IUCN PUBLICATIONS NEW SERIES Supplementary Paper No 22

CONSERVATION IN MALAYSIA

A MANUAL ON THE CONSERVATION OF
MALAYSIA'S RENEWABLE NATURAL RESOURCES

by

Dr. P. R. Wycherley,
The Rubber Research Institute of Malaya.

Published with the assistance of Unesco
(UNESCO/NS/3357/66)

1948

International Union
for Conservation of Nature and Natural Resources
Morges, Switzerland
1969

IUCN PUBLICATIONS MEW SERIES Supplementary Paper No 22

CONSERVATION IN MALAYSIA

A MANUAL ON THE CONSERVATION OF
MALAYSIA'S RENEWABLE NATURAL RESOURCES

by

Dr. P. R. Wycherley,
The Rubber Research Institute of Malaya.

Published with the assistance of Unesco
(UNESCO/NS/3357/66)

1948

International Union
for Conservation of Nature and Natural Resources
Morges, Switzerland
1969

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

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

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

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

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

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

CONSERVATION IN MALAYSIA

TABLE OF CONTENTS

UNION INTERNATIONALE
POUR LA CONSERVATION DE LA NATURE
ET DE SES RESSOURCES

1110 MORGES - SUISSE

In your reply. please refer to :
En répondant, veuillez rappeter:

1948

Ø (021) 71 4401
Télégr. Unicorn Morges

INTERNATIONAL UNION
FOR CONSERVATION OF NATURE
AND NATURAL RESOURCES

1110 MORGES - SWITZERLAND

FOREWORD

This comprehensive manual on the Conservation of Malaysia's Renewable Natural Resources owes its origin, encouragement and publication to the efforts of E.J.H. Berwick, a leading agricultural scientist of many years experience in Malaysia and especially in Sabah, who has lately contributed significantly to world wide conservation as Secretary-General of the International Union for Conservation of Nature and Natural Resources (IUCN).

His friend and former associate, P.R. Wycherley with over two decades of experience in tropical agriculture in Malaysia is an especially qualified author for this publication. It includes an immense amount of highly useful information that will have a wide application to tropical agriculture and forestry throughout the South East Asian region, although Dr. Wycherley has purposely concentrated on Malaysia which he knows best.

The author's sound approach is attested by his own statements (p. 82) that "Man must examine his place in relationship with nature and work with instead of against natural processes". He also recognizes (p. 51) that efficient agriculture is a process of continual use and renewal of natural resources . . . . Agriculture and nature conservation are interdependent at every level not only in the obvious need to manage the soil and water resources wisely, but in various ecological relationships. The way these facts are brought out in this manual will be of special value to all who use it for reference.

Detailed information on the "Pesticide Revolution" of the past 25 years and the risks involved with the increased use of new and powerful synthetical chemicals is both pragmatic and timely.

IUCN is pleased to include this manual in its new publications series as Suppl. Paper No. 22.

Harold J. Coolidge
President, IUCN.

Washington

10th March, 1970.

INTRODUCTION

Botanists recognise phytogeographic regions, each of which has a characteristic floristic composition, that is places within a region have many native plants in common, but outside the region many of the native plants are different even if some are found both within the region and in the surrounding area. The Malasian phytogeographic region includes the Malay peninsular south of the Isthmus of Kra, Borneo, the Philippines, the Indonesian islands and New Guinea.

South East Asia is a geographical and political concept comprising not only the Malay peninsular and archipelago outline above, but also the mainland countries of Burma, Thailand, Cambodia, Laos and Vietnam. Sometimes the island of Ceylon is included also.

Georgraphically these countries lie in the equatorial or humid tropic zone between Central Asia and Australia. Politically and economically they are among the developing nations. Nevertheless there is great diversity. Therefore when discussing any problem in South East Asia or the Malasian region, there are broadly two alternatives open, either to treat the whole area in a superficial manner or to deal with one country in greater detail. The latter course has been chosen here.

Malaysia is central to South East Asia as a whole and is typical of the Western sub-region of Malesia. It is a rapidly developing country, opening up its natural resources and making great strides in education and social welfare. It has been selected as an example to discuss conservation problems in South East Asia.

Malaysia is divided by the South China Sea into peninsular West Malaysia, which is the furthermost tip of the Asian mainland, and East Malaysia comprising the two States of Sarawak and Sabah on the northern shore of the island of Borneo. West Malaysia consists of the States of Malaya, which formed previously the Federation of Malaya, and it is more convenient to refer to West Malaysia as Malaya in a largely geographical account of this nature.

Therefore the following usage has been adopted in this account. Malaysia refers to both East and West Malaysia; for instance the east coast of Malaysia means both the east coast of Sabah and the east coast of Malaya (climatically they have much in common). East Malaysia refers to both Sabah and Sarawak. West Malaysia is sometimes referred to as such but more frequently it is simply called Malaya, especially when it is necessary to specify some part, for example the West Malayan Rainfall Region.

CHAPTER ONE

CLIMATE

Our planet, Earth, receives radiant energy from the Sun. This is the light which enables us to see by day and the energy which plants convert by photosynthesis into food and fuel. The Earth's surface and atmosphere are warmed by absorption of solar radiation. Energy is lost again and local cooling occurs due to radiation of heat back into space and by such processes as evaporation of water.

The Earth traces an elliptical path around the Sun. The distance between Earth and Sun is least in late December and the total solar radiation intercepted by the planet each day is then at a maximum. Six months later the distance is greatest and the energy intercepted is about 7% less. This variation exaggerates slightly some seasonal differences in the Southern Hemisphere relative to those in the Northern Hemisphere, but this is trivial compared with the differences due to the greater proportion of land in the Northern Hemisphere or the other effects of the Earth's motion. The alternation of night and day results from the Earth spinning about its axis, which is inclined at about 23 from the vertical to the plane of the Earth's rotation about the Sun. Owing to this inclination the Northern and Southern Hemispheres are alternately tilted towards and away from the Sun in their respective summer and winter seasons.

The possible maximum intensity of radiation declines as the angle of the Sun's rays departs from the vertical, whether due to time of day or to change in latitude. These factors work together so that at the equator day and night are equal in length throughout the year and there is relatively little variation in the radiation reaching the atmosphere during different months of the year. Most of the seasonal variation in sunshine recorded at ground level near the equator is due to cloudiness and other atmospheric effects.

The greater the latitude the less total solar radiation received during the year and the greater the seasonal variation in its distribution throughout the year, both in the hours of daylight and its intensity. This greater variation beyond the equatorial region than within it, is an interesting contrast in itself, furthermore large seasonal changes outside the Tropics are a major factor in generating the monsoons which are important rain-bearing winds in South East Asia. During the winter months the oceans and in particular the land masses lose heat, the air above them cools and becomes denser, barometric pressure rises and the air flows outward, these winds acquire a circular motion such that they are easterlies as they approach the equator. If they cross the equator they are deflected to become westerlies.

The weather at a given time and place may be defined as the sura of the ambient physical conditions or the meteorological aspects of the environment. The climate of a place is an appreciation of the weather throughout the year. Some of the components of Malaysia's equatorial climate are significant natural resources in themselves, which arise from the motion of our planet about the source of solar radiation and the effect of this upon distant parts where the winds and rain arise. These are beyond the control of mankind, which is perhaps as well at this stage of human development.

Sunshine

Hitherto meteorological stations throughout Malaysia have recorded the hours of bright sunshine and from these may be calculated the intensity of solar radiation in calories per square centimetre per day. More recently some stations have installed solarimeters which measure the incoming radiation. The few direct measurements available enable the values for energy calculated from the hours of bright sunshine to be corrected appropriately.

In Malaysia sunshine increases with distance northward from the equator and decreases with distance from the coast and with altitude above sea level. The approximate increase for each degree of latitude is one third of an hour of bright sunshine per day or 11 cals/sq.cm/day. The decline for every ten miles inland in the lowlands is about 8 minutes of bright sunshine or 4 cals/sq.cm/day. The annual moans of twenty one stations in the lowlands of Malaysia (based on five years records) were 6.5 hours bright sunshine per day and an estimated 435 cals/sq.cm./day. The lowest annual means were at Kuching: 5.1 hrs and 390 cals. The highest were at Labuan: 7.4 hrs and 460 cals. Those are quite high values compared with other parts of the world.

There is a trend of increasing yield of rubber trees from south to north in Malaya, which may be accounted for by the similar variation in solar radiation in conjunction with other factors. The growth of green plants is dependent on photosynthesis, which requires light energy, and there is a correlation between intensity of solar radiation and yield in many crops. Abundant sunshine is a natural asset, but tempered with the disadvantage that the rate of evaporation from soil, plants or open water such as fish-ponds, padi-fields and reservoirs is largely controlled by the intensity of solar radiation. The rate of evaporation is accordingly high in this region. The maximum benefit in crop yields from plentiful solar energy, whose intensity we cannot control, depends upon the availability of water, a resource whose use can be wisely planned to compensate for evaporation. The energy involved in evaporation is about one hundred or more times that stored by concurrent photosynthesis.

At most places in Malaysia the hours of bright sunshine per day and the estimated intensity of solar radiation follow a similar pattern of variation throughout the year. There is a cycle from a trough of low values somewhere in the period October to January rising to peak sunshine in February to April; the cycle is about two months earlier on the west coast of Malaya than on the east coasts of Malaya and Sabah. The west coast of Sabah is intermediate between these. Western Sarawak is rather exceptional, although the trough is in January, the peak is delayed until July, although fairly high values occur in April and May. There is a tendency in South Malaya towards a minor rise in August or September.

Temperature

The air temperature in the shade is lowest about dawn and rises to a maximum in the early afternoon usually between noon and 3 p.m. The mean temperature can be calculated by adding the minimum and maximum temperatures and dividing by two or determined by continuous recording throughout the twenty-four hours, and determining the average.

If a wide range is examined, for example throughout the whole world, the annual mean temperature is correlated with the annual mean solar radiation or more correctly with the radiation balance. The highest annual mean temperatures in the old world are recorded about latitude 10°N instead of at the equator. The annual mean temperature in the lowlands of Malaysia might be expected to show an increasing trend from south to north in view of this general global pattern and the similar trend of increasing solar radiation from south to north. However, the relationship between the annual means of temperature and radiation is not marked in Malaysia and the tendency towards a south-north trend in mean temperature is obscured by strong local modifying influences. Examples of these are the stabilising effect of winds from off the sea, whose temperature is almost constant at 27°C (80°F), and the disturbing effects of air movements down the sides of the mountain ranges and atmospheric convection currents.

The west coast of Malaya is warmer than the east coast. There is insufficient data at present to generalise concerning Sabah and Sarawak. The highest annual mean temperatures of about 27.3°C (81.9°F) have been recorded inland in the lowlands of Malaya's west coast and on the island of Labuan off the west coast of Borneo. The temperature declines with elevation by approximately 6°C/lOOOm or 3°F/1000 ft. The lowest temperatures are recorded at the hill stations.

The monthly moan temperature follows a cycle throughout the year similar to that of sunshine, although the temperature peak is on the average two months behind the peak sunshine in Malaysia. The trough in the temperature curve is on the average less than half a month behind the lowest solar radiation at any place. The

sunshine curve is symmetrical at Kuching only of the Malaysian stations examined and there the mean temperature curve is in phase with the sunshine curve. At most places in Malaysia the highest mean temperature is in May and the minimum occurs during the period November to January.

The difference between the lowest and the highest monthly mean temperature is between 0.7 and 2.4°C (1.2 and 4.3°F) , in Malaysia. There is most variation on some parts of the east coast which are exposed fully to the north east monsoon and at certain central inland stations, but it is least along sheltered coasts. This limited variation indicates how small seasonal differences are in an equatorial climate. This may be contrasted with the difference between the minimum and maximum temperatures during the 24 hours, which is called the diurnal range. The annual mean diurnal temperature range varies between 5.2 and 11.2°C (9.4 and 20.1°F).

The diurnal temperature range is closely correlated with the concurrent sunshine at any place. When conditions favour strong solar radiation inward during the day, there is probably high reverse radiation outward at night. Thus the daily warming and cooling is more pronounced during sunny periods and the temperature accordingly fluctuates more markedly. This accounts for the variation in diurnal temperature range throughout the year at each place; however the variation from place to place is not related to the mean solar radiation. The annual mean diurnal range is usually least close to the coast and the stabilising influence of the sea. Variation increases with distance inland in the lowlands, although some of the cooler hill stations are less variable.

The maximum temperature attained by day follows more closely the sunshine cycle through the year. The peaks and troughs in the maximum temperature lag on the average about one month behind those for sunshine. Since strong radiation induces greater diurnal temperature changes, the minimum to which the temperature falls each night before dawn does not mount as rapidly as the maximum day temperatures during the period of increasing solar radiation. The minimum or dawn temperature curve lags about a month behind that for the maximum or noon temperature. In most of Malaysia the peak and trough for sunshine occur respectively in March and November - December; those for maximum day temperatures are in April and December, those for minimum or dawn temperatures are in May and December-January, and those for the mean temperatures are in May and December.

Hot afternoons are usually too warm for comfortable work, whereas in the cool hours before sunrise some covering is necessary to prevent chilling of the inactive sleepers. It has recently been suggested that the effective temperature, which takes into account air movement and relative humidity as well as the air temperature, is a good index of comfort. The effective temperature

is usually lowest at dawn, rises to a peak at noon or shortly afterwards and then falls to a low value by about an hour after sunset which is followed by a minor rise during the night before dropping to the minimum again before dawn. The mean effective temperature shows a similar pattern of variation throughout the year at most places in Malaysia, usually it is lowest in January and highest in May. The effective temperature declines with altitude and the hill stations are too chilly unless warm clothing is worn. In the lowlands the average effective temperature increases with distance from the coast, which is in accord with experience that small hills exposed to sea breezes are pleasantly cool and comfortable sites.

Relative Humidity

Except for the unstable condition known as super-saturation, the air can only contain a certain amount of moisture. This quantity of water vapour increases with temperature. Excess water condenses as dew or mist especially when the temperature falls. The relative humidity is the amount of water present expressed as a percentage of that which would saturate the air for the ambient temperature, i.e. the relative humidity of saturated air is 100%.

The relative humidity usually attains a high value close to saturation after sundown and maintains this during the night, reaching a maximum just before dawn. The average maximum relative-humidity of the air varies from 94 to virtually 100% in Malaysia. There is a tendency for the average maximum to be greater at places where there is a greater diurnal range in temperature.

As the air is warmed after sunrise so the relative humidity drops to reach a minimum at the hottest time of day. The drop in humidity is closely related to the amount of the temperature rise, that is the diurnal temperature range, both from place to place in Malaysia and from month to month throughout the year. Often the fall in humidity during the day is approximately equal to that predicted from warming saturated air at the minimum night temperature to the maximum day temperature. However, usually the minimum relative humidity is higher than this predicted value because of evaporation of moisture from soil and water and transpiration by plants. Also rain temporarily increases the humidity preventing a fall to the predicted minimum. In the Malaysian region the relative humidity falls lower than the minimum predicted from the diurnal temperature range rather infrequently during dry spells, when reserves of moisture for evaporation have been reduced.

If the relative humidity over the 24 hours is averaged, the mean relative humidity is obtained, which is intermediate between saturation and the minimum attained by day. During rainy seasons the average humidity tends to rise. In the lowlands the monthly mean minimum relative humidity ranges from 45 to 85%, the annual mean minimum relative humidity falls within a narrower

bracket of 60 to 75%. The average relative humidity has a range in monthly means of 70-90% and the bracket for annual means is 80-88%. The corresponding figures at hill stations are all higher. The intermediate hill stations in the cloud belt at about 4,000 ft are the dampest.

The humidity is higher in the shade of forest trees and many delicate plants and animals cannot stand desiccation. Most mosses and ferns are confined to forest conditions or to the cloudy hills. Examples of such habitats must be preserved if the full range of plant life is to survive. There are more immediate applied reasons for studying variations in relative humidity and associated phenomena. Parasitic fungi are often susceptible to dry conditions, especially during their stages of dispersal and invasion of new hosts. Many require critical minimum periods of near saturation or even actual dew formation in order to infect a plant. In some crops it is possible to apply plant protective measures at the most opportune moment to prevent disease by predicting through meteorological observation when the fungus would otherwise attack.

Dew and Mist

As moist air cools its relative humidity rises until it reaches saturation, if further cooling takes place there will be excess water in the air. If the excess remains in the vapour state, the air is supersaturated, but this is an unstable and therefore usually a temporary condition. The excess moisture condenses into water droplets. Condensation on soil, plant or other surfaces is called dew. Condensation as fine suspended droplets is called mist, which forms more readily if there are fine particles of dust or similar nuclei for condensation floating in the air. Dew is probably more common than mist, partly because mist formation may be retarded for lack of nuclei, but mainly because solid bodies radiate heat more rapidly GO the air in contact with them is cooled more.

Dew formation is not regularly recorded at most meteorological stations in Malaysia, but some data on mist have been collected because of its important effect on visibility for navigation of aircraft and shipping.

The number of times mist is recorded during the year is greater in places where the average maximum relative humidity is higher, which is not unexpected. Mist is most common in places where the relative humidity does not fall by day as much as predicted by the temperature range, or in other words where rain and evaporation increase the moisture content of the air so that it is over-saturated at night temperatures.

Mist-free places are known on both east and west coasts of Malaysia and even one place inland, namely Ipoh. Despite these exceptional places, there is a general pattern of fewest mist days

on the west coasts, twice to three times as many on the corresponding east coasts, and about ten times as many inland as near the coast. Mistiness increases as the hills are ascended to the cloud belt, above which on the highest hills there is some decline in the number of mist days.

Correlations between the number of mist days per month and the corresponding monthly mean maximum relative humidity, and with the excess humidity above that predicted from the monthly mean diurnal temperature range, are found in several places, but not at all the stations investigated.

The distribution of mist days throughout the year is rather erratic and it is not possible to give any simple generalisation. Dew formation is probably under similar conditions as mist but more frequent. The amount of dew precipitated is not known, but it is probably trivial compared with the large amounts of water needed to meet the demands of evaporation and traspiration.

Evaporation

The change of state of liquid water to water vapour is called evaporation. This change requires a considerable amount of heat energy, about six times as much energy as that required to raise the temperature from freezing point to boiling point without change of state at atmospheric pressure. Whenever water is in contact with air which is not saturated, evaporation will take place provided there is adequate energy available. There is abundant solar radiation in a tropical climate, the warmth of the sunshine is self evident, and the air is not saturated by day as the relative humidity figures demonstrate. Thus from every water surface, whether a lake, damp soil or the tissues of a plant, evaporation takes place.

Land plants must obtain carbon dioxide from the air in order to make carbohydrates by photosynthesis, therefore they must expose tissues to the air during periods of sunshine in order to assimilate, metabolise and grow. It follows that inevitably they must lose water from these exposed tissues by evaporation or transpiration as it is called in plants, even if the dissolved substances in plant juices reduce the rate of evaporation. Some plants have devices such as closure of the leaf pores to prevent loss of water under severe conditions, but this reduces carbon dioxide supply and photosynthesis. The utilisation of the light energy abundant in the tropics to make plant products, including timber and the food of man, animals and the plants themselves, depends on provision of adequate water to balance the losses by transpiration. This is especially true of most crop plants, which have a high water demand, and in particular of wet padi because water evaporates from the rice fields as well as transpiring from the plants. One or more (often several) tons of water are required to enable one pound of food, timber, clothing, industrial or agricultural product to be obtained.

The rate of evaporation from free water surfaces such as reservoirs has been determined under various conditions. This has been correlated with the losses from pans of specified construction, which provide a convenient means of routine meteorological observation. Such results have been related to other meteorological phenomena such as solar radiation, temperature, relative humidity or saturation deficit, and wind speed, thus it is possible to calculate the potential evaporation from such meteorological records where direct observations on evaporation are not available. Evaporation is very closely correlated with the solar radiation balance, in general the longer are the hours of bright sunshine in Malaysia the greater is the potential evaporation. Evaporation is also correlated with the saturation deficit, (the deficit in water vapour pressure required to saturate- the air). Wind movements enhance evaporation by circulating the air.

The rate of transpiration by various crop plants has been investigated. It is found that a complete cover of vegetation with several leafy layers such as a forest can transpire as much water as would evaporate from a free water surface such as a lake of the same area. Mature rubber trees and oil palms probably transpire as much as the theoretical maximum potential evaporation and similar amounts evaporate from padi fields. The actual evaporation is limited by the water available and during periods of drought is less than the potential.

There are relatively few records of evaporation from reservoirs, pans or catchment area studies in Malaysia. These have been supplemented by calculations from other meteorological data. Calculated values may not appear as reliable as actual observations, but since minor variations in the technique of operating evaporation pans can cause considerable differences, and there is nonetheless reasonable agreement between the calculations and observations, all these results can be pooled to give a fair estimate of the degree of potential evaporation.

Evaporation is expressed in the same way as precipitation as the depth of water in inches per month or millimetres per day. The range in observed values is from 3.5 to 7.7 inches per month (2.9 to 6.5 mm per day) and the range in annual means from 51 to 78 inches per year (3.6 to 5.5 mm per day) at various places. Calculated monthly values range from 4.0 to 7.8 inches per month (3.4 to 6.6 am per day) and calculated annual means vary at different locations from 62 to 79 inches per year (4.3 to 5.5 mm per day). These are relatively large figures compared with the precipitation; indeed pilot . catchment studies indicate that from one half to two thirds of the actual rainfall is evaporated, (including transpiration) and never reaches rivers, reservoirs or the sea.

Evaporation declines with distance inland, roughly one tenth of an inch per month for every ten miles inland (or 0.1 mm per day

for every twelve miles). Evaporation also declines with elevation. This distribution reflects the variation in solar radiation, which also strongly influences the seasonal variation in the rate of evaporation. On the west coast of Malaya the rate of evaporation is greatest in February and is usually etill high in March; on the west coast of Sabah the maximum is in March or April. On the west coasts of both Malaya and Sabah the minimum is mainly in November, although at some places it is October or December. On the east coasts of Malaysia the peaks and troughs are generally a month or two later; the maxima are spread from February to April (especially the latter), whereas evaporation is least in December with low values in November and January.

There is a rough inverse correlation between rainfall and evaporation at most places in Malaysia, and the periods of maximum evaporation mentioned above are nearly all times of low precipitation. Thus when water is needed most, it is least available. The water storage capacity of the soil is likely to be exhausted during dry spells of two or more months.

In some places such as Sitiawan the annual precipitation barely balances the annual evaporation, whereas the other end of the scale Kuching almost invariably has an excess of rain over evaporation. There are many intermediate conditions in which water stress is likely during certain seasons. Such measures to increase food production as double cropping of padi in areas which have only one major wet season, or vegetable growing and cattle grazing throughout the year even where there are two rainy seasons, depend on water being available all the year round, Health and comfort in village and city demand adequate clean water at all times. Simple processing units such as estate or smallholders rubber factories have considerable water requirements and the increasing number cf industrial complexes being developed in Malaysia will magnify these. In many countries urban and industrial development is limited by the availability of water, even when used water is treated and re-used repeatedly. The hydro-electric schemes are sited where there is plentiful water, but its release throughout the year requires conservation and control.

The fate of rain after it has fallen, and what measures may be taken to conserve water, will be discussed in greater detail below. Agricultural, industrial and social improvements in Malaysia demand more water throughout the year, which implies water conservation at every level, locally and in the distant catchments, in the management of each farm and plantation as well as in the big irrigation and water supply schemes.

Wind

The wind has two components of importance, its speed and its direction. The Doldrums form a relatively windless zone near

the equator between the trade winds and monsoons, and shift their latitude as the earth makes its annual orbit round the sun. For most of the year Malaysia lies in the Doldrums and average wind speeds are low. The mean velocity of the wind increases with elevation, but no records are available from Malaysia's highest mountains. At Cameron Highlands (5153 ft or 1561 m elevation) the average wind speed for the year is about 6.3 mph (2.8 m/s), gusts of 40 mph occur on about 14 days during the year and gusts above 30 mph on nearly 60 days each year. These figures are approached or equalled at Kuala Pahang and Mersing, which are much exposed to the South China Sea, and at Bukit Jeram and Malacca which receive the full force of the 'Sumatra' squalls across the Straits of Malacca. The average wind speed falls along the more protected coasts and is least in sheltered places inland, for instance at Kuala Lipis the monthly average fluctuates little from 1.3 mph (0.6 m/s). There is little seasonal variation at such windier places as Butterworth and Kota Kinabalu, both have annual means of 3.9 mph (1.75 m/s), or Bukit Jeram 5.2 mph (2.3 m/s), all on the respective west coasts. Although Labuan and Malacca on west coasts show considerable variation, the greatest seasonal fluctuations in wind speed occur on the east coasts in the contrast between their Doldrums period and the full force of the North Fast Monsoon, for example at Mersing the May and January means are 4.0 and 9.4 mph (1.8 and 4.2 m/s).

The non-directional effects of wind are to dispel mist, to somewhat increase the rate of evaporation, to markedly depress the effective temperature, that is to give a more cool or. chill sensation, and to cause structural damage to some crops such as banana and rubber trees at the higher velocities. Probably because of the comparatively low velocities obtaining at most places during most seasons. much of the plant and animal life in Malaysia seems to be poorly adapted to withstand exceptionally high wind gusts or exposure to wind,. In 1883 large areas of forest in Kelantan and Trengganu were devastated by a hurricane and forest suffered severe damage in Malacca during a storm in 1917. Multiple wind throw patches have been observed recently in Central Pahang, Where left alone, these forests have slowly regenerated. There are indications that some animals, especially primates, suffer if chilled by exposure to abnormally low effective temperatures, in contrast to cattle, in particular water buffalos, which have poor heat tolerance. Provision of an adequate cushioning boundary and enough space for animals to find suitable cover may necessitate larger reserves of the appropriate habitat for the survival of some animals than food supply alone would dictate.

Monsoons

The monsoons are the major rain bearing winds, which persist for some months each year and determine the overall climatological pattern of South East Asia. The outflow of air as

the vast Asian land mass cools in winter generates the North East Monsoon which crosses the South China Sea to reach Malaysia's east coasts from October in the north, striking progressively later further south. The North East Monsoon blows strongly through November into January, slackens a little in February and stills about the equinox after a final upsurge. Heavy rainfall is experienced in all parts exposed to this monsoon and also in the boundary zone where it peters out against the Doldrums lying about the equator.

The other major monsoon is the South West as it is known in Sumatra, northern Malaya and Sabah, or South or South East in much of Sarawak and Southern Malaya, Commencing in May the southerly monsoon continues until August, bringing rain to the west coast of Sabah, but only to parts of the Malayan west coast owing to screening in places by Sumatra.

The reverse exposure of the east and west coasts to these Monsoons, especially the east coasts lying open to the powerful North East monsoon, is largely responsible for the difference of upto two months in the sunshine, temperature and dependent meteorological cycles on the opposite coasts. The major differences in the seasonal distribution of rainfall are largely, but not entirely, due to the monsoons.

The transitional periods occur between monsoons about the equinoxes and for some weeks later, The first transitional period is late March, April and part of May, The second starts in September and continues until November..

Apart from the monsoons, which are persistent prevailing winds, there are more local and frequently changing phenomena. The 'sea' and 'land' breezes experienced on the coasts are due to the differential warming and cooling of sea and land, 'sea' breezes blow from sea to land by day and the 'land' breezes in the reverse direction at night. Day squalls arise on the east coasts and night squalls strike the west coasts, especially across the southern Malacca Straits as 'Sumatras'. Advection currents associated with convection currents, thunderstorms and instability rain are common during the afternoons during the equinoctial transition periods between monsoons in the inland districts. Cold air rolls down off the mountain ranges to raise an evening breeze in foothill areas.

Types of Rainfall

When the wind crosses the sea it gathers moisture and if the air is forced to rise by mountains, the cooling causes precipitation of rain. This is called orographic rain from oros the Greek for a mountain. In Malaysia the small rise on crossing a low coastline is enough to precipitate heavy rain from the air laden with moisture after passing over the warm seas. Hence the heavy rain in districts exposed to the monsoons. Even so the rainfall increases over the foothills and mountains further inland

from the coast

Boundary rain occurs where two air streams converge and force each other upward, as over Malacca during the South West Monsoon period. Boundary rain also occurs when a moisture laden wind presses against a relatively static body of air, for example over Western Sarawak when the North East Monsoon plays itself out against the Doldrums then resting about and below the equator. Thus boundary rain is largely associated with the strong monsoon winds, although the mechanism of precipitation is somewhat different from the orographic.

Instability rain is the commonest form in many parts of Malaysia during much of the year. The sun heats up the land and convection currents rise, which eventually force up rain bearing clouds into colder air where precipitation occurs,, Convection current arise from relatively warm places and the ground is cooled where the rain falls, thus a mosaic of temperature and pressure changes occur which are rapidly brought into equilibrium by fairly strong local wind and rain storms. Such rain is most common during the transition periods between monsoons just after the equinoxes.

Seasonal Distribution of Rain and Rainfall_Regions

The country may be divided up into regions, each with a characteristic seasonal pattern of rainfall distribution. East Malaya and East Sabah are similar in receiving heavy rain during the North East Monsoon and light to moderate rain during the rest of the year. Western Sarawak also receives most rain during the North East. Monsoon, but rainfall is quite heavy throughout the rest of the year boo.

North West Malaya from Kulim northward and the West Coast of Sabah agree in having lew rainfall during the North East Monsoon; both are protected by mountain ranges to their east. Rain falls during the transitions and South West Monsoon in varying amounts. A rather small area around Malacca also has its lowest rainfall during the North East Monsoon, the dry spell sometimes extending almost until the South West Monsoon begins.

The greater part of Malaya lies in the West Malaya rainfall region with heavy rain during the latter parts of both transition periods and fair amounts during the beginning of the North East Monsoon. The remainder of Sarawak or the Central Region has a somewhat similar pattern, although the rainfall is high during the rest of the year compared with other places.

The Interior and South East Regions of Sabah are areas of relatively low rainfall and little seasonal variation compared with the rest of Malaysia. They are distinguished from each other by the Interior usually having somewhat more rain after the first equinox than during the second transition period, whereas in the South East the latter period has the most rain.

The usual annual rainfall in the Interior, which is a plateau surrounded by mountains is 60-75 ins (4.2–5.5 mm/day) and in the South East at the upper limit of this range.

Such relatively low annual rainfall in the bracket 70-80 ins (4.9 - 5.6 mm/day) is known in Malaya or. the west coast around Kuala Selangor and Sitiawan and inland also in the West Malaya Rainfall Region around Kuala Pilah and Lenggong. Although dry spells are quite frequent in these areas of low annual rainfall, the most severe dry spells are experienced in the North West Rainfall Region of Malaya, at Kangar for instance there is no rain at all during January about one year in eight. Dry spells in Malaysia are much less severe and far shorter than conditions prevailing in the arid regions of the world where there may be hardly any rain at all for years.

The whole of Sarawak has consistently heavy rainfall; with only a few local exceptions the annual means are over 120 ins (8.4 mm/day) and. the annual rainfall is over 150 ins (10.5 mm/day) for more than half the records. The rainfall at Matang usually exceeds 170 ins per annum (12 mm/day), South West Sabah around Beaufort also has high annual rainfall about 150 ins (10.5 mm/day). There is another area of fairly high annual rainfall (120 ins/year or 8.4 mm/day) on the East Coast of Sabah around Beluran and Sandakan,,

In Malaya the east coast is somewhat wetter than the west coast owing to the greater exposure to the North East Monsoon. Rainfall increases further inland on ascending into the hills, The annual rainfall throughout the East Malaya Rainfall Region is in excess of 100 ins (7 mm/day) and in the hills of the East Range, especially on the seaward side, rises to 160 ins (11.2 mm/day). Along the western coast of Malaya the annual rainfall is below 100 ins (7 mm/day) and markedly less in places, but increasing inland so that the hills have as high a rainfall as those on the east coast, The Larut hills in the neighbourhood of Taiping receive average annual rainfall up to 230 ins (l6.2 mm/day).

