

The Use of Ecological Guidelines for Development in Tropical Forest Areas of South East Asia

Papers and Proceedings
of the Regional Meeting
held at
Bandung, Indonesia
29 May to 1 June 1974



International Union for Conservation of Nature and Natural Resources
1110 Morges, Switzerland
1975

The International Union for Conservation of Nature and Natural Resources (IUCN) is an independent international body, formed in 1948, which has its headquarters in Morges, Switzerland. It is a Union of sovereign states, government agencies and non-governmental organizations concerned with the initiation and promotion of scientifically-based action that will ensure perpetuation of the living world—man's natural environment—and the natural resources on which all living things depend, 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 organization dedicated to saving the world's wildlife and wild places, carrying out the wide variety of programmes and actions that this entails. WWF was established in 1961 under Swiss law, with headquarters also in Morges.

Since 1961, IUCN has enjoyed a symbiotic relationship with its sister organization, the World Wildlife Fund, with which it works closely throughout the world on projects of mutual interest. IUCN and WWF now jointly operate the various projects originated by, or submitted to them.

The 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 as well as support for certain key international conservation bodies.

WWF 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.

Proceedings of
a Regional Meeting on

the use of
ecological guidelines for
development in the
Tropical Forest Areas of
South East Asia

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the Government of Indonesia, with
the sponsorship and support of the United Nations
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Foreword

Tropical rain forests apparently represent one of the last remaining reserves of unutilized land in the world and are, therefore, now becoming prime targets for development. Although there have been a number of instances where such development has been conspicuously successful, especially in South East Asia, the development of land in the humid tropics does present difficulties which appear to be greater than those in drier or more temperate climates, and there have been many examples of serious failure and irreversible damage.

Nevertheless, if the use of these areas is properly planned and executed, they can make important contributions to the long-term stability and well-being of the tropical countries and their economies.

The formulation of the principles that would lead towards a better use of the rain forests was covered in the publication 'Ecological Principles for Economic Development' by Raymond F. Dasmann, John P. Milton and Peter H. Freeman, prepared for IUCN and the Conservation Foundation, Washington D.C. (John Wiley & Sons Ltd., London, 1973). It was decided as part of the extension of this initiative to prepared guidelines relevant to the development process in tropical forest areas of certain regions of the world based on ecological principles and taking into account conservation objectives.

To this end, an International Meeting on the Use of Ecological Guidelines for Development in the American Humid Tropics was convened in Caracas, Venezuela, from 20-22 February 1974. It brought together ecologists and planners along with specialists from appropriate disciplines and officers of Government agencies in Latin America dealing with agriculture, forestry and land-use. The meeting took into account existing knowledge of tropical forest ecology, including the findings of a number of meetings and conferences that had been held on this topic in recent times.

The second conference, designed similarly to consider the forests of the South-east Asian tropics was convened by IUCN in collaboration with the Government of Indonesia under the sponsorship of the United Nations Environment Programme and with the support of the UNEP Fund. The Food and Agriculture Organization of the United Nations, the United Nations Development Programme, and the United Nations Educational, Scientific and Cultural Organization co-sponsored the meeting. Support was also given by the Swedish International Development Authority and the World Wildlife Fund. Local arrangements for the conference were made by the Institute of Ecology, Padjadaran University, Bandung.

Ecological guidelines based on the findings of these meetings have already been issued as a joint IUCN-UNEP publication (IUCN Occasional Paper No. 10, 1974). The present volume aims to provide, for record and reference, the second series of papers (with some account of the discussions they invoked), which played so important a part in the elaboration of the guidelines. IUCN thanks the many collaborators, both individuals and organizations (especially those referred to above), who contributed to the success of the meeting and to the production of this book.

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Regional Conference on

THE USE OF ECOLOGICAL GUIDELINES FOR DEVELOPMENT IN TROPICAL FOREST AREAS OF SOUTH EAST ASIA

Introductory Remarks

Prof. Dr. Ir. OTTO SOEMARWOTO

Institute of Ecology, Padjadjaran University, Bandung, Indonesia

It gives me great pleasure to greet you at this opening ceremony and extend to you our warmest welcome. It is also a relief to see you all assembled safely at this conference. For the last few days we have been very much worried, since we did not know who would be coming or when and how, except of course for participants from Indonesia, although cables were going back and forth between Bandung and Morges in Switzerland. Therefore we sincerely apologize for not being able to greet and meet you at the Jakarta Airport and assist your onward journey to Bandung. One of our distinguished guests, Dr. Duncan Poore, was booked from Jakarta to Bandung on a flight which did not exist, apparently a ghost plane. But being a noted ecologist he managed, to overcome this environmental problem and arrived safely.

Distinguished friends and colleagues, we are assembled here to consider ecological principles in development. One of the most important principles is not to pollute our environment. We would therefore, greatly appreciate, if you would be so kind as to refrain from smoking. The organizing committee will do its best to assist you during your stay in Bandung and make sure that none of you will be booked on a ghost plane again. It is our wish to make your stay in Bandung both enjoyable and fruitful.

Address of Welcome

Prof. Dr. MOCHTAR KUSUMAATMADJA, SH. LLM,

Rector Padjadjaran State University

(Presented in his absence by Prof. R. Soemitro)

It is my pleasant duty to extend to you our warmest welcome to this conference which is being hosted by the Institute of Ecology, Padjadjaran University. I take great pride in the fact that our Institute of Ecology has been selected as host for this regional conference. I am particularly proud that the Institute does not merely play the role of a passive host, but has been actively engaged in the planning of the conference.

Padjadjaran University has paid much attention to the problems of the environment. We foresaw that willingly or unwillingly developing countries would get

involved in the global environmental issue. It was felt important that instead of passively reacting to the global environmental movement, we should make efforts to play an active role in it, thereby trying to influence the course of the movement in the best interest of the country. For this purpose Padjadjaran University established the Institute of Ecology to—

- (1) keep itself informed of the global environmental movement;
- (2) identify areas of potential advantage and disadvantage which may accrue from this movement; and
- (3) advance the science of ecology as it relates to development in Indonesia.

To achieve the first two objectives we, Dr. Soemarwoto and myself, have been active in various international organizations and participated in many international meetings and conferences. As to the third objective, lectures, research and conferences have been planned and partly implemented. Last March, the Institute of Ecology convened a Seminar on the Management of Water Resources. This conference and the associated Indonesian Meeting next month are also part of this framework of activities.

Before the war Bandung was called by the Dutch 'The Paris of Java'. Its high elevation, 700 m above seal level, gives it a cool climate with a beautiful vista of blue mountains. In 1955 when sentiments of nationalism were at their height, Bandung was selected for the site for the Afro-Asian Conference. Now we enter a new era, the era of ecology, and sentiments of ecology are high, so Bandung has again been selected for an international conference, this time on ecology. I trust that the atmosphere of Bandung—its climate, its scenery and its friendly people—will be conducive to fruitful deliberations and successful conclusions, so that what will be known as the Bandung Conference will make its mark in the history of ecology.

Messages from Sponsoring Organisations

INTERNATIONAL UNION FOR CONSERVATION OF NATURE AND NATURAL RESOURCES:

OPENING STATEMENT

Dr. GERARDO BUDOWSKI,

Director General, IUCN, Morges, Switzerland

On behalf of IUCN, and even if I am separated from you by half of the world, I should like to convey to you how much we appreciate your presence and your interest in this important gathering and how sorry I am that I cannot be with you and take an active part in the discussions. All that concerns the tropical rain forest is at the very root of my interest, and indeed has been the basis of my activities for the past 27 years, and I have read with particular interest the papers prepared for the meeting. I am sure that Bandung and the Institute of Ecology will provide an admirable setting for the discussion of the problems facing South East Asia.

As many of you are doubtless aware, this is the second meeting organized by IUCN on Ecological Guidelines for Development in the humid tropics. The first took place in Caracas, Venezuela in the second half of February this year and centred on problems of land-use for the important tropical moist areas of Latin America. In view of the short time that has elapsed since then, we cannot yet provide you with the Proceedings.

To those of you who have been in contact with IUCN for many years, it may perhaps appear at a first glance unusual for IUCN to deal with such problems as development, forestry and land-use, because you may have become accustomed to thinking of IUCN as an organization of scientists dealing essentially with wild animals and plants as well as wild places. However, while these matters are still at the root of IUCN's preoccupations there has been an increasing awareness by successive General Assemblies and the Executive Board, which are the principal decision making bodies of our Union, that we cannot deal properly with our basic terms of reference unless we concern ourselves appropriately with the many important factors that affect them. The activities of the six commissions of IUCN reflect this endeavour: Environmental Planning; Environmental Policy, Law and Administration; Environmental Education; besides the more traditional trio, Survival Service, National Parks and Ecology. The trend was also reflected during the last General Assembly in Banff Canada, 1972, where the overall theme was 'conservation for development' and it will be at the root of our next General Assembly to be held in Zaire in September 1975 on the theme 'Conservation for decision-makers'. Indeed, the present meeting is deliberately intended to influence decisions about the use of tropical moist forests in a region where this subject has been the object of much controversy for the last few years.

Something, of course, is already known about the ecology of the tropical rain forests, much of it very useful for decision making. But much more needs to be known. Possibly many of you, and quite correctly, will point out the urgent need for more research, in view of the fact that tropical forest problems in South East Asia today are so great. I agree with you but at the same time insist that much can be done with the ecological knowledge we already have. I strongly urge you to establish some guidelines on this basis. We simply cannot afford to wait until all the facts are available because we live in a world where decision makers, faced with pressures from political, military, social and economic angles, *must* take decisions *now* whether they like it or not.

IUCN has also chosen to favour activities that lead to the identification of facts that can influence decision makers and which can give them guidance. Of course we can hardly pretend to deal with some of the political and economical factors that at present exercise an overwhelming influence on decisions; but neither can we ignore them. Our aim is simply to provide a much greater scientific input as early as possible in the process of decision-making.

In short, our ambition is that most decision makers (and particularly planners) should understand the ecological relationships that govern land-use and be made aware as far as possible of the various likely consequences of what they intend to do. These ecological phenomena reflect natural laws, from the energy derived from the sun to the production of organic matter and the interactions of plant, animal, soil, water and climate. We can influence some of these relationships, but hardly change them very much.

For this reason, ecological considerations should be basic, political, economic and social decisions being grafted on to them. This is the ideal for which we hope, but I admit immediately that we may be aiming too high. Nevertheless,

natural laws and inter-relationships will help all of us to identify the ecological guidelines that should come out of this meeting. If these are clearly stated and effectively brought to the attention of those who make crucial decisions about the land-use, planning and management of the tropical moist forests, they can no longer be ignored or completely shuffled aside.

If we succeed, we may help in triggering off a new way of looking at the resources of the biosphere and perhaps even achieve a better way of channeling development towards 'quality of life'. I realise of course that these last words mean many different things to different people with different cultural backgrounds. To me 'quality of life' implies above all the maintenance of a healthy and diverse environment and, perhaps even more important, one in which the options are kept open for present and future generations. If all these aspects of ecological thinking can infiltrate and influence decision making we will indeed have succeeded.

I wish you all the success you deserve in this venture and you can rest assured that the ecologically-concerned world will seize upon any constructive suggestions made for this as for other regions of our planet.

UNITED NATIONS DEVELOPMENT PROGRAMME:

OPENING STATEMENT

GLENN H. ROBINSON,

Project Manager, Land Capability Appraisal Project, UNDP

It was just a few minutes ago that I was asked to make a few comments on the activities of U.N.D.P. in relation to projects that need and utilize ecological information. Projects which are involved in the use of land and the planning of land use seem to me to be the ones which are most in need of ecological information. Those projects implemented by F.A.O. are best known to me.

Within Indonesia, there are at least nine such projects including Support to Livestock Planning, Coconut Industry Development, Upper Solo Watershed Management and Upland Development, Land and Water Resources Development in South East Sumatra, Tree Improvement, Support to Agriculture Planning, Planning and Development of Transmigration Schemes, Strengthening Research on Rubber and Oil Palm in North Sumatra, and Land Capability Appraisal. In addition there is a project for Forest Industry Development in Irian Jaya. Each of these projects involves the use of land and thus has an interest in the ecological effects of specified uses.

The Land Capability Appraisal Project is involved in the evolution of land, the classification of land for specific uses and the making of recommendation for land use. Thus it can provide some service to each of the above projects. Within the Land Capability Appraisal Project, studies have been made relative to soil identification, physiography, relief, water resources, water management, present land use, climate, soil fertility, cropping systems, levels of management, crop yields and some economic evaluations land use. Agricultural uses are emphasized.

Based upon these studies areas of land have been delineated on maps which

are relatively uniform in the various physical characteristics—these are called Development Units.

Next examples of kind of land use—called Land Utilization types—were chosen and used in making Capability appraisals. There are many ways to use land and the Land Utilization types include, for example, forestry, estate crops (coconut, oil palm, rubber, coffee etc), continuous rice, rice in rotation with upland crops, specified rainfed upland crops, etc.

Its land areas (Development Units) are then appraised and placed in capability classes according to land utilization types and levels or intensity of management systems. Five capability classes are recognized.

Information available to the project staff relative to the effect of a land use upon the total environment is taken into consideration in the proposed system of classification. It is expected that new information, and sources of information, will be obtained during this meeting. This will be used in the refinement and possible revision of the presently proposed Land Capability appraisals of the soil/land areas of Indonesia. We want our work to be a part of and hope it will contribute to the total programme of environmental development/improvement.

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS:

OPENING STATEMENT

NORMAN P. KNOTT,

Regional Wildlife and National Parks Management Adviser for Asia and the Far East

We of FAO are pleased to be participants in this worthwhile conference which is so closely related in theme to major programmes of FAO in the management of moist tropical forest.

As you are undoubtedly aware FAO, as the Food and Agricultural Organization of the United Nations, aims to provide technical assistance to developing member states, within the fields of agriculture, forestry and fisheries. This assistance is provided following a request from the Government for such aid.

Within the South East Asia region our activities are at two levels; the country assistance projects and regional advisory activities and projects.

The interest of FAO in the management of tropical forest and its recognition of the interrelation between the management of this resource and human needs and activities, has been shown by Mr. Robinson's summary of the nine technical assistance projects now underway in Indonesia and the fact that during the past year the Regional Forestry staff has been increased from one to six.

Present here today from FAO beside myself, are Dr. Alastair I. Fraser, Regional Tropical Forest Management Adviser, Mr. Peter Enderlein who works with me on wildlife and National Parks Management, Dr. D. M. Ramsay and Mr. K. F. Wiersum of the soil and water Resource Management Project for the Solo watershed and Mr. C. Robinson of the Land Classification project with its headquarters at Bogor. Regrettably, Dr. H. J. Steinlin, Director, Forest Re-

sources Division, Rome, who is listed among the participants, has been unable to attend, but joins in wishing the conference all possible success.

UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANISATION:

OPENING STATEMENT

Dr. GUNTER TRAPP,

Programme Specialist, UNESCO Field Science Office.

It is a pleasure and an honour for me to bring to this meeting the greeting and best wishes for success on behalf of the Director General of UNESCO and of Unesco's Field Science Office for South East Asia in Jakarta, to which I am attached.

The United Nations Educational, Scientific and Cultural Organization, UNESCO, is co-sponsoring this meeting because of Unesco's conviction of its importance and because of its close relations with Unesco's own activities in the field of Ecology and especially the Man and the Biosphere (MAB) programme.

I hope you will bear with me, if I stress here the essentials of this programme, as follows:

Man and the Biosphere (MAB) is an intergovernmental and interdisciplinary programme of research, emphasizing an ecological approach to study of the interrelationships between man and the environment and to problems relating to rational use and conservation of the resources of the biosphere. It focuses on general study of the structure and functioning of the ecological systems, on observation of, and research on, the changes brought about by man in the biosphere and its resources, on the effects of these changes upon man himself, and on the training and specialized information needed on these matters. The Programme is an undertaking of international scientific co-operation between the Member States themselves. It consists of a number of projects defined by the International Co-ordinating Council of the Programme. The execution of these projects is essentially the responsibility of the Member States concerned, with the necessary stimulation and co-ordination provided by UNESCO at the international level. To this end, Member States have been urged to establish national committees ensuring their full participation in the Programme.

In the activities at the international level, close co-operation exists with the United Nations, FAO, WHO and WMO, UNEP, as well as with competent international non-governmental organizations like IUCN. Coordination of action also exists with The International Hydrological Decade, the International Oceanographic Commission, and other UNESCO initiatives.

In the implementation of the MAB Programme, due regard is given to the difference existing between the industrialized countries and the developing countries, bearing in mind the need for establishing international standards and criteria. The social sciences are being more closely integrated in the Programme to ensure its interdisciplinary character.

The activities under the MAB Programme constitute the main axis of

UNESCO action relating to man and the environment. Between the different Projects that have emerged in the framework of MAB, No. 1 is the project on the ecological effects of increasing human activities on tropical and subtropical forest ecosystems, thereby signalling the importance which UNESCO attaches to the special subject to which you will dedicate your time during this meeting.

As the Regional UNESCO Field Science Offices are the extended arms of UNESCO's headquarters into the field, it is clear that they are also actively involved in ecological activities. Some of you will recall our Regional Expert in Ecology, Dr. de Rham, who has been active in most countries of this region but who unfortunately had to leave our Jakarta Office. Before long, however, we will have a new specialist in this Region.

Amongst the forthcoming activities, in which the field science Office for South East Asia in Jakarta is involved, I should like to mention the following:

- * Regional meeting on Ecological Research and Framing Activities in South East Asia to be held in Kuala Lumpur from August 19 to 22, 1974.
- * International training course on tropical ecology (6 month duration) at the University of the Philippines to be held at Los Banos, starting in September 1974.
- * Subregional Seminars in Bogor and Bangkok on tropical rain forest and tropical deciduous forest ecosystems, respectively, to be held in October/November 1974.
- * Finally, various activities of our marine science experts, related to environmental problems.

Let me conclude by repeating Unesco's very best wishes for the success of your work, for the full benefit of the member states of IUCN, of Unesco and of mankind at large.

Opening Address

J. B. SUMARLIN,

*Minister of State and Chairman State Committee for Environmental Affairs,
Jakarta, Indonesia.*

It is indeed an honour and privilege to address this gathering of distinguished scientists from South East Asia, Papua New Guinea, Australia, Europe and North America. As chairman of the State Committee for Environmental Affairs it gives me great pleasure to preside over this Regional Meeting on Ecological Principles for Development in Tropical Forest Areas in South East Asia.

On this occasion I would like to extend a warm welcome on behalf of my government and myself to all participants, particularly to those who have come from abroad. My government is indeed very pleased to serve as host for this important and timely conference.

About two years ago Dr. Gerardo Budowski, Director General of the International Union for Conservation of Nature and Natural Resources, visited Indonesia, and met my predecessor, Dr. Emil Salim. An agreement was reached to hold a conference on ecological principles for economic development. The plan for the conference was then worked out by the IUCN and Dr. Otto Soemarwoto, Director of the Institute of Ecology, Padjadjaran University, who is also a member of the Executive Board of IUCN. In recognition of these efforts, I would like to express my appreciation and thanks to IUCN for convening and co-sponsoring this conference with the Government of Indonesia.

I also wish to express my appreciation and thanks to the United Nations Environmental Programme (UNEP), United Nations Educational, Scientific and Cultural Organization (UNESCO) and the United Nations Development Programme (UNDP) for their support of this meeting.

I am also proud and pleased that the Institute of Ecology, Padjadjaran University, has played a leading role in the planning and execution of this meeting. It is my sincere wish that the Institute will continue to pioneer the advancement of the ecology of development.

Several years ago there occurred in the developed industrial nations a re-awakening over the environmental and ecological consequences of economic growth. In these nations, concern began to be increasingly voiced over ecology, particularly environmental pollution arising as a by-product of rapid growth in consumption, resource and energy-intensive production, and the application of advanced technology in industry, transport and other economic sectors. While problems of environmental pollution are by no means confined to high income and high consumption nations, the nature of the environmental problem in these countries differs in many ways from that faced by most developing nations.

In advanced nations which have already reached high levels of material well being, particularly with regard to nutritional standards, strong views have been expressed opting for zero or near zero economic growth as a means of dealing with environmental problems. This choice is not open to developing countries, particularly those for which a large segment of the population lives at or near subsistence levels. Nonetheless, in the recent past, especially in the pre-Stockholm Conference period, developing countries, who as a group consume

only a small fraction of the world's resources, have been concerned about the possible trade-off between economic growth and environmental protection.

We recognize that environmental problems are not confined to pollution arising from the application of high-output, high consumption technology, whether in the industrial, transport or agricultural sectors, although this may be the prime source of environmental imbalance in developed nations. Indeed, some measure of environmental pollution and short-sighted natural resource husbandry is found in many developing nations as well.

But environmental problems in developing countries have their prime roots in lack of development and poverty. The necessary, but not sufficient, condition for overcoming these problems is more, not less, growth and development. To cite just one example: in some parts of our nation, the pressure of poverty impels marginal economic groups to seek subsistence in agriculture along mountain slopes, using ancient methods of shifting cultivation. The resultant erosion of top soil not only depletes its fertility in tropical highlands, but does incalculable damage to the water resource network through increased silting of lakes, rivers, estuaries and coastal regions. In both the First and Second Five-Year National Development Plans of Indonesia various measures have been adopted through transmigration, agricultural extension and accelerated greening to deal with this problem; but its ultimate solution will depend on the economy's ability to create job opportunities sufficiently attractive to induce movement away from subsistence farming on mountain slopes or toward activities less injurious to the ecology of the tropical highlands. Either way, more, not less, development will be required.

Nevertheless, it is also clear that a policy of pursuit of growth at all costs is not in keeping with the broader aspirations of developing nations, including socio-economic as well as environmental aspirations. Perhaps all of the participants of this meeting will agree that even a carefully modulated development process can lead to changes in the environment which may in turn detract from the welfare of the people, both in the short and long term. In fact, in recent years National Development Plans in many developing countries have increasingly reflected awareness of this problem. In my country's own Second Five-Year National Development Plan, which entered into effect on April 1 of this year, an entire chapter in the core of the Plan is devoted exclusively to the discussion of the need for the protection of the environment, and careful husbandry of our natural resource endowments. Further, the ideas and principles set forth in this key chapter are woven throughout the entire fabric of the Plan document, as a prime focus of the Second Plan is that of ensuring ample potential for *continued* advance for *future* generations of Indonesians through greater attention to environmental questions and issues in resource management. In our view, public investment in infrastructure, particularly water resource development, is one major means of preserving and enhancing the nation's soil and water resource endowments. In addition, the stress placed on environmental protection and resource conservation will be reflected in intensified resource survey and research activity sponsored and directed by the government. Further, sectoral and general government policies, including mining, forestry, taxation and foreign investment policy, will be oriented toward protection of the environment as well as safeguarding that part of our national patrimony in mineral and forestry resources.

As I view the issues, it is clear that the duty of environmentalists in developing nations is not that of assessing the pros and cons of growth versus no growth, but rather to assist in finding ways for accelerating growth and development

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which do not degrade environmental quality and which, in the final analysis, will improve the quality of life for present and future generations of citizens.

I would hope that this view is shared by the participants of this meeting. Our focus in this meeting is that of identifying a set of ecological principles that can serve as practical guidelines for planners and decision-makers in the development of forest areas. This is not an easy task, given the relatively limited evidence that has been accumulated up to now regarding the ecology of South-East-Asian forests, particularly tropical forests, and the relatively recent large-scale exploitation of major stands of tropical hardwoods in the region. This meeting is not merely an academic exercise designed to produce a scientific report on the ecology of forest areas in the region. Rather, the expectation is that one major result of this meeting will be further progress in the forging of practical tools for productive and sensible development of forest areas consistent with environmental objectives.

In closing, I would observe that, thanks to the efforts of persons such as the participants of this meeting, recognition of the role of ecological considerations in development planning is now more widespread than ever. There is now no argument over whether or not ecological questions merit special emphasis in the development process. This question has been settled. The issue now is *not* whether, but *how* sound ecological precepts can be properly integrated into overall government policy, and how to best implement development policy having a strong environmental emphasis. This meeting has chosen one of the more complex of the environmental issues facing many nations in South-East Asia, an issue for which there is ample scope for differences of opinion over the most appropriate set of principles and policies. Let us now begin to subject these principles to the test of intellectual interchange.

In the end, the meeting should set for itself nothing less than the objective of finding ways to putting the soundest of these principles to work for the benefit of present and future generations of people in the region.

In this respect, it is of fundamental importance that in the course of the ensuing deliberations we should focus on the central role of man as an agent of change effecting the state of ecology. Ecological responses to human behaviour need to be studied in depth and at the same time, there is a need for examining social and cultural systems and values which could be enhanced to induce man to behave responsibly towards nature so as to achieve a balanced and harmonious environment.

I trust that we have come together, here in Bandung, because we all share the common belief that as professionals, scholars and decision-makers, we have the moral responsibility to help make our planet a pleasant and decent place to live in.

May I now have the pleasure to declare this 'Regional Meeting on Ecological Principles for Development in Tropical Forest Areas of South East Asia', open.

Introduction to the Theme of the Conference

DR. DUNCAN POORE,
Senior Ecologist, IUCN.

It is my task to tell you the background of this meeting and the way in which we hope to organize it. I had expected to begin by explaining why the meeting was being held but Dr. Sumarlin has done this so eloquently that there is hardly anything left for me to say. But there are still a few points that I would like to make to supplement his remarks.

Those who make decisions in the present world are faced with problems which are more difficult and more urgent than ever before. They are made even more complex by the large amount of information, often conflicting, that is presented to them. What then is the justification for offering yet another set of considerations that they must take into account? It is the belief that, by adhering to ecological principles, their decisions may be made easier, for ecology may sometimes give clear guidance when the evidence from other directions is complicated and confused.

Let me next turn to what we want to accomplish. As Dr. Sumarlin has rightly emphasised, the purpose of this meeting is intensely practical. This is not a meeting to discuss scientific papers and indeed, with the permission to those who have written them, the papers presented to this meeting will not be read, but they are available to you as essential background for your discussion. The purpose of the meeting is to extract guidelines. These are not meant to be obligatory or to have the force of law but to be a list of the considerations which all who make decisions about the use of land and the management of natural resources should take into account in formulating policies and reaching decisions about use.

The experience of the ecologist can broadly be of use in two ways. He can give very clear guidance about the potential of various parts of land for particular uses—what opportunities are offered; and, on the other hand, he can indicate the places where caution is necessary and what constraints should be applied. Too often the second of these is emphasised and the ecologist is thought as someone who is placing barriers in the way of development. But many of the best advances of land use in this region are due to good applied ecology. The traditional cultivation of sawah, one of the most productive forms of agriculture in the world, is an application of ecological knowledge by experience. The introduction and success of rubber is another example of the wise application of ecological knowledge.

There are three stages at which this knowledge can well be applied and it is proposed that the conference should be organized accordingly. The first is in deciding what should be done with the land—planning; the second is in changing from one use to another—conversion; and the third is the management of the land once the use has been determined. So the three critical stages are: planning, where care is necessary because the decisions made are sometimes irreversible; conversion, where there is a danger of damage and unforeseen side-effects; and management, in order to sustain the potential under any particular form of use.

In addition to the guidelines affecting planning, conversion and management of land, it is possible that some general ecological principles may emerge which

underlie all of these and which affect policies or even the goals of development. It is clear from experience that the earlier that ecological knowledge and experience can be used in the process of formulating policies the more likely it is that development will make the best use of the potential of the environment and will run the least risk of damaging it or of producing unforeseen side-effects.

And so I hope that in the course of the discussions you will continually keep in mind the possibility of extracting ecological *principles* from your discussions which may be set out at the beginning of our report as a guide in the formulation of goals and policies. I would like to mention two or three of these before we start. We are now living in a world in which resources are getting scarcer and it therefore has become very important to use those that we have to the best advantage. One principle, then, that I suggest to you is that we should so organize development and the use of resources that we get the greatest benefit for human welfare out of each unit of resource. This does not often happen. For the way in which human life is organized lays greater stress on getting the greatest profit from capital invested and these two objectives do not always coincide. If we could make them do so, then the course of action that is most profitable would also become the one that is ecologically most desirable. There are a few other principles which I believe should apply to land use. That we should use each unit for the purpose for which it is best suited, that we should do nothing that would lower the potential of the total natural resources to serve human needs, and that we should not destroy things now even if they seem of little use to us, for they may have potential for future generations. It is doubtful whether those who lived several hundred years ago could possibly have seen the uses to which we are putting resources now. It is equally likely that we cannot imagine the uses to which our successors several hundred years hence will wish to put the resources and it is our responsibility to pass them on so that they may be used by others in the future. I have one last principle to suggest. Our environment is not constant, the climate has fluctuated through history and, from time to time, there have been natural disasters. Because of our present high population and the advances of technology we are now tending to push land use to the limit of what is possible, and living without any reserve. If a change of climate were to come now it would have very much more serious effects than in the past because our way of life has become so specialized that it has less ability to adapt to new and unexpected circumstances. It is, I am sure, a basic ecological principle that we should try to organize our use of land so as to retain flexibility in order that we may take the best advantage of changing circumstances. These are some of the principles that I think may emerge in the course of our discussions and I am sure that you will find more to add to them.

Next, whom are our guidelines directed towards? In the countries of the region the most important are those who have to make decisions at all levels of government or who influence public opinion in particular ways, Ministers, senior administrators, members of technical departments, Members of Parliament and also those who are concerned with education. But our guidelines, I think, should also be addressed to those from overseas who offer technical assistance, to the UN agencies, the World Bank and to the private companies who offer consultancy services.

A few last words about the organization of the meeting. This has been, as I have mentioned, specifically designed for the formulation of guidelines. There are four main sessions;

1. The ecological input to land use policies and planning;

2. The forest as a resource, national parks and nature reserves, timber production and shifting cultivation;
3. Transformation of forests to forestry plantation and agriculture; and
4. Settlements, infrastructure and industry.

These follow the sequence I have indicated above: land use planning to begin with, followed by the progressive stages of modification—first those in which the natural forest is changed but remains the base of economic land use and next those in which the natural forest is removed and something else is put in its place. As background we have the papers which have been prepared for us and, in addition, I have written a paper which represents a preliminary formulation of some of the guidelines which we may wish to adopt. This is put forward as a cockshy for modification, addition, subtraction, to handle as you wish. In preparing it I have used the results of the previous meeting in Caracas, the points which have arisen in the background papers which have been supplied for us and my own experience of land use in this region and elsewhere. I hope that you will find this some use as a basis for discussion.

Lastly some words about the final product. IUCN will produce a volume of proceedings which will contain the papers and a record of the discussions. It will also contain a report on the conclusions and a text of the guidelines which we agree. In addition IUCN will produce a separate publication at a later date including a more formal presentation of the guidelines based both on the meeting in Caracas and on the meeting here. Our regional meeting which ends on Saturday will be followed by an Indonesian meeting at the beginning of next week and in order that our experience may be available to them the last day of this meeting, Saturday, will be devoted to trying to agree an authoritative text of the guidelines. The morning will therefore be set aside for a small group to draft guidelines on the basis of our discussions and the afternoon will be devoted to a report on the conclusions and the formal approval of the guidelines by the Conference. I trust that we will be able to produce something which is of real value to all of you.

SESSION I

Ecological input to Land Use Policies and Planning

The Chair for the opening session was taken by Prof. Dr. Sasongko Sodo Adisewojo, while Mr. R. G. Downes acted as rapporteur. As a preliminary to the session proper, reports on the current situation were presented for six countries—Australia, Indonesia, Malaysia, Papua New Guinea, Philippines (tabled but not presented due to delayed arrival of delegate) and Thailand. These in a slightly shortened form are set out below and are followed by three Papers, by Dr. R. G. Downes, Dr. H. A. Nix and Prof. F. A. van Baren, which had been contributed as a basis for discussion.

Like the other background papers prepared for subsequent sessions, the three contributions referred to were not specifically presented but their authors were given an opportunity of highlighting some of the main points and explaining their particular relevance to the general topic of the session and the eventual elaboration of guidelines. The same also applied to Dr. M.E.D. Poore's basic paper on the nature and range of the guidelines which it would be the particular aim of the discussions to produce, but his paper is not included in the Proceedings of Session I, since, in its final form, as modified and developed throughout the conference, it is in fact represented by the Conclusions and the Guidelines themselves as set out at the end of these Proceedings.

The report of the Session does, however, include a summary of the more important points made in the discussions, figures in brackets indicating the Guidelines to which particular points are related.

Country Reports

(i) AUSTRALIA

PRESENTED BY

N. C. GARE

In Australia, responsibility for land-use rests with the governments of the six states which formed a federation in 1901, and the Australian federal government which has direct responsibility for certain territories.

A considerable amount of ecological and related scientific data has been collected by natural resource agencies of the various states and of the Australian government, as well as the activities of the universities and museums. Representatives of some of these agencies are present at this meeting. I hope other delegate will have the chance to talk with them about their activities.

The Australian Commonwealth Scientific and Industrial Research Organization (C.S.I.R.O.), especially through its divisions of land-use research, plant industry, soils and wildlife research, has collected and collated a large amount of information, and in specific cases such as the state of Victoria, land-use and land capability surveys have been undertaken. Other agencies have done more limited work related to their specific responsibilities and interest.

It would be fair to say that until recently there has been little attempt to collect all relevant information on a nation-wide scale and use it as a basis for rational development of national sources.

Recently however, there have been encouraging signs. Under the auspices of the International Biological Programme a report has just been completed on the conservation of major plant communities in Australia. An Australian Water Resources Council, consisting of the responsible State and Australian Government Ministers, with a standing committee of senior officers, has been formed to co-ordinate the study and use of national water resources.

A Council of Nature Conservation Ministers, representing the Australian and State Governments, has been formed, and will shortly consider recommendations for an Australian ecological survey, to identify areas or regions suitable for reservation for nature conservation purposes.

The expected trend from these developments will be to build upon the early initiatives, particularly by C.S.I.R.O. and the Victoria Soil Conservation Authority and The Land-use Agencies which it has sponsored in that State, to foster an integrated approach throughout Australia to rational resource use.

There has been a gradual environmental awakening among the Australian community over the past ten years. There is a need now for an appropriate environmental education programme at all levels of the community, to translate this public interest into informed comment and decision-making which will ensure that future resource-use will be the result of integrated planning in which ecological inputs play their proper part. In view of the various limiting factors in the Australian environment, and the haphazard and exploitative nature of much of our resource use in the past, such a development is overdue.

(ii) **INDONESIA**

PRESENTED BY

Ir. H. PRIJONO HARDJOSENTONO

The forest resources in Indonesia are of vital importance not only for the economic development of the country, but for the establishment of the total and continuing wellbeing of the nation. The enacted forest policy has given priority to the sustained yield principle, in which multiple maximum usage of forest land is also emphasized. Logs and lumber are by no means the only benefit to be obtained from the forest resource, the development of which has as a main goal the achievement of the total potential of goods and services rather than just the production of timber. The following points are to be noted:-

1. In 1971 there were 8, 450, 000 ha non-forested land in areas allocated for forest and 4, 523, 500 ha of agricultural land that badly needed measures of soil and water conservation.
2. Since 1971 deforestation has continued to exceed afforestation. From 1969 to 1973 the total of new plantations, mainly in Java, northern Sumatra and south Sulawesi was 120, 159 ha.
3. The 1st Five-year development plan included 3 programs related to Forest Resource Development, namely reforestation and soil and water conservation, development of wildlife nature reserves, and the control of concessionaires.
4. In the 2nd Five-year Development Plan, starting April 1974, the three above mentioned programs have been given priority status in Forest Resource Development.
5. The reforestation and soil and water conservation program has been centered in areas (watersheds) where investments in agriculture, industries, urban development, energy and other public works have been or are planned to be on a large scale.
6. The short-term goal of this approach is to protect those large investments likely to be of most benefit to the people; the long-term goal is to establish forest resources for further economic development of the country in perpetuity.
7. To achieve these goals, coordination among agencies such as fishery, forestry, agriculture, land-use, transmigration and universities has been established, but still needs some strengthening for effective implementation.
8. The reforestation and soil and water conservation program has been supported by seed bank and seed production projects in order to ensure more successful results.
9. Plantation establishment in the program has been encouraged to use the few indigenous species of economic value (i.e. pine, agathis, sungkai mahogany, etc.) in an effort to minimize the disturbance of the ecosystem.
10. Another type of reforestation that has been applied is enrichment planting to develop a high quality forest (forest with few species and maximum value), especially in areas where tropical rain forest has been degraded by improper logging practices.

11. The ecological approach together with social and economic considerations has been used as a guidance in plantation establishment and in enrichment planting.
12. The wildlife, nature reserve and park development program has been directed towards several plant and animal species and areas such as Ujung Kulon (banteng, rhino) Leuser & Kutai (orang utan, tropical rain-forest), Baluran (banteng, prairie), etc.
13. An attempt has been made to develop wildlife and nature reserves in a few large areas rather than maintaining many small areas as was done previously. This should facilitate and improve maintenance of the reserves and parks.

(iii) **MALAYSIA**

PRESENTED BY

Dr. LEE PEN CHOONG

A. General

Forests still cover a large proportion of the land area in Malaysia. Up to 1970, about 24.5 million ha or about 73.2% of the total land area of about 33.5 million ha were still under forests which include both logged and virgin forests, but excluded areas of secondary vegetation or shifting cultivation. Since 1970 it is estimated that about 0.3 million ha of forests have been converted to other uses, mainly for agricultural land development. From surveys designed to provide data for integrated development of the forestry sector, these forests are estimated to contain about 700 million m³ of commercial timber, sufficient to sustain current levels of production for about fifty years. The systematic exploitation of this resource will be a dominant factor affecting the ecology of the forest areas.

The problems which will have to be faced in the future and which are becoming critical now are related to the management of these forests to ensure sustained production of forest produce in perpetuity and the conservation of virgin areas for scientific and ecological purposes. The major management problem in relation to the exploitative forests is the formulation of effective silvicultural systems which are economically feasible and which will ensure rates of regrowth consistent with the national demand for timber. The Malayan Uniform System for silvicultural treatment which has been applied to the regeneration of logged forests within forest reserves has two major drawbacks. The system which has been evolved for the lowland forest systems has been found to be less effective in the hill forests which will form the greater part of the future forest estate. Poisoning of trees which are now not commercially acceptable but which may become so in the next decade or so is also objectionable. Accordingly, there is growing interest in the adoption of polycyclic systems of felling whereby only the overmature trees of the commercially desirable species are removed in the first felling, leaving the currently unacceptable species for subsequent fellings and promoting faster growth of the immature trees. From available growth data it appears that regrowth would exceed removals at each felling so that theoretically the system appears to be feasible. Felling cycles of 25 for lowland forests to 40 years for hill forests

are being envisaged. There are of course unresolved problems arising from practical logging operations which would be economically viable and which would minimise logging damage. The system is also preferable from the environmental viewpoint.

There is growing social and political awareness of the importance of conservation of natural forests for scientific and cultural reasons. Ecological knowledge regarding this is however insufficient. The primary questions concern minimal areas, species extinction and the compability of multi-use management in relation to wildlife, recreation and other uses.

A major impact on the forest areas is their conversion to agricultural use. Given the prospects for development of the main cash crops of rubber and oil palm, it is expected that over a million hectares will be converted to agricultural use over the next twenty years. While the conversion will have a tremendous impact on the natural forest ecosystems, planning of this development is based on sound ecological considerations, so that disruption of the physical environment is minimised. Areas for conversion are selected by reference to criteria of land capability and processes which ensure the establishment of cover-crops before the onset of the following rainy season and, together with the maintenance of vegetation cover along stream edges, minimise erosion and siltation of rivers.

Planning for development of virgin forest areas and their subsequent conversion to agriculture and other uses is best exemplified by the masterplans for development in Pahang Tenggara and Johor Tenggara in Peninsular Malaysia and Miri-Bintulu Regions in Sarawak, regions of largely undeveloped forest areas. Preparation of these Masterplans involves surveys of the natural resources, classification of land use potential according to land capability and finally the allocation of land to agriculture, forestry, urban use and conservation according to criteria of land capability and productivity. Provision is specially made for the conservation of examples of natural ecosystems, especially if these are unique, and for wildlife. These plans also take into consideration the changing ecology, particularly of the hydrological regime, to ensure that future settlement patterns are consistent with the changed ecological regime which will develop. Ultimately the plans also anticipate change in the social and economic aspirations of settlers, in that Settlement patterns are planned in such a manner as will foster development of a wide range of economic activities, particularly those of the secondary and tertiary sectors. Development of these is essential to forestall overdependence on the land-based sectors.

In the management of the forest areas ecological knowledge needs to be further advanced in order to establish a system of national parks and nature reserves which will enable the conservation of representative samples of all known ecosystems and of genetic resources. The long term effects of logging within the exploitative forests particularly in relation to preservation of species and in maintenance of soil fertility and productivity will need to be monitored.

B. Sarawak

Seventy five percent of the total land area (48, 050 square miles) of Sarawak is still covered by forest. Eight major forest types are recognised, of which Mangrove Forest (671 sq. miles), Peatswamp Forest (5690 sq. miles) and Mixed Dipterocarp Forest (30, 030 sq. miles) are of commercial importance.

The Forest Policy approved by the Government in the year 1954, is the authority for all forestry operations in Sarawak and is based on—

1. Permanent reservation of forest sufficient to:-
 - (a) protect the country's environments, soils and water supplies; and
 - (b) supply domestic requirements for forest produce 'that can be economically produced within the country', *subject* to 1(a).
2. Management of the resources for highest possible revenue based on sustained yield principles.
3. Economical use of produce from unreserved land prior to alienation for activities other than Forestry.
4. Promotion of profitable export trade.

The Permanent Forest Estate

11, 951 square miles of forests (approx. 27% of Sarawak) are permanently reserved for production and protection forestry and divided into three categories:

Forest Reserves (2, 530 sq. miles)—in which control of entry and operations are strict;

Protected Forests (9, 304 sq. miles)—from which any inhabitant of Sarawak may take freely forest produce for his domestic requirements, but not for sale or barter (the Conservator of Forests is empowered to close up to one quarter of any Protected Forest for silvicultural reasons);

Communal Forests (117 sq. miles)—constituted expressly for the benefit of communities and managed by the Administrative branch of the civil service under advice from the Forest Department.

The proportions of the major groupings of forest types within the permanent forest estate are summarised below:-

Summary of forest type areas, in square miles

	Permanent forest estate		Whole Country
Mangrove Forest	154 = 23%	of	671
Peatswamp Forest	2, 338 = 41%	of	5, 690
Hill Forest	9, 342 = 31%	of	30, 030
Total	11, 834 = 31%	of	36, 391

Management of Permanent Forest Estate

Up to late sixties, virtually all logging operations in the Permanent Forest Estate were confined to the Peatswamp Forest. In 1969 the first forest reserve in Mixed Dipterocarp Forest was licensed for harvesting.

Mangrove Forest Management

Mangrove forest occurs along the coastline and within estuaries where alluvium has been deposited. It is liable to flooding by saline water, and the degree and frequency of inundation largely determines the mangrove species that grow in any locality. On the seaward fringes *Api-api* (*Avicennia* spp.) and *Pedada* and *Perepat* (*Sonneratia* spp.) are found in pure stands. Further

inland members of the family Rhizophoraceae, including the two species of Bakau (*Rhizophora* spp.) and four species of *Bruguiera* occur and are the most valuable timbers of the forest. In areas that are only inundated at spring tides Buta-buta (*Excoecaria agallocha*) may form almost pure stands. The Nipah palm (*Nypa fruticans*) covers large areas where there is an inflow of fresh water.

In the past, the forest was cut mainly for poles, piles and firewood. Usually, only stems of *Rhizophora* spp. and *Bruguiera* spp. were removed. More recently, one big area located at the mouth of the Rejang River was licensed for chip production. Extraction is intensive under this operation, so that, in order to protect river and sea fringes and ensure the regeneration of the mangrove forest, felling of such colonising species as *Avicennia* and *Sonneratia* is prohibited.

Peatswamp Forest Management

Over the last five thousand years alluvium deposited in sheltered bays and within deltas of rivers has been colonised by mangrove, but with the seaward extension of the mangrove the landward areas have become less frequently flooded and finally not flooded at all, to form the peatswamps that now cover about twelve percent of the land surface of Sarawak. The soil consists entirely of peat or the undecomposed or semidecomposed vegetable matter of previous generations of trees. The forest types tend to change in uniform sequence from the perimeter to the centre of each swamp, though in more recent coastal swamps the sequence may not be fully developed. The types are:-

- A. **Mixed swamp forest.** Occurring on the perimeter of the swamps and covering extensive areas of mainly shallow peat near the coast. This is the most valuable forest type containing Ramin (*Gonystylus bancanus*), Jongkong (*Dactylocladus stenostachys*), Sepetir paya (*Copaifera palustris*) and four species of Meranti (*Shorea* spp.)
- B. **Alan forest.** The forest in this type is similar to that of Mixed swamp forest except that it is dominated by huge, usually very defective, trees of Alan (*Shorea albida*). This forest type is most extensive in the Rejang Delta.
- C. **Alan bunga forest.** Here the forest consists of almost pure stands of Alan (*Shorea albida*) with an even canopy at a height of between 180 and 210 ft. Extensive areas of this forest type occur in the Second and Fourth Divisions.
- D. **Padang alan forest.** In the centre of many swamps 'padang' forest is found. All trees are relatively small (few exceed 72 ins. girth) and the forest has a pole-like aspect. Species are few and the most common dominant is Alan (i.e. the Padang alan), though in some areas in the Rejang Delta Medang padang (*Litsea crassifolia*) is the most abundant dominant. This type is known as the Padang medang.
- E.& F **Padang keruntum forest.** The last development in the swamp forest types is the Padang keruntum, which only occurs in the centre of the oldest swamps in the Baram. The forest is very open and all trees are small and stunted. The only species to exceed 24 ins. girth is Keruntum (*Combretocarpus rotundatus*). Jongkong (*Dactylocladus stenostachys*) is very abundant as a small tree or shrub. Surrounding Padang keruntum forest a sixth forest type, intermediate between

Padang alan and Padang keruntum, is recognised. Neither of these two forest types have any economic value.

Girth-limit cutting is practised in the Mixed Swamp Forest. A 48-inch girth limit is imposed. Annual yield is prescribed on a 60-year cutting cycle. Heavy machinery is not used for extraction in the swamp forest. Damage to the residual stand of old-growth stems under 48 inch girth and advanced regeneration is relatively low. Regeneration of the Mixed Swamp Forest is not a problem. At the present, a silvicultural treatment is carried out in the year immediately after harvesting and consists of the removal, by poison-girdling with sodium arsenite, of any trees 2 ft. girth at breast height which are unsound, damaged and badly-shaped and of undesirable species.

The use of sodium arsenite for poison-girdling is potentially dangerous and the silvicultural section is trying to find an arboricide which is just as effective, less expensive and not dangerous to the rural population.

No alternative land use has yet been found for the mixed swamp forest. It is the Forest Department's intention that all mixed swamp forests in the State-land should be constituted as permanent forests and brought under sustained yield management for timber production.

