemicals used specifically to kill pests; therefore in general they are more likely to kill other organisms than are incidental contaminants. A wide range of pesticides are known to have caused local damage to organisms other than pests, but

only the persistent pesticides, notably the organochlorine insecticides and the alkylmercury fungicides (Swedish Royal Commission on Natural Resources 1967) seem to have caused large-scale effects as a result of their toxic nature. On the other hand the extensive use of phenoxyacetic acid and other herbicides must have had considerable indirect effects on wild animals as well as plants whenever they are used on a large scale, but this type of effect has been little studied.

The analytical study of pesticide residues led to the discovery that polychlorinated biphenyls (PCB), a product and byproduct of the plastics and other industries, have been environmental pollutants since the 1940s (New Scientist 1966,32 612). PCB residues frequently occur in freshwater and marine organisms. Recent work has shown that like the organochlorine insecticides these substances can affect the metabolism of steroid hormones (Risebrough *et al* 1968). There is little circumstantial evidence to suggest that, so far, they are having serious effects on wildlife, but it is a very significant fact that they have been environmental pollutants for thirty years without anyone realising it. From the point of view of some toxicological effects, PCBs are similar to organochlorine insecticides, but from the point of view of control they present quite a different problem. Owing to the obvious dangers inherent in the use of pesticides, many countries have developed administrative systems of pesticide control in order to protect operators, consumers, domestic animals, and in some cases wildlife. On the other hand administrative machinery to control environmental pollution by new industrial products such as the PCBs is much less advanced. An exception is radioactivity, where again the special nature of the hazard led to early and reasonably effective control of pollution.

Many problems are not obvious when pollutants are produced on a small scale; the phenomenon of eutrophication has been known for many years but only since the use of artificial fertilisers has been greatly increased has it been recognised as a major pollution problem of significance to human well-being (Downing 1969). These few instances should demonstrate the great need to watch the environment for unforeseen effects. Probably this can best be done by the study of carefully selected indicator species throughout the world. Meanwhile, until much more is known about the effects of pollution, its prevention is much better and vastly cheaper than its cure.

It should be noted that freshwater organisms are particularly susceptible to damage by pollutants since their habitats are usually much more confined and escape from polluted habitats is often impossible. Also, important consequences follow from the much smaller amount of available oxygen in water than in air; aquatic animals have to pass large quantities of water over their respiratory surfaces and so have a relatively greater exposure to toxic compounds. Also, since pollution of most types usually causes deoxygenation, freshwater species are liable to be asphyxiated by pollutants even when the pollutants are not toxic enough to kill them directly. Thus freshwater habitats are seen to be particularly vulnerable, and so the need to protect them from pollution is particularly urgent. Finally, it should be remembered that freshwater pollution causes pollution of the most vulnerable and economically most important part of the marine environment, the shallow seas round our coasts.

REFERENCES

Downing, A. L. 1969. The effects of pollution on the exploitation of water resources. Journal of the Devon Trust for Nature Conservation, No. **20**, 862-867.

George, J. L. and Frear,D.E.H. 1966. Pesticides in the Antarctic. J.appl.Ecol., **3** (suppl.) 155-167.

Grolleau, G. and Giban, J. 1966. Toxicity of seed dressings to game birds and theoretical risks of poisoning. J. appl. Ecol. **3** (suppl.) 199-212.

Hickey, J. J. 1969. Peregrine Falcon populations: their biology and decline. University of Wisconsin Press Madison, Milwaukee and London.

Hickey, J. J. and Anderson, D. W. 1968. Chlorinated hydrocarbons and eggshell changes in raptorial and fish-eating birds. Science, **162**, 271-273.

Hunt, E. G. and Bischoff. A. I. 1960. Inimical effects on wildlife of periodic DDD applications to Clear Lake, California. Fish Game, **46**, 91-106.

Jefferies D. J. and French, M. C. in press. The effect of pp'-DDT on the size and activity of the avian thyroid. Science.

Koeman, J. H., Oskamp, A. A. G., Veen, J., Brouwer, E., Rooth, J., Zwart, P., van den Broek, E., and van Genderen, H., 1967. Insecticides as a factor in the mortality of Sandwich Terns (*Sterna sandvicensis*). A preliminary communication. Meded. Rijksfacult. Landbouw-wetenschappen Gent, **32**, 841-854.

Moore, N. W. 1967. A synopsis of the pesticide problem. In: Advances in Ecological Research, **4** (ed. J. B. Cragg). Academic Press, London.

Moore, N. W. and Tatton, J. O'G. 1965. Organochlorine insecticide residues in the eggs of sea birds. Nature, Lond., **207**, 42-43.

Moore, N. W. and Walker, C. H. 1964. Organic chlorine insecticide residues in wild birds. Nature, Lond., **201**, 1072-1073.

Peakall, D.B. 1967. Pesticide-induced enzyme breakdown of steroids in birds. Nature, Lond., **216**, 505-506.

Prestt, I. 1969. Organochlorine pollution of rivers and the Heron (*Ardea cinerea* L.) 11th Tech. Meet. Int. Un. Conserv. Nat., New Delhi (these Proceedings p. 95 below).

Ratcliffe, D. A. 1967. Decrease in eggshell weight in certain birds of prey. Nature, Lond., **215**, 208-210.

Ratcliffe, D. A. in press. Egg breakage and eggshell thickness in some British birds. J. appl. Ecol.

Risebrough, R. W., Rieche, P., Peakall, D. B., Herman, S. G. and Kirven, M. N. 1968. Polychlorinated biphenyls in the global ecosystem. Nature, Lond., **220**, 1098-1102.

Rudd, R.L.and Genelly, R. E. 1956. Pesticides: their use and toxicity in relation to wild-life. Calif. Dept. Fish Game, Game Bull. 7, 209pp

Sladen, W. J. L., Menzie, C. M. and Reichel, W. L. 1966. DDT residues in Adelie Penguins and a Crabeater Seal from Antarctica. Nature, Lond., **210**, 670. 673.

Swedish Royal Commission on Natural Resources (ed.) 1967. The mercury problem. Oikos Suppl. **9**, 51 pp.

Tatton, J. O'G. and Ruzicka, J. H. A. 1967. Organochlorine pesticides in Antarctica. Nature, Lond., **215**. 346-348.

Wheatley, G. A. and Hardman, J. A., 1965. Indications of the presence of organochlorine insecticides in rainwater in central England. Nature, Lond., **207**, 486-487.

SUMMARY

Today's pollution problems are quantitatively different from those experienced hitherto, because organisms are confronted with totally new compounds and the recent increase in the scale of pollution is unprecedented.

Environmental contamination by persistent organochlorine insecticides is described as an example of pollution problems in general. Organochlorine insecticides now occur as residues throughout the world. They have different toxicological effects on different species; their sub-lethal effects on the reproduction and behaviour of birds appear to be connected with changes in the metabolism of steroid hormones and with changes in the thyroid. As well as having direct toxicological effects, organochlorine insecticides also affect species indirectly by altering food supply and prey/predator and competitive relationships. The total impact of a pesticide on an ecosystem is the resultant of all the toxicological and ecological effects on all of its species.

Environmental pollution is due both to misuse and to the recommended use of organo-chlorine insecticides. Industrial accidents have led to spectacular kills of fish and birds, but 'normal' contamination of water has reached a level where Crustacea and other sensitive organisms, on which they depend, may be at risk.

The recent discovery of widespread contamination by polychlorinated biphenyls shows

that a potentially important environmental contaminant may exist in the biosphere for many years without man being aware of it.

Freshwater and coastal areas—the aquatic environments most important to man—are particularly vulnerable and urgent measures are required to reduce their pollution. Some measures have already been taken by some countries.

RÉSUMÉ

Les problèmes soulevés aujourd'hui par la pollution diffèrent de ceux qu'on a connus jusqu'ici du fait que les organismes se trouvent confrontés par des produits chimiques absolument nouveaux et que le niveau de la pollution a atteint des proportions sans précédant.

La contamination du milieu par des insecticides aux hydrochlorures de carbone est décrite ici à titre d'exemple des problèmes posés par la pollution en général. Les insecticides aux hydrochlorures de carbone apparaissent actuellement à l'état résidual dans le monde entier. Leurs effets toxicologiques varient suivant les expèces affectées; leurs effects subléthaux sur la reproduction et le comportement des oiseaux semblent être liés à des modifications du métabolisme des hormones stéroïdes et de la thyroïde.

Outre les effets toxicologiques directs, on observe également une action indirecte des hydrochlorures de carbone sur les diverses espèces. Cette action se traduit par une modification des aliments disponibles, des relations proie/prédateur et des rapports de compétition. L'effet global d'un pesticide sur un écosystème est la résultante de tous les effets toxicologiques et écologiques sur toutes les espèces qui en font partie.

La pollution du milieu est due à la fois à une mauvaise utilisation et à un emploi approprié des insecticides aux hydrochlorures de carbone. Certains accidents industriels ont provoqué des hécatombes spectaculaires de poissons et d'oiseaux, mais la contamination 'normale' de l'eau a atteint un niveau qui peut menacer l'existence des crustacées et d'autres organismes peu résistants dont ils dépendent.

La découverte récente d'une contamination très étendue par les polychlorures de biphényle révèle qu'un polluant susceptible d'avoir une action importante sur le milieu ambiant peut être présent dans une biosphère pendant des années sans qu'on en prenne conscience.

Les eaux douces et les régions côtières—qui constituent notre environnement aquatique le plus important—sont particulièrement vulnerables, et des mesures urgentes sont requises pour réduire leur pollution. Certains pays ont déjà pris des mesures à cet effet.

Section B

Pesticide Residues in our Environment

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INTRODUCTION

In the relatively recent transition to modern agricultural practice, pesticides, particularly insecticides, have helped to bring the human population to its highest levels of good health and freedom from hunger. This success has brought with it important problems and controversies which are still with us. The present controversies revolve mainly around questions concerning the importance and meaning of pesticide residues in our environment. The development of highly sensitive methods of sampling and analysis of the environment have made it possible in the last few years to obtain data on the occurrence and magnitude of the residues of the leading insecticides in many ecologically important areas of the earth. Up to the present time, however, sufficient data have been reported only on the DDT complex (DDT, DDE, TDE—hereafter referred to simply as DDT) to allow a tentative assessment of the ecological problems involved and of how they should be considered against the value of such chemicals for human health and human hunger.

In this paper, I would like to review some of the existing data and points of view on DDT residues in the environment.

DISTRIBUTION OF RESIDUES

Residues of DDT which have been reported in the atmosphere, rivers, human food intake, human tissues, soil, fish, birds, birds eggs, other wildlife (penguins, seals, eels, plankton, etc.), grass, sewage, crude fish and vegetable oils are shown in Figure 1 against a background of the latitudinal fallout of Sr^{90} from the stratosphere. Data on a relatively new environmental component, PCB or polychlorbiphenyls,are also shown. The data plotted in Figure 1 were taken from bibliography items 1 through 52. These data represent secondary residues (e.g. in human tissues arising as shown later from food intake) or non-target residues (e.g. in fish and birds) arising from accidental or unintended exposure.

The curve representing Sr^{90} residues in various latitudes indicates the type of residue distribution to be expected from a stratospheric source which is not subject to local distribution by mechanisms characteristic of the troposphere and lower altitudes. Airborne pesticide residues, lacking the initial energy to reach the stratosphere (this involves megaton atomic explosions as in the Sr^{90} case), should be distributed on the earth by mechanisms such as rain and snow (influenced by localized wind currents characteristic of altitudes below the stratosphere). Thus, pesticide residues resulting, for example, from drift of the spray during application would be distributed over a small or large area around the point of application as determined by the particle size distribution in the spray, the wind direction and velocity, and the occurrence of a significant precipitation, i.e., snow, rain or ice. It would be expected, therefore, that the pesticide residue environmental distribution should follow a pattern related to the agricultural, excretory and other activities of the human population, which carry and excrete pesticide residues as they move around the earth. In other words, we should expect to find residues of pesticides of the DDT type wherever we find appreciable numbers of the human population and migratory wildlife.

A study of Figure 1 reveals that DDT residues in the human and wildlife populations and related parts of the environment are most prevalent in the northern hemisphere, par-

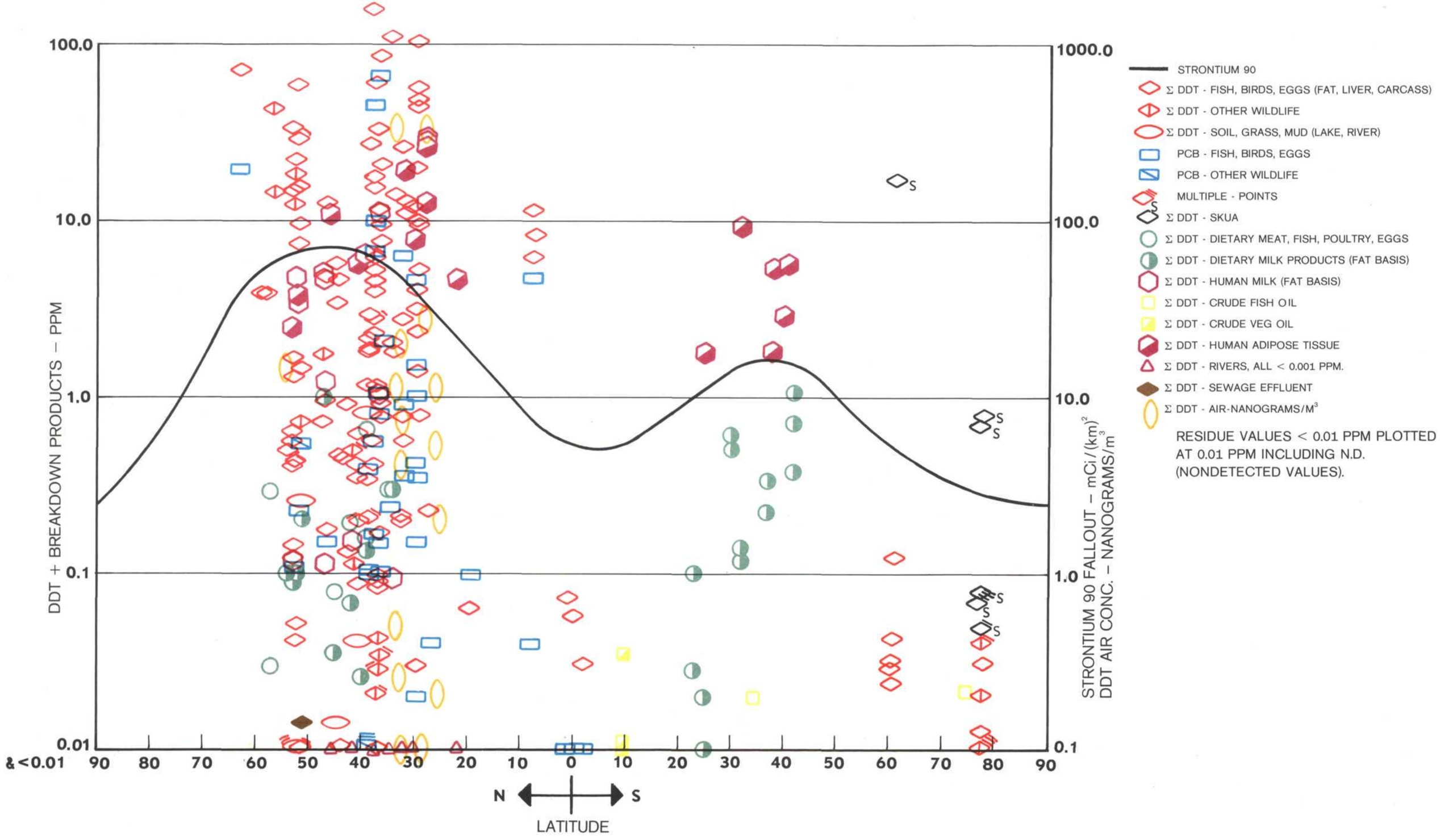

FIGURE 1 – **FALLOUT - STRONTIUM 90, DDT + BREAKDOWN PRODUCTS**

ticularly in the north temperate zone where the insecticide has been most intensively used for the past 15-25 years and where the human population of the world is largest. Residue data around the equator and in the southern hemisphere are much less dense, mainly, possibly, because little research on the occurrence of DDT residues in these areas has been done or reported. The distribution of the few data available (on wildlife residues around the equator and on human tissue and dairy product residues in Australia and New Zealand) suggest that a northern hemisphere type of distribution occurs in these areas also.

Only a small number of data have been reported on Antarctic samples of fish and wildlife and the residues found are quite low for all species except the skua. This bird is migratory, however, and would be expected to show a northern hemisphere residue distribution as it appears to do in the few data available which are shown in Figure 1. The remaining low Antarctic DDT levels are probably related to the human population and its garbage making and excretory processes, and to such other sources as migratory sea life and ships carrying full complements of pest control chemicals. Further evidence that the DDT residues follow a human related distribution lies in the fact that no DDT residues have been found in the Antarctic snow and ice pack at locations and depths free of the possibility of human contamination[3], whereas Sr^{90} residues are found[53].

DDT residues are thus likely to arise mainly from the day-to-day use of DDT to control pests in agriculture, in forests and in domestic and industrial locations and in public health. In these activities, the waters and fish and wildlife may be directly, indirectly or accidentally exposed to the insecticide with the formation of tissue and environmental residues. To minimize or eliminate such residues, particularly where they may be hazardous, we must study the source of each and the mechanism by which it occurs. This may not be possible at present, in all cases, but enough data are available to indicate areas where useful action may be taken. In fact, residues in many areas now receiving much attention in the communications media must soon decline or have already done so since the uses which led to the residues have been abandoned or withdrawn.

Sources of DDT residues

The main uses of DDT are in agriculture and in the control of the insect vectors of several human diseases as indicated[54] in Table 1. Industrial uses include mainly mothproofing of woollen fabrics. Thus, the human and wildlife and other environmental residues are related directly or indirectly to these uses. We shall consider them below separately.

TABLE 1 DDT Uses (1966)

	Metric Tons (Approx.)
Crops	42,000
Public Health	16,000
Industrial	1,000
Total	59,000

HUMAN TISSUE RESIDUES

Human tissue residues can be summarized in terms of residues in adipose tissue. Typical examples[23], [24] are shown in Table 2. The chronology of DDT residues in the U.S.A. shows that by 1956 the residues in human adipose tissue had reached a plateau which was maintained through 1963. Since 1963, there has been little overall change, because DDT dietary intakes in the U.S.A. have been relatively constant [55]. The annual DDT intake balance [56], presented in Figure 2, shows clearly that the only significant source of human DDT residues is the diet.

At the intake shown in Figure 2 which amounts to about 0.002 mg/kg body weight/day for a 70 kg man, the average human consumption of the DDT group in the U.S.A. is well below

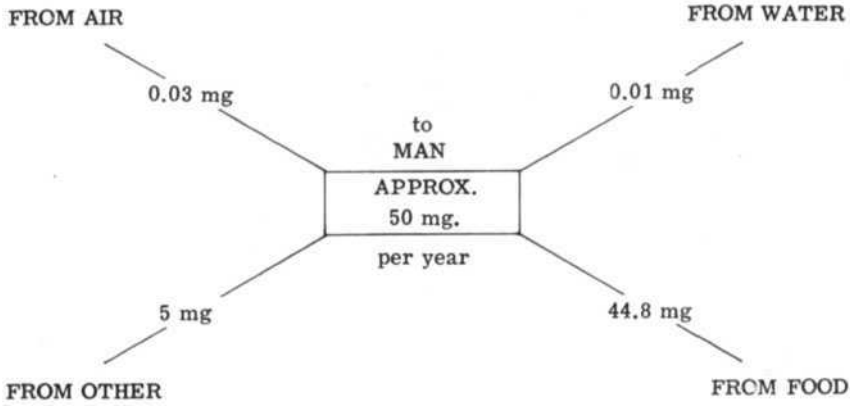

Fig. 2

the allowable daily intake of 0.01 mg/kg body weight/day established by the WHO/FAO Joint Meeting[57]. We can conclude from this that there are not likely to be any human health problems associated with current uses of DDT and the established tolerances for these uses. This means also that, on the basis of human exposures and intakes, there is no justification for severe restrictions on the present uses of DDT.

WILDLIFE AND OTHER NON-TARGET RESIDUES

Just how such residues occur and their significance for the particular species involved still remain, in almost all cases, matters of great controversy. Much of the present controversy over DDT arises from the effort of some of the anti-DDT groups to obtain government bans on all uses of chlorinated and persistent insecticides on the basis of environmental residues and the fear that these may be hazardous.

In several countries notably, for example, the U.S.A., pesticide registration and regulatory procedures have been established which are designed to uncover and define environmental problems with new pesticides leading to use and label restrictions for the protection of

TABLE 2 CONCENTRATION OF DDT-DERIVED MATERIAL IN ADIPOSE TISSUE OF PEOPLE OF DIFFERENT COUNTRIES

Country	Year	No. of Samples	Total as DDT (PPM)
U.S.A.	1942	10	0.0
U.S.A.	1950	75	5.3
U.S.A.	1955	49	19.9
U.S.A.	1954-56	61	11.7
U.S.A.	1961-62	130	12.6
U.S.A.	1961-62	30	10.7
U.S.A.	1962-63	282	10.3
CANADA	1959-60	62	4.9
GERMANY	1958-59	60	2.3
HUNGARY	1960	50	12.4
ENGLAND	1961-62	131	2.2
FRANCE	1961	10	5.2
ISRAEL	1963-64	251	19.2
INDIA	1964	67	26.0

dangered species. In the case of DDT and other established persistent pesticides, re-evaluation of registered uses in the light of reasonably well-established environmental effects should be made via orderly regulatory procedures rather than by sudden government ban, based usually on limited data or inference only. A more reasonable and, in the long run, useful approach would be to define the problem involved in discussions among appropriate government and industry experts, and then, if required, modify or restrict the specific use responsible for the problem.

This approach can still be taken in the important agricultural countries of the world. As a contribution toward the establishment of rational procedures, the remainder of this paper will be devoted to a discussion of the sources of some of the environmental residues of DDT and its breakdown products and what might be done about them. Such a discussion should, in principle at least, be applicable to the entire class of persistent pesticides. Most pesticide residues in wildlife can arise mainly from the following activities by man and/or various non-target species.

CONSUMPTION OF TREATED CROPS BY NON-TARGET SPECIES

While this is theoretically valid, any non-target species which consumes significant amounts of a crop will quickly become a target species subject to direct control measures. Furthermore, with the limitations on crop residues normally imposed by tolerances, this source of residues would not be expected to produce any important effects in non-target species where the crop consumption is within tolerable limits.

CONSUMPTION OF TREATED SEEDS BY NON-TARGET SPECIES

This can be an important source of residues, intoxications and ultimately death in certain non-target species. The consumption of rice seed treated with DDT by pheasants in California[58] produced high residues and mortality in these and other non-target species. At the time such uses were in operation, it was not realized that these problems were likely to arise and loss among many avian species occurred before the agricultural practice could be corrected. This has now been done and wildlife residues and mortality from this source should have disappeared in North America and Europe. In the application of new pesticides in these areas, these potential problems are now considered well in advance of registration and use.

DIRECT APPLICATION TO NON-TARGET SPECIES IN PEST CONTROL PROGRAMMES IN AGRICULTURE, FOREST MANAGEMENT AND PUBLIC HEALTH

With some insecticides, this can be a significant cause of wildlife intoxication and mortality; but is not likely to be serious in the case of DDT and most other chlorinated hydrocarbon insecticides except, possibly, in programmes in forestry management and public health where sprays are applied to or drift over rivers, lakes and other bodies of water containing susceptible fish and other animals. Wildlife and fish mortality from such classically incorrect uses of chlorinated hydrocarbons as the application of DDD to Clear Lake in Northern California[59] and of DDT to the watershed area of the Yellowstone River have been well publicized.

Application techniques have been much improved in recent years. The use of these techniques and wherever possible of pesticides with limited ranges of toxicity, particularly in forest pest control, should greatly diminish or eliminate this type of wildlife loss.

RESIDUES DERIVED FROM ELEMENTS IN THE FOOD CHAIN

The accumulation of residues in a wildlife food web can be expected to have substantial effects where they are sufficiently magnified as they move up in the chain. The Clear Lake DDD case mentioned above is a good example of the movement of a residue in the web which is apparently not metabolized by higher species. The build-up of DDT residues

in a marsh food web has been shown[60] to occur from the application over a number of years of DDT for mosquito control.

The solution to this kind of problem is simple—prevent the accumulation of the residue in the food chain. This does not require, as some conservationists and governments appear to believe, a total ban on the use of the pesticide involved. It may mean the elimination of a specific use or the development of a new technique of application, thus leaving other important and harmless uses of the pesticide in effect for food production.

WATERWAY CONTAMINATION DURING SPRAY OPERATIONS

These situations can arise from:

(1) overrun of the waterway during aircraft spraying,

(2) improper spray techniques,

(3) improper practices such as washing spray equipment in the waterway,

(4) discard of small excesses or remainders of formulation into or near a waterway,

(5) run-off in rainfall or irrigation water during and after an application.

The first four of these can be adequately controlled by education of farmers and the agricultural spraying organizations with, perhaps, suitable penalties involved for violations.

Proper timing of application of the pesticide can in many cases minimize or eliminate pesticide run-off caused by rain or irrigation. In situations where this cannot be achieved with a persistent pesticide such as DDT, an alternative, low toxicity, control chemical, or method should be employed; again, however, keeping other uses of the persistent pesticides in the pest control armory for use where hazards to wildlife can be controlled or do not exist.

WATERWAY CONTAMINATION FROM FACTORY EFFLUENT

Factories engaged in the manufacture of pesticides or pesticide formulations or in mothproofing of wool may, in some cases where adequate effluent treating systems have not been installed, have pesticide residues in the factory effluent of sufficient magnitude to raise the question whether such residues should be allowed to enter nearby waterways. Many such factories pass their liquid effluent to the sewage disposal system of a nearby village. In such cases, the design and efficiency of the village sewage plant becomes of primary concern. Three examples of this type of operation[61] are shown in Table 3. The residues shown may or may not be undesirable additives to a neighbouring river. This depends on the volume per day of the village sewage effluent, the flow-rate of the river into which it empties, and the desired standard of pollution in the river and its ultimate estuarine waters.

TABLE 3 RESIDUES EX FACTORY EFFLUENTS

Type of factory	DDT residues-parts per 109
Manufacture of pesticide formulations	0.059
Manufacture of pesticide formulations	0.67
Mothproofing	0.80

Such factories can, by suitable treatment of their effluent, reduce these residues to negligible quantities in terms of their effect on and accumulation in the environment. In the case of the mothproofing plant, the effluent will also require treatment to remove objectionable dyes, wool fat and other materials. Treatment of the effluent to remove these materials will usually reduce any chlorinated hydrocarbon residues to negligible levels. Where this has not been done, consultation among the appropriate industry and govern-

ment experts should lead to a satisfactory solution of the problem without the need to ban other uses of these important and valuable agricultural chemicals.

INDIRECT WATERWAY RESIDUES FROM AGRICULTURE

Such residues could arise from spray drift, run-off during rains and irrigation, soil erosion and dust storms. It is obvious that the first three are potentially the most important mechanisms by which waterway residues can arise from agricultural use of pesticides, particularly in the case of run-off and soil erosion where the persistent ones, which are well known to stay in place after application, are relatively strongly absorbed by soil particles. Examples showing residues from treatment of rice seeds with aldrin and soil treatment with aldrin in maize culture in the U.S.A. are included since examples of such uses of DDT are not available.

Rice culture in the state of Arkansas is a good example of the application of a persistent pesticide, in the form of seed dressing, to a water system which flows ultimately into the Mississippi River. Some typical data are shown[62] in Table 4. Water from the rice fields which has been in direct contact with aldrin on the rice seeds flows into the White River (above and along the route from Batesville to Jack's Bay) which flows into the Mississippi River below Jack's Bay. Both the mid-season and harvest samples of water show dieldrin residues at or near the limits of the GLC method of analysis. The mud or silt samples from the same locations show uniformly low residue levels below the range of the method.

TABLE 4 INSECTICIDE RESIDUES IN WATERWAYS-WHITE RIVER, ARKANSAS. ALDRIN/RICE-SEEDDRESSING-6 OZ./ACRE

	Aldrin + Dieldrin residue In water—p.p. 10^9	
Sample location	Midseason	Harvest
Batesville	0.009	0.008
Augusta	0.023	~0.008
Crockett's Bluff	0.021	0.008
Jack's Bay	0.007	~0.006
	In mud—p.p. 10^6	
Batesville	<0.02	<0.01
Augusta	<0.02	<0.01
Crockett's Bluff	<0.02	<0.01
Jack's Bay	<0.02	<0.01

In Table 5, the results of a similar study [62] are shown for the soil application of aldrin under maize in a completely agricultural situation in Ohio. In this situation, the only source of aldrin and dieldrin residues in the ditch water is run-off and soil erosion during rains and storms. All water samples showed aldrin/dieldrin residues below 20 p.p. 10^{12}, which is very close to the limits of the analytical method.

In the case of the DDT residues of Table 5, the tendency toward higher residues reflects the fact that DDT is applied to the foliage of the maize (with related spray drift and ease of washing off of the plants during rainfall) not to the soil as in the aldrin treatment.

TABLE 5 RESIDUES IN DRAINAGE DITCH FROM PURELY AGRICULTURAL USE OF ALDRIN UNDER MAIZE

Conc, range, p.p. 10^9	Number of samples in concentration range: Aldrin and dieldrin	DDT + DDE
Ditch No. 1[a]		
<0.01	2	0
>0.01 <0.02	7	0
>0.02 <0.05	0	1
>0.05 <0.075	0	2
>0.2 <0.3	0	2
>0.3 <0.4	0	1
	9	6
Ditch No. 2[b]		
<0.01	2	0
>0.01 <0.02	0	0
>0.02 <0.05	11	1
>0.05 <0.075	0	1
>0.075<0.1	0	1
>0.1 <0.2	0	4
	13	7

[a] Ditch No. 1 drains 100 acres of soil treated with 5 lb aldrin/acre.

[b] Ditch No. 2 receives drainage from Ditch No. 1 and other cornfields and empties into Kankakee River.

Even in this type of use, however, the residues of the DDT group are under 0.0004 ppm where the danger to fish and wildlife is undoubtedly low or non-existent.

The above uses of these pesticides are of great importance in world agriculture and should not suffer banishment as a result of the excessive and uninformed zeal of political, conservation, and consumer groups who base their attitudes on abandoned and now merely historical uses of the persistent pesticides such as those which caused golden eagle deaths from residues in sheep carrion, deaths of grebes from DDD residues in fish, deaths of pheasants and other birds from consumption of treated seeds.

The USDA programme—Monitoring Agricultural Pesticide Residues[63] -has shown that in the heavily treated, purely agricultural areas of the Mississippi River delta in Mississippi and Arkansas no serious build-up of persistent pesticide residues has occurred in the soil, or surface on well water, nor in wildlife after some 10-15 years of use of DDT, endrin, BHC, toxaphene, methylparathion, etc. Examples of their data are shown in Table 6.

That no significant damage to wildlife has occurred is suggested by the fact that bag limits of wild game in the Mississippi delta have been increased in recent years as a result of increase in game populations.

Serious pesticide pollution of the great river systems of the world will not occur from agricultural use of pesticides. This has been shown by the river monitoring programs[64] in the U.S.A. Samples of these data for rivers of the Western and Southwestern U.S.A. where intensive agricultural use of DDT and other pesticides occurs are shown in Table 7.

TABLE 6 MISSISSIPPI RIVER DELTA RESIDUES FROM USE OF DDT IN AGRICULTURE MAY, JUNE, JULY, AUGUST, SEPTEMBER—1964

Area Treated			Residue levels in				
Code	Acres	Cumulative*** Amt. Applied to Cotton in 1964 lbs/Acre	Water Wells P.P. 10^9	Surface Water Sources P.P. 10^9	Quick Runoff P.P. 10^9	Monthly Sediments Ex Surface Water Sources P.P. 10^6	Crops
CHA	148	1.79	N.D.*	N.D.	N.D.	N.D.	*cotton,* soybeans, cabbage, corn
CHB	545	1.84	N.D.	N.D.	N.S.C.**	0.08(av)	cotton, corn *uncultivated*
GRA	602	1.05	N.D.	N.D.	N.S.C.	0.79	*cotton,* soy, small grains, sorghum
GRB	647	7.3	0.10(av)	N.D.	N.S.C.	0. 93(av)	*cotton, soybeans,* sorghum, oats
SCA	616	19.70 up to 1962 & DDT used on surrounding farms	N.D.	0.17(av)	N.S.C.	1.12(av)	*cotton, soybeans*
SCB	647	6.42 (up to 1962)	N.S.C.(3) N.D.(3)	0.21 (av)	1.21	1.05(av)	*cotton*
STA	602	1.56	N.S.C.(4) N.D.(2)	0.09(av)	N.S.C.(5) N.D.(l)	0.08(av)	*soybeans, rice,* wildlands, reservoirs
STB	624	1.07	N.S.C.(2) N.D.(3)	N.D.	N.S.C.(4) N.D.(l)	0.02(av)	*rice, soybeans,* oats, lake, woodland
FBA	632	no pesticides applied past 1964; no chlorinated past 1957	N.D.	N.D.	N.S.C.	0. 004(av)	*cotton, soybeans,* small grains, woods, water
FBB	646	no pesticides in past 10 years	0. 03(av)	N.D.	N.D. (one sample)	0.004(av)	cotton, soybeans, rice, small grains

* N.D. = None detected (<0.05 P.P. 10^9 in water, <0. 05 P.P. 10^6 in soil and sediment).

** N.S.C.= No samples collected.

*** Entire area treated variously up to 10 years prior 1964.

TABLE 7 DDT RESIDUES IN WESTERN RIVERS

River	State	No. of samples	(DDT,DDE,DDD) No. Positive	p.p. 10^{12}
Missouri	Nebraska	12	2	8
Arkansas	John Martin Res. Colorado	12	3	3
Arkansas	Van Buren Arkansas	12	4	6
Brazos	Richmond Texas	6	5	7
Colorado	Wharton Texas	8	3	5
Rio Grande	Anzalduas Dam, Texas	12	7	4
Colorado	Yuma, Arizona	11	3	3
Sacramento	Verona, California	10	1	<1
Yakima	Kiona, Washington	9	5	5
Snake	King Hill, Idaho	10	1	2
Columbia	Dalles, Oregon	12	N.D.*	N.D.

* N.D. = None detected.

The Gulf of Mexico, which receives a large portion of the agricultural drainage of the middle, southern and southwestern sections of the U.S.A.—Missouri, Mississippi, Ohio, Arkansas, Red, Atchafalaya, Brazos, Rio Grande, etc. Rivers—has suffered no reduction in fish and sea food catches nor has the southern Mississippi River during a period when persistent and other pesticides were used throughout the area drained. Data[65] showing this are presented in Table 8.

TABLE 8 MISSISSIPPI RIVER FISHERIES CATCH

Year	Weight in thousands of pounds
1931	82, 383
1956	90,779
1960	86,482

GULF FISHERIES-FLORIDA (WEST COAST), ALABAMA MISSISSIPPI, LOUISIANA, TEXAS

(thousands of pounds)

Year	True Fish	Crabs	Shrimp	Oysters
1940	80,939	18,637	127,838	17,584
1956	660,835	16,910	193,621	13,513
		(1960-35,768)		(1960-16,098)

TABLE 8 MISSISSIPPI RIVER FISHERIES CATCH-continued
OFFSHORE SHRIMP CATCHES

	Pounds	
Pensacola to Mississippi River	1956	1960
0 to 5 fathoms	6,364,254	7,317,178
6 to 20 fathoms	6,406,477	5,886,653
21 to 40 fathoms	1,624,525	598,484
Mississippi River to Texas		
0 to 5 fathoms	16,729,703	21,398,317
6 to 20 fathoms	11,689,968	9,998,925
21 to 40 fathoms	2,244,142	3,863,290
Grand Total:	45,059,069	49,062,847

BIBLIOGRAPHY

(1) Hardy, E. P. *et al.*, Nature, **219**, 584 (1968).

(2) Tatton, J. O. G. and Ruzicka, J. H. A., Nature, **215**, 346 (1967).

(3) Sladen W.J.L., ei *al.*, Nature, **210**, 670 (1966).

(4) George, J. L., Frear, D. E. H., Applied Ecology, **3** Suppl., 155 (1966).

(5) 'Organochlorine Pesticide Residues in Terrestrial and Aquatic Wildlife', O.E.C.D. Study 1967/1968, by G. Baluja, Country Report: Spain.

(6) Holden, A. V., Marsden, K., Nature, **216**, 1274 (1967).

(7) Koeman, J. H., *et al.*, Helgolander Wiss. Meersunters **17**, 375-380 (1968).

(8) Koeman, J. H., van Genderen, H., J. Applied Ecology, **3**, 99 (1966).

(9) 'Results of Analysis of Organochlorine, Pesticide Residues in Terrestrial and Aquatic Wildlife', by Koeman, J. H., van Urk G.,and Mrs. Huisman-de Brouwer, L. H.M. O.E.C.D.-Study 1966/1967. Report by the Netherlands.

(10) Risebrough,R.W., *et al.*, Nature, **220**, 1098 (1968).

(11) Risebrough,R.W., *et al.*, Nature, **216**, 589 (1967).

(12) 'Chlorinated Hydrocarbons in Marine Ecosystems', by Risebrough,R. W. From: Symposium Chemical Fallout: Current Research on Persistent Pesticides (Rochester University—School of Medicine and Dentistry) June 4-6,1968.

(13) 'The Chlorinated Pesticide Residues in Pacific Coast Sea Food', by deVries,D.M., *et al.* Presented at 147th American Chemical Society National Meeting April 8, 1964.

(14) 'Investigation of Chlorinated Hydrocarbon Residues in Animal and Vegetable Fats', by Anna Denes. 1963 Yearbook of the Institute of Nutrition, Budapest 1964:46. pp. 46-47.

(15) Findley, E., Hamilton, G. A., J. Sc. Fd. Agric, **19**, 609 (1968).

(16) Ruzicka, J. H. A., Simmons, J. H., Tatton, J. O.'G. J. Sc. Fd. Agric, **18**, 579 (1967).

(17) 'Pesticide Residue Survey in Australia', Department of Primary Industry, Commonwealth of Australia (Letter to Dr. A. F. H. Besemer, Wageningen, 11 December, 1967).

(18) 'Pesticide Residues in Food, etc.', Laboratory of the Government Chemist. From: Report of the Government Chemist 1965. (P.A.N.S. August 1967). pp. 289-298.

(19) McGill, A. E. J., Robinson, J., Fd. Cosm. Toxicol., 6, 45 (1968).

(20) Wasserman, M., *et al.* Ind. Med. & Surg., **37**, Nr. 4, 295 (1968).

(21) Bick,M.,Med. J. of Australia, 1127-1130 (June 3,1967).

(22) Brewerton,H.V.,McGrath, H. J.W. N.Z.J1. of Science, **10**,486 (1967).

(23) Dale, W. E., Copeland, M. F., Hayes, W. J., Jr., Bull. Wld. Hlth. Org., **33**, 471 (1965).

(24) Wasserman,H.,Hale, A. Congr. Mundial Contam. Aire, Actas 1st., Buenos Aires **2**, 509 (1965).

(25) Abbott, D. C, Thomson, J. World Review of Pest Control, 7, No. 2, 70 (1968).

(26) Unpublished data.

(27) Abbott, D. C, Goulding, R., Tatton, J. O.'G. Brit. Med. J., **3**, 146 (1968).

(28) 'Pesticides in Urban Atmospheres', Tabor, E. C, Presented at 58th Annual Meeting of the Air Pollution Control Association, Toronto, Ontario, Canada, June 20-24,1965.

(29) 'Measurement of the Atmospheric Contamination by Pesticides', Stanley, C.W., Barney II, J. E., Helton, Michael R. (Presented at the 62nd Annual Meeting, Air Pollution Control Association, New York, New York, June 1969).

(30) Huggett, R. J., Griffin, J. J., Goldberg, E. D. Science, **159**, No. 1233 (1968).

(31) Abbott, D.C, Harrison, R.B., Tatton, J. O.'G., Thomson, J. Nature **211**,259 (1966).

(32) Hickey, J. J., Keith, J. A. The Effect of Pesticides on Fish and Wildlife, Fish and Wildlife Service, Circular 226, August 1965, p. 11.

(33) 'Bald Eagle Studies', Robinson, W.H., Hall,C. W.,Ise, G.H., Sheldon, M. G. The Effects of Pesticides on Fish and Wildlife, August 1965, p. 35.

(34) 'Fate and Persistence of DDT in a Forest Environment', Keith, J. O., Flickinger, E. L. The Effects of Pesticides on Fish and Wildlife, August 1965, pp. 44-46.

(35) Casarett, L. V., *et al.,* Arch. Environ. Health, **17**, 306 (1968).

(36) Bro-Rasmussen, F., *et al.,* Residue Reviews, **23**, 60 (1968).

(37) Breidenbach,A.W.,ei *al.,* Public Health Reports, **82**, No. 2, 139-156 (1967).

(38) 'Chlorinated Hydrocarbon Pesticides in Sewage Effluents and River Waters—A Preliminary Survey', W.P.R. Report No. 1138, Water Pollution Research Laboratory, Elder Way, Stevenage, Herts, July 1966.

(39) Unpublished data.

(40) Quinby, G.E., Armstrong, V.F., Durham, W.F. Nature, **207**, 726 (1965).

(41) Egan, H., Goulding, R.,Roburn, J., and Tatton, J. O.'G. Brit. Med. J. **2**, 66 (1965).

(42) Quinby, G.E., Armstrong, V.F., Durham, W.F., see (40) above.

(43) Dale, W. E., Copeland, M. R., Hayes, W. J., Bull, W.H.O. **33**, 471 (1965).

(44) Wasserman, M., Wasserman, D., Zellermayer, L., Arch, Environ. Health, **11**, 375 (1965).

(45) Bick, M., Med. J. Aust. **1**, 1127 (1967).

(46) Brewerton, H.V., McCrath, H.J.W., New Z.J. Sci. **10**, 436 (1967).

(47) Robinson; J., *et al., Brit.* J. Ind. Med. **22**, 220 (1965).

(48) Zavon, M. R., Hine, C. H., Parker, K. D., J. Am. Med. Assoc. **193**, 837 (1965).

(49) Hayes, W. J., Dale, W. E., Le Breton,R., Nature, **199**, 1189 (1963).

(50) Read, S. T., McKinley, W. P., Arch. Env. Health, **3**, 209 (1961).
Brown, J.R., Can. Med. Assoc. **97**,367 (1967).

(51) El Sayed, E. I., Graves, J. B., Bonner, F. L., J. Agr. Food Chem. **15**, No. 6, 1014 (1967).

(52) Organic Pesticides in the Environment, Advances in Chemistry Series 60, Amer. Chem. Soc. Wash., D.C, 1066, DDT + DDE in Rainwater, page 166, Pesticide Content of Dust, Cincinnati, Ohio, page 174.

(53) Libby, W. F., Proceedings of the National Academy of Sciences, U.S.A., **42**, 365 (1956).

(54) Unpublished estimates and *Production Year Book—FAO,* Vol. 21,1967.

(55) Pesticides Monitoring J. **2**, No. 1, 2 (1968).

(56) *Insecticide Residues in the Human Diet,* Campbell, J.E., *et al.,* Arch. Environ. Health **10**, 831 (1965).

(57) 1967 Evaluations of Some Pesticide Residues in Food, FAO/PL:1967/M/11/1, WHO/ Food Add./68. 30, page 62.

(58) Rudd,R.I.,Genelly,R.E.,Coudor **57**,117 (1955).

(59) Hunt, E.G.,Bischoff, A. I., Trans. N. Amer. Wildlife **46**, No. 1, 91 (1960).

(60) Woodwell,ei *al.,* Science **156**, 821 (1967).

(61) W.P.R. Report No. 1138, Ministry of Technology, Water Pollution Research Laboratory, Elder Way, Stevenage, Herts, England, July 1966.

(62) Sparr,B.I., *et al.,* Advances in Chemistry Series 60, Amer. Chem. Soc., Wash., D.C., 1966, p. 153.

(63) Monitoring Agricultural Pesticide Residues, USDA-ARS, 81-113, December 1966.

(64) Pesticides Monitoring J. **1**, No. 2, 38 (1967).

(65) Fishing Statistics of the United States, Fish and Wildlife Service, U.S. Dept. of the Interior, Statistical Digests Nos. 43, 53, 1956, 1960.

SUMMARY

Residues of DDT are likely to occur in the environment more from specific activities of the human population than from a stratospheric pool of the insecticide.

Most of the residues observed in the environment can be related to some particular use. Purely agricultural uses are not likely to cause any significant hazard to fish and wildlife, nor are they likely to lead to serious pollution of the great rivers of the world.

Some uses of DDT and other persistent insecticides have in the past probably caused wildlife damage, but these uses have been abandoned in the western countries and probably also in the rest of the world; e.g., sheepdips, dressing for certain seeds, forest insect control, etc.

A blanket ban on the uses of these and any other pesticides should not be made by any government. Each use or proposed use should be examined in terms of its effect on the environment. Those uses which cause no significant damage or present no significant hazard to the human or wildlife population should be retained. Those which are judged to be hazardous should be rejected. The community of experts in government and industry with the help, where required, of those from the university, should determine the fate of each use after rational, open discussion of the data involved.

RÉSUMÉ

Ce rapport veut montrer que les résidus de DDT trouvés dans un site proviennent vraisemblablement plutôt d'activités humaines spécifiques que d'un pool stratosphérique d'insecticides.

La plupart des résidus détectés dans les milieux environnants peuvent être rapportés â des activités particulières. Il ne semble pas probable que les utilisations purement agricoles de ces produits constituent une menace significative à l'égard des poissons et de la faune, ni qu'elles soient en mesure de polluer gravement les grands cours d'eau du globe.

Il est vraisemblable que par le passé, certaines applications du DDT et d'autres insecticides persistents ont été néfastes à la faune sauvage, mais ces pratiques là ont été supprimées dans les pays occidentaux et probablement aussi dans le reste du monde; par exemple—bains insecticides pour les moutons, enrobage de certaines semences, lutte contre les insectes en forêt, etc.

Aucun gouvernement ne devrait émettre d'interdiction globale portant sur toutes les applications de ces pesticides et d'autres encore sans avoir examiné très soigneusement les effets de chaque type d'emploi sur le milieu environnant. Les applications qui n'entraînent pas de dégâts significatifs ou ne présentent pas de dangers à l'égard des populations humaines et animales sont à maintenir. Par contre, celles qui sont jugées dangereuses doivent être éliminées. Une commission composée d'experts du gouvernement et du secteur industriel et, si nécessaire, d'experts universitaires, devra décider du sort de chaque type d'emploi après une discussion libre et rationnelle des données fournies.

Section B

Organochlorine Pollution of Rivers and the Heron (*Ardea cinerea* L.)

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INTRODUCTION

In the early 1960s a preliminary survey was made of organochlorine residues in the tissues and eggs of wild birds in Britain (Moore and Walker 1964). This showed that of a range of species examined the bird, mammal and fish-feeding predators contained on average higher residues than omnivorous and herbivorous birds and that the Heron had the highest residues of any of the species examined. As a result of this survey a programme of research on predatory birds was started at Monks Wood Experimental Station (Prestt 1966).

The aims of the work on the Heron were (i) to obtain more information about the levels present of the different organochlorine compounds and their distribution within the Heron population, and (ii) to find out if they were having any adverse effects on the Heron population, either through acute poisoning or sub-lethal effects. In 1968 a further programme of work was started in co-operation with the Lincolnshire River Authority and Shell Research Ltd., to try and establish the source or sources of the chemical and trace their distribution in the ecosystem and their pathway to the Heron.

THE BRITISH HERON POPULATION

In 1928 the British Trust for Ornithology started its national survey of the Heron breeding population in Britain (Nicholson 1929). Each year counts are made of the numbers of occupied nests in heronries throughout Britain. Almost complete cover is obtained for England and Wales, but it is less complete for Scotland. The results from this survey have shown that there appears to be a 'normal' Heron population in England and Wales of about 4, 500 pairs. The only major deviations from this occur after hard winters when the numbers decrease. Recovery in subsequent seasons is usually rapid, however, so that after three years the 'normal' population is regained (Alexander 1945). In 1954 a particular effort was made to try and obtain a complete census of the British breeding population and the results have been published in detail (Burton 1956). 1954 came in a run of 11 mild winters (1951-1961), during which the annual breeding population in England and Wales remained very close to the expected 'normal'. The maximum variation recorded was only 400 pairs either above or below the 'normal' and in 5 of the years the numbers were just about the 4, 500 mark. The 1954 results can therefore be used to indicate the numbers and distribution of the Heron in Britain. They showed that the total population of Britain was about 5, 800 pairs; Scotland having 1, 444 pairs, Wales 433 and England 4, 303. The English population was almost equally divided between the eastern (55%) and western parts (45%) of the country. The present study was confined to the eastern part of England which can normally be expected therefore to contain about 2, 400 breeding pairs of Herons.

THE RECENT STATUS OF THE HERON IN EASTERN ENGLAND

The adult population

The national census figures for 1967 to 1969 have not yet been published, so the present status of the British Heron population is not known. The winter of 1962-63 was one of the worst ever recorded in Britain, with severe cold lasting from December to early March. As could be expected the Heron population was greatly reduced as a result, the decrease

being in the order of 41% (Stafford 1969). The winters since 1962-63 have been relatively mild so, from previous experience, we could expect a fairly rapid recovery of the population back to the 'normal' level. Figures published for Lincolnshire, one of the counties of eastern England, show an apparently normal recovery to have occurred within the county as a whole (Townsend and Cornwallis 1967). At the Troy and Willoughby heronries in Lincolnshire, where much of the present work was carried out, the recovery of the colonies was also apparently normal. The numbers of occupied nests in these two colonies and in the county of Lincolnshire as a whole in recent years were:

	1962	1963	1964	1965	1966	1967	1968
County of Lincolnshire	175	101	125	195	190	not available	
Troy Heronry	53	34	52	88	79	59	78
Willoughby Heronry	28	15	20	42	44	49	41

This information, together with preliminary reports from other areas in the east, suggests that the Heron population of eastern England has recovered from the effects of the 1962-63 winter.

The breeding success

Each season from 1966, detailed observations of breeding success were made of a randdom third of the nests in the Troy heronry. The nests are mostly in Oaks (*Quercus* sp.), at a height of about 45 feet, at one end of a large wood. The contents of each of the nests in the sample was recorded at two-week intervals throughout the season by means of an extending pole with mirror attachment. An unusual feature, which became evident at an early stage in the work, was the relatively large number of broken eggs lying under the nests. Observations from a hide confirmed that these eggs were being deliberately broken in the nests by the parent Herons, who then threw them out (Milstein, Prestt and Bell in press). Several of the pairs which broke their eggs laid repeat clutches and some eventually fledged young; this explains the lower figure of pairs failing to fledge young compared to the number breaking eggs.

The main data from the breeding study are:

Year	No. nests studied	Av. clutch	No. pairs destroying eggs	No. pairs failing to fledge young	No. young fledged per total no. pairs studied
1966	23	4.2	8 (35%)	5 (22%)	1.96
1967	19	4.2	7 (37%)	5 (26%)	1.9
1968	20	3.9	8 (40%)	6 (30%)	1.9

A preliminary examination of the eggshell thickness, following Ratcliffe (1967), showed 78 Heron eggs collected in 1968 to have a mean index of eggshell thickness of 1. 58; while 45 eggs collected from 1931-1935 had an index of 1. 98. This shows a 20% decrease in index of shell thickness. Ratcliffe (1967 and 1970) found a 19% decrease has occurred in the Peregrine (*Falco peregrinus* Tunstall), a 10% decrease in the Golden Eagle (*Aouila chrysaetos* (L)), and a 12.3% decrease in the Shag (*Phalacrocorax aristotelis* (L)), in Britain. Hickey and Anderson (1968) recorded a decrease of 18. 8%, in the Peregrine; 19. 8% in the Bald Eagle (*Haliaetus leucocephalus* (L)) and 25.1% in the Osprey (*Pandion haliaetus* (L)), in North America.

CHEMICAL ANALYSIS

The specimens were analysed by the Laboratory of the Government Chemist, London; Shell Research Ltd., Sittingbourne; and at Monks Wood Experimental Station. In all cases gas liquid chromatographic estimation of the pesticide was carried out, with confirmation in a number of cases by thin-layer or paper chromatography (for details of method cf. Abbott *et al* (1965), Robinson et al (1967), Walker et al (1967)).

ORGANOCHLORINE RESIDUES

(a) **In full-grown Herons**

From 1964-1968 a total of 42 dead Herons were received for a post-mortem examination. These were sent in response to requests published in ornithological journals and proved to be a reasonably representative sample of the eastern England population. Most were found dead and autopsies suggested a terminal cause of death by injury, shooting or disease in a quarter of them.

Chemical analysis of the livers showed:

42	(100%)	specimens contained residues of pp'-DDE
38	(90%)	specimens contained residues of dieldrin
16	(38%)	specimens contained residues of pp'-TDE
9	(21%)	specimens contained residues of pp-DDT
8	(19%)	specimens contained residues of heptachlor epoxide
1		specimen contained residues of BHC
1		specimen contained residues of pp'-DDT
1		specimen contained residues of pp'-DME

The mean residues of organochlorine insecticides present in the liver and their ranges (expressed in parts per million wet weight) were:

	pp'-DDE	pp'-TDE	pp'-DDT	dieldrin	heptachlor epoxide	Total
Mean	30.18	0.78	0.12	9.33	0.10	40.52
Max.	240.0	7.5	1.8	60.0	1.7	230.0
Min.	0.2	0.0	0.0	0.0	0.0	0.3

In addition the last 16 birds, received in 1967-68, were also analysed for residues of Polychlorinated Biphenyls (PCB), in the liver. PCB was found to be present in 15 (94%). The levels, expressed in parts per million wet weight, were:

		PCB
Mean	=	97.6
Max.	=	900.0
Min.	=	0

(b) **In Heron eggs**

In 1966 and 1968 a sample of eggs was collected for chemical analysis from a random third of the nests of the Troy colony. In 1966 the entire clutch (average clutch size 4) was collected from each nest. This showed all eggs in a clutch to contain similar residues, so in 1968 only one egg was taken from each nest. Also in 1968 a sample of eggs was taken from a random third of the nests in four other heronries in eastern England.

The results obtained, expressed in parts per million wet weight of the entire egg contents, were:

Colony	year	No. clutches		pp'-DDE	dieldrin	PCB
Troy	1966	23	mean	7.11	4.52	not investigated
			max.	16.89	14.54	not investigated
			min.	0.76	0.79	not investigated
Troy	1968	20	mean	5.45	2.2	5.75
			max.	17.0	6.0	80.0
			min.	0.7	0.3	1.0
4 other colonies in eastern England	1968	60	mean	6.21	1.84	4.69
			max.	26.0	6.3	48.0
			min.	0.3	0.2	0.0

(c) **In nestling Herons**

From 1965 to 1968 a total of 45 dead nestlings were collected from underneath nests in the Troy heronry and 27 from the Willoughby heronry.

The results of chemical analysis of the livers, expressed in parts per million wet weight, were:

Colony	No. specimens		pp'-DDE	dieldrin
Troy	45	mean	5.51	4. 5
		max.	44.2	28.22
		min.	0.2	0.2
Willoughby	27	mean	3.05	4.47
		max,	12.3	14.1
		min.	0.1	0.1

(d) **In fish taken as food by the Heron**

Observations were made to establish the feeding grounds used by the Herons from the Troy colony and an examination of fish dropped by adult Herons and regurgitated by nestlings confirmed the size and species of fish being taken. It was found that the Herons were principally feeding in the nearby rivers and drainage channels and the fish species most commonly taken as prey were: Eel (*Anguilla anguilla* (L)), Roach (*Rutilus rutilus* (L)), and Bream (*Abramis brama* (L)). A random sample of these fish was collected from the feeding grounds, for chemical analysis, by use of an electric fisher.

The results obtained, expressed as parts per million wet weight of the tissue analysed, were:

Species	Tissue	No. analysed		pp'-DDE	dieldrin
Roach	Muscle	45	mean	0.048	0.018
			max.	0.213	0.139
			min.	0.003	0.003
Roach	Liver	7	mean	0.696	0.207
			max.	1. 182	0.319
			min.	0.123	0. 118
Eel	Muscle	18 (grouped into 7 samples)	mean	0.398	0.049
Eel	Liver	14	mean	0.326	0.274
			max.	0.900	0.533
			min.	0.029	0.102
Bream	Muscle	7	mean	0.118	0.036
			max.	0.358	0.055
			min.	0.043	0.012
Bream	Liver	3	mean	1.111	0.449
			max.	1.666	0.706
			min.	0.167	0.142

DISCUSSION

These results show that residues of two organochlorine insecticides, pp'-DDE (a metabolite of DDT) and dieldrin, are widely distributed in Herons in eastern England. The

more recent analytical results, which also included figures for PCB, suggest this organochlorine compound—an industrial effluent—may also be widespread in this species.

Analyses of 620 livers or eggs of Falconiformes and Strigiformes (eagles, falcons, hawks and owls) from Britain, have also shown these same two organochlorine insecticide residues—pp'-DDE and dieldrin—to be almost universally present in terrestrial predatory birds (Prestt 1967). In Britain DDT and dieldrin are applied directly to the terrestrial environment as agricultural insecticides. It has thus been possible to trace their pathway from application to a predator, e.g. dieldrin dressed-seed to seed-feeding bird to bird-feeding hawk (cf. Prestt *et al* 1968). DDT and dieldrin have not however been applied on any large scale directly to rivers and drainage channels, so in the main these chemicals must have entered the aquatic systems accidentally as industrial and agricultural effluents or as fall-out from the atmosphere. The entry of the insecticides into the aquatic and terrestrial ecosystems has thus been different at the initial stage. Once they have entered either a terrestrial or an aquatic system, however, they pass along the food chains to the predators at the ends. The data for the Heron prove there can be a higher concentration in the terminal predator than in its prey species.

A comparison of the residue levels in full-grown Herons with those in full-grown terrestrial predators obtained in the same way during the same period, shows the Heron to have considerably higher average residues (see below).

Species	No. of specimens	pp'-DDE (ppm) mean (max-min)	dieldrin (ppm) mean (max-min)
Heron	42 livers	30.18 (240.0-0.2)	9.33 (60. 0-0)
Sparrow-Hawk (*Accipiter nisus* (L))	31 livers	14.5 (100.0-0.4)	4.4 (16.1-0.1)
Kestrel (*Falco tinnunculus* L)	117 livers	5.0 (45. 0-0)	3.1 (22.8-0.1)
Barn-Owl (*Tyto alba* Scopoli)	67 livers	4.2 (72.0-0)	2.6 (23. 0-trace)

Moreover, a comparison of the residues in the Heron with those in other fish-feeding birds in Britain—Shags (*Phalacrocorax aristotelis* (L)) from the Northumberland coast (Robinson *et al* 1967); Goosanders and Mergansers (*Mergus merganser* L. and *M. serrator L.)* from rivers in Scotland (Walker and Mills 1965); Great Crested Grebes (*Podiceps cristatus* (L)) from English lakes (Prestt and Jefferies 1969)—also show the Heron to have the highest residues (see below).

Species	No. of Specimens	pp'-DDE (ppm) mean (max-min)	dieldrin (ppm) mean (max-min)
Heron	42 livers	30.18 (240.0-0.2)	9.33 (60.0-0)
Shag	16 livers	11.2 (37. 38-1.25)	3.09 (9.84-0.62)
Goosander/Merganser	20 livers	3.39 (43.0-0.2)	0.75 (10.2-0)
Great Crested Grebe	19 livers	13.8 (81.0-0.4)	0.7 (4.6-0)

The concentrations of organochlorine residues found in bird tissues are determined by the rate of intake and the rates of breakdown and excretion of the compounds; the rate of intake being in turn related to the levels of residues contained in the food (cf. Jefferies and Davis 1968). The different levels found in these various predators could therefore have arisen from both physiological differences and from different levels in their foods. It is concluded from studies of terrestrial predators (Prestt *et al* 1968) that in cases of acute poisoning by dieldrin, the residues of dieldrin in the liver are usually greater than 10 ppm. In the early 1960s bans were introduced in Britain on certain uses of aldrin (which is converted to dieldrin in the body) and dieldrin (Cook 1964). It would appear that these bans have resulted in a more immediate reduction in the residues present in the terrestrial system than in the aquatic system, although the 50% reduction in dieldrin levels in the Heron eggs in the Troy colony from 1966 to 1968 suggests some reduction of residues in the aquatic system may also be taking place. The most likely explanation of the lower average levels now present in the terrestrial predators is therefore the limitations now in force on the use of aldrin and dieldrin. Prestt and Jefferies (1969) considered that the differences in the levels of residues in the fish-feeding birds are also more probably a greater reflection of the differences of the residues present in the prey of these species than of physiological differences. If this is correct, the different residue levels found to be present would indicate that rivers in eastern England contain higher residues of these organochlorine compounds than do rivers in Scotland, lakes in England or the sea in general. This is not unexpected, as the rivers of eastern England receive industrial effluent and pass through some of the most intensively farmed land of Britain and then disperse their residues into the sea.

There are no obvious effects of the residues on the Heron population of eastern England. The total number of breeding pairs present appears to be normal, so it must be assumed that the breeding success of the population in general is still sufficiently high to replace any losses that may have occurred as a result of pesticides. Eleven of the forty-two full-grown Herons analysed had liver residues in excess of 10 ppm of dieldrin, i.e. in a range considered exceptionally high and probably indicative of death by dieldrin poisoning (Moore 1965, Presett *et al* 1968). A further fourteen had residues between 5-10 ppm, i.e. at a level considerably above what can be considered as the typical background level generally present in wild birds in Britain. Further research is required to establish why some individuals obtained these exceptional residues. In terrestrial predators dieldrin poisoning has usually been found to be associated with unusually high residues in food, such as can result when granivorous birds feed on dieldrin dressed seed (Jefferies and Prestt 1966). Although it is known there are seasonal differences in the uptake of residues by terrestrial predators, there is less reason to suspect such differences in aquatic predators. The residues present in the fish in the Herons' feeding grounds, during the Heron breeding season, all contained similar relatively low levels. This suggests that some Herons may normally carry a high residue load through feeding regularly on fish which contain relatively low residues. Most of the Herons with very high residues were found dead during the breeding season, which further suggests the stresses of breeding could result in the death of certain individuals carrying relatively high loads.

The breeding study confirms a relatively high over-all output of young from the colony. It is difficult to know what can be taken as the normal breeding success as no detailed research on the breeding of Herons in Britain had been carried out before the introduction of organochlorine insecticides. Also, it is known that breeding success can vary from colony to colony and from season to season. Clutch size appears to be unaffected, but the eggshells laid by virtually every female were of sub-normal thickness and it is reasonable to suppose this is connected with the parental egg-breakage shown by over a third of the pairs in all the colonies under observation. Ratcliffe has discussed the correlation of this change in eggshell weight with the introduction of DDT and BHC and Peakall (1967) and Risebrough *et al* (1968) have shown DDT, DDE, dieldrin and PCB can all induce hepatic enzymes resulting in increased metabolism of steroid hormones. Nothing is known about the susceptibility of the species of fish studied in the present work to the levels of organochlorine insecticides they have been shown to contain, although in the Trout (*Salmo trutta* L) levels of dieldrin only slightly larger than these (0. 2-2. 5 ppm) have proved lethal (Holden 1965).

A summary of the present situation is that through accidental contamination of the rivers, of eastern England, residues of dieldrin and pp'-DDE have built up in the food chains to

a point where (a) all the fish examined have been found to contain residues at a level which in the Trout would be close to a lethal amount and (b) they have become widespread in Herons, to the point that in certain individuals they have proved lethal and in others have probably contributed to breeding failure. The Heron has thus proved valuable as a biological indicator of pollution of river systems, in which the cause of the pollution has still not been established.

REFERENCES

Abbot, D. C, Harrison, R. B., Tatton, J. O'G., and Thomson, J. (1965). Organochlorine pesticides in the atmospheric environment. Nature, Lond. 208, 1317-8.

Alexander, W. B. (1945). The index of Heron population, 1944. Br. Birds, 38, 232-4.

Burton, J. F. (1956). Report on the national census of heronries, 1954. Bird study, 3, 42-73.

Cook, J. W. (1964). Review of the persistent organochlorine pesticides. H.M.S.O. London.

Holden, A. V. (1965). Contamination of fresh water by persistent insecticides and their effects on fish. Ann. Appl. Biol., 55, 332-5.

Jefferies, D. J. and Davis, B. N. K. (1968). Dynamics of dieldrin in soil, earthworms and Song Thrushes. J. Wild. Mgmt, 32, 441-56.

Jefferies, D. J. and Prestt, I. (1966). Post-mortems of Peregrines and Lanners, with particular reference to organochlorine residue. Br. Birds, 59, 49-64.

Milstein, P. le S., Prestt, I. and Bell, A. A. (in press) The breeding cycle of the Grey Heron. Ardea.

Moore, N. W. (1965). Pesticides and Birds—a review of the situation in Great Britain in 1965. Bird Study 12, 222-54.

Moore, N. W. and Walker, C. H. (1964). Organic chlorine insecticide in wild birds. Nature Lond. 201, 1072-3.

Nicholson, E. M. (1929). Report on the 'British Birds' census of Heronries, 1928. Br. Birds, 22, 270-372.

Peakall, D. B. (1967). Pesticide induced enzyme breakdown of steroids in birds. Nature, Lond. 216, 505-6.

Prestt, I. (1966). Studies of recent changes in the status of some birds of prey and fish-feeding birds in Britain. J. appl. Ecol. 3 (Suppl.), 107-112.

Prestt, I. (1967). Investigations into possible effects of organochlorine insecticides on wild predatory birds. Proc. Fourth Brit. Insect. and Fungicide Conference, 1, 26-35.

Prestt, I., Jefferies, D. J. and Macdonald, J.W. (1968). Post-mortem examinations of four Rough-legged Buzzards. Br. Birds, 61, 457-65.

Prestt, I., Jefferies, D.J. (1969). Winter numbers, breeding success and organochlorine residues in the Great Crested Grebe in Britain. Bird Study, 16, 168-185.

Ratcliffe, D. A. (1967). Decrease in eggshell weight in certain birds of prey. Nature, Lond. 215,208-10.

Ratcliffe, D. A. (1970). Changes attributable to pesticides in egg-breakage and eggshell thickness in some British birds. J. appl. Ecol. 7, 91-138.

Risebrough, R. W., Rieche, P., Peakall, D. B., Herman, S. G., and Kirven, M. N. (1968). Polychlorinated biphenyls in the global ecosystem. Nature, Lond. 220, 1098-1102.

Robinson, J., Brown, V. K. H., Richardson, A. and Roberts, M. (1967). Residues of Dieldrin (HEOD) in the tissues of experimentally poisoned birds. Life Sciences, 6, 1207-20.

Robinson, J., Richardson, A., Crabtree, A. N., Coulson, J.C., and Potts, G. R. (1967). Organochlorine residues in marine organisms. Nature, Lond., 214, 1307-11.

Stafford, J. (1969). The census of heronries, 1962-63. Bird Study 16, 83-88.

Townsend, A.D. and Cornwallis. R. K. (1967). Lincolnshire Bird Report, 1966. Trans. Lincs. Nat. Union, XVI, 245-72.

Walker, C. H., Hamilton, G. A. and Harrison, R. B. (1967). Organochlorine insecticide residuces in wild birds in Britain. J. Sci. Fd Agric. 18; 123-9.

Walker, C. H. and Mills, D. H. (1965). Organic chlorine insecticide residues in Goosanders and Red-breasted Mergansers. Wildfowl Trust 16th Ann. Report, 56-7.

SUMMARY

Since 1964 a study has been made in eastern England of the Heron, a freshwater fish-feeding predator. This work has provided information on organochlorine residues in the birds, their eggs, nestling and in their prey. Breeding studies were also made. The Heron is carrying higher organochlorine residues than any other species of wild bird in Britain. Virtually every individual and all their eggs and nestlings contain residues of the insecticides DDT (as the metabolite pp'-DDE) and dieldrin and most also probably contain residues of polychlorinated biphenyls (PCB)—an organochlorine industrial effluent. The average liver residues in the Herons are about 30 ppm pp'-DDE, 9 ppm dieldrin and 97 ppm PCB. The average liver residues in Roach (*Rutilus rutilus* (L.)), the principal prey, are 0. 7 ppm pp'-DDE and 0. 2 ppm dieldrin.

Although some individuals have probably died from dieldrin poisoning the numbers in the breeding population have not decreased. The average number of young fledged per pair is 1. 9, but over a third of the pairs are deliberately breaking their own eggs. Virtually every egg laid has an abnormally thin shell, the reduction in the index of egg-shell thickness being about 20%.

The residues enter the river by accidental pollution from agricultural and industrial use, in contrast to their deliberate application as insecticides to the terrestrial environment. Once in either an aquatic or terrestrial system, however, they pass along food chains and accumulate in the predators at the end.

RÉSUMÉ

Depuis 1964, on pursuit dans l'est de l'Angleterre des études sur le héron, un prédateur de poissons d'eau douce. Ces travaux ont fourni des renseignements sur les résidus de chlorures organiques chez les oiseaux, dans leurs oeufs, leurs petits et dans leurs proies. On a également fait des études d'élevage. Le héron a le taux de résidus de chlorures organiques le plus élevé de tous les oiseaux sauvages de Grande Bretagne. Pratiquement tous les individus, tous leurs oeufs et leurs oisillons contiennent des résidus de DDT (à l'état de métabolite pp'-DDE) et très certainement aussi des résidus de polychlorure de biphényle (PCB), un chlorure organique d'origine industrielle. Les taux résiduels moyens dans le foie des hérons sont de l'ordre de 30 ppm de pp'-DDE, 9 ppm de dieldrine et 97 ppm de PCB. Les taux résiduels moyens dans le foie du gardon (*Rutilus rutilus* (L.)), le principal aliment du héron, sont de 0, 7 ppm de pp'DDE et 0, 2 ppm de dieldrine.

Bien que certains individus soient probablement morts d'une intoxication due à la dieldrine, les chiffres de population adulte nidifiante n'ont pas diminué. Le nombre moyen de jeunes oiseaux par couple est de 1. 9, mais plus d'un tiers des couples brisent volontairement leurs propres oeufs. Pratiquement tous les oeufs ont une coquille anormalement fine; la diminution de l'indice d'épaisseur de la coquille est d'environ 20%.

Tandis que les insecticides sont appliqués volontairement au milieu terrestre, leurs résidus parviennent accidentellement dans les rivières. Mais une fois entrés dans un système aquatique ou terrestre, ils suivent les chaînes alimentaires et s'accumulent dans le dernier chaînon qui est ici le prédateur.

Section B

Chronic Effects of Herbicides derived from Urea on Fish and their Food

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Water is a basic element of the biosphere on which the very existence of organic nature depends. Water pollution, which manifests itself in regular soiling of water with various waste matter, constitutes the greatest danger for water resources and causes a difficult problem for their conservation. Rapidly developing industry contributes to an increase in sewage effluent into open waters. The consequent pollution makes them unfit for fish to live in and for use as a source of drinking water and for industry. While existing legislation and the methods developed for sewage disposal to a certain extent protect waters from intense pollution, it has proved a much more difficult problem to prevent them being polluted by pesticides—the next most important factor in reducing fish stocks in many countries.

Research into the synthesis, industrial production and the practical application of pesticides have certainly been among the greatest achievements of science in recent decades. However, the wide use of pesticides in agriculture, forestry and other branches of the national economy, has been followed by various and often undesirable after-effects on wildlife, including that of the hydrosphere. The majority of alarming questions arising from the use of pesticides bear a direct relation to the fresh water ecosystem.

At present 'pesticide pollution' is mainly characteristic of the countries which have introduced pesticides extensively into agricultural practice. Since highly toxic and persistent substances such as aldrin, dieldrin and arsenical preparations (except for calcium arsenate) are not used in the U.S.S.R. and the application of DDT and heptachlor is restricted, pollution from these sources does not yet constitute a serious threat, although it has been reported from some regions of Central Asia. However, taking into account the ever growing scale of use of chemicals in the national economy of the U.S S.R., pesticides may become a constant actual factor causing water pollution in the very near future. In this connection research workers are now facing a new task, namely the elucidation of the extent of the danger which may arise when waters are contaminated by pesticide residues.

The dangerous effects of pesticides on fresh water life are linked with their toxicity for such forms of life even in small doses, especially in the case of chronic influence, by their accumulation in tissues and organs of water animals, by their passage through food chains and by selective activity in respect of the reproductive system of water organisms.

Pesticides find their way into waters variously: through run off from land treated with pesticides, through wind drift of pesticides sprayed by airplanes and, thirdly, through direct treatment of waters to control winged bloodsucking insects and aquatic vegetation. Weed growth is of course often one of the most important biological obstacles to water use: heavily overgrown ponds cannot be very suitable for pisciculture and excessive weed growth rather adversely affects irrigation systems. In one section of the Kara-Kum canal it slows down the rate of flow from the normal 56 cm/sec to only 10-20 cm/sec. In addition, water losses through evapotranspiration by reeds and cat's tails amounted to more than 14×10^6 m^3 a year, as estimated for only 20 per cent of the water surface of the Kara-Kum canal.

Chemical treatment based upon the application of substances having herbicidal properties is one of the promising ways to prevent waters being overgrown with vegetation. Quite conclusive proofs of the biological and economic efficiency of applying chemical preparations to control undesirable vegetation have been given by many Soviet authors (Shimansky, 1963; Bersonova, 1964; Klimova, 1964; Ryabov, 1964; Kalnozols, 1966), and the rapid pro-

gress in chemistry has made it possible to rely upon the synthesis of an increasing number of efficient new herbicides.

Diuron and monuron (urea derivatives), simazin and atrazin (triazin derivatives), dalapon and other derivatives of 2, 4-D and 2, 4, 5-T, are considered the most efficient preparations available in the U.S.S.R. However their application should not be allowed until a detailed study has been completed of the principal ways in which they are disseminated in and affect water bodies and the living organisms in such water bodies.

The extent of adverse effect of herbicides on water organisms depends not only on toxicity and dose, but also on the chemical composition of the aquatic environment, the status of the organisms and their individual and specific features. The only way in which it can be accurately assessed is to carry out interdisciplinary hydrological, hydrochemical, microbiological, hydrobiological and Ichthyological investigations of the waters concerned.