Intensity of Rainfall

The most intense rainstorm recorded in Malaya was 2 inches (51 mm) in 15 mins at Kuala Lumpur, this was an extreme example of the relatively brief but heavy precipitation commonly occurring as instability rain. In places exposed to the monsoons, especially the East Coasts during the North East Monsoon, rain may continue for five days at an average intensity of about 0.1 ins/hour (6l mm/day) or 12 ins total (305 mm).

On the East Coast of Malaya precipitation in excess of 32 ins (8l0 mm) may be expected during November or December about once every three to five years. Once every ten years more than 10 ins (254 mm) may be expected to fall within 24 hours at East Coast Stations, indeed in places once every five years. This precipitation is most heavy on the seaward side of the East

Mountain Range and the run-off must make its way across a relatively narrow (upto 30 miles wide) but almost flat coastal plain. The greatest precipitation within 24 hours was 24.0 ins (610 mm) near Kuantan. Heavier downpours of such durabions are believed possible.

In the Matang hill area near Kuching in Sarawak, the precipitation in January exceeds 32 ins (810 mm) one year in two and exceeds 6k ins (1620 mm) once every fifteen years. At Kuching itself more than once in every four years the rainfall exceeds 32 ins and exceeds 64 ins once every thirty. Therefore it is hardly surprising that floods occur periodically; it is surprising that they are not more frequent or disastrous.

The landscape is moulded by the environment and after a period of centuries becomes stabilised and adjusted to the average physical conditions. This is largely a living process in which the natural vegetation plays a dominant role. Such a natural landscape can absorb the shocks of all except the most extreme storms of wind and rain. Even when some catastrophe strikes the worst wounds are soon healed although some signs of disturbance can still be seen. When a landscape has been modified by human activity, felling, clearing, burning, over-grazing, cultivation or subsequent abandonment, it may lose both its capacity to withstand extreme conditions and the resilience to recover.

Floods

During January and February 1963 more than twice the usual precipitation was experienced throughout Fast Malaysia, as much as 147 ins (3740 mm) fell at Sematan in Sarawak. Deep floods were widespread. The years of serious floods in Malaya were 1897, 1926/7 and 1966/7. The assessment of the most recent floods is still in progress, but there is some circumstantial evidence, such as the maximum height the river reached at Kuala Kangsar and how rapidly the waters rose, that successive floods have been more dangerous and damaging, If so, this could be related to neglect of soil, water and river bank conservation measures, and to the increasing areas which have been disturbed by human activity. As the country develops more public works and private property are at risk, therefore protection becomes an increasingly important investment as insurance.

The silting up of the lower reaches of the Kinta River, a tributary of the. Perak River, as a result of tin mining further up the Kinta Valley, has caused frequent flooding in both the lower and middle reaches about Teluk Anson and Ipoh. Heavy rain is unable to escape rapidly to the sea because the river bed has been raised by silt and so the waters readily over-flow the banks and flood the country-side. The Batang Padang River in the same area became silted from mines near Tapah; the river changed its course and flooded large areas converting them into inaccessible swamps until reclaimed by the Manik River irrigation scheme. The

inability of flat alluvial plains and of steep hill slopes to cope with the heavy downpours after human interference with the landscape, has been tragically demonstrated when a mining dam broke at Cheras in 1963 and a massive landslip occurred at Ringlet, Cameron Highlands, in 1961,

Periodically intense or prolonged downpours will occur; these cannot be prevented at present, but the results can be ameliorated by good land use, soil and water conservation. Over exploitation cf the land and neglect of conservation measures have led to loss of life, property and land.

The Hydrological Cycle

In the preceding sections rainfall and evaporation have been described and mention made of flooding resulting from impeded river flow. These are all aspects of the hydrological cycle, which is an account of how water, an essential for life, circulates on our planet. The rain falls on land and sea and returns to the atmosphere by evaporation. Only the fate of rain falling on the land will be considered here. Minor forms of precipitation such as dew and hail follow a similar course.

Rain may fall directly onto the soil surface or be intercepted by plants. Intercepted water may be absorbed by the plant, usually to be almost immediately evaporated by transpiration in this climate, or it may drip off the foliage or trickle down the stems to the ground. Raindrops vary in size according to the manner of their formation and the degree of saturation of the atmosphere they have travelled through, in Malaysia's humid conditions raindrops are often rather large. The diameter may be 0.5 to 3 mm which would hit the surface at a speed of 9 to 20 mph (4 to 9 m/sec) respectively. The actual energy involved depends on various factors, but many thousands of droplets fall on a square yard or metre of land during an hour of quite light rain. This energy must be absorbed in some way. If the rain strikes a bare soil surface, much of the energy will be used in dislodging particles, weathering and eroding the soil. With a cover of vegetation the force of the rain displaces and even damages the foliage, although the resilient nature of the leaves and branches can tolerate much damage, and moreover the plants can replace damaged leaves.

When precipitation reaches the soil surface, whether directly or after interception by vegetation, it may either infiltrate into the soil or run off over the surface. If the soil is already saturated with water, the rain cannot infiltrate but must run off. The rate at which rain infiltrates the soil depends on physical conditions at and near the soil surface, on the degree to which the soil is already saturated and how freely water can drain away. The water which infiltrates replenishes the soil water reserves available to plants, and that which infiltrates in excess of immediate requirements and of the soil water storage

capacity percolates through the soil until it appears in streams or is impounded in deep underground water reserves. Percolation into streams and hence gathering of the water into lakes and rivers, which eventually discharge into the sea, is more usual in Malaysia. Deep water reserves, such as are tapped by artesian wells in other countries, are comparatively rare in this country.

The water which runs off directly over the soil surface after reaching the ground also makes its way into streams, lakes, rivers and the sea. However, this direct surface run-off causes erosion and carries off soil material into the streams and rivers to an extent determined by the topography of the land, soil characteristics and the degree of interference with natural conditions. If there is a cover of vegetation rapid run-off is impeded, the eroding effects are reduced and some of the particles are deposited again on the surface, mixed with plant material and not lost to the soil. Vegetation affects the balance between infiltration and surface run-off in various ways. The plant litter on the soil surface forms a filter which removes fine debris and prevents it from clogging the narrow channels through the soil, organic matter improves soil structure so keeping these channels open. The transpiration demands of the plants often bring the soil water content below saturation, but in turn the humus or organic matter added by the vegetation to the soil increases its water storage capacity, Although transpiration may reduce the amount of water reaching streams, vegetation controls loss of soil by erosion and keeps the water free from an over-burden of silt. Streams laden with silt lead to flooding down river as described in an earlier section, or if the silt is trapped in reservoirs for hydro-electric power, urban water or irrigation supplies the life of these expensive installations is severely curbailed, If more water is obtained in the streams and rivers by destruction of the surrounding vegetation, not only is this water dirty, needing costly treatment to render it usable, but its release is erratic, following closely the original pattern of rainfall, drought and storm. Vegetation enables the catchment area to act like a sponge taking up water and releasing it more slowly, smoothing the extremes of discharge rate.

The limited investigations made so far suggest that when rubber trees planted on undulating terrain have established a complete canopy, the rate of run off differs little from that for similar areas with natural forest. The proportion of precipitation (a) which runs off directly over the surface and (b) which eventually contributes to stream flow, including immediate run off, can be determined by prolonged careful measurements in catchment areas. Few such studies have yet been made in Malaysia, but considering these results in conjunction with the measured or calculated evaporation, the following estimates may be made.

In low rainfall areas such as parts of the Selangor and Perak coast and the sheltered inland part of Negri Sembilan, the

interior and south east of Sabah, there is probably very little run off or local contribution to stream flow, because evaporation accounts for most of the precipitation; these areas can be irrigated by rivers which rise in mountains elsewhere.

In intermediate conditions of 9C-100 in (230-250 mm) rainfall per annum fairly equitably distributed, about one third to one half probably reaches the rivers from catchment areas with continuous tree cover. Perhaps one tenth of the rainfall contributes to direct surface run off.

In regions of seasonal rainfall, especially monsoons, the soil in the affected areas will soon be saturated during the rains and in those months 75-90% will run off directly into streams. During the rest of the year conditions will approximate to one of the previous categories.

At continuously wet places such as Kuching at least half the precipitation almost certainly runs off directly during all seasons.

The hydrological cycle is completed by evaporation of water back to the atmosphere. This may be by transpiration of plants growing in the area where the rain fell, or which received the water by rivers or irrigation streams. Water may evaporate directly from the soil, but this is usually relatively little, more is lost from extensive water surfaces such as lakes, reservoirs, rice fields and finally the sea itself.

Water and River Conservation

Several measures to conserve water have already been indicated, moreover soil and water conservation are very closely related, yet these aspects are so important that repetition of some of the foregoing here and under soil conservation needs no apology. At the national level the upper and steeper slopes of the hills should be kept under protective forest, whether they are catchment areas for public utilities or the headwaters of rivers, so that large fluctuations in flow are dampened and burdening of the water with silt is prevented, thereby reducing risk of floods and. low water alternating downstream. Excessively low water prevents navigation, often depletes stocking with fish and leaves no surplus for irrigation. The hills are not the only source of water or of silt in the rivers, which are fed by the surrounding land along their course to the sea. The river banks themselves are constantly being eroded and the resultant silt deposited in slack water on bends (meanders) and further downstream especially in esturine flats, which slowly claim land from the sea. Thus some erosion is inevitable and can serve a useful purpose provided it is under control. If the river is alternately in spate, when the scouring by the torrent and its over-burden will be greatest, and then in low water when the banks will dry out and crack, there will be a rapid breakdown of the banks. Therefore the first measure towards protection of the river banks

is to promote a stable water regime by maintaining the catchment under forest,

There is no doubt that the benefits of a vegetational cover in the catchment areas far outweigh any disadvantages under Malaysian conditions or indeed in most regions of the world. The deleterious effects of exposed or disturbed soil can be disastrous, both by losing soil by erosion and by depositing it where it is not wanted either in reservoirs or in rivers where it may cause flooding. It is unwise to clear large contiguous areas on the upper steeper hill slopes, since calamity may strike during the comparatively short periods before the cultivated crops can cover the soil. Short rotation crops which expose the soil repeatedly are particularly undesirable. Undisturbed natural forest is the best protection in these areas and it is planned to retain about one fifth of Malaya's land area, namely that above 1,000 feet a.m.s.l. (approx. 300 m.), as protective forest for this purpose. This resolution should not be encroached upon, and it seems desirable to observe the stricter rule not to alienate for agriculture land above the 'steep land line', a relatively distinct contour where a marked inflection in the slope of most Malayan hills occurs, although its elevation varies from 150 ft (45 m) in Kedah to 750 ft (225 m) in North Pahang.

The fertile valley bottoms and flat coastal strips are those most suited to intensive market gardening, padi production and other crops requiring regular cultivation of the soil. These must be protected from flooding by wise management of the catchments areas above, which can also provide water for irrigation in those areas where dry spells are likely. In the intermediate areas tree and palm plantations are probably best.

Strips of natural vegetation should be retained on river banks, so that the roots will bind the soil. In most states of Malaya there is legislation to this effect, but it is hardly ever observed or enforced. A fringe of trees along the river banks would help to prevent logs left after felling the forest from being lifted up and swept away by flood waters. Occasional floods are inevitable, but far more damage is done to public works such as bridges, when a great weight of timber crushes against their piers and then lifts beneath the spans on the rising water or forces water downward to scour away the river bed from the foundations because it cannot penetrate or overflow the barrier of matted vegetation. Much damage of this nature might have been spared during the recent floods, if this legislation had been observed in large scale land clearing operations. The Drainage and Irrigation Department endeavours to prevent this damage by the construction of artificial control measures and the re-establishment of natural or other suitable vegetation along the banks.

The law forbids mines specifically from dumping excessive silt in the rivers, and more obscurely prohibits any pollution of

waterways. Organic matter from soil, factory or domestic wastes uses up the oxygen in the water so that fish are suffocated and bacteria may proliferate. Miners have found ways of evading the silt clauses and many others are ignorant of the law or disregard it.

In the cultivated undulating lowlands the object is to retain as much soil on the land and to store as much water in the soil as possible without actual water logging. As always a vegetational cover plays a useful role by breaking the force of the rain and adding to the organic matter in the soil. Tree, palm and other permanent or long rotation crops provide good cover and expose the soil least. Even so since there are several years before rubber trees or oil palms cover the whole ground area, it is good practice to plant a 'cover crop' of creeping legumes or to manage the weeds or grasses between the rows of trees as a protective cover. On the steeper slopes the rows of trees should follow the contours and be prepared as terraces with marginal bunds. The rows are usually ten yards or metres apart, so this is the maximum distance rain water trickles before reaching a terrace, where it can soak into the soil. Thus swift flowing streams, which would erode the soil and run the water off the land too quickly, do not develop. Sometimes additional contour ditches or silt pits are necessary.

Weeds in the rows compete with the trees and it is customary to control these. In the past this was done by hoeing with a changkol and the cultivation of the soil was supposed to reduce evaporation from the soil and increase infiltration. More recent investigations suggest that puddling of the soil and clogging of its interstices may result from the pulverising of soil by the action of such tillage and exposure to the sun and rain. It is probably better to control weeds by spraying with herbicides. The weeds or cover plants between the rows transpire water and in this compete with the tree crop for water. This can be reduced by spraying or slashing back the weeds or covers before an anticipated dry spell, their debris will still afford some protection and organic matter, but because it is beneficial in other ways the vegetational cover should not be eradicated permanently.

On flat land the main measures for water conservation are to preserve the soil surface in a condition favourable for infiltration, and to improve the soil structure and water storage capacity. These are enhanced by plants whether crops or covers. Competitive transpiration by weeds should be reduced, either by intensive cultivation of the crop itself to provide the cover of vegetation, or by keeping the weeds or covers under control when for example a tree crop is still young.

The Climate as a Resource

Apart from the soil and its nutrients, plants require warmth, rain and sunshine to grow. The lowlands of Malaysia are never too cool for crop production. The amount of sunshine varies from adequate to abundant. In order to take advantage of abundant sunshine water is needed. The average amount of rainfall varies from just enough to balance evaporation in some places to a great excess in the hills. There is also variation throughout the year such that excess at one time may not compensate for seasonal deficit. The key to the use of Malaysia's climatic resources is to provide water where it is needed from the surplus elsewhere at other times: moreover the measures to provide for this are closely related to those for flood prevention. In a country where heavy downpours are a recurrent feature, uncontrolled excess rain can soon prove the source of disastrous floods. Whether or not it proves feasible to precipitate monsoon rains over the seas before they reach Malaysian shores, this will not prevent intense storms of accident rain arising from convection currents inland. The coordination of water conservation and flood prevention is an obvious necessity and considerable advances have already been made by the Drainage and Irrigation Department in Malaysia. Even so serious floods involving loss of life and property in recent years show that there is no reason for complacency. Land and other development schemes may result in forest clearance and earth moving activity for various constructions from almost the headwaters to the mouths of the rivers. Under these conditions one of the periodically recurrent heavy storms can do immense damage, unless conservation measures are constantly being applied.

The coordination of conservation practices adapted to hill and plain results in the managed landscape or planned land system. Some of the most valuable agriculturally are those in which a flat or undulating coastal plain or interior plateau of fertile soil receives abundant solar radiation but only seasonally adequate rainfall and is able to make up this deficit by irrigation from protected catchments in the hinterland. The course of the water from catchment to the sea must be gentle and controlled; often it can serve as a public utility on the way. If this type of landscape is mismanaged, its resources are not only wasted but disaster is almost inevitable throughout the whole.

Another landscape common in Malaysia has excessive precipitation throughout from coast to mountain. This cannot cope with even greater flows in the plain, where soils are often less fertile in these cases owing to peat formation. These swampy lowlands, as in Sarawak, may be more suited to continued forestry and the introduction of industrial developments requiring large amounts of water and raw forest products, for example pulp and paper manufacture.

In such planned landscapes, where both large areas and protective strips – for example along river banks - are maintained under appropriate vegetation, there will be room for wildlife and recreation to meet the needs of the aesthetic conservationist as well as the applied conservator; the country will continue to display a fresh and beautiful countenance while exploiting its economic, including climatic, resources.

CHAPTER TWO

SOIL

Solar energy becomes human food energy by two main pathways, and in following these the energy carriers in our food become associated with the other essentials such as amino-acids, vitamins and mineral salts, One pathway is by water in ponds, rivers, lakes or the sea. Water-plants, often microscopic in size, trap solar energy and become the food of fish, which in turn are eaten by mankind. There are variants of this foodchain, for example invertebrate animals including shellfish may form an alternative or additional link as carrion feeders, or in different parts of the world whales or wildfowl may form the last link before man. Important as this water pathway is, especially to provide protein, by far the greatest proportion of human food is obtained by the soil pathway.

Plants root in the soil and obtain water and nutrients from this medium while assimilating carbon dioxide from the air and energy from the sun. Whether we consume these plants directly or animals form an intermediate link in the foodchain, the soil is as essential as our crops which grow in it or our grazing stock. The water pathway may be blocked for such reasons as low nutrient content or excessive salinity or drying out, yet it is a simple medium compared with the soil and research may find relatively easy ways of removing such blockages as occur. The soil is slow to form and is not replaced as rapidly as it can be lost by erosion, misuse or neglect. Its composition and the balance of nutrients are relatively delicate and dependent on living processes.

Soil Function

Plants obtain most of their water from the soil, which as described previously they require to transpire when tissues are exposed to the air in order to assimilate carbon dioxide for photosynthesis. The movement of water from the soil into the plant carries with it dissolved substances which are also essential nutrients for the plants and the animals which feed on them. The nutrient required in greatest quantity is nitrogen, a constituent of aminoacids, and the derived proteins and nucleic acids the substances most characteristic of living organisms. The fertility of the soil, that is its capacity to bear crops, is often dependent on the availability of nitrogen. Phosphorus, potassium, magnesium and calcium arc; also needed in fairly large quantities; sulphur and iron are used to a lesser degree and others such as boron, manganese, molybdenum, zinc and copper are required in much smaller amounts. It is also possible for some substances, especially common salt from the sea, to be present in too great a quantity and so prevent the growth of crop plants. Other toxic substances such as mine wastes containing arsenic cause local problems in Malaya; manganese toxicity is suspected in some Malaysian soils.

Plants can only take up nutrients from the soil in solution. The solubility of salts and hence their availability in the correct proportions is greatly influenced by the degree of acidity or alkalinity of the soil, which is measured on the pH scale (pH 7.0 indicates neutrality, lower values acidity, higher alkalinity). Most Malaysian soils are rather acid. The uptake of salts from the soil is not an entirely passive process, oxygen is needed for respiration to generate the necessary energy to take up some ions against the electrical potentials and concentration gradients. Some plants which live in swamps have developed root tissues with many air spaces which can allow exchange of gasses between cells in the plant roots and the air. Most common crop plants do not have such extensive development of internal air spaces and as a result cannot stand stagnant water-logged conditions. Air spaces in the soil are necessary for these plants. Respiration by plant roots is not the only demand for air in the soil. Many processes in the circulation and release of plant nutrients, especially nitrogen, also require air for respiration by soil micro-organisms.. The fixation of atmospheric nitrogen by bacteria, either free living in the soil or in association with the roots of plants, especially many legumes, requires penetration into the soil of both nitrogen and oxygen. The legume-bacteria association is most important in agriculture. Thus a fertile soil is not a solid mass, but has a structure permeated by fine air and water passages.

The development of a good soil structure takes time. Mineral particles are obtained by the breakdown of the parent materials. The channels between the particles are made by plant roots and soil animals, and by the formation of aggregates. The mineral particles are stuck together by colloidal material, sometimes clay colloids and often organic colloids derived from humus., leaving pores between these aggregates. These colloids or jelly like substances in the soil have other important properties in water and nutrient storage. The nutrient ions or salts would easily be leached away from the soil and lost through the constant washing by the high rate of rainfall in the region, were it not for the clay and the organic content of the soil. A fertile soil is a complicated product of physical, chemical and living processes.

Soil Formation

Soils can be grouped into two main classes, the sedentary soils formed on site from the underlying rocks and the alluvial soils formed from the materials transported from elsewhere by water and deposited on the site from rivers, lakes or the sea. The colluvial soils are an intermediate group, which form on the lower slopes of hills from material washed down by the surface run off of rain water from the upper slopes. There is another intermediate group of old alluvia, whose material was transported so long ago that they have continued to develop at their new locations during a period of geological time similar to that taken

for some sedentary soils to form. Soils are classified into series, each of which is characterised by its parent material and profile, that is. the relative thickness, colour, texture and structure of each layer or horizon in a vertical section. The series are grouped in families, great soil groups and orders in similar manner to the classification of living species. Soil formation starts with the. breakdown of the parent rock into particles, their subsequent weathering and/or transport. It continues with further physical and chemical changes occasioned mainly by the climate including the availability of water, but affected also by the vegetation it can support at each successive stage.

The regions where there is a very wide diurnal or seasonal temperature range, in particular if freezing and thawing are common, physical forces play a major role in weathering the parent material. In Malaysia's equitable, warm humid climate physical action is less important compared with chemical effects, in. particular solution in and deposition from tepid water. Water percolating through the soil continues weathering to a great depth. Substances are dissolved in the water from the top soil and carried downward and either leached away completely and lost in waters draining from the area, or deposited again lower down the profile. The substances available in the topsoil and the chemical properties of the soil water are affected by the presence and nature of vegetation and its litter. Roots penetrate the soil and alter its physical structure, also deep roots bring up nutrients from lower levels and reverse the downward leaching process. Natural vegetation aids soil formation, so do agricultural crops provided there is compensation for the nutrients lost from the site at harvest and reduction of the risk of soil erosion by exposure. These losses and risks are much greater with short term crops like cereals or tapioca than with tree and palm crops.

Topography and Time

Topography and parent material are other important factors in soil formation on which the climate (warm water) and vegetation act. The length of time they can operate depends much on the topography. Steep slopes are always losing materials so that deep profiles are unable to develop. Indeed it is only their cover of vegetation which saves the soils on the steeper land from being lost altogether. The material lost from the steep slopes is deposited in the flatter or low lying areas. Deep profiles may develop on gently undulating land if they remain undisturbed for long periods. Peat formation may occur in the wetter low lying areas of high acidity, the depth reflecting the period of accumulation.

Parent Materials

The parent materials, rocks or geological formations are classified primarily by the way they were formed, namely sedimentary,

igneous and metamorphic rocks, and by their age, which are refected in their chemical and crystalline composition. The sedimentary rocks were deposited as alluvia, sand and gravel (sandstones and conglomerates)) clay silt (shale), coral, shell (limestone) from water and subsequently compressed. The igneous rocks solidified from molten lava in the heart of the earth, granite being the most common example throughout Malaysia. The pressure and heat of the intrusion of the igneous rocks have changed some sedimentary rocks, examples of such metamorphic rocks are quartzite from sandstone or schist from shale, much of the limestone in Malaya has been metamorphosed to marble. Igneous rocks may be metamorphosed by a subsequent intrusion, for example the formation of gneiss from granite.

There are some tracts of basic volcanic material, andersite and basalt mainly in parts of Pahang and Sabah, which yield deep fertile clay-loam soils with a good crumb structure. The shales usually yield clay, clay loam or silty soils with a wide range of fertility. Quartzite yields rather sandy loams, which are shallow and of poor fertility on steep slopes, but fair soils are derived in undulating lowland terrain. Granite weathers deeply producing a well drained soil with a good balance of clay and sand, which stores water and nutrients in depth. The distant parent material contributes to the properties of alluvial soils and the nature of the body of water from which they are deposited exerts an influence too. Sandy river alluvia are often infertile, but marine or coastal clay alluvia are usually richly fertile.

Soil Fertility

Different crops are adapted to different types of soil. Their performance on a suitable soil depends on other environmental factors and husbandry methods su ;h as application of fertilisers. The principles of conservation require that land should be utilised with respect to these soil and other factors in the best way to provide food, materials for clothing, shelter and fuel for mankind, and also recreational amenities. Reserves of wild plant and animal life contribute to man's aesthetic needs and may be considered to be recreational amenities. However, wild plants and animals impinge on agriculture not only as weeds and pests, but as genetic reserves for breeding improved crop plants and as reservoirs of the natural agents which control pests. Timber production under the managed natural regeneration system so well developed in and adapted to this country is an obvious contribution of wild plants to rural economy. The major soil types in Malaysia are reviewed below with respect to their fertility, suitability for conventional agriculture or conservation under more natural conditions.

Recent Coastal Alluvia

The more sheltered coasts of West Malaya and of Sarawak have extensive mangrove forests still tidal and in process of being won from the sea by the advance of the mangrove. Conventional agriculture

is impossible here. Very extensive dykes or bunds would be necessary to keep the salt water out, drainage would also present many problems. The rate of natural advance seems quite rapid. Shell fisheries have been developed in places and the burrowing prawns aid in the aeration and colonisation process. Eventually the land furthest from the sea becomes sufficiently elevated for fuller utilisation and reclaimation, meanwhile very profitable crops of poles and wood for conversion to charcoal can be obtained on a rotational system. This seems the best use of these young soils, which also provide a protective coastal fringe.

Coastal Alluvia

These are the geologically recent soils deposited along the coasts during the last 25,000 years. In general those on the more sheltered coasts contain finer clay and are more fertile. Many of the finer particles were probably first suspended in sea water, where they absorbed various nutrients and were then precipitated when the sea water met less dense fresher water draining from the land. On the exposed coasts coarser sandy material is thrown up by the rough seas, except where erosion rather than acretion is in progress. Other river borne material is dropped when the force of the stream is slowed by running info the sea, either on the banks of the estuaries or in sand bars. The debris of sea and river life, shells and plant material, is also found scattered or in discrete deposits in the alluvium.

Thus the coastal alluvia are very variable in their physical and chemical properties, and the degree to which they become built up and elevated to be drained naturally, or that they may be drained artifically. Harmful sea salt is leached out by rain and carried away where drainage is successful and subsequent inundations are prevented, The drainage and aeration must be adequate to prevent water logging and the formation of harmful sulphides. The coastal clays are among the most fertile soils if these conditions can be satisfied, although irrigation with water of low salt content is often necessary for padi cultivation throughout the year to balance the high rate of evaporation. It is dangerous however to keep some of these soils water-logged by excessive irrigation throughout the year, when sulphides may accumulate.- In these cases a crop with a lesser water demand should be included in the rotation between rice crops, so that there is opportunity for air to penetrate and oxidise the sulphides. In turn it may be necessary to leach out or neutralise sulphuric acid. These soils should be reserved for the most productive agriculture. However, large areas have been lost or their management by drainage and irrigation made much more difficult and costly owing to flooding, which has its origin in erosion upstream as described earlier.

Swamps

Where lagoons have become isolated behind the various coastal alluvial deposits, and sometimes in flat river valleys, a permanent water logged swamp forms. The litter of the plants does not decay rapidly owing to the lack of aeration in the wet soil and plant debris accumulates as peat. At first the swamp receives most of its water from rivers and occasional tidal inundations from the sea, both these may bring some mineral detritis, even if the general conditions are brackish. In areas where the precipitation does not greatly exceed the evaporation, the peat does not become raised much above the water table determined by the sea and rivers. In regions where the rainfall is very heavy, peat continues to accumulate until the swamp surface is raised above the level of other sources of water. Rainwater contains few dissolved plant nutrients compared with those brought in by other sources of water. Any nutrients released by the decay of the peat tend to be leached away by the rain water as it drains off, but much of the peat continues to accumulate.

There are large areas of swamp forest in south east Malaya and even more extensive areas in Sarawak. Their soils are very low in fertility, because all the nutrients are locked up in the organic matter and applied fertilisers are easily leached away. Artificial drainage causes some drying and shrinkage of the peat, but reclamation by such means is a long and costly process. If the peat was removed or destroyed, the clays beneath might prove fertile. However, drainage would remain an important and difficult factor, because the land level would have been reduced to the normal water table or lower, and not only would bunds be needed to keep flood waters out, but pumping might be necessary to get rid of the excessive rain water. Until such massive engineering works can be afforded or pressure on lands is so severe, it would seem the most profitable land use to discover means of managing the extensive tracts of swamp forest to yield the maximum forest products and to retain some as game reserves... Vegetables may be grown by itensive methods, but the market available within the range of economic transport is often limited so that this land use is local only in most cases. The market for pineapples, also grown on these soils, is saturated at present. Thus forestry remains the most promising large scale usage.

Valley Alluvia

Weathering occurs naturally in the hills and where the rivers are slowed down on entering the coastal plain part of the burden carried by the streams is deposited as river valley alluvium, since the coarsest material is usually deposited first, often rather sandy strongly leached soils of low fertility result. The finer material giving rise to clay and loam alluvial soils is usually carried into the lower reaches, the estuaries and flood plains, where fertile soils may be deposited over a period of

time, the risks involved where this process gets out of control due to excessive soil getting into the rivers have already been described.

Older Alluvia

During earlier geological periods river, flood plain and coastal alluvia were deposited in terraces corresponding to the then levels of the sea, ranging from 20 to 270 feet (6-80 m) above the present level of the sea. These terraces are interesting indicators of the geological history of South East Asia. Prolonged leaching of these soils has reduced their fertility. The forest on these impoverished soils is not very valuable in preferred timber species. Fertilisation and cultivation of the less demanding tree crops such as rubber is often difficult owing to multiple deficiencies of both major and trace nutrients, although there are a few isolated cases of very good yields from oil palms on these soils. If abandoned after unsuccessful cultivation, waste lands of lallang and poor scrub are likely to predominate. It would seem wise to expand the cultivated area cautiously taking careful note of past experience.

Shallow Soils of Steep Land

On steep hill and mountain slopes erosion of parent material, especially of sedimentary rocks, is most rapid and the situation is the reverse of that which obtains where alluvium is being deposited. These young soils are shallow and easily lost if their vegetational cover is removed. Twenty times as much soil is lost from the tea and vegetable gardens as that from forest in the Cameron Highlands of Malaya, although the gardens are terraced and the forest is not. These are soils which from their situation should remain for the greater part under protective forest.

Lateritic Soils

In the humid tropics the constant washing of the soil by rain can have various effects. Laterisation occurs when the silicates are, washed out, but the remaining sesquioxides of aluminium and iron accumulate and impart a deep red colour to the soil. The formation of hard concretions is the most typical aspect of this process. There is usually a rather shallow soil covering the hard layers of laterite nodules, which are easily exposed by erosion. These soils are difficult to work, the fertility is moderate at best but often low. The main problem is poor root penetration and thus limited utilisation of the nutrients. The hardier tree and palm crops are perhaps the most suitable usage, although shallow rooted crops can sometimes be grown if the lateritic layer is not too near the surface.

Podzols

Podzolisation is sometimes considered to be the reverse of laterisation. In a podzol a shallow peaty topsoil covers a depth of bleached sandy material extending downward and beneath it is a dark stained layer. The sand is almost pure silica except for a few plant remains on or near the surface. The iron and other materials washed down are concentrated in the dark usually red layer, which may be a hard impenetrable pan. In Malaysia some of these heavily leached podzol profiles are deep (3 ft or 1 m. or more) , they form on old raised beach terraces, as for instance on the East Coast of Malaya or in parts of Sarawak where at least some of the kerangas areas are of this nature.