Mixed Dipterocarp Forest Management

All primary lowland forest on mineral soils is broadly classified Mixed Dipterocarp forest. This is the true Tropical Rain forest, and originally it must have covered about 80 percent of the land surface of Sarawak. The forest is highly complex with numerous species, and is mainly dominated by members of the family Dipterocarpaceae, such as Kapur (*Dryobalanops* spp.), Keruing (*Dipterocarpus* spp.), Mersawa (*Anisoptera* spp.), Selangan batu or Meranti (*Shorea* spp.).

At present only one major forest reserve in the Mixed Dipterocarp forest is licensed for harvesting. Girth limit cutting is also imposed. This forest type is difficult to manage, and its silviculture is still being investigated. A fair amount of information has now been gathered about its ecology. Tractor logging causes extensive damage both to the residual stands and the forest soils. The Forest Department imposes very strict rules and heavy penalties in order to prevent careless logging and minimize damage. The Permanent Forest Estate in the hill areas is still being menaced by shifting cultivators. The Forest Department together with other government agencies are trying to discourage these through education.

National Parks In Sarawak

The participants in the Symposium held at Kuching in 1963, on Ecological Research in Humid Tropics Vegetation, recommended a plan for the creation of a system of National Parks and Nature Reserves in Sarawak as early as possible, before the extensive tracts of primary vegetation still remaining in Sarawak are reduced by agricultural or forestry development.

At the present time, there is one fully legally constituted national park in Sarawak. This is the Bako National Park which was constituted (or established) in 1957. Up to March 1973, it was managed by the Board of Trustees for National Parks in accordance with the Sarawak National Park Ordinance, 1956. On March 28th, 1973, the Ordinance was amended so as to abolish the Board of Trustees and give full responsibility to the Conservator of Forests for the administration, management and constitution of national parks.

Nine new national parks are proposed for Sarawak (see table 1), two of which, namely the Gunong Mulu National Park and the Niah National Park, are in the final stages of their legal constitution with work on their development now in progress.

The Gunong Mulu National Park covers a large area (204 square miles) in the fourth and fifth divisions of Sarawak and includes the second highest mountain of Sarawak (7798 feet), after which it is named. The area exhibits a wide range of vegetation types varying with altitude and geology. Also found here are the spectacular limestone pinnacles of Gunong Api, large caves, clear mountain streams and abundant wildlife.

The Niah National Park includes within it the famous Niah Caves, where one may explore not only a great number of limestone caves, but also observe the collection of edible nest swiftlets, prehistoric wall paintings and the preserved remains of the artists themselves.

The Lambir Hills and Pelagus National Parks are both in the mid stage of their legal constitution. These two parks will provide outdoor recreation opportunities for the people of Miri and the Lower Rajang respectively.

TABLE 1
Proposals under the second Malaysia plan

Name of National Park	Legal Status	Location	Area (in square miles)
Bako	Constituted in 1957	1st Division	10.5
Gunong Mulu	Final stage of constitution	4th & 5th Divisions	204.1
Niah	Final stage of constitution	4th Division	12.1
Lambir Hills	Mid stage of constitution	4th Division	26.8
Pelagus Rapids	Mid stage of constitution	7th Division	8.0
Matang	Earmarked for constitution during the period 1974-1975	1st Division	8.5
Gunong Gading		1st Division	13.0
Similajau		4th Division	15.0
Sabal		1st Division	5.0
Loagan Bunut		4th Division	20.0

Wildlife Protection and Conservation

In 1958, the Wildlife Protection Ordinance was enacted to provide for the protection of wildlife and for the establishment of wildlife sanctuaries. The Conservator of Forests was appointed Chief Game Warden with responsibility for administration of the Ordinance.

The First Schedule to the Ordinance provides for the protection of 15 species of endangered or threatened wildlife, including the Proboscis Monkey (*Nasalis larvatus*), Orangutan (*Pongo pymaeus*) and the Sumatran Rhinoceros (*Didermocerus sumatrensis*). This schedule was amended in 1973 to include 16

TABLE 2
Species Protected under the Wildlife Protection Ordinance

English name	Scientific name	Local name	Year protected
1. Long-nosed Monkey	<i>Nasalis larvatus</i>	Rasing; Orang Belanda	1958
2. Orang Utan	<i>Simia satyrus</i>	Maias.	"
3. Rhinoceros	<i>Rhinoceros sumatrensis</i>	Badak.	"
4. Reef Heron	<i>Egretta sacra</i>	Ujoh laut.	"
5. Cattle Egret	<i>Bubulcus coromandus</i>	Burong apuh; Burong lima ringgit.	"
6. Storm's Stork	<i>Ciconia stormi</i>	Bangau.	"
7. Lesser Adjutant Stork	<i>Leptoptilos javanicus</i>	Bangau.	"
8. White-bellied Sea Eagle	<i>Haliaeetus leucogaster</i>	Burong lang laut.	"
9. Grey-headed Fishing Eagle	<i>Ichthyophaga ichthyaeetus</i>	Burong lang laut.	"
10. Black-naped Tern	<i>Sterna sumatrana</i>	Burong laut; Entala puteh	"
11. Brown-winged Tern	<i>Sterna anaetheta</i>	Burong laut; Entala hitam.	"
12. Pied Imperial Pigeon	<i>Ducula bicolor</i>	Kawa.	"
13. Green (or Edible) Turtle	<i>Chelonia mydas</i>	Penyu pulo; Penyu empegit.	"
14. Hawksbill Turtle	<i>Eretmochelys imbricata</i>	Penyu sisit.	"
15. Leatherback Turtle	<i>Dermochelys coriacea</i>	Penyu timbo.	"
16. White-Crested Hornbill	<i>Berenicornis comatus</i>	Sentuku (Iban)	1973
17. Bushy-crested Hornbill	<i>Anorrhinus galeritus</i>	Kekalau (Iban)	"
18. Wrinkled Hornbill	<i>Aceros leucocephalus corrugatus</i>	Alaubuloh (Malay) Kejakoh (Iban).	"
19. Wreathed Hornbill	<i>Aceros undulatus undulatus</i>	Alau sangoh (Malay) Undan (Iban).	"
20. Black Hornbill	<i>Anthracoeros malayanus</i>	Mau babi (Malay) Gagak or Rengak (Iban).	"
21. Pied Hornbill	<i>Anthracoeros coronatus</i>	Alau Pedada (Malay) Bruie (Iban).	"
22. Rhinoceros Hornbill	<i>Buceros rhinoceros borneoensis</i>	Kenyalang (Iban).	"
23. Helmeted Hornbill	<i>Rhinoplax vigil</i>	Tajai (Iban).	"
24. Malaysian Peacock Pheasant	<i>Polyplectron malacense</i>	Ruai (Iban) and (Malay).	"
25. Argus Pheasant	<i>Argusianus argus</i>	Ruai (Iban) and (Malay).	"
26. Dugong	<i>Dugong dugon</i>	Duyong (Iban) and Doyong (Malay).	"
27. Barless Monitor Lizard	<i>Lanthanotus borneensis</i>	Chichak purba (Malay).	"
28. Tarsier	<i>Tarsius bancanus</i>	Ingkat (Iban).	"
29. Clouded Leopard	<i>Neofelis nebulosa</i>	Engkuli (Iban), Rimau dahan (Malay).	"
30. Slow Loris	<i>Nycticebus coucang</i>	Bengkang (Iban), Ukang (Malay).	"
31. Sunda Island Gibbon	<i>Hylobates moloch funereus</i>	Empelau arang (Iban).	"
	<i>Hylobates lar muelleri</i> *		
32. Grey Gibbon	<i>Hylobates moloch muelleri</i>	Empeliau Labang (Iban); Wak Wak Puteh (Malay).	"
	<i>Hylobates lar muelleri</i> *		
33. North Bornean Gibbon	<i>Hylobates moloch abbotti</i>	Empeliau (Iban); Wak Wak (Malay).	"
	<i>Hylobates lar abbotti</i> *		

* Revised scientific name ref: Groves, 1971

additional species, including the Gibbon (*Hylobates lar*) and all species of Hornbills (fam. *Bucerotidae*), as set out in Table 2.

Thirty one species of wildlife have been designated as 'protected animal'. The Ordinance prohibits hunting, killing, capture, sale, export or possession of such animals and also prohibits the export of Monkeys, Bear and Deer except under licence.

It has been difficult to enforce this Ordinance due to such factors as the large area of the State coupled with the lack of communication facilities, large number of firearms among native peoples, lack of suitably trained staff and lack of public interest.

Through the assistance of the World Wildlife Fund, Malaysia, two wildlife conservation projects are planned for 1974. The first project will involve a survey of the Orangutan population in the Ulu Batang Ai area, Second Division, with a view to recommending to the Government the establishment of a wildlife sanctuary. No such sanctuaries have as yet been established in Sarawak.

A second project, also supported by the World Wildlife Fund, involves a short ecological study of the Rhinoceros Hornbill (*Buceros rhinoceros*) and, if possible, of other indigenous species of hornbills.

There has also been correspondence with the I.U.C.N. and F.A.O. in relation to possible future assistance in the form of various conservation projects.

(iv) **PAPUA NEW GUINEA**

PRESENTED BY

Hon. STEPHEN TAGO

Papua New Guinea, with an area of 463, 500 square kilometres, is one of the last land masses where only limited parts of the natural environment have been seriously disturbed or destroyed. Hence many ecosystems are relatively unaffected by man. Table 1 gives a summary statistical sketch of the situation.

The vegetation ranges from coastal and swamp forests, tropical lowland and monsoon forests to rainforests and montane forests. The topography is rugged, making transport and communications difficult. The population, numbering some two and a half million and speaking 700-odd languages, mainly lives in the rural areas.

The country is well endowed with natural resources and agricultural, fishing, forestry and mineral-based industries will be the main sources of development in the economy for some time to come. The present Government's policy is one of equal development among regions with more responsibility falling to Papua New Guineans themselves. It is a policy aimed at equality, self-reliance and rural development.

The Improvement plan recognises that high rates of economic growth, necessary and essential as they are, do not themselves guarantee the achievement of the above ideals. It places an equal emphasis on social and cultural goals. A natural corollary to this is that environmental considerations must form part of the planning process.

We, like other developing countries, face a spectrum of environment problems.

Many stem from the lack of development. These are problems arising from contaminated water supplies, poor sanitation, nutrition and disease. They are problems which affect the majority of the people. And they are accentuated by rapid population growth.

TABLE 1

Statistical data summary for Papua New Guinea

Source: Country Programme Proposal of United Nations Development Programme Assistance 1973-1977. December, 1972.

A. Geography

Area	463, 500 km ²
Climate	Tropical, with significant local variations in rainfall and temperatures due to topography
Land Utilization (1969-1970)	
Forest Areas	12, 000, 000 ha
Crops	360, 000 ha
Pastures	84, 000 ha
Cleared areas	1, 120 ha
Other holdings	156, 000 ha

B. Population

As at June 1971	2, 520, 000
Growth rate	2.8% (estimated to rise to 3% per annum 1971-1976)
Population Density	5.4 per Km ² , with district variation from less than 1 to slightly more than 23 persons per Km ² .
Age Structure (1971)	42.8% under 15 years 41.8% in 15-44 year category 15.4% over 45 years.

At the other end of the spectrum, the country is beginning to face increased problems arising from developments in agriculture, forestry, industry and urbanisation. These are problems of social disruption—the loss of tradition and cultural orientation, pollution from industrial effluents and mining wastes, and resources deterioration such as the loss of forest and wildlife resources. At present these problems have not reached the dimensions that plague other countries. We have the opportunity of planning our development to avoid some of the mistakes of other countries and so attain a more satisfactory pattern of growth. Essentially, we wish to move toward a well-rounded development programme—one that makes rational use of our natural resources—with the basic aim of improving the lives of all Papua New Guineans.

The achievement of these ideals will require very careful planning to balance the social, political, economic and environmental facts of each particular development proposal and to resolve all possible land use conflicts. This requires adequate data for decision making.

The Australian Commonwealth Scientific and Industrial Research Organization has completed reconnaissance land resource surveys of about fifty percent of the country, covering mainly the high capability land and areas where the majority of the population live. By mid-1975, the surveys will include:—publication of a specialist inventory of the major land resource factors; publication of a resource atlas and the production of a computer-based natural resource data bank.

The Land Utilisation section of the Department of Agriculture conducts detailed surveys of particular areas prior to their development, reporting on the full range of problems relating to development—soils, climate, drainage, and in conjunction with other departments, vegetation management and environmental protection. A major report on soils, irrigation and crop potential in the Markham Valley will be published in 1974. Others are underway.

The Department of Forests has assessed and mapped about 5 million hectares. These surveys broadly indicate high forest resource potential as a preliminary to further development planning. More intensive management surveys have also been completed for a number of areas of the country.

Scientists of the national herbarium have widely studied the forest flora and the first major publication on this aspect is expected in 1974. Research in the conversion and use of major and minor forest products is well advanced, including pulp and paper studies. A widespread forest industry serves the internal market and though there is room for expansion in small projects directed to the village and rural economy, the forward development programme is geared to the export market. The plan provides for maximum processing to be done in Papua New Guinea and these large scale industries will follow an integrated system of saw and veneer mills, plywood manufacture, chip-wood and pulp production. The development will have attendant pollution problems to be reduced to acceptable levels. The first of these large scale industries will come into being in the next few months and contracts for a further six complexes are in the final stages of negotiations. Each unit will harvest completely some 5000 hectares of forest per year so certainly a significant impact will be made on the forest environment.

Land-use plans, will need to be rapidly expanded to ensure utilisation and protection of the soil and other resources. Reforestation will be an integral component of the plans and some 12,000 hectares of existing plantations serve as a useful guide to further planting programmes. Research is being directed to species selection, forest genetics, establishment and cultivation techniques and to protection. Considerable further work is indicated in hydrology and conservation and the monitoring and control of the effects of industrial forest management on social and conservation values.

Owing to its large area of high altitude land coupled with high rainfall, Papua New Guinea possesses considerable potential for hydro-electric power generation and irrigation. Assessment of this potential is underway and a network of stream gauging stations is in operation throughout the country. The first stage of a major hydro-plant for urban and industry needs is nearing completion on the Ramu river and the Government has commissioned a feasibility study of a first stage development in the Purari river which has enormous potential. These schemes and the industries they will attract will require detailed environmental planning. The country's ground-water supplies are large and of good quality and are becoming of increasing importance for urban requirements, particularly where rain water is insufficient to cope with dry periods.

An active programme of wildlife conservation and management by the government has been underway for some time, reflecting the very real interest the people of Papua New Guinea have for birds of paradise, cassowaries, megapodes, crocodiles and many other wildlife species. The programme is designed to maintain the people's sources of high quality protein food obtained from wildlife and cash crops such as crocodile skins, and to safeguard the countries' unique wildlife.

A major development in the programme recently has been the establishment of wildlife Management Areas. These are large tracts of natural habitat, preserved and controlled for wildlife production by village communities with Government assistance. Traditional hunting is continued, but firearms and commercial exploitation is strictly controlled. In Papua New Guinea the use of shot guns is doubling every four years. We regard this danger to our wildlife as very severe.

Another development is the incorporation of wildlife management within the Government sponsored projects for district and village development, along with agriculture, education, health, etc. This means that the village community takes full responsibility for looking after the wildlife which it uses, rather than resenting laws and restrictions superimposed by an outside authority.

A number of the country's unique and diverse forms of wildlife are increasingly threatened by the impact of economic development. In particular, the birds of paradise are in danger of drastic reduction in all accessible habitats because of heavy commercialisation and trade in plumes by local communities. It is proposed to establish a number of Bird of Paradise Reserves over the next several years in which local communities will participate in preservation of bird of paradise and other wildlife in their region. However all the Bird of Paradise habitat is owned by village communities, and it is not possible simply to purchase the land, because of the very complex land ownership in Papua New Guinea.

To help preserve natural flora and fauna there are four existing National Parks, two district parks, and more than 50 proposed parks under investigation. Included also are marine parks, historical sites and nature reserves. These areas are under the control of the National Parks Boards, and committees have been set up to provide special advice, for example the Scientific Advisory Committee and a number of District Advisory Committees. Because of the complex problems in Papua New Guinea the process of acquiring satisfactory establishment and control of national parks area is slow and difficult.

A series of town planning studies for all major urban areas is now almost complete. These plans are concerned with broad urban structure and aim to bring together in a comprehensive plan proposals for land use, utilities, transportation and conservation. They provide the framework within which detailed planning for the next 20 years will be undertaken.

From this report it will be seen that the Government of Papua New Guinea has available to it a wide background of information on its resources and their management. It is no criticism of the agencies mentioned, and which in the past have operated in a degree of technical isolation, if the Government now requires a far greater degree of coordination and a national policy which supersedes individual interests.

The situation at present is inadequate to meet the concern for environment and for the incorporation of ecological principles into policy and planning areas concerning the location of industry, land-use planning and integrated planning of resource utilization. In essence, the problems revolve around:

- (a) The current administrative arrangements for environmental zoning, land-use development, anti-pollution regulations, community development, etc.—often stem from the need for remedial action, not long term principles;
- (b) inadequate legislation fragmented through various departments, making co-ordination difficult;
- (c) increasing numbers of large development projects based around a single resource with little attempt at integrated multiple-resource use;
- (d) limited manpower and poor utilization of the skills available.

In April this year the Chief Minister announced the formation of a separate Ministry of Environment and Conservation supported by an Office of Environment and Conservation within the Department of Lands. The functions and responsibilities are outlined in Annex A. The Office has been established as a policy and co-ordinating group and operational responsibilities will be delegated to other branches of Government. The reasons for this are two-fold: we cannot afford to create a large unit which in many ways would duplicate the activities of other branches of Government and, secondly, all sectors of Government need to be made aware of their environmental responsibilities.

To ensure that rural people obtain the maximum benefits from developments in their areas, the Government is introducing a new system of planning. In this system the people will have a much greater say as to what they want done in their areas. It will be different to the old style of planning whereby all planning and decisions were made by the Central Government without much consideration of their effects on the lives of the rural population. To make sure that all future projects are properly implemented, the Central Planning Office (CPO) is setting up two levels of operations room. In the national operations room, problems relating to projects in the course of construction, and any conflicts between policies, will be discussed and solved. At the lower level, a district operations room is to be set up to supervise all developments in each district. This means that Departments will review their projects regularly. Any problems hindering the development of any of these projects will be solved in this room during a meeting convened between concerned Departments. It is also planned to use it to display development aids so that donors can call in and see for themselves the progress of the aid they have been giving, and assess from project achievements how well we are using their assistance. Since CPO will be greatly involved in preparing PNG's development plans, the office of Environment and Conservation will need to build up close links with this Centre to insure that ecological principles are incorporated into this planning process. The existing *ad hoc* arrangements are not good enough for the scale of national exploitation which now faces the country in the form of large scale forestry, agricultural, industrial and mining ventures.

The task ahead of us is immense, and will seriously tax our limited manpower resources. But there is a growing awareness of the need for incorporating these considerations into national planning. Statements on the need for environmental control have now been incorporated in the national plans, including the need for protective or restorative measures associated with mining and for full environmental impact statements on major projects. However, there is still a great deal of uncertainty regarding the economic and political costs of environmental protection, because of the almost complete lack of

monitoring or other technical services necessary and on the scale required to deal with this problem.

In addition to the policy we must have the technical facilities to back it up. To overcome the problems discussed above we will need to rely heavily on regional co-operation and international agencies for support and assistance. It is in this context that I would like to express my appreciation to IUCN and UNDP for their generous assistance in enabling our delegation to attend this meeting. I feel sure that the results of our deliberations will be of direct benefit to us in our efforts to incorporate ecological principles into economic development planning.

ANNEX A

FUNCTIONS AND RESPONSIBILITIES OF THE OFFICE OF ENVIRONMENT AND CONSERVATION

- (a) to develop and recommend to Cabinet a national environment and conservation policy to promote the improvement of environment and meet conservation, economic, social, health and other goals consistent with the Eight Point Improvement Plan;
- (b) to be responsible for and to co-ordinate all activities relating to environment and conservation and for preventing or controlling pollution and protecting and improving the quality of the environment;
- (c) to formulate specific guidelines for development project appraisal which ensures that environmental and social considerations are given appropriate attention in decision making along with economic and technical considerations;
- (d) to survey both existing and prospective environmental and conservation problems so that appropriate recommendations can be made to achieve the goals of the national environment policy;
- (e) to review existing legislation and regulations; examine alternate pollution control strategies and then prepare and administer appropriate legislation to co-ordinate all activities relating to discharge of wastes into the environment and for preventing or controlling pollution and protecting and improving the quality of the environment and to revise this legislation as required;
- (f) to review the existing and future requirements for training programmes, particularly in comprehensive environmental impact analysis, environmental planning, pollution control and monitoring;
- (g) to establish and maintain liaison with Government Departments, NIDA, CPO and other agencies and institutions within the country, and to develop and extend liaison with external agencies, with an interest in environmental protection, conservation and pollution control;
- (h) to establish a national resource use and pollution register to enable analysis of changes and trend in environmental quality and so plan for improvement;
- (i) to establish and develop a national referral bank of data and information in the environment and conservation field;
- (j) to conduct investigations, studies, surveys, research and analysis relating

to ecological systems and environmental quality and to engage or co-operate with other persons, bodies or institutions carrying out similar surveys or investigations;

- (k) to provide information and reports to the public regarding the protection and improvement of environment and to liaise with the Education Department and other institutions in seeking ways to incorporate environment and conservation information into education curricula;
- (l) to make and furnish such studies, reports thereon, and recommendations with respect to matters of policy and legislation as Cabinet or the Minister may request;
- (m) to develop and implement the most appropriate mechanisms for responding to requests for advice, information or assistance from regional or district governments, and local groups on environmental and conservation problems.

(v) **PHILIPPINES¹**

PRESENTED BY

JOSE VIADO, MARTIN R. REYES, PRIMO P. ANDRES & ANTONIO V. GLORI²

INTRODUCTION

Forests play a big role in providing a healthful environment and in developing the country's economy. They are, however, subjected to reduction and disturbances which subsequently give rise to ecological problems.

The problems need to be identified; necessary researches have to be undertaken in order to provide scientific bases in the formulation of a more effective and workable guide in forest resource management.

To start with, it is thought well to have a brief look into the general background of the newly created Bureau of Forest Development which assumes the responsibility of managing the forest resource.

The Bureau of Forest Development (BFD)

The three defunct agencies, namely: the Bureau of Forestry, Reforestation Administration and the Parks and Wildlife Office have fused into a unified Bureau of Forest Development (BFD) by virtue of the Presidential Decree No. 1 dated September 24, 1972 which sought to 'reorganize the executive branch of the national government'.

The Forestry Reform Code of the Philippines, approved by the President of

1 Working Paper on the UNESCO/MAB Project Development Program on Ecological Research Inputs for Forest Resource Management, hosted by the Bureau of Forest Development, Dr. Garcia Hall, NSBD, Manila, May 22, 1974.

2 BFD Acting Director, Officer-in-Charge of BFD Forest Research Division, Officer-in-Charge of BFD Silviculture Division and Officer-in-Charge of Pests & Diseases Section of BFD Forest Research Division, respectively.

the Philippines on February 5, 1974, defines the functions and jurisdiction of the BFD as follows:

Functions

- (a) To promote the wise utilization, conservation and development of the forest resources of the country, including their associated services relating to water supply, recreation and wildlife preservation;
- (b) To safeguard the national interest in the maintenance of wholesome ecological environment;
- (c) To accelerate the rehabilitation of denuded lands, including those under private ownership; and
- (d) To provide a stable forestry agency and a body of laws and regulations adequate to achieve the national policy.

Jurisdiction

The BFD shall be responsible for the effective, efficient and economic classification, protection, development, management, regeneration, reforestation, occupancy and use of all public forest and forest reserves; the granting of licences or permits for the taking or use of forest products therefrom or the occupancy or use of the public forest; the implementation of the multiple-use and sustained yield management in the public forest, and a comprehensive program of forest research; the protection, development and preservation of national parks, game refuges and wildlife; the implementation of a continuing program of Kaingin management within the public forest; the enforcement of forestry, reforestation, parks, games and wildlife laws. The BFD shall, in collaboration with appropriate government agencies, extend assistance towards the development, utilization and rationalization of wood industries; regulate the operation of sawmills, veneer and plywood mills and other wood processing plants; conduct studies of domestic and world market; provide and support of industrial operations within the public forest; and support fiscal policies associated therewith.

In order to effectively carry out the above functions, the BFD is equipped with five technical divisions, each charged with specific responsibilities (Appendices A & A-1) geared towards a common goal *i.e.* forest conservation. An administrative division runs the whole organizational machinery.

THE FOREST ECOSYSTEM

Classification

The forest ecosystem of the world may be broadly classified according to the two distinct latitudinal regions—the tropical and temperate. Climate and soil, in general, have been recognized as exerting considerable influence on the natural vegetations that in temperate regions are predominantly composed of conifers with an admixture of deciduous hardwoods, while in the tropical regions they are generally broadleaf hardwoods.

Components

A biological community viewed collectively as a dynamic organism, forests exert a remarkable and far-reaching influence on human life. Their develop-

ment is the result of a long evolution and adaptation of organic population to the environment.

The forest ecosystem comprises biological and physical environments. The higher and lower floral life, the surface and subterranean faunal life including microorganisms, belong to the former. The climate, soil and geographical features such as elevation and slope make up the latter.

The habitat components are interrelated and interdependent in such a manner that a major alteration of any of them will produce an interactive effect on the whole forest community.

Characteristics of Tropical Forest Ecosystem

The tropical rain forest is generally characterized by its larger number of species and its multistoried structure. Species found therein are of great diversity and possess marked genetic variability. The plants are generally woody predominated by tall trees with epiphytes. The average heights of taller trees are 'rarely more than 46-55 meters though trees over 60 meters are not uncommon'.

The climatic conditions possess distinct features. The temperature is relatively even and the rainfall spreads over the greater part of the year. There are only two distinct seasons—the wet and the dry.

The soils of the tropical forest, though different in many of their properties, share certain common characteristics. They are red or yellow in color and generally loamy or clayey in texture, invariably with low pH and humus content mostly confined to the uppermost horizons.

Stability Factor

In temperate regions the periodicity of the vegetation goes along with the seasonal variations. On the other hand, periodicity varies much less with the seasonal changes in the tropics. Forest vegetation remains green all throughout the year.

The significance of this phenomenon is obvious. The tropical forest, as a biotic organism, effects an activity in a relatively more continuous manner which thus functions unflinchingly in maintaining a stable ecological balance in the system.

Sustained Productivity and Ecosystem Stability

Timber extraction in the Philippines is oriented towards the concept of perpetual forest productivity. Thus, considering the uneven-age characteristic of the Philippine virgin forest stands, the method of timber extraction being employed is selective logging in which only the mature trees, scattered singly or in groups, are the ones harvested thereby leaving less mature ones to grow and eventually mature. In the process of harvesting, the rate of growth of the stand is determined beforehand and on this the allowable cut in terms of wood volume, within a certain period of time, is based. Thus, in the concept of selective logging, only the growth increment is extracted thus theoretically attaining the sustained yield objective.

The above method bears some ecological implications. For although human activity is introduced, the ecosystem stability is deemed not to be disturbed significantly, considering that sustained productivity is, by inference, arrived at through this system of harvesting.

Present trends of Resource Use

Just recently there evolved a forest management policy which presents a new trend in the resource use. The policy emphasizes multiple-use of the forest which means utilization not only in terms of wood production but also of other equally important commodities that can be derived from the forest such as water and essential wildlife species. The function of forest in minimizing soil erosion, which is another aspect of utilization, is not overlooked. All these aspects are given more or less equal emphasis to such extent as deemed not to necessarily destroy the ecological balance existing in forest areas. Information as to the exact extent, however, is still wanting and yet to be determined through research.

In line with wood utilization, there are, to date, a number of timber licensees operating in the country. The majority of this number is found in Mindanao area where the bulk of our virgin dipterocarp forests is found. These licensees are engaged in the production of logs and other semi-finished products like lumber and veneer. Logs and lumber are exported to U.S., some European countries and Japan. Appendix B gives information relating to the present status of our timber industry.

As everyone may be aware, there has recently evolved a new policy which seeks to phase out log exportation. Now in its first year of execution, a total ban on log exportation will take effect in 1976, after which all logs will be locally processed into finished products. The probable consequences of this scheme, apart from ensuring establishment of more processing plants in the country which would mean additional employment, should be better utilization of wood wastes which will eventually redound to better forest conservation.

RESEARCH

Priorities

Hand in hand with the reorganization of government agencies, was the creation of the Philippine Council for Agricultural Research (PCAR) effected by the promulgation of Presidential Decree No. 48, which empowers that Office to coordinate all agricultural research including forestry and fisheries. The first PCAR Congress in Los Baños, Laguna, in February, 1973, was held to draw up research priorities in addition to monitoring benchmark research information from all the above fields.

Priorities were formulated centering on a silvicultural system embracing nursery practices and plantation establishment of dipterocarps, pines, fast growing species and premium and/or vanishing species such as narra, molave and tindalo; methods of rehabilitating damaged watershed; quest for biological information needed in the formulation of silvicultural and other production practices; growth and yield and preparation of volume tables for hardwood species; and analysis and control of kaingin making. Appendix C lists priorities in detail.

Funding

There appears to be no problem as far as research funding is concerned. For every cubic meter of log locally processed P1.00 goes to a forest research and development trust fund. Also, for every cubic meter of log exported, P5.50 is set aside for forest research. This is not to mention some amount that forest research draws from general funds.

To date, forest research has some P6 million from the general fund and P9 million from the trust fund to finance both on-going and proposed researches for the coming fiscal year 1974-75.

Future direction

Compared with the research undertakings of the defunct forest agencies, the BFD research this time assumes a more purposeful image with its sight focused on the ultimate goal where the aims of other agricultural research ventures converge. It is closely synchronized with the over-all socio-economic development activity of the country.

This reorientation was made possible through the formulation of the long-range integrated research program on forest production during the first PCAR Congress. The long-range research program spells out important avenues of forest research which are as follows:

1. Timber production in dipterocarp forests.
2. Management of important watersheds.
3. Research on fast-growing hardwoods.
4. Production of tropical conifers.
5. Horizontal problem areas which include, among others, analysis and control of kaingin-making and ecosystem studies.
6. Production of high-premium and second-growth hardwoods.
7. Production of mangrove species for rayon, fuel or charcoal, wood and tannin.
8. Supply, growth, regeneration and harvesting of rattan, bamboo and other minor forest products.

SUGGESTED AREAS OF INTERACTION

Among all the government agencies which take care of the country's natural resources, the BFD has one of the widest scope of responsibility in terms of land area. For forests of the Philippines comprise about 57% of the total land area.

Effective management and development of this vast area is not an easy job considering the fact that forest is a living organism, the delicate ecological balance of which hangs on the interplay of other biotic as well as abiotic components.

Presented hereunder are some commonly observed, yet interesting, points of interaction of the BFD with these agencies.

Interface I—Vegetation Establishment Strategies for Mine Wastes

Minerals are among the precious natural resources of the country, in the form of gold, silver, copper, nickel, iron etc. The Philippine mining industry contributes substantially to the economic well-being of the country. The Bureau of Mines (BM) assumes the responsibility of servicing mining industries by way of 'intensive and extensive mineral and geological surveys, exploration drillings, investigation and evaluation of mines and other mineral properties and formulation and recommendation of more realistic and workable rules and regulations affecting the mining industry.'

Some mining operations take place in forest areas. While in the process of operation, forest soils are unavoidably destroyed by dumping of mine wastes on

the forest floor. In many instances, the effluent has a high mineral content which renders reforestation work difficult.

There are accordingly two major types of excavation employed in mining activity. One is the so-called open-pit mining and the other, the underground mining which is simply done by tunneling. The disturbance on the surface soil brought about by the latter is often minimal compared to the former which is commonly used because of least cost.

It is needless to stress that mine waste, being very unstable, is highly erodible. Thus, if mining operates on watershed areas, the danger of siltation of dams and/or watershed catchment, or the possibility of eutrophication of an inland water body, is high.

Interface II—Ecological Implications of Industrial Forest Plantation

More and more logging industries in the Philippines are gradually expanding to more integrated wood processing companies by way of establishing processing plants to make better use of species less suitable for lumber manufacture as well as wood wastes. The Paper Industries Corporation of the Philippines (PICOP) was one of the pioneers in this venture. It has now in operation a big pulp and paper plant with a daily capacity of about 400 tons of kraft and newsprint requiring 1, 600 cu. m. of pulpwood.

To meet this huge wood requirement so as not to hamper its smooth operation, the BFD extended assistance to solve the company's problem of lack of pulpwood materials by granting temporary permission to the company to clear-cut forested areas along both sides of logging roads in the concession for raising fast-growing species suitable for pulp and paper manufacture.

The stability and high productivity of natural ecosystems in the tropics have always been associated with high species diversity. However, establishment of a forest plantation deals, in most cases, with only one species. Experience acquired from practice of monoculture of agricultural crops has shown that, unless the lost natural stabilizing mechanisms could be compensated for in the process of the landscape transformation, disintegration of ecosystem structure and function may result, and may eventually lead to an irreversible decline in productivity.

The ecological implications of monoculture, therefore, need to be studied. Not only productivity should merit concern but also the effects of monoculture on wildlife ecology when considered on a systems approach. A research study on the ecological effects of industrial forest plantations would be a suitable area of interaction between the BFD and private industries such as PICOP and Nasipit Lumber Co. (NALCO).

Specifically, suggested studies will be on the effect of monoculture on erosion and water yield and on its trophic dynamic aspect, all of which may likewise be influenced to a certain degree by the clear-cut method of harvesting appropriate to even-age forest stand.

Interface III—Ecology of Watershed Areas

Perhaps one of the most important resource inputs and likely to play a key role in development activities and human survival in the future, is water. The importance of rehabilitating the watershed areas in the country today cannot be overemphasized. This research area is also a suitable arena of concerted inter-bureau/agency collaborative efforts. No one agency can handle all ecological research aspects of watershed rehabilitation and management.

With burgeoning human population, more marginal areas have to be cultivated, families have to be relocated, industrial plants have to be set up, etc. All these activities, and many more, need a common input—water. Watershed rehabilitation and management, therefore, are a research area relevant to national goals and which can provide a common working ground for the various agencies like BFD, NIA, National Power Corporation (NPC) and DAR. Proposed research inputs in the rehabilitation of damaged watershed areas in the country consist of:

1. Behavioral and socio-economic profile of displaced families near a reservoir;
2. Effects of vegetation establishment on water yield; and
3. Causes of changes in water yield of reservoirs for irrigation and hydro-electric generation purposes.

Behavioral and Socio-economic Profile of Relocated Families

One of the major problems that the country faces today is the proper resettlement of displaced families not only in the urban communities but also in the rural areas. Most of these displaced families are generally low on subsistence level of living. As a consequence of their poor economic conditions their tendency is to move out of thickly populated areas and to settle in areas they can cultivate. However, some of these areas are not suitable for permanent agriculture. The settlers clear the existing vegetation and plant some crops irrespective of the topography and soil conditions. Grass in the cleared area eventually takes over until such time that the settlers can no longer raise crops. Thus, they move again to other areas for the same purpose following the same practice.

As population increases, more temporary communities are established in non-agricultural areas. But instead of improving their living conditions they become more impoverished.

The government, represented by the Department of Agrarian Reform (DAR) saw the plight of these people. Occupied areas were proclaimed as DAR reservation, subdivided to suitable farm sizes and distributed to the occupants.

But most often, the lands so distributed are not classified by the Bureau of Forest Development before they are subdivided and allocated to displaced persons. In many instances, public forest land is petitioned by displaced persons for release and, upon filing the application, they occupy the land and start clearing it thereby destroying the forest cover most consisting of valuable trees that are commanding good prices in the world market. Land areas that are occupied are sometimes so steep for cultivation that the soil is predisposed to erosion.

While the DAR has a very good purpose in allocating lands to alleviate the plight of displaced persons, it is deemed better that this particular endeavour be approached in a coordinated manner with other agencies concerned especially the Bureau of Forest Development. Only areas certified as alienable and disposable within the reservations should be taken over by the DAR for distribution to displaced persons. There is a need also to re-examine the areas especially those suspected of having critical topographical and soil conditions so that proper steps could be undertaken to correct the past mistakes. Similarly, research may be necessary in this connection to verify the reliability of the present guidelines being followed in land classification work.

Causes of changes in water yield of reservoirs for irrigation and hydro-electric generation purposes

The Philippines, essentially an agricultural country, has about 8 million hectares of arable land out of which some 6.5 million hectares are being cultivated and planted to annual and seasonal crops. To boost agriculture in the country necessitates development and proper harnessing of its water resource through the manipulation of important rivers such as Cagayan, Agno, Pampanga, Bicol, Ilog-Hilabangan, Agusan and Cotabato. This is not to mention some 59 lakes which are potential sources of water.

The National Irrigation Administration (NIA) is charged with the responsibility of developing and harnessing these rivers in order that water could be supplied to the farms in the right amount at the right time.

The National Power Corporation (NPC) impounds water of river systems in big reservoirs for generation of electric power.

It is, however, necessary to point out that water availability in the rivers depends in a large measure on the condition of the watershed. Activities taking place therein in the form of timber extraction or any other type of land use may significantly affect water yield quantitatively as well as qualitatively. In fact, changes in water yield are being observed periodically in Ambuklao watershed where human activities are evident.

Attention should not only be focused on the changes in water yield. It should likewise be directed to the possibility of gradual siltation of irrigation dams and canals and hydroelectric reservoirs.

Effects of Vegetation Establishment on Water Yield

There are, to date, 'about 5 million hectares of brush and open areas awaiting planting and of which some 1.3 million hectares are found in critical watersheds urgently needing reforestation'. Critical watershed includes, among others, Upper Agno River Basin, Upper Cagayan River Basin, and Upper Pampanga River Basin.

Investigators claim that the establishment of vegetation provides a good water quality and regulates the flow of water in streams. However, the effects of vegetation on Streamflow varies and depends mostly on the condition of the area at time of planting. For instance, planting over 100,000 trees on an eroding 88-acre watershed in the Tennessee Valley of the United States, accompanied by erosion control measures, reduced peak discharges to a value ranging from $\frac{1}{4}$ to $\frac{1}{3}$ of before-treatment peak values. Surface run-off was also reduced from 69 percent of total run-off to 44 percent. Reforestation in the same region of about one third of a much larger watershed (1,715 acres), together with erosion control measures, reduced summer peak discharge by from $\frac{1}{12}$ to $\frac{1}{4}$ of before-treatment peaks. This marked reduction of peak discharges was likewise accompanied by significant reduction in erosion and sedimentation rates thus providing a better water quality and soil condition.

In the Philippines where climatic and physiographic conditions are very much different, the above results may not hold true. The effect of vegetation establishment therefore needs to be studied.

RECOMMENDATIONS

In view of the foregoing it is suggested that ecological research inputs in forest resource management should cover the following studies:

- A. Ecology of Watershed Areas
1. Behavioral and socio-economic profile of relocated families BFD/DAR/NPC/NIA
 2. Causes of changes in water yield of reservoirs for irrigation and hydro-electric generation purposes NIA/NPC/BFD/PAGASA
 3. Effects of vegetation establishment on water yield BFD/NPC
 4. Factors affecting soil stability in occupied watershed areas BFD/NIA/NPC/BS
- B. Effects of Mining and its waste products on the forest ecosystem
1. Effects of mining activities and products on:
 - (a) Water quality/yield BM/NIA/BFD/BS
 - (b) Aquatic ecosystems (for future consideration) BM/BFD
 - (c) Forest vegetation BM/BFD/PAGASA
 2. Vegetation establishment strategies for mine wastes BFD/BM/NIA
 3. Effects on stream water quality of vegetation established on mine wastes BFD/NIA
- C. Ecological implications of industrial forest plantations
1. Nutrient cycling pattern BS/PICOP/BFD/NALCO
 2. Soil stability BS/PICOP/BFD/NALCO
 3. Hydrologic characteristics BS/PICOP/BFD/PAGASA/NALCO

The implementing agencies proposed in the above list are:

- BFD—Bureau of Forest Development
 BS—Bureau of Soils
 PAGASA—Phil. Atmospheric Geophysical, Astronomical Services Administration
 BM—Bureau of Mines
 NPC—National Power Corporation
 DAR—Department of Agrarian Reform
 NIA—National Irrigation Administration
 PICOP—Paper Industries Corporation of the Philippines
 NALCO—Nasipit Lumber Company

BIBLIOGRAPHY

Bureau of Forest Development, 1974. Forestry Reform Code of the Philippines.

- FAO 1971. Environmental aspects of natural resources management: Forestry. UN Conference on the Human Environment, Stockholm 1972; Agenda Item II (a) ii, FO:HE/72/1.
- Lansigan, N. P. 1973. Forests and our environment. *Forestry Digest*, 1(2): 34-38.
- PCAR 1973 a. An integrated national forestry research program for the Philippines (Revised).
- 1973 b. First national agriculture system research congress. Forestry Research Division Workshop Session No. 12. Forest Production; UPLB. Presidential Committee on Wood Industries Development, 1972. Philippine forestry and wood industries development. Agric. Info. Div., DANR.
- Richards, P.W. 1957. *The tropical rainforest* (An ecological study) 450 pp., Cambridge University Press.
- Spurr, S. H. 1964. *Forest ecology*. The Ronald Press Co., N.Y.
- Tennessee Valley Authority, 1951. Effect of 15 years of forest cover improvement upon hydrologic characteristics of White Hollow Watershed. Hydraulic Data Branch, TVA, 74 pp.
- , 1955. Influence of reforestation and erosion control upon the hydrology of the Pine Tree Branch Watershed. 1941 to 1950 Technical Monograph 86; 95 pp.
- Tourney, J. W. 1928. *Foundations of silviculture upon an ecological basis*. Vol. 1, 438 pp., John Wiley & Sons, Inc., N.Y.

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APPENDIX A. 1

FUNCTIONS OF THE DIVISIONS OF BUREAU OF FOREST DEVELOPMENT

PLANNING AND EVALUATION DIVISION which shall have the following functions: (1) undertake economic, organization and management research relative to forest land management and forest industry development; (2) prepare long-range and annual programs of work; (3) guide the preparation of multiple-use plans for the public forest; (4) evaluate, through a system of field inspection, the quality and quantity of performance as measured against established policies, goals and standards; (5) establish standards for land classification in the public forest; (6) recommend changes in laws, regulations, policies and procedures as needed to achieve agency objectives; (7) maintain agency manuals; (8) and perform such other functions as may be provided by law.

This Division shall consist of functional sections, namely: Program Planning, Performance Evaluation, Forest Economics and Management Analysis.

SILVICULTURE DIVISION which shall have the following functions: (1) maintain a current inventory of timber resources in the public forest, including virgin, cutover and degraded forests; (2) design silvicultural systems for commercial and non-commercial timberlands; (3) prepare guidelines for working unit plans; (4) provide standards for the conduct of post-harvest diagnostic surveys and timber stand improvement activities in the public forest; (5) prepare the program for reforestation and disease and insect control; (6) insure that the boundary of the permanent public forest is established in accordance with the land classification standards prescribed by the Planning and Evaluation Division, and undertake the initial marking of the boundary; (7) and perform such other functions as may be provided by law.

This Division shall consist of functional sections, namely: Silviculture and Reforestation, Timber Inventory, Working Unit Plans and Land Classification.

FOREST PROTECTION AND UTILIZATION DIVISION which shall have the following functions: (1) plan and develop, within the public forest, the programs for protecting the public forest, reforestation projects, national parks and wildlife sanctuaries from fire and encroachment; (2) provide guidelines for the effective enforcement of fish and game laws and regulations; (3) prescribe standards and procedures for the issuance of forestry licenses or permits; (4) issue timber licenses and establish guidelines in the processing of applications for leases and in the preparation of operating plans for the removal of timber and minor forest products in accordance with working unit plans; (5) develop a program for the resettlement of shifting cultivators occupying the public forest; (6) formulate a program for the protection and rehabilitation of watersheds; (7) develop, install and provide technical supervision in the maintenance of forest transportation and communication systems, buildings, and other structural facilities associated with the public forest; (8) and perform such other functions as may be provided by law.

This Division shall consist of functional sections, namely: Timber Operations, Land Uses, Watershed Management, Utilization, Kaingin Management, and Forest Protection and Engineering.

PARKS, RANGE AND WILDLIFE DIVISION which shall have the following functions: (1) formulate the outdoor recreation programs in public forests, national parks, including marine parks and other related recreation units; (2) establish the carrying capacity and range-use requirements on suitable grasslands in the public forest; (3) set standards for the issuance of grazing permits to ensure the utilization of public range lands is in accordance with watershed and wildlife habitat requirements; (4) determine the need for, and recommend, the establishment of wildlife sanctuaries; (5) establish wildlife habitat requirements for application in the managed forest; (6) recommend season, bag and/or creel limits of game and fish within the public forest and the marine parks, lakes and other inland waters which may be under the jurisdiction of the Bureau; (7) and perform such other functions as may be provided by law.

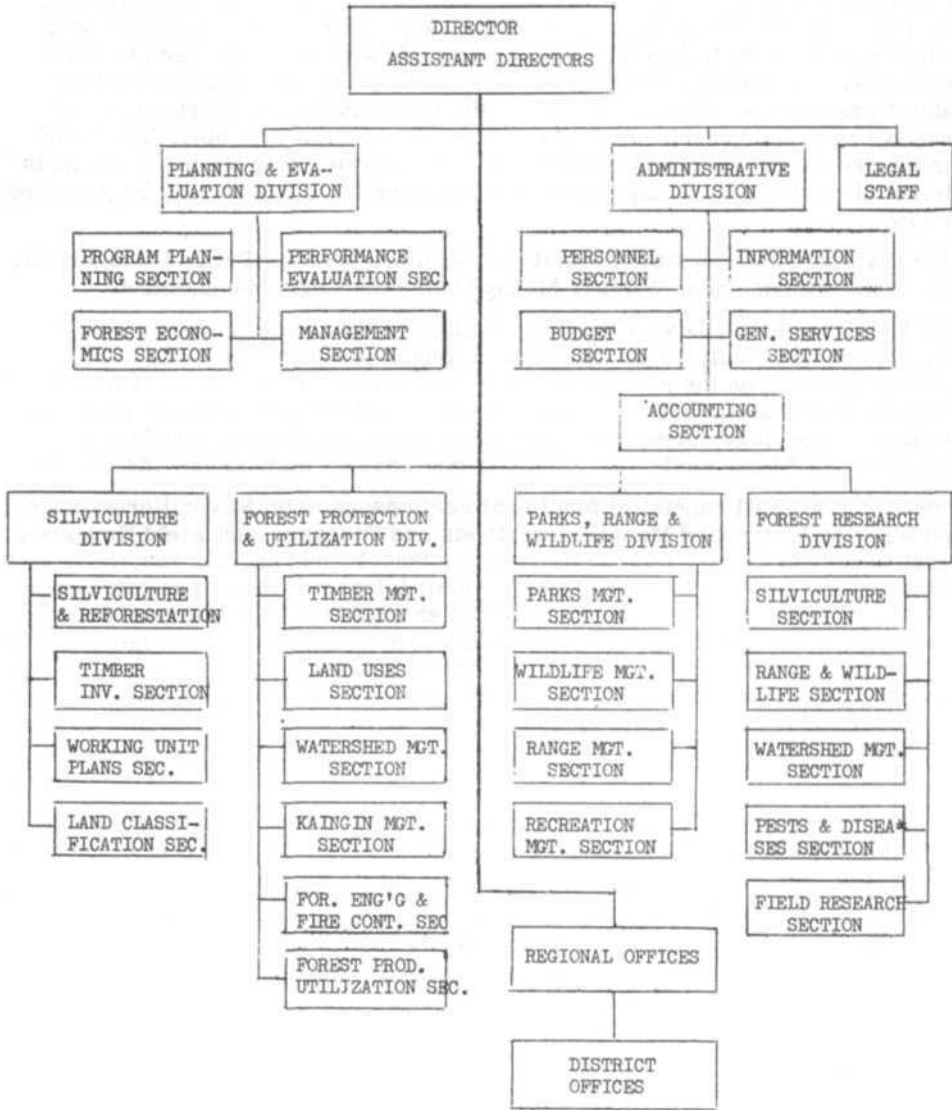
This Division shall consist of functional sections, namely: Parks Management, Recreation Management, Wildlife Management and Range Management.