Some urea derivatives (monuron and diuron) are introduced into the soil in a granular form, which tends to produce a progressive release of a toxic element and to prolong the period of its effect. Thus urea derivatives may persist in soil for 3-4 years. They are practically not absorbed at all by argillaceous soils, absorbed by silt only at a very slow rate and filter through sandy soils. The results of our studies have shown that the diuron concentration in water decreases by half in 3 months through such filtration. Data obtained by the Institute of Experiment Biology of the Uzbek SSR Academy of Sciences and the Central Laboratory of Nature Conservation of the USSR Ministry of Agriculture show, however, that the role of soil in dissemination of the chemical is insignificant. Destruction of plants growing ten metres below the place treated with the granulated pesticide is brought about by their dissemination in flowing water. In one experiment, in the Turkmen SSR, where channels were treated with granulated monuron at a strength of 60 kg/ha, 0. 4, 0. 2 and 0.1 mg/l of monuron were detected in the water at distances of 0. 25, 1 and 1. 5 km, respectively, from the point where the treatment had been applied, but no trace of the chemical could be found in the soil at these three check-points.

Choking up of channels by vegetation impedes the supply of irrigation water to cotton fields and other agricultural land. It is therefore an urgent task in Central Asia to control aquatic weeds in the network of irrigation channels. Large-scale chemical treatment of this network involves the risk that huge quantities of monuron may be carried from subsidiary channels into the main drainage outlet and so into the Amu Darya river. In view of this possibility, the Central Laboratory of Nature Conservation carried out an appropriate study on one of the channels selected for investigation. The data obtained show that monuron released from granules at a concentration of about 0. 3 to 0. 4 mg/l over a period of a fortnight exerts an adverse effect on plankton organisms inhabiting the drain 1. 5 km below the point of treatment. Changes in oxygen content and pH value of water in this section of the channel were not observed, but where monuron has been applied to stagnant water, considerable changes of its oxygen content took place. Thus in a pond well covered with vegetation which had reached the flowering stage, an acute shortage of oxygen was observed to occur together with a rapid accumulation of ammonium and other nitrogen products in its water and changes in pH value. On the other hand, an oxygen deficit does not occur if monuron is applied at an earlier stage in the vegetation cycle, when the biomass of water plants is still small.

When diuron is used in the treatment of a heavy growth of water plants at the flowering stage, it lowers oxygen content to a considerable degree and affects pH value, plankton and fish.

One day after treatment of a water body, the quantity of aquatic plants is reduced. Total disappearance of all water plant species is observed on the sixth day after treatment, no recovery in their numbers or species composition being noted during the period of the study in water containing a herbicide concentration, although when only an algicide concentration was applied regrowth took place within two weeks.

Among zooplankton organisms Crustacea are known to be specially sensitive to the effect of pesticides, including herbicides. During our research work it was noticed that in the first six days after application of chemicals, numbers of Crustacea decreased significantly in water with an algicide concentration (of 0. 2 mg/l), but rose in that with a herbicide concentration (of 2. 4 mg/l). Recovery of numbers and species composition was observed

in the water with lower concentrations, while considerable inhibition of these organisms took place in the water with the higher concentrations of these chemicals.

Diuron is also toxic for fish. Blood is the most vulnerable system and its response to toxicity is very quick compared with the changes which appear in parenchymatous organs. In fish poisoned with diuron, disturbance of the gas metabolism initiates an intensive break down of haemoglobin and erythrocytes. Haemoglobin content sharply decreases and the typical anaemia and leucopaenia which develop appear to be the earlier symptoms of poisoning. This is followed by an increase in haemoglobin content and the number of erythrocytes, resulting from evacuation of blood reserves and an accelerated pathological division of erythrocytes into two or four daughter cells. But, although the erythrocytes and haemoglobin content is at the normal level, pathomorphological changes in blood cells are observable from the time of the first contact of the fish with the toxic substance until their death. Profound irreversible changes in the cytoplasm and karyoplasm of cells after their division are detectable in fish poisoned with diuron at a concentration of 0. 2 mg/l after a much longer period than in fish subjected to diuron at a concentration of 2.4 mg/l.

For example, the lower concentration induces cytoplasmic vacuolisation of erythrocytes only after 2½ months, while the higher concentration produces the cells with fully vacuolated cytoplasm and more pronounced haemolysis and division. Diuron acts as a strong haemolytic agent. In a pond which contained it in an algicide concentration, mortality of one species of fish, the ide *Leuciscus idus,* 2½ months after application, was 52%, whereas when a herbicide concentration was used, mortality rose to 67%. Metabolism was stimulated in the surviving ides in the pond with the algicide concentration of diuron, as was evident in particular from their weight gain. Metabolism and the growth of ides in the pond with the herbicide concentration were inhibited. This slowing down of growth indicates that the organism concerned is living in unfavourable conditions and using up a considerable portion of its food intake to resist the unfavourable factors of the environment, instead of increasing in weight. Deceleration of growth rate is associated with many physiological and biological processes which are of particular importance for the future of the species. Thus there is a considerable increase in the size of the liver, indicating disturbance of its functions and resulting in a marked parallel reduction of the gall-bladder volume and loss of function in the latter organ. In addition haomerrhagic nidi were found in the liver and spleen, and necrobiosis in the liver.

Herbicides therefore affect aquatic fauna in three ways: by producing changes in water chemical composition, by altering the quantity and quality of food and by direct toxic effects. It is usually only the mass mortality of fish following acute poisoning which gives rise to serious concern, because the death of one or a few fish a day in a stable population may remain unnoticed. Yet if the population decreases by half each year, it will be heading for extinction.

The development of human society from the beginning has been based on the use of natural resources, whether they be forests, waters, soils or minerals. The higher the summits reached by civilization, the deeper is the direct and indirect influence of man upon nature and the more difficult it becomes to foresee the possible adverse effects, which may show themselves in a relatively remote future and strike a surprise blow at the national economy. Already the 'clean water' problem is one of the main problems in the development of society. Furthermore, of course, human activities result not only in inland water pollution, but also in the pollution of coastal waters and to a large extent those of the whole of the world's oceans. In view of this, it seems essential to promote and pursue the scientific research which alone can ensure, before it is too late, that the theoretical basis is established for understanding how best to introduce into water use and management the favourable elements resulting from progress in the chemistry, and which will at the same time ensure that scientific recommendations can be elaborated to protect aquatic organisms from adverse effects of toxic substances.

SUMMARY

Due partly to effluent from industrial development, but especially to the widespread use of toxic chemicals in agriculture, which may make a valuable contribution to the national

economy, water pollution is tending to increase. It may be caused by run off from land treated with chemicals, aerial spraying drifted by the wind, or direct application for the control of insects and especially of aquatic vegetation, excessive growth of which may have a serious effect especially in irrigation systems. Some examples of these adverse effects are given.

Nevertheless, despite the proven efficiency of the application of herbicides to control aquatic plants, their use may have undesirable effects and research into those effects is essential. The present paper gives some details of the results of research into the effects of the urea derivatives monuron and diuron. It was found that these substances, which are absorbed or filtered by the soil only if it is sandy, are carried by water and have an effect some distance below the point of application, although they only affect oxygen content and pH value in stagnant water.

Some effects on crustacea are noted, but particular attention is paid to the effect on fish, in which urea derivatives can result in a break down in haemoglobin and the red blood cells, with various side effects, resulting in 52% to 67% mortality according to the concentration of the chemical. These effects are of sufficient importance to emphasize the need for continuing research to establish the best way in which chemicals can be applied to promote beneficial and prevent adverse consequences.

RÉSUMÉ

La pollution des eaux tend à s'accroître; ceci est en partie dû aux effluents d'origine industrielle, mais surtout â l'utilisation très poussée, dans l'agriculture, de produits chimiques toxiques qui d'autre part contribuent à améliorer la production agricole. Elle peut avoir différentes sources: ruissellement dans des sols traités aux produits chimiques, pulvérisations en aérosols entraînées par la vent ou application directe de pesticides et d'herbicides pour lutter contre les insectes et particulièrement contre la végétation aquatique qui en se développant trop risque d'avoir des effets néfastes, surtout dans les systèmes d'irrigation. L'auteur cite quelques exemples pour illustrer ce dernier point.

Cependant, malgré l'efficacité généralement admise des herbicides pour enrayer le développement de la végétation aquatique, leur emploi peut avoir des effets indésirables qu'il est indispensable d'étudier de façon très approfondie. Ce rapport donne quelques-uns des résultats obtenus au cours de recherches sur les effets de deux dérivés de l'urée, le monuron et le diuron. On a constaté que ces substances ne sont absorbées ou filtrées par le sol que dans le cas où celui-ci est sableux. En outre, elles sont entraînées par les eaux et exercent donc leur effet à une certaine distance, en aval du point d'application. Dans des eaux stagnantes, ces deux substances modifient la teneur en oxygène et le pH de l'eau.

Quelques exemples illustrent les effets de ces produits sur les crustacées. Chez les poissons, les dérivés de l'urée sont susceptibles de provoquer la destruction de l'hémoglobine et des globules rouges, ainsi que divers effets secondaires, ce qui entraîne une mortalité de 52% à 67% suivant la concentration du produit chimique. Ces effets présentent une importance suffisante pour qu'il faille souligner la nécessité de poursuivre les travaux de recherche afin de trouver de quelle façon ces produits chimiques auront le maximum d'effets positifs et le minimum d'inconvénients.

Section B

Atmospheric Pollution and its Effects on Natural Ecosystems

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1. INTRODUCTION

Pollutants from a large number and a wide variety of sources, both in home and industry, are discharged continuously in very large amounts into the atmospheres of communities as smokes, fumes, vapours, mists and dusts. Many of these components in high concentrations or following long exposures have been known to produce physiological changes in man, animals and plants.

In human beings, reactions such as local irritation of the respiratory tract or, if the pollutants are absorbed into the blood, tissue changes in the brain, liver, kidneys and other organs are known. Some materials will sensitize an exposed individual so that a subsequent contact will give rise to allergic reactions, such as asthma or localized oedema of the skin and mucous membranes. In animals, essentially the same picture is found as in man but with one very important additional factor. Materials ingested during the consumption of contaminated vegitation may constitute a far greater hazard than those brought into contact with the mucous membranes.

It is clear that on all space and time scales air pollution is an ecological problem. There is 'stress' caused by the emission of waste products into the environment. The 'response' is a physical or biological change in the receptors. The intermediate link in this ecosystem is the atmosphere, which cannot be neglected by those who seek to improve air quality and reduce the capacity of pollutants to interfere with man's comfort, safety or health.

2. AIR POLLUTANTS

Air pollutants are either gaseous or particulate and are commonly found associated with the oxygen and nitrogen of the atmosphere. They are of either natural or artificial composition, either emitted directly as such or formed in the atmosphere by interaction among two or more primary pollutants or by reaction with normal atmospheric constituents with or without photoactivation.

The two most important types of polluted atmospheres are (1) the 'reducing atmosphere', which contains the products of incomplete combustion like soot and sulphur dioxide, and (2) the 'oxidizing atmosphere', in which sunlight initiates photo-chemical reactions between hydrocarbons and nitrogen dioxide to create oxidants.

Smoke is the first air pollutant to have attracted community attention and its history goes back to the 13th century. The immediate cause of the production of smoke in such quantities as to constitute a nuisance was the exhaustion of the supplies of wood fuel in Europe and the introduction of coal as a substitute.

Sulphur dioxide is the second pollutant to cause community discomfort because it is produced at the same time as smoke from the burning of coal. But for over three hundred years, it was not recognized as a separate pollutant, because of the inadequacy of the chemical knowledge then available. By 1600 it was known that sulphur in the coal was responsible for the unpleasant smell and irritation to the nose and throat associated with smoke. With the development of metallurgical industries, sulphur dioxide has become one of the most important pollutants, since most metallurgic ores are sulphides and sulphur dioxide is a major byproduct in most extraction processes.

Hydrochloric acid became a recognized atmospheric pollutant with the development of the chemical industry. Other pollutants introduced by the industry are hydrogen sulphide

from tar distillation, nitrogen dioxide from sulphuric acid production, and hydrogen fluoride from the production of superphosphate fertilizer and aluminium. A variety of poisonous and noxious fumes were introduced by metallurgical industry from such metals as lead, arsenic, zinc and copper. The use of beryllium for a number of industrial purposes has in recent times created a fresh hazard in the form of finely divided beryllium. Among the secondary pollutants formed by photochemical reaction are ozone, formaldehyde, organic hydroperoxides, PAN and other very reactive components, which are among the most troublesome of air pollutants.

Sand and soil are frequently gathered up by winds over deserts or drought areas and carried considerable distances to the discomfort and distress of great numbers of persons. Pollens and similar allergens are a seasonal if not a constant nuisance. Apart from such 'natural' contaminants and organic particulates and viable particles consisting of mostly microorganisms and insects, radioactive pollutants also interfere with natural ecosystems. Strontium 90 is regarded as potentially the most dangerous, because it is long-lived and it is chemically similar to calcium, is readily absorbed and deposited in the skeleton, presenting a potential hazard of bone cancer or possible injury to the blood-forming tissues in the bone marrow. Cesium-137 and iodine-131 are also potential hazards which, when released in the air, are deposited in foliage, concentrated by farm animals and appear in milk. The only major nuclear reactor accident in 1957 at Wind - scale in England carried iodine-131 products over much of Europe. The resulting iodine contamination necessitated the withholding of milk from public consumption for several weeks after the incident.

Nuclear explosions in the atmosphere since 1954 have caused pollution of the whole atmosphere by radioactive debris and the resulting deposition in soils have given rise to small but detectable quantities in all biological material formed during the past decade. Radioactive debris, whether the close-in fallout or the cloud that enters the troposphere or stratosphere, does not, however, constitute a significant problem until it has settled out of the atmosphere.

Modern agricultural practices also contaminate the enviroment in many ways. The main agricultural pollutants are fertilizers and insecticides when airborne. Herbicides do not cause serious environmental pollution as they break down quickly. They may have important ecological effects but not as persistant pollutants, while insecticides cause widespread enviromental pollution, particularly to wild life. Poisons and toxic gases and bacteria and germs used in chemical and biological warfare are not only pollutants but killers. The extensive defoliation programme in Viet Nam by spraying herbicides from aircraft on large blocks of forests, have led to extensive destruction of mangrove forests and caused extensive and far-reaching ecological effects. Regeneration of the defoliated forests is expected to take twenty years.

3. EFFECTS OF AIR POLLUTION

While pollution of the environment has been universal since the beginning of time and much work has been done in detecting and measuring air burdens, little is still known regarding possible injurious effects on living organisms following long exposure by inhalation or deposition of small or even trace amounts of various pollutants. Excellent, comprehensive surveys on the effects of air pollution on human health, animals and plants summarising the present state of knowledge on the subject are available in the book on Air Pollution published by the World Health Organization (1961) and in the Report on a Symposium on Air Pollution and its Effects held in 1967. Air pollution is a problem of great urgency and importance in industrially advanced countries and timely study and action will help forestall the occurrence of many such problems in developing nations.

3.1. Physiological effects on man and domestic animals

Long, continued exposure to sublethal concentrations of many pollutants and combinations are known to have physiological effects. Thus the high incidence of 'chronic bronchitis' in British cities, nasopharyngeal and optic irritation in Los Angeles, and the rapid rises in lung carcinoma among metropolitan populations, appear to be closely associated with

air pollution. The series of studies made to correlate excess crude morbidity and mortality rates with the kind and amount of contaminants known to be present in the atmosphere have shown some positive indications. In the Belgian 'epidemic' in 1930, 63 persons died within a few days, 20 succumbed in the Donora (Pennsylvania) incident of 1948 and about 4000 in the 1952 London episode. The number of deaths represented a ten-fold increase over the expected mortality for those areas.

Periods of severe fog are customarily accompanied by an excess number of reported deaths from respiratory disease. More subtle physiological effects of air pollution are suggested by laboratory observations of suppression of ciliary action, alterations in pulmonary physiology, specific enzymic inhibitions and changes in blood chemistry.

Much experimental work has been done on the biological aspects of air pollutants, especially in animals. Fluorosis in cattle exposed to fluoride-containing dusts has been found to be related to emissions from certain industrial operations.

The exquisite toxic potency of ozone has been made abundantly apparent not only as an acute, fast acting pollutant, but as one with long term chronic insidious potential for all forms of animal life. The chemically recognized immediate effects are dryness of the mucous membrane of the mouth, nose and throat, changes in visual acuity and headache to such more serious temporary changes as functional derangements of the lung, pulmonary congestion and oedema. The reported effects of nitrogen dioxide and associated oxides range from odour, nose and eye irritation, pulmonary congestion and oedema, obliterative bronchiolites and pneumonites and death. Unlike ozone and nitrogen dioxide, sulphur dioxide effects are confined chiefly to the upper respiratory tract and eye, unless absorbed on particulates (aerosols) when portions of the respiratory tract are involved.

Comprehensive and detailed studies of both short term and long term effects of all these pollutants, as well as carbon monoxide, have been made on lower organisms and cell structures and on man and animals. The effects of organic vapours, inorganic mists (sulphuric acid and fluorides), organic mists (gasoline and oils), solids (fly ash, carbon, iron oxide, asbestos, beryllium and lead) and mixtures (gases, gases and mists, gases and solid particulates) have also been studied. Air pollutants have been shown to encourage the establishment of bacterial pneumonias and to enhance mortality from such conditions. The carcinogenic potential of atmospheric pollutants is also well recognized and based on two facts: (1) chemically and biologically identifiable carcinogens are well known products of incomplete combustion and as such are present in polluted atmospheres: (2) there is a higher incidence of respiratory tract cancer in cities or industrialized areas where such materials are present in high concentration.

Air pollutants that have caused serious or wisepread effects on livestock are mainly fluorine and arsenic. Of the two, fluoride has caused widespread damage and has proved more troublesome to control. Sources of airborne fluoride are heavy chemical industries—manufacture of phosphate fertilizer and aluminium, refrigerants, propellants etc. The toxic effects of fluoride in livestock arise from ingesting forage on which the various fluoride forms have either settled or with which they have reacted with consequent accumulation to levels far greater than occurring in ambient air. Gross contamination of forage by airborne arsenicals still occurs although more common in the past, with widespread poisoning of cattle, horses and sheep.

Lead is another major air pollutant. It is a cumulative poison and depending on the amount of lead that may be deposited from dusts or sprays, poisoning and death can take months if slightly contaminated hay is fed, or can occur within 24 hours in animals feeding on or near orchards which are heavily sprayed. In cases of acute lead poisoning the onset is sudden and the course relatively short.

3.2 Effect of air pollution on vegetation

The significant and devastating effects of air pollutants on vegetation, the failure of crops and the death of trees are more important than the effect of pollution in cities. The general types of injury are leaf tissue collapse with necrotic patterns, chlorosis or other colour changes and growth alterations. Injury patterns are highly characteristic of the toxic agent. The complete destruction of vegetation associated with sulphur dioxide pol-

lution from smelters is no longer a problem as such, but the effect of sulphur dioxide pollution remains. The effect of fluorides on plants is also well known. Fluorides appear to act as cumulative poisons to the plant, the main effect being plasmolysis and collapse of the internal cells. Chlorine, hydrogen sulphide, ammonia and other toxic chemicals also produce a dramatic tissue collapse of the leaf. From the agricultural standpoint it is doubly important since vegetation appearing perfectly normal can have a serious deleterious effect on the grazing animal.

Injury to vegetation by air pollutants results not only from industrial sources but also from sources associated with the complexities of urban living. This is illustrated by the photochemical smog problem in Southern California. The effect on vegetation is so marked that the vegetation damage is used as a means of monitoring and defining the extent of the pollution complex.

In some localized areas some of the pesticides especially herbicides can be classed as air pollutants and may damage certain plants. Economic injury to sensitive vegetation may be caused through uncontrolled or careless use of weed killers such as 2, 4-D in its various spray forms, particularly the volatile esters.

It is impossible to make a firm assessment of the cost of air pollution damage to vegetation. An estimate for the whole of California was 132 million dollars, representing visible injury affecting yield or marketablility and indirect effects such as growth reduction and impairment of keeping quality of fruits and vegetables. Including the effects of fumigation which severely mar or kill trees and the cost of erosion etc. the total annual cost was estimated to be over a billion dollars.

Much has been said and little done about means of reducing injury to vegetation from polluted air. The means are breeding programmes, cultural and management practices, land use and quality control.

A plant being a product of its environment, air pollution must be considered as simply another vector of the environment along with climate, soil, insects, diseases and genetic history, as well as care or abuse by man. The patterns of injury created by an air pollutant may not only be modified or obscured by other environmental factors, but the plant may develop patterns of injury difficult or impossible to distinguish from pollution effects. The modifying effect of prior climate—rainfall, temperature and wind—is often difficult to assess. The modifying effect of genetic make-up must also be considered. Closely related to climatic factors are the environmental factors of soil, nutrition and management. To diagnose properly air pollution effects on vegetation, the problem must be studied in the field by observers with a thorough knowledge of local cultural conditions.

4. METEOROLOGY OF AIR POLLUTION

The atmosphere is the medium in which air pollution is transported away from the source and, for a given source strength, its actions govern the length of time, the frequency and concentration to which any receptor will be exposed. On the other hand, meteorology plays only a limited part in the control or elimination of air pollution, since basically it does not affect the source strength of the pollutants emitted and since the fundamental atmospheric processes which govern the dispersion of material are not at present subject to control or modification.

Meteorological factors, all the same, are the chief dilutors and dispersers of atmospheric pollution. The most important meteorological processes for air pollution are dilution of waste substances by diffusion and mixing, their removal by fallout, washout and atmospheric reactions and the promotion by solar radiation of photochemical reactions. These depend on the wind structure, topographic effects and large scale wind and temperature distribution. The most efficient dilutor is wind and the most effective scavenger is precipitation. The effect of land and sea breezes in tropical and sub-tropical areas and the effect of the monsoon over India in cleansing the atmosphere are well known.

Generally speaking, meteorological conditions at night favour the accumulation of air pollutants and in the day time rapid dispersion. An annual cycle in this sequence is imposed by the change in relative duration of day and night as well as by manifestations of characteristic seasonal changes in features of the general atmospheric circulation. The

diurnal and weekly variations in pollution emission arise from man's living habits and the accommodations he has made to social, economic and physiological pressures imposed by his total environment.

Considering the importance of the meteorological aspects of air pollution on both national and international scales, the World Meteorological Organization has recently established an Executive Committee Panel to study the problem. It has also recommended the development of observational techniques and the establishment of networks for monitoring background pollution as well as the development of mesoscale forecasting techniques related to air pollution potential and the study of meteorological requirements for air quality management.

For evolving an adequate climatology of air pollution, it is necessary to have accurate data spread over many years of wind, temperature, pressure, humidity, sunshine, precipitation, visibility and atmospheric composition at the earth's surface and in the first few hundreds of metres of the atmosphere, as well as temperature, pressure, humidity, winds, radiation flux, divergence and ozone distribution in the whole atmosphere. The network in India consists of about 500 surface stations and 20 upper air stations. Direct measurements of air pollution in India are made by the Central Public Health Engineering Research Institute, Nagpur, and data are available for a number of cities and locations in India.

5. POLLUTION MANAGEMENT

With solid or liquid materials, either human or industrial in origin, the three methods of disposal are:

1. Deposition on or burial in the soil.
2. Dilution in streams, lakes or oceans.
3. Treatment to produce a material which can be removed or will not constitute a hazard.

These waste-disposal procedures represent ascending levels of control and indicate a progressive increase in the technical difficulties and cost. Accepting that a certain amount of pollution is unavoidable and may even be necessary, the problem is to hold the concentration of the contaminant at a level which can be tolerated by man, animals and plants.

Two disposal methods are available for the control of airborne wastes, particulate or gaseous:

1. Dilution in the atmosphere.
2. Trapping and treatment to produce a material which can be disposed of without hazard.

The goal is not to prevent all contamination, but rather to select the most practical method of meeting the requirements of a given situation, again accepting that some degree of air contamination is unavoidable in an industrial civilization and in highly aggregated populations. The three major variables to be balanced are:

1. The ability of the atmosphere to dilute the airborne wastes or residues, which includes consideration of the terrain and meteorological factors.
2. The availability of treatment procedures, including consideration of cost and efficiency.
3. The ability of man to tolerate the presence of the airborne wastes.

The capacity of the atmosphere to dilute falls into the realm of the engineer and meteorologist, but it is important in determining the amount of air pollution to be tolerated in any given situation. The ability of the ambient air to receive and disperse to safe limits particulate and gaseous wastes will differ according to terrain, local meteorological conditions, latitude, extent of industrialization, density of population, and season of the year. With the improvement in technical methods, it should be possible to predict with con-

siderable accuracy the amount and kind of contamination which can be absorbed under various circumstances.

The primary objective of air pollution management is thus to exploit the natural capacity of the atmosphere to dispose of waste materials without incurring undue risks of loss and harm because of temporary or long-term alteration of the quality and composition of the air and the underlying surface and vegetation. The 'dispersion meteorologist' concerned with the solution of problems of atmospheric transport, dilution and mixing of airborne materials, has contributed steadily and brilliantly to the solution of the problem of turbulent exchange processes in the atmosphere and his role will increase in importance and complexity as the sources of air pollution grow in number, density and complexity and as the catalogue of pollutants and their by-products proliferates.

Atmospheric pollution is still mainly a national problem of highly industrialized nations. But airmasses recognize no political jurisdictions and in their movements frequently do violence to concepts of local autonomy. As the problems of air pollution reach beyond regional to global scales, we shall have to evolve administrative mechanisms to deal with them on an international basis.

The United Nations recognizing this and noting that the relationship between man and his environment is undergoing profound changes in the wake of modern scientific and technological development and that these developments if not properly controlled will involve grave dangers, has decided to convene a Conference on Human Environment in 1972.

Water, food and air must forever constitute the survival bases of human and other populations. We will pay for them whatever they cost in time, money and effort, since without them we die. It is therefore shortsighted to consider the air resource as a competitively priced commodity. It is priceless.

REFERENCES

1. Air Pollution. Edited by A. C. Stern, Second Edition, Vol. 1, Air Pollution and its Effects. Academic Press, New York, London. 1968.
2. Air Pollution. World Health Organization, Geneva. 1961.
3. Air Pollution Handbook. Edited by P.L. Magill, F.R.Holden and C. Ackley. McGraw-Hill Book Co. 1956. New York.

SUMMARY

Pollutants from a large number and a wide variety of sources, both in home and industry, are discharged continuously in very large amounts into the atmosphere as smokes, fumes, vapours, mists and dusts. Natural contaminants and radioactive pollutants as well as fertilizers and insecticides, when airborne, also cause widespread environmental pollution.

Many of these pollutants in high concentrations or following long exposures are known to produce physiological changes in man, animals and plants. In human beings, the injury is comparatively slight, except during disasters such as that at Donora in 1948 or in London in 1952. But in animals, materials ingested during the consumption of contaminated vegetation constitute a far greater hazard. Air pollution damage to vegetation can be severe and in areas subject to such pollution the annual economic loss is estimated in millions of dollars.

Air pollution on both space and time scales is an ecological problem. There is 'stress' caused by the emission of waste products into the environment. The 'response' is a physical or biological change in the receptors. The intermediate link in this ecosystem is the atmosphere, which cannot be neglected by those who seek to improve air quality and reduce the capacity of pollutants, to interfere with man's comfort, safety and health.

Air pollution is still mainly a national problem of highly industrialized nations. But airmasses recognize no political jurisdictions and their movements frequently do violence to concepts of local autonomy. As industrialization spreads and problems of air pollution reach beyond national to regional and global scales, we shall have to evolve administrative mechanisms to deal with them on an international basis.

RÉSUMÉ

Des polluants d'origines nombreuses et variées—industrielle ou ménagère—sont continuellement et abondamment déversés dans l'atmosphère sous forme de fumées, poussières, vapeurs ou brouillards. Les polluants naturels et radioactifs ainsi que les engrais et les insecticides en suspension dans l'air provoquent également une forte pollution du milieu ambiant.

Au bout de longues périodes d'exposition ou en fortes concentrations, nombre de ces polluants causent des modifications physiologiques chez l'homme, les animaux et les plantes. Chez l'homme, les dommages sont relativement faibles, excepté lors de catastrophes telles que celles de Donora en 1948 ou de Londres en 1952. Au contraire, chez les animaux, l'ingestion de végétation polluée constitue une menace infiniment plus grave. Les dommages causés à la végétation par la pollution de l'air peuvent être très importants, et dans les secteurs subissant cette pollution, les pertes économiques annuelles se chiffrent en millions de dollars.

La pollution atmosphérique est un problème écologique, que ce soit à l'échelle du temps ou de l'espace. L'émission de produits de rejet dans un milieu provoque une certaine 'pression'. La réaction à cette pression se traduit par une modification physique ou biologique du récepteur. Le chaînon intermédiaire de cet écosystème est constitué par l'atmosphère:, ceci est important pour ceux qui cherchent à améliorer la qualité de l'air et à réduire l'action des polluants sur le comfort, la sécurité et la santé de l'homme.

La pollution atmosphérique est encore essentiellement un problème concernant les pays à forte industrialisation. Mais les masses d'air n'obéissent pas aux juridictions nationales et leurs évolutions font souvant fi des concepts d'autonomie locale. Etant donné que l'industrialisation s'étend de plus en plus et que les problèmes de pollution atmosphérique débordent les frontières régionales et nationales, il sera nécessaire d'élaborer des systèmes administratifs qui permettent d'y faire face sure le plan international.

SECTION B: POINTS MADE IN DISCUSSION

In opening the discussion the Chairman remarked that the problems posed by the use of toxic chemicals had given those concerned with nature conservation a new position of importance.

Aquatic enviroments are particularly liable to damage from pollution because (a) there is less available oxygen, (b) the range of organisms in water is more circumscribed and (c) aquatic animals, for example Crustacea, seem to have less resistance to certain chemicals, notably endosulfan, endrin and even DDT. But it is also worth noting that DDT at only one-twentieth of a lethal dose has been found to have serious effects on the thyroid and liver of a terrestrial species such as a pigeon. The inescapable conclusion is that by education and, if necessary, legislation everything possible should be done to prevent avoidable pollution of water by chemicals and that the aim should always be to phase out the use of persistent organochlorines, even if in some countries, especially in the tropics, this may take longer. The significant fact is that where the use of some of these pesticides has been brought under control, the status of all species known to have been affected by them has shown improvement (Moore, U.K.).

We have passed the point of no return in the use of chemicals to give greater security to food supplies, if the advances so far achieved are to be maintained. The possible alternative of biological control has been mentioned, but only one promising method of such control is at present under research in the whole of the U.S.A. It is essential therefore that all interests should collaborate to ensure that chemicals are used with the minimum pollution or destruction of all that man wants to use or enjoy in addition to his food supplies. Even now there are only 8-10 places in the world where exact measurements of chemical residues can be carried out (Appleby, U.S.A.).

We must have interchange of opinions and establish confidence between all interested parties. Other things besides pesticides have played a part in securing food supplies, although the IUCN Committee on the Ecological Effects of Chemical Controls has never maintained that such controls should be abandoned. Nevertheless, there are many more cases of successful biological control then the previous speaker suggested: the alfalfa weavil, for example, also *Bacillus thuringiensis;* and the development of rust resistant varieties. Indeed genetic breeding, fertilisers and farming techniques have been as important for food production as pesticide chemicals. Another point is that although the latter have only been applied, for instance, to less than 5% of the whole area of the U.S.A., the fact remains that a very much larger area has been affected by them. On the other hand there is evidence that the ecological effects of certain chemicals are less adverse than others, for example some very toxic refined nerve-gases because of their formulation, method of application and the shortness of duration (George, U.S.A.).

If a wheat crop is treated with chemical pesticide many insect species may be involved. The question is, therefore, whether if man is to survive, he must really do without insects including butterflies, insectivorous birds and fishes, and so on up the food chain. Or is it not possible under the pressure of public opinion, which wants to see butterflies, that much more specific substances can be devised and that eventually one can look forward to the use of one chemical to control each species if and when it reaches pest proportions ? (Scott, U.K.).

We want butterflies, but on the other hand we also want health and W.H.O. has made it clear that we cannot do without chemicals to control the insects which are vectors of disease. A choice has to be made. Whether more specific chemicals can be found is not yet known, but the Shell Company alone is examining the potentialities of some 8000 chemicals a year (Appleby, U.S.A.).

Stress had been laid on the economic reasons for using toxic chemicals, but the banning of DDT in Argentina in 1969 was also dictated by economic considerations: the U.S.A. had stopped buying Argentinian meat because it contained too high a proportion of DDT residues (Buchinger, CLAPN).

In the first decade after the Lake Success conference of 1949, the far-sighted warnings and recommendations for research into and for the regulated use of pesticides, made at the conference, went largely unheeded by governments and international agencies. During

the second decade now ending, there has been a general confrontation, in which the matter has had to be taken much more seriously, so that in Britain, for example, the banning of certain chemicals or their mode of use, to which reference has been made, have all been agreed between conservationists, industry and government without any legal coercion. Now that ICSU has set up SCOPE, its Special Committee on Pollution of the Environment, it is imperative that a world-wide co-operative effort should be developed between ecologists and industry—between the Guardians of the Biosphere and the Managers of the Technosphere. If this can be achieved, the third decade now beginning may yield more constructive results (Nicholson, U.K.),

Figure 1 in Mr. Appleby's paper is open to different interpretations, but the fact that DDT, BHC and other residues have been found in places like Signy island in the antarctic, well away from the American base, seems to show that there must be a 'drift' of these residues even if it is at a low altitude and not necessarily stratospheric (Moore, U.K.).

A danger which has not been mentioned is that of export of toxic chemicals from countries where they are manufactured but where their use has been banned or restricted, to other countries where the seriousness and urgency of the problem of control may not be appreciated, since it is in fact not yet possible to measure and evaluate it with certainty. This in turn would lead to another risk, namely the misinterpretation or quotation out of context of any suggestion made at this conference that the problem is not serious and urgent, with possibly disastrous results (Miller, U.S.A.).

We must rely on each country or indeed international organisation making up its own mind and reaching its own decisions in these matters. What is vital is that every actual case should be properly and carefully examined, the risk/benefit equation worked out and the final decision reached only on that firm basis (Appleby, U.S.A.).

Turning to questions of air pollution, it might be remarked that the common practice of building ever higher smoke stacks merely ensures that the pollutants are carried further afield. An interesting question is the extent to which air-borne dust reduces/or neutralises carbon-dioxide pollution (Chairman).

CO_2 must be approaching the limiting factors of assimilation, insofar as we continue to cut down the assimilating forests. But perhaps the increasing amount of CO_2 is resulting in higher carbohydrate production and there is in fact still a cancelling out ? (Kuenen, Netherlands).

With the increasing industrialisation in developing countries, would it not be possible for international agencies such as IUCN to assist in making sure that effective steps are taken, for example in India, to locate new industries where there is less chance of creating air pollution? Dr.Mani's paper suggest that there are meteorological parameters on the basis of which the risks of such pollution could be fairly accurately assessed (Mukhirjee, India).

Much is being done to gather the basic quantitative data, but probably only legislation would be effective in persuading industrialists to avoid already heavily polluted areas such as Kahnpur and Calcutta (Mani, India).

One important type of water pollution has not been mentioned at this session. Several large barrages are under planning or construction in southern Asia, notably in the Mekong river basin. Their sites are surrounded by heavy forest, bamboo or other vegetation, yet no attempt is being made, or there are no plans, to remove this mass of material before it is flooded. Its decay will surely have a very detrimental effect on fisheries, which are usually placed second only to power generation as an objective of these projects, and it could also threaten the operation of the power installations themselves, not to mention navigation. It would be useful if this meeting could go on record as supporting much more research into the physical and other effects of decaying vegetation, drowned in the construction of reservoirs, and into the appropriate clearing methods and techniques, as an essential part of proper and balanced management of river basins (Soni, India, and Turbang, FAO Regional Forestry Officer, Bangkok).

SECTION C: SOME ASPECTS OF WILDLIFE UTILIZATION AND MANAGEMENT
(1) WITH SPECIAL REFERENCE TO MAMMALS

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Protection of Wild Animals in the USSR in and out of Use

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Animal protection is a complicated and diverse problem for three basic reasons. First of all, any fauna consists of a great number of various forms: individual cases of conservation-work with small birds, poisonous snakes, large predators or wild ungulates, for example, all have their specific peculiarities. Secondly, the diversity is determined by the fact that the various animal species have differing significance for the man. Thirdly, the attitude towards the conservation of particular animal species is determined by the population of that species: a rare species has to be treated differently from a numerous game species.

Animal conservation is usually dealt with in two ways: (a) in the process of utilization and (b) in the process of protection from utilization. Nevertheless it is important to remember that any one given species can at various times call for total conservation or for conservation combined with utilization. The general task and final aim of animal conservation is conservation of an entire fauna on a basis of rational utilization. But it is clear that the word 'utilization' should be understood as not being restricted to the sense of killing for the sake of producing meat, fur or skins. In fact, even today, the rarest species can be rationally utilized as a genetic source or as an object of study and enjoyment in a zoological garden.

There is no doubt that at the present time conservation of game animals must be carried out in combination with utilization. Rational utilization under modern conditions not only does not conflict with conservation but even promotes it. The latter may come about in two ways. On the one hand a biologically sound cull of a sufficiently high number of individuals out of a particular population of animals may increase the reproduction potential of that population. Secondly, regular hunting of a species over an extended period should involve more than mere killing of the animal: it leads to measures for the improvement of the habitat of the animal, where the hunting takes place; to assisting the species at difficult periods of its life cycle or when it suffers some disaster; and also to breeding programmes.

There are numerous well-known cases of total conservation leading an animal population into catastrophe. An increase of the population of many animal species, especially gregarious ones, such as the beaver, after reaching a certain level may come to a rapid halt, so that subsequent losses are no longer made good, until a certain part of the population has been removed. In other words, only removal of part of the population triggers off the reproductive potential and leads to a new increase.

Obviously, however, the laws of animal conservation should provide both for timing and methods of hunting, including the temporary or permanent prohibition of hunting of those species whose numbers have been sharply reduced as a result of destruction of their habitat or uncontrolled exploitation.

In the Soviet Union, a number of species such as *Alces alces, Saiga tatarica, Bison bonasus, Cervus nippon, Castor fiber, Desmona moschata, Egretta alba, Phoenicopterus ruber,* etc. were completely protected by the hunting laws enacted as long ago as 1919 and 1922. Subsequent decisions of the government of the USSR and of the Union republics completely prohibited hunting of *Cervus elaphus bactrianus, Nemorhaedus goral, Equus hemionus, Gazella subgutturosa, Capra falconeri, Enhydra lutrix, Panthera tigris, Acinonyx jubatus, Ursus maritimus, Francolinus francolinus. Somateria mollis-*

sima, all swan species, some geese species etc. At present the hunting of 18 species of mammals and of 29 bird species is completely prohibited in the USSR, However, the hunting under licence is now authorised of certain species once totally protected, such as the wild ungulates and *Desmona moschata, Castor fiber, Lutra lutra, Martes martes, M. zibellina* and *Callorhinus ursinus*

Biologically, the reproductive abilities of most species are fairly high and the number of animals would rapidly increase under complete protection, provided their habitat was not destroyed. Sable, saiga, elk and beaver can serve as an example, as shown in the following Table:

TABLE 1: NUMBER OF SOME GAME MAMMAL SPECIES IN THE USSR IN PERIODS OF TOTAL PROTECTION CONSERVATION AND SUBSEQUENT UTILIZATION

Species	Hunting prohibited		Opening of hunting		Present number of animals
	Year	Number of animals	Year	Number of animals	
Sable *(Martes zibellina)*	1912	25, 000	1940	350, 000	800, 000
Beaver *(Castor fiber)*	1919	800	1962	40, 000	60, 000
European Elk *(Alces alces)*	1919	100, 000	1950	300, 000	600, 000
Saiga *(Saiga tatarica)*	1922	1,000	1951	1,000,000	1,500,000

This Table clearly demonstrates how, as a result of complete protection, the populations of these four species reached a high level in the 1940's or 1950's, so that once more they could be hunted. Thus the number of elk increased three times, of sable 12 times, of beaver 80 times and of saiga 1000 times during the period of 30-40 years*. Attention is also particularly drawn to the fact that although with the opening of hunting populations were reduced by the actual animals killed, in fact the controlled utilization of these species in the USSR has resulted in further very large increases in over-all numbers.

Turning to some other species, the hunting of which was also prohibited in the USSR, Table 2 overleaf gives some interesting figures.

In the case of these four species, numbers have increased by 5 to 20 times as a result of conservation. However, this is not yet enough to warrant large scale utilization. Limited exploitation of Caucasian tur (*Capra caucasica*) and red deer has begun in a number of provinces, while the management of *Cervus nippon* has assumed the form of maintenance in a semi-wild state.

Numbers of several other mammal species have sharply increased as a result of complete or partial protection (in certain provinces), so that hunting of them can again be permitted. For instance, the roe deer *Capreolus capreolus* is one of the species that was put under protection by the first hunting laws, but has now become a game species in the Asiatic part of its range. The wild reindeer *Rangifer tarandus* has increased two or three times in number in Taimyr and Yakutia as a result of partial protection. One particular subspecies of the reindeer, *R. t. pearsoni,* has now reached the same level of population as it had at the end of the last century, in this case as a result of

* It should be pointed out that the data on original numbers, taken from the work of D. K.Solovyev *et al.* (1926) are very approximate because at that time no accurate counts were being made.

TABLE 2: CHANGE OF NUMBER OF SOME RARE GAME MAMMAL SPECIES AS A RESULT OF PROTECTION

Species	Hunting prohibited		Present Number of animals	Remarks
	Year	Number of animals		
Sea otter *(Enhydra lutrix)*	1924	350	7, 500	
Axis deer *(Cervus nippon)*	1922	900	20, 000	Including acclimatized and semi-domestic animals.
Caucasian tur *(Capra caucasica)*	1924	2,000	25,000	Protected throughout its habitat.
Red deer *(Cervus elaphus* subspp., excluding *C. e. bactrianus)*	1922	40, 000	200, 000	Limited hunting allowed in some provinces.

complete protection. Total prohibition of the hunting of the polar bear, established in 1956, has led to an approximate doubling of its numbers in a period of 10 years. Many examples of this kind could be cited.

The situation is quite different with those species whose habitat has been completely destroyed or sharply reduced. Their numbers outside reservations continue to fall. Naturally, however, habitat destruction has an impact on different species in different ways, according to their ecological plasticity. The best illustration of this is *Cervus elaphus bactrianus.* Despite the fact that this race of red deer has been put under complete protection, its numbers continue to fall as the areas which are its main habitat are lost by erosion in the beds of desert rivers.

The situation is otherwise with *Equus hemionus.* Its desert habitats may seem largely undisturbed, but man has begun to occupy and develop them, for example by the discovery of springs which have been tapped to supply animals with water, and has thus made the arid country adjacent to these water supplies unsuitable for the wild ass.

The main factor decreasing the numbers of now rare predators such as tiger, leopard, snow leopard *Panthera uncia* and caracal lynx *Felis caracal* has been a sharp depletion of food supplies, as wild ungulates on many pastures, including mountain ones, have become replaced by domestic animals protected by man.

Thus, partial disturbance of habitats or the appearance of competing animals can be reasons for the reduction of the number of some rare species despite all the protection given them. For instance, the reason for the continuing fall in the number of Russian desman *Desmona moschata* is changes in river regimes and the introduction of the muskrat *Ondatra zibethica.*

In order to protect species whose habitats are partially or completely destroyed, the establishment of reservations is of extreme importance. At present, there are 88 reserves with a total area of more than 7, 000, 000 hectares in the USSR. Very many species that are taken care of at present are directly indebted to reservations for their existence (*e.g. Equus hemionus, Cervus elaphus bactrianus,* etc.). Thus in 1941, when the Badkhyz reserve was established, there were only about 100 *Equus hemionus* within its borders, which constituted the only habitat for the species in the USSR. During the following 25 years, the number of *Equus hemionus* increased seven-fold and at present there are about 700 animals in the reservation. Similarly, *Cervus elaphus bactrianus* is largely confined to the Tigrovaya Balka and Aral-Mygamba reserves, which contain more than 250 out of the total of 300 surviving animals. The role of reservations and, particularly, the Byelovezhskaya Pushcha, in preserving and restoring the number of bison, which at present has reached almost 300 (pure-bred animals), is well-known.

Reservations have been of great importance in restoring the numbers of several other species, at one time rare and now once again wide-spread and utilized as game species. Thus it is hard to overestimate the role of the Barguzin reserve in restoring the sable *Martes zibellina* population. Again the Voronezh reserve has not only allowed its beaver population to be brought back to a high level, but also made over 2, 000 animals available for introduction or re-introduction to new habitats situated in no less than 25 provinces, territories and republics. The role of the Khoper and other reserves in conserving the Russiam desman has been important. All protected species in the USSR fauna are also indirectly indebted to reservations for existence, by virtue of the development of a scientific interest in their conservation and rehabilitation.

Much attention has also been paid to the conservation of birds in the USSR. At the beginning of this paper, the names of a number of bird species that have been completely protected throughout the territory of the USSR or in particular Republics were mentioned. Since, however, no counts of absolute numbers of birds in the country as a whole have been carried out, it is impossible to give numerical data on the results to date of the protection of rare species. Nevertheless, the general situation with birds is similar to that described above in the case of mammals. Reservations have played an equally decisive role in protecting bird species, especially rare ones.

Thus the Astrakhan reserve has restored the *Egretta alba* population, which had almost entirely disappeared in the Volga delta. The spoonbill *Platalea leucorodia* and the glossy ibis *Plegadis falcinellus* are once again nesting in numbers in this area, as are several other rare species. The eider *Somateria mollissima* was rehabilitated by the Kandalaksha reserve: when this reserve was established, only a few pairs nested, now there are thousands of nests. A number of reserves, such as the Astrakhan, Darvin and Matsadu, have safeguarded and increased the population of the grey-lag goose *Anser anser*, while the part played by the Zhuvintas reserve in preserving the swan *Cygnus olor*, and by the Kazal-Achis reserve in saving the francolin *Francolinus francolinus*, has been very great. Reserves specially designed to protect wintering birds, including such rare species as some of the wild swans, have been especially important.

The decision taken in 1964 to place under complete protection predatory birds throughout the Russian Federation must be classed as an indubitable success. This decision stopped the extermination of many useful bird species, including many rare species of falcons and eagles, which had previously been senselessly killed.

Despite the brilliant results achieved from the protection of sable, European elk and saiga, and the undoubtedly beneficial results of protecting many other rare species, there are still many questions to be solved in saving rare species in the USSR. Thus the status of *Gazella subgutturosa*, *Panthera uncia*, a number of Ovis spp., Desmona spp. and many rare bird species, which are still not properly protected, is extremely unsatisfactory. The numbers of the great lizards *Varanus griseus* and *Naja oxiana* are still falling sharply. Much more attention also needs to be paid to poisonous snakes, because the danger of extermination of all species is very real and needs to be considered in relation to the need for supplies of venom for medical and other research purposes. Moreover, the danger is particularly serious because of the fact that we still have too little knowledge of the life history of snakes and too few data on their natural mortality, their rate of reproduction and their ecological parameters. Because of this poor knowledge of the snake ecology, laws have been enacted in some Republics of the Soviet Union in recent years (1968-69) to provide for a system of capture of snakes only under licence, and for limitations of the season during which snakes may be caught.

To sum up, there is little doubt that it is still necessary for much effort to be made to preserve the riches of the animal world, which can still be of great benefit to man. Experience in the Soviet Union has shown that a scientifically based and well-considered utilization, i.e. rational utilization, of animals is indeed the most important way of conserving them. For this purpose, the standards on which culling or exploitation of various sex and age groups from an animal population should be based, the determination of proper seasons and methods of hunting, etc., have been and still are being worked out in the USSR. There is no doubt that the final goal of fauna conservation should be based on the fact that each animal species is capable of being rationally utilized as a natural resource.

SUMMARY

The varying characteristics of any fauna and of the species of which it is composed, imply that the approach to their conservation must be equally varied, although broadly it must fall into one of two categories — either a total protection from utilization or, alternatively, a plan for rational use. The latter should always be the long-term aim, especially as total protection of a population often finally results in catastrophe, whereas a soundly based utilization can make a positive contribution to the conservation of the species concerned.

In the USSR the general pattern has been to provide total protection of depleted species until numbers have built up sufficiently to allow a properly controlled utilization policy or annual off-take to be re-established. Figures for four such species, sable, beaver, elk and saiga, which were given full protection as long ago as 1912—1922 and released for utilization between 1940 and 1951, are discussed and it is shown that since hunting was again allowed, their numbers have continued to increase. The cases of a number of other species whose conservation is still at various intermediate stages are also examined.

The chief difficulty arises where the decline of a species is due not to over-exploitation but to habitat destruction or, in the case of predators, where prey species have given way to protected domestic stock, or thirdly, where competitive exotic species have been introduced. The answer to these situations must be the establishment of reserves: examples are given of the many instances in which the pursuit of this policy in the USSR has completely restored the status of threatened species, which now once again can be used for the benefit of man, including scientific study.

There are still a number of species, notably some of the reptiles, for which further special efforts at conservation need to be made on the above lines, but all the experience gained in the Soviet Union shows that not only is rational use the most important aspect of conservation, but that it is fully capable of being realised.

RÉSUMÉ

La grande diversité des caractéristiques d'une faune et des espèces qui la composent implique que leurs problèmes de conservation devront être abordés d'une façon toute aussi variée, bien qu'en gros il y ait deux alternatives possibles: soit une protection totale contre toute forme d'utilisation, soit un programme d'utilisation rationelle. Ce dernier devrait toujours constituer l'objectif à long terme de la conservation, étant donné en particulier que la protection totale d'une population se termine généralement en désastre alors que l'utilisation rationnelle peut contribuer de façon positive à la conservation de l'espèce concernée.

L'URSS a suivi un ligne d'action consistant à protéger totalement une espèce épuisée jusqu'à ce que sa population soit suffisamment rétablie pour qu'elle puisse être utilisée de façon contrôlée ou chassée suivant certaines normes de prélèvement annuel. L'auteur fournit des données sur quatre espèces de ce genre—la zibeline, le castor, l'élan et le saïga, qui ont été totalement protégées dès 1912—1922, puis rendues à la chasse entre 1940 et 1951, et démontre que depuis que la chasse a été réouverte, leurs populations n'ont cessé de s'accroître. Il étudie également le cas d'un certain nombre d'autres espèces qui font actuellement l'objet d'une protection plus ou moins totale.

Le problème est plus difficile à résoudre lorsque le déclin d'une espèce est dû non à la sur-exploitation, mais à la destruction de l'habitat, ou encore, dans le cas des fauves, lorsque les espèces proies ont été remplacées par du bétail domestique protégé ou bien quand des espèces exotiques compétitives ont été introduites dans l'habitat. La seule façon d'y remédier est de créer des réserves. Dans de très nombreux cas, illustrés ici par des exemples, la poursuite de cet objectif en URSS a permis le rétablissement total de l'espèce menacée qui peut a nouveau être exploitée par l'homme, entre autres à des fins scientifiques.

Il faudrait encore prendre des mesures spéciales de conservation pour plusieurs autres espèces, en particulier certains reptiles, mais toute l'expérience acquise en URSS révèle que l'utilisation rationnelle constitue l'aspect le plus important de la conservation et, en outre, que cet aspect est parfaitement réalisable.

Section C (1)

Economic Aspects of Wildlife Conservation: Values of Consumptive and Non-consumptive Uses of Wildlife Species

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I. INTRODUCTION

India was endowed with a fabulously rich wildlife heritage. For example, India has over 40 big game animals, whereas North America has fewer than 20 species. Regretfully, however, only remants of many Oriental or Indian faunal forms now remain. Much of India's wildlife today is restricted to a relatively few sanctuaries and parks. Even here, wildlife generally is not protected from encroachment by man and his domestic livestock, or from forest exploitation and habitat destruction.

It is my opinion that wildlife conservation, particularly in developing nations, will be most successful when advocated upon economic principles. To quote from one of India's greatest champions for wildlife conservation, the late Mr. E. P. Gee (1966):

> Where poverty, hunger and often illiteracy are prevalent among the local people, it is mostly of no avail to stress the importance of wildlife and wild places on aesthetic, cultural and scientific grounds. The main emphasis should always be on their economic value; in other words it should be emphasized that rare wild animals are of infinitely greater value to the local villagers if kept alive in their natural habitat... Wild animals, especially rare ones, in their natural surroundings will attract visitors from nearby cities and tourists from abroad, and thus provide the necessary revenue and foreign exchange for the sorely needed development and elimination of the very poverty, hunger and illiteracy which everyone wants to remove.

The purpose of this paper is to illustrate various economic or monetary values of wildlife conservation. The term economics, as here used, denotes monetary expenditures *or* income derived from wildlife conservation through consumptive or non-consumptive uses.

II. THE CONSUMPTIVE USE OF WILDLIFE

(a) Sport hunting

The State of Idaho (U.S.A.) has a bighorn sheep *(Ovis c. canadensis)* population of approximately 2,000 head (Morgan, 1969). Most of these animals inhabit rugged, inaccessible mountain areas during the summer and fall. Upon the purchase of a $10 sheep tag, anyone holding a valid Idaho hunting license is permitted to shoot a trophy ram during the September hunting season.

A ram with a three-quarter curl or longer horns is considered a trophy or legal animal. This restricts the harvest to males four and one-half years of age or older. The annual hunting license fee is $3 for residents and $100 for non-residents.

A total of 602 Idaho sheep tags were sold in 1968 (Table 1). Of these 251 (41.7%) were purchased by non-residents. Based on the return of questionnaires, hunters reported that they spent an average of $292 ($130 for residents and $527 for non-residents) hunting bighorns in 1968. Thus, the reported expenditure per trophy ram killed averaged about $4,236.

It should be emphasized that these figures are minimal, because they include only variable and not fixed costs. Also, most hunters tend to underestimate the cost of hunting by 3.4 to 23.4 per cent (Pearse and Bowden, 1966). The outfitting and guiding of hunters is a major industry in Idaho, and a fair share of this industry's revenue is derived from big-

TABLE 1: TOTAL REPORTED EXPENDITURES BASED ON QUESTIONNAIRE RETURNS FOR BIGHORNE SHEEP HUNTING IN IDAHO FOR 1968 (FROM MORGAN, 191)

Hunters	Number Questionnaires returned	Reported Expenditures	Average	Total Tags Sold	Projected Expenditures	Bighorns killed
Resident	293	$38,114	$130	351	$45,630	16
Non-resident	201	$105,978	$527	251	$132,277	26
Total of	494	$144,092	$292	602	$177,907	42

horn sheep hunters. In 1968, 107 or about 21 per cent of the bighorn sheep hunters who returned questionnaires indicated that they used guides or outfitters. Outfitter and guide fees for a 2-week hunt approximate $750. In terms of recreation, an average of 69 hunter days were expended for each trophy ram killed. This means that bighorns provided a minimum of 2,886 hunter days of recreation in 1968.

Using 1960 and 1968 questionnaire data as a base, and assuming that the present system of an open bighorn sheep hunt through September with unlimited permits is continued, it can be projected that expenditures per trophy ram killed should approximate $7,000 by 1976. Also, almost 800 hunters should take to the field and expend approximately 4,000 days in quest of Idaho's bighorns in 1976.

The percentage of hunter success for Idaho's 1968 bighorn sheep hunt was 7 per cent. Assuming a continued unlimited permit hunt and a 7 per cent success in 1976, the harvest should then approximate 56 rams. Presently, about 10-15 per cent of the bighorn population in Idaho consists of legal rams, which means there is a huntable population of 200-300 rams (Morgan, 1969). Although the recreational value of bighorn hunting in terms of hunter days should increase substantially by 1976, the harvest then should not exceed 25 per cent of the legal rams in the population.

The minimum annual expenditure by sheep hunters in 1968 equalled a mean of about $89 for every bighorn in Idaho. Considering the reproductive potential of a bighorn with a life expectancy of 7 years or more, as well as the projected future from bighorn sheep hunting, the total value for each of Idaho's bighorn sheep increases significantly.

The expenditures or variable costs for bighorn sheep hunting represent only a part of the picture. The total economic value of the bighorn increases considerably with the inclusion of fixed costs and non-consumptive uses, although exactly how much would be difficult to ascertain.

The bighorn sheep, admittedly, is one of North America's most prized trophy game animals, but other species also have considerable trophy value. For example, the House of Representatives for the State of Alaska recently approved a bill calling for the sale of special muskox *(Ovibox moschatus)* licenses for $1,000 to non-residents and $500 to residents. This would have allowed for the shooting of 30 old bulls from the 750-animal herd on Nunivak Island. However, Walter J.Hickel, former Governor of Alaska and present Secretary of the Department of the Interior, would not permit such a hunt. He declared, 'the musk ox is not a game animal and should ...be developed for domestic purposes' (Anon., 1969).

Although many North American game species are highly prized and of considerable economic value, North America has little to offer the trophy game hunter in comparison to the Indian sub-continent. Hunters throughout the world would cherish the opportunity to bag a tiger *Panthera tigris.* The gaur or Indian bison *Bos gaurus* and wild buffalo *Bubalus bubalis* are notable trophy animals, as are the blackbuck *Antilope cervicapra,* spotted deer or chital *Axis axis,* sambar *Cervus unicolor,* leopard *Panthera pardus* and many others. Himalayan species such as the markhor *Capra spp.*, Marco Polo or Tibetan sheep *Ovis ammon,* ibex *Capra ibex* and snow leopard or ounce *Unicia uncia* are in a class by themselves. They are of ultimate trophy value. Almost any price would be considered reasonable by some for the opportunity to hunt such species.

The basic rate for a 15-day big game hunt in India is $3,000. In addition, the hunter must pay for travel expenditures, liquor, firearms and ammunition, packing and forwarding of trophies, tips, and royalty fees to the Government for each head of game shot. Recent royalty fees were, buffalo $200, gaur $150, tiger $150, swamp deer *(Cervus duvauceli)* $150, blackbuck $150, leopard $75, sambar $30, chital $30, blue bull or nilgai *(Boselaphus tragocamelus)* $30, sloth bear *(Melursus ursinus)* $15, and other deer/antelope $7 (Safaris India, 1968). Forage, when utilised by wildlife, may often result in much greater economic returns than when used by domestic animals.

(b) **Wildlife for food**

Economic values of wildlife generally are thought of in terms of recreational values—particularly for sport hunting and fishing. These values are notable and are increasing each year. According to a recent survey, 50 million people or about 1 in 4 people in the United States 12 years old and over, went fishing, hunting or both during 1965. In addition, 8 million people were bird watchers and 3 million spent time photographing wildlife. (U.S.Dept. of Interior, 1965).

Hunters and sport fishermen spent $4 billion in 700 million recreation days, and travelled 31 billion miles in quest of fish and/or game in the United States during 1965. The average sport fisherman spent $130.19 or an average of $5.60 per day and travelled 780 miles during 18.4 fishing days, whereas, the average hunter spends $83.54 or an average of $6.03 per day and travelled almost 616 miles during 13.7 days of hunting (U.S.Dept of Interior, 1965).

Hunters and fishermen in the United States spent $168 million for licenses, tags, permits and stamps during 1968. Receipts from an 11 percent Federal excise tax on sporting arms and ammunition alone, sold during 1968, totalled $31.4 million (U.S.Dept. of Interior, 1969). These figures do not even consider the food value of the fish and game harvested.

The food value of game generally has been overlooked. However, fish particularly marine or anadromous species, have been commercially exploited for food since time immemorial. Salmon fishing, as an example, is the largest commodity industry in Alaska (U.S.A.) and the pink or humpback salmon *(Oncorhynchus gorbuscha)* is the most valuable species. The 1966 Alaskan catch for this species was 40 million fish or 106 million pounds, with a wholsesale value of $55.1 million (Bailey, 1969).

The State of Utah (U.S.A.) is about l/14th the size of India (84, 916 versus 1, 187, 122 square miles). Utah is a mountainous, arid state with a mean precipitation of less than 16 inches per annum, though rainfall varies from 4 inches in some desert regions to 60 inches in a few mountain areas. About 55 per cent of the land is useful for pasture and range, but less than 1 per cent of the state is cultivated (Christensen and Richards, 1969). In comparison, only about 13 per cent of India is used essentially as pasture and range, and over 50 per cent is cultivable (Sarkar, 1965). Nevertheless, the value of Utah's game harvest, much of which comes from her so-called waste lands, is considerable. Almost 1. 5 million game animals were legally harvested in Utah during 1967 (Table 2). The total dressed weight of these animals approximated 12. 8 million pounds and, if valued at $.50 per pound, the mean or food value of these animals approximated $6.4 million.

The daily food requirement for the average man is 2,400 calories. The average Indian, however, subsists upon approximately 2,100 calories per day, and receives only about 50 grams of protein instead of the recommended minimum of 65 grams (Parpia et al., 1964a). Therefore, the average person in India is quantitatively about 12 per cent underfed, as well as qualitatively undernourished. The lack of animal protein in the average Indian diet is particularly noteworthy.

Recent studies in Africa, the U.S.S.R. and Scotland have shown that wild game can often produce more meat and other products of value from the same area of land than can domestic livestock. This is because various wild ungulates are adapted to use a wide spectrum of the natural vegetation, whereas domestic animals concentrate on fewer species and do not utilize the entire habitat as well (Dasmann, 1965b). Most kinds of wild animal carcass also contain a higher proportion of meat than either cattle or sheep (Riney, 1967), drink less water, grow faster, and can be stocked in greater numbers without damage to the range (Martin, 1969).

The forage potential of shrub-dominated arid lands, such as in the south-west United

TABLE 2: SUMMARY OF UTAH'S 1967 LEGAL GAME HARVEST (FROM PERSONAL COMMUNICATIONS WITH JOHN NAGEL, DARRELL NISH AND HOMER STAPLEY OF THE UTAH DIV. OF FISH AND GAME).

Species	Animals Harvested	Mean Weights Dressed (lbs)	Total Weights Dressed (lbs)	Total Estimated Values @$,50/lb, Dressed Wt.
WATERFOWL				
Ducks: Pintail (*Pafila acuta tzitzihoa*)	116, 507 (25%)	1.4	163,110	$81,555.00
Mallard (*Anas platyrhynchos*)	116,507 (25%)	1.7	198,062	99,031.00
Green-winged Teal (*Nettion carolinense*)	74,581 (16%)	.6	44,749	22,374.50
Gadwall (*Chaulelasmus streperus*)	51,263(11%)	1.1	56,389	28,194.50
Widgeon (*Mareca penelope*)	51,263(11%)	1.0	51,263	25,631.50
Others	55,905 (12%)	1.2	67,086	33,543.00
Sub-total	466,026		580,659	290,329.50
Geese: Canadian (*Branta canadensis*)	11,874	6.5	77,181	38,329.50
Snow (*Chen hyperborea*)	2,205	4.1	9,941	4,520.50
Sub-total	24,079		86,222	43,110.00
Swans: Whistling (*Cygnus columbianus*)	241	11.9	2,868	1,434.00
			89,909	44,545.00
UPLAND GAME				
Ring-necked Pheasant (*Phasianus colchicus*)	284,000	2.0	568,000	284,000.00
Chukar Partridge (*Alectoris graeca*)	48,906	1.0	48,906	24,453.00
Sage Grouse (*Centrocercus urophasianus*)	5,089	4.5	22,901	11,450.50
Blue Grouse (*Denragapus obscurus*)	6,773	1.4	9,482	4,741.00
Ruffed Grouse (*Bonasa umbellus*)	8,476	1.3	11,019	5,509.50
Mountain Quail (*Oreortyx pictus*)	26,187	.3	7,856	3,928.00
Hungarian Partridge (*Perdix perdix*)	16,049	.6	9,629	4,814.50
Wild Turkey (*Meleagris gallopava*)	51	9.5	485	242.50
Mourning Dove (*Zenaidura macroura*)	263,949	.2	52,790	26,395.00
Cottontail Rabbit (*Sylcilagus spp.*)	181,872	1.5	272,808	136,404.00
Sub-total	841,352		1,003,876	501,938.00
BIG GAME				
Mule Deer (*Odocoileus hemionus hemionus*)				
Bucks	55,798	140.0	7,811,720	3,905,860.00
Does	25,250	100.0	2,525,000	1,262,500.00
Fawns	9,005	40.0	360,200	180,100.00
Elk (*Cervus canadensis*)	1,029	400.0	411,600	205,800.00
Moose (*Alces americana*)	13	600.0	7,800	3,900.00
Pronghorn Antelope (*Antilocapra americana*)	93	60.0	5,580	2,790.00
Bison (*Bison bison*)	10	600.0	6,000	3,000.00
Bighorn Sheep (*Ovis canadensis*)	9	130.0	1,170	585.00
Sub-total	91,207		11,129,070	5,564,535.00
GRAND TOTAL	1,412,905		12,802,695	$6,401,347.50

States, Mexico and much of India, has been overlooked and largely unexploited. Range managers in such areas generally have tried to increase range productivity with only one goal in mind: creating a better environment for domestic cattle. Water supplies are developed and native plants not consumed by cattle are destroyed if possible. Tradition demands that a grass-preferring herbivore be stocked, while most of the shrubs go untouched. Meanwhile, botanists Bob and Alice Chew found in Arizona (U.SA.) that a representative desert shrub community produced 1, 200 pounds of dry matter per acre per year—twice the annual grass production in many short-grass prairie ranges in the western cattle belt of the United States. Most of the production in desert shrub communities, however, is in the form of leaves and stems of shrubs not utilized by cattle. In these cattle barely survive even at densities of from 1 to 6 head per square mile (Martin, 1969). The utilization of wildlife species better adapted to make use of such lands now marginal for conventional livestock would contribute much to solving world food problems.

Game ranching or cropping, particularly as it is now being practised in Rhodesia, is a recent development which has received widespread publicity. The main arguments favoring the utilization of wildlife over domestic livestock include: most kinds of wild animals produce more protein per given area of land; their carcass contains a higher proportion of protein than cattle or sheep; they can thrive on lands unsuitable for domestic livestock; generally, they do not destroy their habitat as do domestic animals. Several types of wildlife utilization also yield quick returns with little capital investment.

The main drawback to the development of game cropping in Africa has been the lack of men experienced in assessing permissible harvests, planning and initiating the cropping operation, producing a salable healthy product, and distributing it to the available markets (Riney, 1967).

A further prospect lies in the development of new domesticated or semi-domesticated species that could use the land now occupied by existing livestock breeds to yield better crops of meat. Over a century ago, Dr. Livingstone anticipated that the eland *Taurotragus oryx* was suitable for domestication. This was, however, only recently accomplished. The eland, which browses on shrubs and trees, is now herded with cattle, which forage on grasses, and the shared range is well utilized (Martin, 1969). Eland are more gentle and easier to manage than domestic cattle. They grow faster and larger, and produce excellent meat (Dasmann, 1964a). It has even been found that eland milk has approximately twice as much protein and fat as milk from domestic cattle. The carbohydrate content is similar, but eland milk is richer in certain minerals and appears to have valuable keeping properties (Treus and Kravechenko, 1968).

Ecological studies indicate that other likely candidates for domestication in Africa include the African buffalo *Syncerus caffer,* kudu *Tragelaphus* ssp.and impala *Aepyceros melampus,* as well as springbuck *Antidorcas marsupialis* and blesbuck *Damaliscus albifrons* which already exist in a state of semi-domestication (Dasmann, 1968). Even elephants may prove superior to cattle as a meat source in some areas (Martin, 1969). In Asia, the wild buffalo has been domesticated, and the nilgai (the Asian counterpart of the eland) appears to be a likely candidate for domestication.

The conversion or adaptation of wild species to domestication should bring with it several advantages, such as their digestive adaptation to the existing environment, and their behavioural adaptation in terms of mobility through a vast area, and the interrelated behavioural factors between different species of animals (Talbot, 1967). In some situations, formerly wild animals may be mixed with domestic livestock to get a better balance of range utilization. Others may be managed in much the same manner as domestic live - stock. While still others, probably, will have to be harvested as free ranging animals.

The human population explosion behoves all nations to use wisely their natural resources for the benefit of mankind. With the food deficits presently confronting some nations, it is imperative that biological and ecological studies on additional food resources be undertaken. We like to think that science and technology are going to save us from starvation, the image of which already lurks on the horizon. But we have to have a basis on which to use science and technology, and it is this basis, particularly in the realm of wildlife conservation, which we do not have.

III. THE NON-CONSUMPTIVE USE OF WILDLIFE

(a) Sightseeing

In 1946 the State of Utah (U.S.A.) Department of Fish and Game bought private lands and developed what is now known as the Hardware Ranch Game Management Unit. This Unit is located in the heart of the Cache National Forest in northern Utah and consists of farm and ranch lands upon which native grasses are cut and cured during the summer, and then fed during the winter to elk *Cervus canadensis*, which migrate down onto the ranch from the surrounding mountains.

The Hardware Ranch was established for three reasons: (1) to maintain huntable numbers of elk, (2) to protect agricultural lands (there had been many claims against the Fish and Game Department because of crop depredations by elk in the valley bottoms), and (3) to remove pressure from critical winter ranges for the production of mule deer *Odocoileus hemionus*. It was not planned nor envisioned that the Ranch would become an important sightseeing attraction. Even today it offers few amenities for visitors.

The Cache elk herd numbers between 1,300 and 1,800 animals, from which approximately 300 elk are harvested annually by sport hunting. The hunting season is in late fall. Shortly thereafter, the heavy snows of winter force the elk from the high mountains into the low country. Depending upon the severity of the winter, between 300 and 500 elk migrate onto the Hardware Ranch where they are fed. Although the Ranch is about 15 miles from the nearest town, winter visitors soon started to come in numbers to see the elk. Fish and Game personnel accommodated visitors by permitting them to ride on the horsedrawn sleds used to feed hay to the elk. Presently, over 65,000 people visit the Ranch each winter to see the elk and to enjoy a sleigh ride. Over 8, 000 visitors is not unusual for a winter weekend.

A socio-economic study of the Cache elk herd was completed in 1967 (Ashcroft, 1967). By the Gross Expenditure Method, it was found that the annual income from the consumptive use of this elk herd approximated $20,000. This included a fee of $15 each for about 500 hunting permits sold each year plus about $12, 000 spent by permit holders in hunting elk. In comparison and by the same method, the annual revenue for the non-consumptive or sightseeing use of the elk herd was almost $37,000. This was despite the fact that fees were not charged for sightseeing nor for sleigh rides. If a fee were charged, it was estimated that the annual non-consumptive income from this herd could range from $42,000 to over $60,000. Further, it was projected that by 1975, there would be 170,000 visitors to the Hardware Ranch and that the non-consumptive income from the elk would exceed $68,000. At the same time, hunting could be continued at the present level.

This study further reported: visitors, on the average, travelled greater distances to see the elk than did hunters; one-third of the visitors did not hunt; family participation was most pronounced for non-consumptive use; approximately 40 per cent of the visitors were children under 12 years of age; almost 70 per cent of the visitors had visited the ranch previously; and over half the people claimed they were willing to pay up to $0. 50 for a sightseeing sleigh ride.

India has many wildlife areas which, although not widely publicized, are or could easily become major sightseeing or tourist attractions.

Nesting colonies of water birds have been protected by villagers in India since ancient times. In fact, the preservation of such colonies has become a part of the traditional culture of many of the rural people in South India. One of the most spectacular and perhaps the oldest bird sanctuary in South India is near the village of Vedanthangal in the Chingleput District of Madras State. Although only officially recognized and maintained by the Indian Government as a sanctuary since 1936, Vedanthangal has been essentially a sanctuary for nesting water birds for more than a century and a half. Documentary evidence indicates that the villagers of Vedanthangal have actively safeguarded the colony since 1790 (Krishnan, 1960).

The inhabitants of Vedanthangal realized the manurial value of the droppings from the birds nesting in the Vedanthangal tank. This also is attested to by the richness of the fields irrigated from the tank. In addition, the birds help control insects and other agricultural pests. Thus, the villagers benefit by having more bounteous harvests. In turn the birds benefit from the protection afforded them by the villagers. The economic potential

of the nesting colony of water birds as a tourist attraction has only recently begun to be realized.

In 1962 the Government took steps to develop Vedanthangal for the enjoyment of the general public. Since then a tar road leading to the Sanctuary, a parking lot, rest rooms, an observation platform and tower, and nearby accommodations have been built.

I visited Vedanthangal in December 1966, while conducting wildlife surveys for the World Wildlife Fund (Spillett, 1968). I was amazed by the number of visitors to the Sanctuary, and particularly by the bus-loads of students. The Forester stationed at Vedanthangal informed me that there were over 5,000 visitors the previous day, which was a Saturday, and prior to my departure that evening, he claimed that over 10, 000 sightseers had visited the Sanctuary that day.

Most of the visitors were from the city of Madras. Although many could not correctly identify the birds they saw, still they were interested enough to travel over 100 miles and to spend almost an entire day in order to see this wildlife spectacle. As the Utah Department of Fish and Game did, the villagers of Vedanthangal are now reaping unforseen economic benefits through wildlife conservation.

(b) Tourism

The distinction between tourism and sightseeing is often arbitrary. However, sightseeing generally is defined as local travel to places and things of interest for pleasure or education, whereas tourism usually involves more distant travel. Tourism is second only to agriculture as the most important source of income in Kenya. Tourism in East Africa is based on wildlife, and the two species above all others that people travel half way around the world to see are elephants and lions (Leopold, 1966).

India has the lion *Panthera leo persica* and the elephant *Elephas maximus,* not to mention such spectacular animals as the tiger, gaur, Indian one-horned rhinoceros *Rhinoceros unicornis* and Indian wild ass *Equus hemionus khur.* However, in comparison with the African nations, practically nothing has been done to realize the tourist potential of wildlife in Asia.

Producing wildlife for sport hunting is going to continue to be of major importance. But it is not going to continue to be the major aspect of wildlife conservation as in the past. Other values need to be incorporated more and more into wildlife management programs. The frontiers of wildlife conservation, as I see them, lie in the production of wildlife as a crop on private and public lands, and in the management of wildlife for aesthetic values. The latter is the most exciting to me, perhaps because of its sudden emergence and importance, and because it represents the greatest opportunity for both economic and spiritual gains.

IV. Conclusions

Recent studies in various parts of the world have shown that wildlife can often produce more meat and other products of value on a given area of land than can domestic livestock or even agricultural crops (Thomas, 1962). Although difficult to measure, the recreational and aesthetic values of wildlife are of great importance in many countries, including the developing nations of the world. Wildlife can support major tourist and recreational industries which greatly benefit a nation and its people.