In parts of Sabah there are red-yellow soils classified as podzolic by some soil scientists and as latosols by others; these are fair agricultural land if fertilised adequately. The typical grey podzols require heavy manuring, preferably with organic matter, and possibly irrigation to produce agricultural crops of value; if abandoned these heavily leached podzols revert to poor scrub. The natural vegetation is poor, in places careful management can give crops of poles and firewood; the deep roots of these trees bring up nutrients from the lower depths and counter-act the leaching process to a limited extent. Part of the Bako National Park in Sarawak includes podzols. Owing to the infertile soil, many interesting insectivorous and other peculiar plants are found, and even if the stocking with wild animals is not high, it is adequate to justify preservation as totally protected nature reserve and to provide recreational amenities. Shallow rooted coconut palms occupy much of the podzols of East Malaya, the crops are poor and do not repay the heavy fertilisation necessary to effect any improvement; this mistaken land use should not be repeated.

Latosols

These are yellow, red or brown soils of usually deep profile, which have been subject to prolonged weathering and intensive leaching by rain water on site; they are primarily sedentary: soils, although some of the colluvial and older alluvium soils also may be regarded as latosols which have developed since their ancient deposition,, With the exception of disturbed soils, some older alluvia and the young shallow examples in the mountains, the latosols as a group are of suitable physical structure for most crops, but their nutrient content is variable. Some of the widespread latosols derived from granite owe their fertility more to their friable structure enhancing drainage and water storage than to the amount of available nutrients, the latter being low. These soils allow the. roots of tree and palm crops to penetrate deep and tap, the nutrients from a large volume of soil, also the free percolation of water enables weathering and release of bound nutrients, especially potash, to continue deep in the profile.

In some latosols nodules of laterite occur. The most fertile latosols are those rich in. nutrients, well weathered and yet retaining a good crumb structure to a great depth, the best known of these are derived from effusive volcanic rocks. In Malaya, these are known near Kuantan and Temerloh in Pahang and also in Johore. In Sabah they occur in the South East near Tawau and Darvel Bay. Owing to their richness and the easy infiltration of water through the crumb structure, it is sometimes thought that these soils need no management. In fact they respond better than any other soils to good husbandry. Since they are so valuable an asset, it is most important to use these soils for the most beneficial food production and to protect them by careful treatmentv

The latosols, with their wide range in fertility and structure, provide much of the agricultural land and the poorer amongst them support good forest. They are the product of weathering on site for a long period. The soil is still in place in a more or less natural profile, even if the degree of humic penetration in the topsoil has altered under cultivation, unless eroded by exposure and bad management. It does not follow that because latosols are widespread that these soils are sufficiently robust to withstand all abuse. Whenever in nature there is opportunity for contrasting processes to operate, such as where soil formation by weathering on site may pass over into erosion from the site, then it is a warning that careful management is necessary to preserve the balance or to control the rate of soil loss.

Disturbed Soils

Dredging and hydraulic mining for tin is widespread in Malaya. In the process of extracting the tin ore, the soil is washed and loses most of the soluble nutrients. The soil profile is drastically altered, top soil is buried, deep layers of infertile, free draining sand cover vast tracts. In the slimed areas the clay which has been saved cakes and cracks, so that it is easily drained through the cracks but the hard surface between is not readily penetrated by roots and colonised by plants in these locally arid conditions. Natural colonisation is slow; there are many areas fifty or more years old with but a scanty fire prone regeneration of scrub. Rehabilitation by planting trees, such as pines for pulp production, has met with only limited success owing to the low fertility and fire hazards. As for agriculture only intensive methods using large amounts of organic manure are possible on a strictly limited local scale.

This is all the more sad because the 200,000 acres (80,000 ha.) of badly degraded tin tailings represent much which was originally among the best agricultural land in Malaya. The profits of tin mining when prices are high and the revenue earned by government through taxation make it unlikely that alienation for mining would ever cease, apart from the large number of prospecting and

mining leases already given. The following measures might help to ameliorate the worst effects and make rehabilitation easier.

Areas are worked piecemeal at present, rich deposits when the price is low, the poorer only when there is a premium. Old fashioned methods could not reach all the tin in some fields, which are now accessible to modern workings and will be mined again. Several different companies may hold adjacent leases and each worksat its own rate according to its own methods and resources. If complete and coordinated working of a particular area could be introduced, resettled soil need not be disturbed afresh by re-mining or flooding or changes in drainage by adjacent activities at a later date. Sliming in bunded pools with the clay spread on top is a promising method. Coordinated planning to remove limestone and dolomite, which are exposed by hydraulic mining for tin, would make rock available for constructional purposes and for magnesium fertiliser preparation, as is already done on a limited scale to obtain marble and for cement and lime manufacture, This would do no more harm to the landscape than tin mining already inflicts and would make additional spoil areas available, although at the cost of some pumping. The main object would be to relieve the pressure on the rare limestone outcrops for these materials by overall conservation planning,

Limestone

Nearly all the limestone exposed above ground level in Malaysia is in the form of precipitously rising hills or karst towers. The limestone hills are isolated islands, survivors of much more extensive formations in the past. Limestone consists of calcium carbonate, there may be various proportions of magnesium carbonate from nil to equal amounts of calcium and magnesium in the double carbonate or dolomite. These carbonates dissolve in water containing carbon dioxide, a little of which is taken up by rain passing through the atmosphere, as well as in other acids produced by the decomposition of debris from plants growing on the surface. Many drainage channels are formed through the rock. The strong drainage is one of the factors determining the vegetation able to grow on limestone.

The limestone hills present a mosaic of different habitats. There are the steep dry cliffs and pinnacles with hardly any soil except in a few crevices. The top is broken into ridges and valleys, damp hollows alternate with dry ridges. The soil is shallow in most places, because the limestone leaves few residues after dissolving away, occasionally iron oxides accumulate (sometimes as valuable haematite ore), or a peat of fibrous plant remains may form because the dry conditions and low nitrogen status does not encourage rotting. Spontaneous fires sometimes break out, quite frequently on Gunong Api (Fire Mountain) in Sarawak. Their topography alone makes them unsuitable for agriculture. There is no agricultural pressure for these limestone

hills, but their specialised vegetation and the rare fauna of cliff and caves are threatened by quarrying. Often the dry vegetation is burnt off by fires started accidentally or purposefully by mineral prospectors,

Soil Survey

Soils in Malaysia were first described by examination of profiles in agricultural land, where the penetration of humic substances was often deeper than under undisturbed natural forest. Even so the period of cultivation in Malaysia has hardly ever been so long that the relationship is obscured between soils recognised in agriculture at the series level and the soil developed from the same parent material under similar climatic and topographical conditions but still covered by forest. Therefore soil surveys are conducted by visual, physical and chemical examination of soil profiles or of samples from pits dug at selected points in both cultivated and undisturbed land. The soil series or broader units of classification are identified and plotted on maps. The experience with these soil types in agricultural practice enables their inherent suitability for certain crops with or without artificial aids such as drainage or manuring to be assessed. A soil survey throughout the country is one of the stops towards classifying the suitability of different areas for various crops or indicating those parts more wisely left under forest.

Land Capability Classification

Although soil fertility is one of the important factors in deciding the most suitable use for a piece of land in the nation's economy, others must be taken into account. Climate and topography influence the soil, but they have independent effects also. Some crops thrive in a markedly seasonal climate, whereas others are adapted to equitable conditions throughout the year. Erosion control measures on very steep land or drainage of low lying areas may be impracticable or too expensive. The position of the water economy must be determined, whether the area is catchment which should be protected, or in need of irrigation and, if so, whether adequate water is available. Abundantly rich mineral deposits take priority in exploitation.

Reconnaissance soil surveys had covered more than 20% of Sarawak, 30% of Sabah and all of West Malaysia by 1968. The climatic conditions are known in broad outline throughout the lowlands at least, although more detail is needed concerning radiation and hydrology. Topography and current land use are mapped by aerial photographic survey supported by ground investigation. Geological surveys and mineral prospecting locate these resources. All this information is entered on maps and collated for Land Capability Classification as it is called in Malaya; surveys similar in method and object are conducted under other names elsewhere. The purpose is to

recommend the best land use for any area.

Such surveys grew first from the need to be able to alienate the land of most promise for success in agricultural development to the landless settlers, who otherwise would try to satisfy their hunger for land by squatting on land more suited to other uses or by shifting cultivation in protected forests or catchments and so damage the national economy. It has always been appreciated that some non-agricultural uses such as working rich mineral deposits must take high priority for the capital they attract, the employment created and the foreign exchange earned. Water power is also a valuable asset, water supply is necessary for irrigation, urban and industrial development. Since exploitation of these non-agricultural resources depends on good conservation practice in the catchments and channels of safe water movement, the outcome of a well organised comprehensive survey and the wise implementation of its recommendations is not antagonistic to appropriate nature protection projects. The surveyors and planners not only mark some areas as unsuitable for agriculture and recommend retention as forest, game reserve or recreational amenity, but indicate further where misused land should be converted back to these purposes.

Soil Erosion

The Land Capability Classification attaches great importance to the topography of the land, that is the steepness of any slope, because this is a major factor in predisposing the soil to erosion. It is not intended to cultivate land with a steeper slope than 20° (about 1 in 3), The 'steep land line' is detected on topographic maps of Malaya as the level where the contours change from widely to closely spaced and indicates the boundary between the lower slopes less than 20-25° and steeper above. Most of the land of 500 ft (170 m) elevation or more is above the steep land line in Malaya, that is about 40% of the surface of the peninsular. These upper steep slopes should be retained under protective forest.

In the arid and semi-arid regions of the world the scouring action of wind blown particles is a major cause of soil erosion, but this is of minor consequence in Malaysia, where water is the principal agent. Coastal erosion may occur after interference with the protective mangrove swamps, sandy foreshores and coral reefs; these arc special cases of water erosion by the sea and the concurrent inundation of agricultural land by salt water often does equally serious damage. Most soil erosion in Malaysia arises from the action of rain falling on sloping land and the subsequent movements of the water. The amount of erosion depends on the degree and length of slope, the quantity and force of the rain, the presence or absence of vegetation, the properties of the soil and any artifical measures taken such as terracing or silt pitting to reduce the length of uninterrupted slope.

Splash Erosion

The energy of a falling raindrop, or of repeated raindrop blows, may detach a soil particle from the soil surface. When this or other detached particles are struck by further rain, they are flung up into the air and - if the surface slopes - on the average each particle will fall back a little further downhill. The effect of heavy rain on exposed soil is often insiduous, thousands of tiny particles each move a short distance downward during every storm. The cumulative result is that a whole sheet of top soil moves down the slope. The value of vegetation in breaking the force of the rain is evident. The litter serves this purpose also and is often too big to be a easily dislodged as mineral particles, moreover the organic matter helps to stick the soil particles together and modify the soil surface so that the rain water is rapidly absorbed instead of bouncing back. The encouragement of infiltration instead of run-off is important in preventing the next type of erosion too.

Channel Erosion

Rill, gulley, stream and river erosion are varying degrees of channel erosion from the first incipient stages in the field. All arise from water which runs off over the soil surface and gathers together into progressively larger channels following the path of least resistance, which at first may be any slight depression avoiding rocks and other obstructions. As the quantity of water and speed of flow increase so the channel is scoured deeper and wider until adjoining gulleys coalesce and the original surface is lost.

The severity of channel erosion depends on the intensity of rainfall, the proportion which runs off, and the steepness and length of the slope. These factors determine the amount of water and the speed it attains. Vegetation and its litter affect the surface soil and. hence the balance between infiltration and run-off, although this is less important in channel erosion most common during intense rainfall than in splash erosion equally serious during prolonged light rain. Plough furrows and planting rows are agricultural artifacts which provide primary channels for run off; if they run up and down hill, they will concentrate water movement in streams of the maximum velocity. Contour ploughing and terraced planting rows interrupt the rush of water downhill.

Landslips and Slides

Landslips are small landslides; both are most common where clay soils overlie impervious rock strata on steep slopes. Clay is colloidal and can hold great quantities of water, which increase its weight and lubricate the interface between the soil and underlying rock., so that the soil eventually slips and slides downhill.

The risk of landslide is increased by undercutting, either deliberately in road construction or accidentally by stream erosion at the foot of the slope. The role of vegetation appears at first to be uncertain, whether beneficial or otherwise, if it increases infiltration and the water loading of the soil. However, the vegetation also transpires water so that the clay is partially dried out and tree roots improve drainage. Plants differ in their effects and the balance between these processes. Artificial drainage may assist. Early detection of areas liable to landslip enables roads and dwellings to be sited safely elsewhere, or where that is impossible for the banks to be sculptured to reduce the hazard.

Biotic Erosion

Except for man himself, animals cause little direct erosion in Malaysia. In other countries they do on a moderate scale. Burrowing animals undermine banks or eat the roots of plants. This activity or more commonly over-grazing and barking of trees may alter the vegetation and its stabilising influence on the soil. Cattle may puddle the soil and upset infiltration, or their weight cause landslips; however, this is not serious in Malaysia because there is still very light stocking with cattle in most places.

Erosion Control

The old proverbs 'Prevention is better than cure' or 'It is no good shutting the stable door after the horse has bolted' are most appropriate in discussions of erosion control. It is sometimes possible to restore land, if erosion has not gone too far, but this is an expensive procedure relative to the value of the crops which can be taken from such impoverished and rehabilitated soil. Good conservation agriculture is practised in many cases throughout Malaysia., especially in the old established and well capitalised plantations which learnt their mistakes during the early days of clean weeding. However, erosion control should be universal, not just observed by a majority only, otherwise the spoilers of the soil will constantly look for new land elsewhere and erode away the nation's capital resources. Many of the principles and practices of erosion control have been indicated already in explaining how erosion comes about.

The first golden rule is to have an adequate cover of vegetation to prevent exposure of the soil to sun and rain. Where the spontaneous growth or agricultural crop provides incomplete protection, cover plants should be established in the bare spaces. Legumes are favoured in agriculture, because they can improve the nitrogen status of the soil as well. Roadsides and urban open spaces are usually put to grass. A common mistake is to try to get plants to grow on the infertile newly exposed subsoil of recently mechanically cleared sites. This can be

overcome by preparing a seed bed and manuring. Another mistake-is to mow grass too low or to let it be overgrazed. This restricts the root growth too, so that the grass is susceptible to drought and the short tops wither away to unsightly wisps insufficient to protect the soil when the rains return. Run-off may be rapid if the soil is baked and puddled. Fertilisation and moderate cutting give quicker establishment, add more organic matter to the soil and so increase its water retaining and soil binding power, as well as giving a more pleasant appearance. Crop residues should be returned to the soil as far as possible, instead of being burnt as is often the case at present. Crop residues are sometimes grazed by animals or fed to them, in which case the farmyard manure should be returned to the soil.

The next important rule is to follow the contours whether this be ploughing or preparing planting rows along terraces. Contour bunds and silt pits provide an alternative where the land is not so steep as to justify terraces or form an additional measure on very steep land or under mature rubber which has shaded out the ground covers. Sometimes in estates whose field plantings are well laid out, these bunds and pits are forgotten in nurseries because a nursery is regarded as only temporary; nevertheless the need for soil and especially water conservation is all the more in nurseries because they are intensive agriculture, even if it is of short duration. Terraces should slope back into the hill to assist soil water accumulation. Even so provision must be made to carry off any large excess of water safely by gently graded drains with sodded banks. It is often desirable to leave the larger streams surrounded with the original vegetation. Concrete lined drains and silt traps are useful permanent installations in places where occasional flash floods are inevitable. Sometimes a drain or silt pit to protect the upper boundary of a plantation is forgotten and water pours in from behind breaching the upper terraces.

Soil Conservation

True soil conservation as the best use of the land and water resources goes beyond erosion prevention and control. Firstly land mapping and planning can ensure that the right sort of development is undertaken on the land which can sustain it, and that wrong developments are corrected by reforestation. There are social aspects too. Squatters, who have no legal title to the land they occupy, are careless in its use. Cultivators, who are given only short term tenures such as annual leases or who have uneconomically small holdings, will not bother or cannot afford to invest their small capital in effecting improvements to preserve its fertility. Alienation and alignment of holdings must be planned in units for soil and water use. The Malaysian government is taking steps to prevent illegal occupation, fragmentation of holdings and short insecure tensures in future schemes, but there is still much misuse of land attributable to inherited problems of custom, ownership titles or the lack of them.

Although soil conservation is largely a problem of land use planning, agricultural and forestry, public works such as roads and open spaces are important too. The engineer's first problem is to prevent flooding, subsidence and blockage by land-slips of the highways and airfields. However, the effects of rapid run-off and surface erosion over tarmac and short grass on the areas receiving this water and its overburden may be neglected. Sediment traps in the major outlets are often a useful intermediary barrier to break stream flow and deposit soil particles where they can do no harm. Indeed sand caught in these traps can usually be sold as building material.

The Malay expression tanah ayer kita, literally 'soil and water of ours', to describe the land of the country has a deeper meaning. Soil and water are among the most significant natural resources. Water enables solar energy to be used to the full, it must be safely channelled, it can be stored in reservoirs and improved soils, it is replenished. The soil is the basis of the greater proportion of food production, it can be protected and improved, it can be neglected and eroded, but if lost it cannot be replenished in a commensurate period.

CHAPTER THREE

AGRICULTURE

The literal meaning of agriculture is to till the fields. The development of settled agriculture has been the precursor of modern civilisation. Early man gathered wild plant produce such as fruits and roots. He collected also simple animal foods, eggs, insects and honey, much as many of the wild primates (monkeys and apes) do today. Later man became a hunter and a fisherman as well as a gatherer.

Another early stage seems to have been the partial domestication of cattle, sheep and goats in herds and flocks which were grazed in natural rough pastures for their milk, meat and skins. Most of the early graziers were nomads, travelling great distances to find adequate fodder and water for their flocks. They had to travel partly because they lived in the more arid regions where natural grasslands occur and water is scarse, and partly because they kept excessively large herds as indicative of wealth and allowed these to exhaust local resources before moving on, which in turn was due to the need to concentrate the herds for protection. The natural vegetation and terrain of South East Asia has not been suitable for the development of this phase of migrant shepherds and herdsmen, which has been poorly represented in Malaysia. In other parts of this region the grasslands left by abandonment of shifting cultivation have been grazed, but this has not been on so great a scale in South East Asia as in Africa, where large areas were kept under grass by fire and numerous cattle.

The deliberate planting of crops for subsequent harvest as distinct from reliance on collection from self sown wild plants was the great step towards agriculture as we know it. Some believe that the first crops were vegetatively reproduced plants such as bananas and roots or tubers, because these are most easily grown by division of exisisting plants. According to this view crops raised from seed came later, because the idea of saving seed and sowing it is more complicated. These first plantings were probably on recent alluvial deposits by rivers, or on soil exposed by windfalls, landslips or fire caused by lightning.

The next phase was to destroy the natural vegetation in order to plant crops. This required tools and the use of fire. Methods had to be devised of storing food if the harvest was seasonal. A similar development was to supplement the grazing of livestock with fodder fetched from elsewhere or stored in some way especially during the adverse season in the cold or arid regions. These animals kept in stalls and paddocks could be slaughtered when food was scarse. The pressures towards these developments have been less in the humid tropics than in other climatic zones.

Shifting Cultivation

One of the more primitive types of agriculture in the tropics, shifting cultivation, is still practiced by aborigines in Malaya and by other indigenous peoples in East Malaysia. Although there are archaelogical indications from different parts of the world and many current anthropological observations that shifting cultivation has been widespread throughout the tropics from the Stone Age onward, it is largely conjecture to what extent the methods have changed.

It is often assumed that the way of life of the aborigines has remained unaltered until the impact of the twentieth century, whose penetration by such agencies as the transistor radio can be traced and assessed. However, there is evidence that the Temiar of North Malaya did not begin to acquire hill padi from the Malays until as recently as 50 years ago before any disturbances from technicological civilisation reached them. Previously millet was the main cereal crop of the Temiar and still is in their more remote clearings. Millet has been cultivated in Asia for at least 4,000 years. The Temiar grow chillies, tapioca and maize also, they seem to have adopted these crops before accepting padi. They can only have acquired these three crops during the last 400 years because these plants are American in origin and were unknown in the Old World until Columbus discovered the New. Thus, if for no other reason than the acquisition of new crops, we know that there have been some changes, but when, their magnitude and rate are difficult to judge.

Temiar Millet System

Probably the shifting cultivation based on millet as the main crop practiced by the more isolated Temiar is typical of the ancient methods of many of the aboriginal peoples in the region. The Temiar hunt and fish also, which provides most of the protein in their diet. The people of the family or clan group living in each longhouse or village fell an area of nearby primary or old secondary forest and burn the trash. On sloping land simple terraces are sometimes made by lining the larger partially burnt logs along the contours, so that some of the silt and ash collects above them as seed beds. The millet is planted in holes dibbled with a pointed stick and usually only one crop is taken. Afterwards the area is abandoned to invading secondary forest or perhaps bananas, whose wild relatives are secondary jungle species, are planted to give one crop which is not very carefully weeded until the forest is allowed to take over. Other vegetables are grown near their dwellings and the occasional fruits of the jungle are gathered on hunting trips.

The abandonment to secondary forest is the equivalent of turning a field over to fallow. It is allowing a period during which the soil fertility is restored by a covering of forest, even if it is secondary forest different from the primary jungle, but no crops are sown, grown or harvested. If only one crop of millet is taken, the soil reserves are not severely depleted,

the invasion of true species is rapid, and as far as it is possible to judge fertility is completely restored in a period perhaps as short as ten years, when the cycle may be repeated.

While the human population density is low, it is possible for an adeqaute number of clearings or fields, each with its long fallow relative to the cropping period, to be used in turn in the district surrounding the settlement, without any serious deterioration in the soil. However, sometimes soil fertility does become noticeably less and the aborigines move, perhaps only a few miles, and set up in a new area, but by the time they need to move again, the longer fallow has probably restored the soil at the first location. The result is a matrix of undisturbed virgin forest with many islands in all stages of felling, cultivation and fallow. The cultivation is shifting in the sense that it moves from field to field and occasionally the village centre moves too, but from generation to generation the same tribal lands are occupied, the soil fertility and the forest hunting reserves ore maintained. The preservation of ancient varieties of only partially domesticated crop plots, such as unselected millet and bananas, is a useful service to plant breeding.

Severer Systems

When the Temiar adopted dry padi, they often grew two crops instead of only the one usual with millet. Planting up the more thoroughly cleaned and weeded land afterwards with tapioca, which is a demanding crop unless heavily fertilised, continues the process of soil exhaustion. The result is a strong tendency for the grass lallang (Imperata oylindrica) or at higher elevations bamboos (Gigantochloa etc) to take over and to prevent forest regeneration indefinitely when the clearing is abandoned. Soil fertility deteriorates under lallang and does not seem to be restored under bamboo, a thicket of which is very difficult to clear in any case. Fires in lallang or bamboo retard further forest regeneration and encourage leaching of nutrients from the soil.

The use of the hoe, or changkol as it is known locally, in place of the dibble stick may cause more soil disturbance and hence more erosion on sloping land. Irrespective of this, the main factors in turning the course of regeneration from secondary forest to grass or bamboo after abandonment to fallow, are the increase in the period of cultivation and the decrease in the duration of the preceding fallow.

Other undesirable features, which usually occur in conjunction with those already mentioned, are the clearing of steeper slopes and of contiguous clearings with inadequate adjacent forest to assist in regeneration or to provide boundary belts to check the spread of fire or massive sheet and gulloy

erosion. Various influences cause these changes leading to permanent destruction of the forest and its replacement by undesirable 'biotic' or 'fire' climax vegetation, soil erosion and loss of fertility, unless made good by the use of fertilisers and the methods of settled agriculture.

Usually these pressures and changes are blamed on increasing population density, whether this is due to squatters invading an area or to natural increase (population explosion), the resultant land shortage causes cultivation to continue too long with inadequate fallow in adjacent clearings. However, other reasons should not be forgotten. Resistance to shifting when necessary may arise, because one centre is well situated for access by traders, who purchase jungle produce for cash which enables the aborigines to buy sophisticated tools, firearms and radios, and by various official agencies bringing education, medical facilities and social welfare. These outside contacts may be very attractive and break up the traditional pattern with its respect for the tribal forest heritage. Eventually the system may be reduced to one of thoughtless over exploitation as practiced by many who had no stake in the country in the past.

Chinese Gambier System

This is an example of one of the crudest and most devastating forms of shifting cultivation. *Uncaria gambir* is a shrubby climber of the Coffee family, whose fresh leaves yield on boiling gambier used in the dyeing and tanning industry. During the first half of the nineteenth century it was planted extensively in Singapore and later in South Johore by the Chinese. The method was to crop each clearing exhaustively until it yielded too little to be worth harvesting, *lallang* almost invariably invading afterwards. The degradations of the nearby forest for firewood to boil the gambier were equally severe. As each area was ruined, the cultivators moved on further to repeat the process. Often they had no title to the land and certainly made no efforts to restore it. The sole object was the maximum profit for the minimum outlay. The effect of this on the soil in these areas has been long felt.

A similar situation arose in some areas occupied by squatters during the Second World War for the cultivation of subsistence food crops. The lack of fertilisers largely forced them into this irresponsible treatment cf the land, accentuated by the knowledge that they had no title to the land, which was neither their heritage nor to be the patrimony of their children.

These extreme examples should not lead to condemnation of all shifting cultivation. Nevertheless the pressures on the benign primitive systems are increasing and it is doubtful if they can survive long. In some cases settled agriculture must be introduced immediately, especially where shifting cultivation is not the traditional life of the people. In others the shifting

cultivators may survive with varying degrees of success for a few generations more, until probably sooner rather than later, the essential forest fallow cannot be secured, and the land will have to be rehabilitated from lallang or bamboo for settled agriculture or for productive or protective forestry, perhaps at great national expense.

Where the aboriginal shifting cultivators find themselves alongside land development schemes, successfully using the methods of settled agriculture, the aborigines nay copy these methods, much as they have borrowed crops in the past, and settle down to make the best use of their lands under the changed conditions of population pressure. Wise advisors may assist them to do this without complete disruption of their social system and culture. Government planners may reserve the hunting and fishing rights in adjacent forest reserves to the aborigines. The fatal susceptibility of the aborigines to diseases such as measles, chicken pox and mumps, which are regarded as normal childhood complaints among the town dwelling races and other social factors make the adjustment of the aborigines way of life to the modern world very difficult. Equally to try to preserve them as fossil cultures in distant reservations may deny them self determination, political development, education and material advantages, which are regarded by many as the rights of man. Who shall decide- to what intellectual and physical benefits and risks any others shall be exposed to or preserved from contact? Conservation of natural resources brings conflict with the aspirations of people, whether it be the hungry majority in the world or the cultural minorities.

Settled Agriculture and Civilisation

Civilisation is derived from a word meaning to do with cities. Whatever we mean by civilisation, for instance government by law, political and social development, the practice of the arts and sciences, the communication of ideas or oven the waging of modern warfare, has required fixed centres. In these people can congregate, facilities such as machinery and records can accumulate, and. at least some of the people are not toally occupied in food collection or cultivation so that they have time to invent new things and pass on this information by education of their children and neighbours.

The villages of the gatherers, hunters and fisherfolk could be fixed in location, but these occupations were so time-consuming that little was loft over for progress towards civilisation. Also since they could easily exhaust food supplies within a convenient distance from their village, there were limits to the size of the villages sustained in these ways.

The nomadic graziers undoubtedly had more time for spiritual and cultural contemplation with the consequent emergence of religious thinkers, poets, musicians using simple

instruments and story tellers. However, their constant movement virtually limited the records they could carry to oral tradition; similarly advances in building or mechanical aids were either impossible or greatly hampered.

Shifting cultivation in the more fertile areas may have sustained some centres of civilisation, especially where a military caste or a religious priesthood could command as tribute any excess produced by the surrounding cultivators. The Egyptian civilisation was supported by the seasonal agriculture of the Nile delta based on the annual flooding and deposition of alluvial silt, but this was not shifting cultivation in the sense used here, Eventually the modern civilisations of the temperate and mediterranean regions were the product of settled agriculture spurred on by the need to provide for the adverse cold or dry seasons.

The development of settled agriculture has a long history and many variations in different parts of the world, which cannot be recounted here. Settled agriculture is the source of most human food today and thus is still the mainspring as well as the origin of civilisation as we know it. In as far as a conservationist is an advanced or civilised person, he is the product of agriculture and dependent on it. Efficiency in agriculture is essential to feed the hungry millions of humanity in the world today, especially if there is to be any room left over for nature conservation.

Efficient agriculture is a process of continual use and renewal of natural resources, it is conservation in its highest form. Agriculture and nature conservation are interdependent at every level, not only in the obvious need to manage the soil and water resources wisely, but in various ecological relationships.

Human Needs

Agriculture gave us civilisation, but disease limited human population until civilisation produced medicine, public hygiene and sanitation. The result of the latter has been the well known population explosion. Soon (perhaps by 1970) there may be alive on Earth more people than have ever lived on it in the past and died. This increase in human population has created a colossal demand for food. More than half the people in the world are hungry and under-nourished. All food comes from use of natural resources and most of the extra food required must come from agriculture. Adequate food supply may help to relieve tensions between nations jealous of each other's natural resources.

Agricultural food production can be increased in two ways. Firstly expansion of the area cultivated, which means the destruction of more natural vegetation in most cases, although land reclamation and in particular rehabilitation of abandoned areas should not be forgotten. Secondly improving the efficiency of agriculture which

has been achieved by breeding and selection of more productive plants and animals, by the use of fertilisers and by the control of pests, diseases and weeds.

The Pesticide Revolution

Approximately the last twenty-five years have seen a major revolution in the control of the destroyers of or competitors with the crops by means of powerful synthetic chemicals. Moreover insecticides are widely used not only for agricultural purposes, but to eradicate the vectors of human disease, e.g. malarial mosquitoes. All of these chemicals kill something and present hazards to their users, the consumers of the crops and to wildlife. Man, his animals and the natural environment are all in some measure at risk. Incorrect use of dangerous chemicals may poison food and defeat the object of increased production, but there are more subtle ways in which pesticides may make agricultural efficiency more difficult to achieve in future.

Whether wildlife is directly threatened by destruction of the natural habitat for agricultural alienation or is indirectly endangered by the effects of chemical usage spreading beyond the area of application and persisting for long periods, our civilisation is also susceptible to damage. Firstly because the wild flora and fauna are the genetic reserves for improvements in agriculture by breeding and selection of higher yielding and disease resistant plants and animals. Without wildlife these benefits may be curtailed in future. Secondly the chemicals sometimes cease to be effective owing to the appearance and multiplication of resistant pests when recourse must be made to biological control, for which wildlife again provides the reservoir.

Naturally occurring chemicals, especially in plants and micro-organisms, are employed as drugs, antibiotics, insecticides, and as industrial raw materials such as rubber or as the pattern for chemists seeking synthetic substitutes. We cannot afford to lose what may be the patterns for many valuable chemicals as yet undiscovered. Several important enzymatic processes depend on micro-organisms, for example the conversion of carbohydrates and inorganic nitrogen to protein by *Torula* yeasts, which has recently attracted attention for its potential in reducing protein deficiency, which is the greatest growing need in man's diet on a world scale. There are more to be discovered if an adequate range of natural habitats is preserved.

The revolution in pesticides and alternative methods of controlling pests have stimulated great interest in recent years as the effects of the new agents to kill weeds, disease organisms, insects and rodents have become better known. Some examples of each will be considered.