FOREST RESEARCH DIVISION which shall have the following functions: (1) conduct problem analysis, design and implement programs of basic and applied research on the protection and utilization of the soil, water, timber, range, wildlife habitat and recreation resources of the public forest including silviculture, ecology, forest pests and diseases, range, wildlife and forest environment; (2) and perform such other functions as may be provided by law.

This Division shall consist of functional sections, namely: Silviculture, Range and Wildlife, Watershed Management, Pests and Diseases, and Field Research Services.'

APPENDIX A. 2

BUREAU OF FOREST DEVELOPMENT ORGANIZATION CHART



APPENDIX B

PRESENT STATUS OF THE PHILIPPINE TIMBER INDUSTRY

(Source: 1972 Phil. Forestry Statistics)

'TIMBER PRODUCTION

A total area of 9.4 million hectares of production forests was under license for the fiscal year under report, a decrease of 1.2 million hectares from the previous fiscal year.

An aggregate of 16.4 million cubic meters was granted by the Bureau of Forestry as allowable cut for the fiscal year but actual production amounted to only 8.4 million cubic meters or a mere 51 percent of what was allowed to be cut from the production forests. The decrease is attributed to a continuing slump in the wood export market, largely the result of increasing competition from Indonesian logs.

Mindanao continued to be the country's principal timber-producing region, supplying 78 percent of the volume production for fiscal year 1972. The top five timber-producing provinces in the region were Davao, Agusan, Surigao (Norte and Sur), Zamboanga del Sur and Cotabato. Unsurprisingly, these five provinces are the most forested in Mindanao.

Luzon's forests contributed 15 percent of the timber production for the same fiscal year with the following top five timber-producing provinces were Negros Occidental, Negros Oriental, Samar, Leyte del Norte and Palawan.'

'WOOD EXPORTS

From Davao, Surigao del Sur and Agusan came 54 percent of the country's total log exports for 1971-72, which amounted to 7 million cubic meters and worth U.S. \$173.25 million.

Japan was the largest buyer of Philippine logs, importing 77.5 percent of the total volume exported in 1971-72. Taiwan and Korea ranked far behind with 9.9 and 6.9 percent respectively. The rest of the log exports were brought to Okinawa, Hongkong, the U.S. and European markets.

A total of 64.5 million board feet of lumber was exported, with Davao, Negros Occidental and Agusan supplying 69 percent. The entire export volume was valued at U.S. \$9.09 million.

The top three importers of Philippine lumber were Japan, Australia and the U.S. whose combined purchases amounted to 83 percent of the total lumber exported.

Veneer production for 1971-1972 amounted to 764 million board feet, 79 percent of which was exported, worth U.S. \$10.6 million. There were 785 million square feet of plywood produced for the same period, 63 percent of which was exported valued at U.S. \$21 million'.

APPENDIX C

LIST OF PRIORITY AREAS IN THE REVISED PROGRAM FOR FOREST PRODUCTION 1973-1974

1. Silvicultural systems, including seed research, nursery and planting practices, timber stand improvement, and regeneration methods in dipterocarp forests.
2. Biological information needed in the formulation of silvicultural and other production practices in a dipterocarp forest.
3. Regulation of cut, including growing stock, and cutting schedules of dipterocarps.
4. Methods of rehabilitating damaged watersheds.
5. Silvicultural research, including seeds, nursery, planting, stand improvement, regeneration, and fire prevention and control in the production of fast growing hardwoods.
6. Silvicultural systems including seed, planting stock production, fire protection, timber stand improvement, and regeneration of tropical conifers.
7. Studies on growth and yield and preparation of volume tables of fast growing hardwoods.
8. Biological research, including pathological and entomological problems of tropical conifers.
9. Analysis and control of kaingin-making.
10. Development and production of high premium and/or vanishing species such as narra, molave, dao, mahogany, ipil, batikuling, kamagong, kalantas, sangilo, banuyo, betis, lanete and lumbayao.
11. Regeneration and improvement of mangrove forest stands.
12. Studies on growth and yield and preparation of volume tables of dipterocarps.
13. Log production, including logging methods, transportation systems, planning and control of dipterocarp forests.
14. Improving water yield and minimizing soil erosion through proper land use and related practices in watersheds of various geomorphological characteristics.
15. Tree improvement, including selection of trees of superior characteristics, breeding for disease and insect resistance, and for combinations of desirable characters, and mass production of genetically improved seeds of fast growing hardwoods.
16. Growth and yield of pine forests and preparation of volume tables.
17. Growing stock and cutting schedules of fast growing hardwoods.
18. Regulation of cut in pine forests.
19. Collection of forestry economics and related statistics; quantification studies in the economics of forest production.
20. Supply, growth, regeneration, and harvesting of rattan, bamboo, and other minor forest products.

21. Regulation of cut and harvesting of mangrove timber species.
22. Logging methods, log transportation and logging planning and control of fast growing hardwoods.
23. Studies on pine logging.
24. Economic evaluation of forest policies and practices.
25. Determination and optimal allocation of productive resources for/in forest production; optimization studies in forest production.
26. Hydrologic cycle information needed in the management of watersheds.
27. Physio-ecological, entomological, pathological, and other biological studies of fast growing hardwoods.
28. Improvement of genotypes of conifers especially the native pine species.
29. Forestry extension strategies and techniques.
30. Protection of mangrove forests.
31. Improvement of dipterocarp genotypes, including selection of superior phenotypes, breeding, and establishment of seed orchards.
32. Survey and sampling methods in forest production.
33. Forest ecosystem studies.
34. Studies on inventory of mangrove forests.
35. Evaluation of forestry extension activities.
36. Ecology of mangrove timber species.
37. Second growth forest hardwood species such as anabiong, tulo, binuang, and hinlaumo.'

(vi) **THAILAND**

PRESENTED BY
KITINANDA SOMPHERM

ECOLOGICAL APPLICATIONS

The ecosystem is the basic functional unit in ecology, since it includes both living organisms and non-living environment, each influencing the properties of the others. We must understand ecosystems if we are to preserve wilderness areas and endangered species and to maintain a high quality of life. Ecology has many applications which contribute to the well-being of human society. Such ecological applications can be in the fields of conservation, forestry, fisheries, agriculture and public health. Silviculture and wildlife management are perhaps the only kinds of technology that have consistently been based on the principles of ecology. In addition to timber production, forests play an important role in the production of water, recreation and hard to measure values such as aesthetics and biological preserves. Foresters recognized long ago that they had to work more nearly with than against natural processes. Not only must they concern themselves with production but also with the array of impacts such as air and water pollution, erosion,

floods, droughts and the rapidly accelerating processes of urbanization and mining.

It is clearly impossible for any one individual or organization to manage the entire environment. But it is essential that all resource specialists understand the constraints that man's multiple uses of natural resources place on what they can do in their part of the environment. This understanding and manipulation depend on a thorough appreciation of biological science along with awareness of the structure and function of the ecosystems of which the trees and other living organisms take parts. Efforts have been made for years to give all students in schools, colleges and universities an appreciation of nature, of the man/environment relationships and of the ways in which their actions might contribute toward them. As the result, a number of conservation groups were organized, thanks to our young people who had readily absorbed the ideas and seriously engaged in various campaigns and activities intended to protect nature and natural resources and to improve the environment for a better quality of life for everyone.

THE FOREST RESOURCES

The forests of Thailand occur chiefly in the hilly regions surrounding the central plain and in the Southern Region. About two-thirds of the total forest area is in the Northern and North Eastern Regions. They may be classified according to their general appearances into two major types: the wet and dry or the evergreen and the deciduous. Teak is the most well-known tree in the deciduous forest of the Northern Region, and *yang* (*Dipterocarpus alatus*) is the most common tree in the evergreen forest, while *teng* and *rang* (*Shorea obtusa* and *Pentacme siamensis*) are the dominant species in the dry type of deciduous forest.

As in most countries in South East Asia, the forests are owned by the Government. However before 1896, the year in which the Royal Forest Department was established, the forests were owned by either the crown or by the chieftains throughout the country.

Forests play an important role in the economic and social life of Thailand as they are the source of timber supply and they can be converted to agricultural land when needed. Until recently, exporting of timber was one of the country's major sources of foreign exchange earnings. But today, the trend of timber export is going down and its role on foreign exchange earning is no longer significant. If sawn timber, veneer, plywood, pulp and paper products are taken into account, Thailand would become a net importer of forest products: the net import bill in 1970 was about U.S. \$24 million.

The destruction of forests through illegal cutting and land clearing had resulted not only on the reduction of timber yield but also on the loss of their protective values. The case of the North Eastern Region may be a good example of the calamity. The dense tropical forests which once occupied most parts of that region had been, for a long time, slashed and burnt for shifting cultivation, and repeatedly exploited to serve the needs of the growing population. Such destruction had caused soil erosion and frequent occurrences of destructive floods. Deep layers of the rich soil were washed down to the plains below and to the sea, leaving in many areas, only a thin layer of soil and in other areas exposing the bare rock, and causing a change in the micro-climate leading toward greater desiccation and unfavorable conditions for all living things.

LAND USE POLICY

It is the Government's policy to have about 50% of the country or approximately 25 million ha as Reserved Forests of which about 11 million ha have been constituted so far. An additional area of about 1.5 million ha has been set aside for recreational purposes such as national parks, forest parks and game preserves. It seems probable that the areas of Reserved Forests will be further reduced to 20 million ha, with 10 million ha as watershed protection areas and the remainder as productive forests. The total area under agricultural crops in 1972 was about 12 million ha and has increased steadily. It was estimated that agricultural land would increase to 18 million ha by 1985, and to 21 million ha by 2000. Some of it must come from areas currently classified as forest land.

The land shortage is now becoming apparent as the result of rapid increase in rural population and the inability of the traditional agricultural systems to adapt to the present circumstances. The consequence is that considerable areas of the forests have been illicitly cleared and extensively cultivated by hill tribe people and lowlanders. Some of the areas classified as Reserved Forests now contain a sizeable proportion of scrub and waste land, and some are under other types of land use. The increasing encroachment into the Reserved Forests has created serious problems for the reforestation programme as it is becoming more and more difficult to locate planting areas free of illegal squatters. As land pressure continues to intensify, forestry will need to concentrate on the slopes and highlands, relinquishing the lower and more gently sloping areas for agriculture. Concurrently agriculture will need to increase its productivity per unit area through the replacement of the old traditional practices by intensive agricultural methods with proper irrigation systems, proper soil treatment, full control of insects and diseases and using improved varieties. At the same time, all Reserved Forests must be fully protected and managed intensively. The main emphasis in the Government's present Forest Development Plan (1972-1976) is on forest protection against illegal cutting and encroachment and on reforestation. To be effective, such a policy must have the full backing of all agencies of the Government and the forest laws must be strictly enforced.

FOREST DEVELOPMENT PLANNING

The National Economic and Social Development Plans of 1962-66, 1967-71 and 1972-76 all included forestry sector proposals with the main emphasis on forest reservation, inventory, management, reforestation, wildlife protection and research. It is obvious that all forestry projects are directly related to the national forest policy. In theory the project planner must have a clear statement of national objectives or the Government's policies which are provided as part of their strategy for development. But in practice the clear statement of national forest policies is seldom available.

Planning of forest development projects requires a thorough knowledge of the available resources, the economic and social constraints, and the science and technology concerned. Ecological knowledge has been, to some extent, taken into account in formulating policies and planning of most, if not all, forestry projects, particularly in plantation investment. A forest plantation project may consist a number of items of work or decision-making such as choice of

species, selection of site, land clearance, forest nurseries, soil preparation, planting, control of insects and diseases, fire protection and thinning. Each of these items requires a good knowledge of ecology which has been obtained and accumulated from text books, journals, other publications, current research and experiments.

Session I: BACKGROUND PAPERS. No.1

Land-use planning in Economic Development

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INTRODUCTION

The resources available to a community reside in the land and waters over which it has jurisdiction. The resources are of two kinds, those that are renewable and those that are non-renewable. The renewable resources are water, soil, vegetation and wildlife which if properly managed will continue to serve a useful purpose. The non-renewable resources are those such as minerals which can be mined, taken away and used and, except for any possible recycling, that resource ceases to exist as far as that particular community is concerned.

The renewable resources can be treated like non-renewable resources and communities have done this in some countries. Systems of use and management can be of a kind which lead to complete use, destruction or loss. However, with suitable methods of use and management, renewable resources can be used to provide for the needs of the community and at the same time allowed to be self-renewing so that those needs can be provided for one generation after another.

The extent to which the resources of the land and water systems can be useful and remain self-renewing, depends on the degree to which they can be safely manipulated without destroying ecological stability on which self-renewal depends.

Man's ability to manage the water systems is limited, nevertheless the welfare of the water systems—rivers, estuaries, bays and even the oceans, depends on man's use of the adjacent land. Consequently the manner in which the land resources are used will affect not only their capability for continued use but also that of the waters adjacent to them.

Land resources can be used and managed in an intelligent way for the continuing benefit of the community; alternatively land can be wrongly used or wrongly managed and made unproductive. Unfortunately when this happens the bad land use usually causes a multiplicity of problems on other land and waters, sometimes in even quite distant places.

For these reasons the way in which land is used is basic for the welfare of a community. Consequently decisions about the use of land should be based on a proper understanding of each different area and of the constraints on the manner in which it can be manipulated for productive use.

THE NATURE OF LAND

The variations in the character of the land from place to place did not arise by chance. Studies show that there are recognizable patterns and that the changes from place to place can be explained rationally.

At each place the character of the land is due to the particular combination of its constituent features. These features are the macro-climate and the hydrology and other micro-climatic conditions resulting from it, the geology and the topography and the soils resulting from it, and the plants and animal communities that live there. Of these features, only macro-climate is really independent of all others. The properties of the other features are in part dependent on the nature of each other and of the interactions one with the other during the period in which the landscape itself has been developing and evolving.

The particular combination of features which exists at any place is the result of the interaction between them under the climatic conditions which have prevailed during the period of evolution and development. Where the same sets of interactions between the features have occurred, there are similar kinds of land.

The changes in land from place to place are sometimes quite obvious and can be recognized readily by even the most casual observer. However, where the character of the land appears to be the same over large areas there will almost certainly be many differences within that area of apparent gross similarity. Tropical forest areas are misjudged in this way perhaps more frequently than many other major land zones.

The more subtle differences in land which are revealed only after a much closer study by skilled people are frequently those which will determine the success or failure of a system of manipulation imposed on the land for productive purposes. The history of success and failure of irrigation systems in various parts of the world is adequate testimony of the importance of subtle changes in land from place to place.

The evolution of the character of land by the continuing interaction between its features never ceases. In some places where it appears that a climax has been reached there is a stability. In this condition the evolutionary process appears to have reached a pinnacle of sustainable biological production from the array of plant and animal species available during the evolutionary period. Whether or not this is a maximum of biological production, the undisturbed system certainly represents the best combination and relative abundance of the available plant and animal species which can continue to live and compete with each other in the prevailing soil, topographic, hydrological and climatic conditions.

Although such a climax may have been reached there is a continuing interaction among the features. The manner in which these features interact gives rise to the more subtle seasonal and annual variations and these provide important information with respect to the inherent stability of the system. The inherent stability determines to what extent and with what constraints that land may be manipulated either to increase its productivity of useful existing plant or animal species or, alternatively, how the systems may be changed completely and used for the production of more useful introduced species of plants and animals, or even for some of the other uses required by man.

The inherent stability of land can often be assessed from the numbers and diversity of life forms of the plant and animal species which can thrive on it. Generally, those kinds of land having the greatest numbers and diversity are those most stable and most resilient to man's manipulation. The presence of many species and many ecological niches provides a degree of resilience which sometimes makes it almost impossible for man to impose any major change without great expenditure of energy.

The more vulnerable kinds of land are those in which the conditions suit few species and the stability depends on a special set of circumstances such as a single plant species specially adapted to the situation. Such an area of land has a weakness. Any manipulation which destroys that plant species without some action being taken in the system of management to provide an alternative means for exercising the role that those plants played, will create instability and start another series of interactions leading to a new stability mostly at a less biologically productive and more degraded state.

For any kind of use that man wishes to impose on land, the objective should be the creation of a stable ecosystem so that the land will continue to serve its chosen purpose from one generation to the next. This rule applies irrespective of whether use is to be for agriculture, forestry, urban or industrial use, for an airport, a road, or for a water supply catchment or a national park.

THE STUDY OF LAND

A pre-requisite to the planning of the use of land for economic development is a knowledge of the location and distribution of the different kinds of land and their capability for different uses.

Several things are needed for this. First, there is need for a map showing the different kinds of land and their distribution. Second, there is need for a knowledge and understanding of the dynamic interactions between the features of each kind of land and its inherent stability. Third, there is need to assess the critical features by which it is possible to judge its capability for specific kinds of uses, and fourth, there is the need to determine whether or not the land can be manipulated and used for any of these purposes and, if there are hazards in this manipulation, whether they can be overcome.

From this information the decision-maker is aware of the constraints which must be observed when considering the future uses for each of the different kinds of land, and the choice can proceed on a rational basis.

MAPPING OF LAND

The objective of mapping land is to portray on a plan of an area the changes in character of land which occur from place to place. The maps will be at different scales depending on the kinds of differences to be portrayed for those wishing to make use of them. Thus for broad scale planning of the possible uses of land for whole regions, only the major differences in land need be portrayed. However, for the detailed planning of land use, for example the growing of horticultural crops under irrigation, quite minor differences in the character of the land will need to be portrayed.

In the past it was quite common for single features of land, such as the soils, or the plant communities, to be used as the basis for assessing its potential capability for various uses. Soils and plant communities have both been used because it was thought that the particular kind of soil or plant community represented an integration of all other features of land. This is not necessarily so, and its universal acceptance can lead to misjudgement of capability. For example, a soil may have a potential for use in one place but not in another because of the differences in topography or micro-climate at these places. Furthermore the capability of similar soils may vary because there are different soils adjacent to them either upslope or downslope.

For this reason it is better to map land and changes of land from place to place and at the same time try to determine and explain the reasons for the changes in land from place to place across the landscape. This is most important.

To undertake a survey and to produce a map showing the occurrence and distribution of every significant change in the character of the land at the level required for the detailed consideration of its use is a time-consuming and most expensive task. Sometimes it must be done for certain areas, for example when considering the use of land for intensive and highly productive forms of agricultural use, or for urban and industrial use. However it is impractical to make detailed studies for a whole region. Apart from the cost there is the matter of time to do it.

Consequently any system of mapping which can portray the pattern of changes of land and at the same time provide an explanation of the reasons for the changes has great advantages. A person wishing to examine an area for some particular purpose can go into the field, find the changes for himself, and make an assessment of the capability of the land for the particular purpose he has in mind.

For this reason the system devised by my colleague Gibbons and myself and used by the Soil Conservation Authority of Victoria has great advantages.

(i) *Units of Mapping*

Various units need to be used at different levels of detail of the final map to be produced, but they should bear a relationship to each other and all be considered during the whole process of studying land at any level of detail.

The units used by Gibbons and Downes are the land-component, land-unit, land-system and land-zone at increasing levels of generalization. The land-zone is a combination of land-systems, the land-system a combination of land-units, and the land-unit a combination of land-components. With exception of the land-component, each other unit is composed of recurring patterns of the constituent units and these patterns are capable of description and explanation.

(a) *Land-component* — When considering land for some specific use, the unit mapped must refer to an area throughout which there is uniformity of the features of significance and importance for that particular form of land use. Accordingly the land-component is a unit which may vary depending on the particular form of land use being considered. For this reason mapping of land components is only done for a specific purpose.

A land-component represents an area in which the climate (both macro and micro), parent material, topography, soil and vegetation are uniform within the limits significant for a particular form of land use. Environmental features show changes which are often gradual and it is impossible, even after detailed study to achieve absolute uniformity throughout a land-component. Consequently there will be some range of variation which would be significant in assessing the capability of the area for the kind of land use being considered.

(b) *Land-unit*—The land-unit is a group of land-components which are seldom, if ever, randomly distributed across the landscape. Land-components occur as the result of the varying manner of the interaction of the features, and so the occurrence and location of land-components in relation to each other has a rational or identifiable basis. At this scale the changes producing different

land-components are usually due to a change in one feature only, for example topography.

Consequently land-units are patterns of land-components in which the relationship and arrangement of them can be portrayed in a land-unit diagram. The occurrence of these patterns makes it possible to describe quite adequately a large area in terms of the basic sequence or pattern relationship of land-components. The land-unit diagram portrays the variations of the features vertically and the sequential relationship of the pattern of land-components horizontally. Sometimes when two features are interacting to produce the changes as for example both topography and aspect, a plan diagram to show the sequential changes may be necessary.

A map of land-units and the land-unit diagrams enable those requiring more detailed information to find for themselves in the field, the incidence and distribution of each component of significance and importance for the purpose in mind. A land-unit map which may be prepared much more quickly than a land-component map can, if it is used properly, provide essentially the same amount of information about land as a map of land-components.

(c) *Land-system*—Land-system is a unit at the next highest level of generalization. It is a pattern of land-units related on the basis of common features considered to be important for the likely land uses. Land-systems often, but not always, correspond with the areas having differences perceivable by the casual observer. Often the features which determine the boundaries between land-systems are changes in geomorphology or parent material, although at times some land-systems may include a pattern of land-units including some which have different geomorphology or different parent materials.

Land-system diagrams portray the relationship of one land-system to the others in the landscape, and also the relationship of the land-units of which it is composed to each other.

(d) *Land-zone*—The land-zone is the unit which can be used for the primary mapping of the changes on a large tract of country. It provides the basis for deciding which areas should be studied in more detail for assessing the capability for different kinds of land use. Land-zones are in fact patterns of similar land-systems, and the boundaries between different land-zones will always correspond with significant differences in one of the major environmental features such as climate, geology or topography.

(ii) *Scale of Mapping*

The scales of mapping of these units are likely to be of the following orders of magnitude:-

Land-zones	1 to 500, 000
Land-systems	1 to 200, 000
Land-units	1 to 50, 000
Land-components	1 to 20, 000 or 1 to 10,000

(iii) *Land Capability*

For making decisions about the use of land the characteristics of various kinds of land, their spatial distribution and their capability for different uses needs to be known. This means that the characteristics of any particular kind of land must be interpreted and translated into expressions of capability for

various uses. Usually the capability for productive uses of land can be expressed in quantitative terms, but for others, such as a wildlife reserve, assessment of capability is difficult and can only be made on the basis of some commonly acceptable selected criteria. There is one further but not insuperable difficulty because the decision-makers will require some grading of the level of capability of land for various uses.

MAKING DECISIONS ABOUT LAND USE

A community needs land for a number of uses which depend upon the chosen life style of that particular community. At present, it seems that all countries now aspire to the life style of modern western societies. Because of the limitation of the world's resources such a life style cannot be permanently sustained and it is not therefore a life style to be encouraged anywhere. Nevertheless this does not preclude the less technically developed societies from selecting the most desirable features of western life style and incorporating them into their own culture to provide a desirable and permanent life style which is less wasteful than that of the highly industrialized societies.

If this is to be done then the community will need land for production of basic necessities, food, fibre, timber and water. It will need land for urban and industrial purposes, for mining, and for the associated transport systems of roads, railways, sea and airports and for the distribution of energy, power and gas lines. It will need land for production of minerals and other material for buildings and roadmaking. It must have land for the recreation and enjoyment of the people. It needs land for national parks, wildlife reserves and scientific reference areas, not only for the maintenance of plant and animal species and the gene pool they provide, but also as areas of different kinds of land to serve as reference areas from which to judge the effects of man's manipulation of similar land under various kinds of use.

Apart from the uses required for basic subsistence, none are inherently more important than others and this should be recognized. For the total welfare of the community it is just as important to have the non-productive as the productive uses of land in an industrialized society. Although all kinds of uses are equally important, the needs and priorities for satisfying the various needs for land for different uses will change from time to time.

In the decision-making procedures, there should be recognition and understanding that some uses of land are flexible and enable a change of use to be imposed later if so required. Others are inflexible and having made the choice to use it that way, options to use it in some or all other ways are closed, if not for ever, at least for a long time. Uses of land for agriculture or recreation are flexible, for urban or industrial use or for extractive industries are inflexible.

Some uses of land are compatible and others are incompatible. A national park might well serve as an ideal water supply catchment but one could not allow commercial forestry in a national park. However land used for commercial forestry could quite well serve for open space passive recreation.

As a basis for decision-making it is possible to establish a chart for a particular land-unit. The chart will show its potential capability for various forms of land use, whether this capability is high, medium or low according to accepted criteria for that particular form of land use, the hazards involved

in manipulating the land for each of the potential uses, the costs involved in this manipulation and any safeguards required to maintain or recreate the ecological stability, the short and long term needs of the community for each of these uses, whether alternative land is available already for any of these uses, the priority of need for any use and the compatibility or otherwise of the different possible uses.

A chart of this kind, if it is properly prepared and based on adequate data, will almost certainly reduce the range of options for the decision-maker and certainly make the task much easier.

Acceptable criteria by which it is possible to judge the potential capability for various forms of land use will vary for different uses, and may well vary for different specific purposes within any one particular use. For example, different criteria are needed to assess the capability of an area for use as a national park or a wildlife reserve than those used for assessing the capability of land for agriculture. Furthermore different criteria are required to assess the capability of land for the production of specific crops if the land is to be used for agriculture. The main point to be observed is the use of generally acceptable criteria for determining the capability and for rating the level of capability as high, medium, or low for any particular use.

This is not difficult for uses such as agriculture, forestry and grazing, where there is a background of research and experience by which to judge not only the level of capability but also the nature and cost of the inputs to attain different levels of potential productivity which are sustainable on a continuing basis.

It is much more difficult for those uses where there are no generally accepted quantitative measures of the capability to serve the chosen purposes.

This applies particularly to uses such as wildlife reserves and national parks. For uses such as these an area may have a uniqueness that gives it such an inestimable value that comparison with other uses on the basis of the relative capability to serve them appears to be an unnecessary exercise.

When considering the use of land for mineral production it is difficult to derive criteria which are generally acceptable to both the miners and people interested in more conservative forms of land use. Furthermore, the criteria will change markedly when considering the use of the land for the mining of a precious metal or for the production of building materials. The criteria which must come into consideration as an expression of the community's policy toward the mining and use of non-renewable resources will vary according to the policy. For example, in a community greatly concerned about the over rapid mining and use of non-renewable resources or about the undesirable destruction of land having the potential for other uses, the following criteria could be appropriate:-

- (a) Is the material valuable for use in the immediate vicinity of the site from which it is to be extracted, or for use throughout the province or the nation? If not, must it be mined, if so at what rate?
- (b) Is this the only source of that material or are other sources already being mined?
- (c) Is this the only economic source, if so is the purpose for which it is required really necessary?
- (d) Are there substitutes for that material already available?

(e) Will mining affect the capability of that land to serve other purposes temporarily or permanently?

(f) Will mining adversely affect other land resources being used for agriculture, forestry, water catchments or other purposes ?

These are typical of the questions which must be asked and answered before decisions are made.

The welfare of a community depends of how it uses its land. Consequently, decisions about the use of the land are so important that considerable care should always be exercised in the process. Decisions should not be the result of economic, social or political pressures alone. They should be made on the basis of knowledge about the land and its capability.

The following rules for making decisions about the use of land will serve as useful guides:-

(i) Decisions should not be made without adequate information and knowledge about the land, its capability for all possible uses and its relative suitability for each of those different uses.

(ii) Decisions on the use of public land should not be made unless they are necessary; a reserve of uncommitted public land is a most flexible and valuable form of land use.

(iii) Decisions on the development and use of resources of a district should be considered in relation to the whole resources of the region and, for many resources, those of the whole nation.

(iv) Decisions should be made on the basis that all purposes for which land can be used for the welfare of the community are inherently equal, but the needs and priorities may vary from time to time and from place to place.

(v) Decisions should be based on an understanding that different kinds of land have different potentialities for various uses, the most valuable land being that eminently suitable for a number of uses.

(vi) Decisions should be made to provide for multiple use to the greatest possible extent.

(vii) Decisions to use the land for particular purposes should be made in the knowledge that a suitable system of use and management, to ensure that the land will continue to serve its chosen purpose, is available.

LAND STUDY, DECISION MAKING AND PLANNING

In industrialized societies people have become concerned about the effects of industrialization on the environment. The ill effects evident at present are the result of two things. First, bad decisions about land use, that is the location of towns and industries; and second, the misconception that the natural environment would continue to provide a free 'sink' into which industrial and urban wastes could be tipped. Environmental pollution is of interest and importance because it affects so many people. Serious mistakes in decisions about the use of land for primary production have been made in many countries. The consequences, soil erosion, salting and other forms of land destruction, have been equally disturbing.

The current demand for environmental impact statements about proposed development projects in some societies is largely aimed at halting urban

and industrial development, or at least slowing it down and making people think about the environmental consequences as well as the immediate productive and financial benefits. Major changes of land use for any purpose can lead to serious repercussions and need consideration with respect to the likely effects on the environment.

The procedures outlined previously in this paper provide the means of taking into account the effects of any proposed use on the environment and eliminating from further consideration those uses which will be harmful. The technique however has its main application to the consideration of land which has not been too drastically changed from its natural state. In this respect it should be of considerable value in assessing what might be done with areas of tropical forests—a category of land in which large areas have a superficial similarity but a considerable degree of diversity at the detailed level.

For the best use of resources coming from the land, ideally the order of procedures for decision-making should be:-

- (i) Broad land studies to differentiate the different major ecosystems.
- (ii) Interdisciplinary studies to obtain more detailed information about the land and water systems, the resources available in them, their dynamics and the degree to which they may be manipulated safely.
- (iii) Within the capability of the available resources, a definition by government of the life style that the people would like to have. This provides a basis for policy making and for establishing the needs of the community for land for the whole range of uses consistent with that life style.
- (iv) Town and regional planning, and resource development, taking into account the constraints as to the kinds of land use which might be imposed on the different areas of land. This will result in the selection and allocation of areas for different purposes, located to provide the most effective and efficient pattern of land uses which observes the constraints but at the same time provides environmental quality.

Items (i) and (ii) are the tasks for scientists having a variety of disciplines but united in an ecological understanding of the basic principles of conservation; that is the proper use and management of natural resources to provide for the needs of the community now and in future.

Item (iii) is a task for the sociologists, economists, political scientists and politicians in consultation with those who know the environmental constraints.

Item (iv) is the task for the town and regional planners and developers working on the basis of the prior information and decisions and within the imposed constraints. Planners and developers should work all the time in consultation with those who provided that information and made those decisions.

In a democratic society, it is unlikely that an ideal decision making procedure will ever operate smoothly. However, it is an advantage to have such a system even if changing community life style and demands impose difficulties on its operation from time to time.

Decision-makers should always be aware of the continual operation of the ecological principle that change will cause change. Ecologists have the task of perceiving those possible changes and advising the decision-makers about their nature, their effect in time and space and whether or not they have local, regional, national or international significance.

The Influence of Climate on Development of Tropical Forest Areas

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INTRODUCTION

Tropical forests are among the most complex and diverse eco-systems on earth. Their high levels of primary productivity are sustained by favourable and near constant thermal and moisture regimes and essentially closed nutrient cycling systems. However, in their undisturbed state, only a small fraction of this primary production can be diverted to human needs for food and fibre. Inevitably, human population pressures have led to progressive modification and replacement of tropical forest ecosystems so that a greater proportion of net energy flow is directed towards immediate human needs.

One of the greatest challenges confronting man is the development and maintenance of stable land use systems in humid tropical environments. Such a challenge can be met, but only through understanding of total systems. Climate and weather play a key role in ecosystem structure, process and function, and so must play a key role in the development of this understanding.

In this paper, a brief conspectus of the general climatic characteristics of the South-east Asian region is provided as a general frame of reference. Major climatic controls, spatial and seasonal variation in major climatic elements and climatic classifications are considered. Emphasis is given to the role of bioclimatic analysis in developing ecological guidelines for land development and management of humid tropical forest environments.

GENERAL CLIMATIC CHARACTERISTICS OF SOUTH EAST ASIA

The region considered extends from the Indian subcontinent eastwards to New Guinea and northern Australia and is bounded by the Tropics of Cancer and Capricorn. Within this broad region, the major development of humid tropical forest occurs within a band 15 °N and 15 °S of the equator. The term 'Monsoon Asia' can be used for the broader region as a geographic entity (Yoshino 1971) even though classical notions of the monsoon are no longer entertained.

The major weather systems operating in the region form part of the total global atmospheric circulation and it is only through understanding of the dynamics of the total system that complete understanding of component processes can be attained. Recent reviews (Sellers 1969; Manabe 1971; Wallace 1971) indicate considerable progress towards this goal. The interconnections and strong feedback loops between tropical and higher latitude circulations are emphasized. More specifically, aspects of the general circulation in the tropics has been reviewed by Riehl and Malkus (1958), Riehl (1969) and Bates (1972). Comprehensive reviews of the major

climatic controls and resultant climatic patterns in the south east Asian region are provided by Arakawa (1969); and Yoshino (1971).

Regional climatic controls

Developments in synoptic and aerological climatology together with satellite photography of cloud cover have provided new perspectives and supporting evidence for the view that the monsoons of south-east Asia are essentially modifications of the general planetary wind systems. Thus, the seasonal, sun-controlled shifts of the subtropical high pressure belts and the intertropical convergence zones dominate the meteorology of the region. The tropical easterlies, including the trade winds, of the low sun period alternate with winds which have predominantly westerly components (equatorial westerlies or monsoon winds) during the high sun period.

Very simply, the climate of the region is the outcome of a series of mechanisms which maintain the energy balance of the globe through poleward transport of heat energy. Much of the latent heat energy gained by trade winds passing over the heated surface of the tropical oceans, is released by convective mechanisms in the Inter Tropical Convergence Zone (ITCZ) where the trades of the summer and winter hemispheres converge. The poleward transport of this energy in the troposphere completes the meridional circulation known as the Hadley Cell. In addition, there is a poleward transport of moisture and latent heat energy in eddy mechanisms which form as low pressure troughs of great meridional extent. Bjerknes (1969) drew attention to a third circulation in the Western Equatorial Pacific which has an east-west or zonal orientation and which he termed the Walker circulation. The interplay of these three major circulations determines, to a large extent, seasonal and longer-term changes in the climate of the region. Tsuchiya (1971) has analysed rainfall fluctuations in south-east Asia in relation to perturbations of these major circulations.

Ramage (1968) asserted that the tropical continents are a more important source of heat for export to higher latitudes than the tropical oceans. He referred to the mountainous, insular and peninsular area extending from Malaysia through Indonesia to New Guinea as the 'maritime continent'. Certainly the region is a major source of latent heat energy for the total global atmospheric circulation. Changes in the rate of supply of heat energy from this region due to exposed continental shelves and lower ocean surface temperatures during glacial periods were postulated as a possible feedback mechanism triggering glacial advance and retreat (Nix and Kalma 1971).

Although the equatorial westerlies or monsoons transport great quantities of evaporated moisture from the oceans to the land, the rather homogenous air masses exhibit relatively weak atmospheric and temperature gradients. Convective mechanisms are largely responsible for triggering rainfall, although weak cyclonic disturbances can bring more organized periods of showers and rain. In the China Sea, eastern Indian Ocean and Coral Sea, these cyclonic depressions can develop into major disturbances or hurricanes. The eastern Philippines has one of the highest incidences of such tropical hurricanes in the world.

In general, rainfall is at a maximum throughout the region during the high sun period. Topography and differential heating of land and sea play an important role in triggering convective showers and thunderstorms. Because of such local influences, spatial and temporal variation in rainfall within the summer

season can be very great. During the low sun period, the tropical easterlies or trades are dominant and, in general, rainfall is insignificant or low except where they have a long trajectory over warmer ocean water and rise against mountain barriers. Where these conditions are satisfied, extremely high precipitation occurs (e.g. eastern Philippines, east coast of Malay peninsula, southern side of New Britain).

Analysis of satellite photography (Sadler 1969) shows that the equatorial zone between 100 °E and 160 °E exhibits a high degree of cloudiness throughout the year. A recent analysis (Yoshino 1971) indicates that this broad zone is influenced by intertropical convergence zones throughout the year, despite shifts in their mean position. During the northern summer, a very complex pattern of intertropical convergence zones develops over the Indian sub-continent and south-east Asia, but in the northern winter a single zone runs roughly east-west between 0°- 10 °S and between the Malay peninsula and New Guinea.

Local variations in terrain, aspect and proximity to the sea can modify the influence of the major weather systems very considerably. Mesoscale deviations from the regional norm are commonplace. In particular, the complex and elevated terrain and interdigitation of land and sea in the 'maritime continent' makes mesoscale interpretation of climate very difficult. Local effects such as land and sea breezes and mountain and valley winds can be very important modifiers of local climate.

MAJOR CLIMATIC ELEMENTS

Detailed descriptions of variation in the major climatic elements are neither intended nor warranted in this brief review. Solar radiation, temperature, evaporation and precipitation are singled out for attention because of their direct use in various systems of bioclimatic analysis and classification.

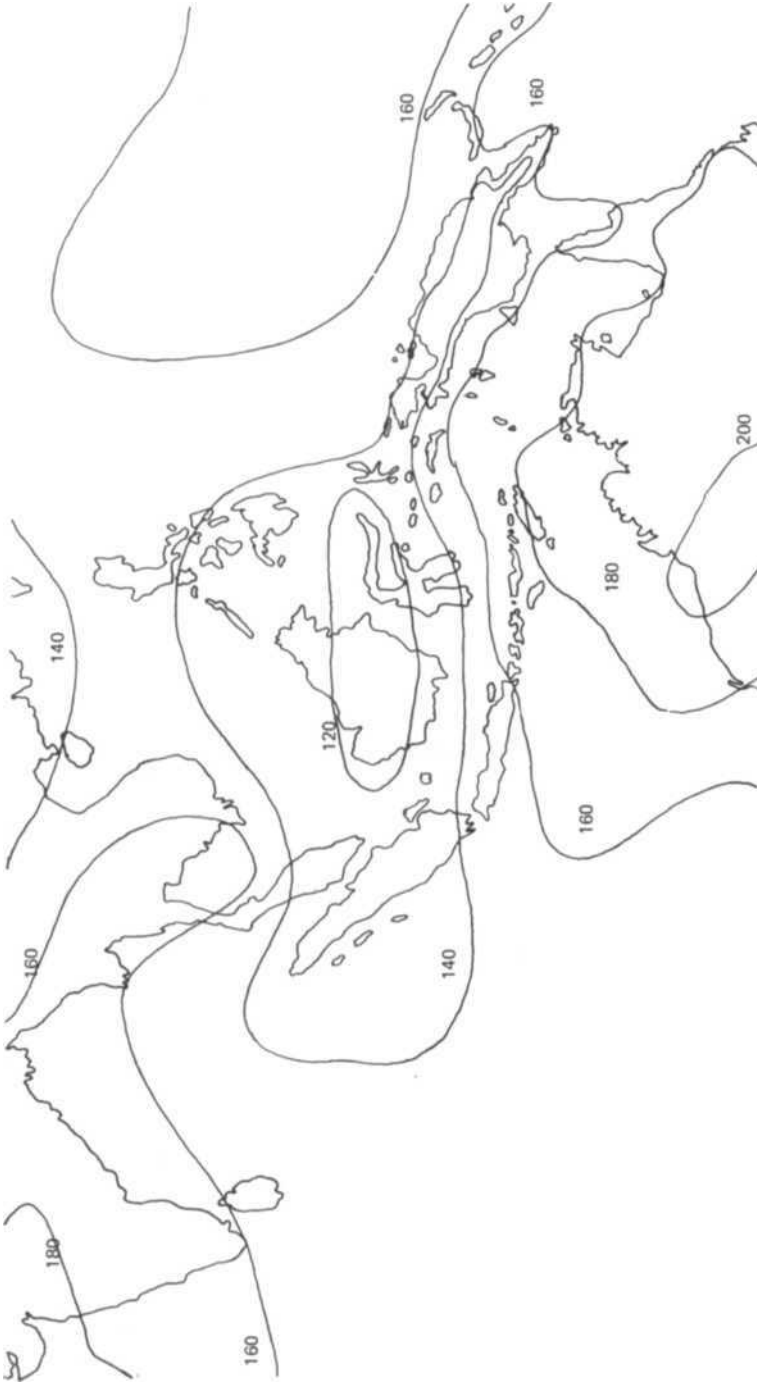
Global solar radiation

Annual values for global solar radiation ($\text{Kcal/cm}^{-2}/\text{year}^{-1}$) are shown in Figure 1. The data used are those of Mani *et al.*, (1967), but with amendments to the south-eastern sector including Timor, New Guinea and northern Australia, using the data of Nix and Kalma (1972). Further, more detailed estimates for New Guinea are available in Kalma (1972).

The intended purpose of Figure 1 is to destroy the popular misconception of the humid tropical zone as a high radiation environment. Cloud cover and suspended aerosols (mainly water vapour) reduce radiation receipts in the ever-wet zones straddling the equator to 60-70 per cent of those received by the seasonally wet-dry environments to the north and south. The band of high cloudiness observed on satellite photographs (Sadler 1969) which extends from Sumatra through to New Guinea is clearly associated with low radiation receipts of 120-140 $\text{Kcal/cm}^{-2}/\text{year}^{-1}$. Regions as far away as 35°-40° north and south of the equator have equivalent annual receipts.

Within the south east Asian region, minimum and maximum monthly totals of global solar radiation are clearly related to the rainfall pattern. During wet months, daily totals everywhere range between 300-400 $\text{gcal/cm}^{-2}/\text{day}^{-1}$, but during dry months or even dry periods between rainspells, daily values rise to 500-600 $\text{gcal/cm}^{-2}/\text{day}^{-1}$. Such additional inputs of radiation are of particular significance for grain filling at the end of the wet season; for

Figure 1. Annual global solar radiation ($\text{Kcal cm}^{-2} \text{ year}^{-1}$)



irrigated crops during the dry season; and for the growth/development balance of perennial and free crops, even where the dry period is quite short.

Temperature

The lowland areas of the whole region are characterized by high mean annual temperatures (26-28 °C) with an extremely low annual range (5 °C) which, normally, is exceeded by the diurnal range (7-10 °C). Thus, for example, lowland stations in the Philippines (Flores and Balagot 1969) have an annual mean of 27 °C, an annual range of 2.6 °C and an average diurnal range of 7.5 °C. In the seasonally wet-dry zones, both the annual and diurnal ranges are greater (10-15 °C and 15-25 °C). At high elevations the annual range is still low (5 °C) but the diurnal range is usually higher (10-15 °C) than in the lowlands.

Altitude plays a more important role in temperature variation than latitude. Calculation of the mean decrease in temperature with altitude is compounded by mesoscale factors such as slope, aspect, exposure, cloud cover and valley and mountain winds. However, Braak (1929) quotes average values of 0.60 °C/100 m up to 1500 m with a decline to 0.55 °C/100 m with increasing elevation in Jawa and these are in general accord with calculations made for New Guinea. The more favourable thermal environments for humans, livestock and crops at levels between 500-1500 m and even higher, have significantly influenced settlement patterns in many parts of the region.

Temperature extremes exercise constraints on biological systems even where occurrence is sporadic and irregular. Freezing temperatures and frost set limits at high altitude, but no precise relation between frost incidence and elevation can be formulated because of mesoscale differences in cold air drainage, insolation, cloud cover and other factors. Sukanto (1969) quotes frost occurrence of varying duration and severity ranging upwards from 1500 m in high land areas of Jawa. The present snowline is variously estimated at 4600 m (Verstappen 1964) and 4300 m (Sukanto 1969), but the only peaks above such elevations are in West Irian.

In the lowlands, very high (> 38 °C) and very low (< 10 °C) temperatures are rare in the ever-wet zones, but are more common in the seasonally wet-dry zones. Usually such temperature extremes are associated with dry weather, clear skies and calm air. In such cases, possible thermal stress is compounded with water stress and serious damage to plantations, crops and gardens can occur.

Evaporation

Water is lost by evaporation to the air from plant soil and water surfaces. Evapotranspiration is the water lost by transpiration from vegetation and evaporation from the underlying surface. Because evapotranspiration rates are modified by soil, plant and atmospheric factors with soil drying, the concept of potential evapotranspiration was introduced to cover the case with soil water supply not limiting. Potential evapotranspiration (PET) is an important reference level in water balance studies and vast efforts have been devoted to methods of measuring and estimating it.

Potential evapotranspiration can be measured directly using a lysimeter or estimated using empirical formulae (Thorntwaite 1948; Papadakis 1961; Fitzpatrick 1963), an energy budget approach (Penman 1948) or an evaporimeter. Network requirements for simple, relatively inexpensive instruments normally restrict the choice to evaporimeter data or empirical estimates based on readily available mean climatic data. The U.S. Class A Pan evaporimeter is

a standard network instrument in the region, but insufficient data were readily available for regional analysis.

Empirical estimates of potential evapotranspiration based on Thornthwaite (1948) and Papadakis (1961) have been made for an extensive network of stations in south-east Asia. Neither estimate gives results which are in good agreement with observed Class A Pan values, but the Thornthwaite estimate is marginally better. The most detailed map of estimated potential evapotranspiration available for south-east Asia has been prepared by Kayane (1971) and uses Thornthwaite estimates for more than 500 stations in south-east Asia.

Estimated annual totals exceed 1000 mm everywhere but for a few restricted upland areas in southern India, Ceylon and Sumatra. Most of the region has values exceeding 1500 mm, but less than 1700 mm. A few restricted areas in central Thailand and south-west India have estimated values in excess of 1800 mm. During the wet season daily values range from 2-4 mm, but during the dry season may range from 4-10 mm.

Precipitation

By definition the humid tropics is a region of high rainfall. Annual average rainfall exceeds 1500 mm throughout most of the region and very substantial areas have values exceeding 3000 mm. Complex terrain, particularly in the 'maritime continent', sometimes causes localized, but persistent, rain shadow effects. Parts of the island of Luzon in the Philippines and the Palu valley in Sulawesi in Indonesia are very dry, with annual totals between 500-1000 mm.