It also must be remembered that many scientific advances in biological and medical research have come through studies of wild species of animals. We never know when some previously unimportant wildlife species will become invaluable or provide some needed clue to human health and survival.

Finally;

> If wildlife had no other value and were an economic detriment, it would still be worth preserving for its sheer beauty and appeal to the human spirit. Societies that spend great sums to preserve historical monuments, works of art, or scenic vistas also must be willing to preserve wildlife for its historic, artistic and scenic merit. Civilized societies in general have shown such a willingness. (Dasmann, 1964b)

V. References

ANONYMOUS. 1969. From Ketchikan to Barrow. Alaskan Sportsman, May 1969. p. 35.

ASHCROFT, William H. 1967. The socio-economics of recreational use of the Cache elk herd. Unpub. M.S. thesis. Utah State Uni., Logan. 78 pp.

BAILEY, Jack E. 1969. Alaska's fishery resources, the pink salmon. U.S.Dept. of Interior, Fish and Wildlife Ser., Fishery Leaflet 619., Wash., D.C. 8 pp.

CHRISTENSEN, Rondo A.and Stuart H.RICHARDS. 1969. A statistical view of Utah's agriculture. Utah Resources Series 47, Utah Agri. Exp. Sta., Utah State Univ., Logan. 70 pp.

DASMANN, Raymond F. 1964a. African game ranching. Pergamon Press, Oxford. 75 pp.

DASMANN, Raymond F. 1964b. Wildlife Biology. John Wiley and Sons, Inc., New York-London—Sydney. 231 pp.

DASMANN, Raymond F. 1968. Game ranching potential in North America. Symposium: Introduction of Exotic Animals: Ecological and Socio-economic Considerations. Texas A &MUniv., College Station. p. 11-12.

GEE, E.P. 1966. Importance of sanctuaries (including national parks) in the conservation of threatened species of large mammals in south and south-east Asia. *Cheetal,* Jour. Wildlife Preservation Soc. India. 8(2): 6-9.

KINDEL, Fred. 1961. Big game harvest trends analysis. Job Completion Report, Fed. Aid to Wildl. Restoration Proj., Idaho Game Population Census and Range Study, 85-R-12, Job No. 13. 42 p. (Typewritten).

KRISHNAN, M. 1960. The Vedanthangal Sanctuary for water-birds. Madras State Forest Dept. 25 pp.

LEOPOLD, A. Starker. 1966. The future of wildlife management. 2nd Ann. Western Student Wildl. Conclave. Ft. Collins, Colo. 21 pp. (Typewritten).

MARTIN, Paul S. 1969. Wanted: a suitable herbivore to convert 600 million acres of Western shrubland to protein. Natural History. 70(2): 34-39.

MORGAN, James K. 1969. Bighorn sheep investigation in Idaho. Job. Completion Report, Fed. Aid to Wildl. Restoration Proj., Idaho Game Population Census and Range Study, PR-85-R-19. (In preparation).

PARPIA,H.A.B.,K.M.DASTUR and B.L.ARMLA. 1964. Science and technology in conservation of food resources in India (presented at the symposium on 'Science and the nation during the third five-year plan', July 28), New Delhi.

PEARSE, P. H. and G. BOWDEN. 1966. Big game hunting in the East Kootenay; a statistical analysis. Price Printing Ltd., British Columbia. 39 pp.

RINEY, T. 1967. Conservation and management of African wildlife. Food and Agriculture Organization of the United Nations, Rome. 35 pp.

SAFARIS INDIA. 1968. Shikar in India (Brochure). Rasalpura Press. Mhow. 7 pp.

SARKAR, P.C. 1965. The new year book. S.C. Sarkar &Sons Privat LMTD., Calcutta. 504 pp.

SPILLETT, J.Juan. 1968. Wildlife sanctuaries in Madras State. J.Bombay Nat. Hist. Soc. 65(3): 1-46.

TALBOT, Lee M. 1967. Wildlife in a changing world—a conservation challenge. Keynote address presented for Joint Professional Sectional Mts. Amer. Soc. Range Mgmt., Soc. Amer. Foresters, and Soil Cons. Soc. Amer., Utah State Univ., Logan. 12 pp. (Typewritten).

THOMAS, J.D. 1962. Observations on the conservation of wildlife in Ghanaian savanna. Ghana Jour. Sci. 2(2): 150-175.

TREUS, V. and D. KRAVECHENKO. 1968. Methods of rearing and economic utilization of eland in the Askaniyanova Zoological Park. Comparative Nutrition of Wild Animals. Proc. Symp. Zool. Soc. Lond. 1966., ed.M. A. Crawford. Zool. Soc. Lond., Academic Press. p. 395-411.

U.S.DEPT. of INTERIOR. 1965. National survey of fishing and hunting. Bureau Sport Fisheries and Wildlife Resource Publ. 27. Wash., D.C. 76 pp.

U.S.DEPT, of INTERIOR. 1969. Sport Fish and Wildlife programs. Bureau Sport Fisheries and Wildlife Bull. Wash., D. C. 18 pp.

SUMMARY

Examples of monetary expenditures or income derived from wildlife conservation are given. Consumptive uses of wildlife are exemplified by sport hunting for bighorn sheep in the State of Idaho (U.S.A.) and the economic value for food of the 1967 game harvest in the State of Utah (U.S.A.). According to questionnaire returns from Idaho's bighorn sheep hunters, an average of $4, 236 was spent in 1968 for each legal ram killed. A mean of $89 was spent by hunters for each bighorn sheep in the state, whereas domestic sheep in that area sell for approximately $35 per head. Almost 1. 5 million game animals, or a total of 12. 8 million pounds dressed weight of game, was harvested in Utah in 1967. If valued at $. 50 a pound, the meat of food value of these animals would approximate $6.4 million.

Non-consumptive uses of wildlife are exemplified by the Hardware Ranch Game Management Unit in Utah, the Vedanthangal Water Bird Sanctuary in southern India, and by tourism in East Africa. Although the Hardware Ranch was established primarily to maintain huntable numbers of American elk by means of a winter feeding program, in 1967 sightseers spent almost twice as much ($37, 000 as compared to $20, 000), just to see the elk at Hardware, as sportsmen spent to hunt them. Economic figures are not available for the Vedanthangal Sanctuary, but over 10, 000 people visited the Sanctuary one day in 1966 when the author was present. Tourism, based on wildlife, is the second most important source of income in Kenya. East Africa's safari trade also is fast shifting from hunting to wildlife viewing or photography.

RÉSUMÉ

L'auteur cite un certain nombre d'exemples montrant que la protection de la faune naturelle constitue une source importante de revenus. L'exploitation de la faune à des fins de consommation est illustrée par la chasse au mouflon d'Amérique dans l'état d'Idaho et par la valeur bouchère totale du gibier à viande tué au cours de l'année 1967 dans l'état d'Utah (U.S.A.). D'après des questionnaires remplis par les chasseurs de mouflons de l'état d'Idaho, il a été dépensé en 1968 une moyenne de 4. 236 dollars pour chaque bélier d'âge légal abattu et un minimum de 89 dollars pour chaque mouflon vivant sur le territoire de l'état, alors que dans cette région, le mouton domestique se vend à environ 35 dollars pièce. Près de 1, 5 millions de pièces de gibier, soit un poids total de 12, 8 millions de livres de gibier habillé, ont été abattues en 1967 dans l'Utah. Si on l'estime à une demi-dollar la livre, la valeur totale de la viande de ces animaux s'élèverait à près de 6, 4 millions de dollars.

L'exploitation des animaux sauvages à des fins non-alimentaires est illustrée par des exemples de l'Unité de Mise en Valeur du gibier du Hardware Ranch, dans l'état d'Utah, de la Réserve d'oiseaux d'eau de Vedanthangal dans le sud de l'Inde et du tourisme en Afrique Orientale. Bien que l'objectif initial du Hardware Ranch ait été de maintenir des effectifs suffisants d'élans américains pour la chasse, grâce à un programme d'affourragement hivernal, en 1967, les touristes ont dépensé presque le double de ce qu'avaient dépensé les chasseurs, rien que pour voir les élans au Hardware Ranch (37. 000 dollars contre 20, 000 dollars). On ne dispose pas de bilan financier en ce qui concerne la réserve de Vedanthangal, mais un jour de 1966, alors que l'auteur s'y trouvait, plus de 10, 000 personnes ont visité cette réserve. Au Kénya, le tourisme dans les parcs et réserves d'animaux constitue la seconde source de revenu national. La pratique du safari en Afrique Oriental évolue également de façon très rapide vers la chasse photographique ou le tourisme paisible poir 'voir' les animaux.

Section C (1)

Research and Management Needs for South East Asian Bovids

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The cattle tribe of the family Bovidae has reached its highest evolutionary development in South East Asia and it is represented by three genera and seven species. This paper will restrict itself to a discussion of those species which occur in forested areas. The Wild Yak *Bos grunniens mutus* will therefore not be referred to.

The objective of this paper is to try to show that the bovids of South East Asia are a valuable but dwindling resource, that drastic steps will have to be taken in order to prevent further deterioration of this resource and that under proper management these animals will be able to play a more useful role for mankind.

PRESENT DISTRIBUTION AND STATUS

The wild Asiatic Buffalo *Bubalus bubalis* is now restricted to two regions of India and to a small area in Nepal. It was formerly much more widespread in Northern India and Nepal and the low country of Burma. Reports from Ceylon, Indonesia and other places refer to feral animals. Remnant populations are few, small and scattered, and may not exceed a total of 4, 000 head. Wild buffaloes are well protected and increasing in Government operated parks in Assam, India and Nepal (Cockrill, *pers. comm.*).

The Tamaraw *Anoa mindorensis*, once of widespread occurrence on the island of Mindoro in the Philippines, has become restricted to the highlands. At least three small but probably viable populations of roughly 100 animals survive in places where they could be protected effectively.

The Anoa *Anoa depressicornis* is restricted to the island of Celebes in Indonesia. Three races have been described: (1) the Lowland Anoa *Anoa d. depressicornis* is found in the swampy forests of northern Celebes, (2) the Mountain Anoa *Anoa depressicornis fergusoni* occurs in the mountains of western Celebes and (3) Quarles' Anoa *Anoa depressicornis quarlesi* inhabits the mountains of the central region of Toradja and the west coast mountains of central Celebes. The two mountain races are believed to have a better chance of survival due to their mountainous habitat. No satisfactory or recently published data are available about their numerical status.

The Banteng *Bos javanicus* has a very restricted distribution on the island of Java, while on Borneo it is still relatively widespread. Its main strongholds on Java are the Udjung Kulon Peninsula and the Valuran area in East Java. Limited numbers may survive elsewhere on the island. The Burmese race still has a wide distribution in Burma, where banteng normally avoid evergreen forests and hilly country (U Tun Yin, 1967). This race may still occur in parts of Thailand and Indo-China. The banteng has almost certainly become extinct in Malaya within the last 30 years (Stevens, 1968). The Gaur or Seladang *Bibos gaurus* formerly inhabited various hilly forest-tracts of the Indian Peninsula, as well as forested areas in Thailand, Burma, Assam and parts of Indo-China. In Malaya it inhabits the lowlands mainly, but it can also be found in the mountains up to an altitude of about 330 m. The gaur has disappeared from East Pakistan. Good populations remain in Burma, possibly as a result of restrictions on carrying firearms which have been in effect for a number of years. No certainty seems to exist about the taxonomic status of the gayal, which was reported by early writers as occurring in the wild as well as in the domesticated state in eastern Bengal and Assam. While Peacock (1933, p. 119) considers it a domesticated gaur, others think that it is the product of interbreeding between the gaur and domestic cattle.

The Kouprey *Bos sauveli* was unknown to science until 1937 and there is little information concerning its former range. It is found in forest glades in two separate regions of northern Cambodia. During recent decades the animal has undergone a marked numerical decline and it is now (1968) thought to have been reduced to about 200 specimens.

PROBLEMS IN CONSERVATION AND MANAGEMENT

Although several reasons can be given for the steady decline in population and distribution of the various South East Asian Bovids, the most limiting factor from the point of view of their ultimate survival may be at present the lack of suitable habitat. Certainly heavy shooting and poaching pressure continues to be a limiting factor. On account of the land hunger of the ever-expanding human populations, less and less suitable habitat remains for these animals. This is particularly true for the lowland rain forest below about 650 m in elevation, which generally offers the best habitat for these bovids. So much lowland rain forest has been removed from the densely inhabited islands of the Indonesian archipelago and the Malayan peninsula that only small remnants remain. The situation is at present not as bad in Borneo, Thailand and parts of Burma, but deforestation is continuing at a rapid rate. Harrisson (1968) has studied the effects of forest clearance on Malaysian mammals in the lowland rain forests of Selangor. He found that the number of species decreased markedly from the primary forest through secondary forest to scrub and grassland. He concluded that the progressive destruction of the native rain forest results in a progressive elimination of the native mammalian fauna. He found that the complete elimination of the forest caused an almost complete disappearance of the native fauna and its replacement by a few species of commensal rats. This cannot be regarded as a general situation.

It should be emphasized that most species of the wild bovids under consideration thrive best in clearings in forests or in open-grown secondary forests. The banteng seems to be most prone to use clearings (Hoogerwerf, *pers. comm.*). More information is needed about their habitat requirements and food habits, but it seems that the system of shifting cultivation in the forests created improved habitats for these bovids. Where this system is being abandoned, it should be replaced by other management procedures with comparable results, namely the development of clearings in various stages of plant succession.

In the case of the Tamaraw, hunting seems to be the major limiting factor. This also seems to be the case for the Mountain Anoa and Quarles' Anoa, while the lowland race has been displaced by cultivation as well.

Although the Kouprey is legally protected by the Government of Cambodia and although a special refuge was established for it, its status is insecure because of hunting and habitat destruction.

The Gaur inhabits the river banks and abondoned ladangs (forest clearings for agriculture), where it feeds on tender grasses and herbs. As more and more of the old ladangs are reclaimed by forest with the decrease in shifting cultivation, less productive habitat remains for the gaur in Malaya. For this reason, the Malaysian Game Department has taken some action to create new habitats in suitable areas. The species is currently being studied in the Taman Negara near L. Weigum in Malaya (Stevens, 1968).

Although the status of the tamaraw is critical, recent developments in the Philippines suggest that there are good possibilities that this can be improved upon. Harrisson (1969) believes that the species can be protected in three sites. The establishment of a small reserve breeding stock in a large enclosure is under active consideration.

One management problem which may be quite serious is the spread of epizootics from domestic cattle to the wild bovids. The wild buffalo has been locally decimated by rinderpest in the 1920's (Daniel and Grubh, 1966). Wild bovids are more susceptible than most mammals to disease. There is, therefore, an urgent need for collaboration between veterinarians and wildlife biologists on this matter.

Recommendations for conservation and management of South East Asian bovids include:

1. More detailed ecological studies to define the requirements of various species more clearly and more regular censuses to ascertain status trends. Special attention should be given to food habits and physiology.

2. Limitations on the number of cattle and control of the movement of domestic livestock through areas inhabited by wild bovids.
3. A comprehensive survey to ascertain which areas of habitat remain that conform to the ecological requirements of the different species.
4. Establishment of suitable reserves which are large enough and include enough suitable habitat to safeguard the survival of remnant populations.
5. Appointment of a satisfactory number of adequately trained personnel to enforce protective measures.

ECONOMIC VALUES

Several of the South East Asian bovids are considered favourite targets by big game hunters, and among these in particular the gaur, the banteng and the tamaraw. With properly organized big game safaris, such as in East Africa, considerable income could accrue from licence fees, expenditures of foreign hunters, fees to guides, etc. This type of utilization requires careful government supervision and management.

Another source of income would be the production of meat, hides and other products through a rational sustained yield cropping operation of various species of wild bovids. ' Much emphasis has been placed on the need for domestication of these species, because in the domesticated form they can be husbanded and killed more readily, and inspected for diseases and parasites. But in my opinion there is also a place for the utilization of wild herds under proper management. This would not only imply good herd management procedures under which old and diseased animals, as well as the annual surplus, are culled, but habitat management as well. Although considerable areas in S.E.Asia have been deforested during recent decades, there are still vast areas of secondary forests or scrub and grasslands that could be utilised under proper management for the production of wild bovids. As Payne (1968) has pointed out, no attempt has been made so far in South East Asia to produce meat from wild bovids from these areas. The meat of the various wild bovids is excellent and their hides make excellent leather.

If thriving herds of wild bovids can be maintained in their natural habitat, I see no particular reason why domestication should be resorted to. Care should also be taken to prevent bastardization of wild stocks with domestic cattle.

With reference to the matter of domestication, this has been in progress with the banteng on the island of Bali and the adjacent part of Java for many centuries. The Java-Madura cattle are a cross between the zebu and the domesticated banteng. Although the Balinese apparently have not made special efforts to improve the breed through selection, nevertheless various types can be recognized today, differing in type of horns, variability in skin and hair colour, loss of pigmentation, etc. (Meyer, 1962).

The gayal is the other domesticated form, derived from the gaur. It is used as a draught animal and for milk production.

A study of the potentialities of the various South East Asian bovids as domesticated animals for the production of meat and other products would require captive herds and a research programme under the supervision of suitable scientists, including specialists in animal husbandry, wildlife biology and veterinary medicine.

The South East Asian bovids represent a valuable gene pool which may be used at some future date to breed improved or higher yielding domestic races. Particularly the gaur, the banteng and the wild buffalo are valuable species in that regard.

The potential value of the wild bovids can be illustrated by describing briefly the value of the water buffalo, which has originated from the wild buffalo. This animal is used as draft power for tilling, and it supplies rich milk and meat that compares favourably with beef. It is capable of performing work and producing milk on a diet consisting only of stubble. Its hide makes an excellent leather. The hide is also eaten in many parts of South East Asia.

FAO and the Government of Australia are studying the water buffalo to learn how its contribution to the food supply can be enhanced. It seems certain that selective breeding could increase the potential of this species (Cockrill, 1967).

In view of the threatened status of some of the South East Asian bovids, it seems not only imperative that more co-ordinated action be taken to safeguard their survival, but also that more research be undertaken to determine their values to man from an economic point of view. It seems that even with the reduced amount of forest area that is now available in South East Asia, there is still ample opportunity for more intensive management of wild bovids for game viewing, hunting and the production of meat and other animal products.

REFERENCES

COCKRILL, W.R. *Pers. comm.* dated September 4, 1969

COCKRILL, W.R. 1967. The Water Buffalo. Scientific American. Dec, pp. 118–125.

DANIEL and GRUBH, 1966. The Indian Wild Buffalo (*Bubalus bubalis*, Linn.) in Peninsular India: a Preliminary Survey. J.Bombay Nat. Hist.Soc. 63(1) : 32—53.

HARRISSON, J. L. 1968. The effect of forest clearance on small mammals. *In:* Conservation in Tropical South East Asia, IUCN Publication, New Series No. 10 : 153—156.

HARRISSON, T. 1969. The Tamaraw and its Survival. IUCN Bulletin, New Series, 2(II) : 85-86.

HOOGERWERF, A. *Pers. comm.* dated September 10, 1969.

MEYER, W. C. Ph. 1962. Das Balirind, Die Neue Brehm—Bucherei, 303 pp. Wittenberg, Ziemsen.

PAYNE, W. J.A. 1968. Development of animal husbandry resources in South East Asia. *In:* Conservation in Tropical South East Asia. IUCN Publication New Series No. 10 : 125–131.

PEACOCK, E.H. 1933. A Game Book for Burma and Adjoining Territories. London, 292 pp.

SIMON, N. 1966. IUCN Red Data Book, Vol.1—Mammalia. Arts Graphiques, Héliographia S.A., Lausanne.

STEVENS, W. E. 1968. Habitat Requirements of Malayan Mammals. Malaya Nat. J. 22(1) 3-9.

STEVENS, W.E. 1968. The Rare Large Mammals of Malaya. Malayan Nat. J. 22(1) : 10-17.

U TUN YIN. 1967. Wild Animals of Burma. Rangoon Gazette Ltd., Rangoon.

SUMMARY

The present status of South East Asian bovids is reviewed briefly. Discussed are *Bubalus bubalis, Anoa mindorensis, Anoa depressicornis, Bos javanicus, Bos sauveli* and *Bibos gaurus.* The most limiting factor from the point of view of their ultimate survival is the lack of suitable habitat, as forested lands are eliminated to make place for agriculture. The number and movements of domestic stock should be controlled in the areas inhabited by wild bovids to reduce competition for food and the possibility of spread of epizootics.

Large enough reserves with suitable habitat should be maintained or established to safeguard the survival of remnant populations, and adequately-trained personnel should be appointed to enforce protective measures. South East Asian bovids have an unrealized economic potential with regard to tourism for big game hunting and viewing. Their meat and other products should be better utilized and management procedures should be developed accordingly, including management of their habitat. Considerable areas remain in S.E.Asia which could be profitably used for the production of these bovids. Wild bovids represent a valuable gene pool. They could be used to improve the quality of domestic cattle and further domestication experiments should be encouraged.

RÉSUMÉ

La situation actuelle des bovidés dans le Sud Est Asiatique est examinée brièvement. Les espèces ayant fait l'objet d'une étude sont les suivantes: *Bubalus bubalis, Anoa mindorensis,Anoa depressicornis, Bos javanicus, Bos sauveli* et *Bibos gaurus.* Le facteur considéré comme essentiellement limitant est l'absence d'habitat approprié, du fait que les terres forestières sont éliminées pour faire place aux terres arables. Les effectifs et les déplacements du bétail devraient être surveillés dans les régions où vivent les bovidés sauvages afin de réduire la compétition alimentaire et les possibilités de propagation d'épizooties. Il faudrait garder et créer des réserves suffisamment étendues comportant des habitats appropriés afin d'assurer la survivance des populations restantes et former du personnel capable d'appliquer et de faire respecter les mesures de protection. Les bovidés du Sud Est Asiatique sont en puissance une valeur économique encore inappréciée: ils constituent un facteur d'attraction majeur pour les chasseurs de gros gibier ou les chasseurs d'images. Leur viande et leurs sous-produits pourraient être mieux utilisés. Il conviendrait donc de trouver des méthodes de mise en valeur de ces animaux et d'aménagement de leur habitat. Il reste en Asie du Sud Est des régions très étendues qui pourraient servir à la production de ces bovidés. Les bovidés sauvages constituent un pool géhique précieux: on pourrait les employer â améliorer les qualités du bétail domestique et il conviendrait egalement d'encourager toute tentative ultérieure de domestication.

Section C (1)

Primate Population Trends in Asia, with Specific Reference to the Rhesus Monkeys of India

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INTRODUCTION

The primate populations of southern and eastern Asia represent important components of the faunal and cultural background of their respective countries, and they also represent major resources for scientific research throughout the world. In many Asian countries, primates have played a prominent role in the literature, art, history, religion and folklore of the country, as, for example, the langur and rhesus monkey in India, the gibbon in China, the Japanese macaque in Japan, the lutong in Indonesia, and various species of macaques in Burma and Thailand. In each of these countries, monkeys and apes have been an important part of the cultural heritage for thousands of years.

Scientifically, these species have played quite another role throughout the world by serving as valuable research subjects in biomedical research. A recent survey by the Institute of Laboratory Animal Resources of the U.S. National Research Council indicated that at least 85, 283 laboratory primates were present in U.S. laboratories in 1968, of which 37, 290 were rhesus monkeys, 1, 777 were pigtailed and stumptailed macaques, 4, 372 were cynomolgus macaques, and 1, 149 were undesignated macaques. This is certainly a minimal figure, and true primate utilization in the United States at the present time is more in the range of 100 to 120 thousand primates per year. Even this degree of utilization is substantially lower then that prevailing 10 years ago, for in 1960, the United States imported 221, 000 primates of which 107, 000 were rhesus macaques from India and Pakistan. This former level of importation prevailed for several years in the late 1950's, when large numbers of monkeys were used in the development and production of polio vaccine. Not only the United States, but Europe, Japan and other countries throughout the world were importing Asian and African primates. There was some concern at the time as to whether this extensive utilization would deplete primate populations, but in general the opinion was held, especially in regard to rhesus monkeys in India, that natural populations were so large that they were inexhaustible. Various popular estimates placed the rhesus population of Uttar Pradesh alone in northern India as in the range of 10 to 20 million monkeys. In other countries of Asia and Africa it was often assumed that the monkey populations exceeded the human population. Although these estimates were not based on specific field surveys, they were widely held, and it was felt that the level of harvest of common species such as rhesus and cynomolgus macaques would not have the slightest influence on their populations.

I became interested in primate population ecology in the early 1950's and had my first opportunity to come to India in 1959, under the joint sponsorship of the Fulbright program and the U.S. National Institutes of Health, to undertake ecologic and behavioral studies of rhesus populations in northern India. With the very able assistance of Dr.Siddiqi and other colleagues at Aligarh University, we first planned an extensive population survey of rhesus monkeys throughout U.P. and adjacent areas. This involved systematic field surveys in villages and towns, roadsides and other rural areas, canal bank habitats, railroad rights-of-way,and forested hills and river valleys in the north. In the course of more than 20, 000 miles of field work by auto, bicycle, train, and on foot, we were able to locate and census about 600 groups of rhesus containing 12, 000 monkeys. Two prominent conclusions emerged from the data: (1) we felt the rhesus population of U.P. was more in the range of 800,000 to 1 million at the most rather than the frequently quoted 10 to 20 million,

and (2) we also felt that the rhesus population of India had declined throughout the late 1950's and was still in a declining pattern.

The main lines of evidence supporting these conclusions were data on the age distribution of the rhesus population in 1959-60, and village interview data on the presence of rhesus in former years. The age distribution of all rhesus groups found in 1959-60, except forest and temple groups, showed a conspicuous lack of juveniles (Figure 1). Groups in all habitats except forests and temples showed less than 11% juveniles, whereas those in forests and temples had 22% to 27% juveniles. Normally juveniles should represent at least 20% of the population, and we felt that the lack of juveniles In most groups was evidence that trapping was affecting population structure and size. The forest groups were able to avoid trapping somewhat more successfully due to the availability of better cover, and the temple groups had a certain immunity from trapping for religious reasons.

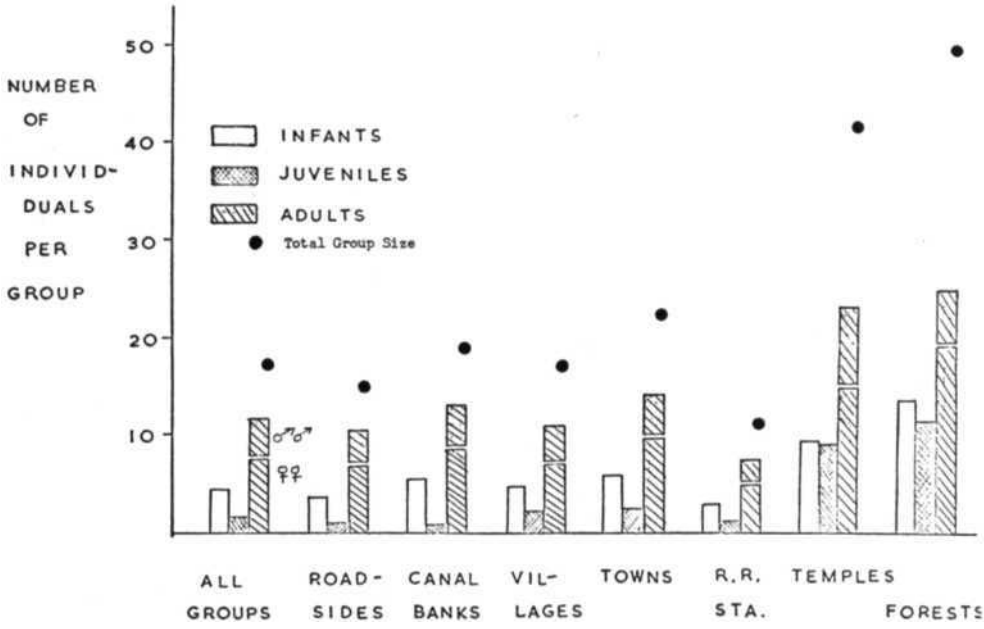

Fig. 1 Rhesus group structures in different habitats in northern India, 1959-60.

The village survey and interview data indicated that 16% of 280 villages in U.P. contained resident rhesus groups in 1960, but that approximately 30% indicated that they had contained rhesus 5 years earlier. Thus there had been a 47% decline in the prevalence of resident rhesus groups in the villages of U.P.in the 5 years previous to 1960.

We felt that there were at least three reasons for this pattern of declining rhesus populations: (1) intensive trapping for export, which was lowering the number of juvenile monkeys and thus lowering adult recruitment; (2) changing attitudes on the part of villagers so that many of them were anxious to rid their areas of monkeys; and (3) changing patterns of land use, including more intensive agriculture, deforestation and single species reforestation.

To study rhesus population trends more satisfactorily over a longer period of time, we planned two census programs for the years following 1960. One would be an intensive census study of 17 rhesus groups in Aligarh district with the hope of censusing each group 2 or 3 times a year for 10 years throughout the 1960's. The second program would be to return in five years to re-survey most of the rural areas, villages and towns studied in the initial surveys to obtain specific data on population changes. Fortunately, we have been able to achieve both of these goals and can report on the results now.

RESULTS

1. Population Surveys of 1964-65

The rhesus population surveys of 1964 and 1965 were undertaken with the purpose of covering precisely the same villages and rural areas as in 1959-60, using the same field techniques at the same times of the year.

In the roadside survey, the number of groups seen in an exact duplicate of 4, 624 survey miles of rural roads in U.P. declined from 406 in 1959-60 to 298 in 1964-65, a decline of 26.6% in the number of groups found. Regional declines varied from 11.0% in western U.P. to 71.4% in central U.P. (Figure 2). There were also significant declines in average group sizes, from 15.1 ± 0.6 individual monkeys per group in 1959-60 to 12.7 ± 0.84 in 1964-65, a decline of 15. 9% (Figure 3).

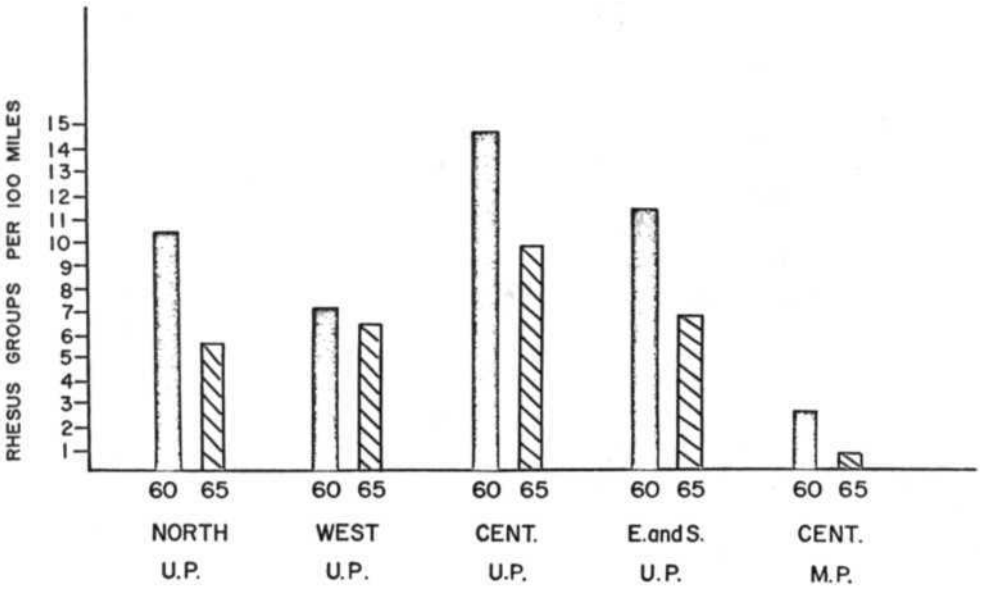

Fig. 2 Relative abundance of roadside rhesus groups, 1960 and 1965, in different sections of Uttar Pradesh and Central Madhya Pradesh.

Thus in the five year period from 1960 to 1965, rhesus populations in rural roadside habitats of northern India had declined on the average of 5% per year in number and 3% per year in size.

Although the average group size of roadside rhesus had declined to 12. 7 monkeys per group in 1965, the distribution of group sizes around this mean was skewed with a few very large groups. Thus, the majority of groups were quite small, usually 5 to 15 monkeys, but there some quite large groups. Figure 3A shows this skewed distribution, with the mean of 12. 7, but with a few groups as large as 55 and 70 monkeys. If these groups are divided into an upper 10% in terms of group size, and a majority 90%, two distinct patterns of group size and structure are seen (Table 1). Thus the upper 10% of the groups have an average size of 30.25 monkeys and a fairly large component of juveniles (28.6%).

These clearly represent groups which are well protected by local custom. The main 90% of the groups, however, had a small group size of only 10.68 monkeys, and a poor juvenile representation of only 6.1%. This suggests that the majority of roadside groups are not protected and are subjected to trapping.

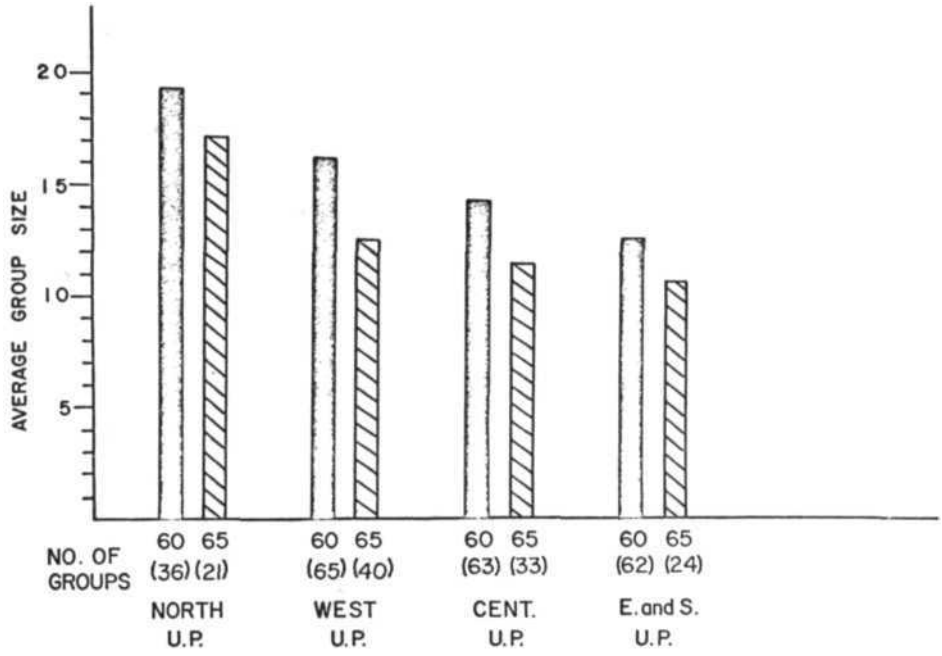

Fig. 3 Relative group sizes of roadside groups, 1960 and 1965, in different sections of Uttar Pradesh.

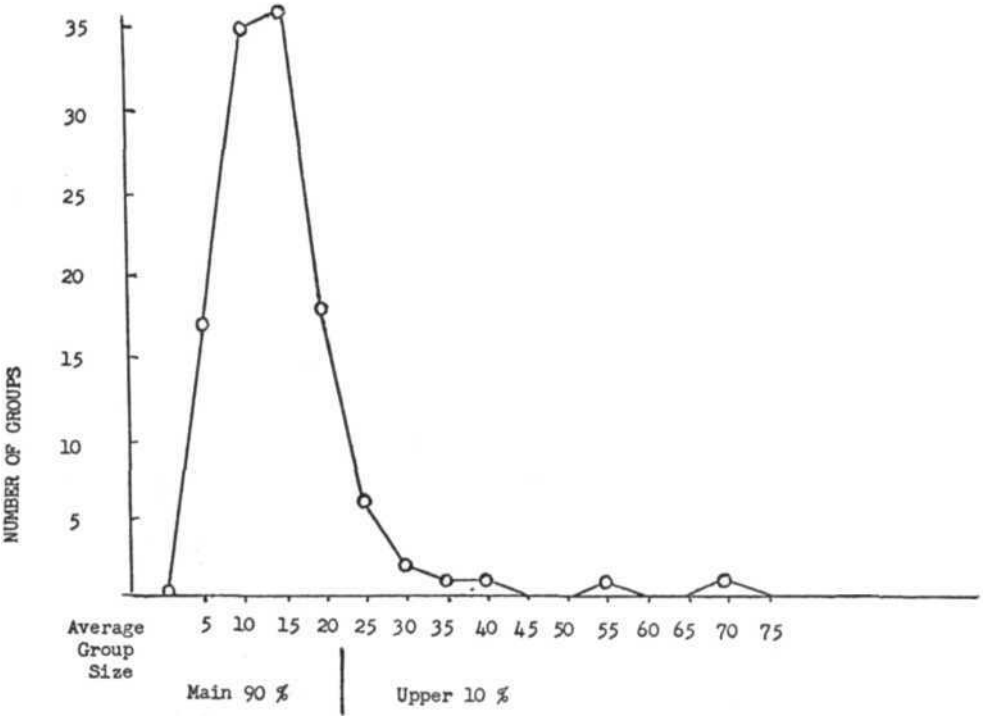

Fig. 3A Frequency distribution of roadside and village rhesus groups in northern India, 1965.

TABLE 1: GROUP STRUCTURES AND POPULATION COMPOSITIONS OF TWO MAJOR CATEGORIES, 1964-1965

Category	Upper 10 Per Cent	Main 90 Per Cent
Number of Groups	12	106
Number of Monkeys	363	1132
Average Group Size	30.25 ± 4.54	10.68 ± 0.51
Average Distribution:		
Adult Male	3.83 ± 0.7 (12.7%)	2.33 ± 0.11 (21.8%)
Adult Female	10.25 ± 1.44 (33.9%)	4.62 ± 0.23 (43.3%)
Infants	7.5 ± 1.73 (24.8%)	3.8 ± 0.18(28.9%)
Juveniles	8.67 ± 2.14 (28.6%)	0.64 ± .09 (6.1%)

In the survey of rhesus populations in villages and towns, an even more complicated picture appeared. In a total sample of 227 villages, the number with resident rhesus groups declined from 38 to 20, a 47% decline in villages with resident groups. In towns, the number with resident rhesus groups declined from 21 to 18, a decline of 14%. The population data showed prominent increases, however, in the size of rhesus groups and in the total rhesus population. Average group sizes in villages had increased from 15. 9 ± 1.2 to 24.4 ± 4.4, an increase of 53%. In towns, average group sizes increased from 22.4 ± 2.5 to 27.3 ± 2.6, a 22% increase.

The net result of these population changes was an overall 9% decline in the total rhesus population of villages, but a 28% increase in the total rhesus population of towns.

These changes suggested a tendency toward urbanization among the rhesus populations of India; that is, a decrease in rural populations, and an increase in towns. We surmised that three possible reasons for this were: (1) villagers, who were more directly concerned with crop protection than townspeople, took a more active role in ridding their area of monkeys; (2) trappers generally avoided town-dwelling monkeys because these monkeys have a higher incidence of respiratory and enteric disease, and are less suitable for export; and (3) in towns, rhesus could find more waste food and live a commensal scavenging life in much the same niche as dogs and rats.

It should also be mentioned that the population surveys of 1964-65 indicated significant increases of juveniles in all groups. The percentages of juveniles in the total rhesus population increased from 5. 9% to 11. 5%, in roadside groups, from 8. 2 to 24. 3% in village groups, and from 10. 5% to 26.0% in town groups (Figure 4). This suggested a lessening of trapping pressure—a fact confirmed by export data. The exportation of rhesus from India had fallen from the range of 10, 000 to 14, 000 per month in 1960 to the range of 2,000 to 3,000 per month in 1965. There were several reasons for this decline, among which were greater efficiency in pharmaceutical production, so that fewer animals were needed to produce the same amounts of vaccine, and greater use of monkey species from Africa and Southeast Asia in research and pharmaceutical production.

Thus, we concluded from the 1964-65 surveys that the rhesus of north India had continued to decline in villages and roadside habitats, but were beginning to show some recovery potential, and had actually increased in towns and cities. This increase of rhesus, however, was occuring in an undesirable segment of the population, and was not producing a healthy or desirable stock of monkeys for either the people of India or for export purposes.

II. Population Studies of Rhesus Monkeys in Aligarh District

The 10-year census of rhesus monkeys in Aligarh district was undertaken to assess more specific trends and basic population parameters of a local free-ranging rhesus population in typical habitats of the upper Gangetic basin. The original 17 rhesus groups first studied in 1959 included 2 groups on the outskirts of Aligarh, 4 village groups, 2 canal bank groups, 1 roadside group, 5 groups located near bridges over canals, and 1 'jungle' group inhabitating a dense forest patch between a canal and agricultural fields.

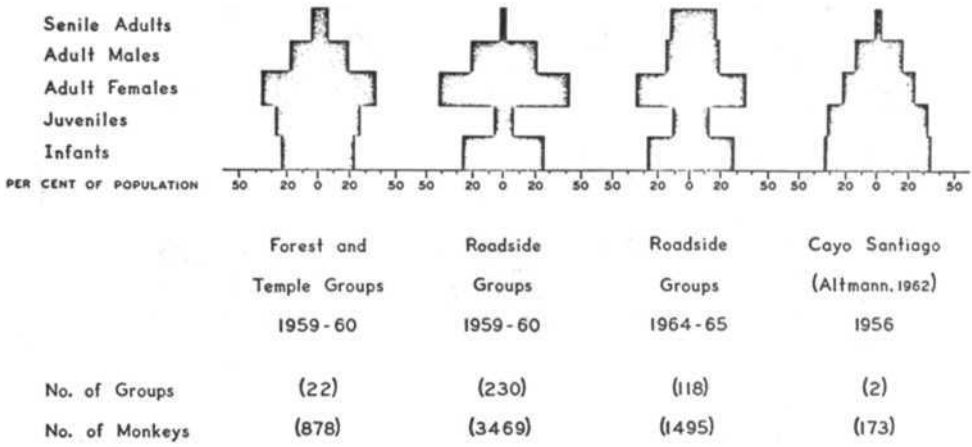

Fig. 4 Age structures of different rhesus populations in India and Cayo Santiago, Puerto Rico. The Cayo Santiago population was protected and artificially fed. In the early 1960's, the Cayo Santiago population was increasing at the rate of 16% per year, whereas the roadside populations of India were decreasing at the rate of almost 5% per year.

The groups were first located and studied in September and October of 1959, and they have been censused at frequent intervals since then. Since July of 1961, it has been possible, through the work of Dr.M. R. Siddiqi and Dr.M. F. Siddiqi, to obtain a census count every four months, in March, July and October of each year. The March census was selected to provide a count before the birth season, the July count, after the birth season, and the October count, after the monsoon.

The original population of 337 monkeys in 17 groups increased by natural reproduction and group fission to 403 monkeys in 21 groups by July of 1962. Since 1962, however, there has been irregular attrition of the total population and the number of groups until only 175 monkeys in 14 groups remained in July of 1969 (Table 2; Figures 5 and 6).

The main reasons for this population decline have apparently been mortality and trapping. Natality has remained high. In fact, an 8-year average of natality has been 82%; that is 82% of all adult females have given birth to one young per year (Table 2). This is excellent production. It is, in fact, higher than the free-ranging Cayo Santiago rhesus population in Puerto Rico which averaged 78. 5% natality from 1959 through 1962, even though this population was artificially fed and maintained in outstanding health. With this natality of 78. 5% per year, the Cayo Santiago rhesus population has increased at the rate of 16% per year, whereas the Aligarh District population with an even higher natality has decreased 4. 8% per year over a 10 year period.

The Aligarh rhesus population has showed higher rates of infant mortality than the Cayo Santiago population. Infant loss in Aligarh averaged 12.7% during the monsoon months, and 11. 5% during the winter months, making a total infant mortality for just 9 months of more than 24% (Table 3). In contrast, the infant mortality on Cayo Santiago varied from only 5.9 to 10.7 percent per annum (Koford, 1965).

The reasons for this high infant mortality are not well documented, but it is known that these monkeys have high prevalences of *Endamoeba histolytica, Shigella flexneri,* and *Mycobacterium tuberculosis.* There is also heavy trapping pressure against juveniles and possibly infants in this area. This trapping pressure has been lessening, however, which has resulted in increased percentages of juveniles in the last three years compared to the early 1960's. In 1968, the population consisted of 26. 3% juveniles compared to 7.1% in 1960. So the population now has a much more favorable age distribution than in 1960.

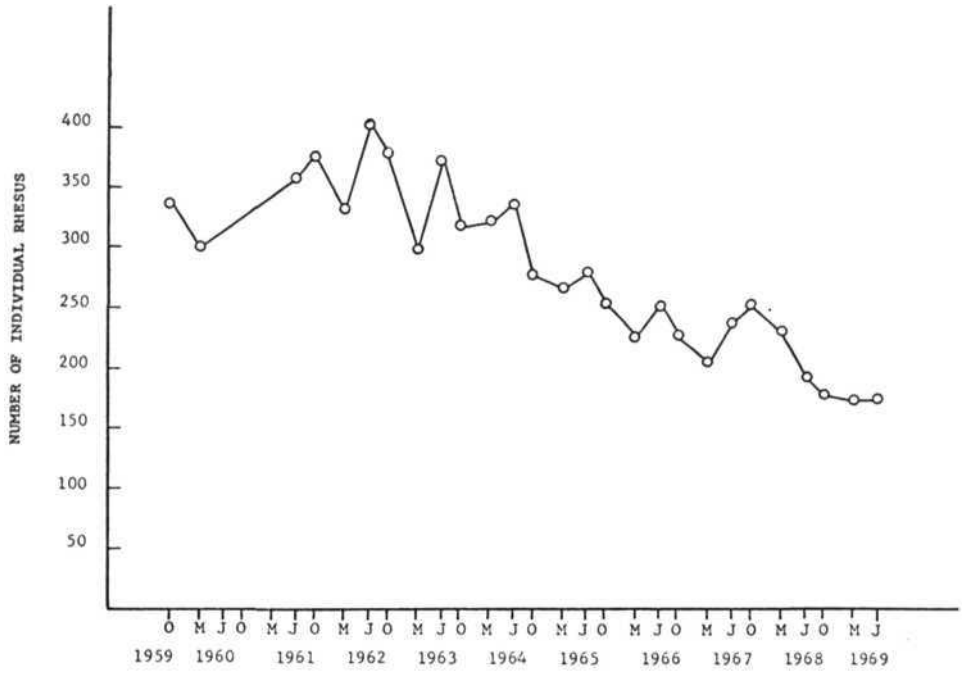

Fig. 5 Population trends of the total rhesus population in Aligarh district, 1959-69. In the bottom scale, 0 stands for October, M for March, and J for July, the months when censuses were made.

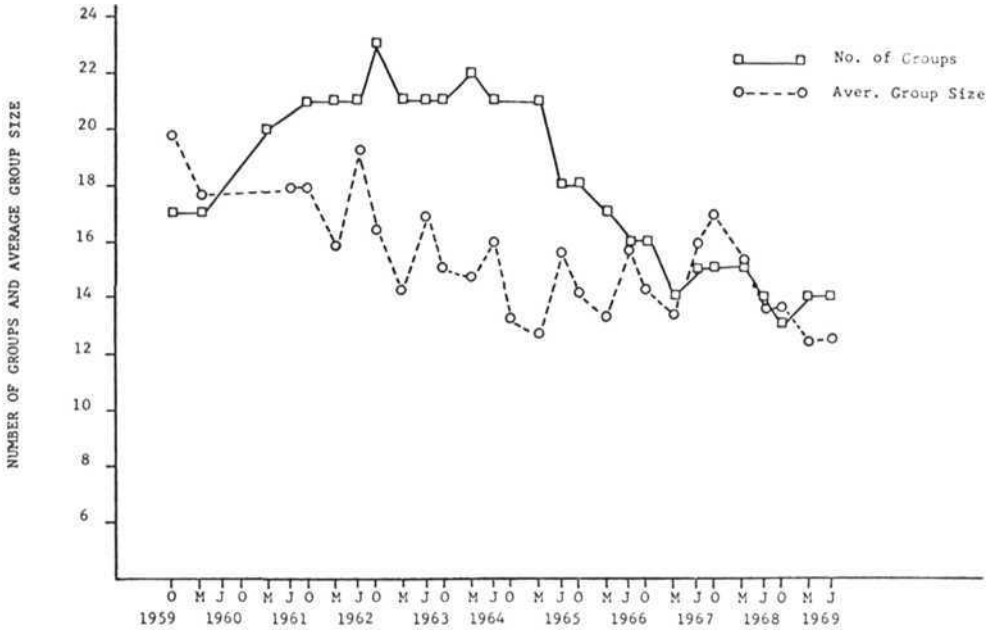

Fig. 6 Population trends of the Aligarh rhesus population in terms of total rhesus groups and average group size.

TABLE 2: POPULATION STUDIES OF RHESUS MONKEYS IN ALIGARH DISTRICT, U.P., 1959-1969

	Year and Month		Total Rhesus Population	No. of Groups in Pop'l.	Average Group Size	Average Group Composition			
						Adult Male	Adult Female	II	JJ
1.	1959	October	337	17	19.8	4.2	8.2	6.0	1.4
2.	1960	March	300	17	17.6	4.0	8.3	3.9	1.4
3.	1961	July	359	20	17.9	3.3	6.8	6.0	1.8
		October	377	21	17.9	3.7	6.9	6.2	1.1
4.	1962	March	332	21	15.8	3.6	6.9	4.7	0.6
		July	403	21	19.2	3.8	6.9	5.6	2.9
		October	378	23	16.4	3.4	6.0	5.1	1.9
5.	1963	March	299	21	14.2	3.0	5.6	4.0	1.6
		July	371	21	16.9	3.4	6.25	5.45	3.45
		October	318	21	15.1	3.1	5.4	4.2	2.4
6.	1964	March	323	22	14.7	2.9	5.3	4.4	2.1
		July	336	21	16.0	2.9	5.3	4.3	3.5
		October	278	21	13.2	2.7	4.5	3.4	2.7
7.	1965	March	267	21	12.7	2.7	4.8	3.5	1.8
		July	280	18	15.6	2.8	5.2	3.9	3.7
		October	254	18	14.1	2.9	4.8	3.5	2.9
8.	1966	March	226	17	13.3	2.6	4.8	3.3	2.6
		July	252	16	15.7	3.1	4.6	4.2	3.8
		October	227	16	14.2	2.9	4.4	3.5	3.4
9.	1967	March	206	14	14.7	3.1	5.7	3.5	2.4
		July	238	15	15.9	2.9	4.6	3.6	4.7
		October	253	15	16.9	3.0	4.7	4.2	5.0
10.	1968	March	230	15	15.3	2.7	4.6	3.8	4.3
		July	191	14	13.6	2.6	4.3	3.1	3.6
		October	177	13	13.6	2.8	4.3	3.2	3.3
11.	1969	March	173	14	12.4	3.0	4.0	2.8	2.6
		July	175	14	12.5	2.6	4.1	3.4	2.4

Another major cause of population decline has been harassment pressure from villagers who no longer tolerate crop destruction by rhesus. This has been responsible for the total disappearance of some groups (Southwick and Siddiqi, 1967). The villagers may directly kill the monkeys or have them trapped out. It should be emphasized that some villagers still religiously protect the monkeys in or near their village. Rigid protection is becoming increasingly rare, however.

We feel that the combination of high infant mortality, juvenile trapping loss and harassment from villagers has been responsible for the population decline of rhesus in Aligarh district. There is now some slight indication that this decline is levelling off (Figures 5 and 6), and possibly these factors are now coming into better balance with reproductive growth.

TABLE 3: PATTERNS OF NATALITY AND INFANT MORTALITY IN RHESUS MONKEYS OF ALIGARH DISTRICT, INDIA.

Year	Natality (1)	Infant Mortality	
		Monsoon (2)	Winter (3)
1961	88%	—	24%
1962	82	15%	22.5
1963	87	23	0
1964	81	21	0
1965	75	10	12.5
1966	93	17.6	12.5
1967	78	0	9.5
1968	73	2.3	10.7
1969	83	—	
$\bar{x}$	82.2%	12.7%	11.5%

(1) Percentage of adult females carrying infants in July (birth season March-June).

(2) Change in numbers of infants, July-October.

(3) Change in numbers of infants, October-March.

DISCUSSION

Although it is difficult to extrapolate from our limited data to the rhesus population of all of India, we feel that our results indicate in themselves that certain segments of the rhesus population are still declining, whereas other segments are apparently increasing. Trapping for export, at its present levels, cannot be considered the primary factor in continued population decline. Such trapping has been light for the past 5 to 7 years, and has been below levels which the rhesus population of India can sustain. Our estimates suggest that the rhesus populations of Uttar Pradesh alone produce a surplus of approximately 65, 000 infants per year—more than those now trapped for export from all of India (see Appendix I).

We therefore believe that the main factors governing future trends in the rhesus populations of India will be the attitudes and practices of the villagers. With increasing emphasis upon food production, most villagers are no longer willing to tolerate crop depredations by rhesus monkeys. On the national scale we do not consider these depredations serious or extensive. They are certainly not as great as crop losses attributable to insects, rodents and plant diseases. But wherever monkey depredations occur they are obvious and blatant. Most villagers, unless paricularly attached to monkeys for traditional or religious reasons, drive monkeys away or have them trapped. We feel that it is likely these trends will continue, and there will continue to be a decline of rhesus in rural India, with a relative increase in towns and cities.

Our data on forest dwelling rhesus are very limited, and not worthy of extensive discussion. A detailed survey of 10 square miles of forest in northern U.P. in 1959-60, mostly in Corbett National Park and around Naini Tal, revealed 7 rhesus groups. In 1965, we re-surveyed the same areas, failing to find one group in the Naini Tal area, and finding

1 additional group in Corbett Park, so that the total population still remained at 7 groups in 10 square miles. Group sizes were approximately the same. On the basis of this small sample, we tentatively conclude that the forest-dwelling rhesus are holding their own. Corbett National Park is, of course, a protected sanctuary area, but its immediately surrounding forest blocks are not.

In general, we feel that the rhesus in India at the present time is not in any danger of extinction, or even further serious depletion, but the distribution, habitat and population quality of the rhesus population are changing. We consider the decline of rhesus in rural India and its increase in urban India as unfortunate for both the monkey and the human population in terms of health and traditional values. It means that the majority of village children in India will grow up knowing the rhesus only in legends—monkeys will not be a part of their personal daily experiences. For each loss of wildlife in rural India, India's natural heritage is thereby weakened. On the other hand, the city dwellers of India will be bothered by relatively aggressive and unhealthy monkeys living in a crowded and competitive environment. In towns and cities, where they are less a part of the natural and traditional scene, they become one more nuisance along with rats, dogs, crows, kites and other scavengers.

II. Other Primate Species in South Asia

Good data concerning population trends are not available on two of the other most prominent monkey species in India, the langur *Presbytis entellus* and the Bonnet macaque *Macaca radiata.* We have the impression that the langur is certainly holding its own, and may even be increasing, but we have no specific data on this.

Two other monkey species in India which are definitely not holding their own, and are in relatively serious trouble are the stump-tailed macaque *Macaca speciosa,* and the lion-tailed macaque *Macaca silenus.*

The stump-tailed macaque was formerly abundant in Assam, and is still there but in very diminished numbers. In 1965, Dr.Mireille Bertrand, Dr. R.K.Lahiri and Dr. George Schaller spent several weeks in Assam looking for suitable groups of *M. speciosa* to observe, and they could find none. Villagers often told them that stump-tails had been present a few years ago, or were now present in the village over the next range of hills. They went on to the next village numerous times, but never found *M. speciosa.* Dr. Bertrand finally had to travel to Thailand to find a suitable group for study and this was surprisingly difficult even there. Throughout Thailand, she heard a similar story—stump-tails were here a few years ago, but now all were gone. Finally she located a few forest groups, but all were so wild and shy that it was difficult to study them.

Dr. Boonsong Lekagul has also referred to the serious reduction of primates in Thailand, including macaques, gibbons and langurs (Lekagul, 1965). Gibbons are suffering from deforestation and habitat destruction, and they are also hunted for the pet trade. Female gibbons with young may be shot to obtain the infant. Langurs are hunted for food and macaques are trapped for export. The Thai government has considered the situation critical and has greatly curtailed legal export of primates.

With regard to the lion-tailed macaque *Macaca silenus* of south India, attempts by Dr. R. K. Lahiri to find study groups in 1965 met considerable difficulty and frustration. The lion-tailed macaque is unique among the genus—it is truly arboreal and quite distinct from all other macaques. It is surely a most valuable animal to maintain in the wild. Its natural range is limited to small areas within the western ghat mountains below Bombay. Dr. Lahiri was able to locate a few groups in Periyar game sanctuary in southern India, but he also found them very wild and frightened of man. Dr. Y. Sugiyama undertook a field survey of *M. silenus* in 1961, 1962 and 1963, and he found four very limited populations near Periyar and in the Cardomom, Anaimalai and Nilgiri Hills (1968). Dr. Sugiyama estimated that the wild popilation of this species was less than 1000 and he felt the possibility exists that this wild population will become extinct. Even now it is generally impossible to obtain adult *M. silenus* for behavioral study. Only young animals are available as pets in animal markets in India, and these are quite likely obtained by shooting the mother.

We feel that very rigorous conservation and management measures should be applied to preserve wild stocks of both stump-tailed and lion-tailed macaques in India.

As for other species of macaques in southeast Asia, very little data are available, but several indications of population decline can be obtained. Dr. Irven Bernstein of Yerkes Primate Center in Atlanta, reported considerable difficulty in finding suitable study groups of pig-tailed macaques *Macaca nemestrina*, on a field survey in 1966. The Regional Primate Research Center at the University of Washington, Seattle, felt that sufficient evidence for a population decline in this species existed to warrant a major effort at laboratory breeding to supply animals for research.

Although there are no detailed data of which I am aware on population trends of the Java macaque or crab-eating macaque *Macaca irus (M. fascicularis)*, Rabor (1965) has written of the great depletion of this species and other macaques in the Philippine Islands. He attributes this depletion to habitat destruction and hunting by native peoples for food. Considerable export for scientific research has also occurred.

The Formosan Rock macaque *M. cyclopis* is totally unknown as to its population status. It is used extensively in Taiwan for biomedical research, and apparently natural populations exist in eastern Formosa, but no specific data on abundance or distribution are available.

It is apparent that primate populations can become extinct even in areas where they are greatly honored and revered. The gibbon *Hylobates lar* played a vital roled in the art, history, dance, music and entire cultural heritage of China for more than 2000 years, and was formerly abundant throughout China as far north as the Yellow River, and as far west as Chengtu and Lanchow. By the year 1644 A.D.,the gibbon had become so rare in China that it dropped out of literature, art and music, and now remains as only a historical entity (Van Gulik, 1967). Even though the gibbon was endowed in the culture of ancient China with wisdom and mystical powers, even assuming a religious role, it still became extinct in most of China. We shall never know all the reasons for this extinction, but it most likely occurred with the deforestation of China and the destruction of the gibbon's habitat.

Throughout the world, habitat destruction is certainly a major threat to primate populations. Deforestation, slash and burn agriculture, and overgrazing are all too common throughout the tropics, and represent very serious trends in Africa, South America, South Asia, Indonesia and the Philippines. With increasing economic pressures, primate conservation is becoming more acutely needed. We feel that two major types of programs should be initiated as soon as possible: first, a coordinated and well planned program of population surveys to provide more accurate data on the ecologic status of important species of primates; secondly, active conservation programs on all endangered species and all species that are directly utilized in biomedical research. The population surveys are necessary to provide the data on which sound conservation practices can be based, and the conservation programs are essential to insure that some of the world's important primate species will still be here ten or twenty years from now.

REFERENCES

BERTRAND M. 1969. The Behavioural Repertoire of the Stump-tailed Macaque *(Macaca speciosa)*. Bibliotheca Primatologica, in press.

BOONSONG LEKAGUL. 1965. Threatened species of the fauna of Thailand. I.U.C.N. Publications. New Series, No. 10: 267-271.

RABOR, D.S. 1965. Threatened species of small mammals in tropical S.E.Asia: the problem in the Philippines. I.U.C.N. Publications. New Series No. 10: 272-277.

SINGH, S.D. 1969. Urban monkeys. Scientific American, 221(1): 108-115.

SOUTHWICK, C.H., M.A.BEG, and M.R.SIDDIQI. 1965. Rhesus monkeys in North India. Chap. 4 in, Primate Behavior, edited by I. DeVore. New York: Holt, Rinehart and Winston, pp. 111-159.

SOUTHWICK, C.H. and M.R.SIDDIQI. 1966. Population changes of rhesus monkeys *(Macaca mulatto)* in India, 1959-1965. Primates (Jour. of Primatology), 7(3): 303-314.

SOUTHWICK, C.H. and M.R.SIDDIQI. 1967. The role of social tradition in the maintenance of dominance in a wild rhesus group. Primates, 8: 341-353.

SOUTHWICK, C.H. and M.R. SIDDIQI. 1968. Population trends of rhesus monkeys in villages and towns of northern India. Jour. Animal Ecology, 37: 199-204.

SUGIYAMA, Y. 1968. The ecology of the lion-tailed macaque *(Macaca silenus* L.)—A Pilot Study. Jour. Bombay Nat. Hist. Soc. 65(2): 283-293.

VANGULIK.R.H. 1967. The Gibbon in China. Leiden, Holland: E.J. Brill. 123 pp.

APPENDIX 1. AN ESTIMATE OF THE PRODUCTIVITY OF THE RHESUS POPULATION OF NORTHERN INDIA

In 1960 we estimated that the rhesus population of Uttar Pradesh was between 800, 000 and 1, 000, 000 monkeys. Adult females constituted 43. 6% of this population and they showed an annual natality, or infant production rate, of 80%. Assuming that the population has declined at the rate of 5% per year throughout the 1960's (based on the Aligarh district sample of 4. 8% per annum as a 10 year average), and starting with an original population of 800, 000, this leaves a population in 1969 of 504, 000 rhesus monkeys for Uttar Pradesh.

If this 1969 population estimate is rounded to 500, 000 monkeys, still showing an adult female sex ratio of 43. 6% and a natality of 80%, this population would then contain 218, 000 adult females producing 174, 400 infants per year. Assuming an infant mortality rate of 25% per year, this results in 130, 000 infants reaching the age of one year. Probably only 30 to 40% of these are necessary for annual maintenance of the population, but conservatively assuming that 50% are necessary for population maintenance, this still leaves 65, 000 infants per year as harvestable surplus. This substantially exceeds present export demands for the whole of India.

If trapping for scientific research at current levels were the only loss factor operating on the rhesus population of India, this population should be increasing substantially every year. The fact that the rhesus populations are not increasing, except in towns and urban areas, indicates that other mortality factors are operative, namely disease and changing cultural patterns.

SUMMARY

Field studies of rhesus monkey populations of north India over the last ten years have shown that these populations have declined substantially. This decline has been due to decreasing protection from the villagers of India, changing habitat conditions and high rates of trapping for export. Trapping has declined substantially-since 1959, and there is now some evidence that rhesus populations in forest areas may be stabilizing. Populations in rural agricultural areas may continue to decline, while those in towns may actually be increasing to a limited extent.

The rhesus populations of India should be considered a valuable cultural and scientific resource and should be manage conservatively to produce a sustainable harvest.

The lion-tailed macaque *(M. silenus)* and stump-tailed macaque *(M. speciosa)* are both rare and endangered in India and should be rigorously protected.

Throughout Asia, Africa and Latin America, primate populations are under severe pressure from deteriorating environments and human exploitation. There is an urgent need for a worldwide program of field research to study the population status, ecology and reproductive biology of many primate species, especially those which are subject to population pressures for various ecological and economic reasons.

RÉSUMÉ

Des enquêtes sur les lieux des populations des singes rhésus dans les Indes du Nord ont démontré que les dites populations ont diminué substantiellement. Cette diminution a été due à une protection décroissante de la part des villageois des Indes, à des conditions d'habitat changeantes, et au taux élevé de la chasse au piège pour l'exportation. Depuis

1959 la chasse au piège a diminué substantiellement et il existe maintenant quelque évidence que les populations rhésus dans des terrains forestiers peuvent être en train de se stabiliser. Il se peut que les populations dans des terras agriculturales et rurales puissent continuer à diminuer, tandis que celles des villes puissent être en effet en train de s'augmenter à degré limité.

On devrait considérer les populations rhésus des Indes comme ressource de valeur culturale et scientifique et on devrait les manier de façon conservatrice afin de produire une moisson susceptible de se maintenir.

La macaque à queue de lion *(M. silenus)* et la macaque à tronçon de queue *(M. speciosa)* sont toutes les deux rares et exposées à danger aux Indes. On devrait les protéger rigoureusement.

Par toute l'Asie, l'Afrique et l'Amérique Latine, les populations de primates se trouvent soumises à une pression sévère par suite des ambiences nuisibles et de l'exploitation humaine. Il y a besoin urgent d'un programme mondial de recherches sur les lieux pour étudier l'état de population, l'écologie et la biologie réproductive de beaucoup d'espèces de primates, surtout celles qui sont rares et en danger et celles qui sont soumises à des pressions de population pour de diverses raisons écologiques et économiques.

Section C (1)

A Comparison of Reproduction in Tame and Wild Elephants

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INTRODUCTION

Although hundreds of Asiatic elephants (*Elephas maximus L.*) have been kept in western zoos and circuses since the middle of last century, a relatively small number of calves have been born in captivity. For the time span between 1902 and 1965, Dittrich (1967) recorded 55 births in Europe and 12 in the United States.

In India, Burma and Thailand, where still thousands of tame elephants work in timber yards, successful breeding occurs regularly, although it is not always in the interest of the owners. Stracey (1963) assumes that 600 calves are born annually in Burmese camps, where some 6000 working elephants live. Hundley (1935) states that Steel Brothers and Co. in Rangoon possessed 1507 elephants, at least 365 of them having been born in captivity. According to the Chief Conservator of Forests in Mysore, 10 captive cows gave birth to 22 calves between 1960 and 1968.

No single record can be found that working elephants have been bred in Ceylon during the last two centuries. According to Knox (1966) and Nicholas (1954) one can assume that under the Singhalese kings until the 17th century, Ceylonese working elephants were crossed with Indian tuskers.

Some information concerning the reproduction potential of wild living and captive elephants is given in this paper. The data have been gathered during a two year field study on the Ceylon elephant (1967-1969) and several visits to working elephant camps in Mysore State in 1968 and 1969. Statistical information has been taken from earlier publications of other authors, mainly Dittrich (1967).

STRUCTURE OF POPULATION

The age of elephants younger than 20 years can be estimated by the relative shoulder height. Age criteria for animals older than 20 years (e.g. fold of the dorsal edge of the ear, proportion of trunk and facial muscles, etc.) are doubtful (Kurt and Nettasinghe, in preparation). Until now only a few dead Asiatic elephants have been checked by molar age, a method adopted successfully several times with African elephant (*Loxodonta africana*) by Laws (1966), Sikes (1967) and Krumrey and Buss (1968). Records of the life span of elephants in zoos and circuses are often lost because of the long period they live in captivity and of changes in ownership, or they are deliberately exaggerated (Seitz, 1967). Therefore, only three age groups will be distinguished in this paper; juveniles (0—5 years), subadults (6—15 years) and adults (older than 15 years).

In Asia, elephants are taken for work after passing their 15th year of life. As long as sufficient wild animals can be caught, it would be too expensive to raise young ones. In the elephant camps in South India, practically only adults and a few subadults are kept. During the last khedda operations in Mysore in 1968, 88 elephants were captured. Two females died. All 31 juveniles, 26 subadults and 5 adults, were auctioned. The Department of Forests kept for its own purposes 4 subadults and 20 adults. They were put to work after a taming and training period of 3 months. Practically all elephants born in Mysore camps, if they survive, are sold to western zoos or animal dealers.

Licences to capture wild Ceylon elephants have not been given to private owners since 1960. The demand for abandoned calves, which are occasionally found and sold by the Department of Wildlife, is rapidly increasing. Of 68 tame elephants, which took part at the Kandy Perahera in 1967,4 were juveniles, 6 subadults and 58 adults.

The average age of elephants living in western zoos and circuses is lower. They are kept for exhibition and shows but not for heavy work. According to Kurt (1960), Maberry (1962) and Dittrich (1967) the three breeding herds of Circus Knie (Switzerland), Portland Zoo (U.S.A.) and Hanover Zoo (Germany) include 12 subadult and 6 adult animals. The demand for young animals under 5 feet shoulder height is rapidly increasing according to the animal dealers A. Meems (Ruhe, Germany) and A. Hächner (Küenzler, Switzerland).

Asiatic elephant camps have practically as many bulls as cows, e.g. Steel Brothers and Company, Rangoon (Hundley, 1935): 109 males and 111 females; Department of Forests in Madras (Richmond, 1932): 34 males and 44 females; Ceylon: 33 males and 35 females. In western zoos and circuses more females than males are kept. Of 63 elephants studied by Benedict (1936) only one was a male. The sex ratio of the breeding herds of Circus Knie, Portland Zoo and Hanover Zoo is 4: 14.

The main reasons for this striking difference between Asiatic and western populations are the supply of suitable and cheap personnel and the methods of keeping elephants. In Asia, there are two or even three mahouts in charge of one elephant. They are seldom if ever changed and are recruited from tribes with centuries old traditions in handling elephants. In Europe and America, labour is expensive; zoo keepers are normally in charge of more than one animal; there is hardly any tradition. In western zoos and circuses, accidents with adult bulls occur frequently during the period of musth (Hediger, 1963), when males become extremely aggressive and cannot be brought under control. Most western zoos and circuses therefore keep no males at all.

Although tame bulls in Asia come regularly into musth—its biological function is not yet clear—accidents happen relatively seldom, compared with the big number of captive males, because of the close relationship between mahouts and elephants. As soon as adult bulls show the slightest signs of restlessness, they are chained between 4 trees and fed with a so-called cooling ration, which may contain opium or other drugs (Evans, 1910). In most Asiatic work camps, elephants are kept chained only during the taming period and musth. After their daily working period of 6 to 8 hours and a bath, they are allowed to roam in the iungle with hobbled forelegs. Contacts with wild living elephants occur frequently and most of the tame females giving birth to a calf have been mated by wild males.

In many western zoos and circuses, elephants still live under absolutely unnatural conditions, being, for example, kept single, never given a bath or a rubbing tree, and without other important features of their natural home-range. Stereotypic behaviour is very common amongst western captive elephants but rarely found in Asiatic ones. In South Indian camps elephants are kept in groups of 4 to 20 animals. The herds of wild living Ceylon elephants contain 8 to 22 animals. The structure of the wild population, based on a sample taken in the Ruhunu National Park and the Lahugala Sanctuary, is: juveniles 32% (16% females, 16% males), sub-adults 29% (16% males, 13% females), adults 39% (8% males, 31% females).

PERIOD OF REPRODUCTION

The reproduction period is defined as the time span between the first successful mating and the last parturition in the average life span of adult females. Table 1 gives some examples, special attention being paid to the age at first parturition.

Zoo and circus elephants begin to deliver calves when still subadult. Parturition by adults is rare, compared with the working elephants, which have babies until old age. The age estimation in the Table can be relied upon, as most of the females came into captivity as subadults. Working elephants deliver their first calves later than zoo and circus animals. The delay seems to be caused by the taming and training period, which takes place at the subadult age. Three pregnant females caught in Mysore delivered their calves in the training camp; they next gave birth after 15, 16 and 23 years respectively.

Wild elephant cows parturate for the first time at the age of about 10 years. Of 36 females older than 6 years, which were captured in the Mysore Khedda in 1968, all animals older than 10 years had well developed mammary glands, a calf at heel or seemed to be pregnant. Among the 5 to 10 year-old females, only one had developed breasts and gave birth to a calf one month after the khedda.

TABLE 1: PARTURITION AGE OF CAPTIVE FEMALE ELEPHANTS

Age	9	10	11	12	13	14	15	16	17	18	19	20	21–25	26–30	31–35	36–40	41–45	46–50	51–55
1.a	1	1	2	3	2	—	2	2	2	2	3	1	4	1	1	—	—	—	—
b	—	—	—	1	—	—	2	1	—	2	—	1	3	2	3	1	—	—	—
2.a	—	—	—	—	1	—	1	1	—	3	—	1	6	—	—	—	—	—	—
b	—	—	—	—	—	—	1	—	—	1	—	—	3	2	1	1	—	—	—
c	—	—	—	—	—	—	—	—	—	—	—	—	—	2	7	2	5	2	1

1. Western zoo and circus elephants according to Heller (1933),Maberry (1962) and Dittrich (1967). a. First parturition; b. consecutive parturitions.
2. Asiatic working elephants according to Evans (1910), MacFie (1914), Hundley (1935), Robinson (1935) and Burne (1942). a. First parturition of cows born in captivity; b. first recorded birth after capturing; c. consecutive paruritions.

As shown in Table 1, elephant cows reproduce until old age. Therefore one can assume that the average age of death is also the end of the average reproduction period.

The life span of elephants has often been extremely exaggerated. According to Seitz (1967) so far only one elephant has been recorded to have lived over 60 years in a western zoo or circus. Of 17 elephants over 20 years old which died in Mysore, 7 were between 21 and 30, 5 between 31 and 40,4 between 41 and 50 and one 55 years (average 34 years). Richmond (1932) gives age estimations of 78 elephants belonging to the Forest Department in Madras: 16 between 21 and 30, 38 between 31 and 40, 16 between 41 and 50, 7 between 51 and 60 and one 67 years (average 37 years). The average age of the elephants in the breeding herds at Circus Knie, Portland Zoo and Hanover Zoo would be some 16 years.

Molar analysis of 42 carcasses in Ceylon suggested that the average life-span of adult wild elephants is some 35 years, but the average life-span for the whole population much lower, only 17 years (Kurt, in preparation). The average age of 88 elephants captured in Mysore in 1968 was 11 years, which may be too low because adult bulls are deliberately not kraaled.

The duration of the reproduction period in zoo, circus and wild elephants is 27 years, if one assumes that the first successful mating takes place at the age of 8 years and the average life-span of adults is 35 years. In working elephants, it would according to Table 1 be some 23 years.

BIRTH INTERVAL

The time span between two consecutive births depends on the length of the period between parturition and next successful mating and the duration of the gestation period, which lasts according to Burne (1942) and Dittrich (1967) 21 months, the extremes noted being 20/22 and 17/24 months respectively.