Aboricides

These are the tree-killers used in both forestry and plantation agriculture. Trees of no commercial value are poisoned in forests regenerating after extraction of timber to leave more space for the growth of the valuable timber species, and so to improve progressively the value of productive forest. This treatment of regenerating forest has been criticised, because quite often the first trees to fill the gaps caused by poisoning are not the most desirable timber trees of the primary forest but species typical of secondary growth. Thus the poisoning treatment may defeat its intended purpose. However, these methods have not yet been tried out for a sufficiently long time to discover whether or not the proportion of favoured timber species is increased in the final stocking of emergent trees, which eventually over-grow the secondary species; further it is not known if treatment extends or curtails the period of temporary domination by secondary species. Experiments in forestry must continue for a whole regeneration cycle, which is longer than a man's working life. Also it is necessary to maintain virgin jungle reserves untouched, neither felled nor treated, as controls to enable future generations of foresters to compare the results of treatment with the original forest, which is so complex in the tropics that no description would be adequate. The oldest treated areas should also be conserved, because these are the most informative experiments for the long term planning of natural regeneration forestry methods.

Sodium arsenite is still the most commonly used tree-killer in forestry. Its salty taste is much liked by many animals, especially large herbivores which commonly use naturally occurring salt licks. Elephants have been fatally poisoned and died in agony from consuming sodium arsenite carelessly disposed of in the forest. Even burying empty tins containing residues is not always enough to prevent wild animals obtaining the sodium arsenite, which is so attractive to them. 2,4,5-T, widely used to kill old rubber trees in Malaysia, is not a satisfactory poison for jungle trees. Nevertheless it is hoped that continued trial will find an alternative to sodium arsenite of lower toxicity to mammals, both wild animals and the human labourers who apply it, perhaps one of those mentioned below for rubber.

Replanting

When replanting rubber plantations the old trees must be destroyed and new trees (or palms) replanted in their place. One way of getting rid of the old trees is simply to poison them and leave them to rot and fall down. This is relatively cheap and needs little capital outlay in equipment. The organic matter of the old trees (equivalent to the amount of timber produced in five years at the maximum rate of growth) remains

on the site to enrich the soil. Better growth of the following crop has been demonstrated in some experiments where the old timber has been left on site instead of being burnt or carried away for fuel. However, if the old trees are just left to fall down, considerable damage is done to the young new plants and there is risk of injury to people working in the area. Therefore it is necessary to fell the poisoned trees while it is still safe to do so and push them over between the rows of young plants. Thus the cost of felling is re-introduced as well as the inconvenience of less easy operation in the field due to the piles of debris between the rows. Tree-poisoning might have been abandoned, but it was discovered meanwhile that the incidence of root diseases in the new stand of trees is reduced by poisoning the old trees or their stumps, the latter being somewhat less effective.

The root diseases of rubber trees are caused by parasitic fungi which encircle the roots and stem base of the trees and cut off the vascular supply between root and shoot, so killing the tree. These fungi are able to live as saprophytes, that is on the material of dead plants, as well as being parasites of living trees. Poisoning and killing the old tree does not kill the fungal parasites or prevent them from living as saprophytes on the old stump. Killing the old stump does allow it to be invaded by many more fungi which are true or obligate saprophytes only able to live on dead material, but unable to infect living tissues, which are the preserve of the parasites. These invading saprophytes compete with the root disease parasites, so that the latter do not expand to occupy the whole stump. These saprophytes and some boring insects unable to attack healthy trees speed the rotting away of the stumps, so that the sources of infection in the new stand have disappeared by the time the roots of the new trees have grown out and might otherwise come into contact with infective material.

Earlier sodium arsenite was the usual poison for rubber trees. When 2,4,5-T (2,4,5-trichloro-phenoxy-acetic acid and its butyl ester) was introduced as a weed and tree killer, it was found that it stimulated old rubber trees to give an extra flow of latex before dying, which paid for the operation. Although perhaps not quite so effective as sodium arsenite according to some investigators, the advent of 2,4,5-T put a reasonably effective tree killer in the hands of smallholders, whose families should not be exposed to the hazards of sodium arsenite. Recently 4-amino, 3,5,6-trichloro-picolinic acid and its derivatives applied by a tree injector have been found to combine very effective killing of old rubber trees with very low toxicity and risk to humans, domesticated and wild animals.

Cacodylic (dimethylarsinic) acid is another promising tree killer. Although an arsenic compound, it is almost non-poisonous to mammals. The inorganic arsenic compounds such as sodium arsenite and lead arsenate are very dangerously poisonous,

but many organic arsenicals are of about the same toxicity as aspirin. These are worthy of trial in plantation agriculture and forestry. They probably will not have any yield stimulatory effect on dying rubber trees. They and other tree killers have a use of growing importance even if of little consequence hitherto, The value of rubber timber for pulping is reduced by contamination of the wood with latex flowing out from the bark on cutting the trees. If the trees are killed first no latex flows on felling.

The use of tree killers in plantation agriculture helps in reducing root disease incidence, enables the organic matter to be conserved on site or old rubber wood to be removed in a form suitable for pulping. The value of tree killing in forestry is perhaps open to debate, but the risks to wildlife can be greatly reduced or eliminated by finding effective, less toxic alternatives to sodium arsenite, and the prospects of finding these are good.

Herbicides

Weeds are plants growing where they are not wanted, in particular those which by doing so compete with crop plants and reduce the yield of the latter, or in the case of plantation tree and palm crops slow down their growth and delay the time of harvest. A wide range of plants may be classified as weeds, including herbs, shrubs and trees. The name 'herbicide' suggests that only soft or herbaceous weeds are the target, but the difference between arboricides and herbicides is more in the mode of application. Arboricides are applied to individual trees, whereas herbicides are sprayed over vegetation to kill both herbs and shrubs. 2, 4, 5-T for example is used in different formulations as both an arboricide and a herbicide. Weedicide and weed-killer are alternative names for herbicide.

Sodium arsenite has been used as a general purpose weedkiller for over 60 years in Malaya. Its use has been restricted by law to places where there are safe storage facilities, the labour are regularly medically examined and the areas sprayed are indicated by danger notices. Despite these and other requirements concerning containers and admixture of a dye, there have been cases of accidental poisoning (not always fatal) of humans and many cattle have died after eating sprayed herbage, whose flavour is attractive to them. A ban on the use of sodium arsenite for weed killing throughout Malaysia was proposed but it has been postponed indefinitely.

The main advantages of sodium arsenite are its cheapness and that it kills the green parts of most plants on contact. Some plants, especially the beneficial creeping legumes sown as cover plants are very sensitive to sodium arsenite spray including accidental drift. Other plants, especially the coarse grasses and ferns, have to be sprayed repeatedly to destroy the green

parts several times before the storage organs are exhausted and the plants are finally killed. Thus the use of sodium arsenite was self perpetuating in that some less desirable types of ground cover became better established than those wanted but suppressed.

Hormone Weedkillers

The hormone or auxin type herbicides, so called because the active ingredients are synthetic plant growth substances, for example 2, 4-D (2, 4 dichloro-phenoxy-acetic acid) and 2,4,5-T, are very selective in their action, killing most dicotyledons (broad leaved plants) leaving grasses and many other monocotyledons hardly affected. Thus if used alone, the suppression of legumes and dominance of coarse grasses among ground covers is even more pronounced with these than with sodium arsenite. Many cultural practices and natural hazards such as fire encourage coarse grasses, whose control has been the object of widespread research.

During recent years now herbicides or new formulations or methods of applying existing weed killers have been sought with the following objects in view. Firstly to provide a general purpose herbicide as cheap as sodium arsenite but less hazardous. Secondly to provide a range of herbicides with specific selective properties, for instance to eradicate coarse grasses with less effect on legumes or to eliminate individual broad leaved weeds such as Mikania from among leguminous covers. Sometimes another weed or population of weeds different from those there before arises in the place of weeds sprayed out. A sequence of different herbicides appropriate to the weed population obtaining at each stage of the cycle may be necessary, This is not necessarily undesirable so long as the problem is recognised, otherwise there may be great wastage on repeating applications which are no longer suitable for the changed conditions, meanwhile some weeds unaffected by the herbicide used may become established and predominant in the planting. This means that the planter must be able to recognise the weeds and act accordingly. Some herbicides are more effective when mixed than applying the same amounts separately, whereas others are incompatible with each other. Wetting agents and new equipment such as nozzles giving very fine droplets have contributed to the efficiency of herbicide usage.

The chemicals used for these purposes in Malaysia today are generally of reduced hazard to animal life. Sodium chlorate is a general contact herbicide; its main disadvantage is that it makes the debris of the sprayed vegetation very inflammable if it dries out; however, that is perhaps loss of a risk in the humid tropics and calcium chloride which attracts moisture is sometimes mixed with sodium chlorate to reduce the fire hazard further. At the rates used in Malaysia there does not seem to be any build up of sodium chlorate in the soil; probably the warm moist conditions aid rapid breakdown.

New Herbicides

The organic arsenicals MSMA and DSMA, monsodium and disodiurn methyl arsenates, are general contact herbicides, which like most organic compounds of arsenic are almost harmless to animals even in a concentrated form. Paraquat is another general herbicide which dries out the plant tissues sprayed. Pure paraquat is quite poisonous, but many preparations on the market are diluted in unpalatable carriers, so that even deliberate ingestion of a lethal amount is difficult and unlikely. Even so there is legislation to provide for suitable containers and warning labels, in particular to reduce risks of dermatitis due to careless handling. When further diluted to the concentration sprayed there is virtually no risk to animals either by inhaling the spray, by contact or by eating the sprayed herbage, vast quantities - too much for even an elephant - would have to be consumed to reach a toxic level. Moreover paraquat breaks down rapidly in the soil.

Although the above are classified as general herbicides because they kill a wide range of plants ; none of them kills all plants; there are certain species resistant to one or other. When resistant species are present ; it is necessary to use mixtures or sequences of two or more herbicides, often one general and one specific to control the particular troublesome plant.

2, 4-D and 2, 4, 5-T have already been mentioned, the amine of the former is currently used in a new formulation instead of the salts and esters in the older preparations. These are selective in that dicotyledons (broad leaved plants) are much more susceptible to them than mo;;t monocotyledons. The cereals are among the. more resistant moncotyledons and 2, 4-D preparations have been much used to clear away broad leaved weeds, although other monocotyledons such as sedges may subsequently become more common in rice fields. Drift of herbicides of this type may do damage outside the area of application. Usually drift is controlled as far as possible in plantation agriculture because sown legumes, rubber trees and even oil palms are susceptible in some measure, so that care is taken to direct these herbicides to the weeds only.

The most commonly used coarse grass killer nowadays is dalapon (2, 2-dichloropropionic acid and its salts). It is not dangerous to wild life and seems to break down fairly rapidly in the soil. Amitrol is used against some grasses unaffected by dalapon.

Significance of Herbicides in Plantations

Plantation agriculture of tree and palm crops covers several million acres in Malaysia and is certainly in aggregate

the largest single user of herbicides in the country. Now that a ban on the acknowledgedly dangerous sodium arsenite as a weed killer has been proposed., the role cf the other less hazardous chemicals in wildlife and natural resource conservation may be assessed.

In the early days clean weeding was practiced. This led to severe erosion on slopes and to reduced organic content and water holding capacity of the soil in all areas. During the next phase there were two rival schools concerning the ground cover between the planting rows, which were kept weeded; those advocating sown leguminous covers and those who favoured natural shrubs, that is a secondary jungle-like growth kept under control by periodic slashing. All grasses were considered to be harmful.

Recent experimental work has confirmed the beneficial effects of many legumes. Natural shrub covers have been shown to be very competitive unless regularly slashed manually, which is expensive, or sprayed periodically with herbicides to check their growth, which leads to their eventual displacement by other ground covers. These recent experiments have shown that Eupatorium, Mikania and Passiflora for example have an adverse effect on tree growth. Ou the other hand the grasses display a wide range of effects from severely depressive (lallang and other coarse grasses) to beneficial results little different from those of legumes (Ottochloa and light grasses). However, a disadvantage of even the more benign grasses is that they easily invade the planting row, where they compete for applied fertilisers and may induce penetration of the tree collar by root disease fungi owing to provision of ideal incubation conditions.

During the early stages at least, clean weeding of the planting rows is desirable for ease of working, and to reduce competition by weeds for applied fertilisers and water. Later when harvesters must work in the area, ease of access is again important;, Therefore experiment and experience have shown that for efficient working, maximum growth and product, the planter needs to keep the planting rows clean weeded. In the areas between the rows, either a cover of sown legumes or perhaps light grasses should be maintained or, if a cover of less beneficial growths is allowed to arise spontaneously it should be controlled regularly.

Weeds have always been eradicated from certain areas. When manual labour is cheap, this can be done by hand pulling or by hoeing with a changkol, which involves soil disturbance, often removes plant debris from where it could provide a mulch, and digs hollows about the trees which later become water logged. When herbicides are used the debris is loft to rot as a mulch on site improving the soil organic content without soil disturbance, which is preferred soil husbandry.

Floral Changes

The flora of the plantations is becoming progressively-poorer in the number of species present. The oldest plantations are separated in distance by other plantations and in time by two or more generations of crop plants from the original forest. There is no adjacent forest to replenish the stocking of the native flora and fewer species survive each successive replanting. Herbicides - like any other weeding operation - are probably accelerating this process. The sowing of desirable leguminous cover plants to fill the space of displaced weeds is good agricultural practice but also impoverishes the flora. The selective action of some modern herbicides gives rise to a rotation of weed populations and the need to use a sequence of herbicides, this gives some variation in the ground cover and may prevent excessive accumulation of any one herbicide in the soil.

If weeding is accepted as part of agriculture, it is doubtful if the introduction of modern herbicides has done more than accelerate certain changes in the floristic composition, which were taking place in any case. Herbicides are probably an improvement on the old manual methods, which are now too costly for economic operation, by reducing soil disturbance and so conserving soil and moisture.

The changing ground flora may be affecting the wildlife of the plantations, which is sparse in rubber but rather richer in oil palm, by encouraging birds which eat grass seed at the expense of those taking the fruit of secondary jungle trees like figs, although far too little is known about this. There is no evidence to date that the modern herbicides of low mammalian toxicity have been responsible for poisoning any wildlife or seriously affecting the flora or fauna, including fish, of streams and rivers draining the plantations. Micro-organisms in the soil are responsible for breaking down the organic herbicides and rendering them inactive. Therefore one might, expect changes in the soil fauna and flora, certain groups becoming more-abundant and others, perhaps those responsible for important processes in the soil, being depressed in their activity. So far there is little evidence of this and certainly no signs of bad effects attributed to this cause. There is urgent need to investigate these possible remote, residual or delayed actions, otherwise some unsuspected side effect may grow rapidly to serious dimensions. Nevertheless these have not yet been demonstrated, even if they have not been looked for on an adequate scale, and on balance modern herbicides are beneficial in plantation agriculture including its conservation aspects.

Blanket Use of Herbicides

During emergency police actions or in wartime, herbicides have been sprayed on roadside scrub and onto forest from the air

to reduce the cover available to the enemy. Foodcrops have been sprayed from the air to deny the enemy sustinence. Herbicides such as 2, 4, 5-T have been employed most commonly. These operations have often been carried out without respect to cost or critical minimal rates to achieve effect. As a result there has been drift over long distances and there have been long lasting residual effects and a predominance of coarse grasses in the regeneration. These instances cannot be quoted fairly as examples of the results of herbicide usage.

Secondary and derivative habitats are exploited by the grasses, a highly evolved group among the monocotyledons, which as a whole are believed by many to be more advanced than the woddy and broad leaved plants of the dicotyledons. If so, human activity such as destruction of forests, grazing of cattle, the indiscriminate use of fire and herbicides, may be aiding a larger evolutionary process of world domination by the grasses. The grasses, especially the cereals and the fodder grasses, are valuable to mankind, who in turn is helping the spread of the grasses. This may be regarded as an unconscious symbiosis (the living together of different species for their mutual benefit), or in fact one partner may be the tool of the other; if so man does not seem to be in control of the situation.

This is speculative, but the large scale clearing of forest by aerial spraying of arboricides and herbicides is now being tested. If the land is going to be cleared in any case, this may be as good a way as any. However, now that grass-killers are also available, it would be instructive to attempt on an experimental scale at least the eradication of sheet lallang or another grass climax by aerial spraying, followed by seeding with trees or legumes.

Fungicides

Fungi are plants unable to make their own food by photosynthesis and live either as parasites of living things and/or as saprophytes on dead plant material. Saprophytic fungi rot damp timber in building or fence posts, although in the tropics termites (white ants) are perhaps even more destructive. Timber is treated with chemicals to preserve it from insect and fungal attack. In normal circumstances there is little or no hazard to human or wild life.

Many diseases of plants are caused by fungal parasites. There are three main ways of combating fungal diseases, breeding and selection of resistant plants, cultural practices and application of fungicides, which are chemicals which should kill the fungus without harm to the crop plant which is host to the parasite. Sometimes one method is adequate, whereas some diseases can only be brought under control by a combination of two or more. The economics of the relative cost of disease control and the value of the crop obtained must be carefully weighed. The soil borne

Fusarium fungi cause wilts of many field crops, for instance the Panama disease of bananas; control might be achieved in some cases by soil sterilisation, but this is so expensive that usually recourse must be made to a resistant variety in the case of bananas, or introduction into the rotation of a completely different crop if no resistant varieties of the original crop are available. This gives time for the amount of infective material to decline.

The mildews, including Powdery Mildew which is one of the causes of secondary leaf-fall in rubber trees, attack only the young leaves in most cases. The germinating spores of mildew are easily washed off by heavy rain or by syringing the foliage, a method now confined largely to amateur growers of roses for show. Although displaced by heavy rain, mildew requires high humidity and water as dew or mist for infection. The germinating spores are susceptible to drying out and also to sulphur dust. Fine sulphur is almost a specific pesticide for mildew among the fungi and for mites among the arthropods. Other forms of life are hardly affected by sulphur dusting and spraying at the usual rates.

Bordeaux mixture (of 2 parts copper sulphate, 1 part quick lime and 100 parts water) is one of the oldest, cheapest, most widely used and still one of the more effective fungicides for many stem and leaf diseases. The deposit which dries on the sprayed parts is only marginally poisonous to most animals if ingested, in practice they would have to consume improbably large quantities of bark and foliage to come to any harm.

There is limited evidence from other countries, not Malaysia, that repeated, very heavy applications of Bordeaux mixture may build up concentrations of copper in the topsoil toxic to soil organisms. The other risk is to life in ponds, rivers and streams, especially to fish which take great volumes of water through their gills in order to obtain enough dissolved oxygen to respire and hence may concentrate soluble poisons in their blood, if large amounts of copper salts are carried off in drainage water. To a certain extent these risks are contrary, if the copper is accumulating in the soil, it is not available in solution in the drainage waters, and vice-versa. The main point is that the rates of application in Malaysia are still relatively small and likely to remain so. Copper is an essential element for plant growth even if in trace quantities, for example a stand of old rubber trees contains about 4 lbs of copper per acre. There must be some copper in the soil to support crop growth and cases of deficiency are known. Moderate additions by way of fungicides are beneficial in these cases and by no means harmful in others.

Modern Fungicides

The quarternary ammonium compounds are detergent type chemicals, whose main fungicidal application in Malaysia is to treat stem and

panel diseases of rubber trees, and they are virtually harmless to all animal life; careless handling of the concentrate may cause trouble to those with sensitive skins, but this is no greater hazard than domestic washing powders. These detergent type fungicides might find wider application or be more efficient if they were not so easily eroded by the rain, the incorporation of greases may be the answer. Tar and bitumen have their uses and by their nature are not hazardous.

The dithiocarbamate group of fungicides are used to control a number of leaf diseases and to prevent 'damping off of young seedlings, the latter is attack at or near ground level by moulds. These carbamates have various metal bases, such as iron or zinc, and most are only marginally toxic, for instance a man would have to eat a teacup-full cf the most unappetising pure substance to come to grief. They are sprayed at such low rates as 2 lbs of active ingredient per acre or l/5th of one per cent concentration. There is no evidence of risk to wild life by inhalation of drifting spray or ingestion of sprayed foliage or fruit at these concentrations or of any build up in the soil.

The collar protectants to prevent penetration by root diseases are based on pentachloro-nitro-benzene, which has negligible toxicity for most animals. Pentachlorphenol on the other hand is much more dangerous, but this is mainly used to treat timber. Thiram also falls in an intermediate category for toxicity. Thibenzole, now used in oil palm nurseries, is also used to free sheep and cattle of worms by drenching them in its solution. It is a rather safer and more effective fungicide than thiram in some respects.

The most dangerous fungicides used in Malaysia today are the organic-mercurials, as little as one twentieth of an ounce of the pure substance could kill a man. If these are sprayed, damaging amounts may be inhaled if the operator does not wear a respirator and goggles, which are uncomfortable in the humid tropics and liable to be left off with serious consequences. These organic-mercurials are recommended to treat those panel diseases of rubber trees which do not respond to the detergent type fungicides. The organic-mercurials should be painted on, even so gloves should be worn, all contact with concentrate, solution and treated surfaces avoided, and even if gloves are worn the hands should be washed thoroughly before eating or smoking in case of accidental contact. Very little animal life, apart from humans, is liable to handle these chemicals or come into contact with treated panels. The risk to wild life is not great, but it is obviously desirable to replace such dangerous chemicals with safer materials.

Cultural Control of Fungal Diseases

The reduction of the incidence of root diseases in the new stand of rubber by poisoning the old trees has been discussed

in the section on arboricides. The establishment of leguminous covers also helps to rot away old stumps which may be sources of infection before they can do any harm. Organic matter rots faster the lower the ratio of carbon to nitrogen; old stumps are rich in carbon and rot slowly, but this can be speeded by adding nitrogen. The favoured leguminous covers enrich the soil, or any stumps they scramble over, by symbiotic nitrogen fixation. The establishment of a creeping legume cover has been shown in experiments to reduce the incidence of root disease. This is the third beneficial effect of leguminous creeping covers mentioned in this manual: first the prevention of erosion, second soil enrichment and improved circulation of nutrients, now the reduction of root disease losses. Blessings do not come singly when natural processes are harnessed to good effect. In this and the following case curative fungicidal treatments have not been found, collar protectants are only preventive measures in rubber to reduce spread of the disease.

Basal Stem Rot of oil palms caused by Ganoderma is serious if old coconut palm trunks, the stems of wild palms or to some extent old oil palm stumps themselves are left lying around in new plantings or replantings of oil palm. Burying these sources of infection is the most economic way of dealing with this risk but burning instead of burying is more correct. Whereas neglect of these precautions usually leads to severe losses.

Slow growth due to overcrowding or inadequate fertilisation or irrigation of many crop plants predisposes them to infection. Excessive humidity due to overcrowding increases disease incidence in the nursery and panel diseases of rubber are prevalent if dense undergrowth is unchecked. Good cultural conditions help to cut down the fungicide bill considerably. Preventive cultural measures are often longer lasting than curative treatments by. spraying.

Genetic Resistance

Few if any plants have been found resistant to the root diseases, whose containment is largely by cultural methods or plantation hygiene to reduce the contacts between the tree crop and sources of infection, assisted by treatment or destruction . of cases when diagnosed. The situation among the leaf and stem diseases is very different.

Resistance to nearly every leaf disease has been found in some individual plants, which may be multiplied if vegetative propagation is possible. Some populations of plants have a larger proportion of resistants than others. Many crop plants have been bred and selected for yield over several generations without adequate attention to disease resistance. Thus when the disease builds up to serious proportions, it is often found that the highest yielding varieties are susceptible, but the resistant strains are low yielding. Breeding and selection programmes are then

necessary to combine the desirable features of high yield and good resistance. This may have to be done for more than one disease at a time.

Resistant high yielding material is the simplest method of economic control of disease; the main difficulty is that it is a long term programme in a world which urgently demands quick results. Sometimes the resistance of a selected variety breaks down; what actually happens in most cases is that a new strain of the disease has evolved which can attack the hitherto resistant selections. An interim measure possible in rubber is to bud-graft a resistant crown onto a susceptible but high yielding trunk.

Resistance may have been lost in cultivated varieties or may break down. Almost invariably search among the wild plants of the same or closely related species of the crop will discover resistant - even if low yielding - material, which can be taken into the programme. The discovery of new disease resistant strains is dependent on a supply of wild plants. It is quite impossible to collect and keep alive examples of every naturally occurring variant in a series of huge botanical gardens. The only practicable way is to preserve examples of every known types of vegetation so that nature itself can be the genetic storekeeper. Malaysia is the centre of the range of the wild bananas, Musa and several collecting expeditions to the forests and aboriginal ladangs have been arranged in recent years. The same argument applies to every crop and country.

Another interim measure is to plot carefully the distribution of plant diseases, for instance Oidium or Powdery Mildew of rubber is more common in North Malaya and the Interior of Sabah, but Gloeosporium leaf disease is more common in South Malaya and South West Sabah, Some reasonably high yielding varieties are susceptible to one disease but resistant to the other and vice-versa. These can be planted in the respectively appropriate areas, although there is some risk that the diseases may spread but this is likely to be rather slow.

With the exception of the organic-mercurial compounds, no fungicides used in Malaysia are very poisonous to animals. None are applied in dangerously large quantities. Cultural control measures are well appreciated, breeding and selection programmes to combine yield and resistance are in progress. The situation appears satisfactory provided there is constant improvement and no relaxation resulting in ground being lost. The cautionary remarks about the pesticide revolution may seem uncalled for, but the next group - the insecticides - should dispel any such illusion.

Insecticides

Insects and other arthropods, such as mites and ticks, are harmful to mankind and his domesticated animals in three main ways, as pests of crops, thus competing for food, as parasites especially blood suckers and as vectors or carriers of diseases. Insects also destroy timber and atap thatching materials. Some insects and other arthropods such as spiders, scorpions and centipedes can inflict painful stings, which are seldom fatal except when someone is unfortunate enough to get multiple stings from wasps or hornets. Such venomous invertebrates or their nests are usually destroyed individually, they are not controlled by regular chemical applications and do not pose the kind of problem discussed here, which is the routine or extensive use of insecticides under rural conditions for agricultural or medical purposes.

Malaysia is fortunate that sleeping sickness and yellow fever do not occur here, although the mosquito which transmits yellow fever is common, which is why it is important that anyone suffering from yellow fever should be kept out of South East Asia. Bubonic plague, carried by rats and transferred from them to humans by fleas, has troubled many countries at one time or another, it is still a terrible shadow which may fall across Asia. Typhus is transmitted by lice and ticks. Flies carry enteritis from faeces to food. Mosquitoes transmit the painful but seldom fatal dengue, the disfiguring and weakening filariasis or elephantiasis in East Malaya and the arbor viral encephalitides beginning to cause concern.

Although there was a heavier incidence of malaria during wartime conditions and occupation, it is difficult for many to realise the terrible effects of endemic and epidemic malaria 70 years ago on the Selangor coast. The victims were anaemic, the children were unable to concentrate on their lessons or enjoy their games, the men were unable to work hard and get a good living for their families, the women bore few children alive. The under-nourished died. In rural areas before malaria eradication began to take effect, an insidious intermediate condition prevailed which sapped the energy of the village people, who as a result were said to be lazy and their children stupid. Although the use of insecticides in malarial eradicant campaigns has had undesirable side effects in certain cases, it is essential to realise what a great benefit freedom from malaria is for the progress, health and happiness of the rural people.

It is difficult to get the maximum yields from certain short rotation crops without the use of insecticides, for instance from the protein rich soya bean or from maize, which is an important constituent in cattle and poultry feed, and so an indirect source of high grade protein. Owing to the short period of growth to harvest there is some risk of harmful residues being consumed by humans or the animal intermediaries under these conditions

of intensive usage. Plantation crops on the other hand present possible occasion for extensive usage and upset of conditions over a wide area.

The natural means of pest control and the various roles of insects as a whole must be reviewed before considering the action, benefits and risks of the various groups of insecticides. The effect, if any, of the vast majority of insects on human life is unknown. The harmful insects constitute a very small yet important minority among the group as a whole. There are perhaps somewhat more beneficial than harmful insects. Some insects pollinate fruit trees and many vegetables, especially the protein rich beans. Other insects provide the natural controls of pests, many are involved in processes of decay and re-circulation of nutrients. The two main types of biological control of pests effected by insects are through predation and parasitism.

Predators

These are the animals which prey on other animals, kill and eat them. Mosquito larvae are eaten by small fish and a wide range of freshwater invertebrates, this may not establish absolute control but it does reduce the number of larvae considerably. These natural predators are seldom able to operate in man made mosquito breeding niches such as empty cans and jars. Adult flying mosquitoes are eaten by a wide variety of larger insects, spiders, birds, toads, lizards and bats, but again this is not absolute control.

Insect eating birds consume both larvae, such as caterpillars, and adult insects in large quantities, especially when the rapidly growing nestlings must be fed. Many animals of different orders eat insects. Other insects are by no means the least important predators of pests. Among the bettor known in Malaysia are the Praying Mantis, which remains motionless until its prey wanders within its grasp, and the Ant-lion larvae which make traps in sandy soil. Others which do not move far in search of their prey are the larvae of the Hover-flies and Lacewings, also both larvae and adults of some Ladybirds and Thrips. One species of Ladybird and some Thrips are pests of crop plants, attempts at their control may kill off their beneficial cousins.

Dragonflies hunt down their prey on the wing, while various ants, beetles and assassin-bugs are predators on the ground. The wasps hunt other insects and spiders to feed to their young larvae. Most of the solitary wasps make a nest, stock it with caterpillars and similar live food which has been paralysed by the wasp's sting, lay their eggs and seal the nest. When the larvae emerge they feed on the living store of food. A few solitary wasps and all the social wasps and hornets carry food to their young larvae and feed them regularly. Social means living together, these are the wasps and hornets which build large nests.

Parasites

Insects, including mosquitoes, are subject to many diseases caused by other organisms, including bacteria, fungi and nematodes, which parasitise them. The majority of the insect parasites of other insects are laid as eggs in the eggs, larvae, pupae or nymphs of their hosts. The eggs of the parasites hatch and their larvae feed on their host until they eventually kill it, sometimes pupating within the pupa of the host. The adults are usually free living and the females often roam far to find hosts for their eggs.

In Malaysia the scale insects and mealy bugs are often parasitised by small wasps. The grubs of cockchafers, which feed on the roots of many crop plants, are parasitised by digger wasps, which dig down into the soil to find the grubs, and by the maggots of parasitic flies emerging from eggs laid in the soil near the cockchafer grubs. Some other cases will be considered under the effects of contact insecticides.

Classification of Insecticides

Insecticides may be classified by their mode of action. The stomach poisons arc- those which are ingested by biting insects as they consume the sprayed plants. Contact insecticides are those which penetrate the insect's body when it touches a solution, suspension or deposit of the poison. Systemic insecticides are absorbed by the plant so that sap sucking pests are poisoned, Fumigants are insecticides whose vapours kill the insects which breathe them, they are most effective in enclosed spaces such as stores, greenhouses, the soil or within enclosed leaf bases. Some insecticides have more than one kind of action.

Insecticides may be classified according to their chemical composition, or according to the pests they are intended to control, but these classifications often coincide with the mode of action classification. Other important considerations are the toxicity of insecticides to vertebrates, including fish, birds, mammals and man himself, and the persistence of this toxicity either on the plant or in the soil.

Inorganic Insecticides

Most of these have been known for many years. Sulphur is used mainly against mites, it is not very effective, but since it has so little effect on other forms of life, it helps to tip the balance to bring the mites under natural control. Lime-sulphur has not been used in Malaysia much.