Despite high annual rainfall totals, which generally exceed annual potential evapotranspiration, dry periods commonly occur because of seasonal patterns of rainfall distribution. Thus, parts of the Isthmus of Khra and of the southern western coast of India have a regular dry season of some months duration, despite annual rainfall of 3000-5000 mm. In regions where rainfall exceeds potential evapotranspiration throughout the year, seasonal variation in rainfall tends to be masked. However, very few locations have uniform rainfall distribution patterns. Regular seasonal peaks and troughs still occur.

The patterns of seasonal rainfall distribution reflect the varying influences of the high-sun equatorial westerlies or monsoons and of the low sun tropical easterlies or trades. A high sun rainfall maximum is the general rule, but low sun maxima occur where the tropical easterlies or trades meet high mountain barriers, e.g., eastern Philippines, central-eastern Indochina, east coast of Malaya north of the equator and the southern side of New Britain and of the central cordillera of New Guinea, south of the equator.

Fitzpatrick *et al.* (1966) used harmonic analysis to resolve the basic components of seasonality of rainfall in the tropical south west Pacific. Brookfield and Hart (1966) used these data as a basis for classification of rainfall regimes in the same region. The insight provided by these studies suggests that a similar analysis of the whole south-east Asian region would be very worthwhile. Secular variation in rainfall throughout monsoon Asia has been analysed by Yoshimura (1971) and used to derive patterns of regional similarity.

Rainfall variability is low in the ever-wet zones and highest in the seasonally wet-dry zones. The coefficient of variation around the annual mean (per cent) for rainfall ranges from less than 10 per cent on the west coast of Sumatra and coastal Burma, but is generally within the range of 10-20 per cent throughout the region. A wide median belt through the Indian subcontinent and large

areas inland from the coast in northern Australia have values exceeding 30 per cent.

Rainfall intensity plays a key role in the important processes of rainfall interception by vegetation, infiltration into the soil, surface runoff and soil losses and in the timing and duration of flood peaks. The widest network can provide a resolution of rainfall intensity no better than unit amount of rain per day or 24 hour period. The pluviometer network in the region, which records rain amounts over unit time periods of minutes, is not adequate for detailed analysis of geographic patterns of short period rainfall intensities.

Average rainfall per wet day provides a crude measure of seasonal and spatial variation in rainfall intensity. Values exceed 25 mm/day in the season of highest rainfall and high average values are characteristic of the wet 'Monsoon' season in the seasonally wet-dry environments. In highland environments average rates are relatively low (3-10 mm/day) and compare with rates common in the temperate zone at higher latitudes.

Estimates of maximum possible rainfall within a specified time interval (30 minutes, 1 hour, 6 hours, 12 hours, 24 hours) for a given return period (10 years, 25 years, 100 years) are needed for the design of engineering structures such as storage reservoirs, bridges, culverts, roads and soil conservation terraces. The WMO Guide to hydrometeorological practices (1965) examines and explains the techniques available.

CLASSIFICATION OF CLIMATE IN SOUTH EAST ASIA

General climatic classifications, particularly the more rational and systematic e.g. Koppen (1913) and Thornthwaite (1931, 1948), play an important role in codifying and communicating climatic information at global and continental scales. Although of limited utility for study of specific genotype/environment interactions or ecosystem process and function, they can be useful in transfer of ecological information by analogy. The utility of any general, multi-attribute classification for any specific purpose depends on the relevance of the attributes used and the choice of class interval.

Perhaps the most familiar and widely used of the general climatic classifications is that of Koppen (1931). His five major climatic groups were designed to correspond with major natural vegetation formations and his A climates include all humid tropical forests variants. Average monthly temperatures exceed 18 °C throughout the year and three major subdivisions based on seasonal rainfall distribution are used.

- Af — Tropical wet climate: rainfall high throughout the year and exceeding 60 mm in the driest month.
- Aw — Tropical wet/dry climate: rainfall has a marked seasonal rhythm with a distinct dry period.
- Am — Tropical monsoon: rainfall high throughout the year but with a short dry season.

All calculations are based on monthly normals of temperature and precipitation.

Previous classifications of south-east Asia's climate using the Koppen system have been updated and amended by Mizukoshi (1971), who has used a much more extensive network of climatic stations. More importantly he provides a more realistic assessment of year climate by calculating relative frequencies of Koppen climatic classes, over a series of years, at each station. The resultant pattern (Fig. 2) of dominant year climates is used as a general

Figure 2.

Dominant year climates (after Mizukoshi, 1975)



reference to distribution of Af, Am and Aw climates in further discussion in this paper.

Although simple, this classification serves a useful purpose in illustrating some key points relevant to existing settlement and future land development. The most intensively settled and populated areas of south east Asia are all in Aw dominant climates; the Am climates have much lower population densities; the Af climates have exceedingly low population densities. Apparent high density enclaves within this zone are upland areas, with modified temperatures and are really islands of Cf climate (mild, temperate, rainy). Thus in the island of New Guinea which has a predominantly Af climate, more than one quarter of the whole population occupies mountain valleys and highlands with Cf climate.

In addition to the general climatic classifications, a veritable host of climatic indices have been developed, particularly with reference to delineation of moisture regime. Kawamura (1971) has explored the patterns of regional variation in south-east Asia expressed by a number of such indices; Lang's Regenfactor, Martonne's Aridity Index, Angstrom's coefficient of humidity and Kira's index of moist and dry climates. However, these indices are of much less value than more direct measures of the seasonal water balance.

An empirical classification based on the ratio of dry months to wet months was developed by Schmidt and Ferguson (1951) and used in Indonesia. The definition of wet and dry months was based on earlier work by Mohr, who defined a dry month as having less than 60 mm and a wet month more than 100 mm of rainfall. Hernandez (1954) used the same approach in classifying rainfall types in the Philippines. The results in both cases illustrate the complexity of rainfall regimes in this humid, tropical insular environment.

Thornthwaite (1948) introduced a form of generalized water balance accounting which involved book-keeping transfers of water in six compartments, i.e. precipitation, potential evapotranspiration, actual evapotranspiration, soil moisture storage, soil moisture deficit and soil moisture surplus. Using monthly mean climatic data, C.W. Thornthwaite Associates (1963) published tables of average climatic water balance data of the continents. Kayane (1971) has presented certain of these water balance components for south-east Asia in map form, together with a composite map showing regions of water surplus and water deficit. For comparison with the map of annual global solar radiation (Fig. 1) and the map of dominant year climate (Fig. 2), Kayane's map of annual water deficit is shown (Fig. 3). The correlations are obvious.

Although empirical and general classifications do convey useful information, they are far too general and imprecise for detailed resource inventory and development planning. At the other extreme, are classifications based on specific genotype/environment interactions. Logically such an approach requires a special classification for each specified genotype (or group of genotypes with similar ecophysiological responses) and, in consequence, tends to be rejected on grounds of impracticality. However, advances in our knowledge of ecophysiology on one hand and in computer based storage and retrieval mechanisms on the other, makes such an approach entirely feasible.

The beginnings of such a crop-specific and system-specific approach are evident in the works of Papadakis (1938, 1965, 1970), Azzi (1939, 1956), Prestcott (1943) and Prestcott and Lane Poole (1947) among others. These classifications are based on known thermal and moisture regime constraints of specific crops or crop groups. The work of Papadakis (1961, 1970) in climatic classifications is of particular interest. He recognizes broad thermal

Figure 3.
Annual water deficit (mm). After Kayane (1971)



and moisture regime limits for a very comprehensive group of cultivated plants, in addition to major structural types of vegetation. Indices derived from a monthly water balance are used as measures of water supply; duration of wet and dry months and the magnitude of leaching potential. The published values (1961) for much of south-east Asia are misleading only because of underestimation of potential evapotranspiration. However, the basic concepts are sound.

Direct coupling of the forcing functions of weather and climate with known ecophysiological responses offers prospects of much more relevant bioclimatic analysis and classification. Fitzpatrick and Nix (1970) derived separate light, thermal and moisture indices for each of three major pasture groups with distinct physiological responses. These indices, together with a multifactorial growth index were used in a bioclimatic analysis of the grassland ecology of the Australian continent. Nix and Kalma (1972) used these same indices in deriving limiting values for major structural and floristic groups in the vegetation of northern Australia and New Guinea. Again, using these indices together with numerical taxonomic techniques, Nix and Austin (1973) analysed and classified the climatic environment of a single species (*Accacia aneura*), an important browse shrub in arid inland Australia.

BIOCLIMATIC ANALYSIS AND SYNTHESIS

Whatever the tropical ecosystem, be it natural, man-modified or man-made, climate and weather exert an overwhelming influence on structure, process and function. The key role of climate and weather in conditioning biological and physical processes and in determining much of the strategy and tactics of ecosystem management needs no emphasis. Yet bioclimatic analysis rarely looms large in the hierarchy of resource evaluation and development planning priorities. The primary reasons for this apparent anomaly are twofold. (1) Methods commonly used provide descriptive rather than prescriptive outcomes and, as such, may be considered irrelevant or inapplicable to the specific problem. (2) Basic climatic data are totally inadequate or non-existent within the proposed development area.

Methods and techniques now available and under active development can do much to relieve these limitations. Systems analysis and simulation techniques permit a much closer coupling of climatic data and the system studied. Developments in climatology (Lettau 1969) can aid in mesoscale extrapolation of limited climatic data and in the generation of synthetic climatic and weather records. However, the basic price of admission to these more sophisticated techniques is *a well balanced standard meteorological network*. This key requirement cannot be emphasized too strongly.

Methods

The development of sound land use policies for humid tropical forest areas, or any area, hinges upon the answers to three basic, but related, questions:

- (1) For any given land use which areas offer the greatest biophysical and socio-economic advantages?
- (2) For any given area which land uses offer the greatest biophysical and socio-economic advantages?
- (3) For any given *land use* or *area* how may productivity be sustained at the highest possible level?

Answers to these questions are sought by a tangled web of institutions—regional, national and international—each claiming responsibility for one or more of them. Yet, if it were possible to *predict* the performance of any given land use, at any location under any specified technology and any set of weather conditions, we could answer all three questions.

A general statement of the problem, then, is to predict the probable outcomes (ecological and economic) of any specified land use. This must be the ultimate goal of economists, agronomists, hydrologists, engineers, ecologists and other specialists involved in land evaluation and management. Progress towards this goal has followed an evolutionary path (Nix 1968) from trial and error, transfer by analogy, statistical correlation, multivariate analysis to the current systems analysis and simulation techniques. Climate and weather figure prominently in all of these approaches.

(i) *Trial and error*

Attempts to relate climate and weather to observed biological and physical processes have roots in antiquity. The simplest techniques of keen observation, coupled with generations of trial and error experiment, have established traditional land use patterns. Given enough time, stable and successful systems can be evolved on such a basis, but the social cost is enormous. Where population pressures are very high and land resources available, this approach is still the primary basis for development and resettlement schemes. Sometimes this is disguised by a thin veneer of technological sophistry.

Traditional land use systems are often highly complex and very finely-attuned to the local environment. The complex timing required to fit land use operations into the climatic cycle has been codified by ritual and custom. Climatic information thus becomes an integral part of the total system. Such finely attuned systems have characteristics which militate against change. Sudden change in any major component—biological, physical or cultural—can lead to massive disruption and even total destruction. In addition, such location-specific technological recipes rarely transfer well and this has important consequences for resettlement schemes.

(ii) *Transfer by analogy*

Most current land evaluation and land classification technology is firmly based upon the concept of transfer of information by analogy. Such methods do not require any detailed knowledge of functional relationships between the attributes measured and the potential use. However, the better this functional understanding the more relevant the attributes selected for measurement and the more useful the resultant classification. The basic hypothesis is that all occurrences of a defined class will respond in a similar way to management for the specified use. Soil and climatic classifications exemplify this approach.

Burgos (1968) provided an extensive review of bioclimatic classification and associated techniques. He concluded that general schemes of classification were of limited use in solving specific problems. However, as pointed out in an earlier section of this paper, general climatic classifications do have some value in codifying and communicating important information about climate.

The classical instance of transfer of information and experience by analogy is the use of vegetation as an index of site quality. Most empirical climatic

classifications have attempted to set class interval boundaries on the basis of major vegetation zones. Where the relationship between the climatic and vegetation class is stable and consistent then the presence of the vegetation may be used to infer the climate. The line zone classification of Holdridge (1947, 1966) may offer possibilities in this direction.

(iii) *Statistical correlation*

The development of mathematical techniques for fitting and testing relationships between independent variables, initiated a spate of correlation and regression analyses which continues to this day. Correlations have been sought between every climatic variable and a host of biological and physical phenomena. In many situations, where a single climatic element exerts a dominating influence on the system, such simple relationships can have useful predictive value. Rainfall is such an element and the literature attests to its importance as a component of predictive indices or equations (Stanhill 1970).

The deficiencies of this approach are due primarily to explicit assumptions of linearity, implicit assumptions that correlation implies causation and the normally location-specific nature of the relationship. Extrapolation to other sites, seasons and/or technologies is not recommended. These criticisms do not imply that correlation and regression analysis should be discarded. Indeed these same techniques find ready acceptance in modelling and simulation techniques (Austin 1971). The difference lies in the basic assumptions and logic.

(iv) *Multivariate analysis*

These techniques represent a further development of correlation and regression analysis and are subject to the same criticisms. Biological response is related to sets of climatic (or other) variables. Although the statistical equations include a more comprehensive set of relevant variables they are still merely static representations of what are highly dynamic systems. They are valid only within the range of values of the attributes used in developing the equation. Again, like their predecessors, they tend to be highly location specific. Despite these criticisms, such methods do have value and when used with a substantial leavening of ecological insight and intuition can produce meaningful results (Noy-Meir 1971).

(v) *Systems analysis and simulation*

The need for a holistic approach to problems of resource evaluation and management has long been recognized. However, until quite recently the conceptual and computational tools needed were not available. Systems analysis is concerned with resolution of a complex system into a number of simpler components and subsequent synthesis into a symbolic representation (diagram, flowchart) and, ultimately, a mathematical model of the whole system. When a model is developed which adequately describes the behaviour of the system it can be used in simulation studies to show how the system can be manipulated for a desired result. Basic concepts and techniques are discussed by Watt (1966, 1968) and Dale (1970).

Despite intensive research on separate components and processes (and perhaps because of it) our understanding of biological systems as a functioning whole is very limited. If we are to mobilise existing knowledge and organize research such that the most important gaps in that knowledge are filled quickly, we need to devote at least as much energy to whole system-orientated research as is

currently devoted to discipline and process-oriented research. The trend towards systems analysis represents an interesting departure from the essentially reductionist approach of Western science toward a holistic approach much closer to Oriental philosophy.

The methods described above are not mutually exclusive. All can be used, either singly or in combination, to develop that understanding of ecosystem structure, process and function which is so necessary for the development of stable and productive land use systems. However, basic systems concepts provide a frame of reference within which all methods can be viewed in correct perspective. The single central concept is that the *whole* system must be understood in order properly to evaluate changes in any component of the system.

Basic data

The methods and techniques of bioclimatic analysis and synthesis depend on the availability and accuracy of climate, weather and biological and other land-use data. An inadequate data base is a poor foundation for any analysis. Often, such a situation is maintained by strong negative feedback mechanisms. Because available data limit the choice and scope of method the results of analysis are of limited utility and relevance. Accordingly, extension and improvement of existing data-gathering networks receive low priority. Such a self-perpetuating cycle can be broken by convincing demonstrations of the utility of modern methods and techniques coupled to an adequate data base. Much has been accomplished by several, United Nations sponsored, international symposia in attaining such an objective.

Given the primary position of basic data in resource evaluation, development and management, the establishment of adequate networks of synoptic, climatological, agrometeorological and hydrological stations should occupy highest priority in national development planning. The World Meteorological Organization has promoted such an objective with considerable vigour and has developed guidelines for network design and uniformity of instrumentation, siting and measurement.

Improvements in the data-gathering network need to be matched by improvements in the methods of storing, retrieving and disseminating the data. Too often, the collection of basic data becomes an end in itself and stored data are not readily accessible to potential users. Computer technology offers solutions to these problems, but a great deal of manual effort is still required in editing, checking and processing historical data. Security of data storage is another important consideration. The climatic records lost in a number of south-east Asian countries during World War II represents an incalculable resource loss.

Applications: general

The methods and techniques of bioclimatic analysis are applied at scales ranging from the global and continental to the national, regional and local. In parallel with changes in scale, it is possible to recognize a hierarchy of methods and approaches ranging from those with greatest generality but least precision to those with greatest precision but least generality. The matching of methods to the scale and purpose of a given enquiry is a very important determinant of ultimate relevance and use.

Whatever the scale or the level of generality and precision, bioclimatic analysis involves a series of logical steps:

1. A recipe, prescription or model of the specified land use is required. This sets out the various climatic, edaphic, biotic and cultural constraints and lists factors known to control performance of the land use system (e.g. threshold temperatures for germination, development, survival; growing degree days during the wet season; soil moisture limits for trafficability; probabilities of storm rainfall exceedance). These factors and constraints may be written down as a set of rules or formalized as a mathematical model.
2. The set of rules or mathematical model specifies those attributes which must be measured.
3. These attributes vary in space and in time. Thus, for climatic elements, the network spacing, the frequency of observation and duration of the record are important considerations.
4. The set of rules or mathematical model is then coupled to the specified data and used to generate predictions for the specified land use.

It should be obvious that the utility of any bioclimatic, or indeed any resource analysis, depends very much on the level of understanding of the particular land use, the skill with which the recipe, prescription or model is formulated and the availability of the specified data. Experienced resource assessors and managers go through these steps mentally and make intuitive judgements. However, unless their basic assumptions and logic are spelled out and set down on paper, their skills and experience cannot be passed on and further developed.

What is needed are *working* models (yet capable of continuous improvement in logical structure and function) which can be used to predict the probable outcomes (ecological, economic) of any specified land use. Although few really comprehensive models have been developed and used (cf. Watt 1966, 1968) a very large number of partial, semi-empirical models have been developed and used in engineering, agronomic, forestry, hydrological and other applications.

Given the multitude of potential land uses possible, it might appear that such a use-oriented point of entry to resource evaluation is less practical than the more traditional multi-attribute general-purpose classification procedures. This would be so, if it were not for the fact that certain key processes are of almost equal significance for a wide range of potential land uses. Accordingly, many of the specified parameters needed for evaluation will be common to many land uses.

The pivotal position of the water-balance in any land-use system provides a good example of such reasoning. Estimation of the various terms in the water balance is of direct significance in land evaluation procedures for engineering, hydrological, agronomic, forest management and other applications. The extensive use of water-balance techniques for agricultural and pastoral land uses has been reviewed by Slatyer (1968) and Stanhill (1973) and for practical applications in hydrology and watershed management by Pereira (1959). The principles of measurement or estimation of the components of the water balance are ably summarized by Chang (1968b).

The water regime of ecosystems is the result of dynamic interactions between weather, soil and plant parameters. As understanding of these complex processes has grown, generalized computational models have been developed for use in bioclimatic analysis. The most general and least precise of these have already been discussed (Thornthwaite 1948; Papadakis

1961). Considerable refinement is possible, even with these simplest of models. Successively modified versions of a simple water-balance model originally developed by Slatyer (1960) have been used in assessment of regional climates of very large areas of northern Australia by the CSIRO Division of Land Research.

Crop ecosystems have received particular attention in water balance research, principally because the water regime significantly influences crop yields. Studies of patterns of water use in relation to crop, soil and weather factors have led to the formulation of operational models for both annual and perennial crop systems, e.g. Fitzpatrick and Nix (1969), for alternating winter fallow-grain sorghum and summer fallow-wheat crop systems in Queensland; Pereira (1957), Wallis (1963) and Blore (1966) for coffee plantations in east Africa; Laycock (1964), Dagg (1970) and Willat (1971) for tea plantations in east Africa. Indices derived directly from water balances have been shown to give good correlations with crop yields in many instances, e.g. Dale and Shaw (1965) with maize; Smith (1966) with coconuts; Nix and Fitzpatrick (1969) with wheat and grain-sorghum yields.

Fleming (1968) presents a simplified procedure for estimating the water balance of any prescribed crop system, dryland or irrigated, on a daily routine basis. For many purposes, the use of weekly mean data may prove quite adequate. Water balance models of crop systems are most concerned with the evapotranspiration term. In hydrological studies of catchment yield and sediment load, the surface runoff term is of major interest. Similarly, the through-drainage term is of direct consequence for leaching and nutrient cycling.

Management of these terms in the water balance is central to any concept of stable and productive land use. It would seem logical then to base development planning on discrete watersheds whether these be small catchments or whole river basins. Pereira in fact argues that the watershed is the logical unit within which interdisciplinary effort should be coordinated. He advocated a 'package deal' of land and water conservation practices, agronomic and/or silvicultural techniques, transport and marketing infrastructure, provision of credit, education and health services.

Applications: specific

The humid tropical forests of south-east Asia transcend national boundaries and occupy an area of continental dimensions. Despite commonly held assumptions of uniformly hot and wet conditions, the region exhibits climatic regimes of considerable complexity. A logical first step in the evaluation of these resources is a comprehensive bioclimatic analysis, on a unified basis, of the whole region.

Examples of such assessments at similar scales are provided by Brichambaut and Wallen (1962) for a large part of Asia Minor and by Cochemé (1968) for tropical West Africa. In both of these studies, genuine attempts were made to mobilise existing knowledge of land use patterns and management strategies and to incorporate these in the analysis. A further example is provided by Nix (1974) who used simulation models of wheat crop systems in an agroclimatic analysis of winter cereal environments in Australia.

Such continental-scale assessments provide a framework for further more detailed analysis; provide first order estimates of land use potential for specified uses; identify deficiencies in data-gathering networks and provide insight into the spatial and temporal patterning of climatic constraints.

The collection of papers edited by Yoshino (1973) and concerned with major climatic controls and resultant influences on the water-balance of monsoon Asia is an important step in this direction.

At the national level, one would expect the development of humid tropical forest areas to fit within some framework of expressed national goals. Thus, if the goal is to maintain the whole population at a given level of nutrition then, logically, the question is which areas offer greatest advantages in meeting this goal. Allocation of scarce resources to promote increased production from existing areas may provide a more rational solution than development of additional forest areas. However, it would seem that identification of developmental priorities on such a basis is comparatively rare in both international funding agencies and participant countries (Nelson 1973). A great many developmental projects are initiated with minimal reference to the broader context of the natural resource base.

Although bioclimatic analysis is an important and essential tool in the armoury of resource evaluation techniques, it is only as good as the available data will permit. It should not be viewed as a static, once-over exercise, but as a continuing, vital, component of the information flow needed for management of the national resource. If the whole approach is based on systems analysis and simulation techniques, then predictions can be revised with minimum delay whenever new facts become available.

At the regional or project level, the emphasis shifts away from identification of potential land uses towards problems of land use management. Dasmann *et al.* (1973) identify the tropical, ever-wet rainforest regions as among the most difficult areas of the world for intensive human settlement and economic development. Certainly, population densities in these *Af* climatic regions are very much lower than in the adjoining *Am* and *Aw* regions of south-east Asia. The reasons advanced for this situation are many and complex and, to some extent, conflicting.

The potential of the humid tropics for production of food and fibre has been the subject of much debate. Chang (1968a) coupled ecophysiological and climatic data to show that potential was limited. Stewart (1970) on the other hand showed that tropical crop and pasture species have very high potential productivity levels when considered on the basis of dry matter per unit time or per unit of light energy input. However, such high levels of productivity are sustained by very high inputs of fertilizer nutrients, principally nitrogen. This confirms the view (Odum 1973) that really large increases in agricultural production depend on the coupling of the agricultural system to an industrial economy, which then provides the necessary fossil fuel subsidies in the form of fertilizer, chemicals, machine power.

Although tropical crop and pasture species are capable of very high levels of productivity, these levels are attained when these species are grown in the seasonally wet-dry environments and in the subtropics. The uniformly high temperatures coupled with relatively low inputs of solar radiation in the ever-wet regions, affects the growth-development balance adversely—even with relatively adapted crop and tree species. In addition to these problems, pests and diseases pose a major threat. Janzen (1973) elaborates on this subject and draws attention to the very real difficulties of developing sustained yield tropical agro-ecosystems and to the very real dangers of simple-minded extrapolation of temperate-zone technologies. Geertz (1963) attributes the continuing low productivity of certain areas in Jawa to institutional and historical factors associated with the imposition of cash crop monoculture and plantation systems.

Given these problems, what is the possible role of bioclimatic analysis ? At the regional or project development level, it is necessary to make a much more detailed analysis of climatic constraints on all components of the land use system (i.e. human work patterns; siting of roads, buildings, earthworks; crop and livestock management strategy and tactics; harvest and storage).

If the term crop is used in the widest sense, then for any crop the whole genotype-environment-management interaction can be viewed as an investment game. Given a finite set of resources (e.g. light, temperature, water, nutrients) which can be assigned probabilities for any given time and location, what is the best possible strategy for allocation of these resources to development of source (productive component) and sink (harvested component) structures? Obviously a thorough understanding of crop systems is required before such a strategy can be developed. Duncan (1967) explores methods of manipulating temperate crop systems for higher yields through such a level of understanding. Certainly less is known about tropical crop systems, but Williams and Joseph (1970) provide an excellent review and summary of what is known. Building upon this base, it will be possible to develop working models of tropical crop ecosystems which, when coupled with appropriate climatic records, can aid in development of management strategies and tactics and in reduction of risk and uncertainty.

ABSTRACT

Humid tropical forests are a significant feature of the south-east Asian region. The general climatic characteristics of the whole region are reviewed and presented as a frame of reference for discussion. Particular attention is given to the major climatic controls and to spatial and seasonal variation in major climatic elements. Climatic classification is considered as a tool in bioclimatic analysis and the application of a number of different classifications to the south east Asian region is discussed.

The development of logic and method in bioclimatic analysis is reviewed briefly. The need for a holistic approach to problems or resource management is emphasized and the possible role of systems analysis and simulation techniques in evaluation, development and management of humid tropical forest areas is discussed. Application of bioclimatic analysis to problems of development is considered in both general and specific terms.

REFERENCES

- ARAKAWA, H. 1969. Climates of northern and eastern Asia. In: *World Survey of Climatology*, Vol. 8.
- ASAKURA, T. 1971. Seasonal variation in water vapor balance over the northern hemisphere and Asia. In: *Water balance of monsoon Asia: a climatological approach*. M. M. Yoshino, ed. Honolulu, University of Hawaii Press.
- AUSTIN, M. P. 1971. Role of regression analysis in plant ecology. In: *Quantifying Ecology*. Nix, H. A. (ed.). Proc. Ecol. Soc. Aust., Vol. 6. Canberra.
- AZZI, G. 1939. *Trattato di ecologia agraria*. Turin, Society Education Internazionale.
- 1956. *Agricultural ecology*. London, Constable.

- BATES, J. R. 1972. Tropical disturbances and the general circulation. *Quart. J. Roy. Met. Soc.*, 98: 1-16.
- BJERKNES, J. 1969. Atmospheric teleconnections from the equatorial Pacific. *Month. Weather Review*, 97: 163-172.
- BRAAK, C. 1929. Het klimaat van Nederlandsch-Indie. Vol. I. Verhandelingen van het Koninklijk Magnetisch en Meteorologisch Observatorium, Batavia. No. 8.
- BROOKFIELD, H. C. and HART, D. 1966. *Rainfall in the tropical southwest Pacific*. Res. School Pacific Studies, Dept. of Geography Publ. G/3. Canberra, A.N.U. Press.
- BURGOS, J. J. 1968. World trends in agroclimatic surveys. In: *Agroclimatological methods—Vroc. Reading Symposium, Agroclimatological methods*. Paris, UNESCO.
- CHANG Jen-Hu 1968a. The agricultural potential of the humid tropics. *Geog. Rev.*, 58: 333-361
- 1968b. *Climate and agriculture: an ecological survey*. Chicago, Aldine Publ. co.
- COACHEME, J. 1968. FAO/Unesco/WMO agroclimatology survey of a semi-arid area in West Africa south of the Sahara. In: *Agroclimatological methods—Proc. Reading Symposium on Agroclimatological Methods*. Paris, Unesco.
- DAGG, M. 1970. A study of the water use of tea in East Africa using a hydraulic lysimeter. *Agric. Met.*, 7: 303-320.
- DALE, M. B. 1970. Systems analysis and ecology. *Ecol.*, 51: 7-16.
- and SHAW, R. H. 1965. Effect on corn yields of moisture stress and stand at two fertility levels. *Agron. J.*, 57: 475-479
- DASMANN, Raymond F., MILTON, John P. and FREEMAN, Peter H. 1973. *Ecological principles for economic development*. London, John Wiley and sons Ltd.
- DUNCAN, William G. 1969. Cultural manipulation for higher yields. In: *Physiological aspects of crop yield*. Jerry D. Eastin, F. A. Haskins, C. Y. Sullivan and C. H. M. Van Bavel, eds. Madison, Wisconsin, American Society of Agronomy and Crop Science Society of America.
- FITZPATRICK, E. A. 1963. Estimates of pan evaporation from mean maximum temperature and vapour pressure. *J. Appl. Met.*, 2: 780-792.
- , BROOKFIELD, H. C. and HART, D. 1966. Rainfall seasonality in the tropical south west Pacific. *Erdkunde*. 20: 181-194
- and NIX, H. A. 1969. A model for simulating soil water regime in alternating fallow-crop systems. *Agric. Met.*, 6: 303-319
- and — 1970. The climatic factor in Australian grassland ecology. In: *Australian Grasslands*. Canberra, A.N.U. Press
- FLEMING, P. M. 1968. Crop water requirements and irrigation. In: *Agricultural meteorology—Proc. W.M.O. Seminar, Melbourne, Australia*. Melbourne, Bureau of Meteorology for W.M.O.
- FLORES, J. F. and BALAGOT, V. F. 1969. Climate of the Philippines. In: *Climates of northern and eastern Asia: World survey of climatology*. Vol. 8. H. Arakawa, ed. Amsterdam, Elsevier.
- GEERTZ, Clifford. 1963. *Agricultural involution: the process of ecological change in Indonesia*. Berkeley and Los Angeles, University of California Press.
- HERNANDEZ, P. P. 1954. Rainfall types based on ratios of dry months to wet months. Manila, Weather Bureau. 31 pp.
- HOLDRIDGE, L. R. 1947. Determination of world plant formations from simple climatic data. *Science*, 105 (2727): 367-368.
- 1966. The Life Zone System. *Adansonia* 6 (2): 199-203.

- HOUNAM, C. E. 1968. The routine measurement of evaporation. In: *Agricultural meteorology*-Proc. W.M.O. Seminar, Melbourne, Australia. Melbourne, Bureau of Meteorology for W.M.O.
- JANZEN, Daniel H. 1973. Tropical agroecosystems. *Science*, 182 (4118): 1212-1219
- KAWAMURA, T. 1971. Representation of moist and dry climate of monsoon Asia according to climatic indices. In: *Water balance of monsoon Asia—a climatological approach*. M. M. Yoshino, ed. Honolulu, University of Hawaii Press.
- KAYANE, I. 1971. Hydrological regions in monsoon Asia. In: *Water balance of monsoon Asia—a climatological approach*. M. M. Yoshino, ed. Honolulu, University of Hawaii Press.
- LAYCOCK, D. H. 1964. An empirical correlation between weather and yearly tea yields in Malawi. *Trop. Agric. Trin.*, 41 (4): 277-291.
- LETTAU, H. H. 1969. Evapotranspiration climatology. *Monthly Weather Review*, 97: 691-699
- MANABE, S. 1971. General circulation of the atmosphere. *Trans. Am. Geophys. Un.*, 52: 313-320
- MIZUKOSHI, M. 1971. Regional divisions of monsoon Asia by Koppen's classification of climate. In: *Water balance of monsoon Asia—a climatological approach*. M. M. Yoshino, ed. Honolulu, University of Hawaii Press.
- NELSON, Michael, 1973. *The development of tropical lands: policy issues in Latin America*. Baltimore, Johns Hopkins Univ. Press for Resources.
- NIX, H. A. 1968. The assessment of biological productivity. In: *Land Evaluation*. G. A. Steward, ed. Melbourne, Macmillan.
- 1974. The Australian environment and its influence on grain yield and quality. In: *Winter cereals in Australia*. A. Lazenby and E. Matheson, eds. Sydney, Angus and Robertson, (in press).
- and AUSTIN, M. P. 1973. Mulga: a bioclimatic analysis. *Trop. Grasslands*! : 9-21.
- and FITZPATRICK, E. A. 1969. An index of crop water stress related to wheat and grain sorghum yields. *Agric. Met.*, 6: 321-337
- and KALMA, J. D. 1972. Climate as a dominant control in the biogeography of northern Australia and New Guinea. In: *Torres Strait-Bridge and Barrier*.
- NOY-MEIR, Immanuel, 1971. Multivariate analysis of the semi-arid vegetation in south-eastern Australia: nodal ordination by component analysis: In: *Quantifying Ecology*. Nix, H. A. (ed). Proc. Ecol. Soc. Aust., Vol. 6. Canberra.
- ODUM, Howard T. 1973. *Environment, power and society*. New York, Wiley-Interscience.
- PAPADAKIS, J. 1965. *Crop ecology survey in West Africa*. Rome, FAO.
- 1938. *Ecologie agricole*. Gembloux, Belgium, Jules Duculot.
- 1961. *Climatic tables for the world*. Buenos Aires, published by the author.
- 1970. *Climates of the world: their classification, similitudes, differences and geographic distribution*. Buenos Aires, published by the author.
- PENMAN, H. L. 1948. Natural evaporation from open water, bare soil and grass. *Proc. Roy. Soc. Lond. A.*, 193: 120-145
- PEREIRA, H. C. 1957. Field measurements of water use for irrigation control in Kenya coffee. *J. Agric. Sci.*, 49: 459-467.
- 1959. A physical basis for land-use policy in tropical catchment areas. *Nature*, 184: 1768-1771

- PERRIN DE BRICHAMBAUT, M. G. and WALLEN, C. C. 1962. A study of agroclimatology in semi-arid and arid zones of the Near East. (W.M.O. Technical note no. 56). Geneva, W.M.O. for Unesco/WMO/FAO.
- PRESTCOTT, J. A. 1943. The Australian homoclimate of the zone of natural occurrence of *Parthenium argentatum*. *Trans. Roy. Soc. S. A.* 67 (2).
- and LANE POOLE, C. E. 1947. The climatology of the introduction of pines of the Mediterranean environment to Australia. *Trans. Roy. Soc. S. A.* 71 (1).
- RAMAGE, C. S. 1968. Role of the tropical 'maritime continent' in the atmospheric circulation. *Month. Weath. Rev.*, 96: 365-370.
- RIEHL, H. 1969. On the role of the tropics in the general circulation of the atmosphere. *Weather*, 24: 288-308
- and MALKUS, J. S. 1958. On the heat balance in the equatorial trough zone. *Geophysica*, 6: 503-538.
- SADLER, J. C. 1969. *Average cloudiness in the tropics from satellite observations*. Honolulu, East-West Center Press.
- SCHMIDT, F. H. and FERGUSON, J. H. A. 1951. Rainfall types based on wet and dry period ratios for Indonesia. *Verhandel. Djawatan Meteorol. dan Geofis. Jakarta*, 42: 177.
- SELLERS, W. D. 1969. A global climatic model based on the energy balance of the earth-atmosphere system. *J. Appl. Meteorol.*, 8: 392-400
- SEN, A. R., BISWAS, A. K. and SANYAL, D. K. 1968. The influence of climatic factors on the yield of tea in the Assam valley. *J. Appl. Meteorol.*, 7: 94-104.
- SLATYER, R. O. 1960. Agricultural climatology of the Katherine area, N.T. CSIRO, Div. Land Res. Reg. Surv. Tech. Paper 13.
- 1968. The use of soil water balance relationships in agroclimatology. In: *Agroclimatological methods*--Proc. Reading Symposium. Paris, Unesco.
- SMITH, G. W. 1966. The relation between rainfall, soil, water and the yield of copra on a coconut estate in Trinidad. *J. Appl. Ecol.*, 3: 117-125
- STANHILL, G. 1973. Simplified agroclimatic procedures for assessing the effect of water supply. In: *Plant response to climatic factors*--Proc. Uppsala Symposium. Paris, Unesco.
- STEWART, G. A. 1970. High potential productivity of the tropics for cereal crops, grass forage crops and beef. *J. Aust. Inst. Agric. Sci.*, 36: 85-101.
- SUKANTO, M. 1969. Climate of Indonesia. In: *Climates of northern and eastern Asia: World survey of climatology*, Vol. 8. H. Arakawa, ed. Amsterdam, Elsevier.
- THORNTHWAITE, C. W. 1948. An approach toward a rational classification of climate. *Geogr. Rev.*, 38: 55-94.
- TSUCHIYA, I. 1971. Fluctuations of rainfall in southeast Asia—equatorial Pacific and low and middle latitude circulations in the southern hemisphere. In: *Water balance of monsoon Asia—a climatological approach*. M. M. Yoshino, ed. Honolulu, University of Hawaii Press.
- VERSTAPPEN, H. T. H. 1964. Geomorphology of the Star Mountains. *Nova Guinea, Geology*, 5: 101-158.
- WALLACE, J. M. 1971. Tropical meteorology. *Trans. Am. Geophys. Un.*, 52: 395-399
- WALLIS, J. A. N. 1963. Water use by irrigated Arabica coffee in Kenya. *J. Agric. Sci.*, 60: 381-388
- WATT, K. E. F. (ed.) 1966. *Systems analysis in ecology*. New York, Academic Press.
- WATT, K. E. F. 1968. *Ecology and resource management*. New York, McGraw-Hill.

- WILLATT, S. T. 1971. Model of soil water use by tea. *Agric. Met.*,8: 341-351.
- WILLIAMS, C. N. and JOSEPH, K. T. 1970. *Climate, soil and crop production in the humid tropics*. Kuala Lumpur, Oxford University Press.
- YOSHIMURA, M. 1971. Regionality of secular variation in precipitation over monsoon Asia and its relation to general circulation. In: *Water balance of monsoon Asia: a climatological approach*. M. M. Yoshino, ed. Honolulu, University of Hawaii Press.
- YOSHINO, M. M. 1971. Water balance problems in monsoon Asia from the viewpoint of climatology. In: *Water balance of monsoon Asia—a climatological approach*. M. M. Yoshino, ed. Honolulu, University of Hawaii Press.

Session I. BACKGROUND PAPERS. No. 3

The soil as an Ecological Factor in the Development of Tropical Forest Areas

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In the Proceedings (1966) of the Symposium on Ecological Research in Humid Tropics Vegetation, held in Kuching, Sarawak, in 1963, the study-group on nutrients in vegetation, soils and soil parent material stated in the preamble to the recommendations of the group that there was little information about the productivity of tropical forests on different soils. It was, therefore, recommended that a research project be formulated to analyse the role of natural vegetation in tropical soil fertility.

The aim of the present paper is to focus attention on some pertinent earlier research and to review the present state of affairs as far as fertility is concerned, in the light of ecological philosophy. In this paper the author deals exclusively with the potential of virgin tropical forest soils for agricultural production. The first question to be answered is whether there is any basis for expecting a high or even average level of natural fertility of a soil that is covered by luxuriant virgin forest. Indeed the casual observer is often deeply impressed by the giants of trees and thick undergrowth of this cover of primary vegetation. It has, however, perhaps correctly been described by Sapper (1935) as a relict of foregone times and this might explain tropical soil expert Charter's rather gloomy verdict (Charter 1949): 'Do not be deceived by the luxuriance of a tropical forest for it may conceal almost sterile soil'. Bayens (1938) points to the deterioration of Zaire's forest soils as a result of natural exhaustion. This is, in a way, confirmed by Richards (1964) when he refers to the paradox of luxuriant tropical vegetation on leached and impoverished soils, pointing out that there is an immense amount of nutrient material in circulation within the closed cycle of nutrients and immobilized within the vegetation itself.

Vine (1954) discussed the question 'Is the lack of fertility of tropical African soils exaggerated?' at the 2nd Inter-African Soils Conference at Leopoldville. Although starting his paper with the statement that the error of the idea that luxuriant growth of equatorial forest indicates inherently high fertility in the soils has been recognised for many years, he strongly criticizes condemning remarks as are to be found in the books of Stamp (1953), and of Gourou (1953). The first author describes the rapid impoverishment of the soils that is brought about by excessive leaching when the forest cover is removed, stressing the lack of knowledge necessary for the sound development of areas where this occurs. This point of view is also held by Botelho da Costa (1953), who writes in his textbook on Angola soils that large investments have been lost because of a wrong assessment of virgin soils. Gourou (*l.c.*) is even more negative in his evaluation of tropical soils, stating that they are very poor in assimilable bases and phosphorus and ill-supplied with humus. Vine definitely rejects the generalized statements of both Stamp and Gourou. In his paper he presents a number of examples from which may be concluded that, at least for the areas of Nigeria with moderate rainfall, the maintenance of fertility

presents much less difficulty than in regions of very heavy rainfall (>2000 mm/year). Nevertheless the natural fertility is problematic, which follows from the data of the West African Institute for Oil Palm Research. An experimental plot that received no manure in 1940 produced 11,600 kg/ha of yams (*Pioscora* sp.) and 2 years later only 5060 kg/ha. The yield of cassava (*Manihot utilissima*) grown on the same plot went down from 6700 kg/ha in 1944 to 1100 kg/ha in 1946. This is not too surprising, as may be concluded from Table 1.

TABLE 1

Data on Forest Soils from Nigeria (after Vine, 1954).

	October 1941		October 1942	
	Before felling and burning	6-18	After felling and burning	6-18
Depth (inches)	0-6	6-18	0-6	6-18
pH	5.0	4.4	5.5	4.4
Base-exchange capacity (m.e.per 100 mg.)	5.6	5.3	5.7	5.4
Total exchangeable bases (m.e.per 100 mg.)	2.5	1.4	3.0	1.5
% Carbon	1.16	0.66	1.09	0.66
% Nitrogen	0.089	0.054	0.083	0.047

The rapid decrease in plant nutrients after clearing the forest and planting one crop of taro (*Colocasia esculenta*) in New Guinea has been described by Reyn- ders (1961) who had the opportunity to study the pattern of shifting cultivation as practised by the Papua population. Analysing the soil he proved that after eight months at harvest time the soil was practically depleted of plant nutrients. Even 10 years after abandonment of the plot, then covered by a poor secondary vegetation, the level of these vital elements was much lower than after the initial clearing of the original forest. To this should be added that the rainfall in the area ranged from 3,000-5,000 mm per year.

TABLE 2

Decline of fertility of primeval forest soil in New Guinea after felling and planting (after Reyn- ders, 1961).

Soil stage	pH	3% acetic acid ppm			
		CaO	MgO	K ₂ O	Na ₂ O
1 day after planting	6.5	4100	600	250	230
1 week after planting	5.9	2700	370	245	80
3 months after planting	7.0	4600	830	180	270
After 8 months at harvest	5.8	250	30	180	40
8 months after abandonment	5.7	tr	tr	105	65
2 years after abandonment	5.6	30	tr	120	55
10 years after abandonment	6.0	1900	450	180	110

A striking example of variations in fertility of virginal forest soils is found in Ethiopia (Van Baren 1961).

TABLE 3

Chemical analysis of rhyolitic soils in the Gossi forests

	Horizon							
	0-3	Profile 70			0-3	Profile 71		
		3-15	15-40	40-90		3-15	15-40	40-90
<i>Granulometry %</i>								
2,000-200	12	128	88	84	5	4	4	3.0
200-20	11	15.5	12	18	9.5	15.5	8.5	19.5
20-2	27	41.5	29.5	28.5	24.5	20.5	23.5	23
2	50	35	50.5	39.5	61.0	60	64	54.5
<i>Acidity</i>								
pH-H ₂ O 4.6	4.6	4.9	4.8	4.6	5.8	5.6	5.3	4.9
pH-KCl	3.8	3.8	3.6	3.6	5.3	4.4	4.1	3.7
Carbon %	10.9	5.5	1.4	0.6	10.5	2.6	1.1	0.5
P ₂ O ₅ ppm/soil	56	12	3	6	43	10	21	16
<i>M-V Analysis</i>								
Calcium	510	300	80	20	1520	750	450	200
Magnesium	160	110	20	5	300	170	130	60
Potassium	100	8	10	10	70	20	10	10
Ammonium	77	18	10	15	65	55	13	17
Iron	5	9.8	10	6	0.4	1.8	2.7	1.9
Aluminium	58	141	161	210	4	20	61	87
Manganese	0	8.5	8.5	0	10	7	3.5	7.5
Sulphate	2	2	14	12	6	2	3	26
Sodium	10	9	13	12	8	8	8	10

The figures are fairly conclusive and not only illustrate the differences between the two profiles, but even more those differences between their individual horizons, particularly in profile 70. It is obvious that clearing a forest with the idea of using a soil of which only the top three centimetres contain the nutrient elements in adequate quantities represents a grave risk. As a second case in point reference may be made to the experience acquired when studying virgin-forest soils collected during a prospecting survey of the Kolombangara Island in the Solomons (Van Baren 1963). The descriptive report sent with them took the line that there could be no doubt that the soil was fertile, in view of the luxuriance of the forest. Table 4, which includes also particulars of other samples for comparison, demonstrates that the opposite is true.

TABLE 4

Results of analysis of soils from Kolombangara, Solomon Islands.

Fertility grade	Sample number	Truog P ₂ O ₅ parts per million/soil	Parts per million in sodium acetate-acetic acid solution				
			Ca	Mg	K	Al	Mn
I	A2	50	800	200	10	10	2
	C1	75	1050	140	25	5	0
II	J2	0	1400	110	10	25	0
	L1	10	1250	175	20	5	0
III	F1	5	1900	110	15	5	0
	K2	5	1850	70	10	10	0
IV	30	0	68	43	8	46	113
	35	0	10	8	4	66	23

The grade IV soils were taken from the virgin forest in the east of the island, and the other samples from parts of the island already under cultivation. The figures are self-evident. Nutrient elements such as calcium, magnesium and potassium are lacking in the forest soil, whereas the Al and Mn contents are high, indicating advanced deterioration. It is clear that this data does not give cause for optimism. Further and more recent information on forest soils from Ghana (Ahn 1970) confirm the opinion that utmost care should be taken when considering exploiting tropical forest soils for agricultural purposes (Table 5).

Ahn points out that the amounts of rainfall in the two regions differ markedly and that the more severely leached soils are generally associated with the higher rainfall areas. The climatic agents also had an impact on the nature of the forest, tree-species and associations. It is mentioned that the Kumasi Ochrosol carries a semi-deciduous forest characterized by the dry facies of a *Celtis-Triplochiton* association, whereas the more weathered Oxysol of south-west Ghana is covered by tropical rainforest (soil qualification according to Charter 1955). In view of the influence of the vegetation on the soil quality it seems worthwhile to pay more attention to the chemical composition of the leaves and consequently to the quality of the organic matter and the humus-clay complex as reflected in pH and saturation percentage. That even the same tree-species grown under different pedo-ecological conditions may have a conspicuously different ash-content and chemical composition of its leaves follows from the data in Table 6.