Table 2 shows birth intervals: the average is about 38 months, the extremes 21 and 62 months. If an immediate separation between mother and newborn took place after birth, the interval is 23 months and 20 days. In cases where mother and infant lived together for at least one year, the next calf is born after some 47 months.

The first year of lactation seems to have an influence on the interval length. Weaning takes place in the first or second year of life. In wild living elephants in Ceylon, the calving interval was found to be 4 years and not 2, as Sanderson (1882) and other elephant specialists assume. A lactational anoestrus of two years was also found in the African elephant by Short (1966) and Laws (1967).

TABLE 2: DURATION OF THE INTERVAL BETWEEN TWO CONSECUTIVE PARTURITIONS

	Young raised by mother for at least one year	Immediate separation after parturition	Situation Unknown
Zoos and circuses*	36 months -- days 37 months 10 days 47 months 28 days 50 months 28 days 55 months 18 days 58 months 18 days 60 months 8 days	21 months 22 days 23 months 27 days 24 months 7 days 24 months 27 days 27 months 6 days ±21 months ±25 months ±25 months	±39 months -- days
Asiatic camps†	34 months 1 day 36 months 14 days 37 months 5 days 48 months 6 days 51 months 22 days 60 months 3 days	±20 months §	28 months 16 days ‡ 38 months 9 days 41 months 15 days 49 months 1 day 62 months 16 days
Average	47 months 8 days	23 months 20 days	42 months 34 days

* According to Heller (1933) and Dittrich (1967).
† Chief Conservator of Forests in Mysore.
‡ Tun Yin (1958).
§ Evans (1910).

JUVENILE MORTALITY

Mortality at juvenile age occurs mainly just before or after parturition and during the process of weaning, as shown in Table 3.

TABLE 3: MORTALITY IN JUVENILE AGE

	Age when died								
	Still born *parturition*	1st–3rd week *m.*	1st	2nd *weanmg*	3rd *m.*	4th	5th year	Reached subadult age	Total
Zoo and circus*	7	9	1	1	3	—	1	11	33
Training camp†	?	12	—	—	—	—	—	—	12
Working camp‡	?	1	1	4	1	—	—	10	17
Total	7	22	2	5	4	—	1	21	62
		47%	3%		14%		2%	34%	100%
Wild Populat‡		14%	0%		44%	—	—	52%	100%

* According Heller (1933) and Dittrich (1967).
† Chief Conservator of Forests in Mysore.
‡ Ceylon population (Kurt, in preparation).

The high parturition mortality in circus and zoo elephants and animals in training camps is caused either by the lack of a suitable 'aunt' or by bad physical condition and inexperience of the mother (weakness of calf, lack of milk, mother rejects calf, etc.). In wild herds, the newborn elephants are accompanied, protected and nursed not only by their mothers but also by some aunts, which are already in attendance during the parturition and even feed from the after-birth. If a mother dies or rejects her baby, one of the nurses immediately adopts the newborn. In working camps of South India, mothers and newborn are free to roam in the jungle for the first year after birth. They are always accompanied by another tame cow. The aunt phenomenon has been partially observed at Portland Zoo and Hanover Zoo (Maberry, 1962 and Dittrich, 1967). Both in tame working elephants and wild ones, juvenile mortality reaches its peak during the weaning period, when calves begin to be independent members of the herd.

According to the few data in Table 3 only 34% of calves delivered by captive mothers reach subadult age and most probably maturity, compared with 52% in wild populations. The highest survival rate is shown by working elephants (59%). In circus and zoo elephants, 33% reach subadult age. All calves delivered by females at the training stage died shortly after birth.

DISCUSSION

Reproductive capacity of Asiatic elephants is very low. In wild herds only half the calves reach subadult age and maturity. In the reproduction period of 27 years, some seven calves are born, namely in year 10, 14, 18, 22, 26, 30 and 34. A birth interval of 4 years must be assumed since juvenile mortality occurs mainly during the process of weaning.

Only the captive populations in Asian working camps could maintain themselves by reproduction. Western zoos and circuses still have to replenish their populations by importing from Asia and most of them still do not meet the basic requirement for breeding because they keep no males.

In many parts of Asia wild elephant populations are rapidly decreasing, even in Ceylon, where they are completely protected. The Ceylon elephant already figures as an endangered subspecies in the Red Data Book of the IUCN (Simon, 1966). The Smithsonian Institution's survey in Ceylon showed, that wild herds of Asiatic elephant do not respond to human interference by population explosions such as occur in some parts of East Africa with African elephants, but suffer a declining reproduction rate due to higher mortality of calves and lower average life span of adult cows.

Elephants in Asia become constantly more expensive to buy because wild populations are decreasing while the calves bred in work camps are more in demand than before for the purpose of the camps themselves. If the reproduction rate in western zoos is to be improved, more bulls must be kept without too close contact with keepers, i.e. unchained, like other potential 'man-killers' (e.g. rhinos, tigers, lions, etc.). This does not mean that there is anything wrong with keeping elephants in chains in circuses and zoos during certain periods, just as is usually done in work camps, but it should only be a part of the relationship between keeper and elephant for as long as it is absolutely necessary for guaranteeing safety for human life. To keep elephants permanently fettered is totally out of keeping with the modern biological management of captive animals. Elephants require more than their daily food. In several modern zoos elephant houses with massive bull stables have been built, where males can be kept safely during the aggressive period of musth. Zoo veterinarians could well investigate methods of controlling musth aggressiveness by the use of tranquilizers, as indeed has been done for centuries in Asia.

Experiences in zoos and working camps, as well as in the field study of the Ceylon elephant, has shown that newborn elephants are raised by the mother and one or more aunts, so that every breeding group should include at least two females. Finally, since western zoos and circuses have hardly any tradition in breeding these popular animals, it would be of great value if much more detailed information on the subject could be made available by Asian countries, such as India and Burma, where elephants are regularly bred in captivity.

REFERENCES

BENEDICT, F.G. 1936. The physiology of the elephant. Carnegie Institution, Washington.

BURNE, E. C. 1942. A record of gestation periods and growth of trained Indian Elephant calves in the Southern Shan States, Burma. Proc. Zool. Soc. London. ser. B. **112**, 27.

DITTRICH, L. 1967. Beitrag zur Fortpflanzung und Jugendentwicklung des Indischen Elefanten, *Elephas maximus*, in Gefangenschaft mit einer Uebersicht über die Elefantengeburten in europaischen zoos and zirkussen. D. Zool. Garten (NF) **34**, 56—92.

EVANS, G.E. 1910. Elephants and their diseases. Government Printer, Burma, Rangoon.

HEDIGER, H. 1963. Gefahrliche Vater. Elefantenbullen verursachen in Europa fast regelmässig tödliche Unfalle. Das Tier **3** (8), 32—34.

HELLER, E. 1933. Elephants in and out of the Zoo. Bull. Wash. Park. Zool. Soc. Milwaukee, **4**, 2–18.

HUNDLEY, G. 1935. Statistical record of growth in the Indian Elephant *(Elephas maximus)* J.Bombay Nat. Hist. Soc, **37**, 487-488.

KNOX, R. 1966. An historical relation of Ceylon. 2nd edition. Tisara Prakasakayo. Dehiwala.

KRUMREY, W. F. and I. O. BUSS. 1968. Age estimation, growth, and relationships between body dimensions of the female African elephant. J. Mammalogy. **49**, 22—31.

KURT,F. 1960. Le sommeil des elephants. Mammalia, **24**, 259—272.

KURT, F. (in preparation). Ecology and behaviour of the Ceylon elephant and other large mammals in the Ruhunu National Park.

KURT, F. and A.P. W.NETTASINGHE. (in preparation). Growth and age criteria of the Ceylon elephant.

LAWS,R.M. 1966. Age criteria for the African elephant, *Loxodonta a. africana.* E.Afr. Wildl. J. **4**. 1-37.

LAWS,R.M. 1967. Occurrence of placental scars in the uterus of the African elephant *(Loxodonta africana).* J.Reprod. Fert. **14**, 445—448.

MABERRY, M.B. 1962. Breeding Indian Elephants, *Elephas maximus,* at Portland Zoo. Int. Zoo Yearbook. **4**, 80-83.

MACFIE,D.F. 1914. Female elephant giving birth to 3 young. J.Bombay Nat. Hist. Soc. 22, 789-790.

NICHOLAS, C. W. 1954. The Ceylon elephant in antiquity. (i) The Singhalese period. The Ceylon Forester (N.S.),1, 52-58.

RICHMOND, R.D. 1932. Elephants. Age to which they live in captivity. J.Bombay Nat. Hist. Soc. **36**, 494-495.

ROBINSON, G.C. 1935. Time of sexual maturity in elephants. J.Bombay Nat. Hist. Soc. **37**, 950.

SANDERSON, G.P. 1882. Thirteen years among the wild beast of India. 3rd edition. W. A. Allen & Co., London.

SEITZ, A. 1967. Einige Feststellungen zur Lebensdauer der Elefanten in Zoologischen Gärten. D. Zool. Garten (NF). **34**, 32–55.

SHORT, R.V. 1966. Oestrus behaviour, ovulation and the formation of the corpus luteum in the African elephant, *Loxodonta africana.* E.Afr. Wildl. J. **4**, 56—68.

SIKES, K. S. 1967. The African elephant, *Loxodonta africana:* a field method for the estimation of age. J. Zool. London. **154**, 235—248.

SIMON, N. 1966. Red Data Book. Vol.1—Mammalia. IUCN, Morges.

STRACEY, P. D. 1963. Elephant Gold. Weidenfeld and Nicolson. London.

TUN YIN, 1958. Twin elephant calves and interval between births of successive elephant calves. J.Bombay Nat. Hist. Soc. **59**, 643—644.

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SUMMARY

The reproduction capacity of Asiatic elephants is very low. During the reproductive period of about 27 years, some 7 calves are born; 30 to 60% of newborn calves reach subadult age.

In several Asian countries, working elephants breed regularly, but it is uneconomic to raise and train the calves as long as sufficient wild adult ones can be captured. Unfortunately, wild populations are generally declining and it is becoming more and more difficult and costly to use them to replenish stocks. Captive breeding therefore assumes increasing importance.

Although many hundreds of elephants live in western zoos and circuses, breeding occurs rarely because the males can usually not be kept under control by the traditional chain method, during the dangerous musth periods. The reproductive rate of western captive populations could be improved if bulls were kept like other potentially dangerous zoo animals, i.e. without too close and continual contact with keepers. Many other lessons from experience with the breeding of elephants in work camps, such as keeping at least two females in each breeding group, should be applied and it would be valuable if much detailed information of this experience could be available.

RÉSUMÉ

Le pouvoir reproducteur de l'éléphant d'Asie est très faible. Durant la période reproductive qui dure près de 27 ans, il nait environ 7 petits; 30 à 60% des nouveaux-nés parviennent au stade subadulte.

Dans de nombreux pays d'Asie, les éléphants se reproduisent de façon régulière, mais il n'est pas rentable d'élever et de dresser les jeunes éléphanteaux, tant qu'on peut capturer un nombre suffisant d'adultes sauvages. Malheureusement les populations sauvages diminuent de façon générale et il devient de plus en plus difficule et onéreux de les prendre en vue de compléter les effectifs. La reproduction en captivité prend de ce fait une importance croissante.

Bien que des centaines d'éléphants vivent dans les jardins zoologiques et les cirques occidentaux, les taux de reproduction y est extrêmement faible, car les mâles sont difficilement contrôlables même enchainés à la période du musth, lorqu'ils deviennent très aggressifs. Les populations occidentales captives en âge de se reproduire pourraient être augmentées si les mâles étaient enfermés, tout comme d'autres animaux captifs éventuellement dangereux, c.à.d. sans un contact trop étroit ni trop fréquent avec les gardiens. Les diverses expériences acquises dans les camps de travail sur la reproduction des éléphants, ainsi de garder au moins deux femelles dans chaque groupe reproducteur, devraient être mises en application. Il serait en outre très utile d'obtenir des renseignements beaucoup plus fournis sur ces expériences.

SECTION C (1): POINTS MADE IN DISCUSSION

Many of the species mentioned in Dr. Bannikov's paper, such as red and roe deer, have subspecies which, because of their size, antlers etc., are famous among sportsmen. It would be interesting to know whether the status of these outstanding forms is showing the same improvement as that of the more ordinary ones (Ranjit Sinh, India).

With only a few exceptions, the subspecies referred to by the last speaker are increasing in numbers and, in some cases, hunting can again be permitted. (Bannikov, USSR).

There is a tendency to exaggerate the importance of the economic argument for wildlife conservation: it is not the only one likely to appeal to people even in underdeveloped countries. Their attitudes and motivation are in fact often as complex as elsewhere and need to be assessed by careful interdisciplinary study. Certainly an approach to the problem based solely on economics in unlikely to lead to lasting solutions (Henning, U.S.A.)

An aspect of wildlife utilisation which is becoming more and more important, especially in tropical countries, is concerned with the trade in 'souvenirs'. These can range from pieces of coral and shells to mounted specimens of birds, mammals and even baby alligators. The trade can be of considerable and continuing economic importance and, as such, actually help in conserving a species, but only if it is wisely exploited on a sustained yield basis. Unfortunately there is always a great danger of over-exploitation, so that it is essential that very strict control measures should be insisted upon by conservation organisations (Märzer-Bruyns, Netherlands).

Most species of wildlife are more prepared to co-exist in modern conditions with human beings than the other way round. We ought to aim at facilitating such co-existence and the approach to wildlife conservation should always be one of good husbandry. This means not only maintaining but also creating the right environment (Bhadwar, India)—which indeed is exactly the idea and purpose of the Wildlife Management Institute, as its name implies (Chairman).

On a point of detail, 30 years seems a low estimate of the average age attained by Indian elephants (Bhadwar, India).

The Ceylon elephant is rather a special case and what applies to it may not apply elsewhere, including the estimate of longevity. In Assam, the fact that very many fewer elephants are now caught than the 300—400 which used to be caught in the years up to the end of the last war, does not necessarily mean that there are fewer elephants; populations seem to be relatively stable, at least where the habitat has not been too disturbed (Stracey, India).

It should be remembered that any estimate of average age is bound to seem low, because of mortality in younger animals, even if some elephants live to 60 or 70 years of age. It does seem as if the Asian elephant differs from the African in being less gregarious and less liable to any tendency to population explosion when there is an alteration in human pressures (Kurt, Switzerland).

SECTION C: SOME ASPECTS OF WILDLIFE UTILIZATION AND MANAGEMENT

(2) WITH SPECIAL REFERENCE TO BIRDS

Chairman: C.R. Gutermuth

Economic Aspects of Bird Conservation in Taiwan

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INTRODUCTION

Taiwan is about the same size as the Netherlands in area and less than one-third the size of the state of New York. It is 384 km in length, 144 km in width at the widest point, and has a massive chain of mountains down its eastern half, with more than 60 peaks over 3000 m in height, the highest reaching 3997 m. Intermediate in latitude between north and south Asia, Taiwan exhibits a wide variety of climate-habitat associations from tropical monsoon to temperate cloud forests and snow capped mountains in winter. Rainfall varies from less than 1000 to more than 6000 mm per year depending on the locality.

Only 25% of the total land area is arable, population density is second highest in the world, and habitation is confined largely to the lowland regions. The rugged terrain, varied climate, high population density and rapid population growth would all seem to mitigate against rapid economic development. Yet, since recovering from World War II, Tawain's agricultural production has increased at an annual rate of 6% a year, undergirding the national income growth rate of 7. 6% a year. Per capita income, which has been growing at 4. 2% a year, is now third highest in Asia. This prosperous growth is accompanied by the highest per capita caloric intake in Asia today, putting Taiwan eleventh in the world in calorie consumption.

Taiwan's remarkable success story has been largely based on the goverment's early emphasis on agricultural development. Agriculture has been producing not only food to feed the people but also surplus capital and labor to be funnelled into the development of other sectors of the economy. Though agriculture comprises only about 23% of the G.N.P. today, production is still on the increase and is supported by a labor force comprising 44% of the total available, the largest single block of labor. Agricultural products accounted for five out of the top ten single-item export goods in 1968, bringing US$ 185 million in foreign exchange[1]. Complementary to the increasing agricultural output, the annual population growth rate has decreased from 3.5% in the 1950's to 2.3% by the end of 1968[8, 9]. For summary of basic statistics see Appendix 1.

Taiwan's economy will continue to develop in the coming years, the industrial sector doubtlessly exceeding the agricultural sector by a considerable degree. Because almost all economically available land has already been opened up to cultivation and because present crop yields are already high, there already is a slackening in the rate of agricultural growth. This inevitable tapering off, however, might be compensated for, in part at least, by increasing efficiency in forestry and forest resources management and in the development of wildlife management, which has so far been completely neglected.

The purpose of this paper, then, is to consider one aspect of Taiwan's wildlife, birds, to outline the role they play in Taiwan today and to emphasize the need for proper management in order to foster continuing renewal of the resource, continuing benefits to the people and, in some cases, outright survival of the species.

HUNTING

Birds are heavily hunted by various people for various reasons using various means. They are taken by guns during the day or, with the aid of a spotlight, at night; they are taken in long nets at night when driven from their roosts, or snatched off the ground in hand nets, also with the aid of spotlights; they are taken on perch traps or by snare. The one feature common to all methods is that the hunting is generally substained and indiscriminate. If a bird can be had, it will be had without further consideration. Hunting therefore, produces continuous pressure on bird populations.

The specimen business [7]. The most noticeable use of birds to anyone who has visited Taiwan even briefly is the sale of mounted specimens. Many small shops display specimens in their windows or on their shelves and, at the well known tourist resort of Sun Moon Lake, dozens of shops specialize in the specimen business, many of them depending on it as a livelihood.

Though hunting pressure for specimens is continuously applied the year round, the heaviest season apparently occurs in the fall when, according to the hunters, the birds look prettier. Biologically, this would correspond to the time following the breeding season and the post nuptial molt when many birds are in new plumage. It is naturally the flashier, more dramatic birds which attract the hunter's guns and the business, regardless of their status in the wild. In July 1967, a survey was made of all specimens on hand for sale at the Sun Moon Lake bird shops. In this off-season, nearly 2000 individuals belonging to 143 species of 43 families were available in 27 shops (see Appendix 2). Among the specimens for sale were a surprisingly large number of Swinhoe's pheasant *Lophura swinhoii,* a species endemic to Taiwan and listed as 'extremely rare in the wild' in the I.U.C.N, 's Red Data Book (5). Also on display in numbers were the Formosan blue magpie *Urocissa caerula* and the Formosan whistling thrush *Myophonus horsfieldi* which, like the pheasant, are endemic, beautifully blue, and highly prized in the business, though not presently rare in the wild. The yellow tit *Parus holsti,* which is probably Taiwan's rarest resident (also endemic but not listed in the Red Data Book) and whose life history remains unknown even today, was also present in the shops. All together, the most highly prized species were represented with 20 or more specimens and are characterized by being either flashy in colour or dramatic in size or shape.

The fall hunting season happens to precede the heaviest demand for specimens. Between October and March come the Chinese national holiday (October 10th or Double Ten), the western New Year and the lunar New Year, times during which foreign visitors are particularly numerous. It is the Japanese tourists who buy the most birds followed by Overseas Chinese (i.e. Chinese living outside Taiwan, especially in Southeast Asia) and then local middle school students. The Japanese and Overseas Chinese buy the expensive, flashier birds like eagles, pheasants, or pittas while the middle school students go for the cheaper varieties like drongos.

The specimen business can be lucrative but the competition is tough, especially at Sun Moon Lake where the number of shops is sometimes greater than the demand for specimens. When business is at its peak, however it is possible for a shop to do anywhere between US$ 250-1200 per *day.* In Taiwan, this represents good business, brings in foreign exchange and compares very favourably, for example, with the average *annual* liquid assets of farm families as reported by the Department of Agriculture and Forestry [8].

If the specimen business is to continue, it would be wise to improve the quality of the taxidermy. Should eventual management procedures result in fewer specimens available for sale, this could be compensated for by higher priced more skilfully mounted specimens. Both foreign and national tourists now have the financial capacity to pay for quality work.

International live bird trade [7]. There is considerable trade in live Mikado pheasants *Syrmaticus mikado,* another endemic pheasant listed in the Red Data Book as 'rare and known to be decreasing' [5]. Briefly, the pheasants are snared by the aborigines who, were it not for the incentive of the business, would not bother with them, and are sold in pairs through a chain of middlemen until they are finally purchased by Japanese or Overseas Chinese, just as in the specimen business. One dealer, known personally to the author, handled approximately 150 pairs of pheasant in a recent year. This would represent a net profit for him of US$ 2250, a total financial exchange of US$ 14, 250 along the line,

and receipt of US$ 7, 500 in foreign exchange. It is now known at the present time how many people are involved full time in Mikado trade but an estimate would put the number around 10, with considerably more dabbling in the business as part-time middlemen. Of course, upon special request almost any animal dealer or pet shop could probably produce a live Mikado within a month due to the interconnecting web of contacts among people in the same general field of business.

Perch-trapping [6]. Brown shrikes *Lanius cristatus* are transient migrants in Taiwan passing through in large numbers every September on their way to Philippine wintering quarters. In the last 40 km at the narrow southern tip of the island, they concentrate in especially large numbers. The open country with rolling hills in this region provides an ideal habitat for perch-trapping shrikes. Sisal *(Agave sp.)* being the dominant vegetation and being a rather uniform one metre in height, it is easy to blanket the hills with traps standing higher than the surrounding vegetation, thereby taking advantage of the shrikes' tendancy to perch in places offering the best vantage point of the environment. Estimates made by the Tunghai University Bird Banding Project in September 1967 and 1968 indicate that somewhere in the neighborhood of half a million birds may traverse this section of the island during this month. In certain areas where trapping is especially heavy, the population probably sustains between 30-50% mortality and it is unlikely that, for the 40 km stretch as a whole, the mortality is any less than 20%.

In all likelihood, these shrikes play a definate economic, nutritional, and social role in the lives of the local people. As this report is being written, the results of a survey of 400 farm households in the shrike trapping region have not yet been evaluated. This survey, conducted by the sociology department of Tunghai University, was planned on the basis of preliminary evidence indicating the shrike trapping (a) may be considered as a kind of annual 'sport', (b) may provide the farmers with available cash to pay hired labour for the rice harvest which immediately follows the shrike migration, (c) may add significant amounts of protein to the diet and (d) doubtlessly provides some local restaurants with a highly profitable seasonal delicacy. In a survey conducted by the MAPS team in 1967, three restaurants purchased 7624 shrikes in 17 days. The shrikes customarily hang outside the restaurants during the day in large, dangling bundles, alive in order to keep them fresh in the absence of refrigeration. Their bills are broken as soon as they are caught so that they cannot peck the handlers. Then at night, they are fried and sold to customers. 7624 shrikes represent a total of US$ 700 in financial transactions and a net profit for the three restaurants of US$ 250. The net profit for the restaurant that handled the most shrikes, US$ 112, could pay a year's tuition for one Arts student at a private university in Taiwan or for 2½ years at the National University. It could feed a university student for seven months and a farmer even longer.

Sisal and rice provide the major source of income for the farmers of this region. Sisal used in making rope and twine, is presently losing out in economic competition with synthetic fibers. The two yearly rice harvests are seldom completely successful. Typhoons hitting the southern part of the island during the summer and early fall may destroy anywhere from 5-75% of the second rice crop, depending upon the stage of growth at the time of the typhoon. In light of these rigorous conditions, the exploitation of the brown shrike takes on an added importance to the local people.

It should also be noted that shrikes, through predation, may well exert a beneficial ecological influence in pest control. A food preference study by Won in Korea, using the collar method on nestling brown shrikes, showed that 86% of their food consisted of insects in the adult or larval stages [11]. It is the same subspecies of shrike studied in Korea *(L.c. lucionensis)* that passes through Taiwan each September.

Night time hunting [6]. The grey-faced buzzard *Butastur indicus* is a transient migrant, passing through the southern tip of the island in large numbers each October toward winter quarters in the Philippines and, in late March and early April, moving up Taiwan's western lowlands toward more temperate breeding grounds to the north. During their southern passage, they are hunted at night while roosting in the forested hills of the southern region. Strong spotlights, run off car batteries slung on the back, locate the roosting birds and they are taken with guns or deadly accurate cross-bow arrangements. One small village can bag as many as 600 of these raptors in one night. In their spring passage northwards, they are again exploited, this time through live trapping in the foothills along the western flanks of the mountains.

The yellow wagtail *Motacilla flava* is an apparently abundant winter resident arriving in September and departing in May. They characteristically roost in sugar cane fields at night and are easily captured when driven from their roosts into nets stretched along the ends and sides of the fields. Eventually, they are fried and eaten.

No intensive studies have been made into the role of either of these species in the lives of the people. It can be said however, that hunting pressure is continuously applied to both species as long as they are present on the island: the hawks are taken by the thousand and the wagtails by the tens of thousands each year.

DISCUSSION OF ECONOMIC VALUES

In determining the values of birds as a renewable natural resource for the people of Taiwan, they must be judged first of all as they relate directly to the local people who deal with them and not, for example, as a percentage of the G.N.P. Though receipt of US$ 7, 500 in foreign exchange for 300 pheasants is infinitesimally small as compared to US$ 185 million for agricultural exports, it nevertheless remains significantly real as income for the local traders themselves. In the perspective of the local economy, therefore, birds do offer attractive economic benefits.

The danger is that indiscriminate, unregulated hunting, though it brings in the profits now, may render the resource unusable in the future, thereby eliminating sustained yields and profits. This points to two further facts. First, protective measures and hunting regulations, though they do exist, have not been implemented; nor are they completely relevant to the present natural conditions in Taiwan. Secondly, no adequate ecological studies or population surveys have been completed yet to serve as a base for proper management proposals. In short, it might be said that there are no regulations worth implementing at the present time. As a step in the preparation of an operable management scheme for birds, the author has presented a top priority list of 20 birds species to Mr. Hunter Eu (previous recipient of a WWF grant for the conservation studies in the United States) to be included in his report on wildlife resources of Taiwan for the Forest and Forest Industry Development Project (see Appendix 3). The purpose of this priority list is to call attention to those species which are heavily hunted and which urgently require protection and/or field studies to determine control measures. The list is relevant to Taiwan's birds today, is based on the preliminary studies cited in this report, and is particularly feasible for implementation in containing only 20 species as opposed to the present regulations which are needlessly overwhelming in numbers and confusing in nomenclature. This list is naturally subject to change based upon further studies or more professional advice and the mechanism for implementation has yet to be set up, but at least a potentially workable beginning exists.

POTENTIAL RECREATIONAL VALUES

Aside from the urgent need to study and regulate the harvesting of Taiwan's avifauna, there also exists the potential to develop Taiwan's wildlife, including birds, as an integral part of the island's recreational planning with its own intrinsic economic values.

Between 1958 and 1968, the number of foreign visitors coming to Taiwan increased 18-fold and within the next five years the number is expected to more than double. Revenue from tourism, if compared against the foreign exchange values of single-item exports in 1968, ranks fifth with US$ 53.3 million [(1)]. Japanese visitors comprised 41.2% of the foreign visitors; Americans second with 30. 4% [(1)].

Much needs to be done to protect wildlife in scenic areas visited by tourists. Western visitors and residents in Taiwan note the singular paucity of birds in areas most usually accessible to them. It is true that not until one gets back into the mountains off the beaten track does one begin to find the expected concentrations and varieties of birds. In more accessible areas, in and around scenic areas, hunting pressure has either driven much of the wildlife away or kept the numbers low or both. By contrast, on Orchid Island off the south-east coast of Taiwan, where no guns are permitted, birds are

abundant everywhere, even in the vicinity of the villages. Flashy birds such as the paradise flycatcher *Terpsiphone atrocaudata* and the Japanese green pigeon *Treron sieboldi* can be found commonly in association with man wherever habitat permits. In the scenic areas of Taiwan where these bird might naturally occur, they can only rarely be observed.

As before, regulations do exist to control hunting in and around scenic areas, but the goverment has not lent the necessary support for personnel training or implementation. With proper all round management and promotion, however, wildlife could become a tourist attraction in itself. With 13 bird species endemic to the island as well as other distributional novelties and a great variety of habitats, Taiwan has the potential to present a diverse and unique avifauna as part of the natural recreational facilities for foreign visitors and, of course, for the residents of Taiwan themselves as economic prosperity enables more leisure time.

SCIENTIFIC VALUES AND CONSERVATION

In some countries, ornithological research has advanced to highly sophisticated levels of inquiry. In other countries, including Taiwan, much of the fundamental data upon which more advanced studies will be based are still being collected.

Field studies since 1964 by the Tunghai University Bird Banding Project [6] have produced considerable quantitative information on the movements of three types of regularly occuring migrants: summer residents, winter residents and transients. Though well over 150, 000 birds have been banded in Taiwan, most of them immigrants, the origins, destinations and routes of some species are still not definately known and, for most species, no intensive qualitative studies on population dynamics have been carried out.

Taiwan's thirteen species of endemic birds are of scientific interest for being endemic, a condition brought about through long isolation. These distributional peculiarities have been well recorded in the literature but the ecological requirements which determine the distribution have yet to be worked out. Nor have the opportunities to study speciation in action been fully realized and, according to the late Dr. Herbert Deignan, several new subspecies remain to be described (3).

Along with any study into the habitat requirements of a given species must come a habitat inventory indicating just how much of the required habitat still exists on the island. This is especially important for those species that are rare and/or intolerant of habitat change. Such habitat inventories have not been made yet, primarily from lack of funds and personnel designated to carry them out. At some point, it will also be necessary to compare the relative effects of hunting and of habitat reduction on the bird populations, a subject about which there are plenty of impressions but few hard statistics.

The widest use of Taiwan's avifauna will depend upon the soundness of the fundamental biological and ecological data available. As much of this information has still not been gathered, the research needed to produce it should be encouraged and given recognition. Given the island's rugged terrain, it is not impossible that future bird population studies will indicate certain species presently thought to be rare are rather more common and widely distributed. The possibility of this revelation, however, is no justification for delayed action now. With the steadily advancing pace of Taiwan's development, the fortunes of a species or an ecologically unique area could be irreparably damaged in a very short time, especially where island conditions make space such a precious commodity. What is inviolate today, may be contaminated almost literally tomorrow.

CONCLUSION

Looking at the present status of birds in Taiwan as a whole, it can be said that it is *not* too late to initiate conservation efforts on their behalf and ultimately, of course, for the overall welfare of the people who are closely associated with them. Taiwan has demonstrated how, through proper methods of implementation, an agricultural development program can be immensely successful. With the same sort of attention and vitality, Taiwan has the potential to develop an equally effective conservation program aimed at

utilizing for the fullest economic, recreational and scientific benefit the available wildlife resources, while at the same time assuring their annual renewal. The potential exists. Encouragement and support are needed.

APPENDIX 1

Some basic statistics about the Republic of China (Taiwan). Superscripts refer to citations at the end.

Length [2]	394 km.
Width (at wides point) [2]	144 km.
Latitude [10]	21.45° to 25.38° N.
Longtitude [10]	121.01° to 122.06° E.
Area [10]	35, 961 sq.km.
Population (1967)[10]	13, 297, 000
Population density (1967)[10]	
per sq.km.	369.8
per sq. km. cultivated land	1,437.5
Population growth rate	
1960's [10]	3. 5% p.a.
1968[2]	2.3% p.a.
Annual rainfall[*2]	
range	916-6, 572 mm. p. a.
average	2,580 mm. p. a.
Tallest mountain: Mt. Morrison (Yu Shan)[2]	3, 997 m.
Agricultural production [10]	
1957-67 av. yearly increase	6.0%
Industrial production[10]	
1957-67 av. yearly increase	14.2%
Gross National Product (G.N.P.)[10]	US$ 3. 5 billion
National income	
1967[2]	US$ 2. 8 billion
av. yearly increase since 1962 [8]	7.6%
Per capita income	
1968[2]	US$ 205
av. yearly increase since 1952 [8]	4.2%
Arable land as % of total area[2]	25%
Calorie intake per capita per day[4]	2,579
Animal protein per capita per day[4]	23.9 g.

APPENDIX 2

Bird species recorded at the Sun Moon Lake specimen shops, July 1967. For some species, the sale price for one specimen is given in U.S. dollars. The price varies, depending on the quality of the specimen and the ability of the purchaser to haggle. In total: 143 species and 1979 individuals.

	Species	*Number*
1.	Little Grebe *Podiceps ruficollis*	1
2.	Sooty Shearwater *Puffinus griseus*	1
3.	Streaked Shearwater *Puffinus leucomelas*	4
4.	Red-tailed Tropic Bird *Phaethon rubricauda*	1
5.	Dalmatian Pelican *Pelecanus crispus*	1
6.	Common Cormorant *Phalacrocorax carbo*	2
7.	Temmink's Cormorant *Phalacrocorax capillatus*	1
8.	Grey Heron *Ardea cinerea*	1
9.	Purple Heron *Ardea purpurea*	1
10.	Cattle Egret *Ardeola ibis*	23
11.	Little Green Heron *Butorides striatus*	8
12.	Great White Egret *Egretta alba*	1

	Species	*Number*	
13.	Little Egret *Egretta garzetta*	2	
14.	Malay Bittern *Gorsachius melanolophus*	8	
15.	Cinnamon Bittern *Ixobryckus cinnamomeus*	12	
16.	Von Schrenk's Bittern *Ixobrychus eurhythmus*	1	
17.	Chinese Little Bittern *Ixobrychus sinensis*	1	
18.	Black-crowned Night Heron *Nycticorax nycticorax*	1	
19.	Teal *Anas crecca*	10	
20.	Wigeon *Anas penelope*	1	
21.	Mallard *Anas platyrhynchos*	1	
22.	Goshawk *Accipiter gentilis*	1	
23.	Crested Goshawk *Accipiter trivirgatus*	5	
24.	Asiatic Sparrow Hawk *Accipiter virgatus*	10	
25.	Golden Eagle *Aquila chrysaetos*	1	
26.	Grey-faced Buzzard *Butastur indicus*	43	
27.	Rough-legged Buzzard *Buteo lagopus*	3	
28.	Marsh Harrier *Circus aeruginosus*	2	
29.	Black Kite *Milvus migrans*	1	
30.	Honey Buzzard *Pernis ptilorhynchus*	1	
31.	Serpent Eagle *Spilornis cheela*	29	($20-50)
32.	Osprey *Pandion haliaetus*	1	
33.	Peregrine Falcon *Falco peregrinus*	1	
34.	Common Kestral *Falco tinnunculus*	16	
35.	Formosan Hill Partridge *Arborophila crudigularis*	19	
36.	Bamboo Partridge *Bambusicola thoracica*	15	
37.	Swinhoe's Blue Pheasant *Lophura swinhoii*	62	($5-10)
38.	Ring-necked Pheasant *Phasianus colchicus*	58	($15-30)
39.	Mikado Pheasant *Syrmaticus mikado*	2	($25-50)
40.	Barred Button Quail *Turnix suscitator*	1	
41.	White-breasted Water-hen *Amaurornis phoenicurus*	14	
42.	Coot *Fulica atra*	1	
43.	Watercock *Gallicrex cinerea*	1	
44.	Moorhen *Gallinula chloropus*	1	
45.	Philippine Banded Crake *Rallina eurizonoides*	1	
46.	Painted Snipe *Rostratula benghalensis*	17	
47.	Turnstone *Arenaria interpres*	2	
48.	Golden Plover *Charadrius dominicus*	1	
49.	Little Ringed Plover *Charadrius dubius*	3	
50.	Common Sandpiper *Actitis hypoleucos*	2	
51.	Little Stint *Calidris ruficollis*	1	
52.	Common Snipe *Capella gallinago*	6	
53.	Pintail Snipe *Capella stenura*	4	
54.	Woodcock *Scolopax rusticola*	1	
55.	Red-necked Phalarope *Phalaropus lobatus*	1	
56.	Whiskered Tern *Childonias hybrida*	1	
57.	White-winged Black Tern *Chlidonias leucopterus*	1	
58.	Little Tern *Sterna albifrons*	1	
59.	Sooty Tern *Sterna fuscata*	1	
60.	Emerald Dove *Chalcophaps indica*	21	
61.	Rock Dove *Columba livia*	2	
62.	Ashy Wood Pigeon *Columba pulchricollis*	20	
63.	Spotted-necked Dove *Streptopelia chinensis*	5	
64.	Eastern Turtle Dove *Streptopelia orientalis*	4	
65.	Red Turtle Dove *Streptopelia tranquebarica*	1	
66.	Japanese Green Pigeon *Treron sieboldii*	40	
67.	Lesser Coucal *Centropus toulou*	12	
68.	Common Cuckoo *Cuculus canorus*	2	
69.	Little Cuckoo *Cuculus poliocephalus*	13	
70.	Blyth's Cuckoo *Cuculus saturatus*	7	
71.	Chinese Grass Owl *Tyto capensis*	5	($15-30)
72.	Long-eared Owl *Asio otus*	1	
73.	Pigmy Owl *Glaucidium brodiei*	11	

	Species	*Number*	
74,	Tawny Fish Owl *Ketupa flavipes*	3	
75.	Brown Hawk Owl *Ninox scutulata*	5	
76.	Collared Scops Owl *Otus bakkamoena*	26	($5-6)
77.	Mountain Scops Owl *Otus spilocephalus*	3	
78.	Brown Wood Owl *Strix leptogrammica*	3	
79.	Savanna Nightjar *Caprimulgus affinis*	4	
80.	White-rumped Swift *Apus pacificus*	2	
81.	Common Kingfisher *Alcedo atthis*	21	
82.	Ruddy Kingfisher *Halcyon coromanda*	86	($15-20)
83.	Muller's Barbet *Megalaima oorti*	311	($3-5)
84.	Pigmy Woodpecker *Dendrocopus canicapillus*	8	
85.	White-backed Woodpecker *Dendrocopus leucotos*	5	
86.	Black-naped Woodpecker *Picus canus*	4	
87.	Blue-winged Pitta *Pitta brachyura*	294	($8-12)
88.	Lesser Skylark *Alauda gulgula*	1	
89.	House Martin *Delichon urbica*	1	
90.	Barn Swallow *Hirundo rustica*	4	
91.	Black Drongo *Dicrurus adsimilis*	11	
92.	Bronzed Drongo *Dicrurus aeneus*	5	
93.	Black-naped Oriole *Oriolus chinensis*	90	($5-15)
94.	Maroon Oriole *Oriolus traillii*	63	($10-20)
95.	Large-billed Crow *Corvus macrorhynchos*	1	
96.	Jay *Garrulus glandarius*	13	
97.	Grey Tree Pie *Crypsirina formosae*	13	
98.	Magpie *Pica Pica*	12	
99.	Formosan Blue Magpie *Urocissa caerulea*	62	($5-15)
100.	Yellow Tit *Panus holsti*	2	
101.	Varied Tit *Parus varius*	3	
102.	White-throated Laughing Thrush *Garrulax albogularis*	1	
103.	Grey-sided Laughing Thrush *Garrulax caerulatus*	5	
104.	Hwamei *Garrulax canorus*	2	
105.	Formosan Laughing Thrush *Garrulax morrisonianus*	1	
106.	White-eared Sibia *Heterophasia auricularis*	19	
107.	Rusty-cheeked Scimitar Babbler *Pomatorhinus erythrogenys*	1	
108.	Lesser Scimitar Babbler *Pomatorhinus ruficollis*	1	
109.	Formosan Yuhina *Yuhina brunneiceps*	1	
110.	Large Cuckoo-Shrike *Coracina novaehollandiae*	2	
111.	Ashy minivet *Pericrocotus divaricatus*	6	
112.	Grey-throated Minivet *Pericrocotus Solaris*	58	($10-15)
113.	Black Bulbul *Hypsipetes madagascariensis*	71	
114.	Chinese Bulbul *Pycnonotus sinensis*	12	
115.	Finch-billed Bulbul *Spizixos semitorques*	12	
116.	Brown Dipper *Cinclus pallasii*	4	
117.	Japanese Robin *Erithacus akahige*	2	
118.	Blue Rock Thrush *Monticola solitaria*	4	
119.	White-tailed Blue Robin *Myiomela leucura*	8	
120.	Formosan Whistling Thrush *Myophonus horsfieldi*	40	
121.	Brown Thrush *Turdus chrysolaus*	11	
122.	Red-tailed Thrush *Turdus naumanni*	4	
123.	Grey-headed Thrush *Turdus obscurus*	2	
124.	Island Thrush *Turdus poliocephalus*	2	
125.	Golden Mountain Thrush *Zoothera dauma*	51	($2-5)
126.	Black-naped Blue Flycatcher *Hypothymis azurea*	1	
127.	Blue and White Flycatcher *Muscicapa cyanomelana*	1	
128.	Narcissus Flycatcher *Muscicapa narcissina*	1	
129.	Rufous-bellied Blue Flycatcher *Muscicapa vivida*	1	
130.	Japanese Paradise Flycatcher *Terpsiphone atrocaudata*	3	
131.	Indian Tree Pipit *Anthus hodgsoni*	3	
132.	Water Pipit *Anthus spinoletta*	2	
133.	Pied Wagtail *Motacilla alba*	13	
134.	Bull-headed Shrike *Lanius bucephalus*	1	

	Species	*Number*
135.	Rufous-backed Shrike *Lanius schach*	7
136.	Crested Myna *Acridotheres cristatellus*	1
137.	Chinese White-eye *Zosterops japonica*	4
138.	Spotted Munia *Lochura punctulata*	1
139.	Sharp-tailed Munia *Lonchura striata*	1
140.	Tree Sparrow *Passer montanus*	1
141.	Russet Sparrow *Passer rutilans*	1
142.	Hawfinch *Coccothraustes coccothraustes*	3
143.	Brown Bullfinch *Pyrrhula nipalensis*	1

Note: A count in July 1969 showed 106 Swinhoe's Pheasants *Lophura swinhoii* (75 males. 31 females) and 8 Mikado Pheasants *Syrmaticus mikado* (all males) on display in the shops.

APPENDIX 3

High priority list of 20 bird species urgently requiring protection and/or population surveys. All heavily hunted.

CLASS I:	ENDEMIC. TOTAL PROTECTION	
	Swinhoe's Pheasant *Lophura swinhoii*	rare (?)
	Mikado Pheasant *Syrmaticus mikado*	rare
	Formosan Blue Magpie *Urocissa caerula*	uncommon
	Yellow Tit *Parus holsti*	rare
	Formosan Whistling Thrush *Myophonus horsfieldi*	uncommon
CLASS II:	BENEFICIAL. TOTAL PROTECTION	
	Grey-faced Buzzard *Butastur indicus*	transient, common (?)
	Chinese Grass Owl *Tyto capensis*	resident, rare
	Ruddy Kingfisher *Halcyon coromanda*	transient, rare (?)
	Black-naped Oriole *Oriolus chinensis*	resident, uncommon
	Maroon Oriole *Oriolus traillii*	resident, uncommon
	Rufous-bellied Blue Flycatcher *Muscicapa vivida*	resident, uncommon
CLASS III:	BENEFICIAL. REGULATED HUNTING.	
	Serpent Eagle *Spilornis cheela*	resident, common
	Collared Scops Owl *Otus bakkamoena*	resident, common.
	Brown Shrike *Lanius cristatus*	transient, common
CLASS IV:	REGULATED HUNTING.	
	Ring-necked Pheasant *Phasianus colchicus*	resident, common
	Muller's Barbet *Megalaima oorti*	resident, common
	Blue-winged Pitta *Pitta brachyura*	summer visitor, common (?)
	Grey-throated Minivet *Pericrocotus Solaris*	resident, common
	Golden Mountain or White's Thrush *Zoothera dauma*	winter visitor, uncommon
	Yellow Wagtail *Motacilla flava*	winter visitor, common

This list of 20 species has been submitted through Mr. Hunter Eu to the Forest and Forest Industry Development Project, a project of the Republic of China assisted by the United Nations Development Program and the Food and Agriculture Organization of the United Nations.

REFERENCES

(1) *Annual Report on Tourism Statistics, 1967.* Tourism Council, Ministry of Communication, Rep. of China.
(2) *China Yearbook, 1968-69.* China Publishing Co., Taipei, Taiwan.
(3) Tetter from Dr. Robert E.KUNTZ, Chairman, Dept. of Parasitology, Southwest Foundation for Research and Education, San Antonio, Texas. June 10, 1969.

(4) *Production Yearbook 1967.* Food and Agriculture Organization, The Monthly Bulletin of Statistics, U.N. as cited in *Food Production and Activities of Taiwan Provincial Food Bureau,1968.*
(5) *Red Data Book,* vol, 2, *Aves,* J.Vincent editor. International Union for Conservation of Nature and Natural Resources, Survival Service Commission, 1966.
(6) Research carried out by the Tunghai University Bird Banding Project (Biology Dept., Tunghai Univ., Taichung, Taiwan) was supported by the U.S. Army Research and Development Group (Far East), Department of the Army under Grant No.DA-CRD-AFE-S92-544-68-G130.
(7) Study carried out independently by the author.
(8) *Taiwan's Agricultural Development, Its Relevance for Developing Countries.* Foreign Agricultural Economic Report No. 39. U.S. Department of Agriculture Economic Research Service. April, 1968.
(9) Taiwan Provincial Institute of Family Planning, Taichung.
(10) *Taiwan Statistical Data Book, 1968* Council for International Economic Cooperation and Development. June 1968.
(11) Won, Ryong-Oh. Kyung Hee University. Seoul, Korea. In press.

SUMMARY

Taiwan's remarkable economic growth over the past twenty years has been largely due to the goverment's emphasis on agricultural development. Farmers today comprise the largest single block of the labor force, soil and water are their most important natural resources, and their agricultural produce is highly competitive on the international market. Birds are also being exploited as one of the island's natural resources through methods of hunting which bring sustained pressure upon avian populations. They are utilized as food, sold as mounted specimens, and traded alive on the international market. This harvesting is not being viewed or managed in the long-range interests of the avifauna or the people who benefit from birds. Nor have the potential recreational values of birds been realized as a source of economic income or as leisure-time relaxation. Yet wise utilization of birds and other wildlife *does* have the potential to compensate, in part at least, for the slackening in agricultural production as close-to-maximum yields are approached. And, with encouragement and support, Taiwan *does* have the capacity to develop a effective conservation effort with the same vitality and concern as shown in the already successful agricultural program.

RÉSUMÉ

L'essor économique remarquable de Formose au cours des 20 derniéres années est surtout dû â l'accent mis sur le développment de l'agriculture par le gouvernement. Actuellement, les fermiers constituent le groupe de travailleurs le plus important; l'eau et la-terre sont leurs principales ressources naturelles et leur production agricole est très compétitive sur le marché international. Les oiseaux aussi sont une des ressources naturelles de l'île et sont exploités comme telle par des méthodes de capture qui mettent une lourde pression sur les populations aviaires. Ils sont utilisés comme aliments, ou vendus sous forme de spécimens naturalisés ou encore vendus vivants sur le marché international. En fait, la chasse aux oiseaux ne tient pas compte, à longue échéance, de l'intérêt de la faune aviaire ou des gens qui en tirent profit. De même, on n'a pas compris que la valeur récréative possible des oiseaux pourrait constituer une source de revenue ou de détente. Et cependant, l'utilisation rationnelle des oiseaux et d'autres animaux *est capable de* compenser au moins partiellement, le ralentissement de la production agricole â measure qu'on approche d'un niveau de rendements presque maximum. En outre, soutenue et encouragée, Formose *est capable* de fournier un effort efficace dans le domaine de la conservation des oiseaux, avec le même vitalité et le même souci de réussite que celui dont elle a fait preuve dans la réalisation de son programme agricole.

Section C (2)

Ecological and Economic Effects of Birds of Prey in the Central Region of the European Part of the USSR

with special reference to the Index of Predatory Pressure' as a means for estimating these effects.

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For the last two decades ornithologists as well as experts in game management have devoted much attention to predatory birds. A great number of special studies have been carried out in many countries. The author's twelve-year (1956-67) study of ecological and economic effects of birds of prey in the Central Region of the European part of the USSR was among them.

These efforts have had not only scientific but also practical consequences which have been reflected in legislation: the official attitude to birds of prey in the majority of countries today is not so bad as it was 10-15 years ago. However, we cannot yet say that they are completely out of danger. Unfortunately, besides the grave threat of poisoning by pesticides, predatory birds are still from time to time exposed to attack by gamekeepers, farmers and hunters.

This state of affairs demands new and continuing efforts to analyse the ecological significance and economic importance of birds of prey under differing conditions. For such a controversial group of birds, we have always been convinced, not only from the point of view of their friends but also of that of the general public at large and even of their ill-wishers, of the vital importance of establishing the true facts.

INDEX OF PREDATORY PRESSURE

Our experience has shown that the data which are most convincing and acceptable to ornithologists as well as to the public, can be obtained by means of a combination of qualitative and quantitative analysis of the influence of predatory birds upon the populations of their victims.

As the main numerical basis for measuring the ecological and especially economic importance of birds of prey, an 'index of predatory pressure' (or more simply 'index of predation') was selected, representing the percentage of individuals taken by predators out of the total number of potential victims. Such an index would seem to give a fairly clear picture of the influence of predatory birds on the populations of their prey species and, in practice, has been found to provide an assessment of the part played by birds of prey which fully satisfied experts in game management. To establish the index of predation pressure (X_a^A) exercised by predatory species 'A' upon the population of prey species 'a' in any area, it is necessary to have the following data:

(1) The total number of predators of the species 'A' (or more often of breeding pairs including their broods), which inhabit the area under study (N^A);

(2) The average number of individuals of prey species 'a' which are taken by each predator 'A' (or more often fed to each brood of that predator) within a specified period (Pa): for the purposes of our particular study, this period usually coincided with the breeding season.

(3) The total number of individuals of the prey species 'a' inhabiting the study area (n_a).

If these data are available, the index of predation (X_a^A) for predator 'A' and prey 'a' can be readily calculated by the following formula:

$$X_a^A = \frac{N^A \times P_a^A}{n_a} \times 100\%$$

Although in our study we. concentrated on collecting as much reliable information as possible for the application of this formula, we also, in order to obtain a deeper and more detailed assessment of the qualitative aspect of predatory influence, collected data regarding age and sexual composition, and the proportion of normal and defective, healthy and sick, individuals in the prey species, both for the population as a whole and for the individuals actually taken by the predators.

METHODS OF THE STUDY

The basic method used in our investigation was to carry out a continuing study over 3-5 years of bird of prey activity within specified areas, which were known as 'stations'. Each station covered from between about 100 and 350 square kilometres.

A programme of this sort could obviously not be executed by one or two persons. So groups of 6-12 observers (usually members of students' zoological clubs) were organized to undertake the study at each station.

The estimate of the predatory population of each station was carried out by means of systematic inspection of the forests it contained. In the course of the investigation, all territories of birds of prey were mapped and every effort made to discover as many of the occupied nests as possible.

The quantitative and qualitative analysis of the food of predatory birds proved to be the hardest part of our investigation. For that purpose we built hides on trees close to occupied nests, from which a continuous watch was kept on an average of between one in five and one in eight of the total number of broods. These observations gave a great deal of reliable information on the composition and number of prey species taken by predatory birds during the breeding season and, by using special techniques, we obtained samples of each prey species brought to the nest, for careful laboratory examination.

Finally, in order to estimate the natural populations of the potential prey species, we followed generally recognized methods of assessing the numbers of voles, mice, birds, frogs and other species present in the area.

MAIN RESULTS OF THE STUDY

The most valuable data were collected at the Vladimir Station (210 sq. km including 152 sq. km of forests) and Oka Station (350 sq. km including 200 sq. km of forests). The former was situated within hunting grounds approximately 200 km to the north-east of Moscow and the latter included the Oka Reserve and its neighbourhood in Rjazan district (about 300 km south-east of Moscow). As was to be expected the number and variety of birds of prey within the protected area (Oka station) was more than that within the hunting area (Vladimir station).

On the Oka station, we counted an annual average of 90 breeding pairs of birds of prey (25. 7 pairs per 100 sq. km or 45. 0 pairs per 100 sq. km of forest) of 12 species (Table 1). The most common were black kite *Milvus migrans korschun* and common buzzard *Buteo buteo,* which formed about 60 per cent of the entire predatory population of the Oka station.

At the Vladimir station we found an annual average of 35 breeding pairs (16. 6 pairs per 100 sq. km or 23. 0 pairs per 100 sq. km) of 6 species (Table 1.) Common buzzard (again forming about 60 per cent of the total) was an absolute dominant among them.

These data and the counts made at other stations made it possible to calculate the approximate number of birds of prey inhabiting the central region of the European part

TABLE 1: NUMBER OF BREEDING PAIRS OF BERDS OF PREY WITHIN OKA (350 sq. km, INCLUDING 87 sq. km OF KEY AREA) AND VLADIMIR (210 sq. km) STATIONS, CENTRAL REGION OF EUROPEAN PART OF THE U.S.S.R.

	Oka station, 1956-1958				Vladimir Stn. 1963-1965		
	Number of pairs						
Predatory species	Within key area* in 1956	Within the whole station	per 100 sq. km	Percentage of total bird of prey pop.	Number of pairs	per 100 sq. km	Per-centage of total bird of prey pop,
Goshawk —*Accipiter gentilis*	1	2	0.6	2.2	2	0.9	5.7
Sparrow hawk —*Accipiter nisus*	—	4	1.1	4.4	4-6	1.9-2.9	15.2
Montagu's harrier —*Circus pygargus*	—	1	0.3	1.1	—	—	—
Black kite —*Milvus migrans korschun*	23—16	32-37	9.1-10.6	37.8	2-3	0.9-1.4	6.6
White-tailed eagle —*Haliaetus albicilla*	1	0-1	0-0.3	0-8	—	—	—
Spotted eagle —*Aquila clanga*	4	9	2.6	10.0	—	—	—
Common buzzard —*Buteo buteo*	4	17-22	4.8-6.3	21.1	17-23	8.1-11.0	57.2
Honey buzzard —*Pernis apivorus*	—	3.7	0.9-2.0	5.6	0-5	0-2.4	8.7
Short-toed eagle —*Circaetus ferox*	—	1	0.3	1.1	—	—	—
Osprey —*Pandion haliaetus*	—	1	0.3	1.1	—	—	—
Hobby —*Falco subbuteo*	—	6-8	1.7-2.3	7.8	—	—	—
Kestrel —*Falco tinnunculus*	—	3-11	0.9-3.1	7.0	1-4	0.5-1.9	6.6
Total	33—26	83-102	23.7-29.2	100.0	32-40	15.2-19.0	100.0

Note: *The column includes only those predators which feed on waterfowl and meadow-birds within key area.

of the USSR (about 270 thousand sq. km including about 120 thousand sq. km covered with forest) which embraces Moscow, Vladimir and parts of Rjazan, Gorky and some other districts. According to this estimate (Table 2) the total number within the Region is about 40, 000 breeding pairs. More than half belong to only two species: common buzzard (38 per cent) and black kite (about 18 per cent).

One preliminary conclusion, based on the ratio of certain species to the total bird of prey population, merits some discussion.

It is obvious that influence upon populations of prey species is more likely to be significant in the case of predators which are numerous or at least fairly common. One of the controversies in relation to the economic importance of predatory birds was the question

TABLE 2: THE NUMBER OF BIRDS OF PREY WITHIN THE CENTRAL REGION OF THE EUROPEAN PART OF THE USSR (ABOUT 270 THOUSAND sq. km INCLUDING ABOUT 120 THOUSAND sq. km OF FOREST)

Species	The number of breeding pairs			Percentage of total bird of prey population
	Within the whole region	Possible limits	Per 1000 sq.km	
Accipiter gentilis	1600	1200-2000	6	3.7
Accipiter nisus	3500	3000-5000	13	8.4
Circus cyaneus	1000	500-1500		2.3
Circus pygargus	800	500-1500	3	1.9
Circus aeruginosus	500	200-1000	2	1.2
Milvus migrans korschun	7500	6500-9000	28	17.7
Haliaetus albicilla	100	50-150	0.4	0.2
Aquila clanga	1400	1000-1500	5	3.3
Buteo buteo	16200	14000-20000	60	38.2
Pernis apivorus	3000	2000-4000	11	7.0
Pandion haliaetus	100	50-150	0.4	0.2
Falco subbuteo	2300	1800-3000	8	5.4,
Falco tinnunculus	3500	3000-5000	13	8.4
Falco vespertinus	400	200-600	1.6	0.9
Other (rare) species	500	200-600	2	1.2
Total	about 40000	35-55 thousand	156 (130-200)	100.0

of what prey is taken by species such as the buzzard and kite, which normally live on voles and mice, when there is a decline or, expecially, total absence of rodents. On the basis of conclusions drawn from past analysis of remains of food and pellets, some game-keepers had supposed that in years when voles and mice are scarce, this item in the diet of the rodent-eating birds of prey is replaced by birds, including the young of grouse, capercaillie and partridge.

Special attention was therefore paid to this question.

The long-term study of birds of prey at the Vladimir station happened to coincide with a complete (4 years) cycle in the fluctuation of rodent populations and therefore provided the opportunity for an analysis of food changes in birds of prey depending on the number of voles and mice available. In the peak period (1963) and at normal levels (1964, 1966) of vole *Microtus arvalis* numbers, the latter formed up to 80- 90% of the total food of the buzzard. But in the period when the vole population was at its lowest (1965), their place in the buzzard's diet was largely taken by frogs (as much as 70-80% of the food) and not by game-bird nestlings.

The increase of the latter in the buzzard's diet was quite insignificant and bore no comparison with the very marked increase in the number of frogs, moles, shrews, nestling thrushes and other items taken.

In the Oka, Kudma (Volga valley near Gorky) and other areas within the study region, there was some evidence of kites feeding, partly, on birds and their young, including ducks. At the first sight this seemed to suggest a threat to the duck population. However, a special examination of the ducks brought to the nest by kites definitely showed that as high a proportion as 80% could not really be considered as prey at all, but had been scavenged after being killed or wounded by hunters or hay-cutting machinery.

The only birds of prey in the study region which were in fact found to prey on waterfowl and gallinaceous birds at all regularly were the goshawk, marsh harrier, white-tailed eagle *Haliaetus albicilla* and, to a lesser degree, the spotted eagle *Aquila clanga.* But all of them were scarce or even very scarce and, therefore, had a minimal effect and in many places no effect at all.

Thus, in assessing the economic importance of birds of prey, our preliminary analysis of the facts discussed above clearly showed that, because of the character of their food or their rarity, none of the predatory birds of the region could be considered as an essential factor affecting game-bird populations. But in the long run such a conclusion would in our opinion be much more reliable if it can be firmly based on a calculation of the index of predatory pressure (IPP) exerted upon these populations.

Accordingly, special attention was paid to this point in a study designed to throw light on the relationship between birds of prey and the grouse Family, Tetraoinidae, which was launched at Vladimir station. The results (Table 3) show that the total index of predation upon gallinaceous species did not exceed 5-6 per cent of their total summer population on the station. The essential thing to note is that about 70 per cent of the total losses inflicted on Tetraonidae was caused by only two pairs of goshawks, while the ten times more numerous buzzard accounted for the other 30 per cent. The hazel hen *Tetrastes bonasia* suffered most from predatory birds (the total IPP reached 9 per cent); pressure

TABLE 3: INDEX OF PREDATORY PRESSURE (IPP) UPON GAME BIRD POPULATIONS AT VLADIMIR STATION (210 sq. km.) DURING SUMMER SEASON 1963-1965

Potential prey species	Total number of individuals (ad. + juv.) of game birds within station in June	IPP, i.e. percentage of individuals taken by *predators* out of the total number of game birds in June-July.		
		IPP by Common Buzzard *Buteo buteo;* 17-23 pairs	IPP by Goshawk *Accipiter gentilis* 2 pairs	Total IPP
Hazel Hen *Tetrastes bonasia*				
1963	1400	0.4	5.0	5.4
1964	1400	1.6	5.2	6.9
1965	1200	4.8	4.2	9.0
Black Grouse *Lyrurus tetrix*				
1963	1000	—	2.1	2.1
1964	1100	2.1	1.6	3.7
1965	1200	—	1.7	1.7
Capercaillie *Tetrao urogallus*				
1963	600	—	1.8	1.8
1964	500	—	2.0	2.0
1965	500	—	1.4	1.4
Other Galliformes, including unidentified spp.				
1963	3000	0.7	4.3	4.9
1964	3000	1.9	4.5	6.4
1965	2900	2.3	3.7	6.0

TABLE 4: INDEX OF PREDATORY PRESSURE (IPP) ON POPULATIONS OF WATERFOWL AND MEADOW-BIRDS IN THE KEY AREA (87 sq. km) OF OKA STATION, SUMMER, 1956

Potential prey species	Total number of individuals (ad+juv.)of gamebirds within key area in June	IPP, i.e. percentage of individuals taken by five predators out of the total number of gamebirds from 1 June to 10 August 1956					
		Kite *Milvus migrans korschun* 23 — 16 pairs*	Spotted Eagle *Aquila clanga* 4 pairs	White-tailed Eagle *Haliaetus albicilla* 1 pair	Goshawk *Accipiter gentilis* 1 pair	Common Buzzard *Buteo buteo* 4 pairs	Total IPP
Ducks (Anatinae)	1700	5.5	4.1	1.0	1.5	—	12.1
Common Quail *Coturnix cotumix*	2100	1.8	—	—	—	—	1.8
Corncrake *Crex crex*	8500	0.8	0.3	0.1	—	0.3	1.5

* 7 pairs of black kite lost their broods and left the key area during the period of study.

upon black grouse *Lyrurus tetrix* and Capercaillie *Tetrao urogallus* was much less: 2-3 per cent. Goshawk pressure was rather steady during the period of the study, but that exerted by buzzards tended to fluctuate in inverse proportion to the abundance of rodents. It was highest when voles almost completely disappeared (1965), lower when the number of voles was on the decline (1964) and lowest of all during the peak of rodent population (1963). In any case, however, the buzzard's summer season impact on Tetraonidae populations, which never even reached 3 per cent take-off in any of the three years of observation, could for all practical purposes be discounted. Further observations made during the autumn season moreover suggested an obvious preference for birds which had been already wounded by hunters.

The pressure on ducks by all birds of prey within the key area (87 sq. km) of the Oka station of which a special study was made (Table 4), was rather higher. Here the IPP slightly exceeded 10 per cent, due primarily to the greater number of birds of prey supported by the Oka Reserve, particularly black kites and spotted eagles.

In comparison, the pressure of these predators on other gamebird species of the meadowland was insignificant. Despite the relatively high IPP for ducks, it is pertinent to add that the duck population in the neighbourhood of the Reserve was slowly but surely growing, thanks mainly to the strict enforcement of hunting regulations but also to some measures taken to reduce disturbance factors during the breeding season.

It is appropriate at this point to emphasize the necessity for an overall approach in estimating the economic importance of any animal. This principle is fairly widely recognized, but unfortunately quite often seems to be forgotten when it comes to evaluating birds of prey. Yet when due account is taken of their impact on harmful rodents, we found for example that each brood of our most abundant species, i.e. the common buzzard, saved roughly about half a ton of grain by devouring hundreds of voles and mice per season. On the other hand, during the special study at the Vladimir station we found that the entire population of predatory birds accounted for the death of not more than about five dozen nestlings of gallinaceous game-bird. In short, in this case, a balance would have to be cast between, on the negative side, the destruction of not more than a dozen* game birds which might otherwise have been bagged by hunters and, on the positive side, the saving of more than a dozen tons of grain brought about by the destruction of rodents.

The conclusion reached, therefore, in estimating the economic importance of birds of prey within the study region was quite clear, namely that they do practically no harm to game species and at the same time are appreciably useful from an agricultural point of view. On this basis, birds of prey as a whole undoubtedly deserve complete protection everywhere. The comparatively few exceptions to this rule can only apply to specific species under specific conditions, e.g. some hawks in the vicinity of poultry farms or pheasant and partridge rearing-pens and, very occasionally, within specialized hunting areas under intensive game management. Even in these cases, however, a strictly limited control, usually confined to the trapping of actually harmful individuals, is all that needs to be permitted. As for casual attempts at control of so-called 'harmful' predators by hunters at large and even game-keepers, our experience shows they are hardly ever likely to be successful, because of the difficulties of identification (e.g. distinguishing between the Marsh and other harriers) or of coping selectively with such rare and wary species as the goshawk.

THE PRESENT STATUS OF BIRDS OF PREY IN THE USSR

Intensive studies of birds of prey in various parts of the USSR, including the investigations outlined in this paper, have promoted a better understanding of their natural and economic importance. The official attitude towards them has undergone a marked change.

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* On general game management principles hunters may be expected to take off about 25% of the population of gallinaceous game-birds during the autumn shooting season. But the proportion of the young game birds killed by birds of prey, which can be considered as a potential part of the hunters' bag, is of course greatly reduced by the losses inflicted on these juveniles by natural factors such as bad weather, food shortage and disease.

The full case was presented by a special All-Union Public Committee on Birds of Prey headed by Prof. S. P. Naumov, with Dr. Rykovsky and the present author appointed as Deputy Chairmen. It led directly to the issue in 1964 of a new directive, with supporting regulations. This declared that, in general, birds of prey should be classed as useful species and that, in view of this, wholesale measures for their control must be terminated everywhere and a total ban placed on bounty payments for killing birds of prey of any kind. Strictly limited control measures were permitted only in respect of the goshawk and marsh harrier, within the hunting season and where game is specially managed. Thus, the problem of protecting birds of prey has now been duly resolved in the USSR and the new legislation has undoubtedly been a great success. In order to consolidate the position, the main effort is now directed to obtaining additional data to cover varying conditions and situations and to constant and patient exposition of the real ecological and economic effects of birds of prey to hunters and the general public.

SUMMARY

The results of a twelve-year (1956-1967) study of birds of prey in the central part of the European region of the USSR (some 270, 000 km^2) are reviewed. Their main feature was an attempt to evaluate the precise influence of these birds, by calculations based on an 'index of predatory pressure' (IPP), namely the percentage of the population of particular prey species killed by birds of prey in a given area during a given period of time (for the purposes of this study the latter being the duration of the breeding season).

In the whole region there are about 160 breeding pairs of birds of prey per 1000 km^2, mostly common buzzard *B. buteo* (38%), and black kite *Milvus migrans* (18%); the two allegedly 'harmful' species, marsh harrier *Circus aeruginosus* and goshawk *Accipiter gentilis*, comprised together less than 5%. It was found that the IPP (exercised largely by buzzard and goshawk) on the grouse family (Tetraonidae) in a 210 km^2 special study area at Vladimir amounted to 5-6%. In the key section of 87 km^2 in the Oka and Oka Reserve study area, the IPP on ducks, exercised largely by black kite and spotted eagle *Aquila clanga*, amounted to about 10%, but the duck population was still steadily increasing.

The damage to hunting interests represented by this level of predation (some 60 young Tetraonidae were killed in the Vladimir study area, for example) is far off-set by beneficial effects such as the saving of an estimated 12 tons of grain which would otherwise have been eaten by the thousands of voles and mice which the birds of prey killed in this area.

This and similar studies elsewhere in the Soviet Union led directly to the promulgation in 1964 of effective regulations for the protection of birds of prey.

RÉSUMÉ

Les résultats d'une étude sur douze années (1956-1967) des oiseaux de proie dans la partie centrale de l'URSS (quelques 270, 000 km^2) se trouvent examinés. Leur trait principal était un essai d'évaluer l'influence précise de ces oiseaux par des calculs basés sur un index de pression prédatoire (IPP), c'est à dire le pourcentage de la population d'espèces prédatoires particulières tué par des oiseaux de proie dans un terrain déterminé pendant une période de temps délimitée (en ce qui concerne cette étude cette période est la durée de couvaison).

Dans la région entière il y a environ 160 couples nidifiants d'oiseaix rapaces par 1000 km^2, pour la plupart la buse *B. buteo* (38%) et le milan noir *Milvus migrans* (18%); les deux espèces passant pour nuisibles—le busard des roseaux *Circus aeruginosus* et l'autour *Accipiter gentilis* représentaient ensemble moins de 5%. On constata que l'IPP (practiqué en grande mesure par le busard des roseaux et l'autour) sur la famille des tétras (Tetraonidae) dans un terrain d'étude spéciale de 210 km^2 à Vladimir revenait à un 5-6%. Dans la section-clé de 87 km^2 dans le terrain de recherches Oka et Oka réserve, l'IPP sur les canards (pratiqué par les milans noirs et l'aigle criard *Aquila clanga* revenait à 10% environ, mais la population des canards s'augmetait continuellement.

Le dommage causé aux intérêts de chasse représentés par le niveau de prédation (par example, une soixantaine de jeunes Tetraonidae se trouvait tués dans le terrain de recherches de Vladimir) se trouve compensé, et de beaucoup, par des effets bénéfiques tels que le sauvetage d'une douzaine de tonnes (estimées) de grain qui autrement auraient été dévorées par les milliers de campagnols et de souris que tuaient dans ce terrain les oiseaux rapaces.

Celle-ci et d'autres études semblables dans l'Union soviétique conduisirent comme résultat direct à la promulgation en 1964 de lois effectives pour la protection des oiseaux de proie.

Section C (2)

Birds in India's Agricultural Economy

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Of all the non-insect agricultural pests in India there is none more serious and destructive than rats. Field rats take heavy toll of cereal grains at all stages from sowing to harvest, and thereafter the ravages are taken over by their urban brethren in storage godowns. The overall loss in food grains attributed to rats is well over 10% of the country's total food production, and in certain areas it is truly staggering. It would undoubtedly be higher still, aided and abetted by the Insects, and make agriculture well nigh impossible but for natural checks on their numbers of which one of the most important and continuous is Birds—the insectivorous species, the diurnal Birds of Prey and the Owls. Continuous natural checks are far more telling in the long run than *ad hoc* measures, however drastic, in times of 'peak cycles'.

Some years ago a special agricultural officer was detailed to study the Sind Mole Rat *(Gunomys sindicus)* with a view to devising control measures against the colossal devastation it was causing in the rice-growing tracts of the Indus Delta in Lower Sind, estimated at between 10% and 50% of the entire crop. The report of the investigation published in the *Journal of the Bombay Natural History Society* (Wagle, P. V., 1927, 330-38) is a revealing document. It shows that the Sind Mole Rat breeds throughout the year, the number of young in a normal litter being 5 to 10. In October and November, however, the litters are particularly large, ranging from 14 to 18 young. The rats when full grown weigh about 8 ounces each and are therefore capable of doing considerable damage individually. They are mostly nocturnal, only occasionally moving about above ground during daytime. While they attack bajri and wheat to a limited extent, the greatest damage is done to rice. In 1925 and thereabouts, even with paddy selling at the now almost incredibly low price of 25 lbs per rupee, the damage in the Indus Delta alone was estimated to be of the order of 23 lakh rupees per annum—this in a 'normal' rat year, and of course considerably more during the cyclical 'rat plagues'. Elsewhere[1] it has been reliably computed that a single pair of rats having 6 litters of 8 young annually and breeding when 3½ months old, with equal sexes and no deaths, would increase at the end of the year to 880 rats. This figure is of course purely hypothetical and the requisite conditions are happily never likely to be attained in nature, but it is based on conservative estimates and is not extravagant as regards the reproduction potential of this fecund group of rodents. Mice are perhaps even more productive. These vital statistics are here introduced merely as a background for a realistic assessment of the magnitude of the services rendered by the Birds of Prey and Owls in containing the burgeoning rodent populations. Many of our larger owls such as the horned or eagle owl *Bubo bubo,* the brown fish owl *Bubo zeylonensis* and the wood owls of the genus *Strix,* subsist predominantly on a diet of rats and mice—both the field species and those that have become parasitical on man in urban areas. In the stomachs of the larger owls I have frequently found the remains of 2 or 3 rats or mice a piece, and as digestion in birds is a rapid and continuing process it is not unlikely that a larger number is destroyed in the course of the night's hunting. Even only two rats a night taken by a single owl would in effect mean the suppression of a potential increase of 880 rats per year, and when it is realized that the birds are engaged in the good work night after night from year's end to year's end, their role as benefactors can be seen in better perspective. The smaller owls and diurnal birds of prey such as the shikra, kestrel and white-eyed buzzard also take regular toll of the rat and mouse population everywhere, in addition to locusts, grasshoppers and a host of other insect pests.

Unfortunately the beneficial role of owls and diurnal birds of prey in our agricultural economy is little recognized or appreciated. To the ordinary countryman owls are just birds of ill omen, and this added to the trifling damage the two classes may occasionally

[1] Hinton, M.A.C., 1920, 'Rats and Mice as Enemies of mankind'. Brit. Mus. (Nat. Hist.) Economic Series 8. London

do to poultry is enough to brand them as undesirable and enemies of the farmer to be destroyed or discouraged in every possible way. In the game laws of even the more progressive states of the Indian Union owls and the birds of prey are classed as vermin and enjoy no protection at any time of the year whether breeding or not. In spite of this bias, however, there has luckily never been an organized *jehad* against them, as in many western countries where pheasants and other game birds are artificially raised for sport at great expense and mistakenly believed to be receiving crucial protection by the slaughter of all possible potential predators. However, with a more scientific study of the ecology, food and feeding habits of owls and the birds of prey and a realization of their value as destroyers of rodent pests a more enlightened attitude of game-keepers is coming about. In India as a whole the lack of statutory protection to raptors and owls has not resulted in any appreciable decrease in their numbers, largely because the man with the gun seldom considers them worth his precious powder and shot. The chief danger to them now lies in the increasing, free and indiscriminate sale and use of chemical pesticides by all and sundry which, if not strictly regulated, will bring about the same sorry state of affairs as in many European countries and the U.S.A. and create conditions from which depleted raptor populations may find it difficult to recover. It is well that the Government of India is alive to the problem of harmful pesticides, and suitable legislation is on the way.

Second to rodents as the most destructive non-insect agricultural crop pests in India come the parakeets—especially the rose-ringed species *Psittacula krameri*— which can be classed as wholly harmful. Their diet at all stages, from hatching to adulthood, consists entirely of grain and fruit, of which they destroy far more than they actually consume. They possess no redeeming virtues from the economic point of view, and in the absence of any natural enemies to keep their numbers in check, their legions flourish exceedingly and batten on the cultivator everywhere.

Along with the parakeets, perhaps the most destructive bird pests of cereal crops in India, especially of paddy in the rice producing areas of the country, are the weaver birds (family Ploceidae), the most widely distributed and abundant species of which is the Baya Weaver *Ploceus philippinus.* Recent feeding experiments with captive bayas have shown that an adult bird weighing 20 g on the average will consume about 3 g of unhusked paddy per day—a quantity equal to about 15% of its own body weight; under natural free-flying conditions the intake is probably higher. In rice-growing areas, and in season, paddy forms the food of adult bayas almost exclusively, supplemented sometimes by a small quantity of weed-seeds and the like. Allowance must also be made for the extra weight of the paddy husk when comparing the birds' food with the huskless rice eaten by humans. Therefore, somewhat arbitrarily, we will assume that a single baya eats only 2 g of rice per day.