Termites used to be controlled by putting white arsenic in the runs and treating the attacked plants with dilute corrosive sublimate (mercuric chloride). These substances are both very toxic and dangerous. They are no longer used for this purpose.

Lead arsenate is a stomach poison of both insects and mammals, but it has relatively little contact effect. Lead arsenate is still the most satisfactory selective insecticide, when it is necessary to kill leaf eating pests without harm to predators and parasites alighting on the foliage. Animals eating sprayed foliage or people handling it carelessly are in danger, stomach poison insecticides without contact effect but of low mammalian toxicity are much needed.

Fluorine and copper based insecticides have been little used in Malaysia. Infrequently copper aceto-arsenite has been used in malarial control. Fluorine compounds are very hazardous. Some substances are on the borderline between the inorganic and organic compounds. The most dangerous is cyanide gas, but it is seldom used except for fumigation under strict control. At the other end of the scale soap and mineral oils, such as kerosene, are virtually harmless to vertebrates. Kerosene-soap emulsions suffocate scale insects, mealy bugs, lac insects and to a lesser extent aphids without any appreciable harm to beneficial insects. Often one round of spraying with emulsion will enable the natural enemies of these pests to re-establish control.

Oil has long been used spread in a thin film, one thousandth of an inch thick, over water to stop the breeding of anopheline mosquitoes, which transmit malaria. The females are discouraged from laying and the respiratory tubes of the larvae are unable to support them at the surface with lowered tension. Unfortunately this is a relatively expensive method where there is a fast flow of water. There is no definite evidence of damage to fish, birds or mammals from this practice, although it has been widespread for many years.

Vegetable Extracts

Nicotine is a contact and stomach poison as well as a fumigant, It is hot persistent but it is very dangerous to man and animals while its action lasts. It is not used much in Malaysia.

Rotenone is the active ingredient in the roots of *Derris elliptica* or *tuba* as it is called in Malay. The ground *tuba* root or derris powder stupefies fish if it is put into a river or pond and if the concentration is too great the fish are killed. Fishing by means of *tuba* is a royal prerogative in most Malay States. Despite the sensitivity of fish to derris, birds and animals have to consume very large quantities before they suffer any serious ill effects. Pure rotenone is much more poisonous, but the normal preparation of the ground root involves a manifold dilution factor.

Derris is a contact insecticide, but it does not persist. It is applied as a dust or as an emulsion. Repeated use on a plantation scale might harm beneficial insects and stupefy or kill

fish in streams, although most of it would be broken down in the soil before reaching streams. Derris probably has a potential use on many short terra crops, especially market garden vegetables, for which an insecticide of low persistence and toxicity to humans is needed. Unfortunately derris has been almost driven off the market by the synthetic insecticides. There is a case to re-investigate derris and perhaps to revive its cultivation in Malaysia, both to save foreign exchange and to provide this and other countries with a safe insecticide.

Pyrethrum is obtained from a plant in the Daisy or Sunflower Family. It is a relatively expensive material and cultivated in the rather drier tropics. A small amount knocks down or paralyses flying insects, a slightly higher dose kills them. Pure pyrethrum is only marginally poisonous to man and warm blooded animals, accidental poisoning is unlikely. It is not persistent, but breaks down in sunlight or in contact with the air or soil. As with all contact insecticides there is some risk to beneficial insects, but if cheap enough it could have application in market gardening. Unfortunately due to the cost, more persistent synthetic insecticides such as DDT are often added to effect kill after knock down by the pyrethrum. The main usage of pyrethrum in Malaysia at present is in aerosols for domestic control of flies, mosquitoes and cockroaches.

The Chlorinated Hydrocarbons

The first of these was DDT, and was first used in Malaysia to deal with the vectors of human diseases, lice and mosquitoes, after the war. It later found agricultural applications. The toxicity of DDT when eaten by mammals is moderate, about half an ounce or more to kill a man. It is much more persistent than the contact insecticides of vegetable origin discussed in the previous section. This persistence occurs on plants, in the soil and in animals.

DDT is still the preferred insecticide in the residual spraying campaign against malaria. A thin film of DDT is deposited on. the inside walls of the village dwellings by spraying every six months. Most insects coming into contact with the DDT are killed. The number of anopheline mosquitoes in the area is not; usually much reduced, but the life span of those coming into houses is shortened so that few of them have opportunity to first bite someone with malarial parasites in their blood, then to incubate and multiply theses through the next phase in the parasite's life cycle and, finally, to infect a new human victim.

In conjunction with chemical therapy and prophylaxis by means of chloroquine and amodiaquine, these campaigns have over the years been successful. Strains of mosquitoes have developed resistance to DDT and it has been necessary to change the insecticide in such cases. Strains of mosquitoes and other insects have developed which are resistant to synthetic insecticides, but not

to vegetable extracts like pyrethrum. Malarial parasites resistant to synthetic drugs such as chloroquine, but not to natural quinine, have arisen also.

Most flying insects alighting on the walls sprayed with DDT are killed, including those which parasitise the caterpillars living in atap roofs. As a result an atap roof thatched with palm fronds, which might be expected to last for two years, have holes eaten in it and begin to leak within two months of residual spraying of DDT. This was one of the first undesirable side effects noted.

DDT has been used to control a wide range of agricultural and horticultural pests. However, owing to its persistence it cannot be used on materials which will be consumed soon. There is no doubt that bagworms have appeared as a new pest on oil palms due to the use of DDT and similar insecticides. DDT was used against cockchafers in one case and almost immediately an infestation of bagworms appeared. In another oil palm plantation the contact insecticide was added quite needlessly as a precautionary measure to a fungicide being sprayed for a different purpose, the bagworm infestation began and grew from that date. In an experiment a small area was deliberately sprayed with DDT and bagworms reached serious numbers in the sprayed area and the surrounding area, but fell off at some distance beyond. There is little doubt that the mobile females of the species which parasitise bagworms were killed in the sprayed area and their numbers reduced over a much wider area owing to their movements in and out of the sprayed area.

BHC or gamma benzene hexachloride is another contact insecticide of this group. It has a limited use in malarial control. Many domestic formulations contain BHC. It is used often to kill soil-borne pests or otherswhich strike close to ground level, both as a seed dressing or dusted along the drills. Although not so persistent as DDT, it often imparts taint to root and short rotation crops. Taint may survive the feeding of the products containing insecticide residues to poultry and appear in the eggs. This may serve as a reminder to the public that the chlorinated hydrocarbons are passed on from one animal to another, often concentrating in the fatty tissues. Quantities inadequate to cause taint are also transmitted and these may accumulate to harmful proportions somewhere in the food chain.

There is at least one case of BHC causing a minor pest of coconut palm to become very serious. Artona is a small moth, whose caterpillars feed on the undersides of the older coconut fronds giving them a scorched appearance. It is parasited heavily by a Tachinid fly and to a lesser degree by an ichneumon fly, also a Clerid beetle eats the pupae. If an outbreak is allowed to take its natural course, within about three months the tachinid has established control, the majority of the moth caterpillars being parasitised. However, when a few acres were

sprayed with BHC to try to eradicate a small outbreak, the Artona spread rapidly until some hundreds of acres were out of bearing. Parasitism was at only a fifth of its normal level for some months. The mobile flies had been killed over a wide area and took a long time to recover.

Cyclodienes

The cyclodiene group includes aldrin, dieldrin, heptachlor and endrin. They are all persistent, even if not in their original form, for example aldrin is converted to dieldrin in the soil. They are all very poisonous, endrin is extremely dangerous, only one hundredth of an ounce could kill a man; the others would require about ten times as much. Birds are relatively more sensitive and fish even more so. As successive plants and animals in the food chain absorb the poison from the earlier link so it becomes more concentrated in their fatty tissues.

Dieldrin has been used in anti-malarial spraying, but its use is now confined to proven cases of resistance to DDT, because so many domestic animals and poultry died after absorbing dieldrin through the skin as well as ingesting it. Cats are particularly sensitive perhaps because they clean their coats by licking the fur so often, and were almost exterminated in some villages in Sabah when dieldrin was first used. Rodents increased when the cats were lost. Needless to say this damaged the image of the anti-malarial campaign. It has even been suggested in Africa that the end result might be an outbreak of plague or typhus.

The cyclodiene group, except for endrin because of its extreme hazard, are recommended for the both preventive and curative treatment of termite attack against rubber trees and other plantation crops. A diluted solution is poured round the bole of each tree. The soft bodied termites are particularly sensitive, although they seem to carry the insecticide to their nests before death, because the incidence of termites in the whole area often falls drastically. Such soil applications are sometimes made to control cockchafers. Apart from the natural controls of cockchafers, few of the flying predators and parasites of other pests are liable to alight on the small area of treated soil. The risks to birds and mammals are probably small. It is tempting to assume that because the termites are soft-bodied and sensitive, only they will be affected, Only a minority of termites are pests of the trees, the remainder being concerned with the reduction of plant debris and circulation of nutrients in the soil. Nobody really knows what effect this treatment has on the soil fauna. Until some observation indicates harm, this economic method of controlling termites is hard to deny, but there is need for investigation.

Several potent chlorinated hydrocarbon contact insecticides, including dieldrin and endrin, were sprayed regularly on the cacao bushes in Sabah in order to control a wide variety of pests attacking

the stems and leaves. It was decided to give natural control a chance and to stop spraying, within one to two years the Branch Borer caterpillar, one of the more serious pests, had disappeared following parasitism by ichneumon.

Spraying of these insecticides was therefore an unnecessary expense, because it was inadequate to control the pests and prevented the development of the eventually successful parasitism. Moreover, spraying or fogging these poisonous chemicals requires precautions such as respirators and goggles, which are unpleasant to wear in a tropical climate. In some cases alternative formulations or modes of application are possible.

Granular forms of these insecticides may be shaken out of disposable plastic dispensers, so that the hands do not come into contact with the granules. The volatility from the granules is only slight, so that there is no inhalation risk to workers in the open air. These granules can be shaken inside the cone of leaves of a maize plant, where their slow contact and fumigatory action keeps out stem borers. Another promising method is to shake the granules onto the ground under trees and palms infested with caterpillars. When healthy caterpillars drop down to the ground to pupate, they come into contact with the granules and are killed, but the parasitised caterpillars and their parasites remain out of contact on the foliage. Eventually the new generation of pests fails to emerge. This method can be used also to reduce the number of ants which farm mealy bugs and aphids on the crops and drive away their natural enemies.

Birds are not very common in rubber plantations, but are plentiful in palm crops and gardens. Birds eat large numbers of insects, but are very susceptible to poisoning by accumulation of insecticides from the many pests they devour. Fish are also sensitive. Now that the dangers of these chemicals are known, it is desirable to use them only in ways which can do the least harm, otherwise birds and fish may bo killed over a wide area as sometimes happens to the insects which are natural controls of pests.

Many hoped that these insecticides would be broken down very rapidly in the warm humid climate of Malaysia. Experiments have shown that the relatively small, dilute applications of chlorinated cyclodiene insecticides to control termites, retain their activity and effectiveness for upto four years on the sandier soils, for over two years on most soils and only in the case of peaty soils is there markedly reduced activity (not necessarily destruction) within three months. There are cases of snakes and birds of prey being killed or reduced in numbers and activity in areas where these insecticides have been used to poison rodents and other supposed mammalian pests. This example is discussed elsewhere, but the conclusion remains, namely that the widespread destruction of wildlife including migrant raptors (birds of prey which travel seasonally) far beyond the place of application

and for long periods is possible under Malaysian conditions. There is abundant evidence of this from other countries, where there have been heavy losses of economically valuable birds in the chain of natural pest and rodent control and of fish, when these chemicals have been used indiscriminately or on a large scale. It is the small scale of usage and the very proper attention to methods of application by manufacturers, selling agencies and users, which have spared Malaysia the worst consequences to date, rather than any special advantage in the environment.

The Organic Phosphates

These organo-phosphorus insecticides have several different modes of action. The more poisonous are directly dangerous if inhaled, the more volatile have a fumigatory effect in enclosed places. They are all stomach poisons if the deposit is eaten. Most have an immediate contact effect, but this diminishes with time in many cases. The most interesting discovery is that some are systemic in their action, that is they are absorbed into the plant and translocated through it, insects sucking the sap are poisoned. The organic-phosphates break down quite rapidly, especially in the soil. Therefore they present virtually no residue problems if an adequate interval is allowed between' spraying and harvest. Similarly there is rarely much build up in soil or rivers.

Parathion was one of the first organo-phosphorus insecticides on the market or to be employed in South East Asia. It is very toxic at about the same level as endrin. It should only be applied by operators wearing full protective clothing, that is a complete waterproof covering, gloves, mask, goggles and respirator, which is quite unbearable in the humid tropics. When human deaths occurred in South East Asia owing to spraying parathion without adequate protection, because the latter was uncomfortable, the then government of Malaya banned the import of parathion and its use in this country. Unfortunately some neighbouring countries still allow parathion despite further loss of human life. Moreover parathion is smuggled into Malaysia and still used illegally and indiscriminately by some market gardeners.

Apart from exposing themselves and the public to terrible risks, these irresponsible users create very difficult problems for the cultivators of other crops and the agricultural entomologists who must advise them. Two years ago there was. an outbreak of Artona moth on coconut palms, which grew to serious dimensions, meanwhile it was noted that the degree of parasitisation by the Tachinid flies was falling alarmingly, also nearby oil palm was attacked for the first time. The palm had not been sprayed with any insecticide, so that although there were close parallels with the case already described and attributed to BHC, it seemed that natural control had not broken

down due to the use of insecticides. However, that was the probable explanation, because it was found that nearby plants of Ladies Fingers, whose fruit are usually bagged to keep away the flics, had been sprayed illegally with parathion, although the culprits did not wish to admit this until too late. The Tachinid fly parasitises both the Artona moth of palm and the leaf rolling caterpillars of Ladies Fingers, it is very likely that the mobile Tachinid flies had visited the latter in search of caterpillars and so been killed over a wide area and prevented from laying their eggs on the Artona. larvae. If the illegal use of parathion had not been discovered a completely misleading explanation of the breakdown in natural control of Artona might have been adopted with even worse results.

Although there has been no secrecy or illegal activity involved, planters have sometimes got their priorities wrong by using non-specific contact insecticides against comparatively minor pests of cover plants, which are an agricultural aid not a crop in themselves. Spraying insecticides to control Ladybirds on creeping legume covers seems to have been responsible for the outbreaks in recent years of Short-horned Grasshoppers attacking both legumes and the rubber, which is not usually affected, owing to destruction of natural enemies. So an unimportant matter can develop into a serious situation.

Subsequently new organo-phosphorus insecticides have been discovered which are much less toxic to birds and mammals, for example malathion is practically harmless (except in certain rare cases of prior exposure to parathion), its smell and taste are unattractive. It is used in malarial control where the mosquitoes have become resistant to DDT, it is less dangerous and has fewer side effects than dieldrin, but malathion's lack of persistence is a disadvantage from the medical point of view.

Trichlorphon is about twice as poisonous as malathion, but that is a hundred times less toxic than parathion. Its direct contact effect fades away quite soon, it is absorbed into the plant and translocated in the sap so that sucking insects are killed. This is called systemic action and is selective in that the sucking pests are at much greater risk than other insect visitors to the plants such as predators and parasites. Trichlorphon was applied to cocoa in Sabah to tide over the gap between the use of non-selective contact insecticides of the chlorinated cyclodiene type and the re-establishment of full natural control. This was particularly useful in the case of bagworms, at first parasites were almost absent, but after the change to trichlorphon Tachinid flies returned to the area and eventually all spraying could be stopped.

Carbamate Insecticides

The best known is carbyral, a naphthyh-methyl-carbamate, of moderate or marginal toxicity to warm blooded animals, it is of

limited persistence. Carbyral controls a number of pests on which hitherto the persistant chlorinated cyclodiene insecticides were used.

Cultural Control and Environmental Modification

Before the synthetic organic insecticides were invented, the range of natural and inorganic chemicals available was limited. Recourse had to be made to cultural methods in agriculture and modification of the environment for preventive medical purposes, of which malarial control was the best known example. The primary objective was to prevent anopheline mosquitoes from breeding and the secondary objective was to prevent contact between the mosquitoes and humans.

Denial of breeding places to the mosquitoes requires a knowledge of the local ecology. In many cases drainage to remove open stagnant water or to get the water in motion is advantageous. Badly constructed drains or contour silt pits and roads too close to the dwellings to be protected often result in new breeding places. Some mosquitoes can breed in moving water, but these are sun loving species. Thus sometimes clearing the land and uncovering the streams may increase the number of dangerous mosquitoes, in these cases bushes and shade should be left along the 3treamsides or the stream broken up into a series of pools by darns. A controlled degree of pollution with organic matter such as cut grass renders stagnant pools unsuitable for mosquito larvae.

The expert malariologist recognises the local conditions, including which types of mosquitoes are important, and adopts whichever methods are most suitable. It was perhaps because of this need for trained personnel and application to specific local conditions that natural control methods became unpopular when powerful insecticides were available. However, now that resistance to insecticides has arisen and to lesser extent, because they have inconvenient side effects which bring malarial eradication into understandable - even if misplaced - disrepute, the old methods are being reconsidered.

Mosquito nets and screens, or air-conditioning for the more sophisticated, are means of keeping mosquitoes from humans. Deviation of mosquitoes by alternative animal targets has been suggested, but this has little practical effect and some drawbacks, especially when other mosquitoes such as Aedes spread heartworm for example among dogs. The burning of incense coils is an old form of repellent.

Cultural methods in agriculture are varied. The growth of plants may be improved by fertilisation to help them get rid of minor pests such as Scale insects. Some advocate only natural manures for this purpose and consider that artificial fertilisers aggravate pest attack. That may have been true when unbalanced

artificial fertilisers were given, but now much more is known about correct plant nutrition, and in any event there is not enough farmyard manure available.

Plantation sanitation prevents large pest populations from building up. Rhinoceros beetles are a serious pest of coconut and oil palms. The grubs breed in almost any debris, for instance old rubber stumps, palm logs or even sawdust. If these are distant from palms there is no risk, but in the vicinity of young palms especially, burning or deep burying of potential breeding material is essential. The growing of tall leguminous shrubs as covers is recommended also, because the Rhinoceros beetle does not fly strongly and its activity is restricted by such a barrier. Stem borers in maize are restrained by burning the trash after harvest. Crop rotation prevents the build up of pests in short lived crops. Different crops susceptible to different pests are planted in succession on the same ground, so that the pest population harboured in the soil after each crop will be without a suitable host to feed on during the next phase of the rotation. This is particularly important in sweet potatoes for example. Dust often kills off beneficial insects more than pests, therefore roads may be sealed against dust with advantage and needless tillage which pulverises the soil should be stopped.

Integrated Methods

The integrated approach is to regard natural biological control, cultural and environmental methods, chemical insecticides and any novel means as partners, but not as exclusive alternative rivals. It is by no means a new approach, but it has been eclipsed in the quarter century during which the synthetic organic insecticides have been in the ascendancy. The disadvantages of the latter such as the development of resistant pests, the creation of new pests owing to the destruction of natural controls, the expense of repeated application, and the hazards in many cases to human and wild life (all of which have been demonstrated on a small scale in Malaysia confirming what has happened on a large scale elsewhere) have led. to a reappraisal.

If there were no natural or cultural controls the pests would have driven mankind from the face of the earth long ago. Nevertheless, the need to grow more food more quickly for more people than ever before, makes it inevitable that man will create conditions of rapid crop growth ideal for an equally rapid build up of destructive pests before natural controls can catch up with the situation. The integrated approach starts with rotation of crops and plantation sanitation and other cultural methods to reduce the risk of rapid pest build up, but when this does occur complete eradication of the pest by chemical means is not attempted. An insecticide and mode of application are chosen which will have the maximum selective effect against the pest and least harm to its natural enemies. Usually the powerful contact insecticides, which temporarily wipe out a pest, have no

such selective action. The initially less powerful but more selective treatments can arrest s pest outbreak long enough to enable natural predators and parasites to reduce it to negligible proportions and so maintain a population of beneficial insects in the area.

Certain baits or traps may be used to increase the specificity. Several night flying moth pests and cockchafer adults are attracted to ultraviolet light. Light traps are set up during the breeding season in threatened areas. Some traps are designed so that insects flying in cannot get out or a non-volatile insecticide or oil kills them or immobilises them until they can be destroyed. Mosquitoes are attracted by carbon dioxide, warmth and humidity, traps are now being designed on this basis. Sex attractants are now sought for specific insects.

Other methods are under trial in different countries and may come to Malaysia later. Examples are the release of sterile males of the insect pests to reduce the number of fertile eggs laid. The bacterial and fungal diseases of insects should not be forgotten, Bacillus thuringiensis is the best known bacterial parasite of insects, which has been tried successfully as a spray against some pests. A fungus has been found on the migrant locust and another on the termite which attacks living trees. Some of these are quite specific in their attack and may be encouraged by cultural methods.

Malaysia has been fortunate in that the consequences of misusing insecticides have been realised before there has been any serious damage done. Agricultural and medical entomologists are alive to the need for integrated, specific control techniques. The understanding and cooperation of the public in the responsible use of insecticides at all levels and in all ways will help this object to be achieved, and also save individuals and their families from fatal hazards.

Rodenticides

Rodents such as rats can transmit dangerous diseases in urban areas, they consume large amounts of stored food and are serious pests in many crops. Rats do not evoke much sympathy from most people. However, when it is necessary to kill rats in or near human dwellings, man and domestic animals, especially pets such as dogs and cats, are at risk. Specific or selective poisons that will kill rodents or rats only are needed, which should be harmless to other mammals. True rodenticides of this type are unknown. Norbormide is perhaps the closest discovered yet, it is much more toxic to rats than to any other species, including mice. Some selective toxicity has been claimed for warfarin, but this is largely due to the baits used, which are more attractive to rats than to other mammals and are laid where they are more accessible to rats than to other mammals.

Nearly all other so-called rodenticides are poisons of equal toxicity to a. wide range of birds and mammals including man. The best known examples are strychnine, fluoracetamide, barium carbonate, zinc phosphide, thallium sulphate, sodium arsenite and endrin, (the last was mentioned earlier as a very toxic insecticide). Any selective action depends entirely on the method of baiting, both materials and location. Of those mentioned zinc phosphide breaks down rapidly to phosgene gas, dangerous in confined places but not attractive to other animals. All the other poisons mentioned in this paragraph are fairly stable and are hazardous to predators of semi-comatose primary victims or to scavengers of their corpses. Therefore discussion of the status and control of bird and mammal pests will consider alternatives to the use of poisons so dangerous to man and useful animals, both domesticated and wild.

Warm-blooded Pests

The birds and mammals which damage cultivations may be considered in two groups, resident pests and temporary invaders from surrounding areas. The stocking of resident pests depends very much on the amount of food produced in the area. Although during the peak period of their growth, rubber trees increase in dry weight of timber at a rate among the highest recorded in any crop, the seasonal fall of seeds - seldom as much as 150 lbs per acre - is meagre fare for most of the larger animals. During the earlier phase the cover plants are also very high producers of vegetable matter, which may be grazed by herbivores, but the latter are usually kept out because of the damage they do to young trees and thus are relegated to the class of temporary invaders. Some rodents live in the covers and are pests of the trees. Seed eating birds sometimes frequent the covers, but the rather poor 'avifauna in rubber plantations consists mainly of those eating insect pests of the covers and trees.

The resident mammal pests of rubber are mainly rats and related animals. Flying foxes, which are large bats, are very rarely troublesome in rubber. The natural controls of the rodents are snakes and birds of prey. Conditions in rubber plantations do not favour wild cats and other mammalian predators. When it is necessary to supplement natural control, traps of a selective design and specific poison baits may be used.

In oil palm the crop of fresh fruit bunches may be as much as 11 tons/acre/annum and the oil extraction may be as high as 22%, in addition there are considerable weights of foliage and stems in the palms and the covers. It is not surprising that quite heavy rat and squirrel infestations sometimes occur and that new pests have arisen, in particular wild parrots especially the long tailed parakeet have taken to consuming the fruit. At present shooting, trapping and selective poison baiting are attempted. There is an urgent need for research into the food chains and to encourage natural control by birds of prey,

snakes and carnivores. The leopard cat, mongoose and other small carnivores control rodent populations in bamboo, secondary and primary forest, their possible role in oil palm plantations seems to have been neglected.

Judging by Malaysian experience with insect pests control measures must depend mainly on natural means with only temporary selective assistance from artificial methods and chemicals. In the humid tropics the climate is favourable to pest population growth throughout the year and traditional methods in the temperate regions of attacking vertebrate pests during the breeding season or when food is scarse in winter are less likely to succeed here.

Cocoa plantations are a relatively new venture in Malaysia. -In Lower Perak cocoa is grown under coconut palms and rodent populations are again high, rats attack the cocoa and squirrels eat into young coconuts. In some areas musang or civet cats have been singled out for persecution by poisoning with endrin laid in banana baits. This is a risky procedure. There is evidence that excessive use of endrin in this way has led to birds of prey being killed and in the case of migrant raptors their loss may be felt elsewhere. In addition to this the campaign may be entirely misplaced; although catholic in their feeding habits, the civet cats and their relatives are carnivores and the young of rodents are a part of their diet. It is dubious how much of the damage done by mammals can be attributed to musang. This may be a case of trying to exterminate a relatively minor pest at the expense of upsetting all natural control including elimination of those which are in fact predators of real pests. These problems await proper investigation.

Padi is subject to bird attack during harvest, but if the padi areas are large enough, bird scaring can be made adequately efficient. In East Malaysia correct timing of padi planting and hence harvest reduces attack by migrant birds such as the Long-tailed Munia but in West Malaysia the main culprit is the White-headed; Munia resident all the year round.. Vegetable gardens have their share of rodents, often rats escaped from human dwellings and in turn domestic cats effect some control. Orchards are sometimes raided by flying foxes, squirrels and other fruit eaters, but these are not usually residents.

Cultivation's Borders

In many developed western countries agricultural land, whether cultivated or grazed, planted woodlands and orchards, constitute the greater part; urban, industrial and mining areas are often large too and natural vegetation is reduced to fringe areas and isolated patches. Such a situation occurs in Java and the 'rice-bowl' of Thailand, but in most parts of South East Asia extensive tracts of jungle remain yet. In Malaysia the forests still cover most of the land area despite the inroads of

cultivation. In the long developed parts, such as Malacca, the jungle is restricted to a few outposts and beyond the boundary of cultivation there is often secondary forest or lallang where past cultivation has been abandoned. In the newly cleared areas agricultural development and primitive forest march side by side.

Inevitably wild life crosses the boundary in places and feeds on crops or attacks livestock ranging from poultry upto cattle or even man himself. When this happens the animals are considered to be pests. However, before considering the relationships between man and invading wild life seeking food after the destruction of the natural habitat, it is as well to repeat that many agricultural pests, especially rats, accompanied man or the extension of man-made lallang and bamboo dominated areas, they did not all come from the jungle. The most common pest in oil palm, Rattus tiomanicus jalorensis normally occurs in secondary forest; the second most frequent, R argentiventer is naturally confined to grassland (lallang); both are of the R. rattus group, never found in deep forest.

Where large contiguous areas of plantations, whether estates or land development schemes, are bounded by forest, a barbed wire fence five feet (1.5m) high, with wire netting for the bottom three feet (1m), will exclude the majority of deer, wild pig and porcupines. Hunting the larger deer, pigs and porcupines the meat of which can be sold using suitable heavy shot guns is a profitable additional control. Humane traps set within the margin of cultivation may be baited with vegetable food which is selectively attractive to the mammal pests. Porcupines seldom penetrate into the plantation more than 100 yards (100m) from the jungle way in. They can be caught in cage traps and then killed for fresh meat. Traps should be visited daily, because not. only is it cruel to starve animals, but other porcupines will not enter a trap in which one of them has died. Porcupines are fond of salt meat. Poisoned baits are very dangerous, because of the risk to domestic animals and the hazard of secondary poisoning of predators and human scavengers. Various repellants work against deer, such as noise from banging scarers (operated by carbide) smell from foetid grease, or visual methods such as tinsel, aluminium paint bands, patterns of black and white dots. It is very dangerous to dig fall pits or set drop spears or sprung wire noose traps (the last mentioned are illegal) for two reasons. Firstly because the direct risk to humans is too great, even in or rather more so in the isolated places where these traps are usually laid, Secondly these traps are quite unselective and kill or maim useful animals as radily as pests.

The natural controls of pig and deer are mainly the larger cats, leopards or panthers, clouded leopards and tigers. These large cats are active animals and need plenty of food, a mother with cubs hunts over a large territory, as much as 50 square miles

(14,400 hectares) is quoted for a tiger. Therefore the death or injury of a large cat so that it cannot hunt is likely to result in an increase in the unmolested population of wild pig over a wide territory. There is cumulative, convincing, well documented and circumstantial evidence that nearly every tiger or big cat which has turned man-eater or cattle-killer has been maimed by a steel wire snare, a shot gun wound or other man-inflicted injury. Several claws or whole paws may be lost or turn gangrenous so restricting the big cat's movements. No longer able to hunt, it must lie in wait until some unsuspecting domestic animal, a cow or goat, or a man, woman or child comes within easy range. Mankind earns just retribution for cruelty and ignorance of the natural balance, although innocent parties may suffer bereavement and the guilty escape.

There is evidence too, perhaps not so fully established as in the case of the big cats, that elephants which take to crop raiding are also victims of wounds inflicted by man's traps and firearms. An elephant with ulcerous sores on its ankle cannot support its great weight in comfort and travel long distances over its usual range. Usually it has been injured on the fringe of cultivation and there it remains, making raids into plantings of bananas, rubber and palms. Sometimes in old age an uninjured elephant may take to crop raiding, but this does not seem to be common perhaps because senile elephants normally succumb to natural causes. An ordinary fence will not keep out determined elephant, but electrified wires, with tension springs at intervals to prevent snapping by a sudden blow, supported on angle posts which are not easily pushed over, have been successful in some areas. The voltage should be adequate to shock, but not to kill, after a while the herd moves away. If a boundary is likely to remain static adjacent to jungle for a long time, an elephant belt can be felled beyond the ordinary fence against pig and deer. An elephant belt consists of felling trees criss-cross, leaving the debris unburnt and allowing dense secondary jungle to grow up. Wild cattle sometimes enter plantations, these methods keep them out. Domestic cattle are kept out by fencing.

Monkeys, squirrels and flying foxes (large bats) can climb, jump or fly over fences. Locally they cause trouble. Monkeys are intelligent and often move away if some of their number are shot and the corpses hung up as a warning or psychological repellant. Elaborate cage traps defeat the monkey's ingenuity without risk to cats and are humane in operation if visited every morning. Squirrels are shot or trapped in fruit baited cages, Flying foxes can be deterred by nets and shooting. Smelly repellants can bo used in many cases and it is probable that chemists will discover new nauseous but not noxious substances.

A well defined and fenced boundary with appropriate repellants just within the periphery does much to keep out

mammalian invaders, who will in time adjust their stocking to suit the area of forest left to them without need to invade cultivation, especially if still subject to natural controls. The predators, such as large cats which hunt pigs and small cats which prey on rodents, are very easily depleted by indiscriminate trapping and poisoning. Traps should be regularly visited, humane and selective in action either by their construction or the nature of the bait. If poisoning seems to be the only solution, selective baits and methods and non-persistent poisons should be chosen as far as possible. Shooting reduces the numbers of some pests and is a deterrent to the more intelligent apart from being profitable and providing a means of taking a crop of meat (protein) from the jungle in the case of pig and deer. The boundary of cultivation can be managed, especially if the significance of natural balance, predation and stocking on the jungle side of the perimeter is understood, respected and protected. This is integrated pest control.