Other examples of the paucity of plant nutrients in the layers below the humus-rich topsoil in primeval tropical forests are found in the study by Sombroek of the Amazon soils (1966) and in the explanatory text to the FAO-Unesco Soil Map of the World, Volume IV, South America (Unesco, 1971). Sombroek notably remarks that the amount of available phosphorus decreases with depth rapidly to very low values (6 ppm after Truog).

An interesting report of Lundgren (1971) on the soils of a montane forest in Ethiopia confirms that organic matter is the principal carrier of the soil's fertility as far as determined by the presence in adequate quantities of plant nutrients. The purpose of the study was to find out whether in the area involved, the Munessa forest, a softwood plantation could successfully be established. Apart from the forest inventory carried out on behalf of the Ethiopian Govern-

TABLE 5
Analytical data for two forest soils from Ghana (after Ahn 1970).

(a) Soil	1	2	3	4	5	6	7	8	9	10	11	12	13	14
(b) Location	Lower Depth	pH	% Pine	%	% C	% N	C/N	% OM	Exchangeable	Exchangeable	Exchangeable	Total	Cation	%
(c) Rainfall	of Horizon		Earth	Clay					Ca	Mg	K		Exchange	Satura-
(d) Parent Material	(in.)								(m.c. per 100 g)				Capacity	tion
(a) Forest Ochrosol (Bekwai series)	2 11	6.4 5.1	100 94	36 40	6.11 1.28	0.454 0.137	13.5 9.3	10.51 2.20	23.74 1.63	7.87 1.24	0.30 0.10	32.93 3.17	43.13 16.00	76 20
(b) Kumasi, Ghana	21	5.0	42	46	0.71	0.085	8.3	1.22	0.50	0.30	0.07	1.08	13.20	8
(c) 55-60 in	33	5.1	31	46	0.40	0.061	6.6	0.69	0.46	0.24	0.07	1.01	10.95	9
(d) Phyllite	46	4.9	79	44	0.31	0.069	4.5	0.53	0.32	0.33	0.03	0.85	9.99	9
(a) Forest Oxyisol (Boi series)	3 7	4.7 4.8	95 95	22 28	2.47 0.82	0.189 0.081	13.1 10.1	4.25 1.41	1.70 0.30	0.79 0.44	0.22 0.07	2.46 1.09	12.60 7.31	20 15
(b) South-west Ghana	16	5.6	52	42	0.67	0.070	9.6	1.15	0.31	0.35	0.02	0.96	7.83	12
(c) 75 in	27	4.9	93	53	0.52	0.059	8.8	0.89	0.26	0.31	0.04	0.78	8.42	9
(d) Phyllite	42	4.9	98	55	0.42	0.051	8.2	0.72	0.25	0.30	0.04	0.72	8.47	9

TABLE 6

Chemical composition of the leaves of *Dacrydium elatum* from Padang and from the Botanic Garden at Bogor, Java (after Hardon 1937).

	Padang	Botanic Garden
Ash	2.16	7.59
CaO	0.59	3.43
MgO	0.33	0.69
K ₂ O	0.52	0.57
Na ₂ O	0.08	0.05
MnO	0.02	0.15
P ₂ O ₅	0.10	0.15

Differences in nutrient composition of litter layers in various countries of tropical Latin America were set out in a review of soils research in that continent and published by the Soil Science Department of the North Carolina State University (1972).

TABLE 7

Nutrient composition ranges in litter layers in Guatemala, Puerto Rico, Ghana and Congo (after North Carolina State University Report, 1972).

	kg/ha/yr		kg/ha/yr
N	74-199	Ca	45-220
P	1-7	Mg	10-94
K	8-81	S	9-10 (one site only)

ment, additional laboratory investigations of the soils were executed in Sweden, allowing the study of the relation of soil, vegetation and altitude. The author compares the data of the Munessa area (ranging in altitude from 2100-2700 metres above sea level) with those of soils of the same nature, so-called Ferrisols, after d'Hoore (1964), from the Ivory Coast, Ghana and Malawi. They show clearly the conserving influence of the altitude notably on the content of organic matter in the topsoil. The Munessa soil (altitude 2100 m) contained an average of 8.67% C, Ivory Coast samples 2.54% C (altitude 140 m) and 11.8% C in the Malawi soils occurring at an elevation of 1200-1800 m a.s.l. From the data presented in Lundgren's report two have been selected which show striking differences in soil organic matter content, although the ecological situation, that is altitude, rainfall, parent material and suchlike factors, seems fully comparable. The forest-type, however, is not the same and it might be of scientific interest to know whether the botanic composition of the forest did play a decisive role.

The evaluation of the data in Table 8 (p. 94) in view of the production potential to be expected is rather speculative as there is little comparative information. The lactate extraction figures (AL) show very low to no easily available phosphorus; only 7.6 in the humus-rich topsoil of plot 3 and zero in the other samples. Also the HCl-extractable P is on the low side. Only K is present in

TABLE 8
Analytical data from two forest soils from Ethiopia (after Lundgren 1971)

Plot No.	Forest type	Altitude m	Depth cm	pH	Carbon %	Nitrogen %	AL-soluble			HCL-soluble			Cation exchange cap. meq/100 g	Base saturation %	
							P	K	Ca	Mg	P	K			Clay %
3	P-C	2265	0-10	6.5	20.09	1.33	7.6	57	1425	100	34	160	16.9	—	—
			45-55	6.9	1.57	0.21	0	34	375	36	14	175	34.3	29.3	69
			95-105	7.0	1.14	0.11	0	34	325	41	12	185	40.4	26.1	76
13	P-A	2415	0-10	6.1	3.51	0.37	0	43	425	55	16	145	37.0	31.3	87
			45-55	6.0	0.82	0.09	0	39	185	36	20	145	76.2	20.0	62
			95-105	6.1	0.59	0.09	0.2	42	250	41	15	130	80.4	19.4	68

P-C = *Podocarpus-Croton*

P-A = *Podocarpus-Arundinaria*

favourable quantities, whereas Ca and Mg are high in plot 3 and average in plot 13. The difference in the two plots is, however, conspicuous and holds a warning that even in seemingly comparative ecological conditions a forest may cover a soil of essentially different quality.

From Brazil information is available that the soil of a tropical forest is generally of a good to very good quality after deforestation and very suitable for agriculture (personal information J. G. Heymeyer). The species of trees growing in combination on one plot is indicative of the quality of the soil. *Aspidosperma* spp. and *Gallesia gorazema* occurring next to each other assure a soil of very high productivity. However, it has also been observed that, although initially crop production is very satisfactory, the soil is exhausted after a few years if no fertilizer is applied. The secondary forest that follows is of inferior quality.

The data presented relating to production potential point to a generally low to very low fertility. This makes it difficult to understand the mechanism responsible for the lush forest growth. A rather widespread opinion is that thanks to a well developed rootsystem reaching laterally as well as vertically over appreciable distances the forest tree has a tremendous reservoir of plant nutrients at its disposition. Observations of Greenland and Kowal (1960) seem to make this less than likely, at least as a 'general' rule. Their study of root-systems of Ghana forests shows that 68 to 85 percent of the roots is found within the top 25 to 30 cm. This would give the subsoil a secondary role in the nutrient cycle. This would underline the risk of indiscriminate reclamation of forest areas.

Attention is finally drawn to a very interesting multinational review on fertility problems of soils of the humid tropics published by the Committee on Tropical Soils of the U.S.A National Research Council of the National Academy of Sciences (1972). The main aspects of the subject are dealt with in 12 papers, and an appendix includes summaries of country and regional reports. The volume concludes with a list of suggested reading. For people interested in developing tropical forest soils, this is a rich source of information.

ABSTRACT

Data collected thus far indicates that the statement that a luxurious tropical forest may cover an almost sterile soil still holds true. A thorough pedo-ecological study should go hand in hand with an analysis of the vegetational cover. Paucity of composition with regard to tree-species and poor regrowth are indicative of limitations in ecological conditions to which full weight should be given before decisions on reclamation of a given forest area are taken.

REFERENCES

- AHN, P.M. 1970. *West African Soils*, Vol. 1. Oxford Univ. Press.
 CHARTER, C.F. 1949. Cacao soils, good and bad. Rep. W. Afr. Cacao Res. Inst.
 ——— 1955. The nutrient states of Gold Coast forest soils. Cacao Conference Report.
 COMMITTEE on Tropical Soils, 1972. *Soils of the humid tropics*. Nat. Acad. of Sciences, Washington D.C.
 D'HOORE, J. 1964. *Soil map of Africa*. Explanatory monograph. Lagos
 FAO-UNESCO, 1971. *Soil map of the world*. Volume IV, South America. UNESCO, Paris

- GOUROU, P. 1953. *The tropical world*. Longmans, London.
- GREENLAND, D. J. and KOWAL, J.M. L. 1960. Nutrient content of the moist tropical forest of Ghana. *Plant and Soil* 12: 154-174.
- LUNDGREN, B. 1971. *Soil studies in a montane forest in Ethiopia*. Dept. Forest Ecol. and Forest Soils, Stockholm.
- MOHR, E. C. J. and VAN BAREN, F.A. 1958. *Tropical soils*. 2nd ed.
- REYNDERS, J.J. 1961. Some remarks about shifting cultivation in Netherlands New Guinea. *Neth. J. Agric. Sci.*, Vol. 9.
- RICHARDS, P. W. 1964. *The tropical rain forest*. 3rd ed. Cambridge Univ. Press.
- SOIL SCIENCE DEPT. North Carolina State University, 1972. *A review of soils research in tropical Latin America*. Raleigh.
- SOMBROEK, W.G. 1966. *Amazon soils*. Centre for Agric. Publ. and Documentation, Wageningen.
- STAMP, L.D. 1953. *Our underdeveloped world*. London, Faber & Faber.
- UNESCO, 1966. Proc. of Symposium on Ecological Research in Humid Tropics Vegetation. Unesco's Southeast Asia Science Co-operation Office, Djakarta.
- VAN BAREN, F.A. 1961. The pedological aspects of the reclamation of tropical, and particularly volcanic, soils in humid regions. Unesco's Humid Tropics Research Symposium, Abidjan, Ivory Coast, 1959. UNESCO, Paris.
- 1963. Fertilité et problèmes agrochimiques des sols tropicaux. *Agroctama*, Vol. VII, No. 3
- VINE, H. 1954. Is the lack of fertility of tropical African soils exaggerated? *Proc. 2nd Inter-African Soils Conf., Leopoldville*, pp. 389-412.

Session I: Summary of the Discussion

The authors of background papers Nos. 1 and 2, **R.G.Downes** and **H. A. Nix**, introduced their papers with a brief account of the main points. **Lee Peng Choong** then made the following intervention:-

'Referring to Dr. Downes's first phase for land use planning, namely inventory, it is essential that if the resulting data are to be used by planners and decision-makers, they are produced in a form readily understood by people without an ecological or technical background. It is also essential to take as full an account of the economic and social environment as of the physical, since the former will set limits on how the land may be used. However, because the economic and social situation is dynamic, it is all the more necessary to keep options so that changes can be accommodated.

Another important point is that while agriculture and production forestry are reversible forms of land use, the natural humid tropical forest ecosystems are so complex that once altered they are practically impossible to restore. We know so little about the interactions involved, that we are equally ignorant about what should be restored or how to do it. For this reason it is simple prudence to ensure that representative samples of all natural ecosystems should be reserved, for scientific study and the maintenance of gene pools, which would allow restoration to be effected if the need arises' (13) *A. Dilmy*: if land use plans are to be viable, they should be preceded by environmental impact assessments (EIA), which cover both the positive and negative aspects of alternatives. (9)

R. G. Downes: measures must be taken to prevent hostile reactions to the EIA: if they are properly carried out and take account of all types of development and non-development alternatives, the over-all result can be the broadening of the basis for decision-making, especially if the alternatives are published and can be subject to public discussion. (9) (11)

The further point was made that there is a close relationship between EIA and cost/benefit analysis. By the attaching of monetary value to alternatives, without adequate knowledge, benefits and costs can be made to look 'balanced' when in fact they are not, hence the great need for economists and ecologists to get together and come to terms. (11)

S. Tago: development projects must be assessed from many different points of view or interests. There is often a great disparity between the 'will of the majority' and the social cost/benefit equation for the minority. The questions of which communities benefit and to what extent must be properly answered by all final policies and decisions on land use. (8)

Soemirat Slamet: the problem of use as opposed to the preservation of non-renewable resources needs some consideration. In this case conservation implies wise use, rather than abstaining from use.

R. G. Downes: but if the decision to use a non-renewable resource is delayed, the land concerned may be used meanwhile as a renewable resource.

J. D. Ovington: forests, which are our concern at this meeting, are nevertheless only part of a country's environmental resources and must, therefore, be integrated within a comprehensive regional development plan.

A. I. Fraser: changing land from forestry to other uses does not necessarily reduce the value of the land or reduce the number of options open and may in

fact enhance both. Care must therefore be taken to avoid excessive protection of resources as well as over-use.

M. E. D. Poore: nevertheless, in the case of forests, options for land use only remain completely open as long as the land is still under its natural forest cover: it is therefore wise to delay development which involves the removal of that cover until a need has been established and a decision is absolutely necessary. (13)(15)

K. F. Wiersum: land use planning should be based on the greatest possible diversity of environmental situations, in order to ensure that as well as the high-yielding, unstable agricultural or industrial ecosystems the low-yielding and stable ecosystems will also be maintained and developed. (15)(17)

The last part of the discussion focused on the need for environmental and ecological education, in schools, through the media and in extension services, but it was agreed that this was essentially a matter of providing a means of implementing land use planning and policy guidelines, by promoting community awareness and understanding of the objectives and problems involved, rather than something which in itself needs to be expressed as a principle or guideline.

SESSION II

The Forest as a Resource—National Parks and Nature Reserves, Timber Production and Shifting Cultivation

The Chair for this Session was taken by the Hon. Stephen Tago, while Dr. Jose I. Furtado acted as Rapporteur.

Three background papers had particular reference to the subject-matter of the Session and are reproduced below.

Session II. BACKGROUND PAPERS. No.4**The Role of National Parks and Reserves in Economic Development**

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INTRODUCTION

In 'Ecological Principles for Economic Development', Dasmann, Milton and Freeman tell us that 'ideally economic development is a process through which nations seek to improve the well-being of their citizens'. They go on to say they assume that 'those charged with national leadership have the welfare of their people first and foremost in mind and that they have the power to control those whose means and ends may differ'.

In this paper I propose to discuss the contributions which National Parks and Reserves can make to the welfare of people in the less developed countries and some of the problems and conflicts involved in establishing and managing such areas in these countries. I also wish to illustrate some of these points from my recent experience in establishing National Parks in Papua New Guinea.

POSSIBILITIES AND PROBLEMS

Every nation which is starting to pursue the objective of improving the welfare of its people faces the problem of how to earn money to finance social development programmes. Top priority is usually given to the exploitation of natural resources such as forests, mineral deposits, fisheries, water resources and cultivable land. Another means of earning foreign exchange is tourism. It is easy to assign a monetary value to these things.

It is not easy to prove the value of tourism to some economists, but in 1971 it was Australia's ninth highest income earner, and it ranks even higher in some less developed countries.

The pursuit of these objectives is not without problems, as a study of both the developed and lesser developed countries shows. The successful establishment of a system of National Parks and Reserves within developing countries can be regarded as an indication that these problems exist, and that they can be at least partly solved by a 'quality of life' approach to development.

The National Park Idea was born more than one hundred years ago. Its birth was during a period of almost unparalleled exploitation of natural resources in the United States of America. The movement represented a voice of national conscience - a feeling that not every tree should be cut down, or every resource commercially exploited.

Today, more than 100 years later, we must note several things springing from this original idea which had its first flowering at Yellowstone National Park in 1872.

Firstly: the U.S. National Park system now consists of over 80 parks and reserves which contribute great social and cultural benefits to Americans and earn millions of dollars from overseas visitors.

Secondly: the National Park Idea has spread to some 145 countries, most of whom were proudly represented at the centenary of Yellowstone in 1972.

Thirdly: and most importantly, the existing and threatened rate of exploitation of the natural environment and its resources in South East Asia and the South West Pacific greatly exceeds that in the U.S.A. one hundred years ago. Today's technology and international markets give a capacity and a demand which call for a far more urgent move than Yellowstone to preserve the best samples of the scenery, ecosystems and culture of the unique lands and peoples of this part of the world.

There are four main benefits from an adequate National Park System:

1. National Parks provide attractive natural settings within which overseas tourists can appreciate local scenery, vegetation, wildlife, history and culture;
2. They provide for the growing outdoor recreation demands of increasingly urbanised populations;
3. They provide scientific reference areas, in which adequate monitoring of changes due to agricultural and forestry monocultures, industrial development and other large-scale environmental disturbances can be based;
4. They provide *gene pools*—the widest possible range of types of plants, animals and other organisms any of which may be essential to the future well-being not only of local populations, but of all people on planet Earth, through their genetic potential.

The possibility for establishing National Parks in this part of the world is still good. There are many large areas which are still basically undisturbed by large-scale developments.

The problems encountered in establishing and managing National Parks in the region may be listed as follows:

- a. Establishing a land use priority in competition with other forms of development or use;
- b. Securing funds for land acquisition, planning, development and management;
- c. Securing adequate control and protection of land and water which is or has been under customary use or ownership;
- d. Recruitment and training of staff;
- e. Securing basic data on which to select areas.

PRIORITY IN NATIONAL DEVELOPMENT PROGRAMMES

The problem is principally one of convincing those in power and their advisers that reservation of resources in National Parks and reserves is just as much in the interest of national development as physical exploitation elsewhere. This is most difficult when people and their leaders are pressing for improved goods and services, and treasuries have the job of financing these things.

Several problem-solving approaches can be used. One is to arrange for a study of national parks and their impact in other countries by government leaders and advisers on overseas tours. Another is to establish, with the assistance of international aid, a pilot project to demonstrate how a National Park may fit into a national development programme, and how its benefits may be measured.

Many countries with established national parks can produce figures to show the part they play in tourist revenue. For example, in 1971, Kosciuszko National Park in Australia was stated to have generated a tourist expenditure of \$35 million (Australian Tourist Commission 1972). These figures at least justify the adoption of a pilot project by a developing country.

In passing, it should not be forgotten that visitors to a country anticipate seeing and doing things they cannot do at home. A well selected national park system provides a continuing environment within which these opportunities can be retained and used again and again. In a world of diminishing non-renewable resources and increasing sameness of culture, no nation can afford to deliberately destroy potential revenue-earners which require only careful selection, protection and management, and which may stand as symbols of the unique environment and culture of each nation as all else around them changes.

In Papua New Guinea, a pilot project has been established at Varirata National Park, 48 kilometres from Port-Moresby, a city of some 70,000 people with facilities for international visitor entry by ship and aircraft. In the first 6 months after opening of the Park, there were more than 6,000 visitors. Based on a recently-established entrance fee of \$1 per car, minimum annual direct revenue from this source is estimated at \$3,000. Local people are in the process of establishing a Craft Centre and Shop, which will sell village-made artifacts and provide tourists with refreshments, tropical fruit and other needs. Eight young local men are employed on the Park, and a search is in progress for others with suitable basic education for training as park rangers. A feature of the Park is an emphasis on the history and culture of the Koiari people, who were the traditional landowners.

The Park has been enthusiastically welcomed by a Government whose 8-Point Development Plan includes 'Decentralisation of economic activity, planning and Government spending with emphasis on agricultural development, village industry, better internal trade, and more spending channelled to the local people and area bodies'. The local people have welcomed not only the increased revenue from tourist services they are beginning to provide, and from employment of some of them on the Park, but also the establishment of the Park as a permanent place for the preservation of Koiari traditions and culture.

SECURING FUNDS

Hard-pressed Treasuries are naturally reluctant to distribute funds for projects which do not show obvious and calculable economic returns. It is important that as soon as a Park is developed to a stage fit for public use, a system of use fees should be established, so that Treasury can see direct evidence of earning capacity. Effort should also be made to measure the indirect earnings of local communities, which should be assisted by the Tourist Authority of the country concerned. A record should also be kept of direct employment of local people on each Park, and of amounts paid to local contractors.

All these figures are important financial data, and help establish the case for

further Government support for the establishment of a Park system. Use should also be made of international organizations such as the World Wildlife Fund (WWF) which provide financial assistance for special conservation projects of world-wide importance. In the case of Papua New Guinea, such support is already promised by WWF for the selection of reserves for the preservation of the famous Birds of Paradise.

SECURING CONTROL AND PROTECTION OF LAND AND WATER AREAS

In many cases the land tenure situation in developing countries is insecure or obscure. In some cases, either a previous colonial government or the new indigenous administration which replaced it, has set aside areas as Parks or Reserves with little or no consideration for the aspirations and needs of the local people. Where this happens, great difficulty must be expected in protecting the special resources which make a Park valuable. The poaching of wildlife in some of the Parks of Africa is an example of such protection problems.

I do not underestimate this problem of protection. It is basically one of education and communication, as well as careful area selection in the first place. What is certain is that a Park will be most difficult to establish successfully unless the local people support the project. This requires early consultation to consider local land-use and development ambitions, and to carefully explain how the National Park concept can benefit local people. Nor is the task complete when the Park is established. It is necessary to mount and maintain an education programme at all levels, but particularly among children and students, who will be the future leaders and adult citizens.

At Varirata in Papua New Guinea, discussions extended over 2 years, during which preliminary work only was done in surveying the resources of the Park. The discussions covered the customary ownership and use of the land, the concern of the local people for the disappearance of wildlife and the alienation of part of the area for an expatriate-owned pig and cattle farm, and the basic proposals for a National Park. In the beginning the Koiari clan leaders were reluctant to give much information on their legends and traditions, but in the end this information began to be freely given for use in making the Park more interesting for visitors and a place of learning for future young clan members. Clan leaders came forward and volunteered information on the increase in wildlife in the Park with the cessation of hunting. They policed this rigidly themselves, though they continued hunting under traditional rules on their adjacent hunting lands.

A conservation education programme for schools is being mounted jointly by the Wildlife Section of the Department of Agriculture and the National Parks Board. School groups have already visited Varirata National Park, an ex-schoolteacher has been appointed as Education Officer by the National Parks Board. A major job for her will be explaining the Park and its functions to visiting school groups, as well as visiting schools herself. Helping local people to identify with a Park, and to participate in money earning tourist services will do much to protect Park values and reduce the need for protection by park rangers. In the long run ownership of parks by the Central Government is desirable to ensure long-term protection. But where customary ties are strong and there is a resistance to purchase or other acquisition by the Government, there is no reason why a long-term lease tenure cannot be arranged. What customary land-rights holders often fear is that Government purchase will result in ultimate sale of their land to other interests. A long-term lease,

providing for reversion to clan ownership in the event of the Government ceasing to require the land for park purposes, usually solves this problem.

RECRUITMENT AND TRAINING OF STAFF

Getting started with staffing is always difficult. While it is possible to utilise existing staff in similar land-use fields such as forestry, such people will usually need the benefit of specialised park management training and some re-orientation of their thinking from exploitation. This can be secured overseas by arrangement with international aid agencies or individual countries. IUCN and FAO can provide advice on overseas training opportunities.

An alternative worth consideration is to seek the loan of one or more experienced overseas park experts. Again the international aid agencies can help in finding the right person and perhaps in arranging for financial assistance. At present Australia is involved in a 5-year assistance programme to Papua New Guinea, and both Australia and New Zealand have expressed a desire to help countries in their general region.

Once a satisfactory link is established with one or more overseas countries, assistance in training park managers and rangers in these countries can be reasonably easily arranged. It is necessary to select people with a certain minimum secondary school education, and preferably give them suitably oriented sub-professional or professional tertiary training. Some forestry and agriculture courses may give useful basic training, which can be built upon by short overseas study and training tours. There is progress at present towards specialised park management courses in Australia and New Zealand, though these are at present at the graduate rather than the sub-professional level.

Again I would like to quote from the Papua New Guinea situation. Two Papua New Guineans have now undergone 3-year Diploma Courses in Forestry at the P.N.G. Forestry College and later practical training courses in National Park work in Australia, as well as practical experience at Varirata National Park. This Park is now being used as a training park. Trainee rangers at the Forestry College will use it for practical experience during college vacations; new diploma graduates will be assigned there for their first field experience. In addition several field trainees are being selected each year after the Form 4 High School examinations. They work in the Park for one year, learning the basics of park management. At the end of the year if they seem suited to national park work, they commence the diploma course at the Forestry College. The presence of an experienced Australian park manager until the end of 1975 will assist in guiding this training system and developing staff as they complete training.

SECURING BASIC RESOURCE DATA

This is a major problem in many less developed countries. In some cases there are data available from land capability and other resource surveys; in others there is very little information, and we have to start from bits and pieces available from various sources.

Whatever the position, we must use all that is available. Forest survey data, geological and soil surveys, military mapping, data from scientific expeditions—all these and other sources can be used. Wherever international aid agencies such as UNESCO, ECAFE, UNDP, FAO and IUCN have been active, their data

should be availed of (United Nations, 1970). Where such data do not exist, a case may be prepared for submission to one or other of these agencies, seeking assistance in setting up a programme to pinpoint key areas for a park system.

In Papua New Guinea several devices have been used. The National Parks Board set up an Advisory Committee of scientific personnel with experience and knowledge in fields such as geology, botany, soils, wildlife, geography, anthropology and so on. A system of District Advisory Committees was also established, to draw upon local knowledge in the various administrative districts. With an experienced overseas officer on loan as Executive Director, a young graduate Geographer was used to collect and collate data, and carry out inspections of high priority areas. Inter-departmental contacts have been developed to the full, and an attempt made to ensure inter-departmental consideration of competing land-use propositions before a park proposal goes before the Government.

CONFLICTS

In considering the conflicts which can arise, we should recognize firstly that conservation means the rational *use* of resources, and *not* locking them away so that they are of no further use to man. The second point to recognize is that there are several forms of use, and they do not all mean physically consuming resources.

Conservation and Tourism

Growing tourist visitation can threaten the well being of delicate natural environments and fragile cultures. Yet it is the very uniqueness of such things which provides so much attraction for tourists.

It is a wise government that recognizes that tourism, particularly from overseas, needs the maintenance of a suitable environment if it is to remain a viable industry. Positive actions by a country to maintain its own special scenic, scientific, historic, and cultural values are of immense value to the tourist industry. The reservation of land and water areas for National Parks and Reserves is one such positive action. Another is the management of these areas so that their special values—scenery, wildlife, culture or history—remain unimpaired. This means control over the density of visitors, where they go, perhaps how long they stay. It means rules of behaviour while they are in a park—no shooting, feeding animals, depositing litter, or removing or damaging plants and other wildlife.

It also means respect for local culture. At Varirata discussions have commenced with the Koiari people for the construction of a small traditional village at a suitable place in the park. It is proposed that some Koiari people would be present in the village during official visiting hours. They would wear traditional dress, and demonstrate aspects of their customary way of life. They would really be actors, and would be paid to do their job as guides and teachers for people visiting the model village. These visitors would be both tourists and Papua New Guinea schoolchildren, especially Koiaris.

This plan would divert tourists from the villages in which the Koiari people live, and where they do not always appreciate disturbance of their domestic lives by bus-loads of people. At the same time it would help their young people to gain a deeper understanding of clan culture and traditions.

So with sensitive and skilful management, National Parks can soften the physical and cultural shock of tourism, introducing overseas visitors to local scenery, wildlife and culture in such a way that understanding is increased on both sides, and damage to valuable resources minimised. This sensitivity of approach must be expressed in the bearing and attitude of Park staff, the way in which roads, tracks and other park facilities are built, the skilful use of local materials and architectural styles in Park buildings, and the way in which legends and culture are portrayed for visitors in the Park educational or interpretative programme. A fully developed approach to the problem would include preliminary action by tourist authorities to prepare people for the places they are to visit. I see no reason why a series of properly-produced short films on the cultures and customs of South East Asia and Pacific Island countries should not be screened on Jumbo jets travelling to this region, instead of Hollywood movies.

Conservation and customary rights

Many cultures in the less developed countries have had their own conservation rules. There have been periods when certain animals must not be hunted, or eggs gathered. There are forests and other places where hunting and fishing are not permitted, and in other cases size limits have been placed on animals, birds and fish which may be captured.

Yet recently in many developing societies these conservation rules have started to break down. The cause may be simply increase in population, perhaps due to better health services and diet. Or it may be the introduction of modern weapons such as the shotgun and sticks of gelignite, or even faster transportation methods such as outboard motors.

When one comes to talk with local people concerning conservation one finds many viewpoints. As in any society, some people care not at all. If the community has had long and increasing contact with Western style technology, one often finds most people with the 'trade-store' philosophy. That is to say, their thoughts are on the things they can buy and sell, rather than on subsistence or exchange use of the products of the land, the rivers and the sea.

In my experience it is easiest to marry conservation and customary land or water rights where the latter are still valued but where people are aware of diminishing crops or harvests of wild products. It is during this period of transition that concerned local leaders still see a value in and a reason for wild lands and wildlife and are prepared to discuss land-use systems which will permit wildlife to be retained and even increase in numbers. Often they will wish to retain hunting rights at least for a period. A flexible approach by Government can allow hunting under agreed rules. One or more central breeding areas may be agreed upon—these will constitute the National Park proper. Adjacent areas may be reserved for hunting, and to these rules will apply. For example, crop limits may be set, or only traditional weapons and hunting methods may be allowed, and so on.

From the conservation viewpoint such a situation is quite acceptable, so long as the rules are agreed upon and kept by both the Government and the local people. In the normal equence of events the way of life of the people would ultimately see the disappearance of hunting, particularly if other national development goals are met. When and if this position is reached it may be relatively easy to add all or part of the former hunting reserve to the National Park.

In other cases, gathering from food trees is important to local people. Pro-

vided harvesting rules can be agreed upon, there is no real conflict between subsistence food-gathering and National Parks. The same might be said for fishing, canoe-making, gathering of building materials and similar pursuits. Only when commercial operations or rapidly expanding populations lead to over-exploitation does conflict become serious. Government planning should take account of these needs and trends wherever possible before conflict situations develop.

Solutions

We have discussed some of the general solutions to these possible conflicts between conservation on the one hand and tourism and customary rights on the other.

Basically it is a matter of adequate communication of ideas and forward planning to allow for the social and ecological factors. Good planning means firstly talking to the people, considering their needs and hopes, looking at the natural and cultural resources we have, and thinking about the good and bad effects possible from tourism. Once all these things have been adequately considered we can handle the situation. Parks must be big enough and situated so as to be able to stand tourist use without deterioration. They should be chosen so that they benefit local people by giving them access to income from tourists while helping to preserve culture and traditions and not disrupting local customary land and water use which is compatible with the National Park purpose.

If the selection of areas for National Parks is done by adequate consultation both with the local people and with other agencies involved in national development and resource use, the conflicts can be minimised. The principal obstacle in less developed countries is non-recognition of National Parks as a valuable item in a development programme. Patient and tireless efforts at education and explanation, using pilot projects to demonstrate, are the only answer to this problem.

ECOLOGICAL PRINCIPLES

If National Parks and Reserves are to continue to be valuable to a country, they must be able to maintain their natural balance. That is, despite use by tourists, the park ecosystems should remain basically undisturbed. Two things are required for this objective to be met:

1. The parks must be properly managed;
2. The land and water area within each park should have been chosen so that the park has as much natural protection as possible against outside influences.

We are concerned here with this second requirement. It is a requirement that often has been overlooked in the creation of National Parks in many countries, so that some parks are in trouble as land use around them changes. The migratory patterns of large animals in East Africa provide an example of an essential ecological factor which appears to have been given little consideration when the great National Parks there were set aside. Today it is a serious problem in the management of some of them. Similar problems beset many National Parks in more developed countries as increasing population and industrial and agricultural development close in on the parks.

Countries in this part of the world can take a lesson from these examples. In

many cases the opportunity will still be present for the following ecological principles to be observed:

- a. A park should where possible occupy the whole of a natural catchment area;
- b. Where the park does not extend to the top of a catchment, the land-use in the upper catchment should be of such a nature and so controlled as to provide protection for the park against water pollution, soil erosion and similar damage;
- c. The migratory and other needs of wildlife should be provided for in the selection of parks to ensure the continued welfare of wildlife species, and this will require biological and ecological studies in considerable depth;
- d. Wherever possible land-use planning should provide a park with protection against air and water pollution and similar adverse influences by zoning other land around it to favour complementary and compatible forms of resource use (e.g. water catchment protection, hunting reserve);
- e. In the case of marine parks, or parks bordering on the sea or large lakes, consideration of currents and tides should be made when choosing boundaries, to protect beaches, shore-lines, reefs, etc. against outside influences;
- f. As a general principle, parks should not be bisected or otherwise divided by existing or future transportation routes, such as roads, railways and canals;
- g. Parks should not surround an area or areas of other land-use, except where the permanent planned use of such land is entirely compatible with the objectives of management of a National Park: a natural reserve for scientific investigation would be acceptable, but not a large village community whose people might wish to change their life-style as their country develops;
- h. Parks should not be located beneath present or future flight paths for modern aircraft, particularly jet aircraft.

It is not only in the location of parks, but also in their planning, development and management that ecological principles should be observed. Some of these principles are as follows:

- a. Fragile ecosystems or parts of a park should not be planned for high or even medium density use by visitors;
- b. Facilities such as toilets, eating houses and overnight accommodations should be carefully located so that the disposal of wastes can be effected without damage to park resources;
- c. In general it is best to keep overnight accommodations and similar facilities outside National Parks, because of the urban-type problems they tend to generate;
- d. Roads, parking areas and other hard-standing areas, which alter drainage patterns, should be kept to a minimum in National Parks;
- e. Where roads, etc., are essential inside a park, they should be carefully located to avoid disturbance to sensitive geological, botanical, zoological and hydrological systems;

- f. Park developments should not take place, or should be kept to an absolute minimum, until an ecological survey of park resources has been carried out;
- g. Management should provide for visitor levels, types of park use, and visitor distribution to be kept within the limits of tolerance of local ecosystems;
- h. Planning and management should provide for all material brought in by visitors to be removed from, and not deposited within, national parks;
- i. Management planning should ensure that the natural water regime of a park is maintained, where necessary by proper legal agreements with other land or water agencies;
- j. Every park must be seen as part of a total region, which which it will interact. To a greater or lesser degree everything which happens in the region will have some influence on the park, and vice versa.

SUMMARY

The short-term and long-term benefits of a National Park system to a country are discussed. In less developed countries there are very real contributions which National Parks and Reserves can make to a sound economy, as well as to the conservation of natural, historical and cultural heritage.

However, it is not easy to establish a recognition of these values. Communication of the national park idea so that parks receive a high priority in land use allocation is difficult, so that the availability of funds for land acquisition, planning, staff recruitment and training, and collection of data is restricted. A further problem is that of customary rights over land and water areas, which make acquisition and management of such areas for park purposes difficult.

Study of national parks in other countries by political and other community leaders is encouraged and facilitated by organizations such as IUCN, UNESCO and FAO, and assistance is available from various international sources to survey national park possibilities in a developing country and possibly establish a pilot project. This is the best way of communicating and demonstrating a new idea to the people and their leaders.

While there are potential conflicts between conservation and tourism, and between conservation and customary rights, they can be solved by co-operation and clear recognition that *conservation* means rational use of resources to provide the best range of services to man.

Finally, it is essential that sound ecological principles be followed in selecting areas for national parks, and in their subsequent management, in order that their full and lasting potential may be realised.

Session II: BACKGROUND PAPERS. No. 5

Forest Management in Relation to Ecological Principles

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THE TROPICAL FOREST RESOURCE AND ITS USE

About half of the total global forest area (1800 million hectares) occurs between the Tropics and of this tropical forest just under a quarter (400 million hectares) lies within the Asia Pacific Region. Typically the humid forests of the Region are characterised by a complexity of conditions, structures and tree species. Because of a shortage of forest scientists in the Region little is known of the autecology and synecology of the many living organisms present and forest management is rarely based on the application of detailed scientific study.

Most of the Asia Pacific tropical forests can be regarded as natural in that they are not planted. Nevertheless most have been modified greatly by man.

The Region possesses a greater population density than the other two main tropical forest regions of the world, there being about 0.8 hectares of forest per capita compared with 5.4 and 3.3 hectares for Tropical America and Tropical Africa respectively. The way of life of some villagers displays a remarkable appreciation of, and adjustment to, the local forest ecology, with the forest providing many needs. Elsewhere utilisation of the forest resource by the local population is destructive.

Whilst the tropical forests of the Asia Pacific Region contain many different tree species, utilisation is restricted to trees of relatively few species; thus more than ninety per cent of the timber exports from Sabah comes from trees belonging to the Dipterocarp family.

The FAO average yield figure of 3.1 cubic metres of wood harvested each year per hectare of forest from the tropical Asia Pacific Region is probably an underestimate because of the lack of records and the difficulty of gauging the use made of the forest by rural people often having unrestricted access to the forests. In general wood from these forests is mainly used as fuel. FAO records indicate that the forest products for the Region consumed per annum (as cubic metres in round wood equivalent per 100 capita) are 23 for sawnwood, 1.5 for plywood, 4.4 for paper and paperboard and 220 for fuelwood.

Commercial exploitation of the forests is hindered by poor access and inadequate knowledge of wood properties. As wood has become more valuable, greater support has been given to wood technology, particularly pulp technology. Recent technological advances are being applied and are resulting in an increased yield per hectare largely by enabling a greater range of tree species to be utilised and greater use of smaller trees. Furthermore the area of forest being exploited is expanding so that in general the volume of wood harvested is increasing rapidly. Taking Indonesia as an example, from 1966 to 1970 the volume of timber exported increased from 301 thousand m³ to 7,413 thousand m³, the proportion of different tree species involved changing greatly.

A multiplicity of other products is gained from the tropical forests of the Asia Pacific Region and some non-wood forest products have become valuable commodities of international trade particularly the oils, tannins, resin and latex.

Often there is a very intimate association between the forest and the local people who have traditional land rights or rights to gather specified forest products. The native population commonly collects from the forest such items as building materials, bamboo, various fibres, medicines, oils for burning, flowers and foliage for decoration and a variety of foods such as fruits, nuts, leaves, honey, underground stems, roots and wildlife.

The value of these forests cannot be gauged solely in terms of the products harvested from them for they also constitute a vital aesthetic component of the tropical landscape, serve to maintain water quality and to regulate water flow particularly from mountainous areas so as to lessen the danger of flooding, protect the soil from erosion and provide a range of habitats for the conservation of native flora, fauna and ecosystems. Furthermore they support small but numerous human settlements often possessing highly developed socio-cultural relationships. The capacity of the tropical forests to fulfil the growing needs of recreation and tourism is largely undeveloped, partly because of failure to recognise their scenic attributes and the potential interest in the wildlife they contain but also because of the poor communications and a fear of the unknown by many people. Nevertheless, the Region now possesses a number of magnificent National Parks, e.g. Kinabalu in Sabah, and their number is increasing. Whilst some tropical forests in the Region have been devastated by wasteful and destructive logging, others have been damaged by mineral extraction, e.g. the tin mining in Malaysia, so that locally forest rehabilitation presents a formidable problem.

MANAGEMENT POLICY

Despite the multiplicity of uses and products of the tropical forests of the Asia Pacific Region, forest management has been orientated on the whole towards wood harvesting. Wood is required both for local consumption and export. With increasing prosperity and population growth local consumption of wood is expected to increase greatly. Large amounts of wood are being exported from the Region to industrial centres elsewhere, notably Japan, Singapore, U.S.A. and Europe, and the world demand for hardwood imports is expected to rise. Consequently, a massive increase is foreseen in the tropical hardwood market provided costs do not increase disproportionately and techniques are developed to utilise the wood from a greater range of tree species. Currently, much of the wood exported is as logs, there being little local processing. Increased local processing of wood may be anticipated because of the employment it can provide for the people of the Region but also because of environmental problems in the importing countries.

For many countries of the Region the tropical forest, with its vast amounts of timber accumulated naturally over the centuries, represents a valuable source of finance capable of being realised quickly to stimulate development not necessarily connected with forestry. Consequently, there is some danger of opportunistic exploitation and of the forest resource in places being so depleted for short term gain as to make forest regeneration unacceptably slow. In more extreme cases irreparable damage may be caused to forest ecosystems through major environmental deterioration, such as severe soil loss taking place following clear felling. Clearly, the major and urgent forestry challenge

in the Region is to ensure that management systems are applied which are economic and provide for increasing production of wood from the tropical forests whilst ensuring diverse forest values are maintained for future generations.

Political realisation of the long term commercial and environmental values of the forest resource is slowly leading to the implementation of better forest management policies. These involve more intensive prescribed forest management resource use, the establishment of permanent forest reserves effectively protected from illegal use and the replacement of the extensive forestry of the past with more scientific management based on forest resource surveys and long term forest management programmes closely parallel to planned industrial development.

Probably the greatest threats to the tropical forests are their widespread and indiscriminate destruction through shifting agriculture, government alienation for agriculture as a result of population increase and destructive exploitation based on short term gain. The danger to the forest is further enhanced by the general shortage of trained foresters in the Region to supervise forestry and logging operations. Nevertheless, the position is not without hope for there is a body of expertise available in the Region covering a range of skills and, if properly organised, capable of developing management schemes to combine forest protection with controlled utilisation. Unfortunately the effectiveness of this expertise is diminished by poor co-ordination, primarily a result of inadequate communication. There is a need for a central organisation to facilitate a rapid interchange of experience and ideas and to provide back-up services (Florence 1972).

FOREST MANAGEMENT

Sound management planning depends upon reliable knowledge of the ecology and extent of the forest resource, and of the likely demands to be placed on it. In many of the countries of the Region forest inventories have either been made, or are planned; most are based on aerial photogrammetry techniques backed by field sampling. For example, detailed inventories with sample growth plots are well advanced for Malaysia, Thailand and Papua New Guinea. In contrast the economics of forestry operations and the forecasting of future demands in order to rationalise forest management policies have been relatively neglected.

The two principal kinds of forest management, namely plantation and natural regeneration tropical forestry, are applied in the Region. Both have advantages and disadvantages.

Plantation forestry

The area of forest planted in the Region though relatively small is continually expanding and this trend seems destined to increase as the population multiplies and with more intensive forest utilisation and greater mechanisation of forestry operations. The future of tropical forestry is seen by many foresters to be in plantation forestry largely because of the immense potential of plantations to achieve rapid growth with a large per hectare production of utilisable wood. Because of the greater per hectare wood production and the increase in the area of forest plantations, the pressures being exerted to make greater use of the more natural forest types could lessen in the long term.

Plantation forestry also provides considerable opportunity to restore a viable forest cover over areas devastated by previous use and particularly by shifting agriculture. Forest grazing and shortage of firewood make plantation establishment difficult in the more populated areas and unconventional techniques may have to be adopted. In Indonesia, for example, the Forest Service has planted mulberries for silkworm rearing by villagers in order to initiate the restoration of a soil and vegetation cover on limestone exposed following clear-felling of forests during the war years.

Few countries in the Region have found it necessary to establish large scale plantations but where plantations have been developed, exotic tree species have frequently been used. Teak *Tectona grandis*, tropical pines particularly *Pinus caribaea*, and various species of Eucalypts are common forestry plantation species and with their use sometimes remarkable gains have been achieved in the production of wood utilisable under current practices. Indonesia has found it necessary to establish about a million hectares of well managed teak plantations on Java, even though there are extensive reserves of indigenous tropical rain forests on the other more sparsely populated Indonesian islands.

Undoubtedly problems of controlling weeds, diseases and insects, particularly termites, will have to be overcome if extensive plantations are established. There is also evidence that plantation forestry may lead to serious soil depletion and loss. The soil under teak plantations is particularly susceptible to sheet erosion because of shading out of the understorey plants so that the soil is exposed to rainwater dripping from the large leaves of teak. As in temperate regions, the loss of biological diversity and the presumed greater risk factor are of concern to foresters and conservationists generally.

Three main management systems are used in plantation forestry in the Region:

- (1) Over large areas, particularly in the mountains, the forest resource is being destroyed by shifting cultivators. Various versions of the taungya system adopted in the Region provide some indication of the possibility of reconciling the conflicting interests of forestry and shifting agriculture. In Laos, for example, small areas, usually in cut over forests, are cleared on a family basis and trees are planted in the fields after waste material is burnt and just before the agricultural crop is planted. Agricultural crops are grown for about two years after which the land is abandoned by the farmers but by this time the trees are well established and able to compete successfully with the luxuriant weed growth.
- (2) In forest areas forest enrichment planting with trees of valued species may be made in small natural or artificial clearings. This technique has given very variable success, depending on site conditions.
- (3) In a few locations, extensive monoculture forest plantations are being established either after forest clearance or on land previously deforested for other purposes.

Gradually, experience of plantation forestry is increasing throughout the Region and undoubtedly, as in temperate regions, greater emphasis will be placed on the genetic quality of the stock used, site amelioration measures, better plantation management, mechanisation of forestry operations and the introduction of multiple use of plantation areas.

Many tropical countries are conscious of their lack of softwoods, the main source of long fibres for paper. Consequently, plantation forestry in the Region may tend to emphasise the need for establishing extensive stands of quick growing conifers, even though such forests will be highly unnatural since

conifer dominated forests are uncommon in the tropics. Special ecological and forest protection problems may well arise because of this change in the basic nature of the forest cover.

Naturally regenerated tropical forests

Naturally regenerated tropical hardwood forests constitute the bulk of the forests of the Region. Because of the heterogenous nature and the scattered distribution of trees of recognised commercial value, logging in the past has been usually extremely selective and consequently relatively rather costly though profitable because of the excellent quality of the trees harvested. Nevertheless, as noted previously, within recent years the range of tree species accepted by industry has increased as the wood supply has diminished and with the application of wood technology research particularly in the use of mixed hardwoods for pulp.

Generally the forests are in relatively undeveloped areas with a small population so that there is a shortage of skilled operators and a poor infrastructure in the sense of roads, bridges and townships. Substantial investment is therefore needed if the naturally regenerated tropical forest resource is to be used to meet the expanding market for timber in the Pacific basin and substantial investment must be followed by comprehensive use of the forest resource.

Because of the need for development capital and technological expertise, much of the recent rapid increase in utilisation of natural forests has been based on the granting of concessions to private organisations, both local and foreign, to harvest the forest resource. Whilst some entrepreneurs have behaved responsibly, others have harvested the forest with little thought of the future and in the interests of minimising logging costs have damaged young growing stock, seedlings and saplings, upset the tree species mix of the forest areas, lessened the likelihood of natural regeneration and in extreme cases exposed the soil to erosion over large areas. Unfortunately it seems that the severe shortage of forest officers in some areas has meant inadequate supervision of the concessionaires both in terms of forest protection and ensuring full returns from the timber harvested.

Various kinds of agreements are made with private organisations. In Indonesia, for example, forest cutting outside Java has largely been by private organisations operating under official permits and licences which prescribe little more than a stipulation of lower tree size limits for cutting, some degree of cutting cycle control and a rather crude silvicultural system of the selection type. Following the implementation of the Foreign Capital Investment Law in 1967, a large number of concessions with areas up to 500, 000 hectares were granted in the Dipterocarp forests of the Indonesian islands of Sumatra and Kalimantan.