In Kerala, which is a predominantly rice-eating region, the quantum of rice under the statutory food rationing scheme is 2 kg per person per month (in addition to wheat etc.), or about 66 g of rice per day. This means that 33 bayas could run through an adult Keralite's entire daily rice ration in the same time! No attempt has ever been made to estimate the baya population in a rice-growing area, even by a rough and ready count, but in the season of paddy ripening it must certainly run into several thousand birds per hectare, which gives an indication of the enormity of the economic loss they must cause to the cultivator. The ravages to the paddy crops are by no means confined to the baya; parakeets, house sparrows and munias add to the cultivator's losses and in winter swarms of buntings, especially the blackheaded and the redheaded species, help to intensify them.

House sparrows *Passer domesticus* are just as destructive to cereal crops; in the winter months their numbers get vastly augmented by migrant extralimital races from the north —*parkini* from Kashmir and *bactrianus* from Turkestan—and Spanish sparrows of the eastern race *P. hispaniolensis transcaspicus.* That at least a portion of these hordes are derived from Russian Turkestan was recently proved by some of the birds ringed in Rajasthan by the Bombay Natural History Society being recovered on their breeding grounds in Kazakhstan from amongst 2 million odd sparrows destroyed by poison in the Alma Ata region in an officially organized campaign against the pests. The dense swarms of weaver birds and sparrows that raid the standing fields of cereals such as rice, wheat and jowar *(Sorghum)* defy estimation; the birds descend on the standing crops like armies of locusts and cause the heaviest damage just when the grain is forming and 'in milk', but

the depredations continue throughout all the stages of the crop. The frantic yells of the cultivator from his mid-field machan all day long only serve to move the rapacious hordes from one corner of his fields to another.

Under natural conditions, untampered with by man, weaver birds subsist mainly on grass and weed seeds. They live in moderate sized flocks and move about the countryside in quest of food. Their populations are regulated and kept within reasonable bounds by the limited food supply and natural enemies. With the increasing practice of intensive monoculture of cereals man has upset the balance of nature and unwittingly invited a concentration of pests, both insect and non-insect. Freed from natural checks the birds have increased and multiplied to pest proportions. Large scale uniform cultivation of cereals, by creating an artificial abundance of food has also fostered an inordinate increase in insect numbers. Insects are as notorious for their fecundity as for their voracity Locusts are proverbial in this respect; they will devastate hundreds of acres in a matter of hours, reducing smiling green fields to a desert of bare stalks.

It is undeniable that next to parakeets the sparrow tribe is responsible for some of the most serious damage to cereal crops in India. In some localities the damage they do is so heavy that the cultivator finds it hardly worth while to harvest what the birds have left behind. The populations of sparrows and weavers need drastic reduction, but perhaps total extermination is not the answer as the Chinese discovered to their cost a few years ago. From all accounts their excessive zeal in the destruction of sparrows produced a boomerang in the shape of redoubled onslaughts by insect hordes released from effective control by birds and only helped to worsen the situation. For it must be realized that while the staple food of the Ploceidae in their adult stage is grain and seeds, which in cultivated areas may consist entirely of cereals, their young are fed throughout the nestling period almost exclusively on caterpillars and soft-bodied insects which comprise some of our most injurious crop pests. The birds usually have two broods every year, of 2 to 4 young each, and the insects to feed the nestlings and partly themselves at this period are often collected in the very fields where their own depredations are committed. By preying upon the insects the birds redeem themselves, at least in part, and from being destroyers often become protectors of the crops, the grain they consume being no more than legitimate hire for the services they render. It is thus that the activities of most granivorous birds are markedly double-sided. They may be overwhelmingly harmful at certain seasons, in certain localities and under certain weather conditions, and overwhelmingly beneficial at other times. Lack of observation, or faulty observation, of the food and feeding habits of birds, sometimes confined to only a part of the annual cycle, is often responsible for equally faulty verdicts on their usefulness or harmfulness to agriculture and forestry. The true economic status of a species can only be determined by a protracted ecological study covering its complete life history—food and feeding habits, breeding Biology and population dynamics. The need for this sort of research is of special relevance in a country like India which has to lean so heavily on her agriculture and forests and is continuingly bedevilled by the ever-rising spiral of population growth and lagging food production. It is only after such a thorough-going investigation that any drastic steps would be justified for meddling with animal populations. Short-cuts have ever proved unwise.

Hitherto the only attempt at a scientific assessment of the food of birds in India, chiefly from an agricultural point of a view, was made in Bihar in the first decade of the present century by C.W. Mason and H.Maxwell-Lefroy. The report of their investigations, published as a Memoir of the Department of Agriculture in India (Vol. 3, Entomological Series, January 1912), is a valuable document. Unfortunately it has been out of print for many years and copies are not easily procurable. Stomach contents of 15 Orders and 40 Families of Passerine and Non-Passerine birds of an intensively cultivated agricultural area were analysed, particularly for the identification of the insect food, and, on that basis, an assessment of the birds as harmful or beneficial to agriculture, or of neutral status, was made. The conclusions were bound to be somewhat one-sided since the investigations largely ignored the other components of the birds' diet and other aspects of the food and feeding habits of many species, such as the different nature of the food brought to the nestlings and eaten by the adults themselves during the breeding season. The accent throughout the investigations was naturally on agricultural economy, and the findings took little account of the various indirect ways in which birds can be beneficial or harmful to other human interests such as forestry, animal husbandry and public health.

Some aspects of the importance of birds to India's forests, and to vegetation in general, are not sufficiently known or appreciated: for example their role in the fertilization of flowers and dispersal of seeds of numerous plant species, economically beneficial or the contrary. Specially adapted nectar-eaters, e.g. Sunbirds and Chloropses, do important service by cross-pollinating many of the flowers they visit in quest of their food. Our experiments have proved, for instance, that the flowers of the Silk Cotton Tree *Salmalia malabarica* (which largely supplies the wood for the manufacture in India of safety matches) are chiefly pollinated by birds—the regular necta-eaters as well as many other non-specialised species. Bunches of flowers were covered over with coarse-meshed wire-netting which permitted access to the usual insect visitors but excluded the usual birds. The result was that whereas the uncontrolled flowers set seed in the normal way, those from which bird contact was withheld withered and dropped off, with very few exceptions due to the fact that, not being adapted exclusively for ornithophily, some of the blossoms were apparently fertilized by visiting insects. Again, the flourishing sports goods industry in Punjab, based mainly on the wood of the mulberry, *Monts* spp., owes much to the seed-dispersing activities of bulbuls and other frugivorous birds which feed on the ripe berries and broadcast the undigested seeds in their droppings. On the other hand, a case in which pollination by birds is adverse to human interests is that of the harmful mistletoe family of plant parasites, Loranthaceae, which cause serious damage to mango trees in orchards and to teak trees in forest plantations and which are largely-some species wholly—dependant on flower-birds for cross-pollination, and on frugivorous birds for seed dispersal. Their flowers are of what is known as the explosive type: in *Loranthus longiflorus*, the commonest species in the Bombay area, the buds are in shape and size exact sheaths for a sunbird's bill, but, even when fully mature, remain tightly closed until pressure is exerted on the tumescent apex by a visiting bird's bill; on a gentle squeeze from the bill-tip the bud suddenly springs open, permitting the bird to insert its bill into the corolla for the nectar. The essential organs of the flower are so placed that in the process they come in contact with the sunbird's throat and forehead feathers. The pollen that adheres to them is carried to the next flower and gets dusted on to the style which overtops the anthers. Experiments preventing access of the regular pollinators—sunbirds, white-eyes and chloropses—to the mature buds showed that the buds shrivelled up and dropped without opening, whereas their uncovered neighbours set fruit in the normal course.

From all this it is obvious and again worth emphasizing that what is essential in order to determine the true status of birds in India and their role in our national economy—agriculture, forest and public health—is comprehensive life history studies of the individual species involved—their ecology, food and feeding habits, migrations and local movements, and their population structure and dynamics. Analysis of stomach contents, though of great value in indicating the food trends, is by itself no enough. It must be supplemented by other analytical techniques and above all by a careful field study of feeding habits to provide the complete picture. In regard to insect food, for instance, many parts such as the wings of moths are discarded before the insect is eaten or fed to the young; therefore they will practically never be found among the stomach contents. Soft parts of insects soon disintegrate making the species of prey unidentifiable except by clues fortuitously provided by hard remains such as elytra of beetles or heads of moths.

Finally, birds have long been suspected, or actually incriminated, in the dissemination of arthropod-borne viruses causing epidemics sometimes fatal to man and his livestock. For example, the incidence and spread of foot-and-mouth disease of cattle in England has sometimes been circumstantially attributed to migratory starlings from the Continent. Or again, the Kyasanur Forest Disease (KFD) of Mysore, caused by a virus practically indistinguishable from that of the Russian Spring-Summer Fever (RSS), is suspected to have reached India from its West-Siberian focus through the agency of migratory birds. With the sponsorship of the Smithsonian Institution, Washington, and other international organizations, investigations are under way by the Bombay Natural History Society on this aspect of Indian bird migration.

Directly or indirectly, beneficially or otherwise, birds affect almost every branch of human industry in India. While their impact is not always obvious or profitable from the economic point of view, there is no doubt that by and large the balance is in their favour; and if aesthetic and cultural considerations are also taken into account, it must be considered overwhelmingly so. Indeed, it has been well said that but for the trees the insects

would perish, but for the insects the birds would perish, but for the birds the trees would perish, and but for the trees the world would perish. If objectively examined from all angles there is little extravagance in this statement: what scanty data we possess in India clearly support its truth.

SUMMARY

Rodents and, particularly, the rats, including species of quite limited distribution such as *Gunomys sindicus*, are rightly regarded as one of the major agricultural pests in India, as elsewhere. Examples are given of the havoc they are known to cause. Equally deserving of recognition is the part played by birds of prey in controlling rodent numbers: a single owl may account for the whole of the potential annual rate of increase of a pair of rats. Unfortunately, this is not in fact recognised in India, where raptorial birds are still not adequately protected.

On the other side of the balance-sheet grain-eating birds do extensive damage to crops and the author can find no mitigating factors in the case of *Psittacula krameri* and other parakeets, which are so widespread and common in India. But with the weaver-bird and sparrow families the situation is different, since, during the breeding season the adults feed both themselves and their young on insects, many of which are injurious to agriculture; so that the over-all balance may well be in the birds' favour and certainly always merits detailed ecological study before any particular species is treated as a pest.

Some other considerations affecting the economic status of birds are reviewed, such as the part they play in the cross-pollination of trees and the distribution of undigested seeds. This may be favourable to human interests, as in the case of trees such as the silk-cotton tree *Salmalia malabarica*, the main source of match-wood, and the mulberry *Morus*, or unfavourable, as in the case of the mistletoe family Loranthaceae. Brief reference is also made to the possible dissemination of viruses by birds, which is at present under active study.

The conclusion is drawn that, although much more research is needed, there is already little doubt that birds do more good than harm to India's agricultural economy.

RÉSUMÉ

Avec justice on considère les rongeurs et, surtout, les rats—y compris les espèces de distribution assez limitée telles que *Gunomys sindicua*—comme un des fléaux majeurs de l'agriculture, aux Indes comme ailleurs. Des exemples se trouvent cités du dommage que l'on sait qu'ils occasionnent. Également digne de considération est le rôle d'oiseaux de prois en limitant la population de rongeurs: un seul hibou peut bien annihiler la totalité du taux potentiel par an d'augmentation d'une couple de rats. Malheureusement on ne reconnaît point ce fait aux Indes où les rapaces ne reçoivent pas encore une protection adéquate.

De l'autre côté du bilan les oiseaux mangeurs de grain font aussi du dommage extensif aux récoltes et l'auteur ne peut trouver aucun élément atténuant dans le cas de *Psittacula krameri* ni dans celui d'autres perruches si largement répandues et si communes aux Indes. Chez les familles, cependant, du tisserin et du moineau, la situation est différente puisque, dans la saison de réproduction, les oiseaux adultes se nourrissent et eux-mêmes et leurs petits sur des insectes, beaucoup desquels sont nuisibles à l'agriculture, de sorte que le bilan somme toute peut bien être en faveur des oiseaux et mérite certainement toujours une étude écologique détaillée avant de traiter comme un fléau n'importe quelle espèce particulière.

Certaines autres considérations portant sur la condition économique des oiseaix se trouvent examinées, telles que leur rôle dans la pollination croisée d'arbres et la distribution de graines non digérées. Celle-ci peut bien être favorable aux intérêts humains, comme quand il s'agit d'arbres tels que le bombax *Salmalia malabarica*, origine principale du bois d'alumettes, et la mûrier *Morus*, ou défavorable comme dans le cas de la

famille du gui, Loranthaceae. On fait aussi une référence courte à la dissemination possible de virus par des oiseaux actuellement l'objet d'une étude active.

On tire la conclusion que quoiqu'on ait besoin de beaucoup plus de recherches, il y a déjà peu de doute que les oiseaux font plus de bien que de mal à l'économie agriculturale des Indes.

SECTION C: SOME ASPECTS OF WILDLIFE UTILIZATION AND MANAGEMENT

(3) WITH REFERENCE TO THE ROLE OF ZOOS

Chairman: C.R. Gutermuth

The Zoo in Asia: Its Importance to Conservation

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The wildlife of Asia, so varied in species and once so abundant in numbers, is one of the continent's most valuable natural resources. But it is a resource that has been squandered, destroyed for food, for fuel, for timber, for sport, and to make way for the demands of civilization. The result of this uncontrolled, unplanned destruction is that what was once one of Asia's richest assets is now in danger of being exploited out of existence.

Wildlife does not mean only wild animals but also the wild plants and their habitats: the forests, savannah, deserts, marshes, mountains and other wilderness places upon which the indigenous fauna and flora depend for their continued existence. The disappearance of wildlife means the removal of a potential source of food in a hungry continent, of a potential source of tourist revenue in a continent seeking to increase its income, and of a potential source of pleasure and recreation for future generations. At the same time destruction of forest habitat jeopardizes the stability of the continent's microclimates. It is now realised that the microclimate of an area, and particularly its rainfall, is often related to the existence of large tracts of forest. If this is cut down, then a much drier, drought climate often results. A further hazard of uncontrolled habitat destruction is the danger of erosion, which undermines the landscape, agricultural development and even the cities themselves. This danger is specially acute in the tropics where the thin topsoils are especially vulnerable to erosion. Conservation, then, is not only the preservation of a few particularly striking animal species, but the conservation of the continent, of the land itself. The underdeveloped countries of Asia are still primarily agricultural economies closely dependent on existing patterns of rainfall. Any disturbance of the continent's microclimates can only be viewed with serious alarm.

However, the idea of wildlife as an important economic and cultural resource is a relatively new and sophisticated concept and one which most people are unaware of or find hard to understand. Traditionally, wild animals and their habitats, if they have been considered at all, have been regarded as an expendable, limitless resource. Few imagined that one day the forests and savannah, the teeming herds of antelope, the magnificent wild cattle, the elephants, the marauding tigers and leopards, and all the other wild animal species, many unique to Asia, might disappear. Another attitude militating against conservation is that in underdeveloped areas where wild animals are common they have been a substantial source of food, while in places where there are dangerous or marauding species, such as the large carnivores, ungulates and elephants, they can be a very real threat to human existence and are consequently much feared. People who have always used wild animals for food and who often regard them with dislike, find it difficult to understand the concept of wildlife conservation when traditionally their lives have been dominated by wildlife destruction.

If the wildlife of Asia is to continue to exist, then these attitudes must be radically changed. On the one hand the governments, the planners, the economists, the architects, the people living in cities, must be made to realise that the wildlife of their continent is a unique, precious natural resource, desperately endangered. And on the other hand the peasants who have to live with the wild animals must be persuaded that they are not to be feared and killed to extinction, but conserved to provide a permanent source of revenue, either from tourism or from game cropping.

In this situation the most urgent immediate problem is conservation education. It is here that the zoos of Asia have such a significant part to play in saving the continent's wildlife: of all existing institutions they have a greater opportunity and a correspondingly great responsibility to educate the public about the importance of wildlife and its conservation. And it is only if the public *can* be educated, at all levels, that it will be possible to save at least some of the continent's animals and habitats for posterity. It is above all through the zoos of Asia that the cause of conservation can best be publicised, for they are already in contact with a public of millions, who must have at least some interest in wild animals or they would not be visiting the zoo. There are other important functions of zoos in Asia, such as providing a means of popular recreation, attracting foreign tourists, undertaking research into the animals in their care, and breeding rare species; and I will refer to these later on in this paper. They are, however, of secondary importance when compared with the educational role of the zoo, for it is on the education of the public that the continued existence of wildlife (and ultimately of the zoo itself) will depend.

The continent, particularly the Indian subcontinent, is already rich in zoos. There is a long history of exhibiting animals in captivity: some of the world's earliest zoos were the menageries of the maharajas and ruling princes. This tradition was further encouraged during the British colonial era when many famous state and municipal zoos were founded in the Indian subcontinent. More recently throughout Asia, as has happened in the rest of the world, many new zoos have been started, while old ones are being renovated and expanded. There are zoos in most of the large cities of Asia. All that is needed is for zoo staff to realise the vital part they must play in wildlife conservation, and in particular to realise the practical measures they should take. In this context it might be useful if the proceedings of this particular session of the congress could be distributed to all Asian zoos listed in the *International Zoo Yearbook.*

The first basic necessity is for the zoos to realise the importance of education. The ordinary visitor to the zoo, the man who is not necessarily interested in wild animals, except as strange creatures to wonder and jeer at, must leave the zoo at the end of his visit with a changed attitude. Somehow he must be convinced that wild animals are more than fairground freaks—that they are beautiful, fascinating and important to his life. He must be made to relate himself to them. His interest must be aroused.

How then can this be done ? The first fundamental requirement is for the animals to be exhibited as sympathetically as possible. The traditional heavy-barred, cramped, cement enclosures must be removed, for when exhibited in these conditions most animals are reduced to obese inertia, or apparently frenzied stereotyped activity—and hardly surprisingly are regarded as objects of fear or derision by the uneducated. Instead of these cement and iron cages, they should wherever possible be kept in open landscaped enclosures that are designed to suit their physical and behavioural requirements, enabling them to be active in a natural manner. How much more interesting and entertaining it is to watch, for instance a group of monkeys living in trees or on a rocky island, than one or two solitary specimens, morosely begging from the public through the bars of a cage. Similarly, tigers, small cats, deer, buffalo, antelope and many others are all seen to greater advantage in spacious, naturalistic enclosures, planted with shrubs and trees. At once, in these conditions, where the animals appear to be living their own lives, or at least an approximation of their life in the wild—mating, nesting, brooding, suckling their young, playing, squabbling among themselves, grooming each other, wallowing in the water, basking in the sun, browsing on leaves and grass, gnawing bones—they attact the attention and consideration of the visitors. Here is a creature, alive and meaningful. What is it doing ? Why is it behaving in this way ? Where does it live in the wild ? Is it dangerous to man? These and many other questions will immediately come to the visitor's mind.

It is at this point, when the visitor has become *aware* of the animal before him, interested and concerned, that the zoo can play a more formal educational role—by providing answers to the visitor's unspoken questions, by extending his interest, by guiding his thoughts towards conservation and towards regarding wild animals as an important, intrinsic part of life—*his* life. By using many of the display techniques developed in modern museums, interest can be aroused and information conveyed, using large simple display panels, beside the exhibits, featuring diagrams, drawings, photographs, short eye-catching slogans and more detailed information. In each case a particular theme should be emphasized, such as the animal's use to agriculture, its potential value as a source of food if its numbers in the wild are maintained and regulated, its dependence on a particular

habitat, its historical, religious or legendary significance, its special physical and behavioural characteristics—and above all the need for conservation. Gradually, from the idea of protecting a single species, the visitor can be introduced to the concept of wildlife and habitat conservation in general. In addition, each enclosure should be provided with labels listing the animals it contains, and the areas where they live in the wild. Simple plans or guidebooks to the zoo should be available and at least some information should be provided in an 'international' language, such as English, if the zoo is to be successful as a tourist attraction.

In addition to the informal education of its visitors by making them interested in animals they see in the zoo, every zoo should also try to develop its formal educational activities. It should stimulate the local education authorities to undertake joint educational schemes with the zoo, providing instructional tours for school parties; zoo staff should take part in local television and radio programmes; regular information should be supplied to the newspapers; lectures should be organised, either in the zoo or outside it. Throughout, the theme should be the importance of wild animals and their conservation in their natural habitats—and of course the importance of the zoo as one of the community's most valuable cultural assets. At first it might seem that such a formal education programme is beyond the resources of many of the smaller zoos, but financial aid is often forthcoming from local municipal and educational authorities or charitable organisations, when the educational value of such a programme is pointed out.

The recreational value of the zoo is generally accepted and little needs to be said, beyond emphasizing how successful a zoo can be as a cultural resource in the underdeveloped community. In areas where few other entertainments are available, the zoo is always extremely popular, and the zoos of the world with the highest attendances are almost invariably in countries where the average income is low and public entertainments few. But because there are few other entertainments, and therefore relatively little competition, the zoo has an even greater responsibility to make its grounds as attractive as possible, with shady tree-lined walks, landscaped enclosures, colourful flower beds, and discreetly placed and simply designed buildings. Great care should be taken to remove the fairground element from the zoo itself. Sideshows, swings and other amusements for children are justifiable as additional attractions, but they should be kept separate from the zoo itself. Nothing must distract from the animals or detract from their importance. At all times they should be the centre of attention and interest. The purpose of the zoo is to convince its visitors that animals are serious, interesting creatures—and it is difficult to do this in a fairground atmosphere. This does not mean that the zoo should be entirely devoted to the animals—trees, plants, shrubs, flowers, lakes and streams all have their place—but they should always enhance the animal exhibits, not distract from them. The zoo should be and is a place of recreation, but it is not an amusement park.

Another function of the zoo in a modern economy is as an attraction for tourists. Visitors to a foreign country are almost always interested in its wildlife, and while many may be unable to afford expensive tours to see the animals in their natural habitats, they invariably wish to visit the zoo. Zoo visiting has become an important part of the foreign tourist's programme, and this trend is reflected throughout the world. The tourist's impression of the country as a whole is very often influenced by his visit to the zoo. From the point of view of national prestige it is therefore highly desirable that a nation's zoos should be attractive and the animals well displayed, for it must be remembered that the foreign visitor will have seen many zoos in other countries and will inevitably compare them in his mind. It must also be remembered that the foreign tourist is primarily interested in local animals, and will want to see a good collection of these. A beautifully laid out zoo with pleasant shady paths and large natural enclosures where local wildlife is attractively exhibited arouses the tourist's interest in the country he is visiting, and he should be provided with as much information as the zoo's resources can offer. Here, the zoo may be able to receive assistance from the local game departments and the ministry or department of tourism which may be able to give funds towards improving the zoo's facilities, and advice about distributing zoo posters and leaflets in hotels, airports and tourist information centres.

In addition to education, recreation and tourism, the zoo can undertake two other important tasks: research, and breeding rare animals. Many of the larger zoos have the resources and the opportunity to initiate projects such as research into animal disease, breeding and behaviour, all of which can have relevance to human research. Even the

smaller zoos can make an important contribution to knowledge by keeping careful records and accumulating basic data on their animals. So very little is known about the basic biology and behaviour of the majority of wild animal species that any observations that can be made, such as gestation and incubation periods, breeding seasons, litter and clutch sizes, longevities, causes of death, are valuable and a real contribution to our knowledge of wild species. And it is only increasing our knowledge of wild animals in captivity that we will be able to conserve them efficiently in the wild. This is specially true with the very rare species and with some of them, where the species is seriously threatened in the wild, its survival may depend on its successful breeding in captivity. This is also true where a species is reduced to a small population living in only one area and which could easily become extinct as the result of disease or destruction of habitat. Here too it is important to have good breeding stocks in a zoo in order to ensure that the species survives.

The zoos of Asia occupy a unique position of importance in the conservation of the area, for it is through them that we hope people will learn how important is the conservation of wild animals and their habitats to the continent. They are in contact with a vast public, both educated and uneducated, and are the obvious and ideal medium for conservation education. However, the reaction of many of the smaller zoos, and even some of the national ones may be pessimistic. Their financial and human resources are often inadequate and they are in need of practical advice and help if they are to undertake this important task successfully. I should therefore like to make a number of recommendations.

My first recommendation is that this Meeting should urge to the governments of all Asian countries to give substantial financial support to their national and if possible their local zoos so that they can fulfil their educational, recreational and scientific roles. Any subsidy given will be amply repaid in the increased popularity the zoos will have with tourists.

My second recommendation is that a regional training school should be set up in tropical Asia for zoo staff. Thus could either be allied to one of the existing large zoos of the area, or to a university. However, in the first instance it would probably be necessary for a zoo expert to make suggestions. Possibly this could form a World Wildlife Fund Project.

My third recommendation is that all zoos should try to form links with their local game departments, universities, educational authorities and tourist organisation. This would results in a very beneficial exchange of knowledge.

My fourth recommendation is that all countries in the region should have a national zoo, displaying both foreign and indigenous fauna. There should also be local regional zoos where the emphasis would be primarily on the local fauna exhibited in sympathetic conditions.

My fifth and final recommendation is that the zoos of Asia should form themselves into regional associations. A very efficient Japanese zoo association is already in existence, but none exists either for the Indian subcontinent or for South-East Asia. If the zoos in these areas can organise themselves into regional associations, then not only will the exchange of knowledge and animals be facilitated between zoos, but they will also be in a stronger position to influence local and national authorities, persuading them to take a more active part in the conservation of the nation's wildlife.

SUMMARY

Wildlife, a resource which Asia once had in abundance but is rapidly losing, includes not only wild animals but their habitat, and conservation is therefore concerned with the whole human environment. It is difficult for people who have long regarded wildlife as an inexhaustible resource to be exploited or a danger to be feared, to understand this and to modify their attitudes; the problem is one of education and in this zoos can play a major role, indeed in Asia it should be their principal function.

Asia is rich in zoos both by tradition and by recent expansion, but those who manage them must give far more attention to their educational function, first and foremost by sympathetic and imaginative housing of animals and display techniques, which will lead the

visitor towards an awareness of animals as part of life—*his* life—and so gradually to an understanding of the need for conservation, and secondly by more formal educational and cultural activities, including a recreational element which however should always be aimed at enhancing and not distracting from the animal exhibits.

Other functions of zoos, of secondary importance in Asia to that of education, are briefly reviewed: their role as a tourist attraction, in research and in the breeding of rare animals, the last two to provide a basis for better management and rehabilitation in the wild.

The paper concludes with five recommendations on measures which need to be taken, if zoos in Asia are to fulfil their essential and highly important role.

RÉSUMÉ

Le monde animal qui fut à une époque une des grandes ressources de l'Asie, mais est actuellement en régression rapide, ne comprend pas uniquement les animaux sauvages eux-mêmes, mais aussi leur habitat; par conséquent, le milieu naturel qui environne les hommes doit aussi être protégé. Il est difficile à des populations qui depuis des siècles considèrent le monde animal comme une ressource inépuisable ou une source de dangers de le comprendre et de modifier leur attitude. Pour résoudre ce problème, il faut éduquer les populations, leur apprendre à respecter le milieu natural qui les entoure. Les jardins zoologiques peuvent jouer à cet égard un rôle de premier plan; en Asie cela devrait même être leur objectif essentiel.

Le continent asiatique, et surtout l'Inde, possèdent un grand nombre de zoos, que ce soit par tradition (ménageries des anciens maharajas) ou par création récente. Mais les directeurs de ces zoos devraient être infiniment plus conscients de la valeur éducative de ces établissements. Il leur faudrait tout d'abord trouver des techniques d'exposition et des systèmes de clôtures qui mettent en valeur les animaux tout en leur laissant une grande liberté de mouvements. Ceci amènerait le visiteur à considérer les animaux comme un élément de la vie—de sa propre vie—et à comprendre ainsi progressivement les raisons et la nécessité de la conservation. Ils devraient ensuite organiser des activités culturelles et éducatives plus officielles, comportant aussi un aspect récréatif, mais sans que jamais l'attention ne soit détournée de l'élément central du zoo—les animaux exposés.

L'auteur ennumère ensuite brièvement les autres fonctions d'un jardin zoologique, qui en Asie présentent une importance secondaire; attraction touristique, étude et élevage d'espèces animales rares, ces deux derniers facteurs devant servir de base à la mise en valeur et à la sauveguarde des animaux vivant à l'état sauvage.

L'article se termine par cinq recommandations portant sur les mesures à prendre pour qu'en Asie les jardins et parcs zoologiques puissent répondre à leur importante vocation.

Section C (3)

Captive Breeding as an aid to Practical Conservation

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Historical records show, and the existence of domesticated beasts proves, that wild animals have been kept in captivity for thousands of years. Our remote ancestors were doubtless initially prompted by the advantages to be gained by keeping animals available for food or by training some of them as aids in hunting or as beasts of burden. As civilisation advanced wild animals were caged for the interest or amusement of the spectator. But only in comparatively recent times has the wheel turned full circle with the very existence of some species dependent upon man's ability to breed them in captivity.

The best known early examples are Père David's Deer *Elaphurus davidianus* and the Wisent or European Bison *Bison bonasus.* The former no longer exists in the wild and the world's entire captive population owes its existence to the 12th Duke of Bedford, who bred this deer in his Park at Woburn in England. -The European Bison survives in the wild only because animals bred in captivity were reintroduced to the Bialowieza Primeval Forest in Poland as recently as 1956, as well as to certain regions of the Soviet Union.

Other reintroductions are becoming increasingly necessary if some species are to survive in a world where little of the earth's surface will for long remain undisturbed by man's activities. It cannot be emphasized too strongly from every point of view, scientific, economic and aesthetic, that such projects should be limited to the reintroduction of indigenous species into their former haunts. The introduction of exotic forms far from their native land, and often simply to provide living targets for so-called sportsmen, is as unscientific as it is undesirable and reflects a state of mind that has progressed little since man finally destroyed the last Great Auk in 1844. The introduction of a species to a suitable alternative environment can only be justified where it is no longer possible for political or practical reasons, such as the destruction of habitat, to reintroduce it to its native land. Even then all the implications of the introduction should be carefully considered with especial reference to the possible effect upon native species and should not be carried out without adequate means of control.

The Pheasant Trust at Great Witchingham was set up specifically to breed threatened species of game birds with a view to reinforcing the depleted wild populations with captive-bred stock. Its collection of rare pheasants is now the largest ever to have been assembled in the world. Of the 48 species of pheasant living in the world no less than 16 are on the IUCN/ICBP Red Book List of endangered species and of these 8 are being bred regularly in the Trust's collection.

Two of the species threatened with extinction, Swinhoe's Pheasant *Lophura swinhoei* and the Mikado Pheasant *Syrmaticus mikado,* are confined to the mountain forests of Taiwan (Formosa). Both are being bred in numbers by the Trust and the first reintroduction of Swinhoe's Pheasant with birds bred at Great Witchingham took place in 1967, in co-operation with the Taiwan government and assisted by the International Council for Bird Preservation and the World Wildlife Fund. In 1968 a further 6 pairs of Swinhoe's Pheasants were released in the same area. In this case the release procedure had been tested during an experimental pilot scheme in 1966 when, with the approval of the Nature Conservancy and the Dorset Naturalists' Trust, 6 pairs of these pheasants were released on Brownsea Island in Poole Harbour, England. The habitat appeared suitable and it seemed most unlikely that there would be any undesirable effect upon native species, furthermore the pheasants would be unable to leave the island and could, if necessary, easily be destroyed after their release. In two years the number of birds known to be alive has increased to nineteen with no additional hand feeding, other than for three or four weeks after their initial release from a pen built for the purpose in a secluded part of the woods.

Preliminary discussions are taking place with the Taiwan authorities concerning the reintroduction of the even rarer Mikado Pheasant in a high-altitude reserve there. In 1968 the total world captive population of this pheasant was believed to be less than 120 birds but in 1969 alone the Pheasant Trust has bred 140 young Mikado.

Similar projects could be carried out with other threatened species in S.E.Asia and the Trust is actively engaged in proposals to reintroduce both the Himalayan Monal *Lophophorus impeyanus* and the Cheer Pheasant *Catreus wallichi,* to parts of the Himalayas where both species are threatened. Negotiations have started with the state governments of Himachal Pradesh and Uttar Pradesh in India and with the National Appeal of the World Wildlife Fund in Pakistan. Both species are being bred in numbers by the Trust and young birds are available.

The reintroduction of any animal is rarely, if ever, the simple matter of releasing specimens bred in captivity, and success can only be achieved by a carefully planned operation. In the case of pheasants and other game birds vast sums of money have been spent in the western world on research into nutrition, control of disease and management. The bulk of this investment has been made by the poultry industry but much has also been done by sporting interests and by such organisations as the Game Research Association in the United Kingdom. The results of all this research can be harnessed to the conservation of rare species.

At the Pheasant Trust, individual pairs of pheasants are kept for breeding purposes in large aviaries, many of them planted with berry-bearing shrubs which also provide shade and nesting cover. The pens are all built on grassland and the smallest permanent aviaries measure 40' x 20' x 7' high and are completely covered by galvanised wire-netting of 1" mesh and 17 gauge. Smaller mesh netting such as ½" is even more effective in excluding predators of all kinds, but is considerably more expensive. Each pen is equipped with a dry, draught-proof shelter in the form of a small hut. The shelters for tropical species such as Firebacks *Lophura* spp. are heated by oil stoves or by electricity during the cold months. Over 100 such pens are in use by the Trust.

All the birds are provided with clean water daily and a constant supply of granite or oyster-shell grit. They are fed pelleted food with an analysis of

Crude protein	19.0%
Oil	2.45%
Fibre	4.9%
Amino-acid values for Lysine	0.94%
Methionine plus cystine	0.66%
Metabolizable energy	1190 calories per pound

Out side the breeding season the pellets are fortified with an anti-blackhead drug Acetyl-amino-nitrothiazole as well as a cocciodiostat and are always fed *ad lib.* Grain is too fattening for some species such as Tragopans *Tragopan* spp., but is fed in small amounts to others.

The eggs are collected daily and stored in a cool place before being set under broody bantams (small chickens) or in electric still-air incubators. The best results are obtained with bantams and a system has been devised where 100 birds are accommodated in rows of setting boxes under cover, where they are fed and watered daily.

After hatching, each brood of young pheasants is removed with its foster-parent to a small movable coop on short grass which is kept well mown. In the English climate additional heat is provided for the first two or three weeks by an electric element fixed to the lid of the coop. All coops are moved on to clean ground daily and the chicks are provided with a constant supply of clean water in a shallow dish. They are fed a proprietary brand of pheasant starter crumbs which have an analysis of

Crude protein	25.0%
Oil	2.6%
Fibre	4.0%
Amino-acid values for Lysine	1.40%
Methionine plus cystine	0.88%
Metabolizable energy	1250 calories per pound

The crumbs also contain vitamins, mineral trace elements, antibiotics and drugs to control blackhead and coccidiosis.

More delicate species are given maggots (larvae of the Blow Fly *Calliphora* spp.), mealworms (larvae of the Meal Beetle *Tenebrio molitor)* and grated yolk of hard-boiled egg, in addition to crumbs, for the first few weeks.

At about six weeks of age each brood is moved with its bantam foster-parent to a larger movable pen measuring 10' × 6' × 4'6" high, fitted with a lean-to shelter. These fold units are moved on to clean ground every few days. When the young birds are fully feathered their foster-parent is removed.

Birds for release must be well grown and strong on the wing. A large temporary pen should be built in a suitable habitat in the area to be restocked. The pen should have plenty of cover as well as dry shelters and the birds should be confined in it for three or four weeks to settle down. Thereafter two or three birds should be allowed to walk quietly out of the open door on alternate days until all have been set free. It is important not to drive them out, or frighten them in case they fly away and get lost. Food and water is put down daily outside the pen for the birds which have been released until they have become completely independent. Those still in the pen are fed and watered at the same time and help to prevent the released birds from straying away. If possible additional food should be provided in the area for several weeks.

In many species of pheasant it is only possible to pen young (i.e.first year) birds together before release, since adult males will fight and kill each other in the pen.

Captive breeding programmes can do much to help build up wild populations of threatened species of herbivores. The Formosan Sika Deer *Cervus nippon taiouanus* is very close to extinction in the wild, but once suitable reserves have been established by the government of Taiwan the species could soon be reintroduced with captive bred specimens. Similar operations could be carried out with many other species of threatened deer.

Predators whether mammalian or avian, present more problems since it is essential that they should be able to hunt effectively when given their freedom. Dr. Curry-Lindahl and the Swedish conservation authorities have reintroduced the European Eagle Owl *Bubo b. bubo* to several parts of Sweden where it had been wiped out. Their method has been in operation for more than a decade and is entirely successful. Large aviaries are built in different parts of the forest where the reintroductions are to take place and a young pair of owls bred in captivity is put in each aviary. When they reach maturity and breed, their progeny are set free when fully fledged, but the parents remain captive. The young owls are attracted to their old home and remain in the vicinity for many weeks where they are fed outside the aviary. During this time they learn to hunt for themselves and gradually loose their parental ties and become truly wild. Since 1964 fourteen of the twenty-nine young Eagle Owls bred in the Norfolk Wildlife Park in England have been presented to the Swedish authorities to help their scheme, while more recently a pair was presented to the German organisation responsible for the reintroduction of this owl in the Eifel area.

Of the 179 bird families covering all species existing since A.D. 1600 representatives of more than 75 families have been bred in captivity and this number could no doubt be increased. This does not imply that all the species of the 75 families breed freely under captive conditions, but it does mean that given suitable management the majority can be bred. The proportion of mammal families, representatives of which have been bred in captivity, is far higher with at least 84 out of a total of 121 excluding man.

Captive breeding operations do not necessarily have to be restricted to zoological collections and in some instances could be carried out with advantage in wildlife reserves. The animals could then be kept under virtually natural conditions but at the same time under constant veterinary surveillance. Other factors such as poaching could be effectively controlled, while the young animals would already be fully acclimatized at the time of their release into the reserve proper and there would be no transport problems. Furthermore in the case of very rare species it would enable large numbers of visitors to see the animals without any risk of disturbance to those living wild in the reserve. Such a project might be considered for the Swamp Deer *Cervus duvauceli,* in the Kanha National Park, Madhya Pradesh. According to Schaller (1967) the wild population of this species in the park has declined alarmingly in recent years probably due to the incidence

of disease such as brucellosis transmitted by domestic cattle, combined with natural predators and poaching by man. A captive breeding programme under veterinary control could do much to overcome this problem.

Before a captive breeding project for reintroduction is started with any species, the following points should be borne in mind:

1. A suitable reserved habitat must be available within the species' natural range where the release can be made.
2. Those conducting the operation must have the necessary experience and knowledge to enable them to breed the species concerned in captivity.
3. A suitable release procedure must have been devised and preferably tried out.
4. It must be possible to continue the captive breeding in order to boost the reintroduced stock over a period of years, if necessary.

Conventional zoos can play an important part in this facet of conservation and many of them are conscious of the part they can play. Recently the Federation of Zoological Gardens of Great Britain and Ireland set up a Conservation and Breeding Committee, the aims of which are to keep a register of all rare mammals and birds kept by member zoos, with especial regard to those species considered to be in danger of extinction in the wild. Member zoos will be encouraged to breed rare species in captivity so that zoos of the future will not have to make further demands on the depleted wild populations. In some cases zoo-bred animals may be used to reinforce those wild populations which have sunk dangerously close to extinction.

REFERENCES

JARVIS, C. and MORRIS, D. (1960). The International Zoo Yearbook, Vol. 2. The Zoological Society of London, 329 pp.

JARVIS, C. and MORRIS, D. (1961). The International Zoo Yearbook, Vol. 3. The Zoological Society of London. 322 pp.

JARVIS, C. and MORRIS, D. (1962). The International Zoo Yearbook, Vol. 4. The Zoological Society of London. 345 pp.

JARVIS, C.(1965). The International Zoo Yearbook, Vol. 5. The Zoological Society of London. 430 pp.

JARVIS, C. (1966). The International Zoo Yearbook, Vol. 6. The Zoological Society of London. 503 pp.

JARVIS, C. (1967). The International Zoo Yearbook, Vol. 7. The Zoological Society of London. 410 pp.

JARVIS, C. (1968). The International Zoo Yearbook, Vol. 8. The Zoological Society of London. 414 pp.

LUCAS, J. (1969). The International Zoo Yearbook, Vol. 9. The Zoological Society of London. 336 pp.

MORRIS, D.and JARVIS, C.(1959). The International Zoo Yearbook, Vol. 1. The Zoological Society of London. 160 pp.

SCHALLER, G. (1967). The Deer and the Tiger. University of Chicago.

SIMON, N. (1966). Red Data Book, Vol. 1. I.U.C.N., Morges, Switzerland.

VINCENT, J. (1966). Red Data Book, Vol. 2. I.U.C.N., Morges, Switzerland.

WAYRE, P. Paper in the journal *Biological Conservation:* in press.

Section C (3)

The Role of Zoos

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IMPORTANCE OF ZOOS

A zoological garden or a park is a connecting link between man and wild life. It is the only place where a city dweller comes in direct contact with wild life in all its cultural, scientific and educational aspects. The present way of life does not leave enough time to watch and study birds and animals in their natural surroundings and environment. Large zoological gardens and parks can certainly help much towards the preservation of wild life, but in small cities also small zoos may play an equally important part in teaching people about our vanishing natural resources. A zoological garden is not meant only for amusement, but should impart popular and visual education in natural history and biology. The difference, incidentally, between a zoological garden and a zoological park is that the former is a place where a number of birds, animals and reptiles are exhibited in a limited area in cages or in the open with the protection of a moat to meet educational, recreational, cultural and aesthetic needs; while a zoological park is a broader term, where the area is comparatively larger and maintained in a state approaching the natural environment, thus to some extent resembling a sanctuary.

CONSERVATION

It is a common feeling that zoo animals are miserable, not having enough space, as they do in their wild state, but in fact experience shows that some mammals and birds live better in captivity and breed freely in quite small enclosures and aviaries. Another common belief is that most animals are unhealthy in captivity, but actually in good zoos the majority of animals and birds are healthier than in their wild state. A good zoo is judged not merely by the number of different species of animals and birds but by the health and contentment of its inhabitants.

As an insurance for wild populations of animals, it is desirable that a good number of such animals should be housed in zoos so that even if in nature their numbers decrease due to accidents, epidemics, poaching or shooting, they may be saved from extinction. Captive breeding must always be done on strictly scientific lines, taking into consideration the laws of genetics and making the best use of gene pools to build up a healthy stock, which calls for cooperation from different zoos all over the world.

Many extinctions in the past have been accidental and due to ignorance or greed. However, destruction of habitat is undoubtedly the major cause of changes in animal populations over the past two or three centuries; the draining of marshes, the felling of forests, modification of grass lands by domestic stock have changed the aspect of land beyond imagination in most parts of the world. No animal in the wild can survive without the habitat to which it has become adapted. Conservation is basically the maintenance of the flow through such a habitat whether it is a jungle, semi-forest or saltmarsh. But although for many years to come zoos will be able to draw on the natural surplus of most wild animal stocks, they cannot assume that this situation will last forever, particularly with species, notably the apes and carnivores, where heavy losses are experienced in the process of capture, in the early stages of captivity and even later through epidemic and virus infections.

ZOO OPERATION AND STANDARDS

Studies in genetics, behaviour, conservation and many other important subjects in natural science should help conservation of animals and birds in a zoo. Of the zoological gardens in India, some are very good, some fairly good and some poor or neglected through their

own fault, carelessness, lack of adequate knowledge or a bad financial position, but the most important factor is lack of real love for birds and animals. Some zoos which are overcrowded with animals or birds are not even prepared to part with a few surplus animals to other zoos and the interest of the officers concerned is lost due to lack of mutual cooperation.

There is no special course or training for Zoo Superintendents or Directors. A person may serve as a Zoo Director for years, but may not know anything about animals or birds, only about administration. A director should be a versatile person and capable of handling most of the subjects pertaining to a zoo, such as Indentification, feeding, rearing and psychology of animals, with some experience also of civil engineering and mechanical technology; but most important of all he should be a true animal lover, having personally kept birds and animals as pets and studied natural history. In fact, a real zoo-man has no fixed hours or time limitations for his work and attends to it with pleasure, if necessary sacrificing other interests.

High standards of sanitation and hygiene are essential and it is important to develop an attachment between the animal and its keeper and vice versa. Wild animals are not actually wild; they become wild with bad treatment and persecution, but respond to love and kindness. This principle should be strictly followed by the Director and taught to the staff.

Animals and birds from different climates usually get adapted and acclimatized to changes and settle down quickly in a new environment. It is always advisable to have few animals well maintained than large numbers in poor condition. The practice in some zoos of keeping domesticated poultry, ducks, geese, pigeons and so on should be entirely eliminated; the emphasis should be on rare and vanishing species and their conservation, for although certain species may not breed in captivity, most of them have now done so and many have thus already been saved from extinction. Adequate protection of animals in a zoo from the public is most important. People are the main source of infection, for they may be suffering from tuberculosis, influenza or other virus or bacterial disease, capable of attacking the animals. Feeding of animals by visitors with unsuitable food, even such things as pieces of glass, stones and pins, at times have proved disastrous. In the Ahmedabad Zoo, the albino Chinkara, probably the only specimen existing in captivity, was injured in the eye by a visitor's umbrella; treatment was of no avail, the injury ultimately developed malignancy and the animal died. On another occasion laxative beans of a herbal plant were given to a pair of bear cubs and ultimately both of them died from colic and severe diarrhoea. A visitor threw a lighted cigarette at an ostrich and the poor bird died from burns and shock. Sometimes when a tame parrot or cockatoo clings to the wire mesh, expecting a friendly tit-bit, it is branded on the toes with a burning cigarette. One visitor put a rubber band on the tongue of a sambar, but this was detected in time and the sambar was saved. Another visitor dropped a big stone on the head of a young crocodile, to see whether it was alive or dead: it died of concussion. Similarly some years ago a well known zoo in India lost a hippopotamus: the authorities did not know what was wrong, till at a post mortem examination a large stone was recovered from its stomach.

It is not always of course the public which is at fault and just as many stories can be told of negligence, time serving and downright cruelty or total lack of skill on the part of the keepers. For example, there was one who tried to catch an eland for treatment by chasing the animal till it fell down exhausted; he killed three eland in this manner. In many cases trapping of one animal in an enclosure is done in such a way that the complete herd is frightened and disturbed; the chaos makes the animals dash themselves against the walls of the enclosure, so that their horns or antlers are seriously damaged and when this happens to the delicate horns of fawns, they later develop crooked and defective horns. From the conservation point of view such zoos are not an asset to wild life but a liability. Only good zoos should be supported and maintained. Animals will only breed provided they find the surroundings and habitat suitable to them in all respects. In certain circumstances, they may fail to feed their young or desert them or kill them intentionally or unintentionally, and in each case the most careful investigation of the reasons is essential. If it is necessary to rear young by hand, the zoo is faced by a difficult problem and it needs tremendous care and study, for example of the composition of the milk of the various animals whose orphaned or deserted young have to be raised.

Although attention to the psychological and behavioural needs of captive animals is also very important—space to play and means of occupying themselves for example—it is

generally accepted that sound and well-balanced nutrition is the key to disease prevention, which is absolutely necessary for successful maintenance of animals in captivity.

In India we still do not have the complete knowledge of the different diets required for different species. These can only be learned by experience or by guidance from other zoos, but there is an unfortunate tendency for many zoos to treat such information as top secret, requests for details being evaded. However, at least the danger of sickness and death caused by over-feeding or by unsuitable food can be lessened by placing a complete ban on the feeding of zoo animals by visitors.

Quarantine is again of great importance. All the new arrivals should be quarantined for a sufficient period to ensure that they are free from disease and can be released safely into the existing stock. A longer period of quarantine is particularly necessary for animals received from dealers, as these often have been kept in very unhygenic, overcrowded and inadequate cages, in infected surroundings which are bound to carry disease. A few dealers are animal lovers, but many have adopted undesirable methods and a 'don't care' attitude, which results in cruelty or misery to the animals in their possession and ultimately their death before or after reaching their purchaser.

Laboratories for research and study into parasites and diseases of wild animals should be established. The Gaur or Indian Bison has been completely wiped out from the Bandipur sanctuary by foot-and-mouth disease carried by domestic cattle. 'African Horse Sickness' is not only spread by contact but is readily transmitted by blood or nasal discharges from infected animals, and mosquitoes trapped in the wild state have been shown to harbour the virus. Animals such as zebras and other horses are of course specially subsceptible to it; mortality is about 90 to 95 percent and it was believed that many Indian Wild Asses were the victims of this fatal virus some years ago. Sometimes animals are their own doctors; a deer or antelope with a fractured leg, if left to lie on the ground in an undisturbed corner, may recover in due course without any treatment, while disturbance for treatment only creates more complications. At times when a nervous, agitated or pugnacious animal becomes dangerous to itself or others or has to be shifted, the modern tranquilizers can work wonders. The correct doses are very important and are related to body weight. The problem of dealing with a pugnacious stag or buck is sometimes solved by cutting off the horns so that it cannot kill the female and the animals have still bred successfully. But another solution, successfully used by me, is to fix pieces of hose-pipe on the tips, which protects the does from being injured, without ruining the horns or antlers.

Each animal, bird or a reptile is psychologically and temperamentally different from another. Wild animals without knowing why, by instinct or reflex action, behave with a definite purpose. Out of two freshly trapped pythons, one may go on hunger strike while the other starts eating normally. Out of two freshly trapped crocodiles, one may remain in the pond under water for days and months together and only come out at night, while the other behaves normally. Out of two freshly trapped birds, one may flap around until it eventually dies of shock, while the other hops about normally. Hence it is desirable that every individual animal and bird should be considered as a unit and studied and treated separately for its well being.

CONCLUSION

E is of course for the sake of food that most animals are killed. Till very recently in Dimapur, a village in Nagaland, in the regular village market, the flesh of various wild animals like gibbons, various monkeys, dogs, pythons and elephants was being sold at rates ranging from Rs. 1/- to 2/- per kilo. The local tribesmen eat anything from the tiny yellow-backed sunbird to the largest elephant. In the period from October to February, in Khasi and Jayantia Hills in Nagaland, 4 to 7 barking deer are killed daily and the meat is sold at the roadside for Rs. 7/- to 8/- per kilo. Even now in Patna, bird-trapper families eat most of the small birds; a preparation of rice or 'pilau' may contain a hundred skylarks or buntings. The Great Indian Hornbill and its young also find their way into the village kitchen. All snakes including poisonous snakes are considered a delicacy.

Rhinos are killed for their blood, which is used for ritual purposes in Nepal, while the horn is used for medical purposes and sold at fabulous prices (the Goverment rate is Rs. 12, 000/- per kilo, while the poachers' rate is Rs. 9, 000/- to Rs. 10, 000/- per kilo).

Bear bile is sold for Rs. 45/- per tola[1] in Calcutta market. The present demand per year is about 7 to 8 kilos, which gives an idea of the number of bears destroyed. Big cats are killed and poached for their lovely fur. Crocodiles, lizards and serpents are massacred in millions each year. There are about 30 to 40 suppliers of hides and skins in Calcutta, each dealer having 3000 to 4000 skins in their stock ready for export.

All this is a non-stop process and unless and until drastic action is taken, it will be difficult to save wild life. The creation of more and better zoos can help to save the remnants of our national heritage. Otherwise a day may come when we can only look at pictures of the treasures of wild life in the past with sad regret.

SUMMARY

In addition to their recreational, cultural and especially educational value, zoos can be of great conservation value by providing an insurance against the possible extinction of species threatened by major changes or loss of natural habitat and other direct and indirect human interference. To fulfil this role, however, it is essential that a zoo should have a sufficiently high standard of management and operation.

The scope of knowledge required of a good zoo Director is analysed, and it is emphasised that he must above all have a genuine love of animals and interest in natural history. He must extend this to his staff and as far as possible to the general public: examples are given of the harm caused by cruelty and thoughtlessness on the part not only of visitors to zoos, but also of bad and unskilful keepers, which can easily turn a zoo into a liability rather than an asset to wildlife.

The need is not only for protection against such malpractices but also for constant attenattention, on a basis of scientific research, quarantine measures and the exchange of information, to meeting the psychological and physical needs of captive animals and combatting disease. Only in this way can zoo animals flourish and be enabled to breed sucessfully, thus in some measure off-setting the constant drain on wild stocks through the killing of animals for food, hides and skins and other products.

RÉSUMÉ

Outre leur valeur récréative, culturelle et surtout éducative, les jardins zoologiques peuvent être d'une grande utilité en matière de conservation. Ils constituent en effet une assurance contre l'extinction possible d'espèces menacées par une modification profonde ou même la disparition de leur habitat naturel ou par d'autres interventions humaines directes ou indirectes. Toutefois, pour être à même de jouer ce rôle, il est indispensable que le jardin zoologique ait une qualité de gestion et de fonctionnement de premier ordre.

L'auteur analyse l'étendue des connaissances que doit posséder un bon director de jardin zoologique. Il souligne très fortement que ce dernier doit avant toutes choses aimer les animaux et d'intéresser aux sciences naturelles et qu'il doit chercher à transmettre cela à son personnel, et dans la mesure du possible au public. De nombreux exemples montrent les dommages causés aux animaux par la cruauté et l'inconscience des visiteurs ainsi que par la méchanceté ou la maladresse des gardiens, ce qui peut faire d'un jardin zoologique un élément néfaste plutôt qu'un atout de la conservation des espéces sauvages.

Pour répondre aux besoins physiques et psychologiques des animaux captifs et combattre leurs maladies, il fait assurer non seulement une protection contre ce genre de méfaits, mais aussi toute une somme de soins constants, fondés sur des études scientifiques, de mesures de quarantaine et d'échanges d'information. De cette façon seulement, les animaux des parcs zoologiques pourront vivre et se reproduire de façon satisfaisante, en compensant ainsi dans une certaine mesure le saignée continuelle d'animaux sauvages tués pour leur viande, leur peau et toutes sortes d'autres produits.

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1 A tola is 180 grains, the official weight of a rupee, which is equivalent to about 12 grammes (Ed.)

Section C (3)

The Contribution of Delhi Zoo to Conservation

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Zoological Gardens, Menageries or Zoological Parks the world over are one of the biggest drains on wildlife resources. Their staff go out on expeditions, lay their own traps and bring home species to enrich their collections. They buy animals at fabulous prices from organised dealers who in turn depend on local trappers. A new trade has developed. Once money is involved, there remains no limit to exploitation. The trappers are always looking for methods which are less expensive and easier, but which may well be harmful to the animals. They set unattended nets, snares and traps and often reach the scene after the trapped animal is dead. In many cases, the animal's struggle to escape results in loss of a limb, canine or some other part of the body. The animals which reach the base camp undergo another torture. Their every attempt to escape is foiled. With the loss of freedom they lose interest in life. In the atmosphere of tension, they stop eating. Crocodiles, gharials, anteaters and dolphins are specially prone to die of starvation, but even big cats, grown-up elephants and gaurs have been known to hunger-strike to death.

With species such as tiger, clouded leopard, gibbon and monkeys, the young are often caught by killing the mothers accidentally or intentionally. They do not always fall into safe hands and infant mortality is inevitable. Young animals are preferred as they are more easily carried by air or smuggled. Transportation losses are great, particularly in case of deer, antelopes and apes. All the 20 elephants shipped from Mysore last year had to be jettisoned one by one in the Arabian Sea on their way to Europe. Out of four tiger cubs sent by air, only two reached their destination. Two Nilgiri langurs were recently despatched to Delhi. Only one arrived safe. Even a white tiger died on the way to the U.S.A. From the point of capture to arrival at a zoo, all such losses are debited to the zoo's account. This loss of wildlife is substantial (apes 95%, langurs 75%, monkeys 25%, cats 50%, otters 80%, goral, bharal and shrew 99%, and deer 50%): there is no denying that zoos are dangerous agencies in wildlife consumption. This is aggravated when a zoo director is a 'stamp collector' and attempts to possess everything under the sun, without caring for the physical and psychological health of the animals and when the criterion for judging a zoo is the number of animals in the collection rather than display and care. This unsound objective, to possess the maximum number of species and equally to replace losses quickly, has taken a heavy toll of wildlife. Zoo managements have also contributed to further loss by inexperience, neglect and experimentation. Probably, there is no zoo director in the world without some 'blood on his hands'. Losses are increased by public sympathy, over-feeding or feeding unwanted, unhygienic, unauthorized food articles, and partly by the vandalism of visitors who poke animals with sticks or umbrellas, throw stones, break the legs of flamingoes and fatally injure small birds and animals.

But fortunately the concepts of zoo management have changed. Directors hate to be called 'stamp collectors' and refuse to bargain with unauthorized dealers. They prefer zoo-bred to trapped animals. Under the leadership of the Zoo Directors' Union, there is an altogether new dimension in zoo management. Breeding of zoo stocks is given priority to make the zoos self-sufficient and records show that the zoos have played a unique role in successful breeding of rare animals, which in the wild had no chance of survival. Typical examples are Père David's deer, Przewalski's horse, European and American bison, Arabian oryx and Nene goose. Symposia held in London, U.K. in 1964 and in San Diego, U.S.A. in 1966, on the subject of 'Zoos and Conservation', under the auspices of IUCN and the International Union of Directors of Zoological Gardens, respectively, led to such recommendations as the establishment of an international code of rules for zoos and other institutions for breeding rare and endangered species. It was agreed that the zoos of the world should take a responsibility in conserving species and that animal breeding should be an important concern of zoological gardens (Jarvis, 1965).

It is heartening to note that as a result of these deliberations many well established zoos have now taken up the altruistic task of breeding the world's rarities. One hopes that the interest thus promoted by zoological institutions will help people to realise the thrill and pleasure of sharing the planet with a variety of fascinating wild creatures and the importance of conserving its dwindling wild life resources. The idea and concepts of conservation have changed from the purely sentimental to the practical approach of today. Unfortunately this evolution has been so slow in comparison with the rapid destruction of wildlife that the situation has become an emergency, so that the main aim of having rare animals in a zoo must now be to conserve them for future generations, keeping them for long enough to develop a sufficient captive stock of which some can eventually be released back into the wild.

In Delhi, we have today a stock of 28 tigers, probably more than remain in many tiger areas of the country, all from our own breeding stock except for three cubs which were rescued when their mothers were shot. The total world stock of 33 white tigers is similarly the result of the breeding programme of zoological parks of Rewa, Delhi, Calcutta, Washington D.C. and Bristol (Thornton, Young and Sankhala, 1967). Judging from our experience at Delhi, climate plays a less important role than living conditions and nutrition. The Delhi Zoo has been uncommonly successful in breeding, rearing and maintaining such rare animals as the brow-antlered deer *Cervus eldi,* Nilgirl langur *Presbytis johni,* lion-tailed macaque *Macaca silenus,* four-horned antelope *Tetracerus quadricornis* and smooth Indian otter *Lutra perspicillata,* as well as the tigers.

The thamin or brow-antlered deer is a beautiful deer found only in Manipur in India. The species has become very rare in recent years and only 100 deer were estimated to be in existence in the Keibul Lamjao Sanctury in 1959-60 (Gee, 1960). Gee states that the species has bred well in captivity in various parts of the world, but actual records of breeding are few. A pair was presented to the Delhi Zoological Park in 1962 by the Manipur State Administration. They were released in an open moated enclosure of about 1. 5 acres. Each deer was given 5 kg of green fodder and one kg of concentrates daily. In addition to this, the deer grazed in the enclosure and were observed to be in good condition. In October 1963, the first fawn was born and thereafter very year the birth of one or two fawns has been recorded. In total, there have been eight births of brow-antlered deer in the Delhi Zoological Park (Table 1).

Similarly, the Delhi Zoo has been successful in breeding the rare four-horned antelope: a pair was received in 1958 and in the last ten years fifteen births have been recorded (Table 1).

TABLE 1

Species	Number of births										
	1959	'60	'61	'62	'63	'64	'65	'66	'67	'68	'69
1. Brow-antlered deer	—	—	—	—	1	1	1	2	2	1	—
2. Four-horned antelope	2	—	—	—	1	—	—	2	1	3	6

Delhi Zoological Park is the only zoo in the world to have bred the Nilgiri langur in captivity. The luxuriant fur and supposed medicinal value of the flesh, blood and organs of this species have caused it to be hunted more than any other monkey. Studies made by the Bombay Natural History Society demonstrate that if the recent forest utilization practices are allowed to continue, both the Nilgiri langur and lion-tailed macaque will be extinct within the decade (Hill, 1960). The lion-tailed macaque has never been common and a recent survey by the Bombay Natural History Society showed that it is now distinctly rare. The Delhi Zoological Park has been successful in breeding both species. A trio of Nilgiri langurs was obtained in 1962 and the first young was born in 1964. One pair of lion-tailed macaque was obtained in 1959 and placed on an island, with trees on it and a moat as a barrier. They soon adapted themselves to their new environment and in 1962, the first young was born and thereafter six births have been recorded, now making a small colony of nine of these monkeys.

Delhi Zoo is also the first to have bred the Smooth Indian otter. Two females gave birth

to five and three young in 1968 and 1969, respectively. They have been kept in large moated enclosures where they burrow and live a natural life. They are given an exclusive diet of live fish.

As already indicated the Zoo is today the main breeding centre for tigers in the world. Since 1962, 65 have been born and at present 28 of them are on display. Many of them have been sent away in exchange or as gifts. In this connection, brief mention may here be made of the contribution made by a number of other zoos in India to the breeding of rare animals. The Sakkarbaug Zoo, Junagarh, has been successful with Indian lion *Panthera leo persica,* having bred 33 lions of pure Indian stock since 1947 and distributed them to various Indian zoos for further propagation (Joslin, 1969). The Mysore Zoological Garden has been uniquely successful in breeding the one-horned Indian rhinoceros, as well as African rhinoceroses and other African animals. The Jaipur Zoo has successfully bred the Indian crocodile for the past 10 years. Alipore Zoological Garden, Calcutta, has been successful with the brow-antlered deer and the lion-tailed monkey.

Success in breeding animals in captivity does not rest entirely on living conditions and nutrition. It is a complicated affair which requires constant observation, patience and common sense. It depends on the time an animal takes to acclimatize and develop confidence. It also depends on the individual behaviour of the animals. There is still too little knowledge about the behaviour, social relationships and diet requirements of many species, all of which need scientific investigation and coordinated research. Every zoo should have a research cell to study the biological and psychological aspects of various animals. Many examples of failure of conservation projects have been due to lack of ecological data on the particular species concerned: in fact, ecology is almost synonymous with conservation or in other words conservation can be interpreted as applied ecology. Since most animals are extremely secretive in their native haunts, a zoo is an ideal place to study their behaviour patterns. Zoos can help to fill in the missing data on feeding, nutrition, reproductive biology, animal behaviour and pathology, and their work can be supplemented by research centres set up in parks and sanctuaries in association with universities. The Delhi Zoological Park is actively engaged in such scientific projects. In collaboration with Delhi University, it has embarked on a research project on the chromosomes of primates. It has also initiated independent research projects on the breeding behaviour of tigers (Sankhala, 1967) and the ecology of painted storks (Desai, 1969).

Most people in India are ignorant of the importance of conservation. They cannot even recognize many of the common animals. They call a lion a tiger and a tiger a cheetah. One of the most important functions of a zoo is therefore to educate the public about wild animals. There are more than 300 zoos in the world and the number of visitors to them every year has been estimated at about one hundred and forty million (Osborn, 1962). If all zoos collaborated in educating the public on the importance of conservation, the aims of mass conservation education could be accomplished in a short period of time. Zoos which cannot play their part in this are not only little more than a drain on the wildlife, but sooner or later will be forced into oblivion by the weight of public opinion.

The Delhi Zoological Park has achieved considerable success in this educational field. With the help of teachers and leaders of organized groups, it arranges guided tours which include a discourse on the conservation, maintenance and ecological aspects of the exhibits. In addition to this, eminent biologists, conservationists and visiting zoo directors from elsewhere in India as well as from abroad are invited to deliver lectures. On the spot wildlife painting competitions are organised annually, children being invited to paint the animals of their choice within a specified time. It has been found that such activities greatly benefit the cause of conservation and help to bring about a realisation that conservation of nature is necessary for the survival of man himself. Various other functions are held every year to promote the cause and television programmes are also organized regularly. Such programmes break down the barriers between education and entertainment, much to the benefit of the general public. Sound and vision have brought a new dimension to the possibility of inculcating an awareness of the crisis facing wild animals.

Recreation of the public is yet another aspect of proper zoo management. A park should be aesthetically attractive for young and old alike. It should have beautiful lawns, colourful gardens, neat pathways and of course an interesting display, so that people can come, relax and enjoy, while assimilating the educational impact of the zoo. Delhi Zoological Park is a good example, with its varied and interesting animals, beautifully maintained

gardens and the magnificent and attractive back-drop of the Old Fort. Another important attraction which has been developed is the mini-bird-sancturary in the lakes. People throng to see and enjoy the birds building their nests, raising their broods, coming in and going out of the Park for food, or training their young to fly. This is an education in itself, as visitors see how, with only little care, protection and food, a bird sancturary can be established amidst a bustling metropolis.

The large enclosures—without bars—of the Delhi Zoo create an atmosphere of freedom, while those provided for the tigers are real Indian jungle with bamboos, Lantana and Zizyphus bushes, reeds, grasses with their ever-changing colours and the moat playing the part of a water-hole. The animals are not exposed to exhibition; they are there but one has to search for them, thus satisfying one's exploratory instincts. The same is true for the lions, as they roam on the sky-line of their wooded enclosure. The elephants have a large area, with a bathing pool, and are unchained. The deer, antelope and rhinoceros enclosures are equally roomy and such species as the zebra and eland can enjoy green grass under their hooves.

In most of the enclosures, attempts are made to simulate the exact natural habitat of the species displayed. Not only the flora but also other fauna associated in nature with the main species on display are included, so that, to take one noteworthy example, with the Indian rhinoceros, barking deer, hog deer, adjutant storks and sarus cranes live in harmony. Along with zebra and ostrich are displayed marabou storks and the white storks. Spotted deer are often found in association with peafowl and sarus crane in nature, so these three species are exhibited in the same enclosure. A similar effort is made with the vegetation, the rhinoceros enclosure being full of tall reeds, sedge and mud holes, while a sample of woodland is maintained for the spotted deer.

A visitor once remarked that he needed binoculars to see animals in the Delhi Zoo. We consider this to be compliment. The animals live as they live in nature. Their petty rivalries and conflicts, family affairs, care for young and other facets of day to day existence are fascinating to watch. But, in addition, they do not have to worry about food, and they get immediate attention if they fall sick or sustain injuries, which could never be possible in the wild. Epidemics, ailments and contagious diseases develop in the wild which take a heavy toll and sometimes even threaten the survival of a species. In a zoo, these hazards can usually be checked and the animals saved by proper treatment. For instance, our white tiger 'Raja' suddenly lost interest in food and within a matter of hours became very sick. He passed blood in the urine and his vitality became very low. The disease was diagnosed as Babesiosis which is usually fatal, but a cure was effected by timely treatment. Two American bisons which developed Pneumonia in the winter of 1968 were saved in the same way and, in the fairly frequent cases of severe injuries to antelope, deer and even lions and tigers which occur during fighting amongst a group, pride or pair, death would often result but for the treatment accorded.

Finally, it is worthy of mention that news of the birth, sickness or romance of animals and birds in the Delhi Zoo often provide our capital city with a much needed change of conversational topic, amusement and relaxation. In short, the breeding of rare or vanishing species, conservation education and the healthy recreation of the people are all positive contributions by zoos to the cause of conserving wildlife. They are the saving grace of a zoo and the consolation of the zoo director in moments of agony due to the 'blood on his hands'.

LITERATURE CITED

DESAI, J. H. 1969. Nesting and Food Ecology of the Painted Stork *(Ibis leucocephalus)* in the Delhi Zoological Park. Accepted for publication, Inter. Zoo Yearb. X.

GEE, E. P. 1960. Report on the Status of Brow-antlered deer of Manipur (India). J. Bomb. Nat. Hist. Soc. 57: 597-617.

HILL. Clide A. 1960. Expedition to India. Zoonoos. XLI No. 7.

JARVIS, Caroline. 1965. Zoos and Conservation Symposium. Inter. Zoo Yearb. V: 97-100.

JOSLIN, Paul. 1969. Conservation of the Indian lion through captive breeding. Report under review. IUCN, IUDZG.

OSBORN, Fairfield. 1962. A new opportunity—Zoos help wildlife. Inter. Zoo Yearb. IV: 65-66.

SANKHALA, K. S. 1967. Breeding behaviour of the tiger in Rajasthan. Inter. Zoo Yearb. 7: 133-147.

THORNTON, I. W. B., K. K. YOUNG and K. S. SANKHALA. 1967. The genetics of the white tigers of Rewa. J. Zool. Lond. (1967) 152, 127-135.

SUMMARY

Zoological parks and zoo gardens have been some of the biggest consumers of wildlife of the world. But the new concept of zoo management of displaying only a few animals and birds in, as far as possible, self-contained eco-units, imparting education to raise conservation consciousness among people, conducting research to discover unknown facts about wild animals for better understanding their physical and psychological needs, and breeding rare and vanishing species for reintroduction in depleted areas, is fast changing the position. Zoos are becoming new reservoirs of wild life and taking a lead in conservation.

The paper describes the contribution of the Delhi Zoological Park, in the field of conservation of wildlife in India.

RÉSUMÉ

Les parcs et jardins zoologiques ont été parmi les plus gros 'consommateurs' d'animaux sauvages du monde. Mais cette situation se transforme rapidement avec les nouvelles conceptions sur l'aménagement des zoos: présentation d'un nombre limité d'animaux et d'oiseaux dans des unités écologiques se suffisant à elles-mêmes autant que possible, diffusion d'un enseignement pour éveiller la conscience du public aux problèmes de la conservation, recherches sur les aspects inconnus de la vie des animaux afin de mieux comprendre leurs besoins physiques et phychologiques et enfin élevage d'espèces rares et en voie d'extinction, en vue de leur réimplantation dans des régions où elles avaient disparu.

L'article décrit le rôle que joue le Parc Zoologique de Delhi dans le domaine de la conservation de la faune indienne.

SECTION C (3): POINTS MADE IN DISCUSSION

Mention has been made in several of the papers of the breeding of rare and endangered species in zoos with the ultimate object of re-introducing them into the wild in their native areas when conditions are favourable. The Arabian oryx operation is a well-known example. But is is also worth noting the interesting case of the blackbuck, which was successfully'introduced into Texas in 1930: there it has flourised to such an extent that a project is now afoot to use some of the stock for reintroducing the species into suitable areas of Pakistan where it has become virtually extinct (Gutermuth, U.S.A., Chairman).

In Japan, where the Association of Zoos now has 90 members, a great effort is being made by one or two zoos to save the last remnants of the Japanese Crested Ibis and the Japanese race of the white stork. Eggs have been laid by a captive pair of the latter for two years but have so far failed to hatch. The present plan is that if they lay again, a pair of the European race of the stork, which have nested successfully in the zoo, will be used to incubate them. As one of the Japanese storks was donated by the Pekin Zoo, this project if it succeeds will be a nice example of international collaboration in more ways than one ! (Koga, Japan).

The recommendations in Lady Medway's paper for the formation of a Zoos Association in India and for the setting up of a Training school for zoo staff deserve the fullest support. Another suggestion, which has been tried out successfully at the Nehru Zoological Park in Hyderabad, is to incorporate in the educational activities of zoos the setting up of a zoo museum, with particular reference to displays not only of prehistoric species but also of those more recently extinct, so as to encourage interest in preventing further extinctions (P.S.Rao, India).

With reference to the serious losses inflicted on animals in the process of capture, Which is largely due to lack of skill and carelessness, two things which could help to improve the situation would be legislation to ensure that only fully qualified dealers, reaching and maintaining specified standards, would be licensed to deal in animals; and secondly, negotiations with all airlines to persuade them to place animals in a different class from normal freight, so that they will never be subjected to mishandling and delays in transit (Leyhausen, Germany).

The problem of using zoo-bred carnivores, such as the tigers mentioned by Mr. Sankhala, would be a particularly difficult one requiring special techniques. Have these ever been worked out or tried ? (Harthoorn, Kenya).

No attempt has yet been made to solve this problem, but it does not seem impossible that success could be achieved if a reintroduction could be carried out in stages, only the second generation being expected to adapt itself fully to the wild, rather in the manner of the Eagle Ows referred to in Mr. Wayre's paper (Sankhala, India).

SECTION D:INTERNATIONAL BIOLOGICAL PROGRAMME

(1) THE SURVEY OF UNDISTURBED OCEANIC ISLANDS SPONSORED BY THE SECTION ON CONSERVATION OF TERRESTRIAL COMMUNITIES (IBP/CT)

Chairman: Professor B.R. Seshachar, *Department of Zoology, University of Delhi, Delhi-7, India.*

Conservation of Oceanic Islands

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1. THE NEED FOR A SURVEY OF OCEANIC ISLANDS

Oceanic islands have always been of great interest to biologists both because of their unique ecosystems, rich in endemic species, and because of their comparatively undisturbed nature. Their remoteness and inaccessibility until lately provided some degree of protection, but this can no longer be regarded as sufficient in face of increasing population pressures, military needs for weapon testing and the spread of tourist and other development. One of the roles of the Conservation Section of the International Biological Programme is that of preparing a World Conservation Review assessing the present position and recommending further conservation measures. The Check Sheet Survey of IBP Areas has been developed to provide a tool for collecting information for this Review. It involves some degree of biological information already existing or else the services of trained personnel in the field. These conditions are often completely lacking in the case of oceanic islands. The scanty available information is usually widely scattered, both geographically and in time. In order to fulfil the requirements of the World Conservation Review for these extremely interesting island areas a special Theme on the Survey of Oceanic Islands has been developed as part of the CT Programme.