Artificial Aids in Agriculture

Agriculture from its definition to till the fields and from its history of converting natural vegetation is an artificial process, that is it is made by man. It is only natural in as far as man's dominance on the earth to the point of self destruction is a natural evolutionary process or divinely fore-ordained. Therefore unnatural or artificial practices and aids must be and have been introduced from prehistoric times to make agriculture more efficient. The rise of synthetic chemical pesticides and their impact on the Malaysian scene have been described in some detail. In other countries pesticide usage got out of control, especially where the consequences of non-selective action and persistence in soil and through the food chain wore not understood. Quite rightly there has been a swing in public and scientific thinking, in some cases this counter reaction may have gone too far, where it has threatened to halt campaigns against the enfeebling diseases of mankind. Wherever thought is stimulated and research into specific and integrated control methods results, then this reaction has been beneficial. Man must examine his place in relationship with nature and work with instead of against natural processes.

Thirty years ago a writer on the benefits of chemistry to agriculture would have made little reference to pesticides. Artificial manures such as superphosphates and in particular nitrogenous fertilisers made from atmospheric nitrogen would have commanded attention. The harvest of crops depletes soil nutrients, and the heavier the crop the greater the loss and more likely it is to exceed natural rates of replacement. The nutrients are not returned to the soil in many cases, for instance the waste from cities usually ends up in the sea. The provision of artificial fertilisers has been a great boon to agricultural food production.

Nevertheless there have been critics of artificial fertilisers. Many claim that lavish use of chemicals has led to lush growth prone to pest and disease attack, or led to deterioration in soil structure, although this is more often due to burning or removing plant debris from the site. Unhealthy growth may occur in some cases of excessive nitrogen application which depresses potash uptake. On the other hand if artificial fertilisers are given in the right amounts at suitable intervals and - equally important - in the right proportions of the different nutrients, the growth and health of the plants is improved. This implies that for each combination of soil type, crop species or variety and to a lesser extent climatic conditions, such as rainfall and solar radiation, there is an ideal combination of fertiliser composition, mode, rate and frequency of application. In the long run these are determined by fertiliser trials, but it takes many years to test every possibility. A less publicised revolution has been going on. Methods of analysing plant tissues, in particular leaves, have been improved in accuracy and automated for speed. These, in conjunction with better soil classification, enable the information gathered from one trial to be extended far more widely and accurately,

Synthetic plant hormones have been used to stimulate rooting and fruit set in a number of crops. There are signs that the next advance may be in the field of new discoveries and applications in the use of synthetic growth substances to control the growth, form and flowering of various crops.

The activities of the plant breeder are considered to be natural by some, since natural properties of the plant are used, although combined by controlled breeding. In other ways they are artificial. However, the genetic reserves, especially to provide disease resistance, are to be found in the wild. This brings us to consider the conservation of natural biological communities.

CHAPTER FOUR

BIOLOGICAL COMMUNITIES

Two or more living things together constitute a community, whether they are of the same species or different species. The characteristics of a community derive from the identity of its components and the relationship between the components. Two communities may consist of the same component species, but differ in the relationship between them, for example in one case a particular species may play a minor role but dominate in another. The International Biological Programme and the International Union for the Conservation of Nature attach great importance to preparing an inventory or catalogue of all types of biological community and taking steps to preserve adequate examples of each. The biological communities in Malaysia are many, varied and generally very rich in species. The task of surveying and describing them, so that coordinated and planned action may be taken to save them, is formidable indeed. Moreover there is need for haste before some of the best remaining or even unique examples are lost, owing to the sites being converted for other purposes. Sometimes there may seem to be conflict between conservation of these communities and land development. Therefore various reasons for this ambitious project will be examined.

Plant Species

Every crop plant is attacked by pests and diseases. Search among wild plants of the same or related species often reveals individuals which. are resistant to one or other of the pests or diseases. Very rarely plants are found which are resistant to most known diseases, but usually different sources of resistance, that is different plants or populations of plants, have to be found to provide resistance against each major disease. Moreover sometimes new races of pest or disease organisms evolve, which are able to attach the hitherto resistant plants, then new sources of resistance must be found.

The plant breeder must then cross the resistant plants with high yielding varieties to produce new selections which combine these desired properties. This can be quite a long term process, with disappointments when resistance breaks down owing to the evolution of new pests and diseases. Despite the time and cost involved and the disappointments, plant breeding is the most important way of raising crop productivity and combatting pest and disease. Sometimes there is no other way of obtaining healthy plants or the use of pesticides is dangerous or these and other methods are prohibitively expensive. Improved crop plants are of the greatest advantage to peasant farmers or smallholders, who have neither the educational background nor the equipment to use dangerous chemical or difficult cultural methods.

Therefore plant breeders need continuous access to the whole range of genetic variability represented by wild plants. One or two examples of the wild species in botanic gardens are not enough. Plant breeders of many crops make regular expeditions to collect examples of wild species to replenish their stocks. They test the new acquisitions against new races of the pest and disease organisms, which may have arisen since the last selection of resistant parents. The destruction of natural biological communities and the rich variation found in them, has given rise to anxiety in the Food and Agricultural Organisation of the United Nations, in case future plant breeders are denied the raw material for their work.

Although many crops are now grown in all tropical countries; the wild species from which they are descended are found in more limited areas. Thus each region or country has responsibilities towards the rest of the world to preserve its own wild flora for posterity. Malaysia is no exception. It is at or near the centre of origin of bananas (Musa), relatives of sugar cane (Saccharum), many fruit trees (Artocarpus, Citrus, Durian, Mango, Mangosteen, Rambutan). many spice and drug plants, and several of the ornamental genera of orchids.

At one time all drugs were obtained from natural sources. The usual sequence of events was that the drug became known from the plant extract and later the chemists synthesised the drug or a related compound with similar properties. If the synthetic was cheaper or seemed more effective, then the naturally produced drug would be driven from the market. However, a further stage has been reached in several cases. Resistance to synthetic drugs has been evolved by certain parasites causing disease in humans and domestic animals. It is often found that the original natural drug is still effective against these organisms. The case of malarial parasites and quinine has already been cited. Similar cases seem to be arising for enteric complaints, diarrhea and dysentry, and recourse is again made to extracts of gambier and ipecac.

Some new drugs have been synthesised without a natural pattern, but this is still exceptional. Even when the synthetic replaces the natural drug successfully without any development of resistance, the discovery of the drug in the first place has been a major benefit to mankind, which might have been indefinitely postponed; if the properties of the natural drug plant had not been discovered first. In recent years phytochemical surveys have been conducted in a number of countries, including Malaysia, when it was realised how few of the potential sources of new drugs had been investigated. Despite this activity it is recognised that so far only a beginning has been made and the greater part has yet to be tackled, The value of atropine, codeine, cortisone, digitalin, morphine, scopolamine and strychnine when correctly used in medicine to relieve pain, induce sleep or stimulate are well known. Colchicine upsets

nuclear division in plants and animals, may there not be some naturally occurring drug to be found which will bring cell division under control and help to remove the scourge of cancer?

These are reasons for preserving as many species and varieties of plants. They are too numerous to be preserved in any other way than by saving representatives of every known type of vegetation. Indeed new species of plants are still being discovered and named, so that no-one could make a complete list of what to try to keep in a botanic garden, which would still be inadequate unless it included the variation within species too. Furthermore it is not easy to maintain little known plants, whose soil, light, moisture, temperature, and nutritional requirements are unknown.

Vegetation

Plants growing together make vegetation. Mention was made earlier of the need to preserve examples of natural forest as controls in forest management experiments. The processes of natural productivity are imperfectly understood, indeed it is one of the objects of the International Biological Programme to investigate them. We are just beginning to learn what proportion of solar energy is utilised by crop plants. We have no means of knowing how this compares with natural vegetation and what are the causes of any differences which may exist. If we knew these, in whichever direction they lay, we might be able to improve crop production by application of this information. These are reasons to preserve vegetation as a whole as well as its components.

Animal Species

There are close parallels to the need to preserve plant species among the animals. Various animals, mainly insects, feed selectively on certain plants or parasitise selectively particular insect pests. If the plant gets transferred to another country without the insect which feeds on it, so that there is no natural restraint in its new environment, it may spread aggressively as a weed. This happened with Prickly Pear Cactus in Australia, Black Sage in Mauritius and Coster's Curse in Fiji, but they were all brought under control by the subsequent import of the respective insects whose feeding is restricted to them. Similarly if an insect pest is transferred without its parasites, it may be much more damaging in its new home, but again can be brought under control by introducing the parasite also.

This is yet another matter of international stewardship; each country must try to preserve the full range of beneficial insects, so that they are available to send to other countries if

previous intentional or accidental exports prove to be unwelcome guests. If a plant or insect is Kept under natural control here, it will not be recognised as a potential weed or pest until it escapes elsewhere without such control. It follows also that the value of the natural controls will not be recognised until this happens, so that there is no knowing what is wanted in advance. It would be quite possible for a potential weed or pest to be under such good natural control in its country of origin, that it and its controlling insect were present in such small numbers that they could easily be exterminated by habitat destruction, but meanwhile escapes could be building up to large numbers elsewhere, the prospect of finding the natural control being lost forever.

The potential of Malaysian wild cattle, seladang (gaur) and banteng (temadau), do not seem to have been fully realised either as ranging beef cattle or as breeding stock, although the Bali cattle are derived from the banteng. Protein is a major dietary shortage in the region. In such diverse areas as Scotland and East Africa it has been shown that ranging wild deer and cattle periodically culled can produce more meat than grazing domesticated cattle, sheep or goats over the same area. This warrants investigation here. Tolerance to heat is variable in cattle and so is their ability to convert coarse grazing, valuable genes for these characters may be carried by the wild cattle. Sometimes it is said that crosses between wild and domesticated cattle are impossible, however, this was said of Swamp and Murrah Buffaloes, but it has been achieved. These and other threatened species should be saved for their possible utility to mankind. Preliminary results from the domestication of Sambur and other local species of deer are encouraging that a high level of protein production is possible without the health and feeding problems found with introduced livestock. Fur animals such as the big cats and skin animals such as crocodiles and monitor lizards are being hunted to extinction. This is destruction of a future source of revenue.

The use of animals for research purposes raises moral and humane issues. However, already the majority of people in urban areas and soon most of those in rural areas will have benefited by research on vaccines, antibiotics and numerous medical investigations using animals. All the golden hampsters in the world are descended from one pregnant female. It is a very convenient laboratory animal and its significance for Malaysians is its extreme susceptibility to leptospirosis. By the time a clinical diagnosis has been made, the patient will be very ill, perhaps fatally. There are powerful antibiotics which can effect a cure if given early, but it is unwise to treat with these antibiotics until a firm diagnosis has been made, because there are serious side-effects in some cases which should be avoided unless leptospirosis infection is proven. Moreover these might be the wrong treatment if another disease had in fact

been contracted, also indiscriminate use of antibiotics may result in resistance and loss of effect when needed. Nowadays blood is taken at an early stage from a suspected leptospirosis case and injected into a hamster, which rapidly multiplies the leptospirochaetes if present and dies. Microscopic examination of the hamster's blood shows the leptospirochaetes before they can be detected in the human victim. There may be many other animals equally important for medical research or diagnostic technique waiting to be discovered.

Animal Communities

Human populations are gowing rapidly, human communities display competition, greed and aggression. Study of these phenomena in mankind is much needed, so that something constructive may be done towards their abatement. However, we find it difficult to study ourselves critically and dispassionately owing to our own emotional involvement. It may be easier to investigate these problems in animal communities, preferably in nature rather than under the artificial restraints of a laboratory. Any chance, however small, that this could lead to the removal of want by population control and the relief of fear by understanding and correcting the causes of aggression, should be siezed, which means the preservation now of the living material for such investigation.

These are all practical reasons for preserving representatives of all living things. There are moral and aesthetic reasons too for consideration later. The types of vegetation in Malaysia will be reviewed to indicate the range for conservation.

The Main Types of Vegetation

Broad types of vegetation are easily recognised. The littoral communities of the beaches and mangrove swamps are our defence against the. sea, behind them are found the freshwater swamp and lowland dipterocarp forest, which in turn give way to the dipterocarp forest of the hills, above which are various montane types.. Only in Sabah on Mount Kinabalu and other mountains is there any alpine vegetation.

These main types are subdivided into various kinds of natural vegetation usually characterised by the more important timber species present. Areas originally covered by undisturbed, primary or natural climax vegetation have had timber extracted or been cleared for cultivation or mining. After extraction of timber from forest reserves, the trees are allowed to regenerate the forest, although usually various weeding operations (discussed under arboricides) are carried out to increase the stocking with economic timber trees, so that neither the first nor the final stages of regenerated forest are quite the same as the natural primary forest. The secondary vegetation which develops on land abandoned after cultivation is very different from primary vegetation and it takes many years (several human

generations) before anything approximately like the original forest appears. After hydraulic mining the recolonisation of the land is very slow and may remain almost without any vegetation for 5 to 50 years according to the proportion of sand in the soil. Thus throughout the areas naturally covered by the main types of primary vegetation are found parts cultivated and mined, and within the latter parts abandoned to secondary vegetation.

Within the areas occupied by the main vegetation types there are parts where the natural vegetation is different due to geological and topographical factors effecting the soil and its drainage, for example the vegetation of quartz ridges, limestone and sandstone hills, or on the ultrabasic rocks of Mount Kinabalu. These types of natural vegetation, which owe their presence to soil conditions, are called edaphic climax formations to distinguish them from the climatic climax formations, which are the types of primary vegetation determined by the climate of the region.

If the objective of preserving living specimens of all species of plants is to be achieved, then adequate examples of all types of natural primary vegetation, including climatic and edaphic climax formations, must be conserved. It is usually considered that the types of secondary or disturbed vegetation will occur all too frequently and need not be specifically maintained. This is largely true, but certain special cases warrant provision in overall planning. For example to make valid comparisons of forest management methods will require untouched forest as control and areas which have been logged and treated in different ways, it is most important to retain the oldest examples of the latter. The wild ginger and plantain type of secondary vegetation arises on the better soils after the milder types of shifting cultivation; the plantains or wild bananas are important material for plant breeding, which may be true of the gingers to a lesser extent. It is important to see that the preservation of this wild ginger and plantain vegetation is not left entirely to chance. It is normally of relatively short duration, soon giving way to mahang type belukar, and is less likely to appear if the aborigines have to abandon shifting cultivation or modify the method so that lallang replaces wild gingers and plantains in the succession. Certain large herbivores such as rhinoceros, elephant and wild cattle seem to achieve their maximum stocking in some kinds of secondary vegetation, the provision of which may prove essential for their survival.

Mangrove Swamps

These are the swamp forest flanking the sheltered coasts. Many of the trees produce viviparous seeds, that is the embryo has already germinated before leaving the mother plant; this may spaed their establishment in adjacent newly deposited mud, or

merely reflect a loss of dormancy where there is no need for it. The zonation of the mangrove vegetation is related to the frequency of inundation by salt water. The pioneer trees, especially api-api, the Avicennia species, have a web of roots radiating out in the mud from which arise vertical finger-like 'breathing' roots. These pioneers in the areas where new land is being won from the sea withstand frequent inundation, although it is doubtful if any can tolerate total immersion every day. The next zone is covered by normal high tides but not by the neap high tides, the stilt rooted Rhizophora species are characteristic.

The zones inundated by spring tides or by exceptional equinoctial tides only are the most productive of poles for fishing stakes and scaffolding, firewood and charcoal. Bruguiera species predominate and Acrostichum fern is characteristic of the ground flora, but the number of species present shows a distinct enrichment in the flora compared with the pioneer zones. Prawns improve aeration and raise the land level in the zone covered by spring tides. In the seldom flooded zone some timber species occur, also several palms are found including Nipa, the source of the best atap.

The major significance of mangrove is that it is an advancing frontier winning land from the sea. The resultant coastal clay soils are often very fertile if properly managed. The fuel resources are renewable provided they are not over exploited to destroy the protective fringe against the sea. Shell-fisheries are valuable. There is fairly rich animal life, including crocodiles and monitor lizards which are now hunted heavily for their skins. Crocodiles are an occasional risk to humans, probably much exaggerated by fear, and their extermination may be viewed with favour by some. Nevertheless they seem to play an important role in controlling the number of monkeys (kera and lotong) and to a lesser extent of wild pig, which would otherwise increase and raid more often the crops on the adjacent drained fertile coastal clay soils. The reptile skins are a valuable export, whose hunting and cropping should be carefully controlled if this source of revenue is to continue.

Beach Vegetation

Whereas the mangrove forests are usually accreting new land if undisturbed, the strand vegetation of exposed sandy and gravelly beaches may be in accretion or recession. Where the land is advancing creeping herbs such as bindweeds, legumes and grasses are found with a fringe of Casuarina equisetifolia or ru trees. Behind this is mixed woodland or a grass and sedge community, the latter if grazing is heavy. The woodland includes various trees such as Terminalia catappa, Calophyllum inophyllum and Barringtonia asiatica (ketapang, penaga laut and putat laut), which are left fringing the sea strand if the shore is receding. Human activity often ensures the replacement of the woodland by coconut groves, but these are usually low yielding. Where the coast is receding rapidly, coconut palms or beach

woodland trees are commonly found leaning onto the beach.

Perhaps because there are few timber species and other economic products from this beach forest, its management seems to have been neglected. The sandy beaches are much more popular seaside holiday areas than the muddy mangrove swamps or even the slimy rocks or sharp coral. Therefore the strand vegetation is much disturbed at popular resorts near large towns. It is probable that holiday makers are speeding the rate of regression. Much as controls may be erksome or engineering works unsightly in the early stages, it is not too soon for precautions to protect the sandy beaches by groins and their fringing vegetation by rotation of public access, as easy transport brings them within the reach of ever greater crowds. Otherwise this amenity may be lost and the coast line left raw and unsightly. The undisturbed beach succession is one of the simplest to study in the tropics, (and is free from the unpleasant conditions of the equally simple mangrove), therefore some examples should be retained for training purposes.

Heath Forest

This is the vegetation of old raised beaches with podzol soils left after prehistoric falls in sea-level. There is little of this left undisturbed. It easily degenerates. It is alternately dry and water-logged so that the gelam association which can tolerate both fire and swampy conditions is often found in such situations today,

Swamp Forest

There are two main types of freshwater swamp forest; firstly the lopak or alluvial type fed by streams and rivers, secondly the peat swamp type, which when fully developed receives only rainwater and as its name indicates builds up a much deeper layer of peat. In areas of high rainfall the alluvial type may be followed by the peat swamp after the vegetable remains have built up the soil level above that of the river water level. Both alluvial and peat swamp forests occur in Malaysia, but the peat attains its greatest depth and the forest its most extreme form in Sarawak.

Some timber species are valuable and highly productive, forestry may prove the best land use for peat swamp forest. For the general reasons already given some areas of the other types of swamp forest should be retained, where water levels have not been unduly disturbed. Gelam (*Melaleuca leucadendron*) is common where alluvial swamp has been heavily disturbed, especially if the water is brackish as mentioned under mangrove. Gelam produces plenty of firewood and charcoal. In places, such as on the margins of Tasek Bera, the great inland lake in Central Malaya, palms, rotan, screw pines (pandan) and sedges predominate. The direct economic value of this community is

probably low, but its indirect value for fish production may be more significant. Its ecological interest is great and its genetic reserve potential as yet unknown.

River Banks and Fringes

Except where human interference has destroyed it, there is a distinct vegetation fringing the rivers. This strip may vary in width from a single line of trees on the river bank to broad mangrove swamps flanking the river estuary and merging with those along the coast. Neither the pioneer mangrove nor the river bank fringe is rich in trees of direct economic value. The main exception to this is the nipah palm, source of the best atap, which occurs extensively alongside the brackish tidal waters of the upper reaches of wide estuaries. The valuable mangrove is behind the pioneer fringe. The valuable forests and agricultural land are behind the river banks, which protect them.

Moving upstream from the mangrove and nipah, a belt of rassau, characterised by a screw pine and associated species, is passed. Then for twenty to a hundred miles according to the width of the lowland plain, gallery forests fringe and overhang the rivers in their natural state. The name gallery is derived perhaps from the resemblance to a choir gallery overhanging the nave of a gothic cathedral. Where Dipterocarpus oblongifolius is the main tree species, the Malay name neram may be preferred for this type of forest.

Beyond the usually fairly broad smooth flowing rivers, the rocky streams are reached. These are bounded by bamboos or by Saraca trees (gapis or golak in Malay). The related tree Saraca indica is known in its homeland after the Emperor Asoka, who turned from war and planted trees as a more satisfying way to establish his memory. Whichever of nipah, rassau, neram, gapis or buloh vegetation fringing the rivers and streams is concerned, the law in most of Malaysia requires that it be left uncut and undamaged in a defined strip along each river bank. This law is frequently not observed, nevertheless the law is on the statute book and nature has provided the fringe vegetation, both are there for a very good reason, simply to provide the mutual protection of the river and the agricultural and forest lands adjoining it.

The reader may turn to the first chapter to recapitulate the basis of water and river conservation. The situation is typical of many; the conservationist, scientist and plant breeder wish all types of vegetation to be preserved according to their general principles, but equally putting this into practice will afford protection of much more.

As a bonus many of the best wild orchids for breeding purposes are found as epiphytes in the neram and gapis river fringes, especially near waterfalls, some of which are scenically beautiful in their natural setting.

Inland Dryland Forest

The vegetation of the coastal fringe and immediately behind it has been considered and also the swamp and river communities. The broad classification of the inland vegetation follows altitudinal zones modified by soil and climatic factors, examples of the latter are where the influence of the monsoons is marked or minor. Foresters consider the lowlands to extend to about 1,000 ft (300 m) above sea-level, agriculturalists have usually taken a somewhat lower level about 750 ft (230 m), because this is the common limit of rubber and oil palm, however, geographers and land capability planners are increasingly using the 'steep land line' mentioned earlier, which varies from district to district. However, the foresters will be followed here.

The greater part of the inland lowland dryland forest can be described as lowland dipterocarp forest, which is characterised by the majority of large trees which emerge above the lower forest storeys being members of the family Dipterocarpaceae, many of which are the most important timber trees. The main exceptions are the specialised vegetation of quartz ridges and limestone hills, most of the latter are less than 1,000 ft high, and some marginal forms characterised by leguminous trees sometimes with kedongdong (Burseraceae).

Lowland Dipterocarp Forest

In Malaya various sub-divisions have been recognised according to timber species of importance. Similar studies are proceeding in East Malaysia, but exactly the same classification is not applicable in each country. The Malayan types are quoted to illustrate the range in such a relatively small area.

Keruing forest is characterised by the large proportion of Dipterocarpus species. Water-logging occurs occasionally and the community is probably marginal to freshwater alluvial swamp. Keruing timber is medium hardwood.

Red meranti-keruing is named after a group of several Shorea and Dipterocarpus species which are light and medium hardwoods. This forest type is common on lateritic soils, which may indicate impeded drainage but not to the extent of water-logging as in keruing forest; the two types merge into each other.

Most of the other types occur on fair to well-drained soil, and are separated in different areas probably due to climatic and perhaps soil differences. These forests produce the most valuable timbers and the lands are under the highest pressure for agricultural purposes because of the soil is usually rich

and well drained. Chengal or Balanocarpus leimii is Malaya's best known and one of the heaviest hardwoods. This very-valuable timber species is most common on rich soils in raid and north Malaya (except in Perlis); it is especially common in the foothills where these are called chengal forest. Another heavy hardwood is damah laut merah (Shorea kunstleri) which has given its name to a forest type also found mainly in the north. Balau forest named after a group of Shorea species yielding heavy hardwoods is more common in the southern and eastern half of the country. None of these forests - chengal, damah laut merah or balau - is dominated solely by the characteristic species, which in each case is simply more common among the emergents and valuable timber species present. Many other tree species are present in all canopy layers of storeys of the forest. This is very different from the temperate regions where one species may form a pure stand.

Kapur forest is about the only type to approach single species dominance among the lowland dipterocarp forests. Kapur (Dryobalanops aromatica) is a gregarious species, which flowers and sets seed more often than most dipterocarps, some of which may not seed for seven or more years. The natural range of kapur is near the East Coast of Malaya. There are small almost pure stands of kapur in Selangor and Negri Sembilan. No one seems to know how they got there, perhaps planted by aborigines. Their exceptional purity suggests artificial aid.

Nemusu forest is also widespread except in North West Malaya, where it is replaced by the mixed white meranti-gerutu forest. The latter is rich in species typical of the monsoon areas further north. There are many other types of lowland dipterocarp forest still ill defined or considered to be intermediate forms.

Non-dipterocarp Lowland Forests

The non-dipterocarp lowland forests, that is those in which dipterocarps do not form the larger proportion of the emergents, are less valuable economically because most of the preferred timber species are dipterocarps. Circumstances such as supply and ease of growing may cause some changes in preferences in future.

Kempas-kedongdong forest is named after the large leguminous tree Koompassia melaccensis (kempas) and a variety of trees in the Burseraceae, mainly of the genera Canarium and Santiria. Kempas is a medium hardwood but the kedongdong group are light hardwoods, all have some undesirable characteristics which detract from their worth as first quality timbers. The forester is less concerned with conservation of this forest type because of its low economic value and since it occurs usually on poor swampy soils there is less pressure to convert it to agricultural purposes. Nevertheless it should not be omitted

from the plan to conserve representatives of every type of vegetation recognised because no one wants it or the land it occupies at present. Furthermore some of the defects of kempas and kedongdong timber can be overcome with modern treatments and equipment, so their relative value may increase in future, especially if supplies of the currently preferred timbers are exhausted later.

The situation is much the same with the merbau-kekatong forest of the foothills characterised by several leguminous heavy hardwood species of Intsia and Cynometra. Merbau timber is of growing importance and this type of forest is often along the border of the agriculturally desirable land.

Specialised Lowland Vegetation

The specialised vegetation of quartz ridges and limestone hills is poor in economic timber species and the small quantities present are difficult to extract. Some timber trees are more common at the foot of quartz ridges although not actually on them. Some quartz ridges and limestone hills are entirely below 1000ft (330m), that is they are within the arbitrary limit of the lowlands. Others straddle or rise through this artificial division and yet other quartz dikes and limestone outcrops are entirely above it. The vegetation of these specialised habitats is determined largely by their peculiar environmental features irrespective of altitude. Thus although these features may occur within lowland forest and provide an additional reason for conserving a particular area, the vegetation of specialised habitats will be considered as a separate problem, intermediate in some ways between lowland and hill forests and separate from either in others, they are largely free from agricultural pressures, but sometimes exploited for minerals. The general problem of lowland forest conservation will be discussed first.

Virgin Jungle Reserves

Foresters have always appreciated the need for untouched portions of forest as controls for their experiments, which serve also as living museums or genetic pools. They have set aside one or more virgin jungle reserves to be kept entirely unfelled in each of a number of the 400 forest reserves. Originally there were over 70 virgin jungle reserves in Malaya varying in size from 25 to over 4000 acres (10 to 1600 hectares), the larger ones being catchment areas also, the usual area being about 300 acres (120 hectares). This is entirely a departmental arrangement and if the forest reserve as a whole is alienated for other purposes, usually for agriculture, the virgin jungle reserve is lost with it. This has already occurred in a few cases and others are pending.

Despite the inroads already made, there are reasonable

prospects of finding examples of all the major types of primary lowland forest in those virgin jungle reserves still surviving, especially if supplemented by new ones in forest reserves lacking them. However, if forest reserves are felled and planted with other crops in an unco-ordinated manner, the last examples of some particular community may easily be lost. Furthermore the smaller virgin jungle reserves cannot survive as entirely isolated islands, they must have a cushioning boundary belt, ideally of forest, although it will be felled, treated and regenerated forest in most cases. It is not easy to define a minimum area for an effective reserve, either to be adequately buffered against the external environment, in particular the lateral penetration of strong sunshine and drying winds, or on floristic grounds. About 100 tree species are found in an acre (0.4 hectare) of undisturbed dipterocarp forest or 250 in 5 acres (2 hectares), each represented by an average of only five individuals, the rarer by only one or two. Some of the largest virgin jungle reserves covering catchment areas can survive on their own. The majority of intermediate size would be most secure if surrounded by productive forest, however, a compromise may have to be accepted in certain cases. For instance if a virgin jungle reserve is the unique remaining example of a particular forest type surrounded by very valuable agricultural land, it would be better to surround it by tree or palm crops as a partial protection than to lose it altogether or to provide no shield at all.

Several virgin jungle reserves have been selected to coincide with natural salt licks visited by wild life. They all have enduring educational, scenic and recreational values in addition to their basic scientific worth. Some are catchments. The need is to classify the virgin jungle reserves according to forest type, to take into account all the other existing and potential attributes, such as providing a wide regional distribution of parks in easy reach of all centres of population, and to make definite recommendations which should be protected in perpetuity. Private individuals, associations like the Malayan Nature Society and official projects such as the Land Capability Classification and the Conservation Section of the International Biological Programme, are all tackling this problem from their respective approaches. It is a complex task and time consuming if a fully comprehensive survey is to be made, meanwhile pressure on land continues, therefore some compromise between the ideal complete knowledge for decision making and the urgency of making decisions must be adopted.

Saving the virgin jungle reserves for posterity should conserve a large proportion of plant species, many invertebrates and smaller warm blooded animals. However, even all the virgin jungle reserves together would hardly support one tiger or one elephant and, fragmented as they are, they cannot support a single large animal. The extent to which the larger forms of wild life can adopt themselves to the conditions of managed productive forest, which will surround the virgin jungle reserves in most

cases, is unknown. The most promising approaches to saving the large mammals will be discussed under national parks.

Secondary Lowland Vegetation

Passing mention has been made of the secondary vegetation arising after various degrees of human interference ranging from the early stages of regeneration in felled and treated lowland forest, through lands abandoned after mild shifting cultivation or after more severe permanent agriculture, to the extremely degraded conditions following mining. Some of these types of secondary vegetation choke out other plants and persist for a long time, and/or they catch fire easily and only species tolerant of fire can survive, thus these forms become biotic climax types, that is they are established and maintained by human activity.

Trees of the Euphorbiaceae often predominate in the secondary forest after extraction of timber species or following short term shifting cultivation. Belukar is the Malay name for such secondary forest. Endospermum and Sapium are commonly associated in disturbed and partly regenerated forest. The mahang group of trees, also Euphorbiaceae of the genera Mallotus and Macaranga, occur on fairly good soil after only one or two years shifting cultivation. This mahang stage probably gives way to Endospermum and Sapium. Mahang belukar is often preceded by either an association of wild plantains and gingers on the better soils or woody scrub of Trema (mendarong) small fig trees and related species on somewhat poorer soils.

On soils, which have been more severely degraded before abandonment, thickets of sendudok (Melastoma the so called Straits Rhododendron) and the scrambling fern resam are found. Eupatorium odoratum, called Siam weed in Malaya and Burma weed in Thailand as each country blames its neighbour, is a frequent foreign invader in this thicket. Various shrubs and trees may slowly take over and develop this thicket into poor forest if it remains free from fire. However, if the soil has been yet more thoroughly degraded before abandonment or fire repeatedly sweeps the area, other forms of belukar or lallang become established. Tetiup belukar, characterised by Adinandra dumosa of the Tea Family, predominates with resam on gravelly lateritic soils of impeded drainage, Gelam, as already noted, forms a fire climax on periodically inundated areas, especially where the water is brackish. The most widespread fire climax vegetation is lallang grassland consisting often of almost pure stands of Imperata cylindrica.