In Indonesia there are several categories of permits and licences, the operating periods of which can be extended on the basis of performance and greater knowledge of the timing of the regeneration cycle. The following four are typical and of these the first three categories are issued by regional governments and the fourth by the central government:

- (1) Annual cutting permits for areas less than 1, 000 hectares;
- (2) Timber licences, for a period of not more than 5 years, on areas up to 5, 000 hectares;
- (3) Timber licences, for a period of 10 years, on areas up to 10, 000 hectares; and

- (4) Concession licences, for a period of 20 years, on areas of more than 10, 000 hectares.

Similarly, utilisation of the indigenous forest in Sabah has increased greatly with the granting of concessions to private organisations seeking timber for export. About 68% of the foreign income from Sabah is derived from timber and of the timber exported about 80%, goes to Japan mainly as logs with little local processing.

The use made of forests and the causes of forest destruction may vary greatly even within a single country. In E.Malaysia the forests are threatened by the poor management of some concession areas and shifting mountain cultivation; in W. Malaysia the lowland Dipterocarp forests are being cleared to provide land for the landless under large scale co-operative agricultural settlement schemes orientated towards the production of rubber, palm oil and other crops. Whilst the value of these crops is recognised, it is becoming increasingly urgent that long term land use plans be formulated and implemented so as to assure reasonable stability of the forest resource area. The alienation of lowland forests increases the importance of the hill forests. Here the problems of regenerating and managing the forest may be more formidable so that management of the forest resource must be considered as a whole.

Much silvicultural research has been devoted to developing silvicultural systems to maintain the indigenous forest as a productive system by natural regeneration of trees since a frequent feature of the Dipterocarp forest is an apparent abundance of seedlings and sometimes of saplings presumably capable of responding to release from competition by the overstorey trees.

Many different kinds of treatment have been tried involving different intensities of exploitation felling to give different degrees of overhead cover by removal of trees of prescribed species. Unfortunately experience has shown there is little certainty that reoccupation of the site by natural ecological succession will be by trees of the desired species. Furthermore, logging may cause much damage: a recent study in Sabah showed that nearly 70% of trees left for retention were damaged during moderately heavy selective logging of the rain forest. Consequently, there is a trend to more concentrated shelterwood methods of treatment in which partial cuts are made, and at no stage is the forest cover totally removed. Where natural regeneration proves inadequate supplementary planting may be used sometimes with wildings collected from the forest rather than nursery grown stock.

A typical advanced example of such a system based on natural regeneration is the shelterwood system of Malaysia (the Malaysian Uniform System) which in certain circumstances can be very effective.

To be successful (in terms of continuing wood production) tropical silvicultural systems in general need to take into account:

- (1) The nature of the residual stand left after logging and in particular the species and vigour of the seed trees;
- (2) The growth, stocking and distribution of seedlings and advanced sapling growth both before and after felling;
- (3) The damaging effect of logging on the residual seedlings, saplings and trees and of logging and extraction roading on the environment particularly on the natural water drainage pattern and soil physical conditions;
- (4) damage to the residual trees by secondary fungal and insect attack following logging damage and damage by wind and bark scorch; and

- (5) the likelihood of weed growth, invasion by pioneer trees and increased luxuriance of climbers.

Because of the great variability and complexity of tropical rainforest there is no universal silvicultural system suitable for general application and the silvicultural method applied ideally should be varied according to the nature of the particular site. Where selection management is used and market factors are important in determining the species of trees to be sold, considerable skill may be required to manipulate the forest to achieve stated objectives of management. In some circumstances selection cutting might not necessarily be the most appropriate treatment.

In many areas of South East Asia there are too few trained foresters available to ensure high standards of operational control are maintained, so that attention has to be directed towards formulating relatively simple prescriptions for the cutting of the growing stock and post-logging treatment. Such prescriptions may be successful; unfortunately they can also degrade the forest, for example, by the progressive removal of the larger more productive trees and by leaving the residual stock in poor condition.

Whilst there are immense problems to be overcome in managing the forests of the Region for wood production, whether by plantation or natural regeneration forestry, the problems of management are greatly magnified when other forest products and values have to be considered, since for these there is even less experience available from which to formulate sound programmes of management and even fewer specialised trained staff to implement these programmes.

SOME IMPORTANT PRINCIPLES OF FOREST MANAGEMENT

In the light of the forecasted expansion of world consumption of many forest products with possibly a greater reliance on tropical countries as suppliers of these products, foreign capital from industrial countries seems destined to play a vital role in the future of the tropical forests of the Asia Pacific Region. Nevertheless, it is important that the interests of the local people are not overlooked and their welfare is safeguarded. Means must be found to involve them fully in the decision making process relevant to the development of their forest resource and to acquaint them with the ecological and other consequences of development.

The governments of foreign countries must accept some responsibility for the ecological consequences of forest utilisation and development schemes abroad which are based on capital investment emanating from them or in which their nationals play an active part. Equally, the granting of incentives by the host country, where necessary to attract foreign capital for some purpose judged worthy, needs to be tempered by joint acceptance of the need to consider the danger of progressive loss of biological capital and biological productive capacity.

Individual forest development schemes should be viewed in relation to an accepted overall land use plan which takes into account all the various goods and services provided by the forest resource. Once the national limits of the forest estate are agreed, its management should be based on multiple use - sustained yield principles.

The tropical forests of the Asia Pacific Region are such diverse and complex ecosystems that it is undesirable to generalise about specific management techni-

ques, and management operations must be designed to take into account the variable ecological nature of the forest.

Since the tropical forests of the Asia Pacific Region are subject to change with more intensive utilisation, attention needs to be directed to ecosystem dynamics and the likelihood of disturbance initiating successive ecological changes. Of particular importance in this respect are changes in the species of plants and animals present, soil deterioration with exposure to heavy rainfall and impairment of water quality with silting and overheating following forest clearance.

Independent environmental impact statements should be required for every development scheme in the tropical forest of the Region. These statements should detail the consequences of alternative management systems on the whole array of forest values and the implications of these consequences to the well-being of the indigenous population.

The inadequacy of scientific knowledge of the nature and dynamics of the tropical forests of the Asia Pacific Region presents a serious obstacle to ensuring the formulation and implementation of wise land use plans. Consequently a special responsibility is placed on forest managers to set aside adequate areas whereby to preserve a good and representative diversity of species and ecological situations.

Whilst, as elsewhere, a case can be made to increase research in forest ecology, there is a particular need to stimulate international research co-operation by the exchange of results and international linking of national research projects so as to cover a continuum of conditions whereby to elucidate broad management principles in relation to ecological conditions.

The direction of much of the forest research underway could be better orientated towards

- (1) improving the present understanding of the interrelationships between forest management and forest ecosystem dynamics, since it is imperative that detailed management is in accord with the ecological nature of particular sites; and
- (2) the development of an interdisciplinary approach appropriate to tropical conditions and capable of providing comprehensive resource inventories and a valid means whereby to derive methods of natural resource allocation based on economic, social and biological considerations.

Sufficient numbers of well trained and adequately paid people must be provided. They should be located so as to be able to oversee forest development projects and to explain to local machinery operators (e.g. bulldozer drivers, tree fellers and road construction teams) what is required of them and to ensure that the entrepreneurs follow the agreed working plan.

SUMMARY

The nature and use of the tropical forest resource of the Asia Pacific Region, and more particularly of South East Asia, are examined and future trends in world trade likely to affect the forest resources are indicated. Various factors affecting the general management policy for the utilisation of these forests are considered and attention is drawn to the serious threats being posed by shifting agriculture, the alienation of land for permanent agriculture in settlement schemes and destructive exploitation to meet the timber needs of foreign countries. The growing and occasionally destructive impact of forestry concessions on the indigenous forest

is seen as a matter of special concern and examples are given of various kinds of concession agreements.

Different systems of forest management based on either plantation or natural regeneration forestry are outlined and some advantages and disadvantages are indicated. No one system is seen as a panacea for forest management. The need for a flexibility of approach is stressed and is particularly desirable because of the ever changing nature of the requirements placed on the forest as society changes.

Several management principles regarded as being especially relevant to the development of the forest resource of South East Asia are given. These take into account the ecological diversity and vulnerability of tropical forest ecosystems, the multiplicity of goods and services being demanded of forests, the critical lack of ecological research and expertise, the advisability for much closer supervision of practical operations and the need to safeguard the interests of indigenous populations with their traditional association with the forests.

In considering a long term solution to the problem of rational use of the forest resource, stress is placed on interdisciplinary studies whereby to consider forest ecosystems in their dynamic entirety, on international co-operation in research, and on the environmental responsibility of all national governments involved in development schemes.

REFERENCE

Florence, R.G. 1972. *The use and Development of Forest Resources in ASPAC Countries*. ASPAC Registry of Scientific and Technical Services. Canberra, Australia. 51 pp.

Session II: BACKGROUND PAPERS. No. 6

Shifting Agriculture in Tropical Forest Areas of South East Asia

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*Department of Geography, Australian National University, P.O. Box 4, Canberra, A.C.T., Australia***INTRODUCTION**

Shifting cultivation is commonly denounced by foresters and administrators in South East Asian countries, as a disastrously exploitative use of tropical forests and, more dramatically, as 'the most menacing land use problem of the tropical world' (Komkris 1970:180). It is condemned for its destruction of primary forest, for its low agricultural productivity, its supposed inability to sustain larger rural production as the need arises, and for the long-term damage which it causes through accelerated erosion and by the establishment of anthropogenic grasslands, dominated by 'lalang' or 'cogon grass' *Imperata cylindrica*. Some support for all these criticisms can be found in many parts of South East Asia, but equally there are many instances where swidden farming* is carried out with meticulous concern for vegetation regrowth and the ecological security of the area which it uses.

Swidden cultivation provides the means, as Geertz (1963:25) has described it, of transforming a natural forest ecosystem into a harvestable one. The unmodified mature rainforest can perhaps meet the food needs of one human being for each two or three square kilometres, in favourable areas; after clearing and burning, the more specialized transitional ecosystem of secondary forest is known to support densities of 30-50 persons per square kilometre, without any evidence that the swidden system is breaking down over time (Clarke 1966:350; Kundstadter 1970:56; Rappaport 1971:118).

In recent years much attention has been given to the classification of swidden systems, but we still have only the most meagre quantitative information about swidden productivity and even regarding the land area and population numbers involved in swidden farming. Most of our detailed information comes from small-area studies made by individual investigators. On a larger scale there is little to guide us, but Spencer's estimates of swiddening families indicate a total population of about 30 million shifting cultivators in South East Asia, in the mid-1960s (Spencer 1966:174). Their numbers will certainly have increased very substantially since then, but in the absence of accurate census and survey data it may be safe to estimate that 15-20 per cent of rural households in the region depend to some extent on shifting cultivation.

Spencer's estimates also provide a valuable guide to the geographic distribution of the swiddening population in South East Asia in the mid-1960s,

* The term *swidden* is now commonly used in scientific literature, for *slash and burn, kaingin, ladang, chena* cultivation and other local names. (Swidden = burned field).

and presumably also in the 1970s. Indonesia had 64 per cent of the total, the second main concentration was in Burma-Thailand-Laos (24 per cent), and the Philippines (7 per cent) followed in third place. Within each of these spatial concentrations it would probably be accurate to distinguish between two swidden groups, 'the near' and 'the far', coinciding broadly in space with the occurrence of Conklin's 'supplementary' and 'integral' swidden systems (Conklin 1957:2-3). The supplementary swiddeners combine shifting cultivation with permanent-field cultivation, or tree cropping, often further supplemented with off-farm employment; integral swiddeners depend on shifting cultivation for their way of life (Figs. 1 and 2).

Supplementary swiddening is certainly now the dominant form in each of the three regions: in Indonesia, for examples, all main ethnic groups in Sumatra combine wet-rice cultivation with swiddens, and the same holds true for Sulawesi and the coastal regions of Kalimantan; integral swiddening is strongest among the groups of eastern Indonesia where wet-rice production is more difficult and in central Borneo (Lebar 1972). In Thailand integral swiddening is dominant in the uplands, where it is practised by about 500,000 hill people but in the lowlands of the northern and north-east regions probably 4 million Thai people depend to some extent on supplementary swidden cultivation.

HISTORICAL CHANGES

Archaeological evidence from Northern Thailand has shown that man tended plants and possibly cultivated them, in the uplands, at least 12,000 years ago (Gorman 1971:305). For the past 4,000 years the major concentration of people in South East Asia has been in the lowlands, where a long succession of technological developments has widened the gap between lowland farming systems, centred on irrigated agriculture, and the upland swidden systems. The results of this long-term neglect of rainfed (un-irrigated) agriculture, whether on swiddens or permanent fields, are often dramatically evident in the contrasting population densities of adjoining areas: for example, in the lowlands of northern Thailand wet-rice fields commonly support a physiologic density (ratio of population to cultivated land) of 600-700 per square kilometre, compared with 30 per square kilometre in the hill swidden areas immediately adjoining.

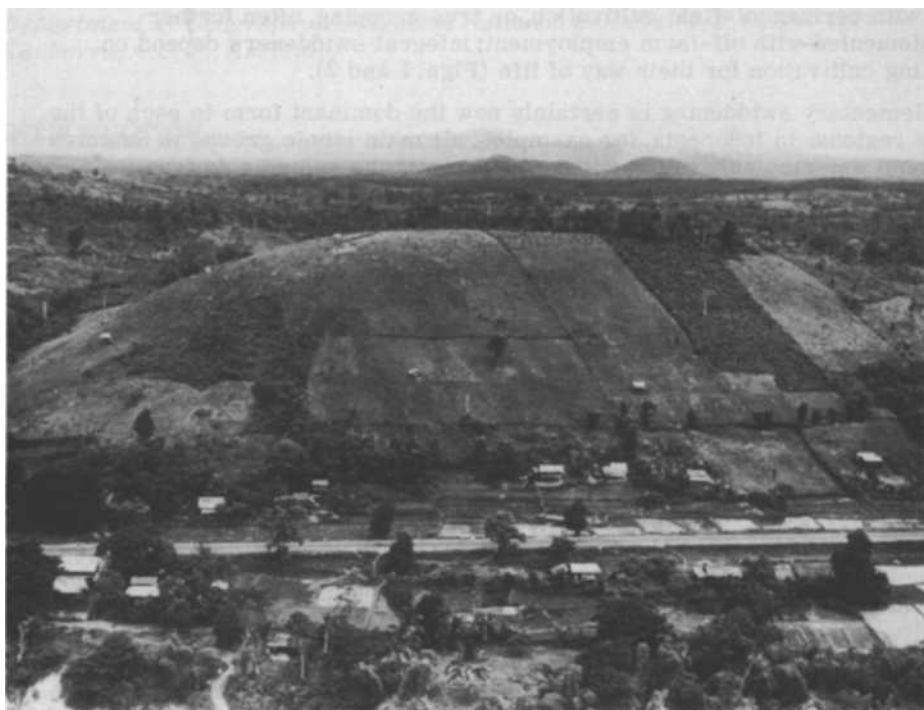
Looking back over the past two centuries we can identify at least four different ways in which shifting agriculture has been both modified and often greatly extended in the tropical forests of South East Asia. First, beginning strongly before the end of the 18th Century, the influence of colonial exchange economies gradually led to the inclusion of cash crops such as pepper *Piper nigrum* and rubber *Hevea brasiliensis* in the cropping patterns of farmers in the forest.

Secondly, beginning in the early 19th Century and continuing to the present, large areas of primary or secondary forest have been cleared (and often cleared of swidden cultivators!) for plantations of cassava *Manihot* spp., tea *Camelia assamica*, rubber, coconuts *Cocos nucifera*, coffee *Coffea robusta*, abaca *Musa textilis*, and teak *Tectona grandis*. Teak planting on the *taungya* system began in Burma in the 1850s, employing swiddeners to plant trees on cleared land which they could then use for cropping, between the rows, for two or three years; it is currently still used in Thailand and perhaps also in other parts of the region.

Thirdly, but mainly in recent decades, there has been the spectacular expansion

Figure 1.

Supplementary swidden cultivation near Sa Town, Nan Province, northern Thailand. Upland rice is grown on the face and rolling surface of the high river terrace, rising about 30 m above lowland fields. The swiddens shown in this photograph were all cultivated for at least two rainy seasons in the years 1967-73.



of swidden cultivation by pioneering lowland farmers who use un-irrigable lowland and nearby slopes for supplementary food production or cash crops.

Fourthly, there are a number of notable instances of more wide-ranging movements of lowland people into remote forested country. One major example is the migration of Karen in the early 19th Century from the Salween valley in Burma to the uplands of western North Thailand, where they now comprise the largest 'hill Tribe' group, numbering about 250, 000 people (Hinton 1973:235-236). The migrations of the Iban (Sea Dyaks) provide a second example: they began their movements into central Sarawak from the southern borderland with Kalimantan early in the 19th Century, cutting and burning swiddens for rice cultivation, so that by 1958 they were considered chiefly responsible for an 18 per cent reduction of lowland rainforest to swiddens and secondary forest (Anderson 1960:203; Freeman 1955:11-20).

If we think of swidden farming as primarily a pioneering form of land use, eventually giving way to permanent farming, then the most significant of these changes was probably the encouragement given to local swidden communities in Indonesia, in the late 18th and 19th Centuries, to make commercial plantings of benzoin, *Styrax benzoin* and *Styrax paralleloneurus*, and pepper in the ladang (forest clearings), at the same time as upland rice. Generally the pepper vines were planted with cuttings of the coral tree, *Erythrina*, and

Figure 2.

A heavily swiddened landscape at elevations of 800-1200 m in evergreen forest, Fang District, northern Thailand. White areas are swiddens where forest has been felled and was drying rapidly, prior to burning (27 January 1974).



began to yield in the third year after planting. By that time the swidden was being abandoned for rice cultivation, but the pepper vines continued to yield well for another five years, after which they were gradually engulfed by *belukar* (secondary forest) (Pelzer 1970:388-9). Later the same procedure was used for developing coffee plantings in West Java, and also rubber and coconut production; in a similar way in the Philippines coconut plantings were made by Kaingineros (swiddeners), in association with their upland rice or maize *Zea mais*; and now in Sarawak a considerable proportion of Iban rice swiddens are planted with pepper and rubber for harvest during the forest fallow after upland rice cropping has ended.

This planting system had important advantages. It produced a major trade in export crops, notably in 19th Century Indonesia, and had the secondary advantage for the Dutch and other colonial administrations in that it effectively anchored migratory swiddeners to their semi-permanent gardens. As time passed many of these swidden communities turned to wet-rice production in order to provide more food at shorter distances from their pepper or rubber gardens. In this way, quite diverse supplementary swidden systems emerged from the addition of tree and vine crops which were ideally matched to the forest fallow phase of the swidden system.

From these strong beginnings in Indonesia during the early 19th Century, the 'commercialization' of swidden farming in South East Asia has gradually penetrated to the most remote farming communities in the tropical forests, leaving very few to practise the traditional subsistence swidden cycle beyond the reach of market economies.

FARMING IN THE FOREST

As swidden farming communities in tropical forest areas of South East Asia have increasingly become anchored to particular territories, either because they were compelled by government agencies, or preferred to do so for economic or cultural reasons, the length of the forest-fallow period has become a critical indicator. Many farmers in the lower montane forest and the evergreen forest of the Thai-Burmese borderland regard a cultivation-fallow ratio of 1:9 as the minimum for the maintenance of yields (one cropping year followed by nine years of forest regrowth). Much the same minimum seems to be accepted in tropical rainforest areas, but already a great many swidden communities in different parts of South East Asia are being forced by population pressure to re-cultivate after 2-5 years of fallow (Hinton 1970: 18; Chapman 1970:233; Seavoy 1973b:527). In these instances the swidden method of nutrient replacement is almost certainly breaking down. As nutrient stocks become depleted, if cultivation is maintained the yields will probably soon settle at a low level unless farmers respond by introducing manuring or other more intensive farming methods for permanent-field agriculture.

Ecological aspects of the swidden cycle

Traditional explanations of the swidden cycles have emphasized the role of vegetation regrowth in replacing plant nutrients after each cropping episode. For example, 'If the vegetation is cut down and burned or its litter is allowed to decompose *in situ*, the nutrients that were present in the biota will be re-stored to the soil. This can sometimes give a high immediate fertility so that, in the first year or two after clearing, crops can be raised successfully. However, if the soils continue to be exposed to the sun and rain, bacterial action quickly breaks down the organic material and leaching removes the nutrients from the surface soil... Thereafter, fertility virtually vanishes, and crops will fail' (Dasmann, Milton and Freeman 1973:55). Many similar statements could be cited, some of which indicate the desirability for the forest-fallow to extend beyond 15-20 years before the next clearing is made.

It now seems clear that too much emphasis has been given to the role of the forest fallow as a means of nutrient replacement and too little to its role in shading-out the grasses and small herbs which infest every swidden, from soon after its first burning (Seavoy 1973b). Swidden farmers themselves usually mention the importance of invading weeds and grasses, rather than declining fertility, as the main reason for abandoning swiddens cut from secondary forest after the first or second year (Figs. 3 and 4). At the same time they will often emphasize that the main advantage in clearing primary forest is that weed regrowth is so much less in the first two or three years of cultivation.

The rate at which nutrient recovery occurs in swidden farming is clearly a matter of great ecological and economic significance. African evidence has demonstrated that accumulation rates for nitrogen, phosphorus and potassium in the vegetation are highest in the first five years of a forest-fallow period and that, with the exception of phosphorus, 'over half the nutrients stored in the 18-year-old fallow... had been accumulated by the 5-year-old fallow' (Nye and Greenland 1960:36). Recent research in Thailand, concerned with nutrient replenishment in a Lua' rice swidden after one year of cropping in secondary evergreen forest (Fig. 5), has also shown a rapid replenishment of nitrogen, phosphorus, calcium, magnesium and

Figure 3.

Regrowth after one rainy season following clearing in dry dipterocarp forest, northern Thailand. Young trees can be seen providing strong competition for grasses, particularly *Imperata cylindrica*



Figure 4.

A swidden cut in secondary dry dipterocarp forest. Nan Province, northern Thailand. Characteristically, for northern Thai supplementary swiddening the fire was lit prematurely before the felled timber had dried thoroughly. Secondary burning will be needed.



potassium in the first four years after cultivation (Zinke, Sabhasri and Kunstader 1970:273-4). The critical omission is organic carbon. This must be replaced in the surface soil from litter accumulation and the roots of plants. During the first few years when grasses and shrubs dominate the regrowth on an abandoned swidden there is only a small accumulation of litter, until sprouting stumps and seedling trees overtop the shade-intolerant grasses such as *Imperata*. Once woody vegetation becomes prominent, 5-10 years after the burn, it has been shown from a study of lowland dipterocarp rainforest in the Philippines that there is an abrupt increase in litter production and organic carbon levels in the surface soil (Kellman 1970:98).

In brief, the key to swidden resuscitation after each period of cultivation appears to be a speedy succession to the dominance of woody vegetation. At the earliest this can be achieved about 5-7 years after abandonment. If the swidden is intensively cultivated over several years, or intensively weeded so that seedling trees and stumps are removed, or if the swidden is burnt during the fallow period, the succession to the stage of 'woody dominance' may be indefinitely delayed. In these circumstances there is the prospect of a protracted phase of grassland dominance and the accompanying prospect that the swidden may not be recultivated for decades.

These remarks highlight the importance of swidden management. Clearly, the skilful swiddeners will display a number of abilities: careful timing of the burn, so that the greatest possible amount of the felled vegetation will be converted to ash (not as in Fig. 4!); judicious weeding, so that fast-growing trees are retained; a measure of 'after-abandonment' care, so that further burning is prevented and the regrowth of trees is assisted; and the possible planting of trees (such as *Casuarina equisetifolia* and *Leucaena glauca*) which will help in the fallow period. The last of these measures is not practised widely in South East Asia. It has been reported from Burma, West Malaysia and Sumatra, and from New Guinea, but there is immense scope for its expansion (Clarke 1966:353; Brookfield and Brown 1963:50-51; Pelzer 1948:30).

Finally, two other ecological aspects of swidden farming need at least brief mention. First, we may note that the problem of accelerated soil erosion in steeply sloping swidden areas will be reduced if intensive weeding can be stopped, particularly where it extends over several years. Swiddens which retain a large population of roots and stumps during a 2-year cultivation phase are seldom very severely eroded, even on slopes up to 30 degrees from the horizontal, particularly if they are cropped to rice. The root system of the crop and the spacing of plants, whether erratically or in rows, are also important factors. Secondly, skilful swidden management is clearly more feasible in the humid forest zones; in areas of dry deciduous and dry dipterocarp forest there is the prospect of slower tree growth and the greater risks, in a drier climatic regime, of accidental burning during the fallow period.

Diversity in swidden management

The quality of swidden management has important repercussions. It has direct bearing on the population size that the swidden ecosystem can support, if the available territory is limited, and as numbers build up the mismanagement practices of any one group will have significant implications for their neighbours. These relationships are well illustrated in the uplands of northern Thailand which is now a congested region (Fig. 2). The region as a whole is ethnically diverse, with seven main 'hill tribes' numbering in all about 500,000 people. The villages of five tribal groups are mainly above 1000 m (Fig. 5),

which represents the approximate lower limit for opium-poppy *Papaver somniferum* production at this latitude. The remaining two important tribal groups are the Karen (nearly half the total population) and the Lua', both concentrated mainly between 500 m and 1000 m in the uplands south-west from Chiangmai.

As Fig. 5 suggests, Northern Thai villages have increasingly looked upslope for opportunities to extend slash-and-burn cultivation. This movement has acted as a potential barrier to Lua' and Karen expansion downslope, as their populations are also expanding, but for the Lua' in particular, the pressure has little significance. Lua' villages commonly maintain a 1:9 cultivation/fallow cycle, operating a well-managed 10 years rotation through defined village territories and sending surplus population to settle in the lowlands (Kunstader 1970:55).

At the two extremes in elevation, swidden farming is not so well managed. The Northern Thai are commonly rather casual, supplementary swiddeners who clear and burn individual holdings, and recultivate too frequently; cultivation/fallow ratios of 1:2 are usual for appropriately low rice yields. More than 1000m higher, the Meo operate a very different and even more drastic swidden system. The Meo are the second largest hill-tribe group (approximately 50, 000 people) and focus their attention on primary forest, or mature secondary forest where swiddens will provide two or three high yields of raw opium and afterwards be cultivated to exhaustion. Little rice is grown and the duration of residence in any area is determined by the population size and the amount of poppy land available, in spells of perhaps five or six years of continuous cultivation. Population growth through migration is uncontrolled and so the moves may come frequently. The overall effects are dramatic. 'The Miao do not progress through a country steadily... they move by hop-step-and-jump' (Geddes 1971:4); as they jump they leave extensive *Imperata* grasslands behind, as a memorial to over-zealous weeding. The effects of Meo depredations are now being felt by other groups, notably the Karen, as land-for-swiddening becomes increasingly scarce.

Swidden productivity

Compared with the agricultural productivity of many lowland areas in South East Asia, swidden farming in the tropical forests may appear to be an unacceptable and outdated use of increasingly scarce resources. Its critics also sometimes contend that the forest-fallow system does not allow increases in agricultural production to be achieved, under the stress of population pressure (Newton 1960:113). These generalizations are not accurate.

Timber extraction is the main prospective alternative to swidden farming in many areas, but the costs of felling higher-value trees in primary forest and then transporting them to market centres or ports are usually prohibitive, unless logs can be floated downriver. Difficulties of access also eliminate re-afforestation with teak or other high-value species as viable alternatives to swidden farming in many areas.

The highest yields of swidden rice shown in Table 1 are comparable with average wet-rice yields in many parts of South East Asia. More generally, however, swidden rice yields amount to only 30-50 per cent of yields obtained on wet-rice land in the same locality, sometimes in the same village (Chapman 1973:191; Hinton 1970:16). The swidden yields are of course reduced to very small levels, if calculated in relation to the total land area used in the cultivation cycle, for example in a 10 years swidden cycle with 90 per cent of the land in fallow during any one year.

Figure 5.

Schematic transect showing the distribution of different ethnic groups of swidden cultivators in the western uplands of northern Thailand. Typical village shift patterns (Meo) and field shift patterns (Lua'; Northern Thai) are shown for three ethnic groups.

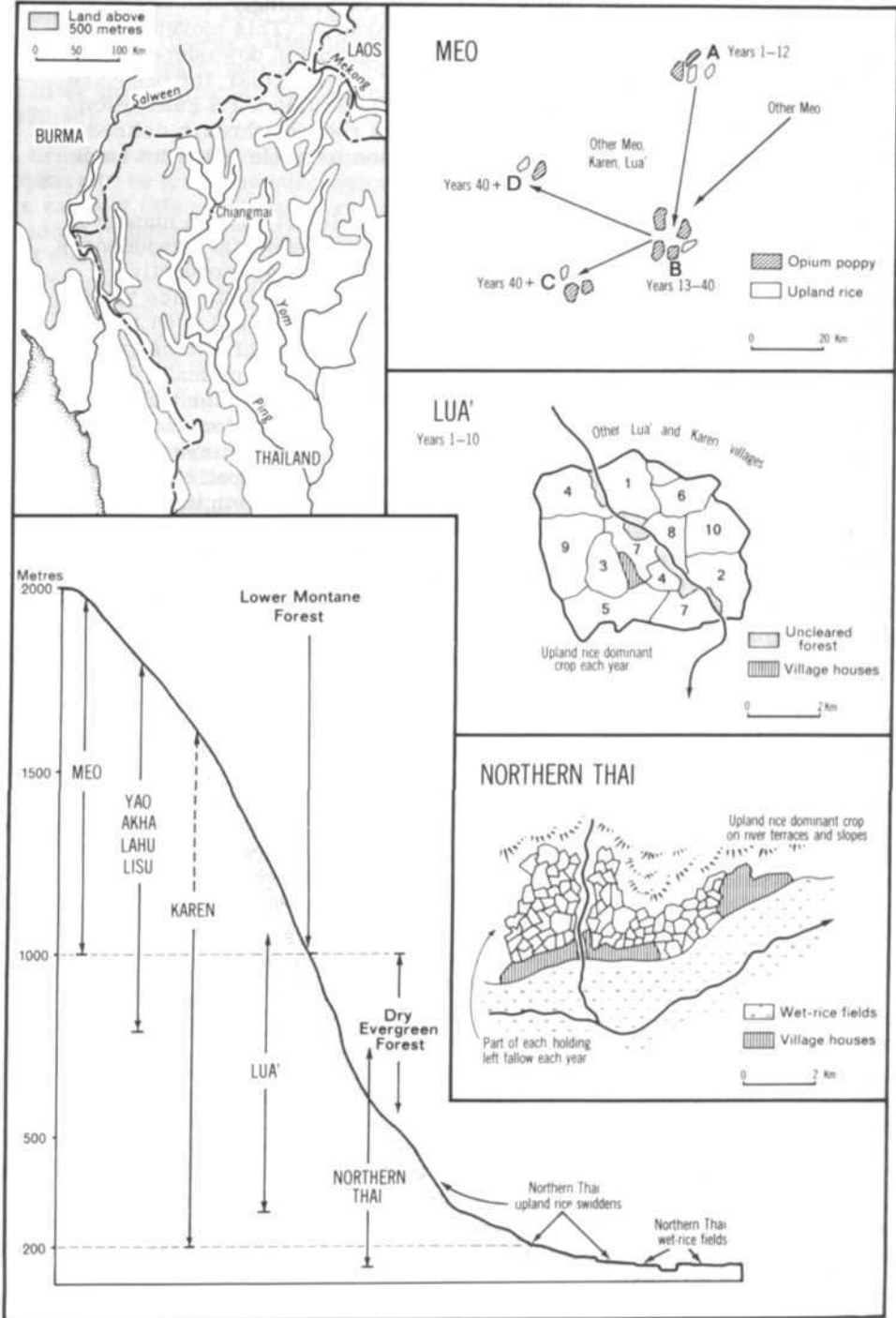


TABLE 1 Estimates of upland rice yields in various swidden farming systems of South East Asia.

Ethnic Group	Location	Upland Rice Yield (kg/ha)	Research Worker (and reference)
YAO	Northern Thailand	1847	Miles (Kunstadter and Chapman 1970:155)
KAREN	Northern Thailand	1464	Hinton (1970:16)
LAHU/LISU	Northern Thailand	1506	Keen (1973:120)
LUA'	Northern Thailand	955	Kunstadter (1970:115)
N. THAI	Northern Thailand	884	Chapman (1973:193)
N. THAI	Northern Thailand	662	Keen (1973:193)
LAMET	Northern Laos	1150	Isikowitz (Kunstadter and Chapman 1970:155)
DYAKS	Kalimantan	1000	Seavoy (1973a:221)
IBAN	Sarawak	674-808	Jackson (1968:80)

N.B. The mean lowland rice yield in northern Thailand, mainly from wet-rice fields, was 2320 kg/ha in the period 1966-68 (*Statistical Yearbook, Thailand, 1967-69:169*).

A notable feature of the data in Table 1 is the marked variation in swidden yields, even within one region. The lowest yields were obtained by northern Thai supplementary swiddeners and by Iban who are also now to a large extent supplementary swiddeners, increasingly dependent upon plantings of pepper and rubber. Why do these groups bother to cut, burn and cultivate swiddens for such low yields? In the case of the Iban, upland rice production is traditional and they have only recently moved in large numbers into an economy partly dependent upon cash income. For the northern Thai, on the other hand, wet-rice farming is traditional and swidden farming provides a useful supplement. For both these groups, swidden production is a less important activity than it is for the integral swiddeners (the other groups listed) whose survival depends upon their rice yields.

So far this discussion of swidden productivity has focussed on upland rice. Are there better returns from other crops, so that as population pressure builds up there may be a change to other crops and rainfed farming systems? Certainly in supplementary swidden areas there are many possibilities, resulting in the main from a lowland situation, with access to market services. The possibilities centre upon tree, vine and fruit crops suitable to particular climatic conditions; such as rubber, pepper, coconuts, pineapples and a wide variety of other fruits. Reafforestation with commercial species, such as teak, is generally not an attractive alternative to swidden cultivation from the viewpoint of the swidden farmer. All too commonly the *taungya* system makes inadequate provision for the wage-labour employment of swidden farmers after the first few years of teak planting, and consequently it can have the effect of dispossessing swidden landholders.

At higher elevations in the tropical forests and in more remote locations the barrier of distance eliminates most alternatives to subsistence production. One exception for many years in the high hills borderland of Burma-Thailand-

Laos has been raw opium production. It is of course now subject to considerable suppression, but also the lower prices being paid to village producers in the early 1970s (approximately US\$40.00 per kg) have reduced the attraction of poppy-growing, so that it is now only about 50 per cent more rewarding per worker than rice production. At the present time there is no well-established alternative to opium, having the same characteristics of high value combined with low weight and low bulk which are prerequisites for a successful commercial crop in remote swidden areas.

THE FUTURE OF SHIFTING CULTIVATION IN SOUTH EAST ASIA

Landscapes such as that shown in Fig. 2 suggest that swidden farming has a very limited future in South East Asia. As population pressure increases, the chief alternatives for swidden cultivators are migration and the progressive transformation of swiddens into terraced fields for rainfed or irrigated agriculture. On the other hand, there are still extensive areas where primary or secondary forests are thinly settled, such as central Borneo, much of the rainforested uplands of West Malaysia and even parts of the Thailand-Laos borderland. Here well-managed swidden systems deserve to remain, and, as the demand for agricultural land increases, new areas of primary forest can be brought out of vegetation storage for prudent swidden farming or tree crops.

The further reduction of primary and secondary forest is an inevitable concomitant of agricultural development in the humid tropics, as it was over so many centuries in western Europe. On the other hand, there is immense scope for reforestation on steep slopes (above about 35 degrees from the horizontal), where intensification of land use by terracing or other means is not easily achieved, and in many 'cogonales' (*Imperata* grasslands) where the physical effort or cash costs for reclamation are far beyond what peasant farmers can provide. In the Philippines alone, 'cogonales' occupy more than one-sixth of the land surface, amounting to approximately 5.1 million ha (Wernstedt and Spencer 1967:103).

The reclamation of *Imperata* grasslands in South East Asia is only one major challenge requiring the heavier involvement of government agencies, perhaps, with international support, in areas of swidden cultivation. On the other hand, many of the region's 30 million swidden cultivators will benefit more directly if government help can be provided for intensification of farming in those areas where the transformation to permanent agriculture is needed, and if government assistance in other ways (for example, increased wage-labour opportunities) can be co-ordinated with agricultural development in regional programmes for the upland areas.

Towards intensification of land-use: opportunities and constraints

Agricultural terracing, mainly for wet-rice fields, and the inclusion of higher value cash crops such as rubber and pepper have become the established ways of intensifying land-use in swidden farming areas of South East Asia. Both measures have the common advantage of dealing effectively with grass and weed regrowth, by drowning or shading out the herbaceous vegetation which so quickly invades cleared fields in the humid tropics.

The successful experience of Dutch colonial administrators in Indonesia demonstrated the relative ease with which the transition from integral to supplementary swiddening could be achieved using rubber and pepper plantings.

On the other hand, the further transition from supplementary swiddening to smallholder production of commercial crops alone is considerably more difficult, as illustrated by the limited success of several land development schemes undertaken in south-west Sarawak during the 1960s. Iban supplementary swidders whose traditional farming system is centred on upland rice cultivation have not adapted easily to a smallholder commercial economy with each household tied to holdings of 4 ha, including 3.2 ha of rubber, and with neither land nor labour for the cultivation of upland rice in the old ways (Dixon 1973).

An alternative measure for agricultural intensification in the more accessible swidden areas, and having greater flexibility than tree cropping when market opportunities fluctuate, is the establishment of mixed-crop production on farmers' cleared fields, using bulldozers to remove the roots and stumps of former swidders. Any effort of this kind involves establishing rainfed permanent-field farming and facing the considerable hazards of soil erosion, nutrient depletion and vegetation regrowth... the reasons why shifting cultivation is practised. On the other hand, if these risks can be kept in check farmers stand to benefit in several ways: from the higher yields made possible by more efficient cultivation, using ploughs instead of hoes; from the ability to use land which was formerly locked up in the regrowth phase of the swidden cycle; and from the use of fertilizers. In Nan Province of northern Thailand the Thai-Australian Land Development Project is attempting a venture of this kind, in an area of heavy population pressure on supplementary swidden cultivation. It concentrates on areas of gentle slope (mostly under 3 degrees) where the costs of construction erosion control measures are relatively small. The long-term risks are that erosion control measures will be neglected and that the less industrious farmers will revert to bush-fallow cultivation, when wage-labour jobs or other opportunities become available. Improved tools, the development of suitable animal-powered equipment for ploughing and cultivating un-irrigated fields, and the introduction of improved seed are all ways in which the productivity of farm labour can be increased in this situation, to discourage reversion to swidden cultivation.

Thirdly, and spanning a much wider range in slopes and elevations, there is the time-honoured practice of agricultural terracing. The advantages of terrace construction as a means towards increased crop production are clearly visible, but the costs in heavy labour inputs are seldom so well recognized. The two outstanding constraints which deter farmers from terracing more widely are steepness of slope, combined with the physical efforts of terrace-building with only hand tools. If the constraints were not so severe we would no doubt find terracing more widespread, and swidden cultivation much less common in South East Asia. In Thailand, hill swidden communities have sometimes built terraces on slopes up to 10 degrees from the horizontal, but it has been estimated that a large part of the upland now under heavy population pressure from swiddening could be terraced efficiently using bulldozers, on slopes of up to 20 degrees (Keen 1973:82, 91). Even without elaborate improvements in the water supply for these terraces, rice yields can be 100 per cent higher than achieved by skilful swidders in the same village (Hinton 1970:16).

All three measures towards agricultural intensification reviewed here can be employed to good effect, but all are expensive in capital equipment or labour, or in the case of rubber smallholdings require financial support for farm households for six or seven years before the new farming systems becomes

productive. Consequently, an increased measure of government involvement appears to be essential if the transition from swidden farming to more productive agricultural systems is to be accomplished speedily, in areas of heavy population pressure. At the same time these development efforts need to be accompanied by clear legal arrangements regarding land tenure, to safeguard the individual or community ownership of terraces or other assets which occupy former swidden land.

The need for regional planning

The possibilities for increasing productivity discussed here are linked to two critical factors, steepness of slope and access to market services. The slope factor assumes major importance in defining the areas suitable for permanent-field plough agriculture (up to 8 degrees, with erosion control measures), or for terraced farming, orcharding and rubber planting (up to 30-35 degrees?), but whatever the specific limits may be in particular circumstances there is a clear need for agricultural planning in all the areas of swidden cultivation in South East Asia. Land capability classification, as a first step in the process of planned development, should be based primarily on slope rather than soil type, in recognition of the greater importance of slope as an indicator of agricultural potential in the humid tropics.

Agricultural planning by itself will be a worthless expenditure of effort unless it takes account of population growth, employment opportunities outside agriculture and the transport system on which economic development depends. Already, for example, some men from remote swidden communities in Mindanao or northern Thailand travel to lowland areas in their respective regions for seasonal jobs or longer-term employment. If these movements are to be further developed, so that real incomes can be increased in upland areas from both agricultural production and off-farm resources, effective regional planning is essential.

CONCLUSION

Earlier in this paper we noted that swidden agriculture was neglected for many centuries, while a long succession of technological developments increased the productivity of lowland agriculture. Improvements which began with better control of water and the use of draft animals have been followed, most recently, by the 'green revolution' in the best irrigated areas of South East Asia. Is there any prospect for a similar 'revolution' in un-irrigated tropical agriculture, including swiddening? Current research aimed at producing high-yielding varieties of upland rice, mungbeans *Phaseolus* spp. and other crops may help to increase the productivity of swidden farming, although the main benefits will be received in areas of rainfed permanent-field agriculture.

If this is the only radical improvement in the lot of shifting cultivators in South East Asia, over the next two or three decades, we shall have failed to take up the challenge presented by our greater understanding of swidden farming and its place in tropical forest ecosystems. We know the circumstances under which swidden cultivation can be a productive and continuing method of forest use; equally, we know the circumstances which lead to destruction of the specialized swidden ecosystems and how these can be avoided. This knowledge should be the basis of comprehensive regional programmes for the present and future economic development of agriculture

in tropical forest areas. If no action is taken, at the least the past policies of 'out of sight, out of mind' towards shifting cultivation will not be easily followed in the future: smoke from swidden clearings and the increasing extent of *Imperata* grasslands will see to that.

ABSTRACT

The extent of shifting or swidden (= burned field) cultivation, has never been accurately assessed in South East Asia. This method of converting primary and secondary forest to agricultural use is probably now practised by at least 30 million people, or 15-20 per cent of the region's rural population. Over the past two centuries swidden cultivation has expanded and become greatly diversified. It is most widespread in Sumatra and the Outer Islands of Indonesia, and secondly in the upland areas of Burma, Thailand and Laos. In both areas and in the Philippines the traditional 'slash and burn' agriculture, carried out in remote forested areas, has been overshadowed by the growth of *supplementary* swidden systems on the margins of permanent farming areas. In Sumatra, for example, most ethnic groups combine permanent-field farming with shifting agriculture; using swiddens for upland rice and cash crops, such as rubber and pepper, to supplement production from the permanent farmland.

Population pressure has led to a drastic shortening of the bush-fallow or forest-fallow period in the swidden cycle. Yet farmers commonly regard a cultivation/fallow ratio of 1:9 as minimal for the maintenance of yields; they recognize the importance of a quick succession from grass-shrub dominance to the dominance of woody vegetation on the former swiddens to avoid depletion of the swidden ecosystem and the establishment of *Imperata* grasslands.

Swidden productivity depends upon careful management of forest regrowth by the entire swiddening community, since mismanagement readily leads to the locking up of cultivable land in unproductive grasslands. As population pressure builds up, swidden farming is capable of increased productivity through better management and greater labour inputs, but the traditional measures for intensification of production are the construction of terraces and (over the past two centuries) the establishment of higher-yielding cash crops such as rubber, pepper, opium poppies and fruit trees in different ecological zones. There is scope also for Government assistance in the establishment of rainfed, permanent-field farming where population pressure is compelling the change to be made to more intensive agriculture, but only where slopes are gentler (below 8 degrees) and the erosion risks are reduced. This highlights the need for effective regional planning of the rural economy in all areas where swidden agriculture is practised.

REFERENCES

- ANDERSON, J. A. R. 1960. Research on the effects of shifting cultivation in Sarawak. In *Symposium on the impact of man on humid tropics vegetation*. Administration of the Territory of Papua and New Guinea, and UNESCO Science Co-operation Office for South East Asia. pp. 203-206.
- BROOKFIELD, H. C. and BROWN, P. 1963. *Struggle for land*. Melbourne, Oxford University Press.

- CHAPMAN, E. C. 1970. Shifting cultivation and economic development in the lowlands of northern Thailand. In *International seminar on shifting cultivation and economic development in northern Thailand*. Bangkok, Department of Land Development. pp. 226-250.
- 1973. Villagers as clients: a study of land development in northern Thailand. In *Studies of contemporary Thailand*, R. Ho and E. C. Chapman, eds. Canberra, Research School of Pacific Studies, Department of Human Geography, Australian National University. pp. 187-212
- CLARKE, W. C. 1966. From extensive to intensive shifting cultivation: a succession from New Guinea. *Ethnology* 5 (4): 347-359
- CONKLIN, H. C. 1957. *Hanunoo Agriculture: a report on an integral system of shifting cultivation in the Philippines*. Rome, FAO.
- DASMANN, R. F., MILTON, J. P. and FREEMAN, P. H. 1973. *Ecological principles for economic development*. John Wiley, London & New York.
- DIXON, G. 1973. Social problems in a planned village in Sarawak. Paper presented at 45th ANZAAS Congress, Geographical Sciences Section, Perth, Western Australia.
- FREEMAN, J. D. 1955. *Iban agriculture: a report on the shifting cultivation of hill rice by the Iban of Sarawak*. London, HMSO.
- GEDDES, W. R. 1970. Opium and the Miao: a study in ecological adjustment. *Oceania* 41 (1): 1-11.
- GEERTZ, C. 1963. *Agricultural involution*. University of California Press, Berkeley & Los Angeles.
- GORMAN, C. 1971. The Hoabinhian and after: subsistence patterns in South-east Asia during the late Pleistocene and early Recent periods. *World Archaeology* 2:300-320
- HINTON, P. 1970. Swidden cultivation among the Pwo Karen of northern Thailand: present practices and future prospects. In *International seminar on shifting cultivation and economic development in northern Thailand*. Bangkok, Department of Land Development. pp. 1-24.
- 1973. Population dynamics and dispersal trends among the Karen of northern Thailand. In *Studies of contemporary Thailand*, R. Ho and E. C. Chapman, eds. Canberra, Research School of Pacific Studies, Department of Human Geography, Australian National University. pp. 235-252
- JACKSON, J. C. 1968. *Sarawak*. London, University of London Press.
- KEEN, F. G. B. 1973. Upland tenure and land use in north Thailand. SEATO, Bangkok.
- KELLMAN, M. C. 1970. *Secondary plant succession in tropical montane Mindanao*. Canberra, Research School of Pacific Studies, Department of Biogeography and Geomorphology, Australian National University.
- KOMKRIS, T. 1970. Forestry aspects of land use in areas of shifting cultivation. In *International seminar on shifting cultivation and economic development in northern Thailand*. Bangkok, Department of Land Development. pp. 179-214
- KUNSTADTER, P. 1970. Subsistence agricultural economics of Lua' and Karen hill farmers of Mae Sariang district, Northwestern Thailand. In *International seminar on shifting cultivation and economic development in northern Thailand*. Bangkok, Department of Land Development. pp. 47-144.
- and CHAPMAN, E. C. 1970. Shifting cultivation and economic development in northern Thailand. In *International seminar of shifting cultivation and economic development in northern Thailand*. Bangkok, Department of Land Development. pp. 179-214.
- LEBAR, F. M. (Ed.) 1972. *Ethnic groups of insular Southeast Asia*. New Haven, Human Relations Area Files Press.