2. BACKGROUND TO THE DEVELOPMENT OF THE PACIFIC OCEANIC ISLANDS SURVEY

During the Eleventh Pacific Science Congress in Tokyo, 1966, a paper on Conservation of Pacific Islands was presented by M.W.Holdgate and E.M.Nicholson on behalf of IBP/CT to a Symposium on Island Ecosystems. This paper recommended a survey of Pacific islands as a preliminary step to the selection of areas or entire islands for conservation. Dr. Holdgate has been deeply concerned in the successful preparation of a series of Agreed Measures for conservation of the Antarctic under the Antarctic Treaty. He pointed out that in principle uninhabited oceanic islands of scientific interest might prove appropriate for some similar type of international treatment. The following Resolution (4.1, 2 and 3) dealing with this matter was put forward by the Symposium and adopted by the Congress:

'In view of the unique significance for world science of a number of islands in the Pacific Ocean which have hitherto, wholly or in part, escaped man-made changes, and in view of the irreplaceable endemic or rare species for which some of these islands form last refuges, and of the serious threats to the continuance of such natural conditions for research, the Congress AFFIRMS the urgent international importance of securing early and effective conservation of natural habitats on such islands. Therefore it is RESOLVED to request representative institutions in member countries of the Pacific Science Association to bring to the attention of their Governments the need to exercise the strictest restraint in relation to such island natural areas, and RESOLVED to request all scientists concerned to accord the fullest co-operation to the International Biological

Programme and to the International Union for Conservation of Nature and Natural Resources in developing jointly with the Pacific Science Association surveys and recommendations which will enable the authorities concerned to establish an adequate permanent series of natural habitats to be conserved as a base for research throughout the Pacific region. The report of actions arising out of these recommendations is to be given to the next Pacific Science Congress.'

The Congress also passed a number of other resolutions which are indirectly relevant to this subject.

3. FULFILMENT OF PACIFIC SCIENCE CONGRESS RESOLUTIONS (4.1, 4.2 and 4. 3).

In fulfilment of this Resolution it was agreed that the task of primary survey allocated to IBP/CT, in association with IUCN, should be broken down into four successive stages.

(i) Survey in the field to supplement published or unpublished information in order to provide basic data for analysis and for the preparation of regional reviews and reports.

(ii) Circulation, critical analysis and revision as necessary of regional reviews and reports, leading to their consideration at a Technical Meeting to be convened by IBP/CT in Collaboration with the other parties at some appropriate place in the Pacific during 1968 or early 1969.

(iii) Approach by IUCN to governments with recommendations for action on the approved programme to be followed up in correspondence and interviews in order to secure maximum effectiveness of conservation of the listed sites.

(iv) Review by the Twelfth Pacific Science Congress in Australia, 1971, of the fulfilment of this resolution and of implications for further measures of conservation in the Pacific, which will be proceeding simultaneously through other channels.

4. TECHNICAL MEETING ON CONSERVATION OF PACIFIC ISLANDS

Stage one of the survey involved the securing of regional reviews of Pacific oceanic islands for presentation to a joint CT/PM Technical Meeting held at Koror, Palau, Caroline Islands and Guam, in November 1968. Twelve specialists from overseas together with scientists working in Guam and the Trust Territory of Micronesia attended the meeting under the Chairmanship of Dr. F.R. Fosberg, and opportunity was taken to hold a special session on marine conservation under the Chairmanship of Sir Maurice Yonge, Scientific Co-ordinator of the PM Section of IBP. After reviewing the various reports and papers available, together with existing published information, the meeting pinpointed the location and nature of existing scientific interests with particular reference to uninhabited oceanic islands in the Pacific. General consideration was also given to Pacific island conservation. Prior to the meeting a draft Check List of islands giving sketchy information on administration, population and geological type had been prepared for use as a working document. It was decided that this could usefully be developed and expanded to form a basic reference source for Pacific conservation recommendations. The expanded Draft Check List has a total of 955 entries for oceanic islands and atolls in five sections made of up 57 Eastern Pacific islands, 287 Polynesian islands, 161 Micronesian islands, 341 Melanesian islands and 109 Non-Tropical islands to the north and south. It now includes additional sections on physical character and biology, land use and human impact, conservation status, and recommendations, as well as details of administration, population and area. A Format Sheet showing the layout of the Check List is attached in Annex 1. The List will be published as part of the Report of the Meeting in *Micronesica* which is due to appear at the end of 1969. It is envisaged that a revised definitive version should be prepared for issue on the conclusion of the International Biological Programme.

5. EXTENSION OF THE SURVEY TO OTHER OCEANIC AREAS

Although acitvity has so far been concentrated on the Pacific oceanic islands, it is proposed to extend the survey to the important Asian and Australasian offshore islands as

well as to the oceanic islands in the Indian and Atlantic Oceans. IUCN will be presenting a report on the Islands of the Eastern Indian Ocean to this meeting. Meanwhile approaches have been made to National CT Conveners in the USSR, Japan, the Philippines. Australia, Indonesia and Malaya inviting them to prepare a complementary list of offshore islands in time for the Twelfth Pacific Science Congress in 1971.

6. RESULTS OF THE CT/PM TECHNICAL MEETING, KOROR, PALAU AND GUAM

As well as reviewing the state of Pacific conservation the IBP/CT/PM Technical Meeting produced the Palau Declaration calling for wise use of the resources of the Micronesian islands (see Annex 3), a Resolution proposing international scientific supervision of a select series of uninhabited Pacific oceanic islands (Islands for Science—see Annex 2) and a total of 33 other Recommendations, of which 22 are Pan-Pacific in their application, 6 are related to specific areas and 5 are restricted to the Trust Territory. The Pacific Science Council, meeting at the Inter-Congress in Kuala Lumpur in May 1969, adopted a recommendation in the following terms:-

> *Welcoming* the recommendations of the Koror meeting, relating to the conservation under international scientific supervision or direct national action of listed uninhabited Pacific islands or portions of islands; *Recognising* that the proposed action is of particular concern to the Ecology Commission of IUCN as well as to the Standing Committee on Pacific Conservation of the Association, which is ready to take appropriate measures to help implementation; *Recognising* the significance of the Koror Recommendation calling for international scientific supervision of certain selected uninhabited islands following the precedent of the Antarctic Treaty; *Recommends* that the Governments concerned be urged to take appropriate action to implement the recommendations of the Koror meeting. *It is further recommended* that the IUCN in co-operation with other appropriate international organisations take steps to develop an international treaty or convention which extends to the Pacific islands conservation status similar to that provided for Antarctic islands by the Antarctic Treaty.'

Progress has already been made on a number of Recommendations. That on the threat to coral reefs of the Crown of Thorns Starfish *Acanthaster planci*, was rapidly taken up by the Guam Legislature. In December 1968 they allocated a special fund to the University of Guam for studies on *Acanthaster* under the leadership of Dr. R. H. Chester and a report on this work was published in *Science* July 18 1969 (165:280). The Recommendation protesting against phosphate mining in the Palau areas was forwarded to the U.S. Department of the Interior and in May 1969 it was learnt that the prospecting permits had been terminated. Other recommendations of a more general nature still awaiting action include that on 'Multi-Resource Land and Water Capability Classification', in which the fragility of island ecosystems is stressed and attention is drawn to the urgent need for resource surveys (see Annex 4), that calling for a campaign to search out and place on record indigenous conservation practices (see Annex 5), and a number of recommendations concerning National Parks including one on the establishment of the Palau Islands National Park, a recommendation for conservation of parts of the Bonin and Ryukyu Islands, and a request for a review of the Aleutian and Hawaiian Islands (see Annexes 6, 7, 8 and 9).

7. OUTSTANDING STAGES

There still remain two outstanding stages in fulfilment of the Eleventh Pacific Science Congress Resolution on the Pacific Islands Survey. These relate to an approach by IUCN to governments with recommendations for action and a review by the Twelfth Pacific Science Congress of the fulfilment of the 1966 Resolution.

In so far as uninhabited oceanic islands are concerned, there is by definition no currently effective enforcement agency on the spot and no existing strategic, economic or other interest to be specially safe-guarded. It therefore appears that, now a list of such islands of first-class importance for science has been drawn up with adequate supporting information and reasons, it should, as in Antarctica, be in principle open to discussion in-

ternationally whether a convention might be concluded, containing provisions similar to those already adopted for Antarctica by the twelve Antarctic powers, with the addition of certain policing arrangements similar to those in the Fisheries Conventions (see Annex 10). Such a convention may be envisaged as containing an initial list of islands agreed internationally to be safeguarded for science. Provision could if necessary be made for due notice to be given by any of the countries concerned for the withdrawal of any of the islands from the convention, if possible subject to the concurrence of the other signatory powers and of some appropriate international agency such as the Economic and Social Council of the United Nations. An alternative approach would be for the signatories voluntarily to agree to international supervision of conservation measures on the above lines, but on the basis that the islands concerned would be given conservation status legally, simply through the laws of the countries possessing them. No doubt various other approaches may be proposed.

8. RECOMMENDATIONS FOR ACTION

IUCN is therefore immediately requested to take up with interested Government the Koror Resolution on International Supervision of selected uninhabited Pacific islands so as to form a group of 'Islands for Science' as listed in Annex 2. This proposal can be seen as an extension of the 'Atoll for Science' project developed in the United States as a proposal to the United Nations. Action will also be requested on a number of the Recommendations of the Palau meeting. Provision has already been made for a half-day session on 'Conservation Status and Problems of Oceanic and Offshore Islands in the Pacific' as part of Symposium K 'Problems of Nature Conservation in the Pacific' at the Twelfth Pacific Science Congress meeting at Canberra in 1971. It is proposed that this meeting should cover the final review of the Pacific Islands survey and will assess the reports on the Pacific Offshore islands as well as the possibility of issuing a revised edition of the Check List of Oceanic Islands. It is essential that in the eighteen months between the Delhi and Canberra meetings the necessary processing with governments concerned should be completed by IUCN with a view to establishing by mid-1971 a firm list which the possessing governments are prepared to earmark as Islands for Science under adequately defined procedures and safeguards. It will then remain for the Canberra Congress to recommend practical means of establishing a generally acceptable international supervisory body of scientists and developing an international programme for conservation and research to put to good use the sites thus to be made available.

ANNEX 1

Format: Draft Check List of Pacific Oceanic Islands

1 Geocode and number	2 *Name* of islands/group CAPS( ) = inhabited and population small case = status not known or changeable small case = known to be uninhabited underlined	3 *Size* km^2 and hectares OR $mi.^2$ and acres	4 *Physical Character* Height Geology: volcanic, acid igneous, atoll, raised limestone. Reef Character Climate Vegetation: description and Fosberg Formation Units Botany: including Zoology: endemic spp rarities etc. Introduced species of plants and animals	5 *Past and Present land use* Prehistoric (pre 1770) 18th-19th Century 20th Century pre World War I World War I to end of World War II Post World War II	6 *Conservation Status* Existing conservation status Recommendations Expeditions and research programmes Publications
Example					
	(Marshall Islands, Micronesia)				
VHQJ 2	Bikar	0.2 $mi.^2$	Atoll, diamond shaped with three islets on reef. Low and dry. Veg: dense *Pisonia* forest, some *Tournefortia* and herbaceous plants. 1A15, lA16b, lB14a, 2B12, 2G12. Many seabirds forming important rookery, 18 spp. Important breeding ground for green turtle, *Cheleme mydas*	A few coconuts planted on Bikar islet. Visited for fishing and birds, probably protected by taboos in pre-European times. Atoll phosphate present.	List A, supposedly protected by order of District Administrator. F.R.Fosberg, *Atoll Res. Bull* 114, 35p. l966 F.R.Fosberg, U.S. Army Report, 1956

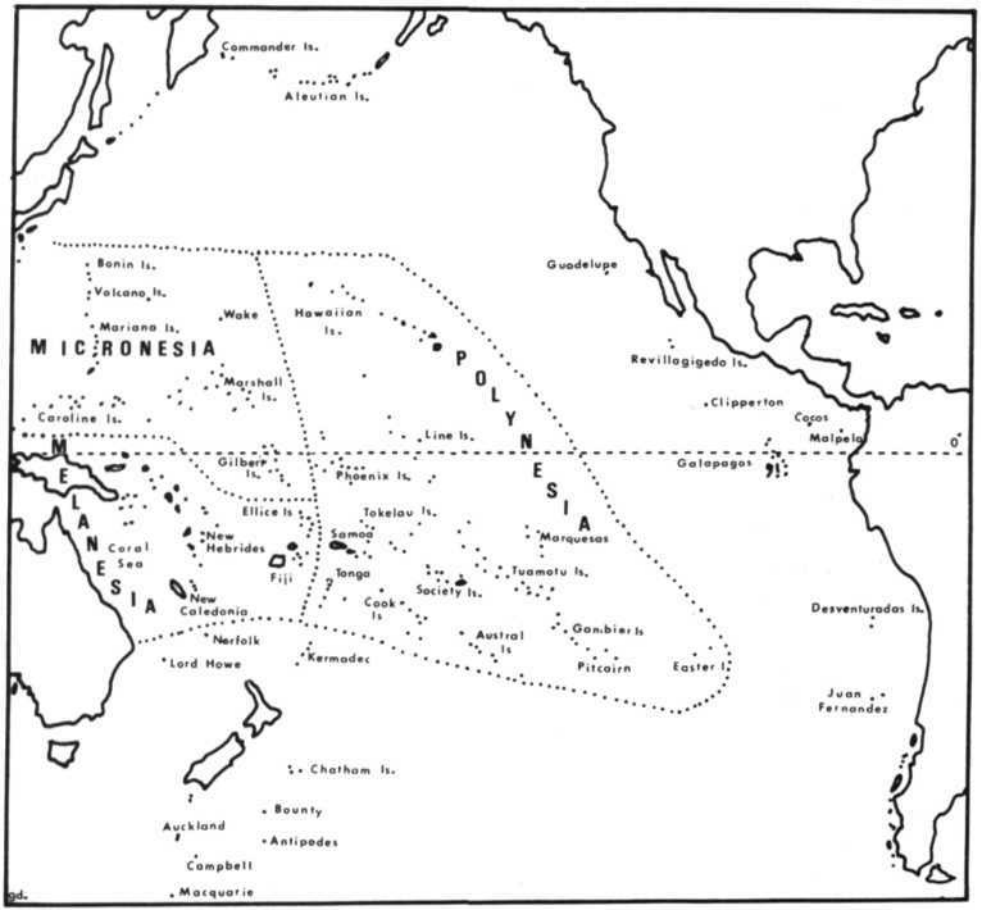
ANNEX 2

List of Islands Proposed for International Scientific Supervision

Ever since Galapagos served Charles Darwin so decisively in demonstrating the origin of species, the great value of undisturbed Pacific Islands as outdoor laboratories for science has been well known. Unfortunately, however, there has hitherto been no practical means of ensuring the conservation of remote unpeopled islands valuable for research. The remnant remaining are increasingly exposed to injury or destruction of their plant and animal life.

The need and the possibility of remedying this situation are being demonstrated both by growth of scientific activity and by the development under the Antarctic Treaty of acceptable methods of international group supervision over uninhabited territories for research and for conservation.

It is accordingly proposed that a select series of uninhabited Pacific oceanic islands should be designated with a view to international agreement so that (subject to due notice) they should be held intact and freely available for research by scientists of all nations. In this way their high significance and the common interest in their permanent use for the advancement of knowledge might be emphasized and made widely known, and their abuse by casual visitors discouraged. A proposed list of such islands as are recom-



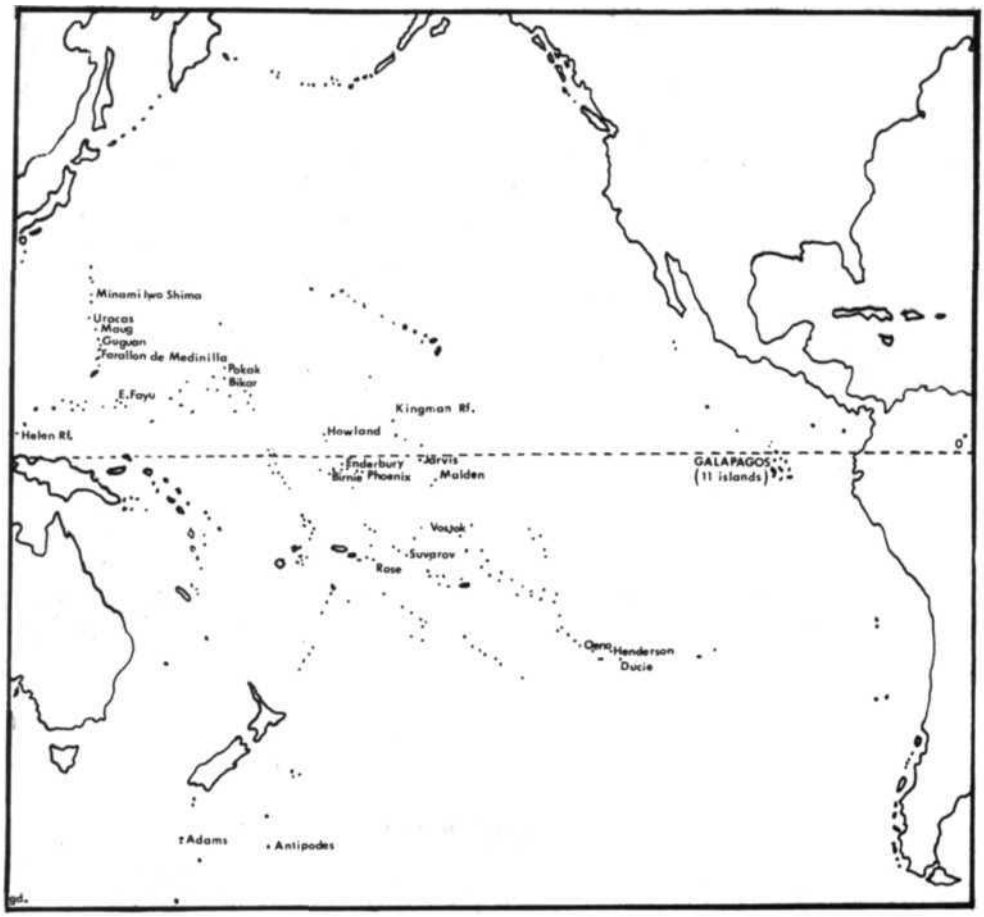
Pacific Oceanic Islands

mended for this purpose (with the ground for recommendation in each case*) is attached. (It is proposed that after further consultation certain Hawaiian islands should be added.)

List of Islands Proposed for International Scientific Supervision

Name	*Island Group*	*Administration*
Minami Iwo Shima	Volcano	Japan
Uracas (Farallon de Pajaros)	Mariana	Trust Territory
Maug	Mariana	Trust Territory
Farallon de Medinilla	Mariana	Trust Territory
Guguan	Mariana	Trust Territory
Helen Reef	Caroline	Trust Territory
East Fayu	Caroline	Trust Territory
Pokak Atoll (Taongi)	Marshall	Trust Territory
Bikar Atoll	Marshall	Trust Territory
Enderbury	Phoenix	US/UK joint
Phoenix	Phoenix	UK (Gilbert & Ellice)
Birnie	Phoenix	UK (Gilbert & Ellice)
Howland	—	US
Jarvis	Line	US
Maiden	Line	UK
Kingman Reef	Line	US
Vostok	Line	UK
Rose Atoll	American Samoa	US
Suvarov	Cook	Independent
Oeno	Pitcairn	UK
Henderson	Pitcairn	UK
Ducie	Pitcairn	UK
Adams	Auckland	New Zealand
Antipodes	—	New Zealand
Fernandina (Narborough)	Galapagos	Ecuador
Espanola (Hood)	Galapagos	Ecuador
San Salvador (Santiago) (James)	Galapagos	Ecuador
Pinzon (Duncan)	Galapagos	Ecuador
Darwin (Culpepper)	Galapagos	Ecuador
Wolf (Wenman)	Galapagos	Ecuador
Pinta (Abingdon)	Galapagos	Ecuador
Marchena (Bindloe)	Galapagos	Ecuador
Genovesa (Tower)	Galapagos	Ecuador
Champion	Galapagos	Ecuador
Gardner	Galapagos	Ecuador

* This is to be inserted at a later stage.



Islands for Science

ANNEX 3

'Palau Declaration' of the IBP Technical Meeting on Conservation of Pacific Islands, in Koror, Palau Islands, November, 1968

The islands of Micronesia possess many natural environments of rare quality and of special significance for world science, for education and for tourism. This treasured inheritance is in the immediate care of the Micronesian peoples and mostly within the scope of the Trust Territory Administration's responsibility to the United Nations. To make wise use of it and to conserve it for future Micronesians and their guests from overseas is an urgent challenge. It can be met if the undoubted goodwill and good intentions of Micronesians can be fully translated into practical legislation with the backing of public opinion and of adequate scientific research and practical measures of education, enforcement, and use and management of resources.

Micronesian citizens, scientists and representatives of the Trust Territory Administration meeting in Koror with visiting scientists associated with the International Biological Programme and the Pacific Science Association, are convinced that Micronesia has the capability for carrying through a first-class programme of conservation as a contribution to the balanced and prosperous development of the Trust Territory. Given adequate support such obstacles as exist could be surmounted without undue difficulty. We express the confident hope that this will soon be done.

ANNEX 4

Recommendation: Multi-Resource Land and Water Capability Classification

The *IBP* Technical Meeting *on Conservation of Pacific* Islands, meeting on Guam, November 26, 1968, NOTED that most areas of land and sea contain a variety of actual or potential resources, and hence can be put to a variety of uses. Some such uses are complementary, while others are exclusive.

It is accepted throughout the world that the most effective use of resources should be based upon land and water use capability classification, to assure that any projected resource use will not be a random matter determined by a quick profit for a few, but will take best advantage of the capabilities of the area and the needs of the people.

Island ecosystems are particularly fragile and vulnerable to abuse, and their resources, terrestrial and aquatic, are strictly limited. Therefore, it is particularly important that the use of their limited resources should be based upon the most rational foundation. Therefore, the Meeting:

1. Calls to the attention of the competent authorities the urgent need for resource surveys and land and water capability inventories;
2. Emphasizes that these surveys must not be based solely on agriculture or other 'cash crops' but must take into account all potential resources and needs (including recreational, scientific and touristic);
3. Urges that on the basis of these surveys, comprehensive multi-resource land and water use capability classification mapping or zoning be carried out—and adhered to—to provide guidelines for the further development of the Pacific Islands for the maximum benefit of their peoples.

ANNEX 5

Recommendation: on Recording Indigenous Conservation Practices

The IBP Technical Meeting on Conservation of Pacific Islands, meeting in Palau during November of 1968 *RECOGNISING* that ethnological studies have indicated that some of the indigenous Pacific Island cultures include features that are in reality conservation practices, whether in the guise of religion, social custom, taboos, or whatever, e.g. the Marshallese custom of setting aside bird and turtle sanctuaries, and *CONSIDERING* that knowledge of these practices is rapidly disappearing under the impact of western culture and whereas the application of knowledge of this sort may become critical to the future ability of islands to carry and support their expanding population on a fixed or decreasing resource base,

the meeting *RECOMMENDS* an immediate and vigorous campaign to search out and place on record as much information on indigenous conservation or conservation-related practices and customs as still available from local indigenous sources, as well as from ethnological literature.

ANNEX 6

Recommendation: on Palau Islands National Park

The IBP Technical Meeting on Conservation of Pacific Islands, meeting in Palau during November 1968, expresses warm appreciation of the successful initiative of the High Commissioner for the Trust Territory of the Pacific Islands through District Order 4. 56 establishing the Ngerukewid Islands Wildlife Preserve the 'Seventy Islands' in its primitive state, but urgently represents that:

1. This comparatively small reserve forms only a minor part of the uniquely rich series of rock islands, coasts and lagoon areas between Koror and Peleliu on the south and the ocean reef to the west, between approximately latitude 7°20'N and 7° 10'N.

2. This unique region plainly merits and requires permanent and secure conservation as an essential and outstanding example of the ecological scenery of the Pacific, as a refuge for many rare endemic plants and animals including threatened endemic birds as the Micronesian Megapode *Megapodius laperouse senex* and the Palau Scops Owl *Otus podarginus* both estimated to be under sixty pairs, and as an area for the scientific researches long conducted from Koror, the major expansion of which is now planned.

3. A National Park thus composed would exhibit features of land and water probably surpassing in scientific significance and in potential tourist attraction any other coastal National Park in the world; and

4. The creation of such a National Park on wholly publicly-owned land and water would strongly contribute to local prosperity for the foreseeable future. If necessary, the area could be zoned for scientific and tourist uses and for some present fishing activities.

The Technical Meeting accordingly *recommends* that:

5. Immediate action be taken by the High Commissioner and the Office of Territories to safeguard the integrity of this area pending thorough survey and demarcation of Park boundaries;

6. The approval of the Palau Legislature and the Congress of Micronesia be sought for the creation of such a Palau Islands National Park;

7. The IUCN International Commission on National Parks be invited to recognise the world importance and to assist in the planning and development of such a National Park, and to seek for it the approval of the United Nations and of the international organisations concerned.

ANNEX 7

Recommendation: on Conservation of Bonin Islands and Ryukyu Islands

The IBP Technical Meeting on Conservation of Pacific Islands, meeting in Koror, Palau Islands, during November 1968, *discussed* the increasing destruction by human activities in the Ryukyus, Bonin Islands and Io Islands and expressed concern over the lack of work for assisting natural recovery being carried on by administering authorities. The meeting *recognized* the urgent need for the reservation of undisturbed areas and the preservation of species in danger of extinction, and *discussed* the counter-measures for aiding natural recovery processes in damaged areas.

Therefore, the Technical Meeting RECOMMENDS that the Minister of Agriculture and Forestry, Minister of Education, Minister of Welfare and Governor of Tokyo give immediate attention to preserving the endemic biota, original vegetation and related habitats:

a. Designating strict reserves as soon as possible;

b. Prohibiting hunting and collecting of rare native plants and animals;

c. Prohibiting spraying large quantities of pesticides;

d. Prohibiting cattle raising;

e. Avoiding cultivation of crops which compete with the conservation of endemic organisms in specific islands (e.g. Bonin great bat *Pteropus pselaphon* versus banana).

The Technical Meeting further RECOMMENDS that H.E. the Prime Minister, H.E. the Governor of Ryukyu Islands and the Commander of U.S. Military Forces in the Ryukyus give attention to preserving islets as a whole (e.g.Senkaku Is.) or large areas including endemic biota, original vegetation and related habitats of Ryukyu Islands:

a. Designating strict reserves (each over 2, 000 ha);

b. Prohibiting clear cutting, burning, and introducing exotic tree species in specific islands (e.g. Iriomote Is., where a pulp company is said to be felling primeval forests);

c. Prohibiting the spraying of large quantities of pesticides;

d. Prohibiting cattle raising.

ANNEX 8

Recommendation: on Aleutian and Hawaiian Wildlife Reservation Areas

The IBP Technical Meeting on Conservation of Pacific Islands, meeting on Koror, November 1968, *expressed* grave concern over numerous reports of unilateral destructive actions by U.S. defence and nuclear agencies in disregard of the official status conferred on the majority of the northern uninhabited islands of Hawaii and of the western islands of the Aleutian chain within the Hawaiian and Aleutian Wildlife Reservation areas. The meeting was surprised and disturbed to learn that the Administration apparently does not support the Bureau of Sport Fisheries and Wildlife in carrying out its obligations to maintain these reserves. It was *RECOMMENDED* that the authority of other agencies to alter and damage these protected areas and their wildlife should be reviewed at the highest level, with a view to clear and definite new directives being given to prevent further violations.

ANNEX 9

Recommendation: on The Hawaiian Islands

The IBP Technical Meeting on Conservation of Pacific Islands, meeting in Palau during November of 1968, COMMENTING that the present national parks in the State of Hawaii, on the islands of Hawaii and Maui, form an admirable beginning of a series of preserved areas which should ultimately include good examples of all of the many natural environments in the Hawaiian Islands and which could afford protection to the very many endemic and threatened species of plants and animals, and NOTING with alarm the present tendency to introduce exotic game mammals and birds without adequate ecological knowledge, RECOMMENDS that:

1. A national park of substantial dimensions be established on the island of Kauai;

2. A State system of natural areas for scientific and conservation purposes be brought into being to protect examples of all important biotic communities for future study and enjoyment;

3. The proposal to introduce Axis Deer to the island of Hawaii and any other planned introduction of exotic game animals be immediately suspended;

4. A comprehensive study of the vegetational history and present ecological status of the various remaining natural terrestrial and marine habitats in the State be undertaken and carried to a point where the conservation needs of the State are clear; it is hoped that the proposed USIBP Terrestrial Hawaii Program will be funded and can carry out this provision.

5. Every feasible effort be made to protect and save from disappearance the many remarkable endemic plants and animals that make up the native biota.

ANNEX 10

Extract from paper 'Conservation in the Antarctic' by Dr.M.W.Holdgate presented at SCAR Symposium on Antarctic Ecology, Cambridge, July/August 1968

Conservation on the southern islands

The land areas north of 60°S, and within the area of interest of SCAR are not subject to the same universal conservation measures, and some indeed have no conservation legislation at all, despite their high scientific interest. Little or no economic crop is likely from these islands, apart from fishery in some inshore waters and the harvesting of the surplus production of male fur seals once stocks have risen to an appropriate level. Conversely, the potential return to scientific knowledge is very great. It may be assumed that for these land areas, as for the land south of 60°S, conservation should be directed largely to the protection of this scientific interest.

The conservation measures required for such islands are not unduly complex. They include:

(a) prohibition of the killing, capturing or molestation of native birds and mammals except under permit for scientific and analogous purposes, at a level which will not cause serious disturbance of the populations, and regulation by permit of the collecting of other animals and plants;

(b) prohibition of the importation of all alien mammals, because of the vulnerability of island vegetation to grazing and bird populations to predation by mammals, both of which are absent from the natural situation;

(c) prohibition of the importation of alien plants and invertebrates, as far as this is possible;

(d) prohibition of any avoidable disturbance of the island habitat, because alien plants, with their associated invertebrates have been shown to spread chiefly in places where the native vegetation has been disrupted by grazing, burning or trampling. Such alien species invade undisturbed vegetation much less readily.

Of these measures, (b) is the most important. Native bird and mammal populations can withstand a substantial level of culling by man, but are rapidly and irreversibly reduced by predation by rats, cats or dogs. Island vegetation, likewise, is well able to withstand a normal level of scientific collection, but liable to irreversible disruption, even with consequent erosion of soil, following grazing by rabbits, sheep or cattle.

It is evident that the general form of the Antarctic Agreed Measures could, with slight modification, likewise be applied to the uninhabited southern temperate islands, and South Africa has done this for Prince Edward and Marion Islands. It is desirable that nations exercising sovereignty over the other islands consider a similar step. The problem is, of course, a global one, and in this context it is significant that the CT Section of the IBP is sponsoring a world-wide survey of oceanic islands of scientific interest, in which SCAR is being asked to participate. Such a survey will place the southern islands in a wider context and help confirm the priorities for conservation.

Section D (1)

The Eastern Indian Ocean Islands

A SUMMARY OF THEIR GEOGRAPHY, FAUNA AND FLORA

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The following notes represent a first attempt to summarise essential data on the geography, fauna and flora of the tropical eastern Indian Ocean islands as a basis for the future planning of conservation in this area.

The information given is based on the latest generally available published sources; but there may well be less easily available publications which have been overlooked. On the basis of this information, it should at least be possible to determine the broad prorities of conservation effort in the tropical eastern Indian Ocean; thereafter the need will be for local surveys and for the assistance of local experts. For this reason, no attempt has been made to designate particular islands as of special importance among others in a group, except in cases where their claim is indisputable (e.g. North Keeling).

The information is arranged under the same main headings as are being used for the IBP/CT International Conservation Programme for the Pacific Islands.

LACCADIVE ISLANDS

Position

About 10-14° N., 72-74° E.; 190 km west of the Malabar coast of India, 180 km north of the Maldives.

Size

The archipelago consists of 24 small coral islands, none of them of more than 5 sq.km in extent or more than about 5 m high. The total land area is c. 28 sq. km.

Physical character

Typical coral atolls, arranged in three lines running more or less north and south; the elevated parts of the atolls (the islands) being generally on the eastern side of the ring. Coral reefs more or less exposed at low water.

Climate

Monsoon climate, with S.W. monsoon April-July and N.E. monsoon November-January.

Vegetation

The natural vegetation was apparently a thick, low jungle, with possibly only five indig - enous arboreal species. The native flora is very poor, consisting mostly of pantropical species.

The natural vegetation has now been extensively cleared, and most of the land surface is under coconut cultivation; there is little other cultivation. (The coconut palm itself was probably originally present, and the reason for the human settlement.)

Zoology

The land fauna is very poor and, as far as known, shows no endemism.

Mammals, *Mus musculus* (Indian form); no other species.

Birds. A few common Indian land-birds breed, and the islands are visited by migrants, of which the full list has certainly not been recorded. Three widespread species of sea-birds breed or probably breed (*Sterna bergii, S.fuscata* and *Anous stolidus),* but the sea-birds have been little investigated.

Past and present land use

Almost exclusively coconut cultivation. The islands have been known for a long time, and have been permanently inhabited at least since the 16th century. Ten of the 24 islands are inhabited. The present population is about 24, 000.

State of scientific knowledge

The botany is well known, the land fauna (in view of its paucity) probably adequately known; but the status of the sea-birds requires investigation.

The main references used in preparing this account are as follows:

HUME, A. O. 1876. The Laccadives and the West Coast. *Stray Feathers* 4: 413-483

PRAM, D. 1892-1894. Botany of the Laccadives, being natural history notes from H.M.I.S Survey Steamer 'Investigator', Commander R. F. Hoskyn, R. N., Commanding. *J. Bombay Nat. Hist. Soc,* 7: 268-295, 460-486; 8: 57-86, 488.

ROBINSON, W. 1847. Description of the Laccadive Islands. Madras *J. Lit. Sci.*14: 1-46.

WATSON, G. E., R. L. ZUSI and R.E. STORER. 1963. Preliminary Field Guide to the Birds of the Indian Ocean, Smithsonian Institution.

MALDIVE ISLANDS

Position

About 1-8° N., 72-74° E., c. 650 km southwest of Ceylon, 180 km south of the Laccadive Islands (110 km from Minikoi, lying between the Maldives and the Laccadives), and 1000 km north of the Chagos Archipelago.

Size

The archipelago consists of a double chain of 19 atolls and a number of other isolated islands, totalling over 2500 islands (of which not more than about 220 are permanently inhabited). No island is more than a few square kilometres in extent, and none is more than about 2 m above sea level. The total land area is 298 sq. km.

Physical character

All of the 19 atolls are very similar: interrupted peripheral reefs, on the higher sections of which long, low islands have been formed; enclosing a wide shallow lagoon generally dotted with small islets and coral sand banks; geologically relatively recent.

Climate

Monsoon climate, with S.W. monsoon April-July and N.E. monsoon November-January. Rainfall ample and well distributed, 90-100 inches. Addu Atoll, at the southern end of the chain, has a less seasonal climate with higher rainfall.

Vegetation

The natural vegetation consisted mainly of evergreen forest, with some large trees, growing on a humus formed by rotting vegetation. Many islands have central marshy areas fringed with extensive reed-beds, rank grass and matted pandanus brakes. There were, apparently, no endemic plants, most being familiar Lido-Malayan coastal species.

This natural vegetation has now been extensively cleared, and the islands are largely covered with coconut palms growing among luxuriant low shrub, apart from airfield installations on Gan and Hitaddu. Many trees have been introduced (e.g. bread-fruit, mango, figs).

Zoology

The fauna is closely related to that of the Indian peninsula and is poor in species. Few species have been isolated long enough to have differentiated.

Mammals: Only two native mammals have been recorded, the flying foxes *Pteropus giganteus ariel* (apparently on all atolls) and *Pt. hypomelanus maris* (on Addu Atoll; status uncertain, as not found on latest visit in 1958-9). Both are endemic subspecies. *Rattus rattus, Mus musculus, Suncus murinus* and, on several islands *Oryctolagus Cuniculus* have been introduced.

Birds: There are only four native land-birds, as follows: House Crow (*Corvus splendens*), Koel *(Eudynamis scolopacea* and two rails *Gallicrex cinerea* and *Amaurornis phoenicurus.* Of these, *C. splendens* and *A. phoenicurus* are represented by endemic subspecies. All these species seem to be reasonably abundant.

There are three breeding species of herons, two represented by endemic subspecies, and 13 known or probable breeding species of sea-birds, none endemic. In addition, about 100 specimens of non-breeding visitors have been recorded, mainly migrants from the north; and further observation will doubtless add to the list.

Reptiles: Five species of lizards and three of snakes have been recorded, none of them endemic, and one sea-snake. One species of tortoise has been introduced. Three species of sea turtles probably nest.

Amphibians: One species, *Bufo melanostictus,* presumably introduced.

Past and present land use

Most of the land surface has been devoted to coconut plantation for many years, copra and coir rope being the chief export. Some fishing is also carried out. The human population was 96, 400 in 1963.

An air base was constructed on Gan during the Second World War, and much of the original vegetation was removed. Further clearance took place in 1957, when a British Air Force staging post was established. Similar but less extensive clearance has taken place on the southern part of Hitaddu.

State of scientific knowledge

The fauna has been recently investigated and is comparatively well known, except for the sea-birds whose breeding status needs further attention.

The main references used in preparing this account are as follows:

DERANIYAGALA, P. E. P. 1956. Zoological collecting at the Maldives in 1932. *Spolia zeylan.* 28: 7-15.

GARDINER, J. S. (ed.) 1903. The Fauna and Geography of the Maldive and Laccadive Archipelagoes. Cambridge Univ. Press.

PHILLIPS, W.W. A. 1958. Some observations on the fauna of the Maldive Islands. Part 1. Introduction. *J.Bombay Nat. Hist. Soc.* 55: 1-3; and subsequent papers in the same journal, by Phillips, Hill, Phillips and Sims, and Palmer, 1958-63.

STODDART, D. R. (ed.) 1966. Reef studies at Addu Atoll, Maldive Islands. *Atoll Res. Bull.* No. 116. Washington, D.C.: Pacific Science Board.

WATSON, G. E., R. L. ZUSI and R. E. STORER. 1963. Preliminary Field Guide to the Birds of the Indian Ocean. Smithsonian Institution.

WILLIS, J. C. and J. S. GARDINER. 1901. The Botany of the Maldive Islands. *Ann. Roy Bot. Garden Peradeniya* 1: 45-164

CHAGOS ARCHIPELAGO

Position

5° 20'-7° 35' S., 71° 20'-72° 40' E.; about 380 km south of the Maldive Islands, 1450 km from the southern tip of India, and 1600 km east of the Seychelle Islands.

Size

The archipelago consists of four atolls and extensive reefs, with a total land area of about 65 sq.km.

Physical character

Low-lying flat sand-cays or elevated reefs, without any surface water.

Climate

S.E. (occasionally S.W.) trade winds blow from April to October. During the remainder of the year, winds are more variable. Dry season typically April-October, wet season November-March; but variable. Total annual rainfall c.2500 mm.

Vegetation

Native vegetation was thick shrub; now very largely replaced by coconut palms.

Zoology

Apparently no native mammals. Cats and rats now established on Diego Garcia.

Birds: The eight land birds which occur, or have occurred, may all have been introduced by man. None shows subspecies differentiation, so far as known. A small heron (*Butorides striatus*) and probably a rail (*Gallinula chloropus*) also occur, the former being a poorly marked endemic subspecies.

Ten species of sea-birds breed or probably breed; the status of several of them needs further investigation.

Past and present land use

Much of the land surface is covered with coconut plantations, on which the human population is mainly dependent (population in 1960: 400 on Diego Garcia, 200 on Peros Banhos, 150 on Salomon).

State of scientific knowledge

Scanty,

The main reference that have been used in preparing this account are as follows:

LOUSTAU-LALANNE, P. 1962. The birds of the Chagos Archipelago, Indian Ocean. *Ibis* 104: 67-73.

RIPLEY, S.D. 1969. Comments on the Little Green Heron of the Chagos Archipelago. *Ibis* 111: 101-102.

ANDAMAN ISLANDS

Position

10° 30'-13° 30' N., 91°-92° E.; about 270 km south by west of Cape Negrais, Burma, and 150 km north of Car Nicobar. Small off-lying islands, not included within the latitude and longitude ranges given above, include: Preparis Island and the Coco group (between North Andaman and Cape Negrais), Narcondam Island (130 km east of North Andaman) and Barren Island (100 km east of Middle Andaman).

Size

The archipelago consists of 204 islands, totalling about 6400 sq.km, the three largest islands (North, Middle and South Andaman) being all very much the same size, 64-80 km long and 20-25 km wide.

Physical character

Main group: undulating, with narrow steep-sided valleys; highest point 732 m (Saddle Peak, North Andaman). A continuation of the mountains of the Arakan Yoma of Burma; consisting

mainly of Tertiary sandstones, also limestones, calcareous sandstones and indurated clays, with intrusive metamorphic rocks. Fringing reefs well developed, especially in the northern islands.

Barren Island (c.8 sq.km) is a vast crater about 360 m high, with a newer cone about 310 m high rising from the middle. Narcondam is volcanic, but with no crater, about 11 sq.km and about 730 m high. The sea bottom slopes steeply down round both islands, and there are no reefs.

Climate

Monsoon climate, with rains early May-early November. Annual rainfall varies from about 2800 to 4320 mm in different areas.

Vegetation

Mainly evergreen tropical forest; very rich, with some endemics, but mainly composed of Malayan and Burmese species (rather than Indian); Dipterocarps prominent among the larger trees. The flora is probably still incompletely known.

Some common weeds and cultivated plants have been introduced, but the vegetation is so far little effected by introductions over the great part of the archipelago.

Zoology

There is a fairly rich fauna, mainly with Burmese-Malayan affinities. At least in the vertebrates, endemisn is mainly at the subspecific level.

Mammals: 23 species of land mammals have been recorded, as follows:
Insectivora. Two endemic species of *Crocidura.*
Chiroptera. Twelve species, including 6 endemic subspecies and one endemic species.
Primates. A monkey, *Macaca nemestrina leonina,* introduced.
Carnivora. One endemic subspecies of palm civet, and one introduced species, the Jungle Cat.
Artiodactyla. The wild pig occurs and has been described as a distinct subspecies, but it may have been introduced.
Rodentia. Six forms of *R. rattus* have been described, but their systematic status is problematical. *Mus musculus* is introduced.
The Dugong, *Dugong dugon,* also occurs, but little is known of its present status.

Birds: About 80 species breed, or probably breed. There are six endemic species (a rail, an owl, a hornbill, a drongo, a starling and a tree-pie), and two other species are confined to the Andamans and Nicobars (two pigeons). The hornbill, *Rhyticeros narcondami,* is restricted to the off-lying volcanic island of Narcondam, the only vertebrate known to be so restricted, and has a total population estimated at c. 200 in 1902 (since when there have been no further reports).
41 subspecies are confined to the Andamans, and a further 14 are shared with the Nicobars.

Reptiles: 42 land species were recorded in 1941, and there have since been a small number of additions. The gecko *Phelsuma andamanense* is of special interest, as its relatives are Madagascan, and not Oriental as is the general rule.

Past and present land use

A very small population of primitive hunters and food gatherers was established on the islands when they were first discovered (the Jerwa on North and Middle Andaman, and the Onges on Little Andaman).

Unsuccessful attempt at colonisation made 1789-96; then no further attempts until 1858, when a penal colony was established (discontinued in 1945). Forest was cleared around Port Blair in the 19th century. Recently there has been some development of forestry, with labour imported from India, and forest has been cleared for settlement of refugees in North and Middle Andaman. But in general, the vegetation, and presumably the animal life, has been very little affected over the greater part of the islands. The Jerwa are

unfriendly to the Indian administration, and large parts of North and Middle Andaman are seldom or never visited. The total population is about 49, 000.

Note: Off-lying islands:-

Barren Island

Information based on Prain's visit in 1891. Forest on outside of main crater; thinner on the inside; new middle cone mainly barren. Has never been inhabited, and few landings have been made. No endemic known.

Narcondam Island

Information based on visits by Hume in 1873, Prain in 1891, and Osmaston in 1904. Densely clothed with forest, but no vauable timber trees found. Figs very numerous, and fruit-eating birds abundant. Population of endemic Narcondam Hornbill estimated as 200. No other endemics known.

Plantains introduced, probably in 1866, but no other plant introductions known before 1891 (pineapple had been tried but failed). Prain himself introduced pawpaw.

Goats and fowls had been put ashore some years before 1873, but no sign of them in 1873.

Earliest landing of which there is an account was 1873. The island has never been inhabited, and is still virtually untouched.

Coco Group

Information based on visits by Hume in 1873 and Prain in 1890:

Main group: (Great Coco, c. 39 sq. km; Little Coco, c. 3 sq.km; Table Island, c. 3 sq.km). Uninhabited, except for Table Island, which has a lighthouse. Natural vegetation forest; fringing reefs. Forest partly cleared on Table Island, and a small abandoned clearing on Great Coco; otherwise vegetation untouched. Introductions: pigs on all islands, 1890-91; pariah dogs on Great Coco, 1890; domestic fowl on Great Coco, 1873; cattle (not feral) on Table Island.

Coconut palms (from which the islands get their name) present when first visited by Europeans; possibly introduced even earlier.

No endemic plants or animals recorded.

Preparis (80 km north of main group, c. 2 sq.km). Low and flat, covered with thick stunted tree jungle; surrounded in all directions by very extensive fringing reefs, partly uncovered at low tide. Uninhabited and seldom visited. No endemics reported.

State of scientific knowledge

The flora has been well investigated, but probably some new forms remain undiscovered. Reliable but inadequate information exists for the vertebrate groups, the birds being probably the best known.

The main references used in preparing this account are as follows:

ABDULALI, H. 1962. The wild pigs in the Andamans. *J. Bombay Nat. Hist. Soc.* 59: 281-283.

ABDULALI, H. 1965. The birds of the Andaman and Nicobar Islands. *J. Bombay Nat. Hist. Soc.* 61: 483-571

ABDULALI, H. 1967. The birds of the Nicobar Islands, with notes on some Andaman birds. *J.Bombay Nat.Hist. Soc.* 64: 139-190

HUME, A. O. 1874. The islands of the Bay of Bengal. *Stray Feathers* 2: 29-324.

MILLER, G.S. 1902. The mammals of the Andaman and Nicobar Islands. *Proc. U.S.Nat. Mus.* 24: 751-798.

OSMASTON, B. B. A visit to Narcondam. *J. Bombay Nat. Hist. Soc.* 16:620-622.

PARKINSON, C.E. 1923. A Forest Flora of the Andaman Islands. Simla.

PRAIN, D. 1890. The non-indigenous species of the Andaman flora. *J.Asiatic Soc. Bengal* 59: 235-261.

PRAIN, D. 1891. The vegetation of the Coco group. *J.Asiatic Soc. Bengal* 60: 283-406.

PRAIN, D. 1893. On the flora of Narcondam and Barren Islands. *J. Asiatic Soc. Bengal* 62: 39-86.

THOTHATHRI, K. 1960. Studies on the flora of the Andaman Islands. *Bull. Bot. Survey India* 2: 357-373.

THOTHATHRI, K. 1963. Contributions to the flora of the Andaman and Nicobar Islands. *Bull. Bot. Survey India* 4: 281-296.

NICOBAR ISLANDS

Position

6° 45'-9° 12' N., 92° 30'-94° E; 150 km south of Little Andaman, and about 130 km north-west of the northwestern extremity of Sumatra.

Size

The archipelago consists of 22 islands, totalling about 1900 sq. km, the largest being Great Nicobar (c. 860 sq. km).

Physical character

Low-lying, with hilly plateaux and ridges; highest point 639 m. The northern group (Nankowry, Kamorta, Trinkut, Teressa, Tillangchong, Car Nicobar, and the small islands near them) consist of plutonic and metamorphic rocks and alluvial deposits. The southern group (Great and Little Nicobar, Katchall and adjacent islets) are characterised by the predominance of calcareous sandstones.

Some of the islands have fringing reefs.

Climate

Monsoon climate, with rains May-November. Annual rainfall varies from about 2290 to 3430 mm.

Vegetation

Northern group: plateaux and ridges covered mainly with park-like heaths; forest restricted to plutonic rocks and older alluvium. Southern group: mainly covered with evergreen forest. Also, on both groups, mangrove forests (not distinct from others of tropical Asia) and beach forests or dune forests in a belt up to 1 km wide round the coasts (dense, with small trees; now extensively replaced by coconut palms in inhabited areas).

Evergreen forest rich in trees, but incompletely explored and no estimate of endemism yet possible.

Zoology

The vertebrate fauna, which is not very rich in species, shows a good deal of endemism at a low taxonomic level, and this is probably true for the invertebrates also.

Mammals: The native (or probably native) species include 3 insectivores and 10 bats. The only large mammals are a monkey, *Macaca irus,* and the wild pig, *Sus scrofa,* both probably introduced but described as local subspecies.

Birds: About 50 species breed, or probably breed. There are two endemic species, the parakeet *Psittacula coniceps* and the bulbul *Hypsipetes nicobariensis,* and two other species which are confined to the Nicobars and Andamans. 29 subspecies are confined to the Nicobars, and another 14 are shared with the Andamans. The degree of subspecific differentiation in widespread species is slightly greater in the Nicobars

than in the Andamans, in accord with their greater geographical isolation, and some species have more than one Nicobar subspecies.

Abdulali has drawn attention to the apparent decrease in numbers of some Nicobar birds in the last hundred years, but this point needs further study.

Reptiles: 33 land species have been recorded, about 25 of which are endemic forms. The pit vipers of the genus *Trimeresurus* are of a special interest, with four species, as nowhere else is such variety in colour and scalation found.

Past and present land use

When first discovered, the islands were inhabited by a primitive tribe, the Shompens, of Malayan origin. Some of these people still survive in their original state in the interior of Great Nicobar, and have little contact with the Indian authorities. Much of the coastal area of the islands (the area of the beach and dune forests) has been planted with coconut palms and there are numerous villages. The population was estimated as about 5000 in the 1860s, and is now about 14, 500.

The interior of Great Nicobar has been least affected by human exploitation, and its forests have been little investigated.

State of scientific knowledge

Reliable and fairly complete information exists on the land vertebrates; but the forest flora is still incompletely known.

The main references used in preparing this account are as follows:

ABDULALI, H. 1965. The birds of the Andaman and Nicobar Islands. *J. Bombay Nat. Hist. Soc.* 61: 483-571.

ABDULALI, H. 1967. The birds of the Nicobar Islands, with notes on some Andaman birds. *J.Bombay Nat. Hist. Soc.* 64: 139-190.

KURZ, S. 1876. A sketch of the vegetation of the Nicobar Islands. *J.Asiatic Soc. Bengal* 45: 105-164.

RIPLEY, S. D. 1961. A synopsis of the birds of India and Pakistan. Bombay Nat. Hist. Soc.

SAHNI, K. C. 1953. Botanical exploration in the Great Nicobar Island. *Indian For.* 79: 3-7.

SMITH, M. A. 1941. The herpetology of the Andaman and Nicobar Islands. *Proc. Linn. Soc.* 153: 150-158.

SRINTVASAN, K. S. 1960. On the fore-shore vegetation of Malacca coast of the Car Nicobar Island. *Bull. Bot. Survey India* 2: 15-25.

THOTHATHRI, K. 1960. Botanical exploration in Car Nicobar and Nancoury Islands. *Bull. Bot. Survey India* 2: 341-346.

THOTHATHRI, K. 1963. Contributions to the flora of the Andaman and Nicobar Islands. *Bull. Bot. Survey India* 4: 281-296.

CHRISTMAS ISLAND

Position

10° 30' S., 105° 35' E.; c. 350 km from Java, 1400 from Australia, separated from both by depths of more than 5000 m.

Size

135 sq. km.

Physical character

Raised coral atoll, max. height c. 340 m, rising in a series of cliffs and terraces to a central plateau. Submarine slopes very steep; narrow fringing reef at two levels, the upper one partly dry at low water in a few places and the lower one about 4 m lower. Much of

the top of the island is covered with a bed of blocks of phosphatic rock or (where weathered) with block fragments of phosphate—nearly pure phosphate of lime, probably derived from fossil guano beds. Nearly the whole of the coast formed of steep cliffs (10-15 m); only a few small beaches.

Climate

Seasons not well marked. Rainfall very variable. Dry season typically July-October, with steady S.E. trade winds.

Vegetation

The whole island completely covered with evergreen forest, untouched until 1888. Some areas have been cleared for opencast phosphate mining, and there has been minor clearance for cultivation. Coconut palms, date palms, bamboo, sugar cane, banana and many other tropical crops have been introduced since settlement (see below), and tracks have been cut through the forest; but the greater part of the vegetation remains unaltered.

Zoology

Native fauna very limited, as a result of the island's oceanic origin and considerable distance from other land. The few native mammals have suffered badly from alien introductions, but the birds and reptiles have been relatively unaffected. Nothing is known of changes in status of any other animals.

Mammals: Five native species, three of which appear to be extinct.

Pteropus melanotis natalensis (fruit bat), endemic subspecies, abundant.

Pipistrellus murrayi (bat), endemic species.

Crocidura trichura (shrew), endemic species (or perhaps subspecies of *C. fuliginosa),* apparently extinct.

Rattus macleari (rat), endemic species, apparently extinct.

Rattus nativitatis (rat), endemic species, apparently extinct.

The extinction of these two rats was apparently caused, not by direct competition with the introduced *Rattus* spp. (see below), but by some other factor connected with their introduction (perhaps introduced pathogens), since the native rats had disappeared by 1908, before the introduced rats had spread widely through the island.

The following mammals have been introduced: *Rattus rattus* (by 1898), *R. concolor* (date?), *R. norvegicus* (date?), *Mus musculus* (between 1897 and 1939).

Birds: Eighteen breeding, or probably breeding, species, of which one is introduced (Java Sparrow *Padda oryzivora)* and one is recently established (Australian Kestrel *Falco cenchroides).* The remaining 16 species consist of 7 land birds, all of them endemic at the subspecific (6) or specific (1) level, and 9 sea birds. The latter include two species of particular importance, and one striking endemic subspecies:

Sula abbotti (Abbott's Booby), which now breeds only on Christmas Island. There was apparently a former colony on Assumption Island in the western Indian Ocean. Population estimates of 500-750 pairs in 1938-40, and of 100 pairs in 1960-64, were almost certainly underestimates. A special study of this species by Dr. J. B. Nelson in 1967 showed that there are probably about 2, 000 breeding pairs.

Fregata andrewsi (Christmas Frigatebird), which is only known to breed certainly on Christmas Island, though some may do so on islands off-lying Java, to the north. The breeding population was estimated at 1, 000-1, 500 pairs in 1938-40.

Phaethon lepturus fulvus (Yellow-billed Tropicbird), a very distinct and strikingly coloured subspecies endemic to Christmas Island. The breeding population was estimated as 300-450 pairs in 1938-40, and probably the same in 1960-64.

Reptiles: The native reptile fauna consists of only six species, so far as known: 5 lizards and one snake. Four are endemic, at least at the subspecific level; the other two

occur also on Java. In addition, a gecko, *Hemidactylus frenatus*, has been introduced (probably after 1898), and has spread into the forest.

In addition to the introductions mentioned above, many invertebrates have been introduced unintentionally by man. Nothing is known of their impact, if any, on the native invertebrate fauna, which is a rather limited one.

Past and present land use

Christmas Island was uninhabited when discovered (1643). Up to 1888, it was seldom visited, and there were few attempts to land.

From 1888 to 1897, there was a small colony of Cocos Keeling Malays settled in, and virtually confined to Flying Fish Cove, the only safe landing place. Some introduced terrestrial arthropods certainly arrived.

In 1897, with the formation of the Christmas Island Phosphate Company, the settlement began to expand, and paths were cut through the forest. Cultivation was extended, forests began to be cleared in some areas, and more important changes in the fauna and flora began.

The situation is essentially the same today. Some extensive areas have been cleared of forest and the underlying phosphate removed, leaving bare scars. The human population is about 3,400 (1966).

Conservation

All the birds are protected by law by the Australian Government, and the protection is reported to be effective.

State of scientific knowledge

There are reliable, relatively complete, and up-to-date records of the birds; and reliable but less up-to-date records of the mammals and reptiles. The main references consulted in preparing this account are as follows:

ANDREWS, C.W. 1900. A monograph of Christmas Island (Indian Ocean). London: British Museum (Natural History).

CHASEN, F. N. 1933. Notes on the fauna of Christmas Island, Indian Ocean. *Bull. Raffles* Mus.,No. 8: 51-54; and other papers in the same issue by Chasen *et al.*, on the topography, birds, Geometridae, butterflies and other insects (pp. 54-101).

GIBSON-HILL, C. A. 1947. Notes on the birds of Christmas Island. *Bull. Raffles Mus.*, No. 18: 87-165; and other papers in the same issue by Gibson-Hill *et al.*, on the nature of the coast, climate, and various animal groups.

GIBSON-HILL, C. A. 1949. The early history of Christmas Island, in the Indian Ocean. *J. Malayan Branch Royal Asiatic Soc.* 22: 67-93.

PEARSON, A. J. 1966. The birds of Christmas Island (Indian Ocean). *Bull. Brit. Orn. Club* 86: 66-71.

VOOUS, K. H. 1964. Notes on a collection of birds from Christmas Island. *Nytt. Mag. Zool.* (Oslo) 12: 38-47.

WATSON, G. E., R. L. ZUSI and R. E. STORER. 1963. Preliminary field guide to birds of the Indian Ocean. Washington: U.S. National Museum.

COCOS-KEELING ISLANDS

Position

11° 49'-12° 12' S., 96° 49'-96° 56' E.; about 960 km southwest of Java Head, and 850 km west-by-south of Christmas Island, the nearest land.

Size

The archipelago consists of two parts: the main atoll, consisting of 25 islands surrounding a broad central lagoon which is partly open to the north and north-west; and sepa-

rated by 15 miles of open sea, a small single island (North Keeling), nearly enclosing a central lagoon which is open to the east. The islands of the main atoll range in size from a few metres long to about 10 km, the total land area being about 14 sq. km. North Keeling is about 1 × ½ km and has an area of about 100 ha.

Physical character

Main atoll: low coral atoll (maximum height about 13 m), with steep seaward beaches and gentle slopes down to very shallow lagoon. Islands consist of broken coral; no true soil, but thin layer of decayed vegetable matter and powdered sand. Some dunes of blown sand (including the highest point). Central lagoon with much living coral.

North Keeling: low coral atoll (maximum height about 5 m), with fairly steep seaward beaches rising to a peripheral ridge, from which the ground slopes down gently to a shallow, sandy-bottomed lagoon.

Climate

Seasons not well-marked. Rainfall variable, both annually and in seasonal distribution (mean annual rainfall 1960 mm); January-June usually wettest, September-October driest. Southeast trade winds blow for most of the year.

Vegetation

Most of the islands covered with dense vegetation, mostly coconut palm, which was present but probably less abundant before the islands were settled, also circumtropical shore trees and bushes. Pulo Luar (the northernmost and most isolated island of the main atoll) has its own lagoon, flanked with mangroves. On the islands of the main atoll the other trees have been extensively cleared to allow coconut palms to spread, but the natural vegetation of Pulo Luar and North Keeling has been much less affected.

Zoology

Native fauna very limited. Probably no native mammals, and only one native land-bird. In addition to the important littoral (especially coral) fauna, the main zoological importance of the islands is as a breeding station for sea-birds.

Mammals: *Pipistrellus murrayi* (otherwise known only from Christmas Island) has been reported, but its status is uncertain. All other mammals are certainly introduced: *Rattus rattus, Mus musculus,* and formerly (on Pulo Luar only) Javanese and Muntjac Deer, which have now been removed.

Birds: Seventeen breeding species, of which four are known to have been introduced (*Gallus varius, Turdus javanicus, Zosterops natalis, Padda oryzivorus).* The remaining 13 consist of 12 sea-birds and one land-bird, the endemic rail *Rallus philippensis andrewsi.* North Keeling and, secondarily, Pulo Luar, are the most important stations for the breeding sea-birds, as also for the rail. There are no endemic forms among the sea-birds (unless *Fregata ariel* and *F. minor,* whose systematic status is uncertain, turn out to be endemic forms). The following estimates of numbers of breeding sea-birds were made in 1941:

Sterna fuscata (Sooty Tern): North Keeling only, not abundant.
Anous stolidus (Brown Noddy): North Keeling, large numbers; a few pairs on Pulo Panjang.
Gygis alba (White Tern): North Keeling, probably 100-300 pairs; Pulo Luar, probably 100-300 pairs; and 2-3 pairs on Pulo Tikus.
Puffinus pacificus (Wedge-tailed Shearwater): North Keeling only, considerable numbers.
Sula dactylatra (White Booby): North Keeling only, 40-50 pairs.
Sula leucogaster (Brown Booby): North Keeling only, 75-100 pairs.
Sula sula (Red-footed Booby): North Keeling only, 3500-4000 pairs.
Fregata ariel (Least frigatebird): North Keeling only, 750-1000 pairs.
Fregata minor (Great Frigatebird): North Keeling only, 1000-1250 pairs.
Phaethon rubricauda (Red-tailed Tropicbird): Pulo Luar only, one pair.
Phaethon lepturus (White-tailed Tropicbird): North Keeling and Pulo Panjang, small numbers

Reptiles: Seven species have been recorded: two turtles, a sea snake, a land snake, and three geckos. Of the turtles, *Chelonia mydas* bred (in 1941) in considerable numbers on North Keeling, and in small numbers on islands of the main atoll; and *Eretmochelys imbricata* in small numbers on North Keeling. The three geckos and the land snake *(Typhlops braminus)* are non-endemic and could have been introduced. The sea snake *(Pelamis platurus)* is apparently a straggler to the islands.

Past and present land use

The Cocos-Keeling Islands were uninhabited when discovered (probably 1609), and remained uninhabited until 1827, when a settlement was established on islands in the main atoll. Population: 1912, 594; 1931, c. 1100; 1941, c. 1450; 1949, c. 1800; 1966, 684; mostly on Pulo Selma. A relay telegraph station was established on Pulo Tikus in 1901. The British Air Force had a large base on Pulo Panjang in 1944, now abandoned. North Keeling has remained uninhabited.

Extensive cultivation of coconuts is carried out on islands of the main atoll, and some other crops have been introduced (especially *Muntingia* (tropical cherry) and *Carica papaya).*

Apart from reducing the native vegetation, human settlement of islands of the main group has led to the disappearance of most of the sea-birds which used to breed there.

State of scientific knowledge

There is reliable and, up to 1949, relatively complete knowledge of the vertebrates, and less complete knowledge of the invertebrates.

The main references consulted in preparing this account are as follows:

GIBSON-HILL, C. A. 1950. A. note on the Cocos-Keeling Islands. *Bull. Raffles Mus.,* No. 22: 11-28; and other papers in the same issue by Gibson-Hill *et al.,* on the corals, Echinodermata, Mollusca, Crustacea, Insecta, fishes, reptiles, birds and mammals.

WATSON, G. E., R. L. ZUSI and R. E. STORER. 1963. Preliminary field guide to birds of the Indian Ocean. Washington: U.S. National Museum.

Section D (1)

SEAMEC Regional Center for Tropical Biology (Biotrop) and Conservation in South East Asia

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INTRODUCTION

In 1965 the South East Asian Ministers of Education Organization (SEAMEO) was established. It has a council (SEAMEC) whose members are the respective ministers of education of the member countries. The council meets once a year to decide on basic policies of the organization. To carry out the day to day duties it maintains a secretariat (SEAMES) which is located at Bangkok.

The present members of the SEAMEO are Indonesia, Laos, Malaysia, Philippines, Singapore, South Vietnam and Thailand.

As stated in the Charter of the Organization the purpose of the organization is 'to promote cooperation among S.E.Asian nations through education, science and culture in order to further respect for justice, for the rule of law and for the human rights and fundamental freedoms which are the birthrights of the peoples of the world'. To achieve these aims, SEAMEO has established several projects, one of which is the Regional Center for Tropical Biology (BIOTROP). It was agreed that BIOTROP should be established within the framework of the National Biological Institute (NBI) in Bogor, Indonesia.

SOUTH EAST ASIAN PROBLEMS IN CONSERVATION

Conservation depends on the existence of rules and regulations. To be effective, these rules and regulations must be based on a sound body of scientific knowledge and strong popular support. Unluckily in South East Asia these two latter factors are largely still missing.

The region of South East Asia forms a part of the Old World Tropics. It stretches from mainland Asia to Australia and is bounded by the Pacific and the Indian Ocean. It does not have vast landmasses. As a result the climate is mild without extreme heat, cold or drought. There are also no large seasonal fluctuations in temperature and daylength. The seasons we have here are not summer and winter, but dry and wet seasons which are affected by the monsoon winds resulting from the summers and winters of Australia and mainland Asia. These conditions are clearly different from those prevailing in temperate regions. Since the lives of living organisms are closely interrelated with the environment we must expect that the biology in general, and ecology in particular, of this region to be different from those of temperate regions. In other words, from the standpoint of South East Asians, biology as we know it now, which is primarily based on observations and measurements under temperate conditions, may be termed atypical. But it is not uncommon to assume that the theories and concepts of temperate regions are equally valid for the tropics. This situation brings serious consequences.

The scarcity cf biological data hampers the development of rational methods of management of renewable natural resources. The population increases together with the rising demands of South East Asian peoples require an accelerated growth of their economy. To achieve this, forests are being cleared for logging and agricultural purposes; more and more chemicals, i.e. pesticides and fertilizers, are being applied in agriculture; dams are being constructed for power generation and irrigation; etc. These activities are causing pronounced changes to the environment which interfere with the delicate balance of nature. With the little knowledge we have about our environment, we cannot predict what kind of consequences these changes will bring. But already severe damage has been done, such as erosion and floods, which endanger the very existence of biological resources.

In teaching, irrelevant materials are too often taught to students, while those that are relevant are neglected. For example, the effect of low temperature treatment of seeds on subsequent flower development and leaf abscission of deciduous trees in autumn, etc. are standard examples in biology teaching. But rarely, if at all, are mentioned such phenomena as the seasonal flowering and fruiting of mangoes, the inter-relationships of epiphytes to their hosts, etc. The irrelevance of teaching materials to our nature is a major factor in preventing the teaching of outdoor biology. Thus biology has little meaning to students, except as bookish knowledge which they have to learn to pass their examinations. In general, our students do not gain much understanding of our natural environment. As a result our youngsters have little appreciation for nature. And yet, if conservation is going to be effective, it must be based on strong popular support.

Luckily, although this is the general picture, there are already signs of improvements in several schools in South East Asia. More and more students are taken into the field and are asked to observe and examine living materials. It is also encouraging to note the increased interest in nature societies, although many people still consider these societies as merely picnic clubs. But at least a beginning has been made which eventually will lead to the support of the general public for conservation.

A major difficulty in correcting the situation is the serious shortage of competent biologists. Of course, there are South East Asian biologists who have been trained in good institutions in advanced countries. But many times they are put too soon into administrative posts. Those who stay in universities usually have a very heavy teaching load, so that they scarcely find time to do research. And yet research is the single effective tool for acquiring new knowledge and to test the validity of existing concepts and theories. Furthermore, without being actively engaged in research, one cannot teach how to do research. Therefore, even though South East Asia can produce university graduates, it will for sometime to come remain dependent on outside help for its scientific activities, both through bilateral aid and international scientific cooperation. However, scientific cooperation, as in any other cooperative endeavour, requires that both partners are capable of contributing to the success of the undertaking. Ideally the contributions of the partners should be of equal weight. Furthermore, the contributions of a partner should not only be limited to the implementation of the scientific projects, but should begin at the planning stage and extend through the interpretation of the scientific data and the application of results. Thus the project would be geared to the common needs of the partners and not merely to satisfy the wishes of any one party.

If we look to South East Asia, it is apparent that this ideal situation does not exist yet. To be sure South East Asian countries have participated in international scientific activities. However, South East Asia has not been able to reap the full benefits from these activities. This is due to the fact that the research capabilities of South East Asia are still limited, which in turn also limits its capability of making a contribution in the planning stage of the research projects to be undertaken. In many cases, therefore, the projects are better suited to the needs of developed nations rather than to those of developing nations, even though the projects are being carried out in this region. This has the grave consequence that many projects are in fact widening the scientific gap between South East Asia and the developed nations and in making South East Asia scientifically more dependent on the advanced nations. Under the given conditions, it is not easy indeed to resolve the problem.

BIOTROP'S AIMS AND OBJECTIVES

Recognizing the above situation, BIOTROP aims at achieving the following objectives:

(1) To strengthen the scientific capabilities of South East Asia;

(2) To acquire through cooperative research pertinent biological data which are needed for the rational management of the renewable natural resources;

(3) To enhance participation of regional scientists in international scientific cooperation as full and equal partners.

The first requirement for the development of science is the availability of the manpower which has the capability to do research. In this respect, BIOTROP feels that instead of offering formal classroom courses and lectures, which are normal programs of universities, it will concentrate more heavily on training for researchers. For this purpose,

experienced senior scientists from within as well as outside the region will be invited to work at the Center. To them will be attached young regional scientists, who will participate as full members of research teams with agreed individual areas of responsibility. Thus these young scientists will be taught, through direct personal involvement in ongoing research, the 'art' of basic discovery in biological work and the practical ways of applying this to the needs of their countries.

This approach of 'training through direct involvement', however, does not entirely preclude the organization of formal courses. Several selected areas will be offered as the need arises.

In addition to serving as a training ground, the research projects are also intended to acquire much needed biological data of the region. While much basic biological research is necessary for the improvement of agriculture, this sector of the environment receives the most attention from country agricultural research institutes as well as other sources. Rivers, lakes, reservoirs, the nearshore marine environment, swamps, forests, all portions of the natural environment able, just like tended land, to yield enormous benefits, have been relatively least favored as far as research is concerned. Therefore, it has been decided to stress in BIOTROP, at least initially, research into the non-agricultural portions of the natural environment. Three major ecosystems have been selected for this program, i.e. tropical forests, man-made lakes and coral islands. Research on the ecology of pests constitutes the fourth program.

The forests of South East Asia are now subjected to extensive as well as intensive exploitation. Although relatively much research has been done in this area, there are still many gaps in our knowledge about our forests. Such 'simple' things as the germination of seeds of many forest trees and the morphology of seedlings are still unknown. And these are the very informations needed for effective measures for regenerating the forests. Under these circumstances we can foresee the grave danger which is now being faced by our forests. And we know that the destruction of forests has far-reaching effects on wildlife, water regime, soil, etc.

Coral islands are presently relatively undisturbed by man. However, coral islands with their lagoons offer great potentialities for intensive sea-farming for the production of seaweeds, fish and other sea products, with the attendant use of fertilizers and pesticides. Research in this direction has already been initiated in several places. But suprisingly little is known of the biology of coral islands.

Primarily due to the increasing demands for power, many dams have been constructed in this region. Many more are being planned or under construction. Again very little is still known on the effects of these dams on the natural environment.

To combat diseases, such as malaria, and to increase agricultural production the old time method of biological control, which requires long and meticulous research into life cycles, life habits and natural enemies, has been almost completely abandoned. Instead we depend exclusively on the use of pesticides. At a glance this latter method is easier and gives quicker results than the former one. However, it must be admitted that the behaviour of pesticides under tropical conditions is still very poorly known.

It is clear then that research in these areas is urgently needed. Otherwise it is feared that economic development could well turn into an 'ecologic boomerang', as so candidly reported by Barry Commoner for many places. Therefore, BIOTROP intends on the one hand to help increase the benefits from natural resources and on the other hand to help avert the 'ecologic boomerang'.

Because participation in the BIOTROP research is not restricted to the regional scientists, it will also offer ample opportunities for international contacts and cooperation. Indeed BIOTROP is actively seeking the cooperation of non-regional scientists and international agencies. Because of the nature of its research objectives, BIOTROP would warmly welcome to work closely with IUCN. For example, BIOTROP would be happy to arrange with IUCN for the implementation of IUCN's resolutions and recommendations, which are relevant to South East Asia. It is indeed in BIOTROP's interest to help in the economic development of South East Asia and at the same time to help maintain this region as a healthy and pleasant place to live in.

SUMMARY

South East Asia has embarked on large scale economic development. This, together with the population pressure, is drastically affecting the natural environment. In view of the scarcity of sound scientific data, which consequently prevents the formulation of effective policy measures, it is feared that this economic development could turn into an 'ecologic boomerang'.

BIOTROP aims at strengthening the research capabilities of South East Asia. This would positively affect the teaching of biology in this region and would enable this region to acquire pertinent biological data which are needed for the rational management of the renewable natural resources, thus helping to avert the danger of the 'ecologic boomerang'. Three major ecosystems—tropical forests, man-made lakes and coral islands—and a fourth program on pest ecology have been selected as the main initial objectives of research.

BIOTROP would warmly welcome the cooperation of IUCN.

RÉSUMÉ

L'Asie du Sud Est a entrepris un très vaste programme de développment économique. Ceci, joint à la pression de population, affecte très fortement le milieu naturel. Etant donné la rareté de données scientifiques valables, ce qui empêche l'instauration de mesures officielles effectives, il est à craindre que ce développement économique ne se transforme en un 'boomerang écologique'.

L'objectif de BIOTROP (Centre Régional de Biologie Tropicale) est de renforcer les possibilités de recherches du Sud Est Asiatique. Ceci aurait une influence positive sur l'enseignement de la biologie dans cette région et permettrait d'acquérir les données biologiques indispensables à une organisation rationnelle de l'exploitation des ressources naturelles, en contribuant ainsi à écarter le danger d'un 'boomerang écologique'. Trois grands écosystèmes—forêts tropicales, lacs artificiels et iles Coralliennes—ainsi qu'un quatrième programme d'écologie des déprédateurs animaux et végétaux—ont été sélectionnés à titre d'objectifs primaires des travaux de recherche.

BIOTROP souhaiterait vivement que l'IUCN collabore à ses travaux.

SECTION D (1): POINTS MADE IN DISCUSSION

The main IBP/CT check-sheet survey of type-habitats, together with the more specific survey of islands, which we have been discussing, and much of the prospective programme of organisations like BIOTROP, of which we have been told, are all really part of the 'World Conservation Review', which was called for at the last General Assembly at Lucerne. This has a number of useful tools at its command, such as the IUCN Red Data Books and UN List of National Parks, and now the CT check-sheets, and it seeks to answer four questions: (1) What ecosystems are there? (2) Where are the best samples? (3) Are these samples properly protected? (4) What more needs to be protected on what scientific basis? In the particular case of islands, in considering the 10 to 2 0,000 islands of the Pacific we have arrived at a list of some 35 possible 'islands for science', which at least is a starting-point, though more sifting may be needed. The subsequent action which IUCN is called on to undertake in order to attain the objectives, falls into five stages: first discreet publicity for the whole project, without reference to particular islands, and establishment of contacts with the Universities and organizations specially concerned: then the formal approach to the governments responsible for the islands finally selected; perhaps the covening of a meeting at which a 'founder-member' group of ten or a dozen islands would be established and a list of others for further consideration and negotiation; the latter could involve the promotion through suitable organizations of expeditions to lesser known islands for the purpose of evaluation; and, finally, the conclusion of agreements covering the future protection and status of the 'islands for science', which could take the form of an international Convention, specific Treaties or even a formal exchange of assurances (Nicholson, U.K.).