Bamboos are large woody grasses and form dense thickets after severe shifting cultivation or similar disturbance under a variety of conditions in the lowlands and especially in the foothills, so forming a transition type to hill vegetation among secondary associations. Like lallang, bamboos spread by underground

stems or rhizomes which forms a dense choking network. New shoots extend as fast as one foot (30 cm) per day and soon overtop tree seedlings, the fastest growing of which require two to three weeks to make the same height extension. After this rapid extension in height of the bamboo shoots, their foliage spreads out and shades tree seedlings, finally when the bamboo shoots fall they smother struggling saplings. Thus these bamboo thickets appear to be a very persistent artificial or biotic climax. In north west Malaya the White meranti-gerutu forest is the natural climax in this region where seasonal changes are more pronounced, but after shifting cultivation a Schima-bamboo forest or thicket takes over. Schima (changkoh in Malay) is a tree in the Tea Family like Adinandra. Schima, whose timber, Gegatal, has limited use, is about the only tree to be able to survive with bamboo, perhaps it manages to get in during the dry season.

Dipterocarpaceae predominate in lowland and some hill forests. Trees of the Leguminosae and Burseraceae are characteristic of certain types of lowland forest. Different families are typical of the mangroves. Similarly other families supply the main elements in secondary vegetation, for instance the Tea Family and the Euphorbiaceae. However, throughout the world the family most typical of derived and disturbed vegetation is the Gramineae consisting of woody members, the bamboos, and herbaceous forms, the grasses and the cereals selected from them for their grain. The savannas of the tropics and sub-tropics are grasslands or grasslands with inadequate trees to form a continuous forest canopy. The savannas are believed to have gained in extent at the expense of rain forest by the occurrence of fire and increased grazing by herbivorous animals, often assisted by human activity. Bamboo thicket and, above all, lallang grassland are examples of the Gramineae displacing with human aid the rain forest here in the heart of its natural range.

Lallang, curse and challange

Lallang, Imperata cylindrica, is found from the Cape of South Africa through Africa and Southern Asia to the islands of the Pacific. It is wind-pollinated and its prolific seed are air-borne also. Once established lallang spreads by underground rhizomes some distance below the soil surface. The erect shoots form a very thick stand. It is suspected that secretions from lallang suppress the growth of other plants, however, this is not proven, but the characteristics already described give lallang many advantages in competition with other plants. The responses of lallang to fire and to a lesser extent to grazing ensure its predominance over large areas for long periods. Green lallang will burn or smolder slowly, old lallang dried out during a drought spell burns fiercely, nevertheless the underground rhizomes are not killed. Seedlings of most other herbs and tree saplings of all but a few fire resistant species, such as gelam common only in limited areas, are destroyed when fire sweeps

through lallang. Fires may be started by lightning, but more often they are started by humans, either deliberately, say, to drive out wild pig or accidentally from cigarette ends, sparks from village fires, railway locomotives and so on.

Experience in rubber plantations and experimental plantings of tropical pines shows that lallang slows down the growth of trees, so that it is many years before the trees begin to shade-out the grass, even if the trees are not choked out beforehand. Such areas are usually neglected in any case and it is rare that there is effective fire prevention, thus fires will almost certainly occur before any planted or self-sown trees can assume any ascendency. A fire every three years is usually enough to ensure the indefinite dominance of lallang and annual fires are by no moans uncommon in lallang areas.

The detailed effects of lallang fires are unknown, indeed this is an urgent and important subject for study in the tropics. Judging by investigations in other kinds of vegetation elsewhere, it is certain that a large proportion of the nutrients, especially nitrogen, literally goes up in smoke, taking with it much potential litter and soil organic matter, which is so significant in the retention of mineral nutrients in the soil. With the loss of plant cover and organic matter in the top soil, accelerated physical erosion of the soil surface and leaching of nutrients from the site may be expected. Under lallang and a regime of periodic fires there is no prospect of soil improvement or of more beneficial secondary vegetation becoming established.

Neither wild nor domestic cattle nor sheep, goats and deer will graze coarse standing lallang. They will browse on the young shoots after a fire. Very careful management of the grazing pressure will enable the lallang to be eradicated and replaced by a sward of low grasses without development of the extreme bare soil condition. Unfortunately the deliberate management of lallang lands in this way, which should be followed by fertilisation to improve the new pasture, is very rare in South East Asia. This aspect too is worthy of study and careful extension work to implement the conclusions. Meanwhile existing knowledge is adequate to rehabilitate lallang lands and return them to profitable plantation agriculture by mean s of the judicious use of herbicides and fertilisers, The cost is about the same as felling and clearing new forest areas. The extra manuring costs are balanced by the land already being cleared of trees and free from root disease sources for example. As pressure on land increases in South East Asia there is need to give higher priority to the restoration of abandoned and neglected land, such as that covered by lallang, instead of clearing new virgin lands until the best use has been made of the areas already exploited.

This brief review of the main types of secondary vegetation, and a reminder of the extremely bare conditions which persist for so long after hydraulic open cast mining, serve to show that once the natural forest has been displaced by mining, permanent or shifting cultivation, there is no prospect of regenerating the original forest within a century or more. If all examples of a primary vegetation type are lost, it is certain as far as we can tell that it is lost for ever, because its components will not be available to participate in the slow re-growth. Therefore it is urgent to plan adequately now to save examples of every type of natural primary vegetation and to relieve the pressure on virgin lands by rehabilitating abandoned areas. This latter task is limited not so much by lack of knowledge, but by complications due to land ownership, leases and titles, and by lack of capital among poor smallholders and bankrupt companies.

Specialised Communities

These are the edaphic climax communities of limestone hills, quartz dykes and the unmetamorphosed sandstone outcrops, in which soil conditions overweigh the effects of altitude. As noted this specialisation with respect to soil due to the parent rock results in both an isolation from the more typical surrounding communities and at the same time provides a link crossing the altitudinal boundaries.

Sandstone and Mudstone Ridges and Plateaux

Until recently only one or two areas of these unmetamorphosed rocks were known, more thorough surveys have discovered more, even so they are one of the most restricted geological formations because igneous intrusion has been so widespread. Sandstone and mudstone were ancient alluvial soils or sedimentary deposits from primaeval seas and lakes, which have since been aggregated and compressed. They have been elevated in more recent geological history. Both are easily eroded, the more common sandstone is free draining whereas the mustones provide an impermeable layer covered by elevated swamp vegetation. Fossils are found in these rocks.

Under the more extreme conditions the forest is often low, little more than a scrub. As will be remarked for limestone, these sandstone hills are oases of rare species, relic flora confined to the few surviving representatives of their ancient and once more extensive habitat. The exceptional concentration of rare endemic species in these restricted areas give some encouragement that modestly small reserves, such as the virgin forest reserves, might preserve a significant proportion of our plant heritage if given adequate protection from uncrupulous collectors. The present protection of these areas derives from their relative inaccessibility and limited knowledge of their location. In future this must be drastically re-inforced by

legislation applied to the problem and enforced.

Quartz Ridges

The soil is shallow, sandy and often overlaid with a dry, acid, slow rotting peat. On this soil there grow several plants generally thought of as typically epiphytic, in particular some orchids and rhododendrons. The rhododendrons and other members of the heath family are often associated with mountains, yet they occur on quartz ridges at much lower elevations than they grow on mountains of granite rocks, for instance as low as 700 ft (210m) on a quartz ridge near Kuala Lumpur. Other interesting features are a predominance of species with strong Australian affinities, especially among the conifers, and of a few rarities found nowhere else. Festoons of lichen are common in places. These ecological and phytogeographic problems have long been recognised, but fully satisfactory explanations have not yet been advanced and further investigation is needed. These are ready made research topics for senior science students at school and university.

There is hardly any pressure on the quartz ridges for agricultural or industrial purposes. The main risks are to some of the smaller ridges if the surrounding area is cleared and their dry vegetation is exposed to fire. Several ridges are scenically beautiful and others provide fairly strenuous ridge walks. Thus they stand high on the list of amenities for recreation and aesthetic appreciation. The rarities on them may require some protection from greedy collectors. At first such protection must come by suitable legislation for national parks and nature reserves, but eventually this must come spontaneously from an educated and appreciative public.

Limestone

In every part of the world limestone hills have a flora characteristically different from that on other rock formations. This derives partly from the different chemical composition, almost pure carbonate of lime or of lime and magnesium, in contrast to the predominately siliceous nature of many other rock formations. As a result the primary soils from limestone are not acidic, although peat may form on top of limestone. Owing to its permeability limestone is strongly drained, which is accentuated in Malaysia by the steep rock faces of most of the limestone hills or karst towers. As the water drains downward it dissolves away the limestone resulting often in large hollows, in which the atmosphere is damp; moisture loving plants such as *Begonia* are found at the bottom of the large sink holes.

This variety of habitats, damp and dry, limestone rock and peaty soil, is largely responsible for the many plant species found on the limestone. The difference in the flora of the limestone hills from the surrounding areas is due mainly to the

chemical differences. Limestone was once more widespread in South East Asia, but much has been eroded away by ancient seas until the survivors from the old flora and invertebrate fauna are crowded on these island like outcrops. About one tenth of the species of flowering plants in Malaya occur on the limestone, and in turn at least a quarter of these are restricted to the limestone, that is about 2% of Malaya's flora is found nowhere else.

In the temperate regions there is a strong alpine element in much of the limestone vegetation, but in Malaysia the affinities seem to be with the lowlands but often of the drier or at least seasonally drier regions. This is probably true even in Sarawak where the twin peaks of Gunong Api and Gunong Benarat exceed 5,000 ft (1,500m), there is deep peat on their summits which supports a heath like vegetation with elements in common with the sandstone hills.

Within the limestone hills caves were hollowed out by the prehistoric streams as they flowed into the seas, which probably cut the steep cliffs and overhangs of the karst towers as they are now. These caves are of great archaeological significance in much of Malaya, and at Niah in Sarawak there is perhaps the most important prehistorical site yet found in S. E. Asia. In Borneo the swiflets which produce the edible bird's nests, a delicacy for many epicures, roost in the caves. There is interesting animal life in caves throughout Malaysia, which will be considered under threatened species. These caves go with the covering limestone domes and their rich vegetation. The hills are a striking and characteristic part of the landscape. These are all reasons for their preservation. Nevertheless many hills are being quarried away for their rock, simply because it is easily obtained. Workmen and mineral prospectors set the vegetation alight accidentally or deliberately. Planning which hills to save and which to exploit, and making use of the alternative sources of limestone exposed by hydraulic open cast mining, could save many of these unique features.

Hill and Montane Forests

There are no sharp altitudinal boundaries, but rather there are topographical distinctions, for instance the transition from the flanking slopes to a ridge top is often marked. Thus as the demarcation between lowland dipterocarp and hill dipterocarp forest is usually arbitrary, so is the upper limit of hill dipterocarp forest at 2,500 ft (750m), above which is upper dipterocarp forest. Floristically the upper limit of upper dipterocarp forest, where it passes into montane oak forest, is more distinct, even so the figure of 4,000 ft (1,200m) is a rough guide only. The same may be said of the montane ericaceous forest appearing at about 5,000 ft (l,500m). Where the montane oak and ericaceous forests are in the cloud belt, they are so rich in mosses as to be called mossy forest.

In general the nearer the coast, the more exposed, the more isolated or less the total height of a hill or mountain, the lower all these altitudinal zones appear. The steep lower slopes of some relatively small coastal hills have vegetation whose affinities are clearly with hill forest, although well below the 1,000 ft (300m) mark. When the 'steep land line' has been determined throughout the country, reference to it may resolve these anomalies resulting from the arbitrary classification. On the other hand these zones are found towards their higher limits in the sheltered valleys of the large central mountain ranges.

Mount Kinabalu in Sabah is the largest mountain between the outlying Himalayas and New Guinea. It is 13,455 ft (4040m) high. The foothills facing north-west are close to the coast. Moreover so large a mountain can but be unprotected in places. Thus the montane oak forest comes lower on the exposed side to 3,000 ft (900m) but does not appear until the usual 4,000 ft (1,200m) on the sheltered side. The montane oak forest also extends higher than usual in places to 5,500 ft (1,650m) or is mixed with ericaceous vegetation on some aspects upto 8,000 ft (2,400m) in response to the size factor. There is a band of dwarf oak forest at 9,500 - 10,000 ft (about 3,000m). This zonation is further complicated on Mount Kinabalu by the extensive intrusion of an edaphic climax on ultrabasic rocks, which outcrop at both medium (1,500 - 4,000 ft; 450 - 1,200m) and high (7,000 - 9,000 ft; 2,100 - 2,700m) levels. The ultrabasic rocks are so called because of their low silica content, however, they yield a rather acidic soil. Quartz ridges also occur at several levels.

Coastal Hill Forest

As indicated already, the nearer the coast and/or the steeper the slope, the lower the coastal hill forest descends. One form of it in West Malaysia is characterised by *balau laut* (*Shorea glauca*), which is a valuable heavy hardwood.

A type, which may be transitional between coastal hill, lowland and inland hill forest, is characterised by a mixture of *keruing* - *resak* - *mengkulang* (species of *Dipterocarpus*, *Vatica* and *Tarrietia*) all medium or heavy hardwoods.

Inland Hill Forest

the *balau* - *keruing* of forest is probably another transitional type, in this case between lowland and hill forest.

The true hill dipterocarp forest of the medium slopes is the *balau kumus* - *damar hitam* forest named after *Shorea laevis* and *S.multiflora*, which are heavy and light hardwoods respectively.

Ridge Forest

The lower ridges in Malaya are clothed with the smoky blue crowns of the emergent Shorea custisii or seraya, a fine light hardwood. Beneath them are the troublesome spiny, stemless palms of bertam (Euglissona triste) which are troublesome to travellers and in regeneration. On ridges on granite especially these two species are very common. On higher ridges in the hill zone and grading into the upper dipterocarp forest above occurs merpauh daun tebal (Swintonia spicifera), a fair medium hardwood, in almost pure stands.

Agathis alba, a conifer or softwood called damar minyak in Malay, occurs in quantity on some ridges, especially where there are shallow sandy soils. Perhaps it indicates a transition from these ridges of the hill zone to forests of higher zones and to the quartz ridge flora, with all of which it has affinities as well as indicating an Australian element.

The Future of Hill Forest

The hill forests are not so well known yet as the more heavily exploited lowland types. Owing to the mosaic of topographical effects it is not easy to define the limits and characteristics of the different types, which show many transitions. Nevertheless there are a number of commercially valuable timbers in the hill forests and, as the lowlands are exploited and converted to other land usages, the future of controlled and enriched natural regeneration forestry will lie increasingly in the hills. Control must be exercised not to work too large areas at once, because these forests are above the steep land line and in a zone of erosion risk even under managed forest.

The best methods of management must be discovered and meanwhile ample protected reserves are necessary to provide for re-seeding if required, these should be suitably sited to act as barriers against the spread of erosion or fire. Also it will be desirable to see how the animal life it is desired to conserve can adjust itself to the new conditions, various methods of management may be tried to help them to adapt successfully. In some cases, it will be necessary to try to maintain animals displaced from the lowlands as well as the original hill fauna. Vertebrate animals have proved very adaptable in some past cases, if given adequate protection during the transition and help in habitat modification. This may be the main range of the large cats in future as well as of Malayan forestry, so that these forests will have a double protective function for the land and the fauna.

Upper Dipterocarp Forest

In this region dipterocarps predominate among the emergent trees in most types of dryland forest upto about 4,000 ft (1,200m),

although the local upper limit varies as mentioned. Although the trees yielding the valuable timbers chengal, keruing kesat and merawan batu are found in this upper dipterocarp forest, the logs are usually smaller than those of similar hardwoods from the lowlands and their extraction is definitely more difficult. These are areas of even greater erosion risk and it would seem wiser to leave them out of even the mild, controlled exploitation planned for the hill forest zone in the strict sense.

There are local variants in this zone, probably due to edaphic conditions, for instance the thickets of the dwarf palm, Livistona, on Gunong Tahan. This vegetation also occurs lower down near the coast. The ridges in the upper dipterocarp forest have a dense pole forest, not unlike that found at lower elevations on sandstone and quartz ridges.

The secondary vegetation is not well known in Malaya, because fortunately there has not been extensive clearing at this elevation so far, Experience in Sabah, where shifting cultivation has frequently been practised as high as 4,000 ft (1,200m), shows that lallang and other coarse grasses may form a fire climax at least up to this level. Indeed secondary vegetation seems to be of broadly similar types throughout the zones of lowland, hill and upper dipterocarp forest; plantain and ginger thicket, mahang belukar, bamboo and lallang all occur according to the degree of disturbance. One of the wild batai trees of Derris related to the tuba plant is common when mild shifting cultivation is abandoned at the higher levels. A variety of ferns are often the pioneers in re-colonising soil exposed by natural landslips. The prospects of quick or easy rehabilitation of maltreated and neglected land in the hills are as bad or indeed worse than in the lowlands.

Montane Forests

Whereas the distinctions between the different altitudinal zones in dipterocarp forest are largely arbitrary, the montane forests are demarcated in that different families predominate and the transition in any given locality is often quite marked. The dipterocarps have few or no representatives.

Montane Ericaceous Forests

Although the floristic distinction between the montane ericaceous forest and the montane oak forest is quite distinct and often relatively abrupt, again the altitudinal level varies with locality, it is about 5,000 ft (l,800m) in Malaya. It occurs lower on exposed ridges and shares some elements in common with the vegetation of the quartz ridges in the lowlands. On the other hand on Mount Kinabalu the ericaceous species, Rhododendron and Vaccinium, do not assume their characteristic predominant role until much higher 11,000 ft (3,300m), although some species are present lower down, especially in the cloud or mossy zone 5,500 - 9,500 ft (1,650 - 2,850m).

This ericaceous forest consists of low, twisted and gnarled trees. In the cloud belt they are often loaded with mosses forming peat hags on the branches, this occurs also in montane oak forest in zones where the mists hang. Such forest has no commercial value, yet is is the keystone of a conservation pyramid reaching down to the lowlands, which are protected by the controls exercised at higher levels.

Alpine Zone

Apart from some open heath and grassland on the summit of the highest mountain in Malaya - Gunong Tahan - the only vegetation which qualifies as alpine is that on Malaysia's highest peak Mount Kinabalu. Above the tree line at 12,000 ft (3,600m) the vegetation has many structural and floristic afinities with that of the temperate alpine or sub-polar regions, for instance a Buttercup, a Cinque-foil, a Meadow-grass and a Hair-grass. Since the southern element is strong, sub-antarctic might be a more appropriate name than sub-arctic. Much of the vegetation is hidden in hollows or cracks between the rocks, or at least gains its first foothold there. Grasses, mosses, ferns and prostrate ericaceous shrubs are among the more frequent.

This vegetation is in no danger from exploitation, except by tourists and naturalists who collect too many plants for which they have no proper use. The highest peaks in Malaya and Sabah, West and East Malaysia, are within the respective National Parks, Consideration must be given to means of making the National Parks safe against ignorant and careless or greedy and inconsiderate visitors. This legal protection should extend also against changes in alienation and other encroachments. National Parks have a role in the conservation of threatened species, which can be coordinated with tourist interest. Before bringing these ideas together consideration must be given to what species are in danger and how this too can be coordinated with overall plans.

CHAPTER FIVE

THREATENED SPECIES

As an average, one mammal and one bird species have become extinct somewhere in the world each year during the last fifty years. This is not a response to some change in climatic conditions or due to displacement by more advanced species of the same group in a process of natural evolution. This is a direct response to human technological developments enabling man to change the face of the earth and to kill on a greater scale than ever before. The desire of making for a more comfortable existence as such is trivial compared with the urgency created by the increase in human population, largely ill nourished and malcontented, consequent on advances in public hygiene.

The extremely slow, imponderable forces of evolution have produced the universe, our planet and life upon it as we know it. In this slow process some forms of life have become extinct, but meanwhile during the same long duration of time others have evolved, succeeded and replaced them. The impact of mankind has been largely towards destruction and extinction of species without producing a commensurate number of new forms capable of independent survival. His crop plants and domestic animals seldom run wild, they need complicated protection, but he does make it possible for existing species to run riot as weeds and pests. Therefore the suggestion, that mankind's present activities threatening the survival of so many species, including the human, on this Earth are merely an acceleration of a natural or divine process, is impious, conceited or foolish according to your philosophy.

The Threats

The threats to living species fall into two main categories:- i) the indirect, by destruction of the habitat or natural environment in which it lives, and, ii) the direct, by killing it before it can adequately reproduce itself, in order to eat it or to use some part of it or to keep or display it; unfortunately for the animal victims in particular, although this happens to plants too, the killing is not always immediate but includes keeping in captivity or trying to cultivate under unsuitable conditions.

The relative seriousness of these threats varies with each case. In general plants are most seriously threatened by habitat destruction. Plants cannot flee into another area. Although some have means of dispersal equivalent to legs and wings, there is no place for them to go. A plant occupies a particular niche or habitat because it is adapted to the conditions which occur there, the surrounding areas with different characteristic plants have different conditions; if a plant tries

to invade these areas - and it is indeed constantly trying to spread even if its habitat is not threatened - then it cannot because the space is already occupied by other plants better adapted to the conditions prevailing there. It may sound ridiculous to regard the dipterocarps or any major section among them or even a single species as threatened, because this family of valuable timber trees is characteristic of forest covering thousands of square miles. Yet it is quite possible for every part of the range of a species or of several species to be alienated for agriculture especially in the lowlands, because so much of the best forest grows on the best land.

Some orchids are threatened by habitat destruction, for instance those on limestone, but often over-collection is an equal or greater risk. So many cannot resist the temptation to pick a flower or take a whole plant, because it is beautiful or rare. Often there is some misguided, vague idea that it will be possible to preserve it in cultivation and that in fact something is being done for conservation. In fact many plants so collected are forgotten, found shrivelled and withered at the end of the journey and thrown out. The cultivation of rarities is a job for experts, who are not necessarily professionals but are at least those with knowledge, time, patience, interest and reasonable facilities. If there is success in growing, it should be followed by multiplication and distribution. Even if the collection is for study, it must not threaten the existence of the species for other students in later generations. Some collectors say they never take more than half what they find, three such collectors in quick succession will decimate a population. Courses in natural history in schools, in biology at the universities and in wildlife management in the forest and game departments should include instruction on how to collect specimens, especially how to take sufficient suitable material to effect identification without unnecessary excess or damage to the species' survival. If students are trained to make full notes on every specimen, including the purpose of collection, as a routine, this increases the value of the specimens taken and discourages wanton, wasteful collection.

These arguments apply to animals also. Habitat destruction reduces the range available to many animals and some invertebrates in particular may have very special requirements. Nevertheless there are good prospects of many animals being able to move physically and to survive in their new homes, especially if, to assist them in adaptation, some management is applied to the reception area, which must now carry a higher stocking or attain a new equilibrium between the invading and resident species.

Over-collection by naturalists threatens a number of rare species, in particular the cave fauna where the living fossil trap-door spiders have caught the imagination of the unthinking. The suppliers of specimens threaten the giant toad, if not with

extinction at least with artificial pressure towards the smaller size classes and a modification of its relationship with other species. The cone shells are disappearing from the reefs to become dead bric-a-brac. The reptiles and the big cats lose their lives and their skins to decorate society's expensive women. The collection of live specimens for medical research, zoological gardens, circuses and as picturesque pets is accompanied by an appalling casualty rate. Often ten or more deaths in capture or transit for every one which reaches its destination, and that destination is usually a dead end too as far as mating, breeding and maintaining the species is concerned. There is a minority of zoos which are trying to care for and breed rare animals, there should be more, but for the greater part this traffic in live animals is a cruel and pointless inroad on the world's wildlife.

The Hungry

Turning from these instigators of over-collection of live and dead animals, it is almost a relief to consider the problems of those who kill or make the first capture because they are in need. They may need money to buy food, clothing, fuel and shelter for their families. Often they kill simply to eat in response to the primitive hunger for protein. Protein deficiency is a painful fact of existence for half the world's population. At first it seems impossible to conserve wildlife in the face of such a problem.

Nevertheless there are examples of how a species has been preserved in greater numbers than before and at the same time a greater recurrent crop of food has been taken from it, when this is planned and controlled. Wherever this can be demonstrated to the hungry man, there is a reasonable chance that he will cooperate in conserving this resource for himself and posterity. Perhaps the prospects of educating the greedy, sophisticated exploiters of wildlife and obtaining their cooperation are more remote than getting the understanding and cooperation of, the man whose main problem is a fundamental need to eat. However, we can but try to cure the problem of the man on the ground, and hope that this cuts off the supply to the greedy middleman and luxury users.

Stocking

This is the first of several simple concepts which can be applied to wildlife management. Alone it is significant, but in practice it must be combined with others for the maximum advantage. The principle of stocking is simply that a given area of land vegetation or volume of water under relatively stable conditions can support a certain mass of animal life. It follows that if one attempts to support a larger mass of animal life without a drastic modification of the conditions, then part of the animal mass, that is some of the animals, must either move out of the area or remain there, starve and eventually die.

The principle of stocking does not define whether the animals are all of one species or of different species. It does not define the distribution of age, size or sex classes within the population or rather mass (weight) of animals concerned. The principle of stocking requires only that a certain total weight of animals should not be exceeded under given conditions, this applies as much to fish in water as animals on land. This total weight could be made up of a few, large, old, isolated, no longer reproductive individuals, or of many, small, young, over-crowded, competitive, not yet reproductive individuals, or it could consist of a balanced population of all categories. If the last is achieved, instead of waiting for the old animals to die naturally after perhaps occupying space without reproducing for some years, some of the animals past their reproductive prime could be culled for food. Similarly a proportion of the young might be taken before they were ousted by the more vigorous or fell victim to predators or disease.

Such culling or cropping of wildlife, usually of pig, deer or wild cattle, may compete with the big cats and other animals it is desired to conserve. This probably forces a similar adjustment in their stocking, namely that if culling eliminates the old and ineffectual among the prey, only the fittest among the predators will survive also. Thus without altering the overall stocking it is possible to have more active breeding animals and take a culling to provide protein for human consumption.

Management

The culling by hunting for meat of game as it approaches or exceeds the limit of stocking is an obvious form of management, once the principle of stocking is appreciated. When a new equilibrium has been attained, the animal population will consist of breeding animals and their young, a proportion of which can be taken as a regular crop. Of necessity this taking of game is by shooting, which is regarded by professional hunters as an occupation and by amateurs as a Sport. The hunting of game as a sport is criticised by some on humanitarian or ethical grounds. However, only the practising vegetarian has a case. The journey to the abattoir and the butchering of domestic animals is still far from humane in the fullest sense of the word, it is simply conveniently delegated to others and kept from public sight in most cases.

The management of game by regulated hunting means that the animals have one more predator among many. Man as a predator has the power to kill discriminately and so to preserve an ideal proportion of age groups in the game population and thus foster its survival. The hunt itself taxes human endurance and ingenuity, moreover people are often prepared to pay for the privilege. We no longer pretend that animals enjoy being hunted

either by us or by natural predators, but we do not pretend - although we like to forget - that many domestic animals spend their last hours waiting in line for death with the blood of their own kind constantly in their nostrils. Hunting by shooting with appropriate weapons has a place in the management of wildlife for their survival.

Related aspects of management concern determining the best time to carry out culling. Usually it is best not to disturb the animals while the young are still tender. Where there is a seasonal climate, it is often best to cull before the adverse season. At the end of the favourable season the stocking is at a maximum and will fall during the adverse season. The difference in stocking between the good and the lean season is realised in nature by death of the excess animals. They can be taken as crop at the end of the favourable season. The adverse season in Malaysia is usually the dry spell in the fore-year. However, such procedures should not be applied on a large scale until they have been proved by suitable experiments.

In temperate regions the traditional duties of gamekeepers in charge of raising birds for shooting are to protect the game birds by destroying natural predators or so called vermin, especially during the nesting season, to feed the birds during bad spells, to modify conditions as believed to be beneficial, for example to burn old heather, and to keep away unauthorised hunters or poachers. Wild life conservators may have to carry out similar tasks for animals in Malaysia. Hatcheries are very important in turtle conservation. Modern concepts are less harsh on natural predators, because these are part of the natural control system of stocking, and many are threatened species themselves. Habitat modificatior in order to increase the stocking capacity is often necessary, although less dangerous means than fire are recommended. Poachers must be rigorously excluded, not just because they are thieves or dodging payment of revenue to the government, but because their activities can jeopardise the entire plan to maintain the correct stocking and age structure of the population.

Habitat Modification

Animals have several different requirements, the most obvious is suitable food, including water and adequate salt in the diet or access to salt licks. Under natural conditions an animal may not get most of its food, water and salts, all in the same place, but may browse or hunt in one place, drink in another and visit salt licks elsewhere. Serow are strangely attracted to limestone; hills although they roam far over the granite too, perhaps they need to eat lime rich plants occasionally.

Animals also need various kinds of 'cover'. Many cattle, especially water buffaloes, have poor heat tolerance and they need

access to water for bathing as well as drinking, or they need shade from the heat of the sun. Primates on the other hand are susceptible to chill, especially those like the orang-utan with rather thin hair. Thus their sleeping cover must be warm as well as hidden from their enemies. Protective cover is most important during the breeding season and the requirements are often more stringent than cover for mere sleeping or resting. A bird's nest is breeding cover, which it constructs for itself; however, both a suitable site and appropriate materials are needed.

Often an area would be able to carry a heavier stocking or to carry more species, if some lacking factor was supplied or developed by modification of the habitat. If the vegetation is slashed occasionally to produce more grass or undershrub, a considerable improvement in herbivore stocking and consequently of predators may be achieved. It is probably best to rotate the portions treated in this way over the larger area available, so that they can undergo natural restoration of soil fertility by forest regeneration like mild shifting cultivation. Also the regenerating thickets may provide suitable cover for some purposes. In cases it may be necessary to plant shade trees. The provision of water by diverting streams or the creation of artificial salt licks are now well known aids to management. These artificial devices may be located where the game warden or wildlife conservator chooses. This may be in some protected place away from likely disturbance or poachers.

The treatment of regenerating productive forest is habitat modification on a very large scale. Treated forest, especially if the old trees have been poisoned, is rich in secondary growth species, which seeems to figure largely in the diet of some wildlife in particular large herbivores. Thus these areas may be able to carry a larger stocking of wildlife than before. Of course a tree poison less attractive and less toxic to wildlife than sodium arsenite is an even more urgent necessity in these circumstances. Since there seems to be less difference with altitude in the nature of secondary vegetation than in the type of primary forest, it may be possible for some animal species to extend their range up into regenerating hill forest. This is not known yet and more investigation is needed.

The tree top animals may lose their habitat in the earlier stages of forest regeneration and treatment after timber extraction. This danger may be reduced if the forest is worked as a mosaic of different stages of regeneration. This may not appear to be the most efficient use of timber extraction trails and similar facilities, because loggers prefer to open the minimum mileage, remove all the timber they can and then abandon these tracks. In future it may be better to preserve a network of roads for easy access by forest officers, game wardens and other conservators of wildlife to manage the forest and game animals within it. A mosaic of forest compartments in different stages

may be less prone to erosion, fire hazard and other risks than a large tract all at the same stage. A mosaic may provide the right conditions for animals which require different types of cover and feeding grounds. At present there is too little knowledge about the needs of wild-life and a mosaic pattern has a better chance of supplying these than a uniform system.

Animals on the Danger List

In every part of the world certain species are in great danger of extinction. Every year fewer live specimens are reported. The few survivors are broken up into smaller and smaller groups, less and less able to defend themselves, separated by large areas of land alienated to other purposes which they cannot traverse for lack of suitable food and cover, or which it is too dangerous for them to venture into, thus these small isolated colonies cease to maintain themselves as adequate breeding populations.