- NEWTON, K. 1960. Shifting cultivation and crop rotations in the tropics. *Papua and New Guinea Agricultural J.*, 13: 81-118.
- NYE, P. H. and GREENLAND, D. J. 1960. *The soil under shifting cultivation.* Farnham Royal, Commonwealth Agricultural Bureaux.
- PELZER, K.J. 1948. *Pioneer settlement in the Asiatic tropics.* New York, American Geographical Society.
- 1970. The swidden cultivator as producer of agricultural exports: an Indonesian case study. In *International seminar on shifting cultivation and economic development in northern Thailand*, Bangkok, Department of Land Development. pp. 383-405
- RAPPAPORT, R. A. 1971. The flow of energy in an agricultural society. *Scientific American* 224 (3): 116-133.
- SEAVOY, R. E. 1973a. The transition to continuous rice cultivation in Kalimantan. *Annals Assoc. Amer. Geogr.* 63 (2): 218-225.
- 1973b. The shading cycle in shifting cultivation. *Annals Assoc. Amer. Geogr.* 63 (4): 522-525
- SPENCER, J. E. 1966. *Shifting cultivation in southeastern Asia.* University of California Press, Berkeley and Los Angeles.
- STATISTICAL YEARBOOK, THAILAND, 28, 1967-69. Bangkok, National Statistical Office.
- WERNSTEDT, F. L. and SPENCER, J. E. 1969. *The Philippine Island World.* University of California Press, Berkeley and Los Angeles.
- ZINKE, P. J. SABHASRI, S. and KUNSTADTER, P. 1970. Soil fertility aspects of the Lua' forest fallow system of shifting cultivation. In *International seminar on shifting cultivation and economic development in northern Thailand.* Bangkok, Department of Land Development. pp. 251-293.

Session II: Summary of the Discussion

Short introductory statements having been made by the authors of Background Papers Nos. 4 and 5 (th author of Paper 6 was unable to be present at the conference), Prof. **Anwari Dilmy** asked to present a statement on the future of the forests of south-east Kalimantan, of which the following is a summary:-

'The region contains 300, 000 ha of peatswamp forest; 900, 000 ha of lowland 'food' or 'paddy'-belt, including 120, 000 of rice fields and 200, 000 of coconut, rubber and fruit; 600, 000 ha of lalang (*Imperata*) grassland, the so-called 'cattle'-belt; and 1, 200, 000 of Dipterocarp and other species forming the 'forest'-belt. Under the regional plan, 25% of the land is to be under forest, so about a sixth of the lalang area, or everything above 600 m altitude, will be reforested.

For the last 3 years the conversion of lalang into more productive cattle grassland has been under study and the preliminary report by Ir. Muhansjah of the College of Agriculture states that *Brachiaria decumbens* does well, being tolerant of low soil fertility and a 5-months dry season, if it is planted after *Imperata* has been ploughed up, since it grows faster than the *Imperata* can recover and suppresses it: the same applies to *Panicum maximum* and *Paspalum hexandrum* which yield respectively 7-12 and 12-18 tons per ha/year, as does *Paspalum plicatum*, while the leguminous *Centrosema pubescens* and *Stylosanthes guianensis* can also suppress lalang. On the other hand, *Paspalum dilatatum* and *Setaria fasciculata* have been unsuccessful. Using the better grasses about 1000 ha of good grazing have now been established and support 16 farmers with 100-300 cows each.

In 1974 the Provincial Government is importing 10, 000 Bali cattle, with the aim of allocating 10 per village per year and building up a meat export business. However, it is not the intention that the 500, 000 ha of lalang should be entirely allocated to stock-raising, and if the soil becomes more fertile parts will be used for cultivation and production forest.

Our President has also asked us to study the conversion of part of the peat-swamp forest to rice-growing, which experience over the past 75 years has shown to be possible if the peat layer is not thicker than 4 m. In the Second 5-year Plan, there is a project for establishing 100, 000-150, 000 ha of new ricefields between the Barito, Kapuas and Kahayan rivers. However, if the ecological balance of the peatswamp forest is to be maintained, some of it must be kept in reserve, so that its hydrological function, and value as a sanctuary for birds, crocodiles, monitors and other animals and, last but not least value for tourism, can be fulfilled. In any case where the peat layer is thicker than 4 metres, and the cultivation potential becomes marginal, reservation is the best land use.

In southern Kalimantan there are still about 3000 families of shifting cultivators, though a start has been made with settling them by mixing 10-20 of these 'nomad' families with new settlers from Java:Madura or more densely populated parts of south Kalimantan. We hope this will solve the shifting cultivation problem in about 10 years under the tutelage of volunteer lecturers, social workers and students who stay in the villages for six months at a time. ' (33)

The next matter to be considered was the format of the guidelines to be established on the basis of Dr. Poore's first draft and the discussions.

On the one hand, some feared that, as drafted, they were much too general, but **N. C. Gare** considered that they cannot be very specific if they are to be broadly applicable. It was eventually agreed that they would have to be considered individually and widened or narrowed in scope as necessary to achieve a satisfactory balance.

A. Dilmy: for the guidelines to have maximum positive benefits, the planners and decision-makers must be in close communication (as indeed were their representatives at this conference).

M.C.Downes: another aspect of communication is 'at the grass-roots' level, which implies that decision-makers take into consideration the traditional local practices and uses of resources, some of which are ecologically very sound.

M. E. D. Poore: there is a problem about what is the optimum size for reserves, since it could be argued that any size is too small: the sensible answer however is simply to make reserves as large as is politically and economically possible.

A. Kartahardja: a guideline is needed on the control of firewood cutters. (30)

A. I. Fraser: I would support fixing the amount of firewood on a per capita/annum basis, probably allowing about a cubic metre to be extracted per ha. The burning of cow dung and other organic matter for fuel as an alternative to firewood is an unwise use of something which ought to be put back into the soil. (30)

Kittinanda Sompherm: all such controls are really dependent on having a continuing monitoring system at national and international levels. (12)(23)

Soegiarto Aprilani: the essential steps in decision-making are to-

- a. define the problem(s) and set the objectives;
- b. gather all available basic and supporting data;
- c. make a preliminary assessment of the situation and predictions;
- d. formulate a 'final synthesis' in regard to management goals;
- e. make the decision;
- f. carry out field assessments to test predictions (monitoring); and
- g. continually re-evaluate decisions so as to improve the quality of such decisions when first made in the future.

Turning to the topic of shifting cultivation—both *Lee Peng Choong* and **Prijono Hardjosentono** advocated resettlement efforts to get people away from the practice, even of in the process the rights of those concerned should be respected. **J. W. Doyle**, however, noted that for some types of land shifting cultivation may be the best use and **M. E. D. Poore** considered that there was no *ecological* reason why indigenous systems of shifting agriculture which were in reasonable balance should not be allowed to continue: however, when stability is disturbed, ecological damage inevitably occurs. (32)(33)

J. D. Ovington: the land use of indigenous people should never be ignored: civilised people should always try to accommodate such traditional usage and the people who practise it and to avoid sacrificing them. (34)

S. Tago: in Papua New Guinea the government is trying to integrate modern crops and techniques with traditional habits. (33)

B. C. Agaloo: settled shifting cultivators in the Philippines have caused problems by drifting back to their original highland forest areas, accompanied by lowlanders from the settlement areas. The government has now had to place strict limits on areas of land which may be used for shifting cultivation.

K. J. White: guidelines are needed to cover the productivity and not just the protection of tropical forest areas. (27)(28)(30)(31)

A. I. Fraser: it would be useful to supplement appropriate guidelines by a checklist of factors which need to be considered when trying to apply them. (15)(75)

H. A. Nix: Such a checklist could well show what are the absolutely minimum data required for development planning at the local, national and regional levels.

Didin S. Sastrapradra: returning to shifting cultivation and the suggestion implied in the draft guideline that it can sometimes constitute a stable form of land use, I do not believe that this is ever the case in Indonesia.

Soekisno Hadikoemoro: in support of that last remark, an example can be quoted from West Irian, where despite the fact that the human population is low and, therefore, as Prof. Soemarwoto has suggested, there should be no pressures to prevent a stable system of shifting cultivation to be continuously maintained, there is a trend towards the shortening of the fallow period which is definitely causing soil degradation.

M. E. D. Poore: the authors of background papers 5 and 6 both reached the conclusion that stable shifting cultivation can and does exist. Clearly, when the way in which it is practised is not in harmony with the environment, as in the example just quoted, in which the fallow period becomes too short for fertility to be restored, it needs to be discouraged and this can be brought out and the need for great care in avoiding environmental degradation duly emphasized, by splitting the draft guideline into two parts. (32)(33)

SESSION III

Transformation of Forests to Forestry Plantations and Agriculture

The Chair was taken by Dr. Jose I. Furtado and Prof. Dr. J. H. Koeman acted as rapporteur.

Professor Koeman also contributed a background paper for the Session, dealing with some of the problems involved in the use of agricultural chemicals. The session was prefaced by his summary of the main points in this paper and also by general introductory remarks by panel-members Dr. D. M. Ramsay and Mr. L. S. V. Murthy.

Session III: BACKGROUND PAPERS. No. 7**Problems Associated with the use of Agricultural Chemicals**

J. H. KOEMAN

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INTRODUCTION

It is to be expected that in many developing countries the use of agricultural chemicals will increase markedly in the forthcoming years in order to improve the productivity of the natural resources. According to Perfect (1972), who quotes calculations based on data from FAO production yearbooks, pesticide use would need to increase some 70-85 times for productivity to rise fivefold. Likewise the use of fertilisers will also increase appreciably, one reason, for instance, being that many of the high-yielding varieties of rice and wheat have a much higher fertiliser demand than the strains which were grown formerly. However, it has become well known about the last 20 years that extensive applications of agricultural chemicals may also give rise to detrimental environmental effects, much as damage to other resources like fisheries and a general deterioration of natural ecosystems. It has been stressed (Odum 1969) that man has generally been preoccupied with obtaining as much 'production' from the land as possible, thereby tending to neglect the many protective functions natural ecosystems have. In this way the latter values could become seriously endangered by further developments. It is the aim of the present paper to provide some guidelines for the selection of chemical methods which will minimize environmental damage. Attention will be given especially to pesticides. Some remarks will also be made on fertiliser applications.

GENERAL CONSIDERATIONS

Particularly with respect to pest control in agriculture, it should be the purpose of future studies to devise control methods which are injurious to so-called uneconomic species, the 'plague organisms', but relatively harmless to economic species. Here 'economic species' not only include crops and other agricultural products, but also the many species of plants and animals which form part of the protective ecosystems referred to. Although it is to be hoped that really selective, chemical or biological, methods will be developed in due course, it is most likely that, at least for some years to come, pesticides will have to be used which are not perfectly selective in their mode of action. Therefore one should try to use these chemicals as selectively as possible. In this connection it is important to mention that the environmental hazard a pesticide may represent is not only related to its toxicity with respect to various taxonomic groups of organisms, but also depends strongly on the likelihood that non-target organisms will get exposed to a toxic dose. An important prerequisite in the selection of pesticides which are safe from an environmental point of view, therefore, is to be able to judge the probability that other organisms than the species to be controlled will be in contact with the compound concerned. One should know the possible interactions of

pesticides with the environmental factors such as soil, water micro-organisms and higher organisms, and the way in which these interactions can be modified by technical means. The final aim could be to design computer models which can be used to predict the environmental fate of a pesticide under various environmental conditions. However, at present the information available is generally too limited to draft appropriate models through which the computer can produce the adequate answers. Nevertheless the descriptive models, which are already useful today, will gradually develop into mathematical models as more data on the variables involved become available.

The ability to predict hazards which may result from pesticide applications depends on a proper judgement of a large number of parameters. These can be grouped in three categories according to the successive phases which characterize the fate of a chemical in the environment, viz. the exposure phase, the kinetic phase and the dynamic phase. The first one defines the way in which the environment gets exposed to the chemical in first instance, the second phase describes the movement of the chemical through the environment, and the last one, the dynamic phase, is indicative for the final toxic reaction with certain organisms. Some of the most relevant parameters are listed in Table 1.

TABLE 1

Some of the major parameters to be judged for the prediction of the environmental safety or hazards of pesticide applications.

Phase	Parameter
Exposure phase	Formulation used Application procedure Dose-rate Frequency of application. Area covered Target treated
Kinetic phase	Water solubility Soil adsorption Physico-chemical conversion Biological conversion Biological turnover in organisms Trophic transport
Dynamic phase	Acute toxicity Chronic toxicity Effect on reproduction Mutagenicity

THE EXPOSURE PHASE

Pesticide applications generally aim at optimal transfer of the compound to the object to be protected or controlled. For this purpose a wide range of technical procedures has been developed. Since the possible occurrence of negative side-effects not only depends on the type of pesticide used but also on the methods of application, some remarks will be made on these procedures.

Formulation and Application

In general, pesticides are never applied in their chemically or technically pure form, but as mixtures in combination with various auxiliary ingredients. These formulations can be either solid or wet. To the former belong the granular formulations and baits, while the latter make up the formulations used for spraying.

Granular formulations are sometimes used for the application of pesticides in the aquatic environment, for instance for the control of aquatic weeds. From an environmental point of view the advantages of granular formulations over sprays are: a better localization, the reduction of drift to adjacent areas, and generally the avoidance of excessive concentrations at the time of application and shortly afterwards. However, the prolonged presence of the compound due to the gradual release from the granules may under certain circumstances be disadvantageous. The application of pesticides in baits can be particularly hazardous when these are not only taken up by the pest organisms, e.g. snails, ants or rodents, but also by other species. Sometimes this hazard can be reduced by a proper deposition of the baits, for instance by placing them in the entrance of the burrows in the case of rodents. To some extent the dressing of seeds with pesticides should also be considered as a bait formulation because generally it cannot be avoided that, after sowing, part of the seed will be consumed by granivorous birds and mammals. This aspect will be discussed more extensively under *The Target Treated* below. Sprays can be made up in various ways. The most common formulations being solutions in oil or water and suspensions or emulsions of respectively wettable powders and emulsifiable concentrates in water. The environmental persistence and mobility of a pesticide can be influenced markedly by the type of formulation applied. Oily formulations, for instance, promote the penetration of the pesticide through leaf surfaces and therefore diminish the chance that appreciable amounts run off.

In considering the possible side-effects of pesticide applications, attention should be given also to the equipment used. Factors such as droplet size and spraying volume significantly affect the radius of action of the spraying activities. Moreover it will make a big difference whether for instance handspraying equipment, like knapsack sprayers, is used or aircraft. Generally with aerial spraying the application is far less selective than with groundspraying. It could be recommended that aerial spraying should not be allowed in areas close to places where pesticides could have undesirable environmental effects.

Dose-rate and Frequency of Application

The dose-rate applies to the amount of pesticide which is required to destroy most or all individuals of a pest species within a certain area. It need not be stressed that one should always select the minimum dose level which is just sufficient to get the desired effect. However, it still regularly happens in many countries that serious environmental damage occurs as a consequence of overdosing. In order to minimize the dose-rate, a proper use should be made of the formulation and application techniques referred to above under *Formulation and Application*.

The persistence or residence time of a pesticide in the environment, e.g. the length of the period during which the compound is present in a significant concentration, strongly depends on both the dose-rate and the frequency of application. There is a general tendency to relate the possible environmental

persistence of a pesticide mainly to its molecular stability. In this connection the organochlorine pesticides are for instance generally labelled as persistent, and other pesticides, like the organophosphorous compounds, as being non-persistent. However, there are agricultural areas in the world, for instance in the Netherlands, where the latter compounds are present in measurable concentrations at any time of the year. It should be realized that the persistence of a chemical in the environment reflects a steady state condition which is not only related to the degradability of the compound but also to its rate of entry.

The Area Covered

In most cases the pest species to be affected are not randomly distributed, but are confined to certain localities like the soil, a special plant or a peculiar habitat. Pest control will be most selective when only these localities are submitted to pesticide applications. However, for economic reasons the so-called coverage sometimes markedly exceeds the distribution limits of the pest species. For instance, in tsetse control operations in Africa, optimal advantage can be taken of the extensive ecological knowledge about the tsetse fly. It was found that the flies can be eradicated by applying pesticides in a very discriminatory way. Using knapsack-sprayers pesticides are applied to part of the potential resting-sites of the flies, namely tree trunks, branches, creeper tangles and aerial root systems to a height of about three feet. It will be obvious that a switch over to aircraft for tsetse control gives rise to a much higher coverage and therefore increases the chance that undesirable side-effects will occur.

Apart from the relative coverage, viz. the proportion of an area which is actually treated with a pesticide, it is also important to consider the total coverage, namely the total surface treated within one pest control operation. Particularly in large scale operations, like for instance the extensive spraying operations which took place in Indonesia in connection with the so-called BIMAS project (e.g. Beers 1970; Gorbach *et al.* 1971), there is some likelihood that the application will cover the whole or almost the whole geographical range of various species of organisms one wants to preserve. In connection with tsetse eradication programs in Africa it was recommended that the size of areas treated with insecticides during one season should be kept within the limits of the ecosystem concerned in order (a) to prevent the extermination of local species or races, and (b) to allow the reoccupation from adjacent still untreated areas (Koeman *et al.* 1971). This principle is also applicable to other types of pest control operations.

The Target Treated

Pesticides can be applied to the soil (e.g. nematicides), water (e.g. molluscicides, larvicides) or plants (e.g. herbicides, insecticides, fungicides) depending on the plague one intends to control. The range of dispersion of a pesticide and the number of species which will be exposed also depends on the type of target treated. Generally the environmental distribution of the pesticide and the numbers of organisms exposed will be relatively small in the case of soil applications and relatively large when aquatic ecosystems are treated directly. An application of special concern is the fungicidal or insecticidal treatment of seed for sowing. In many countries of the world wild animal populations have suffered severely from seed-dressing applications. The pesticides mostly concerned are the organochlorine insecticides aldrin and dieldrin, the organophosphorous insecticide parathion and the alkylmercury fungicides.

These applications may give rise to primary intoxications in many species of granivorous animals and secondary poisoning of scavengers and other predators. For the treatment of seeds of rice, wheat and other crops pesticides should preferably be selected which have a relatively low acute toxicity for birds, mammals and other vertebrates. This will at the same time diminish the likelihood of mass mortalities in man due to the abusive use of dressed seed for making bread. Many incidents of this kind have been reported in recent years, e.g. alkylmercury poisoning in Ghana and Iraq in 1967 and 1972, respectively (Bakir *et al.* 1973; Derban 1974).

THE KINETIC PHASE

The kinetic phase refers to the pathways along which pesticides and their derivatives (e.g. metabolites and photoconversion products) move through the environment. Again a number of key-parameters can be distinguished.

Water Solubility and Soil Adsorption

A good water solubility generally implies that a pesticide will be very mobile in places where transport in the water phase is possible. The advantage can be that the pesticide is diluted quickly to a non-toxic level. On the other hand a disadvantage could be the relative large soil mobility some of these compounds have, which may give rise to leaching of the pesticide into the drainage water and the subsequent contamination of streams and canals. Soil adsorption also markedly affects mobility in the soil as well as transport in the environment in general. A strong binding of a pesticide to the clay and organic matter components of the soil immobilizes the compound and in most cases virtually eliminates its biological activity.

Physicochemical and Biological Conversion

Most pesticides are transformed under the influence of a large number of abiotic and biotic environmental factors such as water, oxygen, ultraviolet light, temperature, inorganic catalysts and the enzymes of many species of living organisms.

Fortunately the transformation of pesticides mostly results in the complete inactivation of the compound. However, occasionally activation may occur in the first instance at a certain conversion step such as the oxidation of parathion to paraoxon. Another example is the modern fungicide benomyl which is activated by hydrolysis to BCM (methyl 2-benzimidazole carbamate). The biochemical breakdown of pesticides is particularly dependent on the composition of the microflora and fauna and various environmental conditions such as pH, temperature, humidity and oxygen tension. For instance the pesticide lindane is broken down more readily under anaerobic than aerobic conditions (Hill and McCarty 1967). It is therefore necessary to consider the local conditions before predictions can be made about the metabolic fate of pesticides in a certain part of the environment. There are indications that many pesticides may be broken down quite readily in the anaerobic mudlayer in the ricefields which form such an important agro-ecosystem in South East Asia. Moreover it is very likely that the high ambient temperatures in the humid tropics as compared to the temperate regions will generally increase the rate of biochemical degradation.

Biological Turnover in Organisms

The Biological turnover in organisms here refers to the processes of absorption, distribution and elimination. Elimination not only includes the excretion of a chemical compound, but also its possible metabolic inactivation. Of toxicological importance is the ultimate internal load which will be brought about when organisms are exposed to pesticides. The final tissue concentrations reflect the balance between the rate of uptake, the degree of tissue binding and the rate of elimination. As a rule of thumb lipophilic pesticides, e.g. pesticides with a relatively high oil/water partition coefficient, are more easily taken up by living organisms than hydrophilic water-soluble pesticides. The former type is able to penetrate directly through membranes like the skin, the gills and the intestinal wall. The final tissue level markedly depends on the ability of the organism to metabolize and excrete the compound. The metabolic capacity can differ appreciably from one species to another. Experimental studies have shown that cold-blooded animals are on the whole less capable in this respect than warm-blooded animals (Dewaide 1971). However, it cannot be excluded that at the high ambient temperatures in the tropical environment the microsomal enzyme systems may be more active. At present no detailed information is available about the metabolic capacity of various animal groups in the tropical environment.

Trophic Transport

Particularly in connection with the organochlorine pesticides much attention has been paid in recent years to the process of trophic accumulation of pesticides in so-called food chains. Food chain accumulation mainly depends on two factors: (a) the biological turnover in the successive species in the food chain (see *Biological Turnover in Organisms*), and (b) the ecological relationships between the species. Accumulation is likely to occur mainly with pesticides which are easily taken up by organisms, but not readily eliminated and in trophic systems which are characterized by specialized predator-prey relationships.

THE DYNAMIC PHASE

The dynamic phase reflects the final toxic reaction of pesticides with living organisms. The sensitivity for pesticides can differ markedly among different species or different taxonomic groups. Some examples of acute toxicity data (median lethal concentrations and doses) for a number of pesticides with respect to crustaceans, fish and warm-blooded animals, are summarized in Table 2 (data from Jung 1973). The peculiar susceptibility of certain species or groups should be taken into consideration in connection with the selection of pesticides for pest-control programs. With reference to fish and invertebrates, information has so far been collected mainly on the acute toxicity of pesticides and other chemicals (e.g. Muirhead Thomson 1971). Particularly in cases where long term exposure of for instance fish and fish food organisms is likely to occur, chronic toxicity data will also be required. This should include information on possible effects on reproduction, on mutagenicity and teratogenicity and other special effects. As far as warm-blooded animals are concerned, one can rely in the first instance upon the already existing toxicity data, which chemical companies must submit to governmental authorities in various countries before applications can be approved officially. This information generally includes acute and chronic toxicity data for species like rats, mice, dogs and sometimes birds, while

acute toxicity data are provided for fish. Moreover valuable information is contained in the monographs which are regularly published by the joint FAO/WHO expert groups on pesticides.

TABLE 2.

Acute toxicity data (median lethal concentrations and doses) for pesticides with respect to crustaceans, fish and warm-blooded animals.

Pesticide	Toxic concentration $\mu\text{g/L}$			Toxic dose mg/kg b. wt	
	Crustaceans		Fish		Warmbl. animals
<i>Organochl.pest.</i>					
Lindane	48-	400	18-	10,000	40- 500
DDT	0.36-	100	2.1-	10,000	10- 500
Dieldrin	10-	1,400	3.4-	125	5- 500
Endrin	1-	20	0.2-	1,000	1- 50
Thiodan	5-	240	0.1-	30	24- 500
<i>Organoph.pest.</i>					
Parathion	0.4-	12	10-	10,000	0.17- 32
Diazinon	0.9-	800	30-	5,300	32- 1,150
DDVP	0.07-	18	700-	10,000	5- 500
Malathion	1-	100	2.3-	29,400	50- 500
<i>Carbamates</i>					
Carbaryl	0.8-	40	1,000-	13,000	2.8- 700
Barbane	3,000		530-	1,300	240- 5,000
<i>Herbicides</i>					
2,4,5-T	730		590-	60,000	100- 5,000
Diuron	160-	40,000	100-	350,000	500- 5,000
Paraquat	3,700-	100,000	1,000-	135,000	5- 500
Trifluralin	240-	8,800	10-	13,200	2,000-10,000

THE OVERALL JUDGMENT OF PESTICIDE HAZARDS

By a proper judgment of the different phases and parameters discussed, and supposing that adequate information is available on the biological and other environmental conditions in and around areas to be sprayed, one generally will be able to predict the major hazards which could arise from pesticide applications. This will at the same time provide an opportunity to select those

pesticides and application methods which are least likely to cause undesirable side-effects. It must be mentioned that many environmental casualties with pesticides which have occurred in the past, like large scale mortalities of fish, birds and other animals, could easily have been predicted if the parameters outlined in the present paper had been taken into account beforehand. However, for a full assessment of the environmental hazards, additional toxicological studies may be required, for instance to measure the rate of biodegradation of pesticides under certain special environmental conditions as mentioned under the heading *Physicochemical and Biological Conversion*. A general recommendation could be in this connection that every large scale pest control operation will be guided by retrospective epidemiological studies by means of chemical and biological monitoring techniques. In this way unexpected effects can be discovered at the earliest possible moment. It need not to be stressed perhaps that scientists involved in studies of this kind should be skilled biologists, able to detect subtle changes in the ecosystems concerned.

SPECIAL HAZARDS IN THE HUMID TROPICS

The different structure of tropical ecosystems as compared to those in temperate regions implies that the toxicological data obtained in the latter cannot generally be used without qualification to assess the risks of pesticide use in the tropical environment. In comparison with temperate ecosystems the following generalizations can be made for the humid tropics:

- (a) at about equal levels of ecosystem maturity, species diversity, species equitability (evenness in the apportionment of individuals among the species) and food-web complexity are higher in tropical ecosystems (Paine 1966; Pianka 1966; MacArthur 1969);
- (b) seasonal cycles are generally less important; and
- (c) the rate of degradation or disappearance of pesticides will be higher as a consequence of various factors such as those mentioned under *Physicochemical and Biological Conversion*.

Some of these conditions will diminish the risks involved in the use of certain pesticides as compared with in temperate regions, e.g. (c) above, while conversely others could be worse, e.g. specialized trophic relationships.

As mentioned under the heading *The Area Covered*, when large areas are treated, for instance by aerial spraying, irreversible damage may occur because certain species are affected over their whole range of distribution. On these grounds a number of tropical ecosystems can be distinguished which could be damaged seriously by large-scale pesticide applications, for example: (a) mangrove swamps, (b) highland streams, (c) localized lake systems, (d) mountain forests, (e) islands and (f) specially protected areas like national parks and game reserves.

A special remark should be made on the wet rice agro-ecosystem. In many parts of South East Asia rice is cultivated in areas where fisheries interests are also important. In former times the use of certain pesticides which are highly toxic for fish such as thiodan and endrin has regularly caused serious fish mortality in various countries (see Kok 1972). If it is decided that fish should be preserved in these areas pesticides should be selected or application techniques be designed which will prevent this effect. Furthermore there are documented cases of intentional misuse of certain pesticides in

tropical rivers and lakes to catch fish. Such an incident took place in the Alas river in North Sumatra in August 1973, where endrin levels of about 1 mg/kg fresh weight were recorded in the tissues of the fish. It will be obvious that whole fish populations may be threatened seriously in this way.

A major hazard for the future could be the ever-increasing use of herbicides in agricultural practice (see Kasasian 1971). Although most of these compounds are generally not very toxic for animals, their destructive effects on the vegetation could very well result in undesirable secondary effects on other organisms. For instance, various fish species are dependent on certain submerged weeds for the deposition of their eggs. Many beneficial insects will not be able to complete their lifecycle when certain plants fail to be present.

This type of secondary effect may also occur when large amounts of fertiliser are introduced in certain areas. Particularly when it is likely that their application will give rise to eutrophication of adjacent waters, the species composition in these places may alter drastically.

REFERENCES

- BAKIR, F. *et al.* 1973. Methylmercury poisoning in Iraq. *Science* 181: 230-241.
- BEERS, H. E. (ed.) 1970. *Indonesia. Resources and their technological development.* The University Press of Kentucky, Lexington, U.S.
- DERBAN, L. K. A. 1974. Outbreaks of food poisoning due to alkylmercury fungicide. *Arch. Environ. Health* 28: 49-52.
- DEWAIDE, J. H. 1971. Metabolism of xenobiotics. Thesis. Nijmegen.
- GORBACH, S., HAARRING, R. KNAUF W. and WERNER, H. J. 1971. Residue analyses in the water system of East Java after continued large-scale application of Thiodan in rice. *Bull. Environ. Contamination Toxicol.* 6 (1): 40-47
- HILL, D. W. and McCARTY, P. L. 1967. Anaerobic degradation of selected chlorinated hydrocarbon pesticides. *J. Water Poll. Contr. Fed.* 39 (8): 1259-1277.
- JUNG, K. D. 1973. Extrem fisch toxische Substanzen und ihre Bedeutung für ein Fischtest-Warnsystem. *G. W. F.* 114 (5): 232-234, and special tables distributed by the Hygiene-Institut des Ruhrgebiets, Gelsenkirchen, Germany.
- KASASIAN, L. 1971. *Weed control in the tropics.* Leonard Hill, London.
- KOEMAN, J. H., RIJKSEN, H. D., SURIES, M., NA'ISA, B. K. and MACLENNAN, K. J. A. 1971. Faunal changes in a swamp habitat in Nigeria sprayed with insecticide to exterminate *Glossina*. *Neth. J. Zool.* 21 (4): 443-463.
- MACARTHUR, R. H. 1969. Patterns of communities in the tropics. *Biol. J. Linn. Soc.* 1: 19-30.
- MUIRHEAD THOMSON, R.C. 1971. *Pesticides and freshwater fauna.* Academic Press, London, New York.
- ODUM, E. P. 1969. The strategy of ecosystem development. *Science* 164: 262-270.
- PAINE, R. T. 1966. Food web complexity and species diversity. *Am. Naturalist* 100: 65-67
- PERFECT, J. 1972. Insecticide use in the tropics. *Biologist* 19 (3): 149-151.
- PIANKA, E. 1966. Latitudinal gradients in species diversity: a review of concepts. *Am. Naturalist* 100: 33-46.

Session III: Summary of the Discussion

The discussion began with general recognition that in South East Asia, as elsewhere, much transformation of forest land is inevitable. The responsibility of ecologists is to try to ensure that proper controls are applied to the process, so that it results in the least possible degradation of the human environment.

Mrs. Sri Soewasti Soesanto: it is equally important that ecologists should endeavour to secure the retention of adequate samples of all types of habitat in their original state. This involves the problem of preventing settlement in too close proximity to critically important areas. For example, if people are allowed to settle near marshland, there is bound to be a health hazard unless pesticides are used to control mosquitoes, and this will adversely affect the biological productivity and other values of the marsh. (14)(18)(55)(77)

Achmad S. Sarnita: such considerations raise all the issues mentioned in Paper 7 about the use of persistent chemicals, the disposal of residues, the danger of over-application of pesticides and the difficulty of ensuring that they are used at an optimum level. It seems to imply that it may sometimes be necessary to restrict agricultural production and hence the run off of toxic chemical residues from the land, so as to prevent contamination of a watershed and damage to fish stocks. (58)(68)

J. H. Koeman: the most acute problem is to find ways to lessen a delayed reaction to a gradual accumulation of pesticide residues. Hence the constant need to find formulations that are not hazardous to non-target fauna or flora, or, alternatively, to devise some method of capsulating or 'time-release' of pesticides, to reduce the possibility of a build up to toxic levels which could affect a wide spectrum of living things. (61)

Lee Peng Choong & H. A. Nix: the question of the input of fertilizer and energy also needs to be carefully examined and we should avoid suggesting in the guidelines that high productivity can only be achieved by confining agriculture to areas of very high natural fertility, which tend to be limited in number and extent. We must recognize the needs of those who are trying to make a living and raise the level of productivity in places where this can only be done by high energy and fertiliser input. (15)

R. G. Downes: the guidelines should be considered as pointing the way to the objectives that are ecologically desirable. This does not mean that they are, in any sense, 'rules' or 'laws' intended to prevent the use of pesticides, fertilisers or energy, but rather that they indicate that it is good ecological sense to prefer an agricultural system which relies on low inputs of these things. (39)

Kittinanda Sompherm: one of the dangers in the transformation of forestland is that extensive clearing, frequently followed by a strong trend towards monoculture, can easily lead to an upsurge of insect damage, as seen in many teak and rice-growing areas of Thailand.

In answer to a question by **Lee Peng Choong**, about the possible loss of fertility and hence productivity brought about by soil disturbance in the process of terracing, the consensus was that, although initially there was some deterioration (since most nutrients would have been concentrated in top soil layer), this could be temporarily compensated by fertiliser application and, in the long-term, the prevention of erosion and stabilizing the soil through terracing was quite certainly advantageous. (37)

H. Haeruman: we need guidelines to cover the critical need for rapidly expanding production to meet world food shortages. In Indonesia this need has already led to governmental support for the conversion of tidal mangrove forest into agricultural land, a process that is very expensive in terms of fertiliser and energy input. (47)(50)

Glenn H. Robinson: it is imperative that the process referred to, which also extends to peat swamp forest, should be combined with proper control of water levels and of burning, to prevent excessive shrinking and loss of soil. It is also necessary that the chemical composition of the soils involved should be determined in advance, so that management practices can be adjusted accordingly. (47)(75)

N. P. Knott: turning again to a topic which perhaps is more relevant to that of the previous Session, the 'Forest as a Resource', although it may also sometimes involve a more or less significant degree of 'Transformation', I feel there should be a guideline on the subject of wildlife production. There are several examples of this in South East Asia and also many further possibilities for wildlife management on a basis of semi-domestication, whether by way of captive-breeding or of a 'Lapp/Reindeer' type of activity, using such species as bateng. (45)

M. C. Downes: in Papua New Guinea wildlife management seeks a balance between production and conservation, the raising of domestic or domesticated livestock in the villages and the exploitation of the wild animals of the forest on a sustained yield basis. Species which have been handled in this way have included wallabies, cassowaries and crocodiles. (42)(45)

M. E. D. Poore: any guidelines on this topic will have to be allocated to two different sections—sustained yield cropping to 'Forest resources' and domestication of wild animals to 'Forest transformation'. (27)(29)

L. S. V. Murthy: I think it will have to be recognized, however, that humid tropical forest is not of very great value from the point of view of wildlife production.

Anwari Dilmy: that would certainly not apply to Kalimantan where, with a low human population, we have a very good stock of wild pig, deer and buffalo, the first-named being a pest species since in this predominantly Muslim area it is not used as food. The only species, however, which is exploited and exported on a fairly large scale is a domesticated goose. (29)

A. I. Fraser et al.: waterflow is affected by logging activities, and it is important to remember that in Asia water is just as much a resource as timber. This needs to be reflected in guidelines, which should also draw a clear distinction between running water and the static water supplies of lake, reservoir and swampland. The common practice of converting marshland into cultivated land, already referred to by Mrs. Sri Soewasti Soesanto, should also be considered and covered. (47)

Mrs. Sri Soewasti Soesanto: the point I particularly wanted to make is that, wherever water is scarce, human needs and uses of it should always have priority, which would not be the case if drainage and transformation to agriculture is allowed. (48)(50)

N. P. Knott: many streams and small rivers in Asia are naturally infertile because of the impoverished soils through which they flow, but silt from erosion and organic detritus may still make them, locally, of a high potential for fish production, provided they are reasonably unpolluted. Management of

this resource, therefore, needs to be keyed in with cultural practices and pollution control. (52) (55)

L. S. V. Murthy: this also raises the question of the proper control of herbicides and pesticide seed-dressings, both in relation to methods of application and the assessment of direct and indirect toxicity. (60) (63) (68) (70)

Cheah Leong Chiew: some progress is being made in Peninsular Malaysia in developing better and less objectionable (because more specific) arboricides and methods of application. (60)

A. Hekstra: it is worth pointing out that the use of herbicides and arboricides is often dictated by a hope of reducing labour costs, and in populated areas with high unemployment this trend should if possible be resisted.

SESSION IV

Infrastructure, Engineering Works, Land Industry

The Chair was taken by Mr. Kittinanda Sompherm and Dr. M. Makagiansar acted as Rapporteur.

In the absence of a background paper, Dr. Makagiansar gave a stimulating introduction to the Session, of which the following is a summary.

It was fundamental to the application of ecological principles to economic development that goals should first be defined and this required the consideration of alternative life styles. A development model was needed and the missing link in the process of providing one was the contribution of the social sciences. Any realistic model should show the interdependence of the social sciences with the physical and biological sciences. Hitherto there has been too little communication between them.

Dr. Makagiansar compared the characteristics of the old and new models of development. The old, with its emphasis on growth of GNP, the flow of technology and capital intensive development with industrialization as a prerequisite, had often led to increased disparity between the rich and the poor. The dangers of this were now apparent as the limits of the resilience of ecosystems were being reached. The social sciences therefore had a crucial part to play in the development of tropical forest regions.

In contrast, the new development (the 'ecodevelopment' advocated by Maurice Strong of the U.N. Environment Programme) must depend upon a sensitive perception of goals and methods, and utilization of resources carefully related to the resiliency of the ecosystem.

It followed that any guidelines must at this stage be tentative ('guidelines for guidelines') and adapted to local circumstances. This new approach—

1. required redefinition of life styles;
2. presumed an interdisciplinary approach centred on man;
3. should not only be oriented to basic needs; but
4. should also involve a continuing attempt to establish relations between growth patterns and social and cultural institutions;
5. should incorporate environmental quality in every stage of the development process (necessitating a link between education and the environmental conditions of those being educated); and
6. required a futurological outlook but one that recognizes the presence of ultimate limits.

Session IV: Summary of Discussion

A. Karahardja: in this Session we turn from shifting cultivation to the problem of shifting civilisation, or what to do now and in the future with human settlement. The question is whether something of the simplicity and freshness of the rural scene can be brought into urban areas or whether the polluted atmosphere and noise of the cities will be allowed, with the industrialisation of agriculture, to invade the countryside. Nothing can now stop the flow of villagers to the towns and the flow of industry to the country unless a balance can be achieved by good planning. In this connection it is worth recalling the principles laid down by Sir George Stapledon in his book on 'Human Ecology' (see the second edition edited by Robert Walker, and published by Charles Knight & Co., London, 1971), which can be summarised as follows:

1. industrial production should be based as far as possible on renewable resources;
2. productive industries must be designed on a biological model so that residues and wastes are recycled;
3. the soil must be treated as a living material;
4. a high proportion of mixed farming must be legally enforced;
5. nutrition should be treated as the foundation of health;
6. a proper balance between urban and rural must be established; and
7. economic arguments must never have priority over ecological arguments.

I hope that attention to these principals will help us in developing guidelines from this Session.

Soemirat Slamet: I am rather disturbed by the assignment of 'Priorities' as between economics and ecology in the last of the principles just quoted. The two should be integrated and not treated as separate sciences. (70)

M. Makagiansar: it has to be realised that in so-called developing countries, the momentum comes from the process itself but also from the urge to escape from poverty.

R. G. Downes: we do not want to get into the position of having superficial studies of many supposed environmental effects of every development project. What is really wanted is an institution with environmental perceptiveness, skill and integrity, in which people have faith and which not only decides on which projects should be subject to close scrutiny but also the particular kinds of studies to be made, if necessary in considerable depth, so that the environmental effects can be properly assessed for the decision-makers.

A. I. Fraser: of all the aspects of 'Infrastructure' perhaps road building has the greatest ecological impact (bringing about such things as settlement, indiscriminate clearing, hunting, recreational uses and fire hazards) and needs special attention.

R. G. Downes: the important principle is that roads by themselves should not be allowed to determine the land use of the areas through which they pass.

A. Dilmy: but this is almost inevitable in the case of forest land unless the road is built round its border and not through the forest. (73)

M. E. D. Poore: perhaps the answer which should be incorporated in guidelines is that road-siting must be part of a regional development plan, construction up to best engineering standards, and continual monitoring maintained of the effects, in both the short and long-term, with such remedial measures as may be necessary. (72)

R. G. Downes: the trouble is that some mistakes are inevitable and, although the damage can sometimes be repaired, it is more usual that we have to live with them. Guidelines can do little remedy the ills produced by past development, since they are essentially concerned with the planning and execution of new development.

H. A. Nix: the important principle is that the cost of monitoring its environmental effects should be included in the basic cost of every project. (76)(77)

The ensuing discussion, in which many participated, tended to concentrate on water development schemes and the need to assess, monitor and plan the necessary measures to meet such effects as the overall impact of an impoundment on a river system, including sedimentation, management of the surrounding vegetation, treatment of decomposing vegetation submerged by an impoundment, eutrophication, fish introduction, and the development and utilisation of recreational, touristic and wildlife values. It was emphasized that these matters should receive attention throughout the affected watershed or river system and not just in and around the reservoir or other major waterwork constructed. (74)(75)(79)(80)

The other main topic discussed was the resettlement of human populations displaced from areas inundated in these projects. This was recognized as presenting formidable social and environmental problems and illustrated mainly by experience in Indonesia. Some speakers regarded the resulting transplantation of populations as presenting great social dangers, others as something quite inescapable which in fact offered great opportunities, of which the benefits far outweighed the disadvantages.

A. Dilmy quoted his personal experience of the resettlement of some 10, 000 people in Kalimantan among a population of quite different linguistic and social background, which was so successful that now, 30 years later, it is impossible to distinguish the migrants from the former residents. People are very flexible and can quickly adapt to new social and physical conditions. Nevertheless, as others argued, resettlement should be undertaken with great caution and only after careful study of the social, economic and public health problems involved and physical and biological conditions of the land to be occupied. (76)(77)

A Summary of the Conclusions of the Conference

DUNCAN POORE

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PREFACE

I prepared a paper entitled 'An approach to ecological guidelines for tropical forest areas of South East Asia' as a basic document to be discussed by the Conference. This drew on a number of sources: the background papers submitted by other participants; material derived from the conference on the same subject in Latin America held at Caracas from 20-22 February 1974; and from my own experience. It also owed much to discussion with many colleagues.

The course of the proceedings during the Conference followed the sequence of arguments and guidelines in this paper; and the Summary of Conclusions presented here therefore corresponds fairly closely to this earlier paper in structure and content, but has been altered and added to in order to reflect the important issues raised during the Conference and to provide a suitable introduction to the GUIDELINES approved by the Conference which follow this Summary.

Introduction

The pressing need of the countries of South East Asia is to develop their resources to improve the quality of life of an increasing population and, at the same time, to provide the base for a stable and continuing prosperity. The speed with which this development is taking place presents governments with problems of unusual complexity in planning the best allocation and management of land; and these problems are further complicated by growing shortages of raw materials and rising costs of production throughout the world.

The main purpose of the meeting was to explore ways in which the experience of the ecologist may best help in reaching wise decisions about development. His claim that he can help is based on his knowledge of the interrelationships between organisms and their environment and because of the long time scale within which he works. Many of the successful developments in the past, such as the introduction and expansion of the cultivation of rubber and oil palm, have been based on the intelligent application of ecological knowledge.

In very general terms the ecologist may help in two ways: by identifying opportunities for making the best long-term use of the land; and by drawing attention to the situations where care must be taken if deterioration or other undesirable side effects are to be avoided. He can therefore help to provide the decision maker with a framework in which the long-term costs and benefits of any policy or action can more accurately be estimated.

Where rapid development is needed there are temptations to make rapid capital out of resources that are readily available or to adopt forms of exploitation or use which have been successful elsewhere but which have not been sufficiently tested under local conditions.

Ecology gives the capacity to predict—if sufficient facts are available. The

earlier, therefore, that ecological knowledge is taken into account, the better the use that will be made of local resources in the process of development and the less the danger of costly mistakes or long delays while projects are assessed and reformulated. Perhaps most important, the ecologist can draw attention in advance to courses of action that are likely to lead to any long-term or irreversible deterioration of the resource.

There should, therefore, be a significant input of ecological knowledge when policies are being formulated and alternative programmes being considered. This input should not be delayed until projects or other kinds of specific action for development are actually being planned.

Ideally this input should be positive and ecologists should be intimately associated with the formulation of national objectives and the policies deriving from them, as well as during the more detailed and technical stages such as drafting legislation, planning the allocation of land to various uses, or designing development projects. If the ecological contribution is made at these early and formative stages, its positive and constructive nature will be most evident.

When ecological advice cannot be provided or has not been requested sufficiently early, it is very likely to contain elements of caution and constraint. In such circumstances it is useful to make it obligatory that any proposal for development activity (whether for new laws or regulations or for a particular development project) should be accompanied by an assessment of its 'environmental impact' so that unforeseen and damaging consequences may be avoided. The environmental impact assessment is a useful means of ensuring that ecological experience is taken into account in the process of development, but it should be recognized that this is only a partial and imperfect substitute for using ecological experience at an earlier stage.

In either case, public consultation is useful in ensuring that policies and decisions are based on as wide a foundation of knowledge and views as possible while also making the public aware of the whole range of environmental issues involved. The importance of education in the broadest sense cannot be over-estimated; for it is only by having a public fully alert to environmental issues and well informed about them, that the operation of ecological guidelines will gain wide acceptance. A contribution to the meeting by Dr. Makagiansar emphasized the philosophical framework necessary for the most effective continuing development.

Ecological predictions can only be made on the basis of facts and these are often incompletely or imperfectly known. Research and survey are certainly necessary in some instances to provide the information necessary to take wise decisions. But there is often a temptation to collect information for its own sake and to be reluctant to take decisions on knowledge already available. The guidelines frequently stress the need for facts and the assessment of facts before taking action; this should be interpreted as meaning *sufficient* facts for the kind of decision to be made. This is a matter of fine judgement which can only be resolved by discussion between those who have to make the decisions and the appropriate specialists—and will vary from case to case.

Each development is in itself a form of experiment. As far as possible, therefore, each project should include provision for 'monitoring'—checking at periodic intervals the way in which the development is affecting the environment and the extent to which the predictions made beforehand are justified. This process is invaluable in assembling the facts that are necessary to improve the quality of future decisions. The same considerations apply to

monitoring as to research; it can become an activity with its own momentum collecting information which is unnecessarily detailed.

While it is an essential ingredient in improving the development process, the objective should constantly be kept in mind when designing programmes. More is not necessarily better; the best is to collect enough but not too much.