The suggestion that the work already in hand in the Pacific should be extended to the Indian Ocean, where although a good deal of work has been done in the last decade knowledge of the ecosystems is still rather scanty, is very timely. The Marine Biological Association of India will be holding a Symposium on 'the Indian Ocean and adjacent seas—their origin and resources' from January 12-18, 1971, and one of the sections will be devoted to the geology, fauna and flora, with special reference to endemism and speciation, of oceanic islands. This should fit in very well with the objectives described by Mr. Nicholson. On a minor point of detail with reference to Dr. Snow's paper, I can definitely confirm the breeding in the Laccadives of the noddy and sooty terns (Silas, India).

Adams and Antipodes islands which are included, in Mr. Nicholson's List of proposed 'islands for science' (Annex 2) are already strictly protected under the aegis of New Zealand's Sub-antarctic Islands Committee and, since they can be visited by scientists on application, virtually have an international status (Maclachlan, New Zealand).

In addition to the meeting to which Mr. Silas referred, the five countries of the South Pacific Commission are also planning a meeting in 1971, probably preceding the Pacific Science Congress, to discuss conservation. It is also worth noting that the U.S. National Academy of Sciences has been concerned with the study of atolls for at least 20 years and the series of interesting reports that have been published brings out the point that, although the terrestrial fauna and flora may be comparatively poor, the submarine environment is of the greatest complexity and scientific interest (Coolidge, President of IUCN).

Although the stress in these papers has been on oceanic islands, the claims of off-shore islands both for their scientific interest and because of the pressing need for conservation, must not be forgotten. Yakushima island, only about 60 km from the mainland of Kyushu though part of the Ryukyu chain, is a case in point. Though inhabited, it has magnificent cedar forests and other natural areas which could be saved for science (Mishima, Japan).

The reference to the 'atolls for science' project can be briefly amplified. It was launched by the U.S. President's Council on Marine Sciences and the first atoll, declared in 1967, was Rose Island. The list of Pacific 'islands for science' drawn up by the CT survey will need further study, as it includes some which are rather disturbed but omits others such as Laysan in the Hawaii group which are of great importance (Ripley, U.S.A.).

Due to the status of Hawaii as one of the U.S.A., the list of possible islands in it to be safeguarded for scientific purposes has been kept separate, but Laysan is certainly on it. The two New Zealand islands referred to by Mr. McLochlan, have been listed because as he said they can already to some extent be regarded as models. Further south, Macquarie, which Dr. Polunin mentioned, is regarded as part of the sub-antarctic group to which Annex 10 of my paper refers (Nicholson, U.K.).

One of the difficulties which has to be faced in compiling information on islands from published sources, is that some of it may be out of date or erroneous and the errors tend therefore to be repeated. For instance, in the Andamans the indigenous carnivore is almost certainly not the palm civet *Paradoxurus* as stated in Dr. Snow's paper, but a mongoose *Herpestes,* but not apparently the common species *edwardsi* as one might expect if it had been introduced (Spurway, India).

No reference was made to the introduction of the chital to the Andamans. Although it does not seem to have multiplied, the same cannot be said for other introduced species and the mynah and sparrow, for example, are the most obvious birds in the vicinity of Port Blair. This is unfortunate since though the Andamans might be regarded as 'off-shore' islands, there has been some speciation, notably of course the Narcondam hornbill. Some 'advisers' still talk about making further introductions, but these should be prohibited except after the fullest consultation and investigation of possible effects (Abulali, India).

There is a police post in Narcondam: it might be more appropriate if there was a research station. The difficulty is that Government is always looking for a practical development motive: thus an exploratory mission was organised to the Andamans and Nicobars, in which seven Departments were involved including the Zoological and Botanical Surveys, but the objective was rehabilitation and settlement, with an emphasis on water supplies and mineral resources. These conflicts of interest have to be taken into account when assessing scientific priorities. Another difficulty is that the establishment of research stations is costly and, although local ecological studies are important and could well be provided with some 'out-station' laboratory facilities for research, much of the work to be done still consists of making collections, which can be more easily identified and studied in existing national museums and institutions (S.K. Mukhirjee & Krishne, India).

The implications are that this is just what the CT survey is about, namely to discover the undisturbed areas of high scientific interest and to assess the problem of reserving some of them for that purpose. There are really two stages, first to carry out an analysis and determine the scientific priorities, and then to persuade the government that the latter are more important than other development or exploitation (Seshacher, Chairman).

The difficult problems are in fact to win the support and interest of the countries responsible for undisturbed islands or parts of islands, which are important for science, and to find the necessary funds for an action programme. This is why the long-term intergovernmental 'Man and the Biosphere' programme which is now being launched is highly relevant to what we have been discussing. Recently the scientists who have been working out projects for the MAB programme have included in their proposals studies of island ecosystems and studies of the ecology and rational use of those ecosystems. This is likely to provide a very valuable basis on which IUCN's own initiatives and activities can be built, especially as the aim of MAB is that the participating countries themselves will organize and carry out the projects with any necessary assistance that can be given by international organizations (Budowski, UNESCO).

It is very important that islands set aside for science are used for science, which is where the MAB programme can play a vital part. Scientists as a whole *must* seize this opportunity on a continuing project basis. The Aldabra affair and the setting up of a research station on that island by the Royal Society are relevant (Nicholson, U.K.).

In presenting Dr. Soemarwoto's paper, in his unavoidable absence, I have tried to stress that one of the principal objectives is to involve young scientists in south-east Asia in active field-work which has a practical value and relevance to the specialised conditions of the region; but there will be plenty of opportunity for international assistance and co-operation. Although the main aim must be economic development, BIOTROP should be able to make a contribution to the survey of island ecosystems, the setting up of germplasm banks, etc., though no priorities are yet established (Somadikarta, Indonesia).

What is principally needed is an assurance of a long-term programme, with full governmental support which will have to be on a country by country basis, since many of the BIOTROP themes would take at least ten years to develop effectively (McClure, Thailand).

The paper under discussion and several previous papers have repeatedly referred to the need for co-ordination. What is needed is for organizations such as IUCN, perhaps through special sub-committees of its Commissions, to give much more attention to promoting and assisting inter-disciplinary co-ordination at all levels among member states and organizations. The lack of such co-ordination plus shortage of experts and money discourages enthusiastic young conservationists in developing countries (Dave, Kenya).

Chairman: Professor B. R. Seshachar.

Primary Production of Chakia Forests and the IBP/PT Study of Organic Productivity and Nutrient Cycling in Monsoon Forests, Grasslands and Croplands

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INTRODUCTION

Man must exploit nature in order to live. His basic needs are met from the organic products of plant and animal species. As demand for biological products is increasing with population growth and cultural evolution, the pressure of exploitation leads to direct and indirect extinction of many species. We have begun to realise that such elimination of species very often upsets the balance of nature and erodes the stock of genes which otherwise could await future exploitation.

Conservation and landscape management show our concern for rehabilitating *Homo sapiens* as an entity of the biosphere. They focus attention on ecosystems which gave birth to man. The orderly flow of energy and cycling of minerals and water in which primitive man was participant, demand understanding of the structure, function and environment of the ecosystems. It is hoped that such understanding will lead him to proper manipulation of the systems including his own, so that *Homo sapiens*, whose physical evolution has been overtaken by cultural evolution, may survive on this already sick planet.

In order to fulfil the above objectives, the International Biological Programme aims at world-wide measuring of organic productivity as a function of environmental and biological interaction in the basic ecosystems and the adaptation of the human system to a pattern of environment. The Varanasi group of ecologists is pledged to intensify its participation in this programme through the study of organic productivity and mineral cycling in the dry deciduous forests of Chakia (Varanasi). Some preliminary work covering certain aspects of primary production (though secondary production is also included in the project) is reported in this paper, with suitable discussions relevant to the general theme.

STUDY SITES; CLIMATE AND SOIL

The sites lie in Varanasi and Gorakhpur districts of Uttar Pradesh. The natural vegetation of the region is monsoon deciduous forest (Northern tropical deciduous type of Champion 1936). But because of the dense population all the alluvial tracts in the Ganga plains are cultivated, barring a few patches of *Shorea robusta* plantations in Gorakhpur or grasslands maintained under grazing. Small areas of natural but secondary forest are found on the Vindhyan hills south of Ganga. Except for the reserves, which are also open to cattle grazing, most of the hilly terrain is being precariously put under bamboo and *Eucalyptus* plantations, for producing paper pulp, or heavily exploited for timber, bidi leaves *(Diospyros tomentosa* leaves, used for country cigarettes) and minor forest products.

Thus, there are three diverse sites of study lying within 200 km of each other with more

or less similar climate. Chakia site lies in the southern part of Varanasi between 24° 42' to 25° 50' N latitude and 83° 22' to 83° 40' E longitude. It is a part of the catchment area of Karmanasa and Chandraprabha rivers. The elevation varies between 90-365 m above sea level. The soils are shallow and bright red on the uplands and deeper but of brown colour in the depressions and ravines. The secondary forests range from an open *Butea* community to an almost closed-canopy *Terminalia-Shorea* community. In general, the maximum crown cover is provided by *Diospyros tomentosa* followed by *Shorea robusta* and *Terminalia.* The total basal area of all the trees covers above 0.1-0. 5% of the ground. All the trees lose their leaves in April-May although the process starts in some cases 4-5 months earlier. But on account of simultaneous bursting of vegetative buds very few trees remain naked for a long time except for *Salmalia, Kydia* and *Sterculia* which may do so for several months together. Rao (1967) has ordinated about 100 stands of non-Sal areas on the site and reports that most of the stands acquire position on 1300-2300 continuum space. Altogether 18 leading dominants are recorded with behavioural patterns of their own on continuum space. *Soymida febrifuga* is the pioneer and *Diospyros tomentosa* the climax species.

The Gorakhpur plantation site lies at 26° 45' N latitude and 83° 22' E longitude and at 76 m. above sea level. *Shorea robusta* plantations are managed here by the forest deparment, generally following the 'taungya' system. This site provides known and even-aged (not necessarily even-sized) trees growing on the deep medium textured alluvium of the plains. Hence, studies in this site are valuable for making comparisons.

The third site is at Varanasi within and outside the University campus (25° 18' N latitude and 83° 1' E longitude). It is situated on old alluvial deposits of Ganga (the uplands) with sandy loam, at an elevation of 80 m above sea level. The area is densely populated and heavily cultivated leaving a few grasslands open to grazing. Studies on the production of grasses and maize crop have been conducted in this area.

The climate of the sites is mainly influenced by monsoon. There is an average rainfall of 1000 to 1100 mm of which approximately 93% falls through frequent showers and downpours in July-September. The mean maximum temperature varies 32°C-35°C with diurnal fluctuations of less than 10°C during the period. The rest of the year is almost dry with rare showers in October to March. Frost is very rare in the winter. January is the coldest month with the mean maximum and minimum temperatures of 23. 6°C and 7. 8°C respectively. The mean maximum temperature in May, the hottest and driest month, is about 40. 8°C.

Thus, it will be seen that plant growth is possible throughout the year with stored moisture in the soil. Nevertheless, three flushes of meristematic activity alternate with equal frequency of slow growth, fruiting and ripening. Thus there are six periods or 'ritus', of two months each, of phenological importance in the year. The fact that maximum growth is obtained during the rainy season shows that it is limited by drought in other seasons. It has a bearing on the methods of measurement of organic productivity in the region.

It may further be noted that the high Himalayas about 500 km north of the sites protect the entire region from cold winds, so that climatically and biologically it remains tropical, being contiguous with the peninsular part of the country to which it is completely exposed. The westerly wind blowing throughout the dry seasons is conditioned by high insolation over long stretches of the continent.

THE FOREST ECOSYSTEM

The study is based on a typical deciduous forest dominated by *Shorea robusta* as found in Chakia. Since the dominant tree in the natural population does not yield to age analysis, many of the figures presented in the study are based on plantations of different age at Gorakhpur. The tree dimensions as related to age, have therefore, been freely applied for deductions from the natural community.

The biomass fractions of sample trees from the plantations *of Shorea robusta* at Gorakhpur are set out in Table 1. It is seen that there is higher investment in canopy development in the younger trees and that the older trees accumulate more of bole and less of root weight.

TABLE 1: BIOMASS FRACTIONS OF SAMPLE TREES OF *SHOREA ROBUSTA* EXPRESSED AS PERCENTAGES OF TOTAL DRY WEIGHT (AFTER SATYANARAYANA-UNPUBLISHED)

Age (years)	Girth (cm)	Biomass fractions				Total Shoot
		Root	Bole	Branches	Leaves	
10	33	21.9	63.9	7.1	7.1	78.1
16	38	22.1	64.2	7.6	6.1	77.9
22	48	20.0	75.5	2.4	2.1	80.0
28	55	21.2	66.7	9.0	3.1	78.8
35	Si	20.5	72.9	4.6	2.0	79.5
38	70	14.1	79.3	3.9	2.7	85.9

TABLE 2: STANDING BIOMASS, ANNUAL INCREMENT AND LITTER FALL IN A TYPICAL TROPICAL DECIDUOUS FOREST DOMINATED BY *SHOREA ROBUSTA*.

	Dry weight kg/ha	% of total biomass
Biomass fraction (1)		
Bole and branch	102, 000	80
Leaf	5,000	4
Root	20, 000	15
Total	127, 000	
Annual increment (2)		
Bole, branch and root	7,800	60
Leaf	5,160	40
Total	12,960	
Non-photosynthetic biomass increment as % of total		6
Annual litter fall (3)		
Leaf	5,000	
Branch, flower, fruit, etc.	2,000	
Total	7,000	
Annual return through litter fall as % of annual increment		54

(1) Estimates based on density of 600 trees/ha and average biomass of 170 kg/tree (after Misra *et al.* 1967). Root taken as approximately 20% of the bole and branch weight (after Satyanarayana, unpublished).

(2) From Misra *et al.* (1967). Average annual increment in bole + branches + roots taken as 13 kg/tree. Average annual production of leaves taken as 8. 7 kg/tree.

(3) From Singh, K. P. (1968). Non-leaf litter assumed to be about 30% of the total.

Clear felling of a 20 x 40 m plot of the forest in the summer of 1968 by Raman (unpublished) revealed 78 individuals belonging to 21 species. The dry weight of the standing crop was found to be approximately 50 tons/ha. However, the 35 year old plantation of *Shorea robusta* at Gorakhpur, according to Satyanarayana (unpublished), has yielded 310. 6 tons dry matter per hectare.

Table 2 gives data for standing biomass, annual incremental and litter fall for the forest as computed from sources indicated therein. It will be seen that a scaffolding biomass of 122, 000 kg per ha (bole, branch and root) supports annually a photosynthetic biomass (leaf) of 5000 kg/ha or approximately 4% of the total. The latter in turn fixes the energy equivalent to 10% of the biomass. The energy conserved each year as against the energy of the annual litter fall of 7000 kg/ha transferred to the soil each year, amounts to 6% of the total biomass. Nevertheless, the annual return to the soil is 54% of the annual increment.

As shown by Singh, K. P. (1967a), the litter completely decomposes within 3-15 months after the advent of rainy season. Thus more than half of the energy stored during the year becomes dissipated through microbial activity. The energy thus lost is shown (Table 3) to be present in the form of various organic compounds of the litter which can be exploited by man (Singh, K. P. 1967a). The implication of such exploitation should, however, be examined in light of mineral circulation within the ecosystem.

TABLE 3: RETURN OF ORGANIC SUBSTANCES IN LITTER FALL OF DECIDUOUS FOREST COMMUNITIES AT VARANASI (Kg/Ha) (AFTER SINGH, K.P. 1967a)

Communities	Starch & Sugar	Fat	Pentosan	Cellulose	Lignin	Protein
Terminalia-Shorea	284	213	551	1567	1416	328
Tectona	198	132	454	1061	938	227
Diospyros -Anogeissus	114	206	317	893	1018	161
Shorea-Buchanania	114	69	279	765	904	133
Butea	22	14	73	253	154	116

Figures given in Table 4 are significant for evaluating the mineral system of the sites. Energy fixation cannot proceed without the movement of water and the elements within the plant. The capacity of energy fixation and collection of elements from the environment differs from plant to plant. Singh, K. P. (1969) has reported wide differences in nutrient concentration in leaf litter of tree species growing together in these forests. Hence, the figures based on analysis of *Shorea robusta* alone can be mere approximation. They are, however, valuable in identifying the problems for detailed investigations.

The availability of exchangeable Ca, Mg, K, P and N per hectare in the soil up to 50 cm depth shows that the soil reservoir of these elements is sufficient to bear many times more of biomass than that of the available standing crop. The nutrient reserve of forest soils is not so low as generally believed. Even the soils of humid tropical forests of the Western Ghats (India), which were generally labelled as poor, were found to have high nutrient concentration in upper layers (Singh, K. P. 1968a). In fact the biomass nutrients are of the order of approximately 6. 5, 8. 3, 16. 7, 25. 5 and 11. 3% of the overall corresponding nutrient values of Ca, Mg, K, P and N present in the ecosystem (Table 4). It is interesting to note that annually the plants return to the soil through litter fall and mineralisation about 80% of the annual uptake of Ca, Mg, K and P, and about half of the nitrogen. Detailed account of nutrients returned annually to the soil through litter fall in 5 communities of these forests has been presented by Singh, K. P. (1968b). It is surprising to note that the input of nitrogen through rain is more or less of the same order as contributed by the litter; or the annual inputs almost balance the annual withdrawal of nitrogen by the plants from the soil. The input figures for dust, losses through leaching and export of biomass by way of grazing and timber exploitation are not known. But looking to the huge soil reservoir and continued exploitation through past centuries it appears that nutrients do not limit growth of forest in these regions. But total removal of litter by man for exploiting the organic compounds may have serious repercussions.

TABLE 4: ESTIMATED NUTRIENT STATUS OF A TYPICAL TROPICAL DECIDUOUS FOREST DOMINATED BY *SHOREA ROBUSTA*.

	Nutrients					
	Ash	Calcium	Magnesium	Potassium	Phosphorus	Nitrogen
Available nutrients in 50 cm depth of soil (kg/ha)[1]		9660	1230	1385	385	4060
Available nutrients in trees (kg/ha)[2]						
i. Bole + branch	1938	510	81	204	102	357
ii. Leaf	230	55	15	35	10	90
iii. Root	380	102	16	40	20	12
Total	2548	667	112	279	132	519
Total nutrients in soil and plant biomass (kg/ha)		10327	1342	1664	517	4579
Nutrients in plant biomass as % of total		6.5	8.3	16.7	25.5	11.3
Annual uptake of nutrients (kg/ha)[3]						
i. Bole + branch + root	148	39	6	16	8	27
ii. Leaves	236	56	15	36	10	92
Total	384	95	21	52	18	119
Annual return through litter fall (kg/ha) leaves, twigs and fruits, etc.	322	72	18	42	14	56
Return as percentage of annual uptake	84	76	86	81	77	48
Inputs						
i. Dust	(not knowi)					
ii. Precipitation (in open, kg/ha)[4]		23				51
Export						
i. Timber and fuel	(not known)					
ii. Grazing and insect damage	(not known)					
iii. Leaching and runoff	(not known)					

(l) After Singh, K. P. (1967a).
(2) Calculated from biomass data presented in table 1 and the chemical composition data of Kaul *et al.* (1963).
(3) Calculated from annual increment (Misra *et al.* 1967) and chemical composition data of Kaul *et al.* (1963).
(4) Data from Agarwal and Roy (unpublished).

Misra (1968) has discussed elsewhere the tremendous rate of energy fixation in these forests. But the rate of energy dissipation is equally fast. The magnitude of secondary production in the forests, therefore, between the two steps seems to be limited. It is no wonder that our wild herbivorous and carnivorous populations have to lead a precarious life. Indeed, the wide and rapid fluctuations in these populations are linked up with the highly dynamic primary production system.

The magnitude of turn over and the high rate of mobility of the nutrients, nevertheless, do expose the system to the vagaries of the physical forces of the environment so that over-exploitation of the biomass may cause serious disturbances like soil erosion and moisture loss.

THE GRASSLAND ECOSYSTEM

The grasslands in Varanasi are maintained by man and his grazing animals. Left to themselves, the sites would produce scrub or low forest. On the other hand, many of the forests degenerate into savanna on account of intensive grazing. The number of annual species increases with grazing, but it is usually double the number of the perennial ones. Non-graminoid species are sometimes common.

Studies in the net community productivity of grasslands in the University campus were initiated by Singh, J.S. (1967a and 1968) through the harvest method. The sites selected were exposed to different degrees of biotic interference. In general the variation in standing biomass of these sites corresponds with the seasonal distribution of rainfall. But the biomass of individual perennial species shows varied patterns, some showing peak biomass in rainy season, while others in winter or twice a year or in summer season. Because of this behaviour sampling becomes difficult and the year has to be divided into arbitrary periods for calculation of net production. Net above-ground production was found to be maximum on heavily disturbed sites and minimum on the least disturbed sites. The underground production, on the other hand, shows a reverse trend. Choudhary (1967) has shown that root production in some species precedes shoot growth. The rate of turnover of the underground biomass in these grasslands is about twice as fast as that of American prairies. The total productivity is maximum ($7g/m^2$/day) in the rainy season; the average for the whole year being $2g/m^2$/day, of which 40% is underground. Evidently, these rates are higher than those of the temperate grasslands.

Choudhary (1967) made a detailed study of seasonal variation in calorific value in different biomass fractions of *Dichanthium* grasslands within the University campus. The data indicate that in *Dichanthium* the energy content per unit dry weight is lower than that for many of the temperate species and there is large seasonal variation in calorific values.

Evidence has been gathered to indicate that diversity of species in these grasslands increases productivity, while dominance increases community stability but reduces production (Singh and Misra 1969). These conclusions are contrary to the generalisations made by McNaughton (1967) with respect to Californian grasslands. The explanation of this contradiction may lie in the fact that seral grasslands of the forest climate are fundamentally different from the climatic climax grasslands.

Recently Singh and Misra (1968) have computed the efficiency of energy capture by the grassland vegetation of the University campus. Taking into account only 50% of the incident radiation as being photosynthetically active, they found the average efficiency for total net production (above-ground and under-ground) to be 1. 66 and 0. 34 percent, respectively, for the grand growth period (June-September) and for the whole year. With respect to total net production the efficiency remains almost constant with varying degree of biotic disturbance. However, in comparatively protected fields energy is stored in the underground parts with greater efficiency, while with increasing disturbance more energy is accumulated in aboveground parts.

Further work in progress includes measurement of the grassland productivity by the gas flow method using a simple self-assembled apparatus (Dwivedi); and cycling of certain major (N, Ca, P) and trace elements (Agarwal, Tripathi and Upadhyaya). Some of these workers are using 32p in their investigations. Productivity studies have also been extended to other parts of Varanasi supporting *Heteropogon* grasslands (Pandey).

Recent studies by Singh, J.S. (1967b) on the dry matter production in *Cassia tora,* an annual ruderal plant of gregarious habit, indicate greater production than the nearby grasslands. The maximum production in this species, at a density of 17 plants/m^2 attained within 3 months time, is 2306g/m^2 as against 742g/m^2 in the local grasslands. In *Amaranthus spinosus* (another plant of ruderal habitat) Gopal (unpublished) recorded production of 2460g/m^2 dry matter at a density of 140 plants/m^2 in a 4 months period of growth. Cultivation of certain provenances of *Cassia tora* at two temperatures indicates greater dry matter production when plants are grown at 30-40°C than those at 15°C. Further, the dry matter yield of plants originating from different latitudes is different (Singh, J. S. 1967c). Similar report has been made by Singh, K. P. (1966, 1967b), who found greater dry matter production in *Portulaca oleracea* at 35°C as compared to 15°C.

Pandey (1968) studied the competition between several crop and weed species with reference to phosphorus uptake. Using 32p he found that in general in early stages of crop growth weeds share 50-80% of the total phosphate uptake from the soil. Severity of competition during the juvenile phase was shown by him to be due to similarity in rooting patterns of the species.

THE CROP ECOSYSTEM

The crop ecosystem is entirely a man made system as both the species and the environment, particularly the soil component, are synthesised by him. A study of the maize crop in Varanasi (Rao *et al.*, unpublished) gave about 780g/m^2 dry weight for 78 days old crop. Stem weight was twice as much as either root, leaf or seed; the latter three being almost equal. During the actual period of growth, the rate of production was found to be as high as 10g/m^2/day. However, on a yearly basis the rate is much decreased.

COMPARISON OF PRODUCTIVITY IN DIFFERENT ECOSYSTEMS

Table 5 makes a comparison of rates and efficiency (based on 50% of incident solar radiation) of production at forest, grassland and cropland sites at Varanasi.

TABLE 5: RATES OF PRODUCTION AND EFFICIENCY OF SOLAR ENERGY CAPTURE BY DIFFERENT ECOSYSTEMS AT VARANASI.

Ecosystem	Productivity		Efficiency of energy capture
	g/m^2/yr	Kcal/m^2/yr	
Forest	1296	5922	0.63*
Grassland	744	3220	0.34 * (1.67)†
Cropland (maize)	780	2609	0.28 * (0.90)†

* On annual basis.
† On basis of 78 days' growth period.

It is evident that productivity on an annual basis is highest in forests, whereas croplands are the least productive, despite the fact that they receive maximum attention in form of agricultural practices. Even during the active growth period grasslands utilize a greater amount of solar energy than crops.

Ovington and Lawrence (1967) have reported the efficiency of energy capture by maize fields, their most productive ecosystem, to be 0. 94% for a growing season of 92 days and 0. 35% for the whole year, taking total incident solar radiation into consideration. Computing on the basis of gross production, Golley (1960) reported the efficiency of an old-field Broomsedge community at South Carolina to be 0. 3-0.4%. Based on the average annual input of solar radiation and dry matter yield of cereals, Penman (1968) has recently

estimated this efficiency for certain tropical countries including India to range between 0.02 to 0.04 per cent.

It appears that total biological production in natural ecosystems, especially the forests, far exceeds that of man-made crop ecosystems. Forests constitute a relatively efficient means of site utilization since the photosynthetic tissues are well dispersed vertically above the earth's surface and roots are able to spread throughout a large soil volume (Ovington 1960).

CONCLUDING REMARKS

The data presented in this paper although based on different site investigations and a number of assumptions do bring out certain facts of significance.

1. It would appear that despite heavy inputs and manipulations, man has not improved much upon the natural rate of organic production. Perhaps the moment man learns the technology to convert all organic products into food, agriculture will become obsolete and this in turn will bring about tremendous changes in our landscape planning.
2. Misra (1968) has drawn attention to a much higher rate of primary productivity in the tropical regions as compared with the other climatic zones. This is coupled with a high range of nutrient mobility in the warm climate with alternating humid and drought seasons in the year. Rehabilitation of such a highly dynamic system after destruction will therefore be much more difficult in comparison to more sluggish ecosystems found in other climates.
3. Misra *et al.* (1968) have shown that free supply of oxygen in terrestrial ecosystems leads to a rapid dissipation of biological energy as compared to aquatic situations. The structure of secondary production in the two types of environment, therefore, differs in as much as more of plant biomass accumulates on land and more of animal biomass in water. Hence, animal populations are more vulnerable to disturbances in the functioning of the ecosystem on land than in water.
4. Animal populations in highly dynamic ecosystems are prone to greater fluctuations in the tropics than in the cooler climates. Man, therefore, will have to depend more on a vegetarian diet in the tropics.
5. Land management and conservation practices must be based on the functioning aspects of the ecosystem rather than merely on population characteristics.

REFERENCES

CHAMPION, H. G. 1936. A preliminary survey of the forest types of India and Burma. *Indian For. Rec.* (N.S.) Silvi. 1: 1-126.

CHOUDHARY, V.B.1967. Seasonal variation in standing crop and energetics of *Dichanthium annulatum* grassland at Varanasi. Ph.D. thesis, Banaras Hindu University, India.

GOLLEY, F. 1960. Energy dynamics of a food chain of an old-field community. *Ecol. Monogr.* 30: 187-206.

KAUL.O.N., P.B.L.SRIVASTAVA, A.C.GUPTA and R.P.SHARMA. 1963. Site quality and nutrition uptake in Sal *(Shorea robusta)* forests of U.P.and Bihar. *Indian For.* 89: 293-300.

McNAUGHTON, S. J. 1967. Relationship among functional properties of Californian grasslands. *Nature* 216: 168-169.

MISRA, R. 1968. Energy transfer along terrestrial food chains. *Trop. Ecol.* 9: 105-118.

MISRA, R., J. S. SINGH and K. P. SINGH. 1967. Preliminary observations on the production of dry matter by Sal (*Shorea robusta* Gaertn. F.) *Trop. Ecol.* 8: 94-104.

MISRA, R., J. S. SINGH and K. P. SINGH. 1968. New hypothesis to account for the opposite trophic biomass structure on land and in water. *Curr. Sci.* 37: 382-383.

OVINGTON, J.D. 1960. The ecosystem concept as an aid to forest classification. *Bull. Internatl. Soc. Trop. Ecol.* 1: 44-47.

OVINGTON, J.D. and D. B. LAWRENCE. 1967. Comparative chlorophyll and energy studies of prairie, savanna, oakwood and maize field ecosystems. *Ecology* 48: 515-524.

PANDEY, H.N. 1968. Crop-weed competition for phosphate nutrition. Ph.D. thesis, Banaras Hindu University, India.

PENMAN, H.L. 1968. The earth's potential. *Science Jour.* 4: 43-52.

RAO, C.C. 1967. Phytoecological studies on a piece of watershed land in the vicinity of rivers Karmanasa and Chandraprabha (Varanasi district). Ph.D. thesis, Banaras Hindu University, India.

SINGH, J. S. 1967a. Seasonal variation in composition, plant biomass and net community production in the grasslands at Varanasi. Ph.D. thesis, Banaras Hindu University, India.

SINGH, J. S. 1967b. Effect of population density on growth performance and dry matter yield of *Cassia tora* L. *P.L. 480/Ecological Annual Report,* B.H.U. page 24-30.

SINGH, J.S. 1967c. Growth performance of *Cassia tora* L. plants of different seed origins raised at different temperatures. *Ibid.* p. 12-23.

SINGH, J.S. 1968. Net aboveground community productivity in the grasslands at Varanasi. *Proc. Symp. Recent Adv. Trop. Ecol.* (R. Misra and B. Gopal-ed.): 631-654.

SINGH, J.S. and R.MISRA. 1968. Efficiency of energy capture by the grassland vegetation at Varanasi. *Curr. Sci.* 37: 636-637.

SINGH, J. S. and R. MISRA. 1969. Diversity, dominance, stability and net production in the grasslands at Varanasi, India. *Can.J. Botany* 47: 425-427.

SINGH, K. P. 1966. Effect of temperature on growth of *Portulaca oleracea* L. *P.L. 480/ Ecology Annual Report,* B.H.U. page 82-88.

SINGH, K. P. 1967a. Production, chemical composition and decomposition of leaf litter and soil properties in five deciduous forest communities at Varanasi. Ph.D. thesis, Banaras Hindu University, India.

SINGH, K. P. 1967b. Effect of temperature on growth of *Portulaca oleracea* L. (narrow leaf variety). *P.L. 480/Ecology Annual Report,* B.H.U., p. 74-79.

SINGH, K. P. 1968a. Nutrient status of forest soils in humid tropical regions of western Ghats. *Trop. Ecol.* 9: 119-130.

SINGH, K. P. 1968b. Litter production and nutrient turnover in deciduous forests of Varanasi. *Proc. Symp. Recent Adv. Trop. Ecol.* (ed. R.Misra and B.Gopal): 655-665.

SINGH, K. P. 1969. Nutrient concentration in leaf litter of ten important tree species of deciduous forests at Varanasi. *Trop. Ecol.* 10: 83-95.

SUMMARY

Man's future depends on proper natural resource management ensuring him organic products from plants and animals sufficient for his ever-expanding needs. The International Biological Programme provides an opportunity to measure and study organic productivity as a function of environmental and biological interaction in the basic ecosystems and the adaptation of the human system to a changing pattern of environment. The Varanasi group of ecologists has focussed its attention on the primary productivity of woodlands, grasslands and croplands. The preliminary studies have revealed much higher rates of annual dry matter production in tropical forests as well as grasslands, compared to corresponding temperate ecosystems. Tropical woodland ecosystems are characterized by fast movement of nutrients and energy within their framework. Nutrients, save for lack of moisture, do not seem to limit growth of forests in these regions as the soil has a large reservoir of them. High mobility of nutrients, nevertheless, does expose the system to the vagaries of the physical forces of the environment so that continual and excessive export of the biomass may cause serious disturbances like soil erosion and

moisture loss. Rehabilitation of so highly dynamic a system after destruction will, therefore, be much more difficult in comparison to more sluggish ecosystems found in other climates. It is concluded that land management and conservation practices must be based on the functional aspects of the ecosystems rather than merely on population characteristics.

RÉSUMÉ

L'avenir de l'humanité dépend de l'utilisation rationnelle des ressources naturelles qui fournissent à l'homme des produits organiques animaux et végétaux suffisant à ses besoins toujours croissants. Le Programme Biologique International nous donne l'occasion de mesurer et d'étudier la productivité organique en tant que résultat des interactions de la biologie et du milieu dans des écosystèmes de base, ainsi que l'adaptation du système humain à un milieu changeant. Le groupe d'écologistes de Varanasi a porté toute son attention sur la productivité primaire des forêts, des prairies et des terres cultivées. Les études préliminaires ont révélé des taux de production annuelle de matière sèche beaucoup plus élevés dans les zones boisées et les prairies tropicales que dans les écosystèmes correspondants des régions tempérées. Les écosystèmes des forêts tropicales sont caractérisés par une migration rapide des éléments nutritifs minéraux et de l'énergie à l'intérieur du système. Etant donné que le sol contient de bonnes réserves d'éléments minéraux, ceux-ci ne semblent pas constituer un facteur limitant en ci qui concerne la croissance des forêts tropicales, tandis que les variations saisonnières de l'humidité en sont un. Toutefois, la grande mobilité des éléments minéraux expose le système à l'influence des variations des forces physiques du milieu, de sorte qu'une exploitation continuelle et excessive de la biomasse peut entraîner de sérieuses perturbations telles que l'érosion du sol et des pertes importantes d'eau. Il sera donc infiniment plus difficile de rétablir un système aussi dynamique après sa destruction que de rétablir des écosystèmes moins actifs existant sous d'autres climats. En conséquence, les pratiques d'exploitation et de conservation doivent être fondées sur les aspects fonctionnels des écosystèmes plutôt que seulement sur des caractéristiques de populations.

Section D (2)

Plant Gene Pools and Their Relevance to the Conservation of Flora

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The rapid spread of high yielding cultivars has resulted in the replacement of wild and semi-wild species and a threat of their complete extinction. While it is true that a majority of the cultivated varieties have desirable attributes of productivity under domestication, they are not necessarily the best competitors under natural selection. Moreover, the primitive cultivars contain several adaptive gene blocks which if incorporated into the background of the cultivated varieties can substantially improve their range and degree of adaptation. Some of the adaptive combinations are of immediate utility and others are of future use, such as resistance to a pest or a disease which has been relatively minor so far but may assume an epidemic form with the change in micro- and macro-environments due to inputs like fertilizers and water.

For the above reasons, it is necessary to conserve primitive and semi-wild relatives of cultivated plants. This involves an analysis of their adaptation to specific habitats and of their capacity to survive and multiply in other environments. In short, a study of the biology of adaptation has to be undertaken in maintaining gene pools. The collection, preservation and utilization of the relevant material needs to be undertaken as a cooperative effort by several countries, since one or two countries cannot provide the full range of habitats. Subsequent to collection of the primitive types, the material has to be tested in a number of environments and properly classified on genetic criteria and utilized for specific objectives.

With the above objectives in view, efforts have been made to collect diverse sources of germ plasm in material related to crop plants like rice, wheat, sorghum, Pennisetum, pulses and oilseeds. During the past decade such a programme has been undertaken on a large scale by the Indian Agricultural Research Institute and several collections of germ plasm particularly of wheat, sorghum, Pennisetum and other millets, oilseeds and pulses have been assembled and are being evaluated. These studies have revealed several interesting features which have resulted in a programme of collection of millets in the East African regions particularly in the Ethiopian centre of origin. Some of the major conclusions of the study so far conducted on gene pools during the past five years will be summarized in this paper.

The genetic diversity of plants which are of direct or potential use to man is of considerable importance in plant breeding. The usefulness and utilization of large collections of genotypes which are either in the advanced or primitive stages of cultivation along with their wild relatives is dependent upon our knowledge of plant adaptation, which is a major component of productivity. Development of genotypes which can adjust to several environments is important under intensive cultivation and may need considerable reorganization of the genetic make up of the population. General adaptation over a range of environments involves ability to utilize the favourable and resist the unfavourable factors, such as drought and pests. Statistical methods for estimating adaptability and the selective components of wide adaptation are now being intensively investigated (Finlay and Wilkinson, 1963; Eberhart and Russell, 1966; Roy and Murty, 1967).

From the performance of recent high yielding varieties, some of the components of wide adaptation have been identified to be photo-insensitivity, synchrony of development and a plant frame which can respond to favourable inputs with stability under unpredictable environments. Classification of macro-environments and the inter-action of genotypes with environments, using the above mentioned procedures, will help in comparing information on the performance of genotypes in different environments. The nature of this interaction of genotypes helps to determine breeding procedure for further improvement. A variety

with a high regression coefficient and a high phenotypic mean for yield is the most desirable. Such an analysis is presented below for rice, sorghum and Pennisetum.

EROSION UNDER LOCAL ADAPTATION

The rapid spread of improved varieties tends to eliminate several ancestral types which may combine one or more desirable characters, particularly resistance to pests and diseases and drought. Some primitive cultivars appear to carry a diversity of adaptative gene combinations and, therefore, should be preserved (Frankel, 1968). Research into these factors is in progress for a large number of cultivated crops, like wheat and rice, some other cereals, like sorghum and Pennisetum, and to a limited degree some pulses. Due to the long term effects of natural or human selection, adaptation can result in the loss of useful alleles which may not be directly selected and which may be at low frequencies. Secondly, selection for one or more attributes may result in a correlated response for some other characters in an undesirable direction. Therefore, high local adaptation to specific environments while conferring on a population immediate fitness to existing conditions, reduces the flexibility of the material to meet future contingencies. Such diverse effects could include the genetic erosion of alleles for productivity, instability of performance under changed environments and narrowing of variation available for selection. The geographical distribution of desirable stocks in a world collection of over 12, 000 genetic stocks of millets, and the grain characteristics within each region are given in Tables 1 and 2. It can be seen that the geographical distribution of types with desirable attributes is non-random for each character. Their frequency in each region can be related to the past history of selection forces operating in that region (Catalogue, Murty *et al*.1967).

However, the nature of relationship between genes which are related in function, has in some cases permitted several desirable attributes in the response, such as early maturity, height, grain size and size of embryos, resistance to disease and superior photo-synthetic efficiency. The combination of productivity and wide adaptability does not appear to be difficult to achieve under domestication. However, for increasing the potential of the population, the following aspects appear to be relevant:

1. The effect of selection for earliness and dwarfing in some crop plants.
2. Selection for drought resistance.
3. Selection for diseases and pest resistance.
4. Natural selection for specific environments.

Some of the specific examples of loss of favourable alleles under limited human selection and substantial natural selection are indicated in the Tables (see also Table 3). Thus the selection for late maturity and drought resistance in Nigerian sorghum has resulted in the loss of alleles for synchrony of development, compactness of panicle, and capacity to respond to irrigation and fertilizers. In other genotypes from Upper Volta, Mali and the adjacent African regions, the situation is similar. Similarly, selection for compact earhead in sorghum has resulted in the loss of genes for dwarfing, response to fertilizers, competitive ability, grain quality and resistance to diseases, in general limiting their adaptability. This has also happened in Egypt, India and Ethiopia.

However, in cases such as those of certain Sudan shorghums, where there was no selection, considerable variability has been retained for practically all desirable attributes, such as earliness, dwarfing, photo-synthetic efficiency, grain quality and resistance to pests and diseases. Nevertheless, loss of alleles for drought resistance has taken place in this material, also probably due to genetic drift.

In the case of Pennisetum, selection for very large ears in western Africa has resulted in non-synchrony, low number of tillers, high ratio of vegetative matter to grain, susceptibility to damage by birds due to loss of bristles, smaller grain size and to some extent shattering. This also has resulted in late maturity and photo-sensitivity. On the other hand, selection for earliness and long bristles has resulted in loose ears, abortion of some spikelets, transformation of some fertile spikelets into bristles and reduction in the size of ear and leaf. Some useful characteristics such as increased tiller number and response to fertilizers were retained, while the alleles for disease resistance have been lost. Selec-

TABLE 1: GEOGRAPHICAL DISTRIBUTION OF DESIRABLE STOCKS IN THE WORLD COLLECTION OF SORGHUM (as % of total desirable stocks for each character)

Country	Character		Resistance to pests			Resistance to disease		
	Regeneration capacity	Lodging	Thick stem	Stem borer	Shoot fly	Sugary disease	Rust	Large seed
India	38.88	28.83	38.20	18.40		49.38	53.68	50.00
Ethiopia	3.48	0.93	3.94	6.90		1.23	0.54	0.00
Mali	2.08	1.23	0.56	0.00		0.41	1.63	0.00
Nigeria	3.48	4.21	20.78	14.95		3.07	0.82	2.70
Sudan	5.56	4.44	6.17	13.22		5.94	6.28	7.90
Uganda	0.00	1.63	3.38	2.30		1.64	1.63	0.00
Upper Volta	1.38	0.70	1.68	5.18		0.61	1.63	0.00
Other African regions	20.83	15.42	7.30	20.68	several	6.55	7.08	10.05
Mexico	4.17	9.11	5.25	0.57		9.00	3.27	5.26
Other American regions	18.07	29.66	15.74	12.64		18.84	20.17	21.05
Japan	0.69	0.46	0.00	3.45		1.64	1.09	0.00
Nepal	0.00	0.00	0.00	0.57		0.20	1.09	0.00
Other Asian regions	0.69	0.70	0.00	1.15		1.02	1.09	2.70
Australia	0.00	0.46	0.00	0.00		0.41	1.09	0.00
Total No. of useful stocks	144	428	178	174	1860	488	367	38

N.B. Several stocks were found resistant to ceroospora, helminthosporium and downy mildew diseases.

TABLE 2: GRAIN CHARACTERISTICS OF SOME GEOGRAPHICAL GROUPS OF MILLETS

Country	Glume colour	Glume covering	Seed size	100 seed wt. (gms)	Seed colour	Endosperm colour	Endosperm texture	Grain hardness (kg)	Sub-coat colour
Sorghum									
Nigeria & W. Africa	Light red to dark red	20 to 50	Medium to bold	3.5	Yellow to yellowish brown	White to light yellow	Partly to highly glutinous	10.6	Colourless
Ethiopia	Brown to red	–do–	Small to medium	3.5	Brown to red	White	Starchy or partly glutinous	8.6	Colourless or brown
Uganda	Red to purple	20 to 40	Medium	2.0	Light red to red	White	Starchy or partly glutinous	4.3	Brown to light purple
India	Straw to red	40%	Medium to bold	2.6	White to yellowish brown	White to light yellow	Partly to highly glutinous	7.8	Colourless
U.S.A.	Light red to red	25%	Medium	2.5	Light brown to red	White to yellow	Partly glutinous	5.4	Brown to red
Pennisetum									
Nigeria	Brown	60%	Medium	1.0	Light slate to slate	White	Sugary or partly glutinous	—	—
Uganda	Brown	50%	Medium	1.1	Light slate to slate	White	Partly glutinous	—	—
India	Yellow of brown	50%	Medium	0.7	Light slate to slate	White	Sugary or partly glutinous	—	—
U.S.A.	Brown	65%	Medium	0.7	Slate	White	Highly glutinous	—	—

TABLE 3: NATURE OF GENETIC EROSION IN LOCALLY ADAPTED MILLETS

Country	Characters favoured	Useful characters retained	Characters for which Genetic erosion occurred
A. Sorghum			
Nigeria	Late maturity, large grains	Head length, free threshing, glutinous endosperm, resistance to leaf spot and insects.	Tiller no., dwarfing, synchrony of tillering, response to favourable environment, compactness of panicle, yield/unit area. Result is very limited adaptation, resistance to floral diseases, leaf senescence.
Upper Volta, Mali and Senegal	Late maturity	As above.	As above
United Arab Republic	Large ear head intermediate grain size	Earliness, tillering synchrony.	Dwarfing, grain quality protein vs. starch ratio, resistance to to leaf diseases.
Sudan	Mostly natural selection	Earliness, dwarfing, high photosynthetic efficiency, grain size, grain quality, resistance to several diseases and pests.	Tillering, ear length, drought resistance.
Ethiopia	Compact ears	Resistance to some pests and diseases of ear.	Competitive ability, ear size, grain density and quality, resistance to diseases.
India	Head size, compactness & grain quality	Intermediate grain size, long stem, pest resistance, drought resistance.	Photo-insensitivity, leaf senescence, disease resistance, protein content, response to environment.
Mexico	Resistance to leaf diseases	Early maturity, regeneration capacity.	Resistance to insects, grain size.
U.S.A.	Dwarfing photo-insensitivity	Response to favourable environment, slow leaf senescence.	Ear size, grain and endosperm texture, resistance to most pests and diseases.
B. Pennisetum			
Nigeria and West Africa	Late maturity, large ears, drought resistance	Resistance to pests and leaf diseases, compactness of ear.	Tiller number, synchrony of tillering, grain size, non-shattering, bristling response to favourable environments, resistance to smut.
Ethiopia, Uganda and adjacent East Africa	Early maturity, high tillering	Thin stem, good regeneration, leafiness.	Ear size, compactness of ear, resistance to rust, leaf diseases, grain weight.
India	Drought resistance.	Early maturity.	All characters for productivity.

tion from material with limited variation, used in the introduction of Pennisetum in India, has resulted in genetic drift for alleles responsible for several useful characters including male sterility, which is important for exploiting heterosis.

In rice, selection for fine grain without simultaneous selection for response to fertilizers has resulted in poor yielders with late maturity. Similarly, intense selection for rust resistance in wheat has probably resulted in the loss of several desirable alleles for productivity and early maturity (Goswami, 1967). Selection for earliness in cotton has to some extent resulted in the loss of fibre strength due to irregular deposition of cellulose in the fibres. In Bengal, gram selection for large seed size has resulted in types with limited reproduction potential and loss of resistance to blight.

The above examples indicate that erosion of alleles for productivity could be rapid. However, some of the assumptions that wide adaptation is incompatible with high performance do not appear to be borne out by the data of the world collection, for instance in the case of such genotypes as IR-8 in rice, CSH-1 in sorghum, HB-1 in Pennisetum and the Mexican dwarf wheats and their derivatives. The common characteristics of these widely adapted varieties are given in Table 4.

Recently released high yielding varieties of cereals are far superior to the corresponding local varieties not only in their mean yields, but in showing anything from a 50 to 300 per cent more favourable response to improvement in the environment. This capacity has added to their adaptability. The diversity of the alleles and gene combinations brought together in them, appear to have provided the genetic bases for their wider adaptation as well as for their improved plant frame. Such diversity can be obtained by using some of the specifically adapted types, including wild and semi-wild cultivars, in crosses with high yielding types possessing a medium to large range of adaptation. Selection for a high phenotypic index and high regression coefficient will ensure favourable response to environmental improvement.

It can be concluded that indiscriminate selection by man for a few specific attributes has resulted in the loss of several desirable traits in plant populations. It has also narrowed the variation between populations, thus limiting the sources of new variation. While this is true of natural selection also under very unfavourable environments, the adverse effects of the latter on genetic variation are considerably less as compared to intensive

TABLE 4: SOME CHARACTERISTICS OF WIDELY ADAPTED POPULATIONS OF SOME CEREALS

Crop	Favourable characters	Unfavourable characters
Rice and wheat	Synchrony of tillering, photo-insensitivity, maturity, erect leaf, dwarf plant type, early vigour, slow senescence of leaf, response to favourable environments, high photo-synthetic efficiency.	Limited tiller number, moderate to low disease and pest resistance, variable root development, coarse grain and poor seed dormancy, limited leaf number.
Sorghum and Pennisetum	As above and thin stem and more leafiness.	As above and poor regeneration capacity, low resistance to disease and pest, coarse leaf, mostly non-glutinous endosperm, small to intermediate grain size, threshability not very good.
Gram	Early maturity, resistance to leaf and soil borne diseases, resistance to drought.	Small grain size, less uniformity of starch deposits, resistance to pests low.

human selection, since natural selection never completely eliminates alleles for meeting the needs of unforeseen circumstances a plant population may have to face in future. The progress of crop improvement will be accelerated if these phenomena are taken into account and the material is periodically replenished with new and diverse sources of alleles by hybridization or introduction and r etention of alleles for male sterility and apomixis, which permit retention of variability in the population.

SUMMARY

Domestication or development by selection of crop-plants results in greatly increased productivity, but may also involve a loss in such qualities as adaptability to environmental changes and disease resistance, which could be restored or improved by incorporation of gene blocks from primitive varieties. Hence the need for the latter to be collected, studied and conserved.

The work in this field of the Indian Agricultural Research Institute has been directed to a variety of plant populations and this Paper summarizes some of the results of the last five years. Selection of improved varieties may involve loss of alleles occurring at low frequencies and reduced flexibility for meeting environmental contingencies. Some 12, 000 genetic stocks of millet have been collected and analysed, with results summarized in the Tables.

It is suggested that the use of genetic material, including that derived from wild cultivars, in increasing the potential of a plant population, is especially relevant to selection for early maturing, dwarfing, disease and drought resistance and adaptability for particular environments. In addition to millets, examples are given of loss of desirable characteristics in a number of other crop-plants. However, adverse long-term effects on productivity can certainly be off-set, provided the range of genetic material is maintained and due regard is given to the fact that under natural selection, alleles for meeting environmental variations are not completely eliminated. Through periodical replenishment from new and diverse sources of alleles wide adaptability can be successfully combined with high productivity and a favourable response to environmental improvement ensured.

RÉSUMÉ

La domestication ou la création de plantes cultivées par sélection engendre un accroissement de la productivité, mais peut aussi entraîner la perte de qualités telles que la faculté d'adaptation aux transformations du milieu et la résistance aux maladies. Ces propriétés pourraient toutefois être restaurées ou améliorées par l'incorporation de groupes de gènes provenant de variétés primitives. Il est donc nécessaire de récolter ces dernières, de les étudier et de les conserver.

Les recherches effectuées dans ce domaine par l'Institut de Recherches Agronomiques de l'Inde ont porté sur diverses populations de plantes. Le présent article résume quelques uns des résultats obtenus au cours des cinq dernières années. La sélection de variétés améliorées peut entraîner la perte d'allèles apparaissant peu fréquemment et une diminution de la faculté d'adaptation aux facteurs du milieu. On a récolté et analysé environ 12,000 souches génétiques de millet; les résultats de ces analyses sont résumés dans les tableaux.

Il semble d'après cela que l'emploi de matériel génétique, y compris de matériel issu de cultivars sauvages, accroisse le potentiel de populations de plantes et convienne particulièrement à l'amélioration de qualités telles que maturation précoce, nanisme, résistance aux maladies et à la sécheresse et faculté d'adaptation aux conditions particulières du milieu. D'autres exemples mettent en évidence la disparition de caractères utiles chez un certain nombre d'autres plantes cultivées. Toutefois il semble que les effects négatifs à long terme sur la productivité puissent être contrecarrés à condition que la gamme de matériel génétique soit toujours aussi large et qu'on tienne compte du fait que dans la sélection naturelle, les allèles d'adaptation aux variations du milieu ne sont pas entièrement éliminées. L'apport périodique de matériel provenant de sources d'allèles nouvelles et différentes permet d'allier avec succès une grande faculté d'adaptation à une productivité élevée et d'assurer une réaction positive des plantes à une amélioration du milieu.

Section D (2)

Population Differences in Buffel Grass *(Cenchrus Ciliaris)* at Ahmedabad, India—Ecotypic Characteristics

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Cenchrus ciliaris Linn. (Buffel or Anjan—a perennial grass) is an inhabitant of dry sandy areas throughout Africa, the Canary Islands, Madagascar, and eastwards to India. In India, it occurs mostly in the western states of Rajasthan, parts of Punjab, and Gujarat. In these areas extensive grasslands dominated by *Cenchrus ciliaris* occur on sandy to silty situations during the monsoon months of June to September, exhibiting great morphological variations. It may be added that *Cenchrus ciliaris* is one of the most important fodder resources in the entire sandy arid and semi-arid zones.

The present paper aims to differentiate the populations in *Cenchrus ciliaris* based on the morphological variabilities in nature and under transplant experiments. Net primary productivity and a gene pool of the segregated populations have also been established, both of which have relevance to conservation.

The district of Ahmedabad, where the studies were undertaken and the populations distinguished, lies in northern Gujarat between lat.N20°0' and 23°4',and long. E 71°6' and 72°9',with an average altitude of 100 m. The climate is tropical monsoon-dependent, semi-arid and hot. Winters (December and January) are mild with minimum temperature never going below 4°C. Summers (March to June) are hot and dry with absolute maximum temperature reaching 47. 8°C. Rains are experienced only during the monsoon months of June to September. Rainfall is extremely erratic with an annual average of 650 mm. Underlying soil is coarse alluvium, and the terrain is almost flat. Soils show differences even with slight change in physiography, being mostly sandy on elevations and clayey in depressions.

MATERIAL AND METHODS

1. Variations in the populations in nature

Distinction of the populations was first made in natural grassland. For this purpose a statistical analysis of the following morphological characters was made: colour of spike, length of spike, number of spikelets per spike, number of flowers per spikelet, length of bristle, diameter of bristle cup, depth of bristle cup, length of fourth internode from apex, and shape index (length/width) of the fourth leaf from the apex. Anderson's (1949) diagrams were prepared and the populations distinguished.

Exclosures of varying size were established in natural grasslands at Ahmedabad in which one or the other ecotype (population) is dominant. Seven monthly records of the harvests were taken, starting with growth at the onset of monsoon until the drying of the shoots in the month of January.

2. Transplant experiments

150 clones (four bulb stage) of the segregated populations were transplanted into the Botanical Gardens during November/December, 1967. Clones were sown at a distance of 50 cm and the plots watered daily except during monsoon. The following studies were made on these plants:

(a) Morphological characters—identical observations to those made on populations in natural grassland.

(b) Phenology. With the onset of monsoon, the previous year's root-stocks give out new foliage and seedlings also emerge. Foliage is put up very fast and within fifteen days

to a month, depending upon the populations, mature plants are obtained which subsequently start flowering. The exact date of the floral initiation was noted in each population.

(c) Cytological distinction. Morphology of the somatic chromosomes in the root tips of the seedlings was studied. The seeds were obtained from the transplant experiments. From the karyotype studies, idiograms and chromosome formulae were prepared after Sharma and Sharma (1959).

(d) Nutritive value. The nutritive value of the plants of each population was estimated in terms of crude fibre and crude proteins.

3. Edaphic correlations

Soils and subsoils were analysed for: texture, water holding capacity, pH value, organic carbon, total nitrogen, total cation exchange capacity, and exchangeable elements like sodium, calcium, potassium and phosphorus. For all these estimates, the methods outlined by Pandeya, Puri and Singh (1968) were followed.

RESULTS

The results of the above research have been set out in a series of seven diagrams and histograms (Fig. 1-7).

1. (a) Variations in the populations of natural grassland

Anderson's scatter diagram (Fig. 1) clearly segregates 11 populations of *Cenchrus ciliaris* at Ahmedabad.

An analysis of the variation in the 8 morphological characters is given in Table 1 (see appendix). It will be seen from the table that length of the fourth internode, l/w ratio of the fourth leaf, number of spikelets per spike, number of flowers per spikelet, length of bristle, diameter of bristle cup and depth of bristle cup are all highly significant at 1% point level in all the populations distinguished, making the characters specific for each population. Here replicates were insignificant.

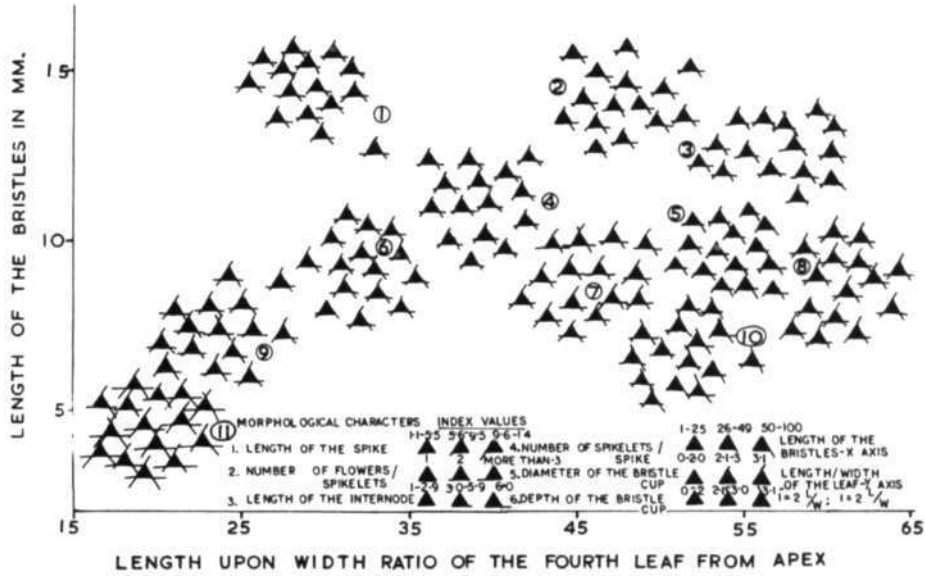

Fig. 1 Anderson's (1949) Scatter diagrams segregating 11 populations of *Cenchrus ciliaris* in nature.

On the above basis, 11 populations ('ecotypes') were confirmed. The ecotypes were named RM 1-11, in honour of Professor Ramdeo Misra of Banaras Hindu University, Varanasi India. The ecotypes have been arranged in decreasing order of the length of bristle (a quantitative character which is least variable within a population of the species) and correlated with the colour of the spikes at maturity, which varies in the 11 ecotypes from greenish yellow to dark brown with violet tinge (Fig. 2).

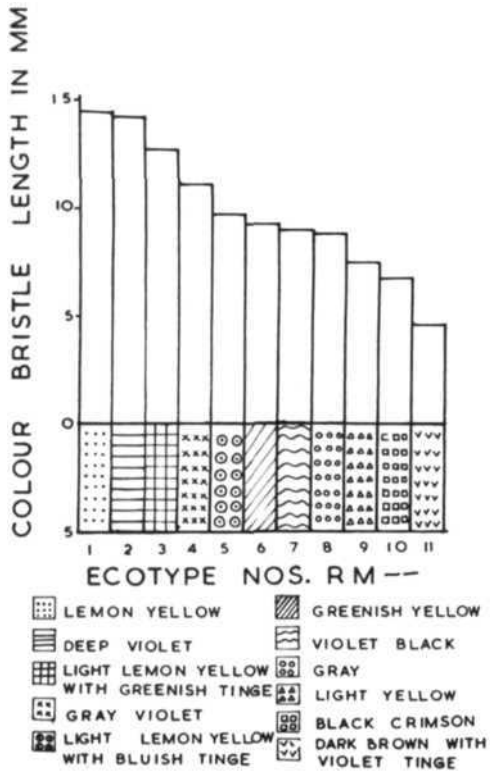

Fig. 2 11 ecotypes of *Cenchrus ciliaris* have been arranged in decreasing order of the length of bristles. Colour of the spikes at maturity is also shown.

1. (b) Net primary production

The highest yield of herbage was recorded on September 5 in the grasslands dominated by RM 1–4, 6 and 8–11, while where RM 5 and 7 were dominant, it was recorded on August 5 The ratio of aboveground to underground biomass was greater than 1 where the exclosures were dominated by RM 1–6 and 10. In RM 7, 8, 9 and 11 dominant exclosures the ratio fell below 1 in some particular months. The most productive grasslands both from the viewpoint of green and oven-dry weight as well as of underground biomass were those dominated by RM 4 (5. 944 kg of oven-dry matter aboveground per m^2) and 7, with the ecotypes 3 and 6 the next most productive in aboveground dry weight and witn RM 10 and 11 the lowest yielding.

2. Transplant experiments

(a) Morphological characters. The transplant experiments indicated that all the clones of the 11 ecotypes retained their morphological distinctions, confirming the segregated populations (Fig. 3).

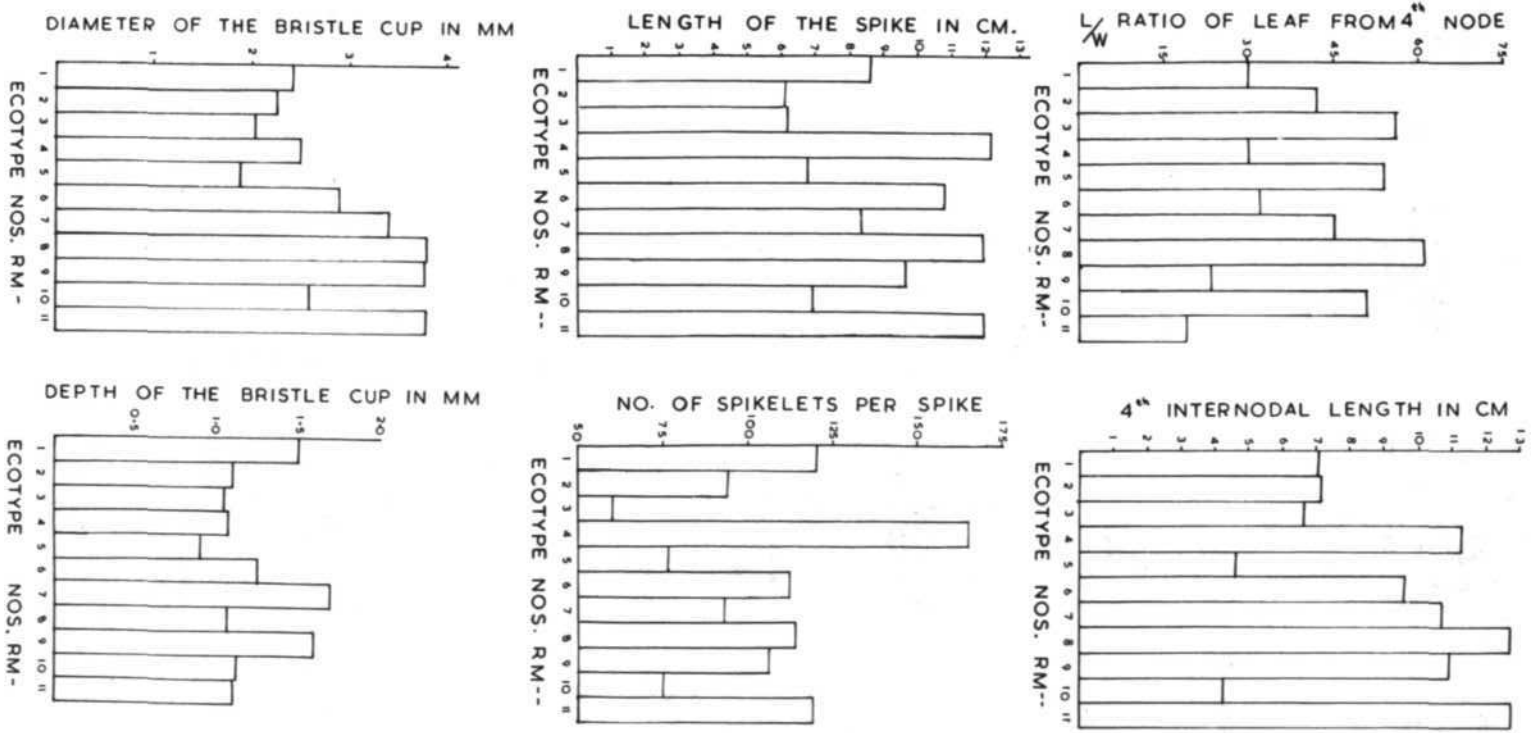

Fig. 3 Magnitude of L/W Ratio of the leaf from 4th node; length of 4th internode; length of spike; number of spikelets per spike; diameter of the bristle cup; and depth of the bristle cup in the 11 ecotypes of *Cenchrus ciliaris* under transplant experiments.

(b) Phenology. The period of floral initiation tends to synchronise with the length of bristle in the 11 ecotypes (Fig. 4). Thus RM 1 with longest bristle takes the longest period to flower (July 30, onwards), and RM 11 with the shortest bristle flowers in the shortest time (June 30, onwards). Exceptions to this very general rule are RM 8 and 9.

(c) Cytological distinctions. In all the ecotypes, the number of chromosomes is 2n = 36; however, large variations in their morphology make the chromosomal formula specific for each ecotype (Fig. 5). Thus cytological distinctions confirm the existence of the genetically fixed 11 ecotypes of *Cenchrus ciliaris.*

(d) Nutritive value. The crude fibre and crude protein contents in the 11 ecotypes are presented graphically in Fig. 6. In all cases the fortnightly values of crude proteins are higher during the month of July, just before flowering, and decline gradually in the subsequent months. Crude fibres behave in the opposite direction. In terms of protein, RM 1, 6 and 7 have higher nutritive value.

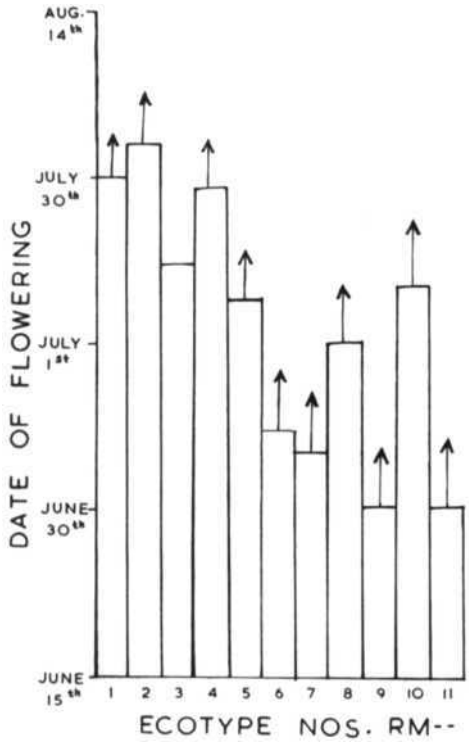

Fig. 4 Phenology: Date of the flower initiation in the 11 ecotypes of *Cenchrus ciliaris.*

3. Edaphic correlations

Soil characters show a definite pattern of variations under the 11 ecotypes (Fig. 7). Starting at a medium level under RM 1, the clay content in the underlying soils shows three distinct peaks under RM 5, 8 and 11, with decreases under the intermediate ecotypes. Arranging the ecotypes in decreasing quantities of clay content, the following order can be given: RM 5, 8, 11, 9, 1, 4, 2, 6, 10, 7 and 3. Practically the same order is maintained with respect to water holding capacity and chemical characters like electric conductivity, total nitrogen, organic carbon and the various exchangeable elements. Thus the ecotypes seem to be well correlated to the soil conditions. Where the soil can support one or more ecotypes, populations do occur in mixed form.

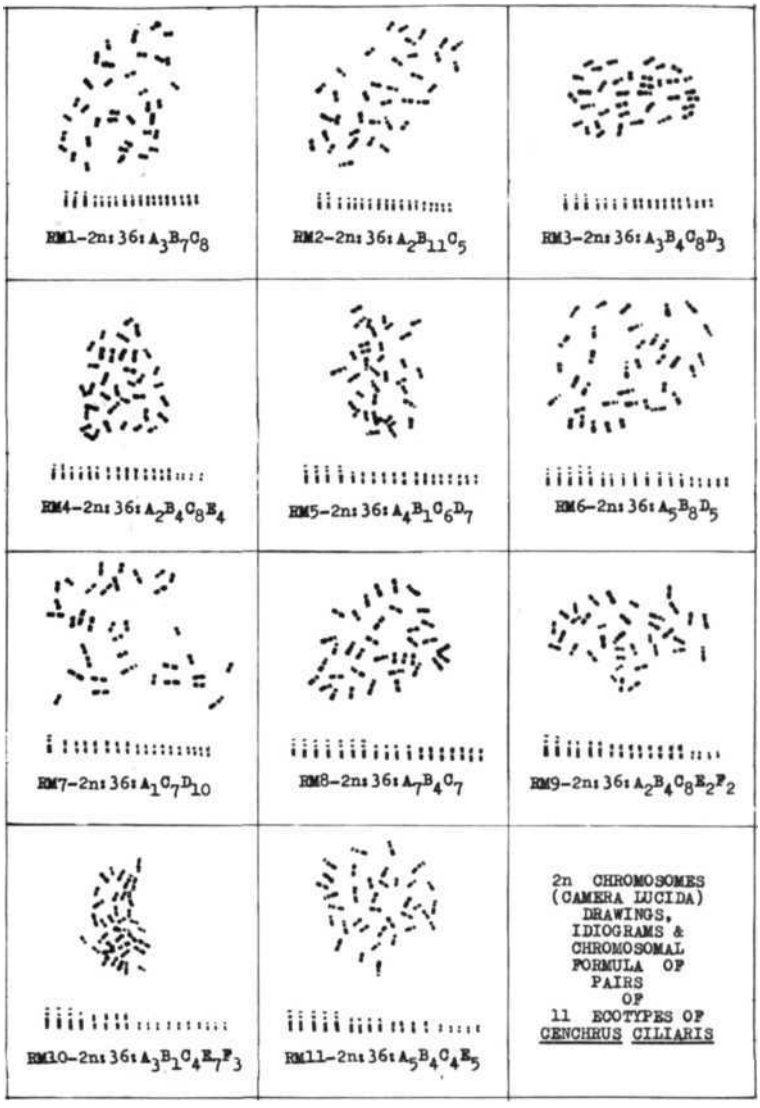

Fig. 5 Chromosomal morphology:

Type A—Comparatively long chromosomes, longest in the set are with two constrictions, primary and secondary; one located at median region and the other at subterminal distal end of the short arm.
Type B—Long chromosome with terminal primary constriction
Type C—Long chromosome with median primary constriction
Type D—Medium sized chromosome with median primary constriction
Type E—Short chromosome with median primary constriction
Type F—Short chromosomes with terminal primary constriction
Magnification x 1, 000 (Angle 24°)

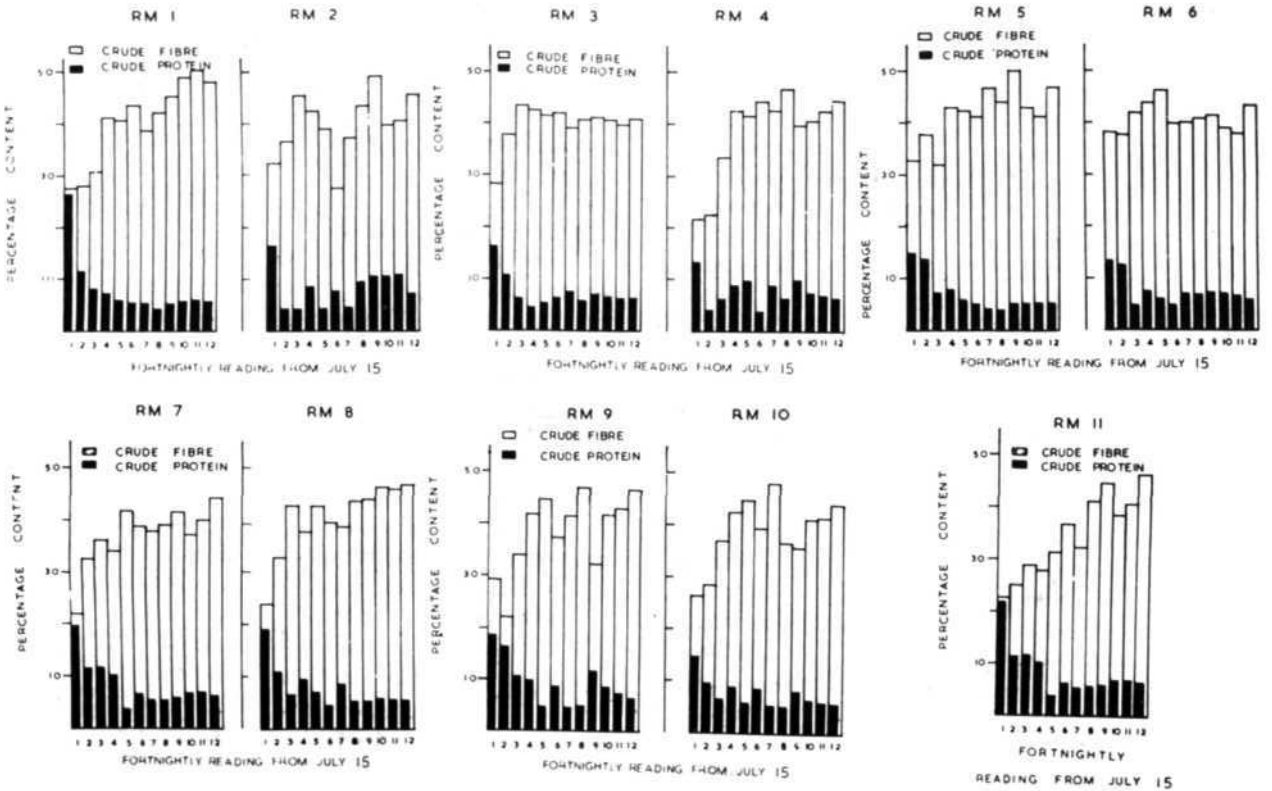

Fig. 6 Nutritive value of the 11 ecotypes under transplant experiments: Histograms show fortnightly variations in crude fibre and crude protein contents in the 11 ecotypes starting from July 15.

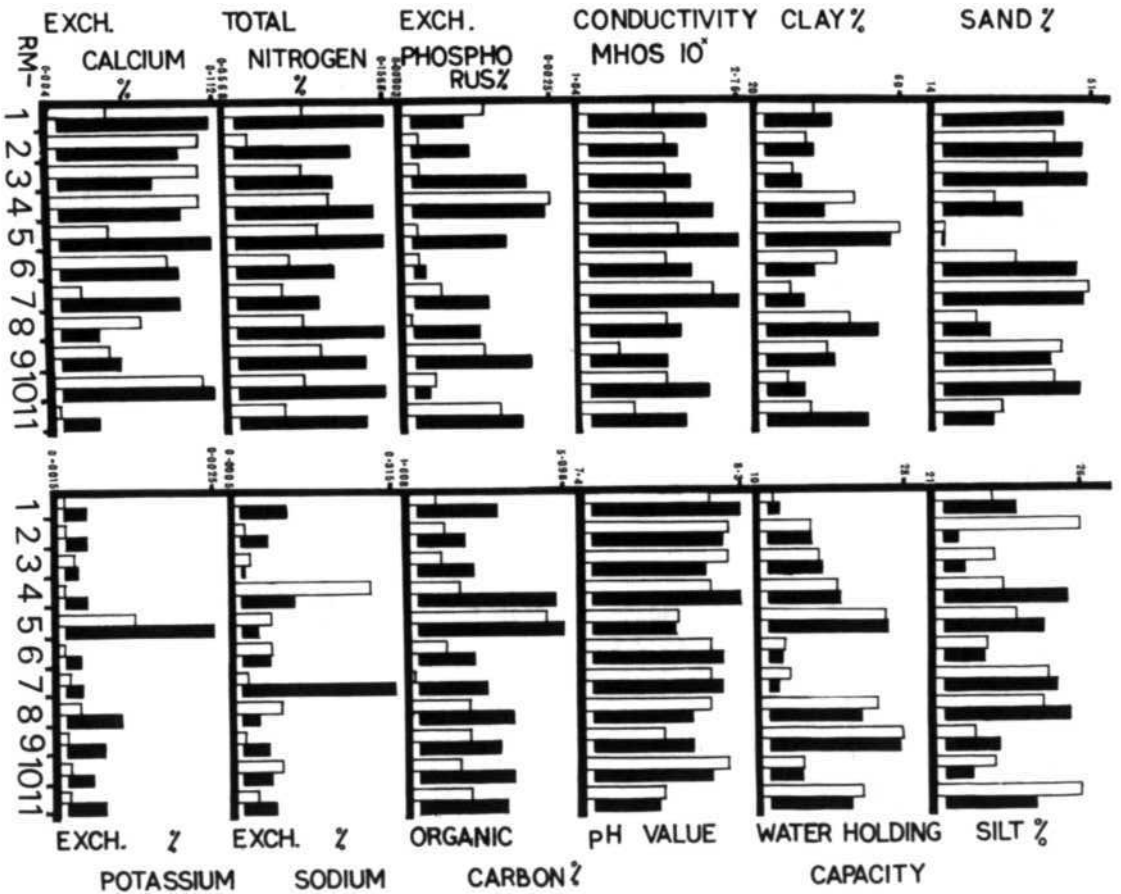

Fig. 7 Soil and subsoil-physical and chemical Characters; under the 11 ecotypes in nature. The shaded histograms indicate values in the soil upper layers and the blank histograms are for the lower layers or subsoil. All values in percent of dry wt.of soil.

DISCUSSION

Eleven populations (ecotypes) of *Cenchrus ciliaris* have been distinguished at Ahmedabad. These ecotypes have distinct morphological, cytological and physiological characters (nutritive value). In this respect, Turesson (1922,25 and 30) has given certain basic propositions for the genecology: (1) Wide ranging species show spatial variations in morphological and physiological characters; (ii) Much of this infraspecific variation can be correlated with habitat differences; and (iii) To the extent that ecologically correlated variation is not simply due to plastic response to environment, it is attributable to the action of natural selection in molding locally adapted populations from the pool of genetically different variation available to the species as a whole. Further, Heslop-Harrison (1964) has given an excellent review on the subject. He had grouped a number of causative factors leading to the formation of ecotypes. Apart from other factors, edaphic adaptations (including adaptation to soil moisture) appear more relevant in the present studies, as evident from soil correlations. Such edaphic adaptations have been described by Bradshaw (1952), Wilkins (1957, 60a and b), Walker (1954), amongst others. In their studies, edaphic variations are found to have selective pressure and the impact may be severe to bring about edaphic ecotypes. The work of McKell *et al:* (1960) on *Dactylis glomerata* has clearly shown the existence of ecotypes based on soil moisture stress. Further, McMillan (1956a and b, 1957, 1959a and b, 1960 and 1961) has shown that within a plant community different populations of a species may grow graded on the basis of soil moisture. From his studies, he has concluded that 'the role of the ecotype in community function is clearly one of allowing vegetation to adjust to its habitat'.

In the present studies, since the soil physical characters and constants have a very similar mode of variation to that of the chemical characters and are complementary to each other, it is better to take edaphic factors as a whole. The ecotypes of *Cenchrus ciliaris* appear to be adaptive to soil characters. The populations thus grade into each other in various proportions, depending upon the grading of the habitat.

From the studies on productivity potentials of the 11 ecotypes, it can be said that RM 4, 6, 5 and 3 can be profitably grown in arid and semi-arid parts of the tropical world. A gene pool of the 11 ecotypes of *Cenchrus ciliaris* has been maintained and the germ plasm can be distributed on request.

REFERENCES

ANDERSON, E. 1949. Introgressive Hybridization. John Wiley & Sons, N. Y.

BRADSHAW, A. D. 1952. Population differences in *Agrostis tenuis.* I Morphological differentiation. *Nature* 169,1098.

HESLOP-HARRISON, J. 1964. Forty years of Genecology. *Recent Advances in Ecology,* 2: 159-247.

McKELL, C. M., E. R. PERRIER and G. L. STEBBINS. 1960. Responses of two subspecies of orchardgrass *(Dactylis glomerata* subsp, *lusitanica* and *judaica)* to increasing soil moisture stress. *Ecology,* 41: 772-78.

McMILLAN, C. 1956a. Nature of the plant community. I Uniform garden and light period studies of five grass taxa in Nebraska. *Ecology,* 37: 330-40.

McMILLAN, C. 1956b. Nature of the plant community. II Variation in flowering behaviour within populations of *Andropogon scoparius. American J. bot.* 43: 429-36.

McMILLAN, C. 1957. Nature of the plant community. III Flowering behaviour within two grassland communities under reciprocal transplanting. *American J. bot.* 44: 144-53.

McMILLAN, C. 1959a. Nature of the plant community. V Variation within the true prairie community-type. *American J. bot.* 46: 418-24.

McMILLAN, C. 1959b. The role of ecotypic variation in the distribution of the central grassland of North America. *Ecol. Monogr.* 29: 285-308.

McMILLAN, C. 1960. Ecotypes and community function. *American Nat.* 94: 245-55.

McMILLAN, C. 1961. Nature of the plant community. VI Texas grassland communities under transplanted conditions. *American J. bot.* 48: 778-85.

PANDEYA, S.C., G.S.PURI and J.S.SINGH. 1968. Research Methods in Plant Ecology. Asia Publishing House, New Delhi, London, New York.

SHARMA, A. K. and Archana SHARMA. 1959. Chromosomal alteration in relation to speciation. *Bot. Rev.* 25: 514-44.

TURESSON, G. 1922. The genotypical response of the plant species to the habitat. *Hereditas* 3: 211-350.

TURESSON, G. 1925. The plant species in relation to habitat and climate. *Hereditas* 6: 147-236.

TURESSON, G. 1930. The selective effect of climate upon the plant species. *Hereditas* 14: 99-152.

WALKER, R.B. 1954. The ecology of serpentine soils. II Factors affecting plant growth on serpentine soils. *Ecology* 35: 259-66.

WILKINS, D. A. 1957. A technique for the measurement of lead tolerance in plants. *Nature, London,* 180, 37.

WILKINS, D. A. 1960a. Recognizing adaptive variants. *Proc. Linn. Soc.,* London, Session 171: 122-26.

WILKINS, D. A. 1960b. The measurement and genetical analysis of lead tolerance in *Festuca ovina. Rep. Scot. Plant, Breed. Stat. 1960:* 85-98.

APPENDIX

TABLE 1: ANALYSIS OF VARIANCE FOR MORPHOLOGICAL CHARACTERS OF *CENCHRUS CILIARIS* IN NATURAL GRASSLANDS AT AHMEDABAD.

D. F. = degree of freedom.

Characters	Factors	D. F.	Summation of squares (SS)	Variance $V_1 = \frac{SS}{D.F.}$	F value $= \frac{V_1}{V_2}$
1. Length of the 4th internode	(a) Ecotype	10	1087.78	108.77	18. 85 (significant at
	(b) Replicate	14	80.90	5.78	1.001 1% point level)
	(c) Error	140	807. 29	5.77	-
	(d) Total	164	1975.97	-	-
2. Length of the spike	(a) Ecotype	10	665.74	66.57	20.42 (significant at
	(b) Replicate	14	76.17	5.44	1.670 1% point level)
	(c) Error	140	456.10	3.26	-
	(d) Total	164	1198.01	-	-
3. Length/width ratio of the 4th leaf	(a) Ecotype	10	23916.80	2391.68	48.79 (significant at
	(b) Replicate	14	105.86	7.56	0.154 1% point level)
	(c) Error	140	6861.83	49.02	-
	(d) Total	164	30884.49	-	-
4. Number of spikelets per spike	(a) Ecotype	10	1913.52	191.35	0.13 (not signifi-
	(b) Replicate	14	11440.77	817.20	0.580 cant)
	(c) Error	140	197070.30	1407.65	-
	(d) Total	164	210424.59	-	-
5. Length of Bristle	(a) Ecotype	10	314.75	31.47	3.59 (significant at
	(b) Replicate	14	40.24	2.87	0.33 1%point level)
	(c) Error	140	1228.60	8.77	-
	(d) Total	164	1583.59	-	-

TABLE 1 (cont)

D.F. = degree of freedom

Characters	Factors	D.F.	Summation of squares (SS)	Variance $V_1 = \frac{SS}{D.F.}$	F value $= \frac{V_1}{V_2}$	
6. Depth of bristle cup	(a) Ecotype	10	13.26	1.32	26.52	(significant at
	(b) Replicate	14	1.02	0.07	1.460	1% point level)
	(c) Error	140	6. 72	0.05	-	
	(d) Total	164	21.00	-	-	
7. Diameter of bristle cup	(a) Ecotype	10	79.85	7.98	39.92	(significant at
	(b) Replicate	14	4.69	0.33	1.65	1% point level)
	(c) Error	140	27.37	0.20	-	
	(d) Total	164	111.91	-	-	
8. Number of flowers per spikelet	(a) Ecotype	10	153.91	15.39	36.60	(significant at
	(b) Replicate	14	3.04	0.22	0.52	1% point level)
	(c) Error	140	58.27	0.42	-	
	(d) Total	164	215.22	-	-	

SECTION D (2): PART A, PRODUCTIVITY AND GENETICS: DISCUSSION

Although the importance of the International Biological Programme is still not recognized by adequate support and funding, the basic studies being undertaken under its auspices are in fact absolutely essential to the conservation or proper use of resources. Haphazard action to try to protect individual species of flora and fauna from gatherers and hunters is not enough nor likely to be effective in the long run: the whole complex of the natural environment needs to be maintained and, to do this successfully, its processes must be better understood, to which productivity studies are crucial (Seshachar, Chairman).

The basic lesson to be learned from productivity studies in the monsoon-dependent tropical region considered in my paper is that by far the greatest part of the biomass, something like 98% in natural forest areas, is made up of plants, while secondary production in animal biomass accounts for only the remaining 2%. At best, perhaps 12% of the vegetable materials could be converted into animal protein, which implies that, under these conditions, man must depend mainly on plant production and that manipulation of the ecosystem should only be undertaken after most careful analysis (Misra, India).

Two points are worth noting in connection with the safeguarding of gene pools: first, in the case of plants, the amount of material is so large that the necessary germ plasm 'banks' could not possibly be maintained without international co-operation, including restriction of indiscriminate collecting that has often caused the loss of genetic material which it may or may not be possible to reconstruct; secondly, the possibility of restoring adaptability to environmental changes and disease resistance in cultivars by incorporating genes from primitive varieties may help to reduce dependence on pesticides and herbicides (Murty, India).

The last point is supported by the fact that resistance to stem-borers seems to be correlated with stem-thickness which can be improved genetically, although it is also necessary to be able to identify the species of borers present (Pandeya, India).

It is also worth noting that in the Calcutta area over half the cultivators still prefer 'deshi' rice rather than high-yielding varieties, because it is less dependent for good results on fertilizers and pesticides, which only a percentage of people use, and some sort of crop can usually be assured (Odend'hal, U.S.A.).

The papers under discussion are of particular interest because, although they are certainly of great importance to conservation of natural resources, they deal with problems which are not very often discussed in conservation meetings. It would be interesting to know Dr. Murty's views on the importance of establishing botanical nature reserves specifically for the protection of wild relatives of cultivars and whether any examples of such reserves are known to him (Morzer Bruyns, Netherlands).

Dr. Murty has touched on an issue of considerable concern to IBP/CT internationally. In seeking to identify and designate natural areas to be conserved for the benefit of future science, we have been working primarily on the basis of locating the full range of ecological types and selecting the best samples of each and, secondarily, depending on the guidance of the Survival Service Commission and other sources concerned mainly with endangered species. We do not, however, have any generalised guidance in selecting natural areas which may be of outstanding importance for conserving gene pools. If we could be provided with advice on what is required and how to locate and identify it, we would gladly extend our area of search accordingly, although we would look to the Utilization and Management (UM) section of IBP for the necessary collaboration (Nicholson, U.K.).

It should be possible to set aside areas where plant variation is specially noteworthy in the same way as faunal reserves, except that they could often be of quite small size and yet quite adequate. Regions which come to mind in this connection are West Africa, S.W. Turkey, the Rift Valley and the Colombian and Mexican highlands (Murty, India).

It is worth mentioning the importance of safeguarding rich natural areas near great cities and in particular near Universities for use not only as 'breathing areas', but also for ecological studies and for the maintenance of plant varieties and gene pools—purposes that can be quite easily reconciled with one another. The Old Delhi Ridge is a case in point, threatened by 'one-track-minded' development and too much emphasis on introduced exotic species; the Delhi Planning Authority should remember the importance of keeping adequate samples of the natural vegetation (Varshney, India).

Section D (2)

The Ecological Impact of Domestic Stock on the Gir Forest

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1. INTRODUCTION

When cattle become 'a burden on the land or its people', it is often because the numbers of domestic stock exceed the carrying capacity of the land. The result is that there is overgrazing, which both increases erosion of the soil and lowers the quality of the fodder. In India, Sagreiya (1940) estimated that between 20 and 60 per cent of the cattle are uneconomic, while according to Banerjii (1952) over 60 per cent or two-thirds graze forest land, which makes up 20 per cent of the total land mass. Banerjii calculated that only one acre of pasture per head is available and that this can hardly support an animal in a healthy state for more than one month.

It would be possible to improve the quality of the fodder by introducing a system of rotational grazing. Many forest grazing areas are controlled by rotational grazing rules. But in several Wildlife Sanctuaries, all managed by state forest departments, overgrazing has been recorded. For example, in the Gir forest, no system of rotational grazing has yet been introduced and the present paper, therefore, is an examination of the effects of uncontrolled grazing in this particular area.

2. THE GRAZING ANIMALS OF THE GIR

The Gir is famous not only for its Indian lions *(Panthera leo persica)* but also for the Gir buffaloes, which are very good milk producers. Some 5, 000 cattle graziers live in 100 hamlets scattered throughout the forest. Their stock is mostly buffalo, of which there are some 17, 000 at present, and their economy depends on ghee produced from buffalo milk. The Gir has been extensively grazed by buffalo for more than 200 years, but it has only recently been noticed that the habitat is deteriorating. The evidence for this deterioration comes from the herdsmen, who claim that the land cannot support as many baffaloes as it could 25 years ago. In 1966, after a severe drought, the number of buffaloes dropped from 25, 000 to the present level, due to starvation.

One reason for the decline in quality of the fodder may be that formerly the herdsmen were semi-nomadic and moved their buffaloes out of the forest during the monsoon, when malaria was rampant. With the eradication of this disease the herdsmen and their buffaloes remain in the Gir during the monsoon, when heavy grazing does most damage to vegetation and soil. Other domestic stock in the Gir include a number of cows, ranging from 5, 000 to 20, 000 according to the season. There are also up to 1, 000 goats, but these are restricted to a few places on the outskirts, because the forest management plans forbid goats in the Gir.

In addition, there are a few wild herbivores, of which chital *Axis axis,* Nilgai *Boselaphus tragocamelus* and sambhar *Cervus unicolor* are regularly seen in numbers not exceeding 20. Four-horned antelope *Tetracerus quadricornis* and Indian gazelle or chinkara *Gazella gazella* occur in only a few parts of the forest, and total numbers of wild ungulates are so low that it is likely that their grazing impact is extremely small.

3. DESCRIPTION OF THE GIR FOREST

The Gir forest lies in the centre of the Kathiawar Peninsular in the Gujarat State. It is some 200 miles north-west of Bombay and 175 miles south-west of Ahmedabad. The total area of the Gir under forest is said to have been 1200 sq. miles at the turn of the century, but due to clearance to provide timber and agricultural land the area was reduced to 483

sq. miles by 1920. Since 1920, no detailed survey of the forest area has been made, but it is likely that it has shrunk well below 483 sq. miles as a result of agricultural encroachment around its borders.

Physiography: the Gir is approximately 40 miles long and 15 miles wide. Elevations range between 741 and 2, 128 feet above sea-level. It is hilly in parts without extremes of relief. The perimeter of the forest lies on the plains below the hills. Five perennial rivers flow from the hills, which are the catchment supplying the surrounding agricultural lands. Parent rock is basalt, trap and limestone. Soils on the hills are generally red or yellow, but on some there is virtually no soil cover, while fertile black soils are found on gently sloping parts of the forest, along the rivers and on the plains leading into agricultural land.

Climate: the region is characterized by three seasons: cool-dry from late October to February, with minimum temperatures as low as 35°F; hot-dry between February and June, with maximum temperatures of 110°F; and monsoon from late June to early October, with the bulk of the annual rainfall during this period. The average annual rainfall varies from 19 inches in the extreme east to 35 inches around Sasan in the west. The Gir lies in a semi-arid area and on average every third year is a drought, with less than 10 or 20 inches of rain.

Vegetation: The vegetational types fall largely within the Tropical Dry Mixed Deciduous classification of Champion (1936). Santapau (1956) and Talbot (1956) have already described aspects of the vegetation and the following account incorporates some of their observations.

(1) Open Teak *(Tectona grandis)* forest. This is typically found on red soils in hilly areas. Trees are about 10 metres high, and the canopy consists of 70-90% of aged, crooked teak. The understorey includes thorny species of *Acacia* and *Zizyphus.* Common grasses include *Themeda quadrivalvis* and *Sekima nervosum.*

(2) Open Mixed Deciduous forest. This is found on red or yellow soils of gentle or steep hillsides where the rainfall is less than 25 inches. Teak does not grow in areas of such low rainfall. Non-thorny deciduous species such as *Boswellia serrata* and *Wrightia tinctoria* reach a height of 12 metres to dominate the canopy. The understorey is sparse, with thorny species such as Zizyphus and Acacia. The common grasses include *Sekima nervosum* and *Heteropogon contortus.*

(3) Closed Teak forest. Typically found on gentle slopes with black soils. Trees are about 15 metres high, and the canopy consists of 60% teak. Other co-dominants are non-thorny deciduous trees. The understory consists of *Carissa carandas* and other dense evergreen shrubs, along with deciduous shrubs such as *Helicteres isera.* A dominant grass is the tall shade-tolerant *Apluda mutica.*

(4) Thorn forest, closed or open 4-8 metres high with a canopy of 70% *Acacia arabica.* This formation is commonly found on the flats or gentle slopes around villages and on the perimeter of the taller forests. It is typically best developed on rich black soil with poor drainage.

(5) Dry tropical riverain forest. This is restricted to both the perennial and the intermittent streams. The canopy is dominated by evergreen species such as *Syzygium rubicundia* and *Pongamia glabra,* which rise to 25 metres; a dense understorey consists of evergreen shrubs, such as *Carissa carandas,* and the ground cover of shade-tolerant grasses such as *Oplismenus burmannii.*

(6) Hilltops. They are often treeless and dominated by grasses such as *Sekima nervosum* and *Heteropogon contortus.*

Distribution of the forest types: generally the open teak occupies the north-western region of the forest while the thorn forest is found in the west and south-western region. The closed teak occupies the central and southern portion of the forest while the open and mixed deciduous forest is found in the eastern region of the Gir.

4. THE ECOLOGICAL IMPACT OF DOMESTIC STOCK ON THE VEGETATION AND SOIL

(a) On the species composition of the ground flora.

Fenced areas were set up in overgrazed areas. All domestic animals were kept out of the fenced areas, known as exclosures. The vegetation in the exclosures was compared with the vegetation outside. Since the exclosures were only closed to grazing for one year few changes could take place. It was, however, observed that there were relatively more forbs than grasses in the grazed areas when compared with the ungrazed areas.

Furthermore, certain unpalatable forbs such as *Cassia tora* were particularly abundant outside the exclosures. A comparison of the abundance of annual and perennial species of grasses in the two situations also showed that even after one season's growth the exclosures contained a higher ratio of perennials to annuals. In particular the palatable perennial grass *Dicanthium annulatum* greatly increased.

(b) On the production of the ground flora.

During the monsoon the grazing pressure in the Gir kept most grass swards below a height of 15 cm. The production of grasses was always higher than that of the forbs in the exclosures, while that of the forbs often exceeded the grasses in the grazed plots. At the end of the growing season less than 300 kilos of dry matter per hectare of ground flora remained for the animals to graze for the remaining eight months of the year. The evidence suggests that heavy grazing had little stimulating effect on growth, since grass or herbs seldom covered more than 30% of the ground, compared with 80-100% in the exclosures.

In the ungrazed areas some growth of perennial grass continued during the dry season by utilization of the moisture of dews, but in the areas open to grazing no growth took place.

(c) On regeneration of the forest trees.

The growth of tree seedlings in exclosures was compared with the growth of tree seedlings in grazed areas. Whilst the tree seedlings in the exclosures grew successfully, those in the grazed areas remained stunted and all new growth was removed. Teak does not appear to regenerate naturally in the Gir, but is perpetuated by coppicing and stump planting. All domestic animals are banned from areas where teak is being re-established and the forest officers are able to keep the majority of stock out of the plantations, at least for the first year. This is certainly essential, since it has been observed that the buffaloes not only browse the young leaves of tree seedlings but also break the stems with their horns and hooves. It was also noted that the forest department is successfully perpetuating teak forest in all areas where it is present naturally, but that attempts to introduce it into thorn forest areas have been unsuccessful, probably because of uncontrolled grazing.

More than one third of the Gir is covered by thorn forest, predominantly *Acacia arabica.* It is believed that this type of thorn forest is increasing at the expense of certain non-thorny tree species and that *Acacia arabica* may be the only species able to regenerate under moderately heavy grazing pressure. However, it was found that even *Acacia arabica* did not regenerate successfully where the overgrazing is very severe. Such areas are typically bare of ground flora and without tree cover and, for example, occur near to settlements or waterholes.

(d) On the soils.

Throughout the monsoon the ground cover of grazed and ungrazed areas was measured. In grazed areas, it rarely exceeded 30%, while in the ungrazed areas it was 80-100%. In consequence 70% of the soil in the former was exposed to erosion by rain, particularly where the tree canopy was open. The long-term effect of this will be to completely change soil structure and composition. F.R.Bharucha and K.A. Shankanarayan (1958) have studied the effects of overgrazing on the soils of the Western Ghats of India. They found a decrease in the moisture content, organic matter and the total exchangeable bases, in particular calcium.

Trampling, combined with the removal of cover by grazing, affects the structure of the

soil. Measurements were made of the degree of compaction of the soil in the areas open and closed to grazing. The soil in the grazed areas was extremely compact, thus increasing runoff and making seedling establishment less likely. The soil in the exclosures, after only one year's closure to grazing, was much less compacted and more porous to water. This shows that the structure of the soil can recover remarkably quickly from overgrazing.

5. THE ECOLOGICAL IMPACT OF DOMESTIC STOCK ON THE WILDLIFE

(a) On wild ungulates.

Wild ungulates must once have been common enough to be the main food of the Indian lion, but as previously stated all are now rather rare. Of the three most common, the chital is chiefly a grazer, while the nilgai and sambhar are normally browsers. During the monsoon, there is a super-abundance of food for both domestic and wild ungulates, but by the end of the growing season little ground flora remains, less than 300 kilos of dry matter per hectare as already mentioned. Even on steep hillsides or in teak plantations, where domestic stock are unable or forbidden to graze, the grass is removed by fodder cutters from surrounding villages. Thus it would seem that there is insufficient grass to support large herds of chital in the dry season. The rarity of two other grazers, the four-horned antelope and the chinkara is perhaps also due to so little food being available.

The accessible browse is removed by buffaloes, which can reach up to 7 feet, and this must greatly reduce the food for wild browsers. However, it should be noted that the policy of the Forest Department favours the unpalatable teak rather than the more palatable species such as *Zizyphus*, and this too must greatly reduce the amount of food for sambhar and nilgai.

Tentative calculations suggest that less than 10% of the Gir is suitable for herds of wild ungulates at the height of the dry season.

(b) On the lion.

The 1968 census of the Indian lion showed that about 170 lions are in the Gir forest, which means that there is about one lion to every 3 square miles. Despite this high density of lions, few wild herbivore kills have been recorded. This may be partly because overgrazing has thinned out the forest so that there is little stalking cover for the lions. In addition the lions are now accustomed to killing domestic stock. But it is unlikely that domestic stock have actually made the Gir into unsuitable habitat for the lions, since lions are able to live in almost any habitat save dense forest.

6. FACTORS ASSOCIATED WITH THE DOMESTIC STOCK

(a) The ecological impact of repeated tree lopping.

The cattle graziers lop trees for two purposes. Firstly this provides browse in the form of fresh leaves which the buffaloes could not otherwise reach. Secondly it provides thorn fencing to protect the settlements from lions and keep the buffaloes in corrals. The lopping to provide browse does not normally kill most species of trees, as they can withstand pollarding.

However, it is thought that repeated lopping has led to dynamic change in one large area of about 60 square miles, dominated by *Acacia arabica.* This is the Devalia block, which was said to have once been dominated by *Wrightia tinctoria* and other non-thorny trees. Observation suggests that *Wrightia tinctoria* is unable to withstand repeated pollarding and so has been eliminated, allowing *Acacia arabica* to replace it. This change is unfavourable for two reasons. Firstly *Acacia arabica* suppresses the growth of grass, and secondly *Wrightia tinctoria* is probably more palatable than *Acacia.*

The graziers are now largely sedentary and around each settlement many trees are cut down. Only thorny species such as Acacia arabica survive within a radius of about 200 yards of each settlement. Since there are more than 100 of them, the wildlife habitat is extensively disturbed.

(b) The impact of the graziers on the lion and the wild ungulates.

The graziers have no firearms, are poor and vegetarian. In consequence they do no harm to the wild ungulates. Indeed wild ungulates have been observed in daytime visiting the water troughs provided for the buffaloes.

However, human activities do affect the lion. Bushes of evergreen shrubs such as *Carissa carandas*, which form seclusion cover for the lion, are burnt away. The herdsmen often drive the Hons off buffalo kills and, having done so, have been known occasionally to place poison in the carcass. In one instance 7 lions died after feeding on a poisoned carcass. However, the extent of damage done to the lion population by poisoning is unknown.

7. DISCUSSION

Talbot (1959) stated that 'at the present rate of attrition the Gir could only last another 20 years'. Fortunately this prediction is not likely to come true. Management by the forest department is maintaining the forest. The exclosures described above demonstrated the remarkable capacity of the habitat to recover from the effects of overgrazing, shown by the increase in the proportion of the palatable perennial grasses to annuals, after only one year's protection and an improvement in soil structure in the protected area.

It has been suggested in some quarters that the cattle graziers and their buffaloes should be removed from the forest. Some seven schemes for their removal and resettlement outside the sanctuary have been put to the State Government. The idea was that the resettled population would be grouped into dairy cooperatives and that fodder would be cultivated and harvested for stall-feeding of the animals. However, all these schemes have been rejected partly because of lack of funds and partly because the graziers do not want to change their way of life.

It would be better to accept the fact that cattle graziers and their buffalo will remain in the Gir for the present and then evolve a system whereby the quality of the fodder is improved to the benefit of both wild and domestic stock. The forest working plans prescribed that the newly regenerating areas of forest should be closed to grazing for the first five years of their growth. If this regulation could be enforced, between one sixth and one eighth of the forest would be closed to domestic stock at any one time. Since the areas are not fenced the wildlife has free access and would benefit from the increased fodder, The graziers would benefit, since the productivity of the forest areas would recover and limited fodder cutting would be permissible and encourage stall feeding of livestock.

The most satisfactory scheme for balancing domestic and wild ungulate grazing might well be a system of rotational grazing involving the division of the grazing areas around each settlement into three paddocks. These would be grazed in rotation for four month periods: during the monsoon, when there is a superabundance of fodder, the stock could be excluded from two of three paddocks while at other times of the year two of the three paddocks would be grazed and the third left for the wild ungulates. Each paddock would be separated by a low thorn fence over which the wild ungulates could move freely.

The future of the Gir forest in short depends on much greater co-operation between the cattle graziers and the local forest department in applying up-to-date management policies from which both they and the important Wild Life Sanctuary will stand to benefit.

8. REFERENCES

BANERJII, J. 1952. Modern trends in ecological management of grasslands in the world background with special reference to the tropics. *6th Inter. Grassld. Congr*. pp. 513-519.

BHARUCHA, F.R.and K.A.SHANKARNARAYAN. 1958. Studies on the Grasslands of the Western Ghats, India. *J. Ecol.* 46, 681-705.

CHAMPION, H.G. 1936. A preliminary survey of the forests of India and Burma. *Indian For. Rec.(N.S.) Silv.* 1-238.

SAGREIYA,K.P. 1940. Grazing control in reserve forests. *Ind. For.* No. 7.66: 409-418.

SANTAPAU, H. 1955. Contribution to the flora of the Gir forest in Saurashtra, *Indian For. Rec.(N.S.)* 4(6): 105-170.

TALBOT, L.M. 1959. A look at threatened species. A report on some animals of the Middle East and Southern Asia which are threatened with extermination. Fauna Preservation Society. 133 pp.

SUMMARY

An analysis is presented of the effects of uncontrolled grazing by domestic stock in the Gir forest, particularly by buffalo for which the area is renowned, as it is for its lions. The condition of the habitat and the grazing potential are known to be deteriorating. Wild herbivores are too few to be a significant factor.

The situation, physiography, climate and vegetation of the Gir are summarized, the last-named being classified under six heads. The effect of exclosures in over-grazed areas is described. After only one year they showed a higher ratio of perennial grasses, some recovery of soil porosity and 80-100% plant cover as compared with 30% in grazed areas where, at the end of the growing season, less than 300 kilos of dry (ground flora) matter per hectare remained. Tree seedlings only grew successfully in the exclosures, a fact recognized by the forest department ban on grazing in areas where teak is being re-established. Only *Acacia arabica* was found capable of regenerating under moderately heavy but not intensive grazing pressure. The compacting and other effects on soil structure, through trampling and denuding of 70% of the soil surface in grazed areas, are stressed.

The effects on wild ungulates are examined. At the height of the dry season probably only 10% of the Gir remains suitable for grazing species, a process accentuated by cutting of fodder in areas inaccessible to domestic stock. Lopping of trees has affected food supplies of browsing species; changes effected by this practice in one 60 square mile area are described. Ungulates are not directly molested and lions only occasionally, the latter being mainly affected by burning of thick cover.

The future of the Gir is nevertheless considered to be reasonably promising, with proper forest management and in view of the capacity of the habitat to recover under protection, provided graziers can be persuaded to cooperate with the forest department in applying rotational grazing systems, which would ensure improved food supplies for both wild and domestic herbivores.

RÉSUMÉ

L'auteur analyse les effets du pâturage non restreint du bétail domestique dans la forêt de Gir, et en particulier du pâturage des buffles qui, comme les lions, font la renomée de la région. On sait que l'état de l'habitat et du potentiel de pâture se détériore peu à peu. Les herbivores sauvages sont trop peu nombreux pour constituer un facteur significatif.

L. auteur résume ensuite la position géographique, la physiogeographie,le climat et la végétation de la Gir qui se divise en six types phytologiques différents. Il montre l'effet d'enclos protégés dans des secteurs soumis à un pâturage excessif. Au bout d'un an, ces zones encloses présentaient déjà un pourcentage plus élevé de graminées pérennes, un certain rétablissement de la porosité du sol et un couvert végétal de 80 à 100% contre 30% dans les zones pâturées, où en fin de période de croissance des plantes il restait moins de 300 kg de matière sèche végétale par hectare. Les jeunes plants d'arbres n'ont réussi à se développer que dans les secteurs enclos. Cette constatation avait amené de departement forestier à émettre un décret interdisant le pâturage dans les zones de replantation du teck. Seul *Acacia arabica* est capable de se régénérer quand la pression de pâturage n'est pas trop grande, mais il ne le peut pas si cette pression est trop forte. On souligne les effets de tassement du sol et autres provoqués par le piétinement du bétail et la dénudation de 70% de la surface du sol dans les zones soumises au pâturage.

Les conséquences du pâturage excessif pour les ongulés sauvages sont ensuite examinées. Au fort de la saison sèche, il ne reste probablement que 10% de la région de Gir qui puissent être utilisés par les espèces broutantes; ceci est encore accentué par la fauche de l'herbe dans les endroits inaccessibles au bétail domestique. L'élaguage des arbres a

réduit les réserves de nourriture des brouteurs de feuilles. On décrit les changements amenés par cette pratique dans un secteur de 15. 540 hectares. Les ongulés ne sont pas chassés, et les lions uniquement de façon occasionnelle, mais ces derniers sont surtout affectés par le brûlage des couverts épais qui leur servent de refuge.

En dépit de cela, l'avenir de la région de Gir semble assuré dans la mesure où la forêt est correctement exploitée et du fait que les secteurs protégés se rétablissent bien. Mais il sera *nécessaire* que les propriétaires de bétail apportent leur collaboration au départment forestier en appliquant des systèmes de rotation des pâturages, ce qui assurera une amélioration des réserves de nourriture pour les herbivores sauvages et domestiques.

Section D (2)

A Preliminary Report on the Ecology of Cattle in Rural West Bengal

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INTRODUCTION

Diverse agencies in the past and present have been involved in numerous programs to investigate and improve the productiveness of Indian cattle. Some of these studies conducted at large institutions have a restricted relevance to the typical village situation, and field studies often emphasize only a single aspect of cattle ecology. An intensive study of a large rural cattle population integrating many ecological factors would be advantageous. This is the objective of the present study which is presented as a preliminary report. Eventually an economic and energetic balance sheet will be prepared for this particular cattle population.

Current management practices have been described (1, 2, 3), and some of the social and religious implications of prevailing attitudes toward cattle are presented by Shah (4). Using available national statistics, Harris (5) challenges ideas on the unproductive nature of the zebu cow. Several have mentioned the threat to wildlife and conservation by the excessive numbers of cattle overgrazing the forest areas (6, 7, 8). In some of his more recent publications, Whyte gives a most comprehensive review of the current Indian cattle situation (9, 10, 11).

The present study is being conducted in Singue *thana** in Hooghly District about 25 miles northwest of Calcutta. The *thana* covers 56. 9 square miles and is 4 to 8 miles west of the Hooghly river. It lies within the Tropic of Cancer and has a monsoon climate. Rainfall varies between 50 and 70 inches per year and yearly temperature extremes range from 45° to 110° F. The humidity is high for most of the year. Topographically, the area is a flat alluvial plain with meandering streams and canals. Trees and numerous ponds are mainly found near areas of habitation. The principle crops are rice, jute, bananas and vegetables. During the drier parts of the year, certain areas are irrigated.

Almost none of the cattle can be classified as specific breeds according to the description of Indian cattle by Joshi and Phillips (12). They are small, but appear to be well adapted to their environment. Most of the cattle are stall-fed, mainly on by-products of crops grown for human consumption. Few fodder crops are grown; there are no regular pastures and grazing is restricted to fallow fields, along road sides, etc. The dung is used as cooking fuel and fertilizer. Some of the milk is sent to Calcutta mainly for making confections.

METHODS

Essentially this investigation involves four integrated approaches:

1. A census of humans and domestic animals.
2. A feed consumption and productivity study of cattle.
3. A land utilization study.
4. An agricultural management study.

Based on the 1961 census (13), 11 *mauzas*† of Singur *thana* were selected for study from a randomized sample stratified according to human density and land area. A represen-

**Thana* is a police station jurisdiction and is a geographical sub-division of a district.

†*Mauza* are geographical sub-divisions of a *thana*. There are 103 mauzas in Singur *thana*.

tative portion of the non-municipal urban areas was added. These 12 areas represent 10% of both the human population and land area of Singur *thana.*

1. The Census of Humans and Domestic Animals.

Three censuses of the same area will be conducted. The first census was between July and December 1968, the second between January and July 1969 and the third census is currently underway. During each census the following information is obtained from each household.

(*a*) *Humans.*

1. Name, occupation, religion and caste of the head of the household.
2. Age and sex of each member.
3. Number of members earning money outside Singur.
4. Type of housing construction.
5. Amount of land owned and kinds of crops cultivated.

(*b*) *Domestic animals.*

1. All species, including cattle:
   (a) Age and sex.
   (b) Month and year of acquisition.
   (c) Cost or method of acquisition.
   (d) Kinds of food fed the day before our visit.
   (e) Morbidity and mortality history where appropriate.
2. Cattle (only):
   (a) Major use of bulls and bullocks.
   (b) Females;
      1. Total number of calves produced.
      2. Month and year of last calving.
      3. Milk yield the day before our visit.
      4. Date and method of last insemination.

2. The Feed Consumption and Productivity Study of Cattle.

Fourteen households were selected for study by a random sample of three contiguous *mamas.* The cattle of each household were observed for one day, from the time they were taken out of the cow-shed in the morning until their return that evening. During that time all food fed and dung and milk produced was weighed for each animal. Also the amount of time spent grazing and working was determined.

This study will be conducted on the same cattle at three different times of the year. The first one was done for one week during the hot season (April 1969). The second will be done during the monsoon season and the third during the winter season.

3. The Land Utilization Study.

This was done in conjunction with the second round census (January to July 1969). Each plot of land in the 12 study areas was visited once during the 6 months period. The kind of crop planted or major use was recorded on the day of our visit. This study will be repeated during the third census period.

4. The Agricultural Management Study.

This study consisted of a questionnaire (more properly called a 'schedule') developed at the conclusion of the initial census and incorporated into the second round census. It was designed to elucidate the general household management of such things as cooking fuel, fertilizer, milk, etc. A revised schedule is being used during the third census.

RESULTS

At this time, only the preliminary analysis of the census and the feed consumption and land use studies are available.

1. The Census

The results of the initial census conducted between July and December 1968, may be seen in Table 1.

TABLE 1: TOTAL POPULATION AND DENSITY OF HUMANS AND CATTLE

Mauza No.	Land Area (acres)	Humans		Cattle	
		Total Pop.	Per sq. mile	Total Pop.	Per sq. mile
1	174.43	504	1,848	101	310
1	401.00	1,717	2,741	444	709
3	251.10	710	1, 822	227	579
i	212.21	1,201	3,630	312	943
5	616.85	2,823	2, 935	687	714
6	859. 10	3,950	2,944	963	718
7	112.40	115	654	47	267
i	312.62	997	2,042	229	469
i	269.22	178	423	36	86
10	109.02	619	3,621	108	632
11	343.08	2,387	4,458	527	984
*12	46.79	926	12, 691	78	1,069
Total	3,707.82 (5.79 sq. miles)	16,127	2, 785	3, 759	648

* Represents non-municipal urban area.

Even with the exclusion of the non-municipal urban area the population density was very high. There were 2, 660 people and 644 cattle per square mile. For every acre there were 4 people and 1 cow.

There were 1, 584 goats and 29 buffalos enumerated in this area. The chickens and ducks together numbered 2, 621 and pets (mainly parrots and dogs) 320.

A total of 2, 497 households were interviewed with an average of 6. 5 people per household. Hindus accounted for 86% and Muslims for 11% of all households. Santal (tribal people) were 1. 7%.

For the cattle population, 1, 660 (44%) were males and 2,099 (56%) were females. Fig. 1 shows the age distribution for each sex. The total number of cattle 3 years of age or less was 1, 333. Of those 4 years or older, 1, 158 were males and 1, 268 were females.

Table 2 shows the means of acquisition of male and female cattle. When one considers only bullocks, 82% were purchased and only 12% were born at the household where they were working. The average cost of those purchased has not been calculated at this time.

Most of the cattle were stall fed. Of the households with cattle, 91% reported they fed straw on the day before our visit. 81% fed oil cake, 71% wheat bran, 33% cut grass and 18% allowed their cattle to graze. These figures apply to information collected only during the first round and may differ on a seasonal basis.

Most of the males were bullocks maintained mainly for ploughing. About 100 of the bullocks were reported too young to work in the fields. Most of the intact males were calves with only 28 mature bulls in the census area.

Information is available from 2, 055 of the females concerning their lactation status (Table 3). Very few cows had calved before they were 4 years old. Thus, out of 1, 232

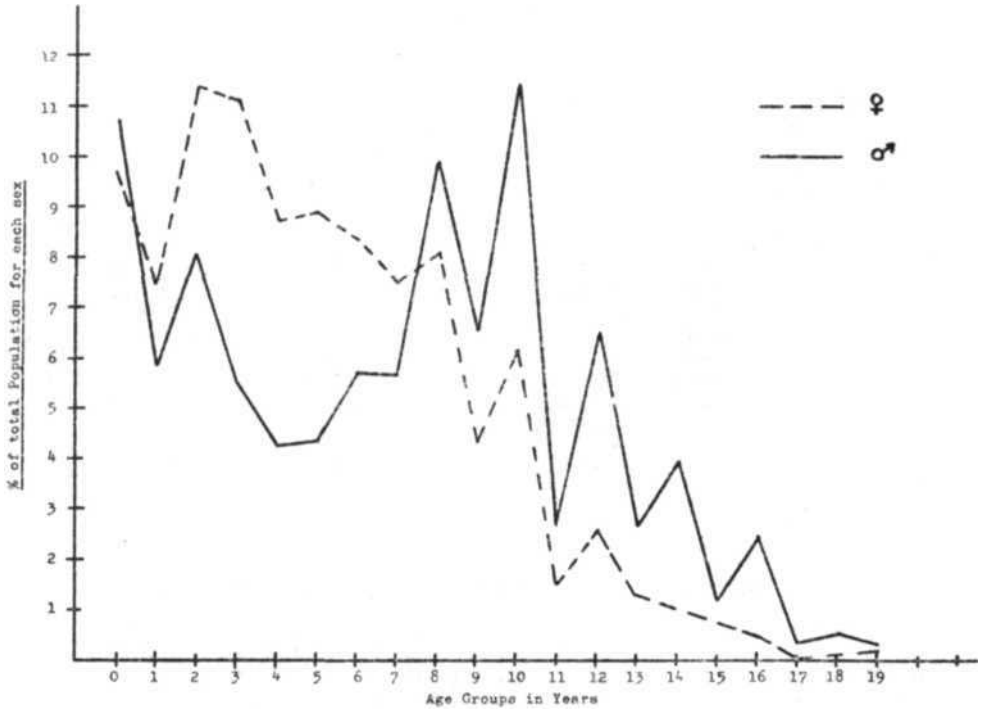

Fig. 1 Age Structure of Cattle by Sex

cows over 4 years, only 497 (40. 3%) were lactating. Above the age of 4 years, 213 cows of those recorded had still not had their first calf.

The average milk yield-per day per lactating cow was 1. 150 kg (2. 5 lbs). Cows in the 8-9 age group had the highest daily average yield (1. 274 kg) and the 4-5 age group had the lowest (1. 013 kg). The milk yield per day correlated with the stage of lactation is shown in Table 4. Forty-two cows were still lactating after one year and 20% of the total were beyond their 10th month of lactation. The total milk yielded per cow, for a lactation period of 12 months, was about 430 kg (950 lbs).

The average number of calves produced per cow for the different age groups for 724 cows is shown in Table 5. Only cows which had one or more calves are included. Of the 448 services recorded only 24% were by artificial insemination.

TABLE 2: MEAN OF ACQUISITION OF CATTLE

	Males		Females		Total	
Means of Acquisition	No.	%	No.	%	No.	%
Born at present Household	535	32.2	1,308	62.3	1,843	49.1
Purchased	1,012	61.2	362	17.3	1,374	36.6
Others*	46	2.7	380	18.1	426	11.3
Not Recorded	67	4.0	49	2.3	116	3.1
TOTAL	1,660	100.1	2,099	100.0	3,759	100.1

*Others means by exchange, renting or as a gift.

TABLE 3: LACTATION STATUS OF COWS

Age Group	Not calved	Calved Lactating	Dry	Total
0-3	817	1	5	823
4-5	184	98	75	357
6-7	25	136	165	326
8-9	3	116	137	256
10-11	1	79	77	157
12 and older	0	67	69	136
Total	1,030	497	528	2,055

TABLE 4: MILK YIELD BY STAGE OF LACTATION (ALL AGES)

No. Months after calving	No. of cows recorded	Av. daily milk yield per cow (kg)
1-3	72	1.768
4-6	111	1. 215
7-9	83	1.055
10-11	25	0. 700
12 and above	42	0.626
TOTAL	333	1. 150

TABLE 5: AVERAGE NUMBER OF CALVES PRODUCED PER COW BY AGE GROUP

Age Group (years)	No. of Cows recorded	Average Number of Calves produced per Cow
4-5	110	1. 2
6-7	231	1.9
8-9	185	3.1
10-11	118	3.8
12 and older	98	5.9
TOTAL	724	3.0

Foot and mouth disease is reported to occur on a yearly basis in the Singur area. Active cases were observed in the study area from August to November 1968. Beginning in October, the families contacted during the census were asked if their cow had been infected recently. The data collected during the last half of the first census is presented in Table 6. All sexes and ages were reported to have been infected. The prevalence of the infection in cattle by *mauza* varied from 10. 6% to 91. 6%.

The results of the second round census are not completely analysed, but the evidence suggests that the cattle population will remain fairly stable, while the human population will increase.

TABLE 6: PREVALENCE OF FOOT AND MOUTH DISEASE IN CATTLE BY SEX (ALL AGES)

Sex	No. recorded cattle	No. reported infected	Prevalence (%)
Bull calves and bulls	328	118	54.8
Bullocks	933	431	46.2
Females	1,417	519	36.6
TOTAL	2, 678	1,068	39.9

2. The Feed Consumption and Productivity Study of Cattle

This study involved 24 cattle, i.e. 13 females, 8 bullocks and 3 young males. The ages ranged from 4 months to 14 years and their weights from 90 to 624 lbs. Four bullocks worked on the day of our visit. One pair ploughed for 5½ hours and the other pair for 4½ hours. Six of the 10 adult females were lactating. The daily milk yield ranged from 0. 263 kg to 1. 700 kg, with an average of 0. 800 kg. The average daily dung production was 7. 2 kg (wet weight) for adult females, 10. 4 kg for the adult males measured and 4. 3 kg for calves.

The average consumption per day of the major food items by classes of cattle is shown in Table 7. The weight of the food is expressed as wet weight. There were 6 calves less than 4 years and their average weight was 156 lbs (70 kg). Adult bullocks numbered 8 and had an average weight of 514 lbs (233 kg). Ten adult females averaged 280 lbs (127 kg). Six of the 24 were allowed to graze at some time during the day of our visit. On the average they grazed for 4½ hours per day.

Other items fed included chopped banana tree stems, cabbage leaves, paddy husks, and rice water. Definitive results are not yet available for the nutritional composition of the complete diet. Cursory examination of Table 7 suggests that this portion of the diet is more than adequate for maintenance, based on total digestible nutrients (TDN),but is

TABLE 7: AVERAGE DAILY CONSUMPTION OF MAJOR FEEDS

	Average amount consumed per head per day (kg) for cattle by age group		
Food	M & F < 4 years	Bullocks > 3 years	Cows > 3 years
Paddy Straw	2.004	4.848	3.141
Oil Cake	0.091	0.330	0.167
Wheat Bran	0.130	0.230	0.194

deficient in protein† (D.C.P.). At the end of the subsequent feed studies, a more adequate estimation of the nutritional status of these animals will be possible.

The costs of the major cattle feeds were obtained from the local markets. The daily cost of the feed listed in Table 7 was: for calves, Rs 0.31 (US$0. 04); adult female Rs 0.49 (US$0. 06) and Rs 0. 79 (US$0. 11) for bullocks. For the 6 lactating cows a similar individual analysing of the value of the major feeds was determined. All but one cow was found to be economical considering the value of the milk produced on a daily basis, at the time of this study.

3. The Land Utilization Study

The results of this study are presented in Table 8. Our calculated total area shown is 1. 47% less than the figure given for the same area in the official census handbook (13) (see Table 1).

TABLE 8: LAND UTILIZATION OF STUDY AREA*

General Land Use	Area (acres)	Percentage
Land devoted to seasonal crops	2,534.79	69.4
Land devoted to year-round crops	456.72	12. 5
Non-cultivated areas	661.93	18.2
TOTAL	3,653.44	100.1

*Includes 46. 79 acres of non-municipal urban area.

The land reported devoted to seasonal crops also included those plots observed fallow and ploughed. The year-round crops were bananas, bamboo, mangoes and others. The non-cultivated areas were settlements, roads, ponds, canals, rail roads and levees. The largest areas were for seasonal cultivation. Appreciable portions of the land were occupied by settlements (6.0%), ponds and canals (8. 5%) and banana groves (7. 8%).

4. The Agricultural Management Study

As mentioned earlier, no results of this study are available at the present time.

DISCUSSION

It must be stressed that this paper is only a preliminary report. As more results are analysed and a more thorough evaluation becomes possible, many figures presented may be subject to change.

Estimating from our sample the 56. 9 square miles of the entire *thana* would have 158, 700 people and 36, 950 cattle. For a rural area the density is very high.

Females are in excess of males in the cattle population which may be explained by the fact that Singur is within the Calcutta milk shed area. There were milkmen in 4 *mauzas*, some of whom owned as many as 20 cows. (The average number of bovines per household was 1. 5 for all households.) All of the buffaloes were owned by milkmen.

The age distribution curve (Fig. 1) reflects the fact that the younger age groups had a preponderance of females, while there were more males in the older age groups. Most of these older males were bullocks which had been purchased. It may be that bull calves are considered a liability for the first 4 or 5 years and are sold as young as possible.

† Determined by using Morrison's feed consumption values (14) and Sen's figures for TDN and D.C.P. requirements for Indian cattle (1).

The productiveness of the cows seems low, particularly when compared to western standards. But actually, western values have very little applicability to the Indian situation. The fundamental reason for the keeping of cattle is completely different. In western countries, meat and milk are the principle products, but in India traction power is the main product and milk is only of secondary importance. Large beef and dairy herds are the basic units in the west, while multipurpose family cattle are the rule in India. In the west large segments of the economy are involved in growing animal fodder crops or large areas are devoted to range land for feeding cattle. Neither is developed in India to any great extent. The cattle food consists mainly of by-products of food crops grown for human consumption. In the west the cattle products are marketed to a large widespread consumer population, while in India the power and most of the milk are both used locally. The main factor determining the feeding regime in the west is the greatest profitable return, but in India it is the minimum economic resources available on a family basis. To sum up the differences, in the west cattle are big business, in India they are a family business.

Western livestock experts point out that there has been very little selection for increased productivity in the typical village cattle. However, some of them may fail to appreciate the value of natural selection in determining which of the cattle will survive in such village situations. *Bos indicus* has many physiological adaptations to tropical climates (15) and has lower energy requirements than *Bos taurus* under certain conditions. When due consideration is given to the rigors of the climate, the economic level of the owners and the nutrient inputs, it may be that the productivity of these animals is quite respectable under the circumstances.

Foot and mouth disease has a very specific syndrome that may be recognized by the lay public. Since it apparently occurs every year, the villagers are familiar with the signs. The limitation of merely asking if an animal is infected is realized. However, we can get some idea of the severity of an outbreak by this method. It should not be misconstrued from Table 6 that bulls are more susceptible than bullocks or cows. As already pointed out, most of the intact males were calves, and the younger animals would be more susceptible. Also, it has been shown that most of the bullocks are purchased and some, being new to the area, may be more susceptible. For the females, we should be able to trace back in our records and find out if those infected were the young and recently purchased.

At this time we shall present only one brief example of how we intend to integrate the material from the separate studies. We can calculate the capability of feeding the cattle with regard to the amount of straw which may be produced in this area on a yearly basis.

From the initial census we know there are 1, 333 male and female cattle under 4 years; 1,158 males and 1, 268 females over 3 years. By relating these figures to the amount of straw consumed per head per day from Table 7, an estimation of the yearly consumption is possible for this particular cattle population. This estimation shows that 4, 464, 000 kg of straw might be consumed per year.

From Table 8 we see that 2, 534. 79 acres could be planted with paddy. From actual field measurements we have estimated the yield of straw in this area to be 2,050 kg per acre (4, 520 lbs). Thus from one year's crop of paddy there could be theoretically 5,190,000 kg of straw available, which exceeds that needed to feed the cattle at the consumption rate given.

Even though there is a very high density of cattle, the area may be self sufficient with regard to straw. This is significant as, surprisingly, straw appears to supply a large amount of the energy intake. It contributes over 80% of the total digestible nutrients of the major food items listed in Table 7 (14). With the acquisition of more complete data a more accurate estimation of the figures presented will be possible.

REFERENCES

1. SEN, S. K. (1967). Handbook of Animal Husbandry; Indian Council of Agricultural Research (I.C.A.R.);New Delhi, 618 pp.
2. SINGH, H. (1966). Domestic Animals. National Book Trust, India; New Delhi, 155 pp.

3. KUMAR, L.S.S.ei *al* (1963). Agriculture in India, Vol. III: Animals; Asia Publ. House, Bombay, 236 pp.
4. SHAH, A. B. (ed) (1967). Cow-slaughter. Horns of a dilemna; Lalvani Publ. House; Bombay, 82 pp.
5. HARRIS, M. (1966). The Cultural Ecology of India's Sacred Cattle; *Current Anthropology*, Vol. 7: pp. 51-59.
6. SPILLETT, J. J. (1967). General Wild Life Conservation Problems in India; *J. Bombay Nat. Hist.* Soc; Vol. 63: pp. 126-138.
7. SCHALLER, G. B. (1967). The Deer and the Tiger. A Study of Wildlife in India; Univ. of Chicago Press, Chicago; 370 pp.
8. GEE, E. P. (1964). The Wild Life of India; Collins, London; 192 pp.
9. WHYTE, R.O. (1968). Land, Livestock and Human Nutrition in India; F. A. Praeger Publ., N.Y.; 309 pp.
10. WHYTE, R. O. and M. L. MATHUR (1968). The Planning of Milk Production In India; Orient Longmans; Bombay, 221 pp.
11. WHYTE, R.O. (1964). The Grassland and Fodder Resources of India. I.C.A.R.New Delhi, 553 pp.
12. JOSHI, N. R. and R. W. PHILLIPS (1953). Zebu Cattle of India and Pakistan. Food and Agriculture Organization, Rome. 256 pp.
13. RAY, B. (ed) (1965). Census 1961. Hooghly District Census Handbook. Government Printing, West Bengal, Calcutta.
14. MORRISON, F. B. (1961). Feeds and Feeding, Abridged. Morrison Publ. Co., Clinton, Iowa, U.S.A. 696 pp.
15. HAFEZ, E. S. E. (1968). Adaptations of Domestic Animals. Lea and Febiger, Philadelphia, 415 pp.

SUMMARY

An area of 5. 79 square miles in rural West Bengal was surveyed to determine the human and domestic animal population. Three censuses will be conducted of the same area to note the changes of the population. Concomitantly with the census work, 3 other studies are being conducted, i.e. a land utilization study, a feed consumption and productivity study of cattle and an agricultural management study. The preliminary analysis of all but the last study is presented.

The results show a population of 16,127 humans and 3, 759 cattle, in the study area, which is high for a rural area. The sex ratio of the cattle population was 100 females to 79 males. There were more females than males in the younger age groups (below 7 years of age), while males (mainly bullocks) exceeded females in the older age groups. Most female cattle were retained at the household of their birth, while most bullocks were purchased. Both males and females have an unproductive period of 3 to 5 years after their birth. The average daily milk yield per lactating cow was 1.150 kg.

Prevalence figures for cattle are given for an outbreak of Foot and Mouth Disease as determined by collection of case histories during the first round census.

The cattle feed consisted mainly of by-products of crops grown for human consumption. Average consumption per head of straw, oil cake and wheat bran are given for 24 cattle. Theoretical calculations suggest that the area available for paddy production could supply the straw required to feed this particular cattle population at the rate determined by the feed consumption study.

RÉSUMÉ

Dans la partie rurale du Bengal Oriental, on a délimité une région d'environ 1.497 hectares, afin d'y recenser la population humaine et les animaux domestiques. On effec-

tuera trois recensements dans cette même zone pour déterminer les variations de population. Parallèlement, on a entrepris trois autres études portant sur l'utilisation des terres, la consommation alimentaire et la productivité du bétail, et la conduite de l'agriculture. Ce rapport présente les résultats préliminaires de toutes ces études excepté la dernière.

Dans cette région, on trouve une population humaine de 16.127 individus et un cheptel de 3. 759 têtes, ce qui est beaucoup pour une zone rurale. Le sex ratio du bétail est de 100 femelles pour 79 mâles. Dans les groupes d'âge inférieurs (moins de 7 ans), on trouve plus de femelles que de mâles, tandis que dans les classes plus âgées, il y a plus de mâles (surtout des boeufs) que des femelles. La plupart des animaux femelles restent dans leur lieu de naissance, alors que la majorité des boeufs ont été achetés. Mâles et femelles ont tous deux une période improductive de 3 à 5 ans près la naissance. La production laitière moyenne par jour et par vache en période de lactation est de 1,150 kg.

Des informations recueillies lors du premier recensement sur les cas de fièvre aphteuse ont permis un tableau des pourcentages d'animaux atteints, par sexes.

Les animaux sont principalement nourris avec les résidus de cultures destinées à l'alimentation humaine. La consommation moyenne par animal de paille, de tourteau et de son de blé a été calculée sur 24 animaux. D'après des calculs théoriques, il semble que la zone convenant à la production de paddy puisse fournir la paille nécessaire à l'alimentation de la population de bétail étudiée, compte tenu des chiffres fournis par l'étude sur la consommation alimentaire de ces animaux.

SECTION D (2): PART B: ECOLOGY AND ECOLOGICAL IMPACT OF CATTLE

POINTS MADE IN DISCUSSION.

In introducing Mr.Hodd's paper in his regretted absence, the point which needs perhaps to be made is that it once again demonstrates that man is apparently the only species which with the assistance of his domesticated stock destroys its own habitat. The remarks of the well-known agriculturist and ecologist Mr. Leslie Brown seem pertinent when he writes—'hardly any of the natural grazing areas of Africa have been extensively damaged by ungulates: even in the best managed farm areas the reverse is true. Where wild animals do damage habitat, it is triggered off by competition with man'. In the Gir forest the depletion of the five wild herbivores is due to cattle: the carnivores now depend on cattle, so that if the latter were removed the carnivores would dispapear and the main attraction and now recognized revenue-earning capacity of the sanctuary would be lost. Nevertheless, here is an opportunity for an imaginative plan, which would presumably involve some system of zoning and the regeneration of the whole grazing potential. In 1966 the drought was disastrous for human interests simply because there was no stamina left in the environment (Futehally, India).

One of the reasons for the spread of thorny trees such as the acacia and *Zizyphus* species is that other tree species have been barked and broken down by being used as rubbing-posts by the domestic buffaloes, and not only destroyed by their browsing. The important point which is brought out in different ways by both the Papers is that nothing can be achieved without the co-operation of the villagers and to obtain that co-operation in the Gir sanctuary area they must be convinced of the agro-economic values of the wildlife and themselves directly benefit from those values. Basically this is a social rather than a scientific problem (Santapau, India).

Much the same problem applies to the incursion of cattle into the Hazaribagh National Park in Bihar. It is all tied up with the peculiarities of the local cattle economy and if it is ever to be brought to an end, something more concrete than appeals to their aesthetic sense will have to be offered to the villagers (Odend'hal, U.S.A.).

Although social and economic problems have been emphasized, the need for continuing scientific and ecological research should never be forgotten: for example, rehabilitation of the Gir forest by regeneration of tree and grass cover is a slow business due to the nature of the soils, so that the best way to manage it is a difficult technical problem (Pandeya, India).

Section D (2)

Studies on the Ecology and Conservation of Freshwater Lakes of Kashmir

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INTRODUCTION

The state of Kashmir has numerous natural lakes which could be potential sources of food and recreation. No information is available at present on these high altitude lakes. The investigations planned involve the study of lake morphometry, thermal structure, and qualitative and quantitative studies on phyto- and zooplankton, Primary productivity studies are also planned in the later stages of the investigation.

The streams of Kashmir offer unlimited opportunities for the angler. Trout is the most sought-after fish. Attempts would be made to improve trout stocks and culture by artificial induction of spawning in trout by pituitary injections.

The entire trophic system for classification of aquatic habitats was conceived on the basis of productivity (Thienemann 1925; Fritsch 1931, Ohle 1955): eutrophic or shallow waters with green to yellow and brownish green water, have a high productivity; oligotrophic or deep cold waters, with bluish to greenish transparent water, have low productivity; while mesotrophic waters lie in between and dystrophic waters would have little cause for productivity.

OLIGOTROPHIC LAKES

These comprise the largest expanses of lentic freshwater bodies in Kashmir. They are as a rule very transparent, lack much dissolved nutrients and thus have little planktonic algae. But due to continuous upwelling the deeper layers of the water are sufficiently rich in dissolved oxygen to maintain animal life throughout the year. The bottom deposits are devoid of bad odours due to presence of oxygen and harbour a rich fauna; while the upper layers are also high in oxygen content.

Fishes of oligotrophic lakes typically are trout or landlocked Salmonidae. In Kashmir, *Schizothorax* (marinka) and mountain barbels are also note-worthy (Das 1963). Examples of oligotrophic lakes in Kashmir are Manasbal, Tarsar and Marsar.

EUTROPHIC LAKES

Eutrophic lakes in Kashmir have a greenish or brownish water, are never transparent, are nutrient rich, and have an abundance of Phytoplankton almost throughout the year, which may have spring peaks, autumn peaks or monsoon peaks, forming soupy green water or surface mats of living and dead plant material. The deeper layers of these lakes are deficient or devoid of oxygen, specially in low altitude countries of the world. Here each Phytoplankton peak is followed by a zooplankton peak, which provide enormous amounts of food for some adult and all young (larval) fishes. Large bottom deposits accumulate, mostly from the rain of plant and animal carcasses from the upper productive layers of the water, so that in summer a black foul smelling (due to H_2S) deposit is formed due to decay and anaerobic conditions prevail; while the upper layers always have very high oxygen.

Typical fishes of eutrophic lakes are 'coarse fish', e.g. carp, *Schizothorax, Barbus* etc. Examples of eutrophic lakes are abundant throughout Kashmir, especially in the valley (5000 feet), e.g. Dal and Wooler.

LAKE ECOLOGY

All lakes appear to have started as oligotrophic lakes and then slowly become eutrophic with passage of time. The suspended plants and associated animals die from time to time and settle into deeper waters, where they decay and liberate nutrients into the water. Eutrophic lakes become shallow due to evaporation and lack of precipitation in the catchment areas, so that light can penetrate almost up to the bottom. The nutrients are then utilised by other plants, and in course of time more nutrients accumulate in the lake making it eutrophic.

This is seen nowhere better than in the eutrophic lakes of Kashmir (Das 1962). Most of these lakes (Wooler, Manasbal, Anchar, Dal, etc.) were born more than 10, 000 years ago during the last glacial period when there were enormous masses of oligotrophic water in the Kashmir valley at a 5, 000 ft. elevation. With continuous evaporation and silting up by mountain stream feeders, these lakes became shallower and more eutrophic, developing an enormous amount of aquatic vegetation which fills the lake bottom and sides today (Das *et al.* 1963). This vegetation has been the main factor in the rapid production of the mirror carp introduced into Kashmir some ten years ago. So much has the mirror carp spread that the once famous local fishes (marinka, barbels and cobitids), specially the marinka *Schizothorax,* are verging towards extinction in the lakes and have now taken mainly to the rivers and streams of Kashmir. This rapid eutrophication of Kashmir lakes has also been helped by human agency, by constant dumping of night soil and garbage into the lakes—specially near human habitation. An extreme case of such water pollution and contamination is found in North Italy, where the beautiful lake Lago d'Orta has been converted into a biological desert in only 25 years by the dumping of copper and ammonia wastes into the water from a factory started on the foothills of the Alps. The lake is now literally devoid of all aquatic plants and animals including fish.

The process of eutrophication of an oligotrophic lake is beautifully seen in the large Subalpine lake Zurich in Switzerland. This has been under almost continuous study by limnologists from the later half of nineteenth century. Eighty years ago, it was a clear oligotrophic lake with spare plankton, high oxygen content even in deeper waters, and with an oligotrophic fish-population of white fish, trout and pike. Lake Zurich is divided into a lower larger and deeper part and an upper shallower part.

In natural evolution the lower deeper part would have remained oligotrophic much longer than the upper part. Instead due to growth of Zurich city on the shore of the lower basin and consequent influx of human sewage and industrial wastes, the lower basin underwent rapid eutrophication, whereas the shores of the upper basin remained sparsely populated and has remained completely oligotrophic even today. The trout and whitefish have almost disappeared from the lower eutrophic lake basin and the pike population has also decreased rapidly, being replaced by a typical eutrophic fish population of 'coarse' fish such as bream and carp. The same may be said of the recent change towards a coarser grade of fish in Lake Erie in North America, which is fast becoming a eutrophic lake due to human 'fertilization'.

FISH PRODUCTION

It follows *ipso facto* that all shallow oligotrophic lakes may be easily converted into eutrophic ones within a few years if man puts organic wastes, fertilizers and treated sullage and other nutrients into the waters. This is specially important in tropical developing countries for artificial lakes of impounded waters and other oligotrophic expanses of water created by high dams (such as Bhakra in India), since the quantity of production of fishes is the main concern in such countries rather than the quality. The introduced mirror carp has all but solved the food-fish production problem in Kashmir (indigenous species cost Rs. 3 to 4 per kilo, whereas carp sells for one rupee to Rs. 2 only). It appears therefore that for such lakes the immediate problem is speedy fertilisation and the production of rapidly spreading herbivorous species such as the mirror carp and Chinese carp. This may be called lake fish farming (comparable with the large 1500 acre crop fields of U.S.A., Canada and U.S.S.R.), and should be subsidized by the respective governments, F.A.O., PL-480 funds and other international aid to developing countries. The main ecological factors to be controlled are water level, erosion and silting, water pollution and water fertilization.

Fish ponds and fishtanks have become the main source of subsidiary protein food in all inland regions of tropical and sub-tropical countries. It has been estimated that for the world as a whole, an annual grand total of 4, 600, 000 tons of fish are obtained from the fresh and brackish waters. Out of this total, over 1, 000, 000 tons are obtained from lakes, ponds, tanks and rice fields. This has been given a fillip in recent years in the developing countries (India, Burma, Pakistan, Ceylon, Philippines, Thailand, Indonesia, Cambodia, Malaysia, etc.) by direct programme of aid through F.A.O. and allied organizations. The results of this programme of expansion of the pond and tank culture have not been very encouraging due mainly to lack of prior knowledge of ecology of these waters in different regions of the world.

The mere sowing of fish seed indiscriminately in all lentic water bodies does not automatically lead to fish-production in these waters. The author has recorded (Das *et al.* 53-58) several such cases in which 10, 000 fry were liberated in each pond and after a year only zero to 50 fishes were left in each. This high mortality or extinction was mainly due to several ecological conditions in these ponds. The main cultivation fishes in Kashmir are carp and barbel, with a few catfish.

The chief methods of evaluating pond production have been measurement of the crops produced such as bottom—fauna and fish (Machean 1936; Patriarche and Ball 1949; Hayne and Ball 1953; Alikunhi 1958; Das *et al.* 1958). In some instances the size of the plankton crop has been estimated by making plankton counts and using radio active carbon methods (Strickland 1960). The production of plankton and their quantitative fluctuations during the season of the year have been intensively studied in India (Das et al. 1956, 1957, 1958 and 1959). Such ecological studies now form the backbone of pond culture in all countries of the world.

It has been demonstrated experimentally (Hasler and Jones 1949) that growth of aquatic macrophytes in some way inhibits plankton production. Nutrient materials in water, especially phosphates and silicates (Enbody 1928, Bennet 1943: Das et al 1956, 1957, 1958) or competition for light (shading effects) have been mentioned as a mechanism by which the larger aquatic plants suppress plankton blooms (Hasler and Jone 1949). In tropical and sub-tropical countries light as a limiting factor may be ruled out as ample insolation is present throughout the year. Quantitative estimation of nutrient salts in pond and tank water have conclusively proved that the Phytoplankton (and matachronous zooplankton) blooms occur in tropical and sub-tropical waters only when phosphates and silicates are above a threshold value (Das *et al.* 1957-1958).

The problem is nowhere better illustrated than in Kashmir where from 25 to 30 per cent of cultivable waters are rendered unfit for fish culture due to excessive growth of water hyacinth and other weeds. Natural ponds and old tanks, therefore, must be subjected to comprehensive ecological studies before a programme of fish seed introduction is begun. Macrophytes, if present excessively, should be removed by standard mechanical or chemical (dalapon amitrol) methods; predators of fishstocks (predatory fishes and insects), competition for food and parasites should be eliminated; control of water supply to the pond (and its occasional total removal) should be taken in hand; control of nutrient salts in the water and addition of fertilizers may be undertaken, before the chosen fish-species or its fry is introduced. New ponds constructed by excavation and construction of embankments should be standardized and stabilized ecologically for at least one year to secure maximum plankton production and optimum macrophyte production for shade and fish food. Optimum production of fish can only be obtained by such an ecological balance.

CONCLUSIONS

One tenth of the world fish catch comes from fresh waters, while in India it amounts to a third; therefore, it may be concluded that a study of freshwater ecology is essential for optimum fish productivity. This study should include such wide aspects of the abiotic environment as temperature, salt content, dissolved oxygen and carbon-dioxide, hydrogenion concentration, salinity, turbidity, insolation, bottom-deposits and movements of water (rheophilic and limnophilic) species. The biotic environment is as important for fish production as the abiotic and should consist of studies of inter-specific and intra-specific relationship of fishes, the relationship between fish and other aquatic animals and the dependence or otherwise of fish species on specific aquatic plants. Lotic waters have mainly rheophilic fishes, while lentic waters are inhabited by limnophile species.

The *horizontal* spatial distribution (riverine, lacustrine, trout section, barbel section and bream section of rivers) and the *vertical* spatial distribution (pelagic, demersal and subdemersal) should be determined for each fish species. Thus a trout species if introduced into the bream section (lower reaches) of a river, and a barbel introduced into the trout section (upper reaches) of a river would share the same fate—*extinction.* The all important studies on the ecology of the fish food organism has lead to the conception of 'fundamental link in the life-cycle of fishes' (Nikolsky 1936). Fishes may be *euryphagic* (feeding on a large variety of foods), *stenophagic* (feeding on a few different foods) and *monophagic* (feeding on one type of food). Similarly, they may be herbivorous, omnivorous, or carnivorous and predatory, according to their normal basic food (Das 1958). *Planktophagic* freshwater fishes are not common, but some important Indian carp and barbel species feed systematically on plankton even as adults. *Benthophagic* species (such as *Cyprinus carpio)* thrive best in lentic water with copious benthophyton. A third category, the *Periphytophagic,* consist of species suited to moderately flowing streams but also having the ability to graze, such as *Schizothorax varicorhinus.* Food spectra of commercially important species are useful for determination of *niches* in the fish *biome* (Das *et al.* 1957; Nikolsky *et al.* 1958). In the majority of fishes, there is a widening of the food spectrum as they grow in size. New freshwater fishery projects or acclimatization projects should only be carried out after a detailed study of the feeding inter-relationships and food supply of the species concerned.

SUMMARY

Based on current studies of the freshwater lakes of Kashmir, an account is given of the ecological features of such lakes. For this purpose a classification based on productivity is generally recognized as the most satisfactory.

The general conditions, fauna and flora of oligotrophic and eutrophic water bodies are summarised and the transitional process from the former to the latter, with special reference to Kashmir conditions, is described. Parallel examples from northern Italy, Switzerland and North America are also given.

In most developing countries, it is the quantity rather than quality of fish production which is important, to which the key seems to be eutrophication and introduction of rapidly spreading herbivorous species such as mirror carp. But for measures towards that end to be really successful, basic ecological studies are essential, to determine, for example, the inter-relationships of macrophytes and plankton, and of individual species of fish and their food. Without proper knowledge of environmental requirements, the only result can be extinction.

RÉSUMÉ

Des études portant sur les lacs d'eau douce du Cachemire ont permis de déterminer les caractéristiques écologiques de ces lacs. Nous avons adopté un mode de classification fondé sur la productivité, et qui passe pour être le plus approprié à cet effet.

Les conditions générales, faune et flore de lacs oligotrophiques et eutrophiques sont résumées et le processus de transition du premier type au second est décrit, compte tenu des conditions particulières au Cachemire, Des exemples parallèles provenant d'Italie du Nord, de Suisse et d'Amérique du Nord viennent illustrer cette description.

Dans la majorité des pays en voie de développement, l'aspect quantitatif de la production piscicole prime sur l'aspect qualitatif. Il semble que l'accroissement de la production puisse être assuré par l'eutrophisation et l'introduction d'espèces herbivores à multiplication rapide telles que la carpe miroir. Mais pour assurer la réussite de ces méthodes, il est indispensable qu'elles soient fondées sur des études écologiques approfondies afin de déterminer par exemple les interrelations entre les macrophytes et la plancton ou entre les poissons et leur nourriture. Sans une connaissance parfaite des exigences du milieu, l'emploi de ces méthodes ne peut qu'entraîner l'extinction des espéces introduites.

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