The Guidelines resulting from the meeting are set out below in the relevant section of this paper (see page 171). They are arranged under the following headings:

- A. Land-use policy and allocation of land to various uses (Guidelines 1-17).
- B. Retention of the natural forest as a resource (18-34)
- C. Transformation of natural forest into field and plantation crops and fisheries (35-47).
- D. Water resources (48-51).
- E. Management of fisheries in river systems (52-56).
- F. Guidelines on pesticides (57-70).
- G. Infrastructure, engineering works and industry (71-81).

A short general discussion under each of these headings follows.

A. LAND-USE POLICY AND ALLOCATION OF LAND TO VARIOUS USES (Guidelines 1-17)

Land allocation

The natural vegetation of the humid tropical region of South East Asia is forest. Except for small areas, the uppermost slopes of the highest mountains, for example, and swamps and landslips, the whole land has been covered with trees. This forest is both the richest and has had the longest period of continuous development of any in the world. It also remained almost undisturbed in many parts until very recently. In almost all other parts of the world, with the exception of Amazonia, virgin forest has been almost totally destroyed.

In this region man has settled widely in the seasonally drier areas, but his inroads into the rain forest itself have been limited, and usually confined to tracts near the coast or accessible up the larger rivers. To a much greater degree, therefore, than the rest of the world the region has entered the second half of the 20th century with its resources of soil, vegetation and animal life intact. Moreover in many parts of the region, though not in all, stable and productive forms of agriculture have developed which have retained the fertility of the original forest soil.

Both of these features, the amount of intact forest cover and good indigenous agriculture, allow a greater degree of choice in planning land utilization; the approach can be more flexible because more alternatives are open. These are advantages of immeasurable value and every care should be taken to retain them.

A most important characteristic of this forest is that it is self-perpetuating. Undisturbed, it will protect soil, water, timber, wildlife and scenery without deterioration or need for any management. It is both the most protective and least expensive use of land.

From the viewpoint of economic development, however, the forest has often been looked upon as an obstacle, and its best standing timber as a resource to be creamed to provide investment for other forms of development. There is no doubt, too, that much of the forest covers soils that are suitable for productive sustained agriculture or other uses.

For both these reasons the reserve of untouched forest has rapidly decreased in the last decade and the process is accelerating. This is partly due to the large scale opening up of new land for agriculture, as in Jenka, Johore and the Pahang Tenggara schemes in W. Malaysia and partly to meet the vastly increasing demand for timber from Japan and Korea. An ECAFE* report published this year estimates that all the accessible virgin forests in the Philippines and W. Malaysia will have been logged in the next ten years. Indonesian forests may last for 30 years.

Where timber extraction takes place, either as a stage in the planned development of suitable land for agriculture or in the planned conversion of primary forest to the exploitation of a sustained yield of quicker maturing timber species, this is a normal and acceptable aspect of land use. But much of this extraction meets neither of these conditions and cannot be justified according to any principles of good land use.

In any well planned development, the allocation of land for particular uses is basic. It should attempt to match objectives to the resources available; and avoid using resource capital as a substitute for income. If well done, such allocation assigns to each desirable use a proper share of the most appropriate lands available, the end result being potentially more valuable than any known alternative. A prerequisite to this is an inventory to determine the degree to which different land areas are suited for and will tolerate the various potential uses. This may do much to prevent conflicting claims for the use of land.

Once land has been allocated and used for certain purposes, it is often impossible to restore it to its original state. This may be because we do not know how to do so—even with all our present knowledge of science the smallest area of tropical forest cannot be reconstructed; or because it is too expensive. The wise allocation of land is therefore of the highest importance for it will ensure the best immediate use and the least possible restriction of future use.

In this connection it may be helpful to consider the degrees of change to which the forest (or other natural ecosystems) may be subjected—as follows:

- (a) Virgin, unmodified forest.
- (b) **Modifications** of forest, e.g. forest managed for production of timber or other produce, for wildlife, recreation, etc. Cycles of shifting cultivation in balance with their environment.
- (c) **Transformations** of forest in which the forest is totally removed and replaced. These may be into trees (forest plantations, fruit or cash crops); into land for arable or pastoral farming; or into man-made structures (roads, towns, reservoirs, mines, etc.).

If areas are suitably chosen with proper respect for their ecological

* ECAFE Asian Industrial Development Council. Report of the Study Mission on hardwood resources in the Philippines, Indonesia and Malaysia 1974.

characteristics, these modifications and transformations can be carried out with no loss of fertility and indeed the capacity of a site for a chosen use may be greatly enhanced—for example by terracing and irrigation. But it is either impossible or very expensive to move back up this sequence (from (b) to (a) or from (c) to (b) to (a)). It should be recognized that the decision to transform or to modify is for practical purposes irreversible.

With misallocation or mismanagement, however, there can be another kind of change:

(d) **Degradation** of site. By erosion, invasion by weed species (e.g. *Imperata*) etc.

If this takes place, the usefulness of the site for almost all uses is permanently impaired. Exceptions to this are for example the use of degraded sites for rubbish disposal and, occasionally, a secondary value for wildlife.

Regional environmental resource surveys

Regional environmental resource surveys are necessary for wise and successful development.

For agriculture and plantation forestry, the main prerequisites are a knowledge of the climate and soil, the relative importance of these varying according to circumstances. For the management of natural forests for timber production, the present composition of the forest and its potential for adequate regeneration are important. In both, accessibility to markets and availability of labour have to be taken into account. For natural areas, which are to be conserved and managed as such, it is their present vegetation and fauna, the extent to which they are unique or representative of important ecosystems, and their intrinsic characteristics that are important. Against these intrinsic values must be set the potential to support urban and industrial development: mineral deposits, potential dam sites, routes for roads, sites for new towns, etc.

Where detailed surveys of climate, soils, vegetation and fauna, mineral resources, topography and hydrology are available, these will supply the required information. If such surveys are not already being carried out, they should be started as soon as is feasible. Of particular importance is the early setting up of a regional meteorological network and the systematic collection of relevant statistical information (on population, health, hydrology, etc.).

But, where such detailed surveys are not available, there are short cuts which will provide very valuable information. Much can be accomplished by the use of remote sensing or by air photography, such as the extensive surveys carried out in Kalimantan, W. Malaysia and Sarawak. Where more detailed information is not available, vegetation surveys can be valuable for regional planning. These proceed from the premise that vegetation, especially undisturbed vegetation, gives a good general measure of climatic conditions and thus of the potentialities and limitations of an average site for various kinds of land use. Within each zone there are of course extreme sites where the nature of the soil overrides or compensates for the influence of climate, and offers special potentialities or imposes special constraints. In most circumstances knowledge of both climate and soil is necessary to assess capability reliably.

Because the majority of the nutrients on a site covered by tropical forest are in the vegetation at any time, the luxuriance of the forest is no measure

of the fertility of the soil on which it stands. If cleared carefully, so that the structure of the soil and its nutrients are retained, some forest soils are fertile, others infertile. If intended for agriculture, soils must be surveyed according to their potential for agriculture, and the findings of surveys should be supplemented by crop trials before large areas of forest are opened up. Unless these are promising, land should be left as unmodified or as managed forest.

B. RETENTION OF THE NATURAL FOREST* AS A RESOURCE **(Guidelines 18-34)**

The natural forests of South East Asia are of great importance in four respects:

- (a) as sources of forest products, both plant and animal—timber, fruit, latex, drugs, bamboo, rattan, honey, fish, animal skins, etc.;
- (b) because the forest acts as a guardian of soil fertility, prevents erosion, regulates the runoff of water and possibly has a moderating influence on climate (protection forest);
- (c) as samples of forest ecosystems containing the genetic resources of the plant and animal species (and the varieties of these) in the region; or examples of untouched natural landscapes (national parks and nature reserves); and
- (d) as part of the world's total reserve of forested land.

As such they contribute directly to man's economic activities, contain a reservoir available for possible future use and make a very important present and potential contribution to the psychological and cultural well-being of mankind.

Management in order to obtain a crop of forest produce requires some modification of the forest (except where it is conducted by indigenous food gathering peoples) and will be dealt with in the next section. This section is concerned with maintaining areas of forest substantially in their natural state, and providing for the conservation of wild animals and plants.

In the course of land-use planning it may be decided to leave forest untouched in order to have a reserve of unallocated land but, in the case of protection forest, national parks and nature reserves, land should be allocated specifically for these purposes.

Conservation of natural ecosystems

Within the region of South East Asia there are a great number of forest types, and other natural ecosystems, each containing its own combination of species according to local differences of climate, soil, altitude and geological history. It is highly important to conserve samples of each of these, sufficiently large to be self-perpetuating and to encompass the range of the larger mammals and migratory species. Particularly important is the conservation of samples

* The term 'forest' is used for simplicity but the same principles apply to other unmodified ecosystems.

of lowland rain forest on fertile soil, for these contain ecosystems of the greatest richness and luxuriance. Such ecosystems have been almost completely destroyed by centuries of agriculture in temperate regions and this is now much regretted in countries where no examples remain.

If samples of the various types of forest are chosen well and chosen early (which implies a survey of the resource), the percentage of the total land area devoted to them need not compete unduly with other forms of land use; and, by careful planning and management it may be possible to combine their protection with other socially and economically valuable uses (e.g. recreation, education and tourism). A land classification for purposes of nature conservation is given in Table 1.*

TABLE 1

Categories of Land Use In Relation to The Conservation of Flora, Fauna and Ecosystems

-
- (1) Natural ecosystems, unmodified or hardly modified by human activity. (A sample of these should be maintained inviolate; if disturbed, their integrity is seriously and perhaps irreversibly impaired.)

 - (2) Semi-natural ecosystems in which conservation should be the primary purpose of management, but which are consistent with or depend on other forms of land use in varying degrees. (Areas in which animals or plants are cropped as a resource should be included here.)

 - (3) Areas which should not necessarily be conserved as total ecosystems, but which are necessary to provide for the whole or part of the life cycle of particular organisms (e.g. wildfowl feeding grounds).

 - (4) Areas in which other uses should predominate, but in which the conservation of wildlife can be ensured by various management expedients.

 - (5) Areas in which the wildlife interest is so low or other uses are of such importance that conservation of flora and fauna should be confined to ensuring the health of the land and preventing irreversible deterioration.
-

Protection forest

Protection forest should include all steep land where forest cover must be maintained in order to prevent soil erosion and to regulate the quantity and quality of the water leaving the catchment. Use as protection forest is compatible with a limited amount of harvesting of forest produce provided that this does not interfere with the maintenance of the forest canopy. Its

* This Table is taken from Poore, M. E. D., 1971, Conservation of Vegetation, Flora and Fauna as part of Land Use Policy, in *Plant Life of South-West Asia*, Eds. Davis, P. H., Harper, P. C. and Hedge, I. C, Aberdeen (The Botanical Society of Edinburgh).

objectives also coincide with the conservation of natural ecosystems and of wildlife, provided that harvesting is not in this case permitted.

The place of wildlife (wild animals and plants)

The conservation of natural ecosystems will provide a reservoir of populations of wild plants and animals and of the variation within them under conditions which will enable evolution to continue under substantially natural conditions. But, in addition to these protected areas, there is great scope for managing other land in such a way that it contains an abundance of wildlife, and, wherever possible, this should be made a supplementary objective of management. With the careful application of ecological knowledge, it is frequently possible, for example, to maintain substantial populations of wild plants and animals in areas of forest that are being managed for an economic crop—indeed these wild plants and animals may themselves be part of the crop. Where the land has been transformed for intensive agriculture, the maintenance of wild populations is sometimes more difficult, but the more ecological knowledge can be applied to maintaining a number of species in such areas, the less is the risk of epidemic outbreaks of pests.

Multiple forest values

Although the primary purpose of such forests must in all instances be protective, it is usually possible to allow areas in them to be used for scientific research, education and recreational tourism provided that part remains completely protected and the use of the rest is regulated so that it is consistent with the primary aim of protection. Indeed their value to society except as a reserve of genetic material, is because of their importance to science, for education and for recreation. But their value for all of these will decline if the protective function is neglected.

Modification of natural forests for timber production

The domestic needs for timber and wood products and the requirements of the export trade are met from three sources: by the removal of areas of virgin forest, from managed indigenous forest derived by silvicultural treatment from virgin forest, and from plantations. Both of the last should ideally be managed on a sustained-yield basis; the former is exploitative.

The rate of timber extraction has grown very rapidly in the last decade mainly because of the increased demand for timber from the area particularly by Japan and Korea. A paper on Forestry Trends in the Asia-Far East Section prepared for the Asian-Pacific Forestry Commission forecasts a 4.5 times increase in demand for saw logs and veneer and a 9 times increase for pulpwood. It questions the capacity of the resource to meet the demand; expects that a situation of surplus will move to scarcity; and that supply from the primary forest will have to be replaced by that from secondary forest or plantations, both producing wood of a different quality from that being harvested now.

Many areas of lowland forest on fertile soils are being alienated for agriculture. Such lowland forest has so far been the main source of marketable timber. There is already sufficient silvicultural knowledge (based on research) to manage many such areas for sustained-yield production and substantial areas are being managed in this way. Henceforth forest reserves are likely to have to be set up on poorer soils or in hill forest. But although research is now being carried out, silvicultural knowledge is not at present adequate in many circumstances to manage these successfully.

Where the primary objective of management of production forest is timber, combined with that of minor forest produce and wildlife, the objectives are usually met most satisfactorily in a forest having a structure and composition near to that of the natural forest, as this tends to be most stable under local conditions and provides best security against epidemics, etc. Therefore it is advisable to go no further than necessary in changing species and structure.

Experience shows that manipulation of the natural forest may produce a crop that is economically more valuable than the original forest, but having fewer species with higher growth rate and timber of more uniform characteristics—usually with wood of lower density.

An assessment of the ecological situation (climate, topography, soil and vegetation) will enable an ecologically sound decision to be made about the future use of a particular forest-covered area—for example, as managed sustained-yield forest based on the existing composition of the natural forest, replacement by a man-made forest, agriculture, industry, etc.

If it is determined that land shall be managed as productive forest for a sustained yield, the stages set out in Fig. 1 may be followed. A knowledge of the ecological conditions of the site, of the composition and structure of the forest, and of the biology of the main species will indicate what to do and how to do it.

Modification of natural forest by shifting agriculture

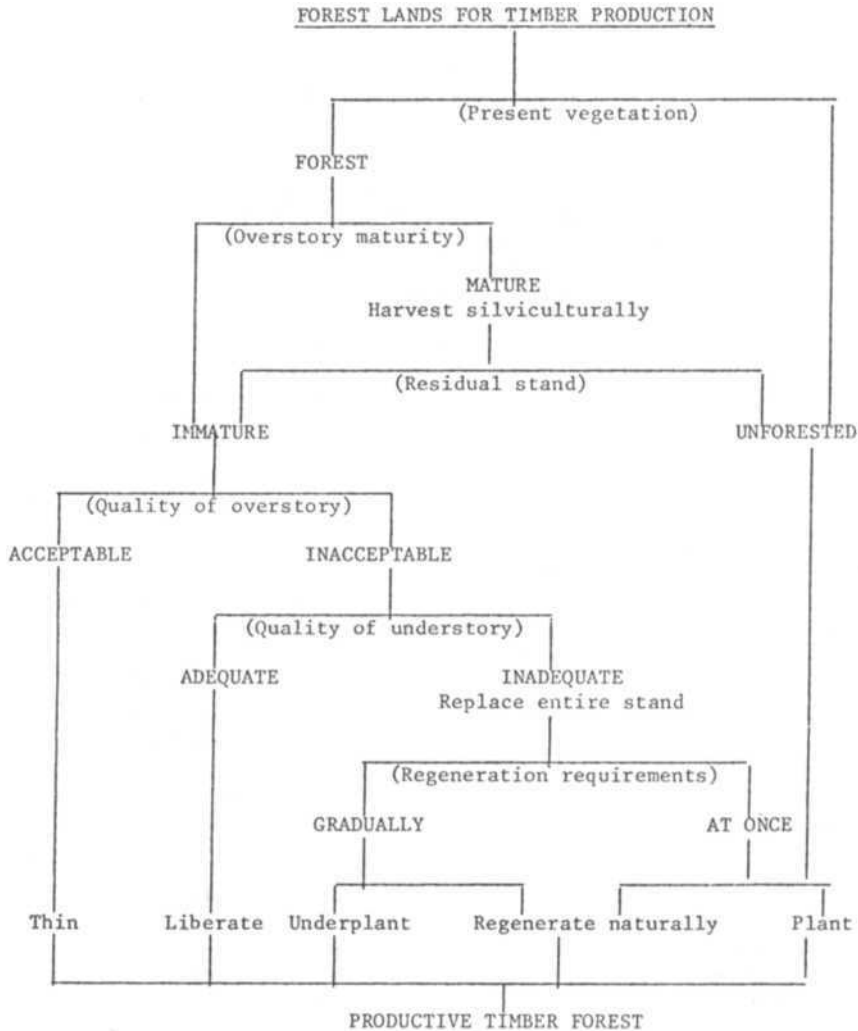
Shifting agriculture ('swidden cultivation') can be defined as a system of the rotation of fields rather than of crops, by short periods of cropping (one to three years) alternating with generally longer fallow periods (up to twenty years or more, but often only four to eight years) and characterized by clearing by slash and burn and the almost exclusive use of human energy employing the parang, digging stick or hoe. But within this category there are many kinds of agriculture which reflect the adaptation of man to many different ecological conditions under various circumstances of technology and the availability of labour.

There is an important distinction between those systems of shifting agriculture which are, and those which are not, in balance with the environment. The former, which are usually only possible where the density of population is low, are thought to be a harmonious adaptation to ecological conditions and not to lead even to a slow loss of fertility. In contrast, the latter, which arise when the balance of a stable system is upset or when new areas of forest are colonized from outside, are not in harmony with prevailing conditions and lead to deterioration of the areas where they are practised. It is important to recognize also the distinction between 'integral' systems which provide all the subsistence of a society and 'partial' forms in which the cultivators derive some of their income from cash cropping or other sources of income.

Many forces are at work, among them increases of population and spread of technology, which are tending to upset this harmonious relationship, where it still occurs. When such changes are considered likely it is important to plan in advance for the social adjustments that are inevitable.

The relationships of these forms of shifting agriculture and other modifications and transformations of forest are shown in Fig. 2.

Figure 1
 Sequential Selection of Silvicultural Practices
 (after Wadsworth)



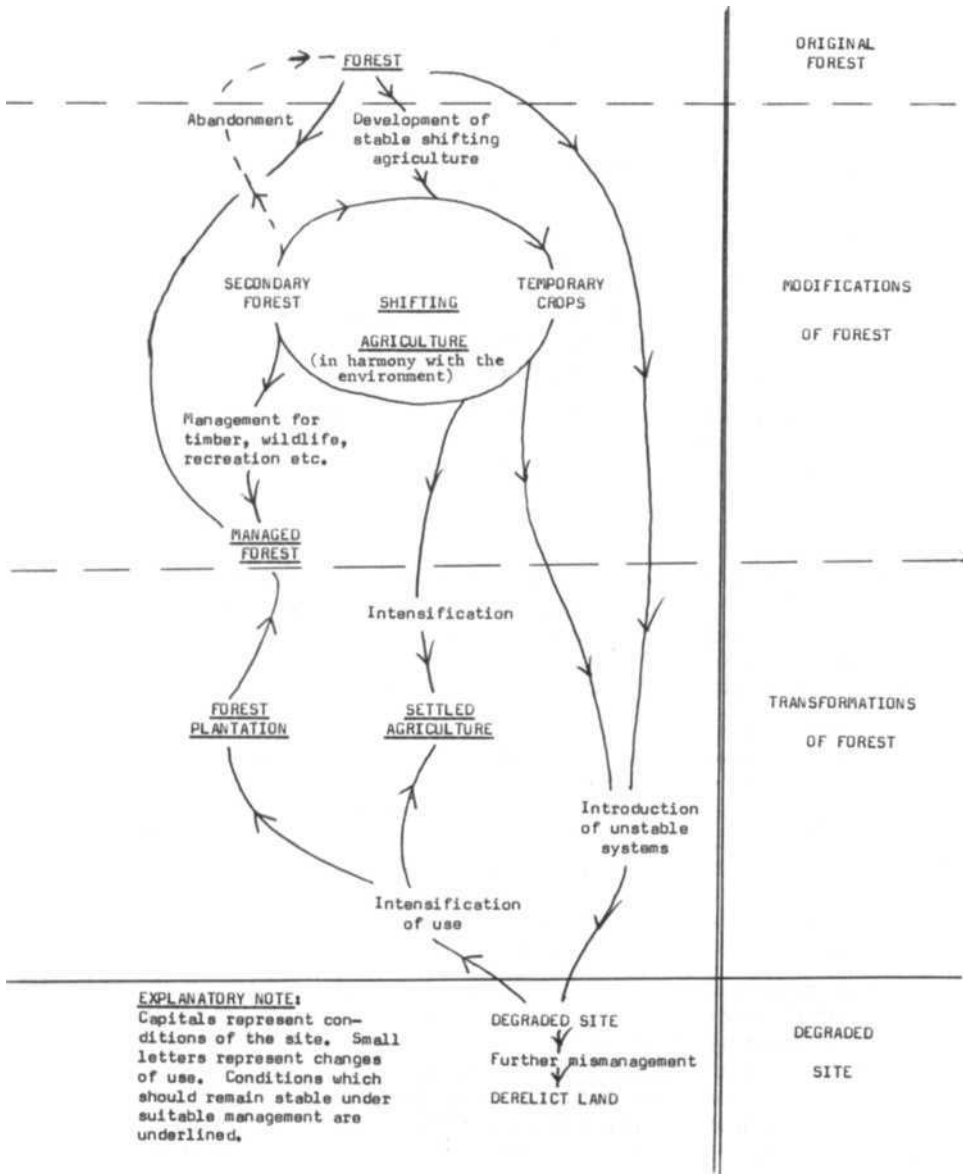
C. TRANSFORMATION OF NATURAL FOREST INTO FIELD AND PLANTATION CROPS
 (Guidelines 35-47)

Highly successful systems of agriculture both for food and cash crops have been developed in South East Asia, but large areas of belukar and lallang bear witness to efforts that have been less successful.

The humid tropics are not an easy area in which to conduct stable and profitable agriculture. Soils are often infertile and have a poor structure;

Figure 2

Interrelationships of Shifting Agriculture with Other Uses



they are readily damaged by exposure to insolation and the impact of rain drops; many areas with high rainfall suffer from periods of intense drought; and conditions favour the rapid growth of weeds and serious infestations by pests.

Most of these difficulties can be overcome, on fertile soils, by careful choice

of site and crops, and suitable techniques for clearing the land and subsequent management. It should be recognized, however, that the greater the degree of specialization or tendency towards monoculture, the greater is likely to be the dependence on imported energy and fertilizer. Where systems of productive agriculture exist which do not depend on great imports of energy and fertilizers these will have the advantage of stability in a world in which energy is likely to become scarce and more expensive.

Management for animal production

The conversion of humid forests to open grasslands for the grazing of ruminant livestock should be approached with caution. These pastures have sometimes proved productive, particularly where they have been developed on fertile soils, but more often they have failed, resulting in degradation of the areas and low productivity of the livestock. As a consequence alternative systems are urgently required both to improve animal production and to prevent unnecessary destruction of forest.

One alternative would be to restrict ruminant livestock to drier savanna regions. There are, however, serious constraints on livestock production in these areas also, the main one being the intense seasonality of forage production. This constraint has not yet been economically removed despite many and varied efforts to effect solutions. The use of combinations of measures such as the introduction of exotic grass and legume species, water storage, supplementary feeding of livestock during the dry season and seasonal breeding may ultimately lessen the effect of the intensely seasonal supply of forage. Any major improvements are likely to depend upon the successful conclusion of a major investigational programme directed specifically to the production problems of savannas.

A second alternative would be to improve those areas in the humid tropics that have already been cleared and have become degraded. This might be effected by a policy of intensification that would include: the introduction of exotic tree and pasture legumes (or the development and intensive use of local species if available), reduction in the size of paddocks, the introduction of rotations using large numbers of cattle on small areas of pasture for short periods, and the use of fertilizers if these could be economically justified. What must be emphasized is that management of both livestock and pastures in the humid tropics is very different to management in the dry tropics.

Another promising alternative could be the integration of livestock production with field and tree crops, fish ponds and forestry. Most by-products of field crops can be used by ruminants and the possibilities of the integration of livestock with tree crops are particularly promising. Livestock can be easily integrated with coconut production in regions where the total rainfall is more than 1800 mm and, with correct management, could be integrated with rubber, oil palm, fruit and nuts. Programmes of investigation should be started immediately to ascertain how integration can most economically be accomplished. Pigs and ducks can be combined with fish culture. There may also be some possibilities for integrating forestry with the management of game animals for meat production.

In those areas where adequate labour is available, a system of very intensive agriculture, which integrates livestock with field and tree crops and with fish ponds, could recycle organic matter and nutrients and might be economic under certain circumstances. It would have the added advantage of providing the farmer with a varied and nutritious diet.

D. WATER RESOURCES
(Guidelines 48-51)

In addition to any other use, all areas of land discharge a function in the collection and release of water; and the rate at which water is released and its quality are of crucial importance for many human activities.

Generally speaking natural vegetation provides water of higher quality and a more even discharge than areas which have been modified or transformed. For this reason there are strong reasons for maintaining natural vegetation cover on steep slopes liable to erosion and accelerated runoff.

In considering any change of land use or management within a catchment prime consideration should be given to the effect of this on the quality and quantity of water, and the periodicity of discharge.

E. MANAGEMENT OF FISHERIES IN RIVER SYSTEMS
(Guidelines 52-56)

The water bodies of the South East Asian humid tropics are characterized by great diversity in hydrology and biology, seasonal variation of water level and a locally high potential" for producing protein.

The complexity of these ecosystems is reflected by the large number of species present, which demonstrates the very effective occupation of existing ecological niches. Although the numerous interactions between species are not yet well known, a reduction in quantity, and especially the extinction, of abundant or important elements of the aquatic fauna may have disastrous side effects for the whole system. The exact nature of these effects cannot be foreseen.

The introduction of exotic or alien species into these water systems is dangerous and in some instances has proved disastrous. Experience in the American tropics shows that the resulting improvement of fisheries has been disappointing. The introduced species have often, indeed, had a damaging effect and, once established, have proved almost impossible to eliminate.

In large river systems, management of the fisheries or regulation of the water regime in one part may have effects in other and distant parts by modifying the migration and spawning of fish species.

The situation is different in enclosed water bodies under direct human control where monocultures can be highly productive and exotic species can be most successful.

F. PEST CONTROL
(Guidelines 57-70)

Controlled use of pesticides is necessary both in controlling disease and in increasing agricultural production. Some adverse effects have been recorded as a result of excessive or indiscriminate use of some pesticides, leading in some instances to hazards to health and to crop losses due to the emergence of new pests, but there is not nearly enough information about the quantities of those chemicals used, their environmental effects, and their ultimate fate. These circumstances can combine to cancel the beneficial

effects and to create a potentially serious threat not only to the environment, but to crop protection and public health.

**G. INFRASTRUCTURE, ENGINEERING WORKS AND INDUSTRY
(Guidelines 71-81)**

Large capital projects are difficult to alter once begun, even if alterations seem desirable. This is because they require a long period for planning with considerable investment of money and manpower. As they represent a large social commitment they develop, too, their own political momentum. For these reasons the possible harmful effect of both require early attention in planning and design.

Roads, for example, can set in train developments which lead to misuse of resources and badly situated human settlements. Attention should be given to the incidental effects when choosing the route and design of new roads.

There is already considerable experience from the building of dams in the tropics. High costs and serious problems of management affecting both the reservoirs and lower river courses may be caused by damming waters with heavy loads of sediment or a high content of nutrients. The problems of sedimentation are greater in small than in large dams. Impoundments which expose large areas along their shores at low water can cause problems for lakeside settlements, for farming and for fisheries. No resettlement has been fully successful round any tropical impoundment. The social and financial costs of these projects have often been grossly underestimated because the data to assess their effects have been lacking or inadequate. Nor have the benefits been properly assessed.

Ecological Guidelines for development in Tropical Forest Areas of South East Asia

A. LAND-USE POLICY AND ALLOCATION OF LAND TO VARIOUS USES

1. Great care should be taken in reaching decisions on the designation and allocation of land for various uses.
2. National and regional resource surveys should be undertaken to ensure the designation of land for the most suitable purposes.
3. The development of any new region should be planned as a whole, including the infrastructure of settlements, roads, dams, water supply, siting of saw-mills, processing plants for agricultural products and other industry. A total catchment area is recommended as an appropriate unit for planning.
4. Decisions about how land shall be used should be based on a proper understanding of each different kind of land, its capability for different uses, and the constraints which must be observed when it is manipulated for productive purposes.

The "capability" for various uses should be assessed separately in order that the merits of alternative patterns of development may be compared.

5. When they are not already available, surveys should be started as soon as possible as a basis for decisions about land use, for example: of social structure, of climate, topography and land form, soils, vegetation and fauna, mineral resources and hydrology.
6. Until the results of detailed surveys are available, the greatest use should be made of the results of remote sensing and the use of vegetation as a measure of climatic and soil characteristics.
7. Land having a wide range of capabilities should be retained as far as possible in a flexible form of land use to maintain the widest possible choice for future generations, whose needs and skills may be different.
8. Planning should provide for foreseeable requirements. Subject to the inherent capability of the land (see Guideline 4), allocation to various uses should be based on the needs of the community as determined by its chosen life style. This requires a balancing of the national interest against the interest of any special groups in the community.
9. Environmental effects of alternative courses of development or changes in land use should be assessed in advance. These should, at least, include: effects on local populations; on health and social well being; on river flow and water quality; possible influence on local climate; soil; effects on the range and abundance of wildlife*. All studies should include not only the region to be developed, but also the surrounding areas, and, in particular, the whole catchment area of any river system affected. This assessment may take the form of an "environment impact assessment" or other appropriate means.
10. Laws, regulations and policies on land use which will affect (among others)

* 'Wildlife' is taken to include all species of plants and animals and populations of them.

forest areas should also be subjected to an environment impact assessment *before* being passed.

11. Planning should be undertaken as far as possible in consultation with those likely to be affected in order that they may be fully aware of possible alternatives and may be able to contribute to reaching decisions. This process may proceed by stages and take time. At each stage the social costs and benefits of alternatives should be evaluated.
12. As part of planning process, arrangements should be made to monitor the effects of any major development and observations should be made on change of significant variables including those listed in Guideline 9. The result of these observations may be used to modify the course of development, if necessary, and to provide experience to guide future ventures.
13. Particular care is necessary in making decisions to modify or to transform forest or other natural land, because these processes can only be reversed with difficulty, if at all.
14. Because any modification will affect the intrinsic value of natural communities and ecosystems, suitably large samples of these should be designated and allocated for protection as far as possible before any allocation to other uses. Even on rich agricultural soils, the retention of a proportion of land in its original state has value, especially to preserve samples of unchanged communities, but also to provide controls in comparison with which the changes brought about by agriculture can be measured and assessed. This is particularly urgent in lowland forest.
15. In addition to assessments of land capability for other purposes, an assessment should be made of the intrinsic merit of land in relation to the conservation of flora, fauna and natural ecosystems. Suggested classes for such a land capability classification have been given in Table 1 (page 163). This assessment should be set against others (for agriculture, timber production, minerals, etc.) in determining the use of land.
16. Before felling of forest or major harvesting of forest produce is carried out, an assessment of the possible final use of the land should be made in order to enable proper phasing and planning for development.
17. Before considering modification or transformation of untouched areas, every consideration should be given to:
 - (a) adapting to more productive uses areas which have already been changed (e.g. savanna for pine plantations);
 - (b) intensification of existing uses;
 - (c) using areas for more than one purpose, if these are compatible.

B. RETENTION OF THE NATURAL FOREST* AS A RESOURCE

18. Guidelines 13 and 14 recommend allocation of representative samples of natural ecosystems and protected areas. These should be maintained as a reservoir of genetic material, for their scientific and educational value, as samples of outstanding or typical natural landscapes and as a

* The term 'forest' is used for simplicity. It should be taken to include other natural ecosystems.

reservoir for wildlife, which may be utilized in surrounding areas. In specific situations where there are areas of outstanding and possibly unique value, high priority should be given to their protection which should be given precedence over other forms of land use.

19. In order to fulfil these functions the areas protected should be related to the needs of the plant and animal communities that it is intended to protect. Wherever possible examples of different ecosystems should be included within large areas, representing, for example, different altitudinal zones on a mountain or in the upper parts of a water catchment.
20. Wherever possible examples of different ecosystems should be included systems should be surrounded by buffer zones taking advantage of physiographic and other natural protective features. These should be maintained under natural vegetation but can be used for any forms of economic land use which do not interfere with the integrity of the protected area.
21. Areas which are too steep or unstable for timber extraction or transformation to agriculture should remain as protection forest and be managed so that they perform the functions of soil protection and water regulation.
22. The objectives of management for such protected areas should be carefully defined and adhered to. They should include maintaining part of the area completely undisturbed; but in the remainder, use for scientific study, for education and for recreation should be encouraged, provided that these uses do not conflict with the primary purpose of protection.
23. There should be a management plan for each protected area, and the course of management should be monitored to assess whether the original objectives were reasonable and the management has been successful.
24. In planning the overall development of any area, consideration should be given to providing means for the migration of animals and dispersal of plants between protected areas.
25. Areas set aside for the protection of steep slopes and catchment areas may be used to take a harvest of forest produce, provided that this does not interfere with their primary function of protection. The same applies to the buffer zones of protected natural areas but not to the reserves themselves.
26. The protection of plant genetic resources in natural protected areas should be supplemented by documented collections, for example, in botanic gardens, arboreta and seed banks, but these alone are no substitute for protected areas.
27. The objective for the management of an area for the production of timber or other forest produce should be to maintain the potential for the maximum sustained yield.
28. Such forest should be managed according to the best principles of silviculture and in such a way that the composition and structure are altered no further than is necessary from that of the natural forest.
29. All areas of managed forest may have a very important supplementary value as a habitat for wild life. Management should be aimed as far as possible at maximizing this value. The wildlife may provide a significant source of food, of revenue from exploitation and of reserve stocks of the species concerned.

30. Predicted timber requirements should take account of the local requirements for fuelwood, which under certain circumstances can represent a very large demand on the productive capacity of the forest. Where the viability of the forest is threatened by fuelwood collection, special plantations should be established as near the site of demand as possible and alternative sources of fuel should be developed.
31. In order to help to meet predicted timber demands, plantations should be developed as rapidly as possible over suitable sites. Where agricultural land has been abandoned, such land should be utilized for plantation forestry rather than clearing indigenous forest for plantations.
32. Where the current practice of shifting agriculture ("swidden cultivation") is in harmony with the environment and not leading to long-term degradation, it should continue as necessary but with regular monitoring to ensure that changes in the situation, arising for instance from population increases and social change, can be foreseen and any necessary adjustment made.
33. When shifting agriculture is not in harmony with the environment it should be discouraged. If it does not already exist, it should be prevented as far as possible by providing instead for well-planned land settlement. Where it has already occurred, efforts should be made to transform it into settled agriculture or into forest plantations by intensification of use accompanied by appropriate extension services, provided that this is consistent with land capability factors.
34. All measures should be designed with the greatest possible consideration for the interests and values of the indigenous community and in full collaboration with them.

C. TRANSFORMATION OF NATURAL FOREST INTO FIELD AND PLANTATION CROPS, ANIMAL PRODUCTION AND FISHERIES

35. Land should only be used for cultivation or plantation crops when sufficient survey of the ecological conditions has shown that the area is suitable for such crops if appropriate methods of cultivation are used; and field trials or observations have confirmed this assessment.
36. Any modification or transformation of the existing vegetation must be carried out in such a way that the least possible harm is done to the soil by radiation and rainfall, in order to retain organic matter and fertility.
37. Careful studies should be made of traditional and indigenous systems of agriculture which have often remained for long periods in balance with their environment and have produced a sustained yield under these conditions. Every attempt should be made to extend such stable and productive indigenous systems, or suitable elements of them.
38. Wherever possible, tree crops should be integrated into systems that include the raising of animals and production of food crops.
39. As far as possible systems of agriculture should be favoured that do not rely heavily on the importation of energy and fertilizer.
40. Particular attention should be paid to the public health problems arising from forest clearance.
41. Plans for increasing animal production by introductions into the humid

tropics should take into account the reaction of the various types to the climate and to pests and diseases.

42. Improvements in ruminant livestock production can most suitably be obtained by:
 - (a) development of new and suitable breeds;
 - (b) increasing the productivity and hence the carrying capacity of existing pastures by the use of multi-species forage and stress on improvements in management;
 - (c) integration with field and tree crop production; and
 - (d) the utilization of all available by-product feeds.
43. The improvement of non-ruminant livestock production can probably best be accomplished by ensuring continuous and economic supply of suitable feeds, which should include as many locally produced by-product feeds as possible. There are also possibilities for integrating pig, chicken and duck production with fish production.
44. Every effort should be made to improve the productivity of existing savannas by the introduction and testing of new forage species, the solution of the problems of dry season feeding and overall improvements in management.
45. Further efforts should be made to domesticate indigenous animals for sustained production (e.g. deer, banteng, crocodile).
46. Special attention is drawn to the danger of introducing species of animals for domestic purposes under range conditions where there is any opportunity for escaping into the wild. (Animals such as buffalo and goat have caused considerable ecological and economic damage in many situations after escape from domestic control.)
47. Careful studies should be made before the transformation of mangrove and swamp forests to agriculture or fisheries so that long-term and irreversible effects to these ecosystems can be avoided.

D. WATER RESOURCES

48. In land-use decisions adequate provision must be made for safeguarding and perpetuating water supplies for domestic, food, power and industrial requirements.
49. Multiple use of catchments should be consistent with the above objectives and include full provision for present and future fishery and wildlife needs.
50. The utilization of the water resource should be based on the needs of the people, first consideration being given to domestic needs and that required for food production.
51. Management of the catchment should ensure delivery of water of the quality required.

E. MANAGEMENT OF FISHERIES IN RIVER SYSTEMS

52. Every effort should be made to retain the species diversity in natural

water bodies, unless these are allocated for intensive fish cultivation purposes.

53. The introduction of exotic species into water systems should only be considered after all other possibilities of increasing production, such as the encouragement of selected native species, have been exhausted, and should only then be carried out after careful trials and with stringent precautions.
54. In large river systems regulations for fisheries management must take into account the riverine spawning migrations of many species. Protective legislation designed to maintain a breeding population of such species may need to apply to large portions of any river system and to include the estuaries.
55. In floodplains that have high seasonal potential for fish production, and which are also farmed at low water, farming methods should be avoided which may damage aquatic life. Special care should be taken in the use of pesticides, and persistent chemicals toxic to aquatic life should not be employed.
56. Artificial breeding of important species should be developed for the deliberate stocking of suitable waters.

F. GUIDELINES ON PESTICIDES

57. Governments should immediately establish a centralized organization to collect and interpret information on the kinds, amounts, distribution and local application of all pesticides (insecticides, herbicides, fungicides and others), both those used for public health as well as for control of agricultural and forestry pests.
58. Regulations should be developed on production, importation, formulations, sales, distribution and application. These should be made enforceable. Criteria may be found in similar regulations in other countries of the world. Regulations should stipulate: that pesticides and pesticide formulations which may represent a special hazard to humans and other organisms should be sold and/or distributed only by designated persons, preferably under licence.
59. Programmes of biological control and integrated methods of pest management should be encouraged (including mechanical control).
60. Wherever possible those pesticides should be used that are specific to the pest. Moreover in general the selectivity of pesticide applications should be optimized by selecting appropriate formulations and techniques of application.
61. Research and development should be promoted into selective pesticides which are degradable in the environment.
62. Spraying from the air should be prohibited near areas where the chemicals might have undesirable effects.
63. The amount of pesticide used and the area covered in its application should be kept as small as possible by a proper judgement of the degree of infestation at which damage becomes unacceptable, by using detailed knowledge of the habits of the pest and by avoiding overdosing.
64. In large scale operations application of the pesticide should be confined

within the limits of the ecosystem to be treated to avoid exterminating local taxa and to permit recolonization from outside by non-target organisms which have been killed off in the area of application.

65. Local research should be undertaken on the toxicological and ecological effects of various pesticides, as the results of research in temperate regions do not necessarily apply in the humid tropics.
Pesticides now in use should be examined first and the results of research should be used in designing regulations for their use.
66. Research should be carried out into the development of pesticides suitable for the protection of tropical crops. Wild plants in tropical forests may have evolved chemical protection from insect predation, and it might be profitable to examine indigenous plants in order to identify and produce those substances in them that may limit attack by pests.
67. Large scale operations should be guided by epidemiological studies and by means of biological and chemical monitoring, including: changes in populations, physiological and behavioural changes, appearance of resistance or tolerance to chemicals in target populations and of concentrations of pesticides and their conversion products in soil, water and biota.
68. The methods selected for pesticide applications should be compatible with the local environment conditions.
69. Great care should be exercised in treating fresh water bodies with herbicides in order to avoid dramatic irreversible changes in the vegetational structure and a subsequent deterioration of whole ecosystems.
70. Pesticides for dressing seed should be selected whose acute toxicity will be low enough not to cause poisoning in grain-eating animals as well as in human beings, if treated seed should be eaten.

G. INFRASTRUCTURE, ENGINEERING WORKS AND INDUSTRY

71. In all developments of this kind, besides the probable socioeconomic effects, the probable ecological impact should be assessed in advance and the changes which occur afterwards should be kept under observation.

Roads

72. Just as with other projects, planning for roads should be treated as an integral part of a regional development plan, and should take into consideration any long-term or incidental effects of the environment.
73. If possible, no roads should be routed through areas designated as reserves or parks; but, if other considerations make this unavoidable, management plans for such reserves or parks should be drawn up before the roads are built and land clearing or other activities not consistent with the objectives of management should be strictly forbidden. If necessary, increased provision should be made to ensure that illegal clearing does not occur.

Water-ways, dams, etc.

74. When planning and executing the improvement of existing water-ways, canals, etc., special attention should be paid to the total effect of these works on the characteristics of the water and the living conditions of the

people living near these water-ways. Public health and environmental problems that might be solved by any such improvement should be given special attention.

75. When planning any dam or significant change of river regime, special attention should be paid to the effect of it (or alternatives) on the flow and on the physical, chemical and biological characteristics of the water, both at and below the intended works. This is necessary to assess possible consequences for human health, fisheries and wildlife, and to assess the risk of infestation by water weeds. These should include advance studies, during at least one year, of:
 - (a) Streamflow, sediment load and bed load;
 - (b) water chemistry;
 - (c) precipitation and the chemical content of rainfall;
 - (d) aquatic vegetation and its dynamics;
 - (e) aquatic fauna, especially fish of economic importance, their life histories, food and feeding habits, reproductive patterns, spawning and migration;
 - (f) groundwater in the neighbourhood of the proposed reservoir;
 - (g) the sedimentation patterns and water regime of floodplains, estuaries or deltas downstream.
76. Arrangements should be made to monitor the variables in Guideline 75 (a) to (g) above and the cost of doing so should be included in the project.
77. Public health problems that may be caused by or associated with an impoundment must be anticipated and their management needs and costs included in the cost benefit analysis and future management plan. The problems of mosquito and snailborne human diseases require special attention. If resettlement schemes or spontaneous population movements near the proposed reservoir are likely to bring new populations in contact with disease, the risk of this must be assessed in order to design programmes of public health.
78. Any proposed resettlement should take into account the present social, cultural, economic and health conditions of those to be resettled and their future needs. Resettlement should be carried out in consultation with them and should be carefully planned and timed.
79. Any problems of weed infestation after impoundment should be anticipated as far as possible and steps taken to prevent such infestation.
80. Preparations should be made in advance to manage the fisheries in the period following impoundment and to provide for the resettlement of displaced animal populations.

Industry

81. The planning, design, construction and operation of industries should take into account the possible adverse effects of industrial pollution (physical, including thermal, chemical and biological) and other disadvantageous ecological effects. Standards of quality for water, soil and air should be based on proper ecological principles.

Vote of Thanks

Professor Otto Soemarwoto thanked all who had helped in the preparation and organization of the Conference and in bringing it to a successful conclusion, and in particular the Co-President, Dr. Duncan Poore, for all the work he had done on drafting the guidelines, which had served so well to focus the discussion and to lead to concrete results.

Dr. Poore then expressed thanks on behalf of IUCN as well as himself for the contribution made by all participants to the valuable outcome of the Meeting and especially those who had prepared papers and taken part in panels. The meeting had run exceptionally smoothly because all the material and secretarial needs of the delegates had been so well and elegantly provided for.

The Conference had been particularly grateful to Dr. Sumarlin who had found time, in a very busy life, not only to open the Conference and encourage us with his thoughtful and wise address, but also to come to the final session, hear something of the result of our labours and experience for himself the spirit of agreement.

Dr. Poore presented Dr. Sumarlin with a copy of the text of the Guidelines and invited him to close the Conference.

Closing Address

Hon. J. B. SUMARLIN PhD.

*Minister of State and Chairman of the State Committee for Environment,
Jakarta, Indonesia and President of the Conference*

We are now at the end of our conference. I should like to apologize to you all that due to the heavy work-schedule in Jakarta, I was not able to join you in your deliberations.

For the last four days you have been working very hard in this conference and it was reported to me that there were considerable arguments about various points. This is not unusual in a conference, and I am not troubled by it at all; rather I am happy, since it shows that the participants have had a real interest in the subject of the Conference and have been actively engaged in the discussions.

I am happy that a report has been produced and that a few moments ago it was adopted. We have now in our hands the concrete results of the Conference, although of necessity some editorial improvements and polishing will still have to be done. It demonstrates that a multidisciplinary approach to an ecological or environmental problem is workable and that not only can scientists in different fields communicate with each other but also scientists, planners and decision-makers, since these are the three groups which have been assembled at the Conference. For this achievement, IUCN and the Institute of Ecology, which planned and organized the Conference, deserve every commendation.

I am very happy indeed that this Conference has taken a positive view on development, and that the results are intended to help planners to develop forest areas in a more rational way, to maximize the benefits of development for the people, and to take into account the needs of future generations and of preserving or promoting decent and harmonious environmental conditions.

The practicability and suitability of the guidelines presently produced, for the planning process of forest areas in South-east Asia, will, of course, have to be tested in practice. But at least we have taken the first step which can be used as a basis for further improvement in the future.

At the end of this Conference I would like very much to express my appreciation and thanks for your interest and active participation in the discussions which contributed so much to its success. I also wish to thank the Rector of Padjadjaran University and particularly the staff of the Institute of Ecology, who have taken such great pains to make this Conference run smoothly

Last but not least I wish to thank Dr. Duncan Poore, my Co-President of the Conference, who prepared the draft guidelines and thus enabled us to conduct our deliberations in an orderly manner.

Finally I wish you a safe journey home. 'Selamat jalan dan sampai berjumpa lagi'.

I now officially declare the Conference closed.

**REGIONAL MEETING ON ECOLOGICAL GUIDELINES FOR DEVELOPMENT
IN TROPICAL FOREST AREAS OF SOUTHEAST ASIA. BANDUNG,
INDONESIA, 29 May to 1 June 1974**

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