This stage may not be recognised or, even if it is, no action may be taken. When a species is in this condition, it may linger on for a few years, but it is often too late already. Just when a move is made to rescue the last survivors, it is found that the species is already extinct. There are animals in that condition in Malaysia. The more important will be reviewed from the sea through the reefs and beaches to the forests and hills.

Dugong

The sea-cows are a group of mammals which live entirely in the sea. The sea-cows browse on green seaweeds in shallow coastal waters. The Dugong is the representative of the sea-cows in South East Asia. It is so fully adapted to life in the sea that if it is stranded on the shore, it cannot get back into the sea without assistance and will starve to death unless killed for its meat.

Dugong may get caught in fishermen's nets or in fish traps, where they drown if not brought to the surface soon, because they are mammals and must breathe air. If they do not drown the fishermen usually kill them, mainly because the meat is good to eat, but also because the Dugong may damage the nets or are mistakenly believed to feed on fish and reduce the catch, which is quite wrong. The various improvements in sea fishing, powered boats and larger nets, may account for the apparent decline in numbers. 50 years ago their meat was said to be quite commonly sold in Malaya and Singapore, but the last specimen dead or alive in these waters was a decayed one nearly 20 years ago. There seems to have been a similar decline along the coast of Sarawak, previously various personal ornaments were made from the tusks, which only the male bears, but now these are no longer

obtainable. Only on the East Coast of Sabah do Dugong still seem to be fairly plentiful, although most reports are of animals taken in nets and traps.

It is difficult to suggest measures likely to be effective in saving free ranging marine mammals prone to accidental drowning in fish traps and nets, even if it was possible to prevent deliberate killing of captured animals by enforcement of legislation for protection (which does not exist on the statute books of most countries in the region). Here is a problem in which the skin-divers may help. The sub-aquarists have been criticised for over-collection of shells, but here is a way in which they may help to redeem their reputation among conservationists. Very little is known about the Dugong, there are only vague indications about its feeding and cover requirements. Skin-divers have reported animals which may be Dugong. If they can confirm this and follow it up by discovering the favourite feeding grounds and more of its natural history, then it may be possible to declare submarine nature reserves in the most suitable areas. The reserves or underwater parks must be kept free of fouling and there should be no fishing by net or trap in the vicinity. The Dugong should be afforded legal protection against deliberate killing throughout their range. If rescued from the brink of extinction, it might one day be possible to use Dugong in the better ordered cropping of the sea, which is still one of the most extensive natural resources hardly exploited in a rational manner.

Coral and Shell

The corals belong to the same group of animals as the jelly-fish and sea-anemones; both the latter are soft bodied. The familiar jelly fish float in the sea but the sea-anemones are sedentary. The corals are also soft bodied and sedentary, but they secrete calcium carbonate around and beneath themselves, so that it forms a hard shell or external skeleton. Only the topmost layer of a large coral reef is living, the greater part below consists of the accumulated shells of old dead organisms. The various patterns the coral assumes are due to the ways in which the organisms lay down their shells and are positioned in relation to each other. Coral requires warm water and sunshine.

The common sea shells are the outer coverings of molluscs, for instance cockles, mussels, oysters and snails. Among the most attractive shells are the cowries and the cones. Some of these attract high prices. As a result skin-divers collect them in large numbers and have almost wiped out the more beautiful in easily accessible places. Coral is also collected. Perhaps this over-collection is unlikely to cause any but the rarest species or those whose natural distribution is limited to easily accessible places to become extinct, these certainly are at risk.

However, it is bad enough that these animals can no longer be seen alive in those parts of the sea most accessible to the sub-aquarist of average ability or the Tourist for whom glass bottomed boats may be provided.

Only a small proportion of these underwater trophies are taken for scientific study or are lodged in zoological museums. The majority are sold commercially, others are kept as personal momentos of the collector's prowess. As the accessible reefs are stripped, so many sub-aquarists recognise this as a challenge to assault the more difficult. Many of the coral reefs in Malaysian waters are separated by mangrove; those in the adjacent open seas are relatively isolated, as for example those near the Langkawi, Sembilan, Perhentian and Tioman groups. The sea currents are not very strong in the South China Sea and are even weaker in the sheltered Straits of Malacca, as a result eggs and larvae of the reef organisms, including coral and molluscs are not easily carried by the sea from undisturbed reefs to those which have been denuded of all their fully grown breeding stock. The members of the Malayan Sub-Aqua Club have voluntarily agreed to stop trophy hunting on certain islands. Their public spirited action should be re-inforced by implemented legislation to prevent other non-participants in this agreement from greedily undoing this good beginning.

These are not the only threats to the reefs. Fishermen have sometimes used dynamite to kill and take large fish hiding in the coral, which would cut their nets if conventional methods were used. Coral has been blasted also for limestone where other sources are limited. Near the port of Singapore many reefs have been polluted by oil and industrial wastes, others have been silted up by dredging operations or with material carried down by rivers from areas of soil erosion. Reef organisms are very sensitive to silt and toxic chemicals. This is most common near ports, which are being developed throughout Malaysia. If soil erosion, production of industrial effluent or the use of pesticides is extensive upstream, large rivers may be a source of pollution of the inshore reefs, shell beaches and other marine fringe habitats.

A coral reef is sometimes the front line barrier against the sea, we do not know what may be the consequences of its loss. The reefs harbour fish, which might otherwise be caught or trapped in such large numbers that they would no longer survive unless they had these refuges, but what if these naturally protected places are broken open and destroyed? Skin-diving is a growing sport for local visitors and for tourists. There is much that is spectacular to be seen. There is much to be learned about the biology of reef and shore life. Underwater photography, fish tagging, turtle and dugong reporting, coral and shell inventories are the sub-aquatic equivalent of bird-watching and are perhps even more exciting, interesting and rewarding. These

are the alternatives to hunting and collecting. These are all reasons for the conservation of adequate representatives in submarine nature reserves.

Turtles

Turtles are shelled reptiles of the zoological order Chelonia. They can be divided into (i) the true Turtles which spend their lives in the sea or freshwater, except when the females come on land to lay their eggs, their limbs are converted into flippers, (ii) the Tortoises which live on land and whose feet are clawed, and (iii) the Terrapins which are equally at home on land or in the water, often living along river banks. In all three groups there are vegetarian and flesh eating species. The vegetarians provide the choicest flesh. Some of the flesh eating and especially the carrion feeders are dangerous to eat owing to toxicity. The eggs of all species are edible.

Marine Turtles

Five species are known in Malaysian waters. The Loggerhead Turtle is sometimes found, but it does not seem to breed on Malaysian coasts. The Hawksbill Turtle does not seem to breed here either. Both the Loggerhead and Hawksbill are carnivorous feeders on fish, molluscs and crustaceans such as crabs and prawns, neither is taken for its flesh and since it does not lay its eggs on our shores in quantity if at all, protection of the species must lie in other hands. The Hawksbill is the source of commercial tortoise - shell and some animals are killed to obtain it. The invention of many more serviceable substitutes may reduce pressure on this species.

The Pacific Ridley Turtle is the smallest and most agile - at least on land - of the marine turtles of Malaysian waters. It probably eats most food, seaweeds, shellfish and carrion, at any rate there does not seem to be any demand for its meat. The eggs are small. The nests are shallow and easily uncovered by dogs as well as humans. However, the nests are widely scattered both in range and on individual beaches. Its agility enables it to travel as far inland as the sand extends and it makes its nest in both hard and soft sand. Nests have been reported from widely separated sandy shores of all coasts of Malaysia. This makes it difficult to collect the eggs and place them in hatcheries, but it also means that collecting the eggs to eat or sell is correspondingly unrewarding, especially as the eggs are small. Therefore it is not easy to do much for the Ridley, but it may be less acutely threatened, even so the numbers seem small.

Philosophy of Marine Turtle Conservation

The female turtle comes ashore and digs a hole on a sandy beach above the usual high tide level. She deposits a clutch of eggs in the hole and then covers over the nest and returns to the sea.. Some two months later the eggs hatch and the young hatchlings scramble up through the sand, make their way down the beach and into the sea. Humans may collect the eggs for eating as they are laid. The hatchlings run the gauntlet of crabs, dogs and seabirds as they make their way down the beach. In the water they are preyed upon by sharks and other carnivores and by seabirds if they swim near the surface. They are more agile in the water than on the beach, even so predation must be severe. Cluthches of 50 to 100 eggs are laid, each female probably lays several clutches in a season. Thus quite large numbers of eggs are laid to allow for the many natural losses if the population is to be maintained.

Not all beaches are suitable for turtles to lay their eggs. Firstly they are confined to the warmer regions because the eggs are left to incubate at ambient temperature, unlike a bird sitting on its nest. The turtles cannot dig through sand which contains too much gravel and pebble. The nest must be high enough above high water mark not to be flooded, however, on many beaches sufficiently high sites are too far up for the larger turtles to reach them, especially if the beach slopes steeply. Also these high sites may have too many tree roots liable to prevent the turtle digging a hole with its rear flippers.

Nevertheless there are many beaches which appear suitable, but turtles never come to them. Some beaches used to be visited regularly by turtles, but all the eggs were collected year after year and/or the females were slaughtered for their meat, now no turtles visit them although the species concerned are not yet extinct throughout the world. This suggests that the turtles return to lay their eggs at the place where they hatched. This has been demonstrated in various migrant fishes and birds by respectively tagging fins or fixing numbered aluminium bands on the legs of the birds. It is very difficult to mark turtles by these methods, because the hatchling may increase two to ten thousandfold in bulk before it returns as a laying mother.

Therefore, if human activity either renders the beach concerned unsuitable as an egg laying site, or destroys the population of turtles either as adults which return to the beach or as eggs whose hatchlings would return to the beach, that site is lost for ever as a breeding ground. The only exceptions are that, provided the beach is still suitable, some female turtles stray in and are better treated than their forebears, or clutches are transported to the beach to re-establish nests whose hatchlings enter the sea from that site. The former does not seem to happen, there are still too many hungry people waiting on shore for the

stray, and the latter does not seem to have been tried.

The philosophy of turtle conservation has the following elements. Firstly to protect the female adults coming ashore to lay their eggs. Next to collect the eggs and to save a proportion of them for a protected hatchery, allowing the remainder - usually the majority where there are enough - to be sold for human consumption, this latter retains the sympathy and interest of the local people who would otherwise eat all without thought for the future. The proportion of eggs saved are transplanted to a hatchery of artificial nests. Ideally the hatchery should be in the most suitable part of the beach so that on the average the nests do better than if left to nature. Work is going on also to determine the optimum clutch size in a nest, so that clutches which are too large can be divided or too small clutches can be combined in one nest. The hatcheries are protected from terrestrial and avian predators.

When the hatchlings emerge, they must be conveyed to the sea with the least risk of loss, but also with the best chance of return. There are many arguments about how they should be done. There are three main methods employed.

(1) To allow the hatchlings to make their own way down the beach to the sea immediately after hatching, the only difference from nature being the presence of the hatchery supervisors to keep away predators.
(2) To transfer the newly emerged hatchlings directly from the hatchery to deep water offshore.
(3) To keep the hatchlirgs in pools until their yolk sacs are absorbed, providing artificial food such as grass clippings during the meanwhile, and then taking them out to deep seawater. Supporters of this method claim that the hatchling without its yolk sac is far more agile and able to evade its predators. Against this skin-divers have observed that hatchlings with yolk sacs are still remarkably agile.

The author should declare his opinion, which is that method (1), the hatchlings scrambling down the beach under protection should be adopted as the nearest approach to nature until one of the other methods is proved better. Proof will only come when, either we can mark the animals suitably and compare returns after release by the different[1] methods, or different methods are tested over a period of ten or more years on otherwise comparable sites, the latter unfortunately being in short supply.

Those who study animal behaviour speak of imprinting, which means that certain specific actions early in life will determine other specific actions later in life. If we are right that turtles 'home' to the beach where they hatched, we have a case

of imprinting, hatching in a place seems to determine returning to the same site to lay eggs. However, the imprinting may be more crucial than that. It is seriously suggested that unless the young hatchling moves down the beach of itself as guided by obscure, instinctive forces, the female will not make the full return trip up the beach to lay her eggs. Perhaps she will discharge her eggs at sea if the need to come ashore above the high tide mark has not been imprinted on her by making the journey down the beach. We do not know, until we do perhaps it would be best to follow nature as closely as possible. Young hatchlings crowd on the seaward side of enclosed hatcheries after emergence. By instinct, imprinting, heredity, whatever term is chosen, they have the urge to return to the sea whence their mother came. If it is at all likely that eventually she, the adult from the female hatchling, will observe the same in reverse, than we must prefer method 1 to methods 2 and 3. Method 3 has the further disadvantages that while the hatchlings remain in a nursery losing their yolk sacs, a debatable advantage, they not only become progressively separated from any chance of imprinting but become adapted to an artificial diet. The main turtle conservation programmes in Malaysia will now be reviewed.

The Green Turtle

The adult Green Turtle, *Chelone mydas*, is a vegetarian. Its flesh is the traditional constituent of turtle soup. Its eggs are edible like all other turtles' eggs. It is under constant pressure, including open sea hunting of the adults by power boats and excessive collection of the eggs for food. At present it has a wide range of nesting sites on island and reef-protected beaches around the South China Sea and to a lesser extent in the Indian Ocean. In Malaysia the major breeding colonies are in the northern part of the east coast of Malaya and on the turtle islands of Sarawak. The turtle conservation programme of longest standing in the region is that in Sarawak for the preservation of the Green Turtle which was initiated by the Sarawak Museum and continued by a Turtle Board. The numbers of turtles have continued to decline, which may be due to excessive open sea fishing with large nets by firms operating power boats from distant countries, or to the initial choice of method (3) above as the mode of release. More recent programmes in Kelantan use Method 2. If the wrong method of release is being used, the conservation programmes may be ensuring the extinction of the animal, because the majority of the eggs are either eaten or the hatchlings from the rest may never return to lay. Until Green Turtles are re-established, the taking of them for meat should be discouraged by international agreement.

Leathery Turtles

These are the largest marine turtles and differ in that the shell is leathery instead of consisting of 'tortoise-shell' plates. Luth is the common name and Dermochelys coriacea is the scientific name. The Luth is carnivorous or perhaps a scavenger. Poisoning of humans eating its flesh has been reported. It is not normally taken for food. It used to nest in the West Indies, in Ceylon, in New Guinea and at various places on the Thai and Malay peninsula. The only large breeding site known today is that near Dungun on the east coast of Malaya. Until about 1950 there was no metalled road connecting this part of Malaya with the rest and it was not until 1964 that the last of the ferries was replaced by a bridge. Hence information has been lacking owing to isolation.

The village elders claim that 50 years ago many more Luth came ashore at Rantau Abang to lay their eggs and that the population has declined. This would bo in accord with experience elsewhere. The villagers admit that they have been collecting turtles' eggs for as long as they can remember. Since 1947 those collecting eggs have been licensed and paid the government fees upto $25,000 (Malayan currency) per year. From the cost of eggs in the market it can be reckoned that during the years when high fees were paid at least 300,000 eggs must be collected to pay for the licenses alone, which is a third to a half of the probable total of eggs laid each year. The inference is that the licencees collect every egg to make a living. In 1951 the Turtles Enactment was extended to the State of Trengganu, but the purpose of this seems to have been to regularise the collection of the license fees by the government and not to afford any greater protection to the animal.

In 1952 a zoologist identified the turtles of Rantau Abang as the Luth and published a report suggesting that since egg collection was local there was no risk. Collection could only be local, because nearly all the Luth are concentrated on seven and a half miles of beach. To the north the sand spits run northward and to the south southward, this seems to be the stable centre of the beach system. The slope is not too steep for those large turtles. Following this report on the Luth's egg laying, but without any emphasis on the virtually total egg collection in progress, further popular accounts appeared in the illustrated press. These and the opening up of the east coast road brought tourists in large numbers, many of whom rode on the turtles' backs and frightened them and prevented them from laying their eggs.

Since 1961 a hatchery has been in operation under the aegis of the Fisheries Department and the Trengganu State Government at Rantau Abang. The scheme was initiated by the Malayan Nature

Society and the University of Malaya; zoologists from the latter are studying optimum clutch size, the siting of the hatchery and mode of release. Release method 2 is used, however, if there is no evidence of Luth returning in quantity soon a change may be made. During the first five years over 50,000 eggs were transplanted and more than half of these have produced hatchlings which were released at sea.

The tourists have also been brought under a measure of control by the issue of leaflets instructing them how best to observe the turtles and warning them that it is an offence to disturb the turtles. The bulk of the eggs, 99%, are still consumed as food and provide 50 tons of first grade protein each year, the annual requirement of 2,000 people. If the hatchery technique and the relase method can be improved and the effectiveness of the entire operation demonstrated, then the following will have been achieved:-

1. A rare species will have been saved from extinction.

2. Protein will have been provided for those who need it.

3. Tourists will have been provided with a fascinating spectacle.

4. Government will obtain revenue from licenses and tourism.

It will then be time to consider transplanting clutches by air to the beaches which used to have breeding turtles in other countries. There is no reason why other countries should not re-establish their turtles and operate them in a similar way. The world survival of Luth depends on one beach in Trengganu at present. If some natural disaster such as a tidal wave swept away that beach or the development of the Malayan east coast brought in fouling with oil by shipping, then habitat destruction would have overtaken excessive collection in forcing the Luth into extinction. Therefore the old breeding sites should be revived so that the risks are more widely spread.

Freshwater Turtles

The most common freshwater turtle in Malaysia is the Mud Turtle, *Trionyx cartilagineus*, of the soft-shelled turtle family. It is widely distributed in swamps and in slow flowing rivers. The eggs are rather small and are not much sought after. The flesh is sometimes eaten. It does not seem to be seriously threatened, partly because it is widespread, partly because there is no great demand for the flesh or eggs compared with other species, and finally because it can inflict a severe bite.

The Mud Turtle lies in the mud waiting for fish and frogs to come within range, when its head shoots out on its long neck and seizes its prey. If disturbed by humans or dogs it usually

withdraws its head and then suddenly extend it to give a heavy snap of its powerful jaws. The long flexible neck enables it to reach back almost as far as its rear limbs.

River Terrapin

The Malay name Tuntong is applied to all the larger river terrapins, but the main species is Batagur baska. The largest nesting area is on sand bars between 40 to 60 miles up the Perak River. The number of eggs laid each year has fallen drastically from nearly half a million 30 years ago to only one twentieth of that number most years now and some years there are even less. The eggs are fairly large with a harder shell than the marine-turtles', the flavour is the most highly prized of all. According to law only licenced egg collection is allowed. The licencee is allowed to keep one third of the eggs collected for his own use or for sale, one third are sent to the Sultan and one third are to be re-buried in a hatchery. The hatchery is meant to be guarded and the hatchlings should be reared until they are large enough to be safely released. The licencees can claim refund for green vegetables purchased to feed the young hatchlings.

Despite this legislation, of which the original dates from 1915 and the earlier protection of the river terrapins as a royal preserve, the population has declined severely. There are several reasons for this. There are many poachers who steal the eggs from the licenced areas and never place any in a hatchery. It is also dubious if all the licencees are conscientious in their duties concerning saving one third of the eggs for the hatchery or in operating it properly. Also the licencees are ordinary village folk and may not know how to run a hatchery, by selecting a convenient site they may choose one which is unsuitable due perhaps to water logging. The young hatchlings are easy prey and need protection from the sun also. The method of release required by law, rearing the hatchlings until they have grown is similar to method 3 for the marine turtles, although after rearing the terrapin hatchlings are sometimes allowed to scramble into the river instead of being carried out to deep water.

Therefore the pioneer legislation on turtle conservation in Malaysia is probably failing for two. main reasons. Firstly it is not being properly observed and enforcement is necessary. Secondly there is doubt if the hatchery methods enjoined by the law are the best, either to ensure that the clutches are re-buried in the most suitable manner in well sited hatcheries, or that the method of release is biologically sound to cause the females to return to lay. The Game Department is endeavouring to enforce the law and to carry out the much needed research to improve hatchery technique for the river terrapin, however, the resources which can be devoted to this are slender and still inadequate. More public support is needed.

There are about ten other species of terrapins in Malaysia, which seem to be spread widely throughout the rivers of the region. Very little is known about their status. Perhaps they are not seriously threatened because their nesting sites are too widely scattered for systematic egg collection.

Land Tortoises

There are three species of land tortoise in Malaya, none of which seems to be seriously threatened, although only one is common. They live in hill forest and are free from egg collection or molestation at present.

Crocodiles

The estuarine crocodile is a large carnivore of mangrove swamps, the lower reaches of rivers, some inland lakes and mining pools in the lowlands. It is a danger to man and domestic animals, however, the excellence of its skin as high quality leather is the main reason why hunting has now severely reduced its numbers. Fear of crocodiles results in little sympathy for their fate. They probably play a useful role by controlling excess pig and monkey pests in the mangrove fringes of cultivation, which may be compared with that of the big cats inland.

If crocodiles become extinct, or at least they are hunted out of existence in Malaysia, a source of revenue will have been lost. In other countries experimental farms have been set up to rear crocodiles, both for their skins and for their flesh. Perhaps one of the most fearsome animals will be saved from extinction by captivity even if not complete domestication.

Gharials

The Gharial (*Tomistoma schlegeli*) has a more slender snout than the crocodile. The Gharial is confined to freshwater. Although carnivorous, eating fish, the Gharial has not been known to take human life or attack even goats among domestic animals. Not much is known of their numbers, but Gharial are probably on the decline because they are mistaken for crocodiles.

Monitor Lizards

The large lizards have some superficial characters in common with the crocodile and its relatives, but they are actually members of distinct groups. Monitor lizards are now under pressure too, for their skins which are known in the trade as 'lizard skins'. The demand is growing as crocodile skin becomes more difficult to get. About 40,000 monitor lizard skins are exported from West Malaysia each year.

The Common Water Monitor, Varanus salvator, lives near streams and rivers widely throughout Malaya, They attain 8 ft (2.4m) in length. The largest specimens are those most often killed for their skins, although the flesh of the smaller is perhaps more readily eaten. It is carnivorous and also a scavenger. It takes a wide range from shell fish, birds and reptiles' eggs to small birds and mammals including domestic poultry. Like-all predators it can be a destroyer of domestic animals when it gets out of control, but predators also play an important part in the control of other animal pests such as rats, which are far more serious pests and dangerous carriers of disease if they are allowed to multiply unchecked. Destruction of large lizards and snakes may give rise to such a situation.

Marine Snakes

There are about 20 species of sea snakes in Malaysian waters, all of which are venomous, that is their bite is poisonous due to venom injected from hollow teeth or fangs into the wound. The sea snakes or Hydrophiidae are recognised by the strong lateral flattening of their tails. Their bite is relatively painless, but the venom is very strong in some species and. fatalities are frequent among human victims. However, it seems that persons swimming in open water are seldom bitten. The majority of cases occur when the sea snakes have been trapped in fishing nets.

Only one Malaysian sea snake, Laticauda colubrina, the Amphibious Sea Snake, comes ashore to lay its eggs when these are at risk by destruction of the eggs or the nesting habitat. The Amphibious Sea Snake is the least dangerous of all. As far as is known the young of all the other sea snakes are born alive at sea, where they must run the gauntlet of their natural-predators. These totally marine snakes come into conflict with man when caught in fishing nets, when the more poisonous sea snakes seem to frequently have the best of the encounter.

Even if one wished to exterminate sea snakes, there is very little prospect of doing so, unless drastic measures were used which would destroy most beneficial sea life as well. Moreover this would probably leave a greater abundance of many more dangerous sea hazards such as the larger jelly fish and perhaps some cone molluscs. In order to reduce human fatalities there should be better education of fishermen about sea snakes, how to avoid being bitten and what to do if bitten. Some modifications of fishing methods may help to reduce risks. Provision of first aid kits to treat for the shock consequent on the fear of death after being bitten would probably help, as might wider availability of suitable anti-venoms.

Land and Freshwater Snakes

The hundred and ten or more land and freshwater snakes in Malaysia may be classified into the following broad groups. 14 snakes of fresh, brackish and tidal water, these are all harmless. The other are 15 burrowing snakes, 18 arboreal snakes which live in trees and seldom visit the ground and 63 ground snakes. Most of the venomous land snakes are ground snakes, certainly all the dangerous ones are. The venomous snakes are 2 Cobras, 4 Kraits, 4 Coral snakes and 7 Vipers.

The 2 cobras are the most dangerous of all, the large King Cobra or Hamadryad is aggressive in defence of its brood and can inflict a massive dose of venom. The King Cobra is widely destributed in forest, it feeds on other snakes and lizards. The common Cobra feeds on rats, mice, frogs and toads. The control of rodents is an important service. Despite the dangerous nature of a Cobra bite, human deaths are not frequent.

Among the 3 Kraits, one is known to have rather weak venom, one has strong venom and the strength of the venom of the third is not known, however, in all cases of doubt it is safer to assume the worst. In practice the Kraits are not aggressive, biting only if disturbed usually only if actually trodden on. The foot is most commonly bitten and ordinary foot-wear provides considerable protection. Anti-venoms are available.

The Coral snakes often have large poison glands and/or powerful venom, but they are unable to deliver a dangerous dose to humans because their mouths are too small and the fangs are located at the back of the mouth. The only records of humans being bitten are of a child's finger and the web of skin between a man's fingers. The Coral snakes are not aggressive, most are brightly coloured. Therefore it is very easy to see them and leave them alone, there is very little risk of being bitten.

The venom of all the snakes discussed so far is a nerve poison and if eventually fatal is due to paralysis of the respiratory muscles. The venom of the Vipers causes bleeding both internally and externally. Despite extreme discomfort death by Viper bite is rare. Some of the Vipers are arboreal. Many feed on rodents.

The danger of the venomous snakes is perhaps exaggerated. Many cannot bite a human under normal circumstances or are reluctant to bite. Nevertheless death from Cobra bite or a most unpleasant experience from Viper bite are risks. Malnutrition may lower resistance to snake bite. Shock is the immediate effect of snake bite, treatment for this is the first aid, to be followed by anti-venom if necessary. Snake venom is now being used

experimentally to treat thrombosis, even coronaries. If snake venom provides a cure for thrombosis, thousands may have reason to be glad that the fear of snakes has not resulted in their extinction before this discovery could be made.

Many snakes both venomous and harmless feed on rodent pests, some burrowing snakes feed on termites. These are important useful functions. It is quite understandable if Cobras, Kraits and Vipers found near human dwellings are killed. However, the wholesale destruction of all snakes, the majority of which are harmless and many harmless species are found in homes and gardens, only increases rodent pest problems. It is this attitude which is a threat to useful snakes. A few such as the python are killed for their skin, flesh or because they are poultry raiders. In general land snakes play a useful role in the natural balance.

Freshwater Fish

The rivers form the traditional route in this region for us to resume our journey from the sea to the forest. Until modern times the rivers were the main means of transport and settlements spread along their banks. Leaving the estuarine mangroves with their rich shell-fisheries, we enter the realm of freshwater:- rivers, streams, lakes and ponds, irrigation ditches and rice-fields, reservoirs and mining pools. Freshwater fish are an important source of protein. Some of the smaller species - unsuitable as food - are much prized by aquarists. Freshwater fish are thus both an important food resource in protein-hungry areas and a wild life treasure appreciated all over the world. Fish are relatively sensitive to pollution, their health and productivity is a measure of the water's ability to support life free from disease upon its banks as well as in its depths.

Most fish obtain the oxygen necessary for respiration by diffusion of dissoved oxygon from the surrounding water through their gills into the bloodstream. Since oxygen is not very soluble in water (and less dissolved in warm than cold water), large volumes of water must pass through the gills to supply enough oxygen. As a result fish are very sensitive to reduced oxygenation of the water and to poisons dissolved even at very low concentrations. Pollution of water moans contamination with untreated sewage to many people. Although not the only form of pollution, this is certainly one of the most dangerous, because infection with cholera, dysentery, typhoid and other epidemic diseases may be associated with it. However, sewage is also an example of a very large class of substances, including nearly all domestic and industrial waste, which create a demand for oxygen in order that they may be broken down. This depletes the oxygen in the water, if this happens rapidly the fish normally

present are suffocated and die. If a low oxygen status is maintained over long periods, a population of air-breathing fishes may survive and multiply. Water weeds killed by herbicides also use oxygen when rotting and produce the same effect,

Even when organic matter such as sewage, waste food, rubber or oil palm factory effluent has been treated before entering the river or has been broken down by natural bacterial processes in the water, the resultant inorganic salts may yet cause trouble, because these are the nutrients of plants. Excessive growth of water-plants can deplete the dissolved oxygen in the water at night when their respiration is not balanced by photosynthesis. The growth of large or small water weeds may be so thick as to choke waterways. Finally some microscopic plants, algae, which multiply rapidly or 'bloom' in enriched waters, can produce toxic substances dangerous to man or animals drinking the water. All these effects can result from large amounts of inorganic salts, especially soluble nitrogen and phosphate, reaching the water from other sources, for instance leaching of agricultural fertilisers.

Small additions of inorganic fertilisers or of treated organic matter increase the productivity of freshwater, but large amounts during short periods or frequently repeated lead to death of fish, foul and dangerous water. There are quite complicated methods of trying to restore conditions in polluted lakes and rivers, but those arc expensive at best. Various methods of sewage, waste and effluent treatment and nutrient recovery have been devised. As well as the economic saving of nutrients, which would otherwise be wasted., these treatments must be applied before discharge into rivers to maintain them in a healthy and productive condition.

There are two other major sources of pollution, one of which has long been serious in Malaya and the other has hardly affected Malaysia yet, although there have been local catastrophes elsewhere. The first is the suspension of silt in the water. Silt is discharged by mines into rivers, and although there is legislation to limit the amount disposed of in this way, control is largely ineffective. Erosion of soil from agricultural land, construction sites and badly conserved river-banks adds to the overburden. Silt clogs the gills of fish and, oven if it does not always suffocate them outright, makes them more susceptible to reduced oxygenation. This is another reason for controlling soil erosion. The other danger is poisons contaminating the water due to mining operations. These are only locally serious to date. Persistent insecticides are a growing, more widespread risk. Their effects and. means to reduce their hazards are discussed in an earlier section.

How bad is pollution of rivers in Malaysia? The lower

reaches and indeed moat of the upper reaches of all rivers in West Malaya and of an increasing number in East Malaya and Sabah have lost their sparkling, lucid quality and are visibly muddy especially when viewed from the air. A survey of the Gombak River in 1962 showed it to be virtually deoxygenated and unhealthily polluted where it entered the urban area of Kuala Lumpur. Pioneer surveys in Malaya and Singapore indicate that all rivers are seriously polluted downstream from all large urban areas and this is a situation which is deteriorating. Urgent preventive and remedial action is needed if the fish of Malaysia's rivers are to be conserved, either as a food source or as distinctive wildlife.

Fish as Wildlife

The foregoing is concerned mainly with conserving fish as a food resource in an environment healthy for the associated human population. However, if the whole range of fish species are to be conserved for science, sport and aquarists, the different kinds of habitats must be preserved. The majority of Malaysian freshwater fish species are restricted to pools, rivers and streams shaded by trees, typically in forest. The mountain torrent streams in hill forest and at higher levels would seem relatively safe so long as the policy of protective forest above the 'steep land line' is observed. Some areas of swamp forest are likely to remain uneconomic to drain and so to provide refuges for their characteristic fish fauna» It is the lowland forest which is threatened with almost complete elimination by land development and with it the undisturbed forest stream and pool habitats. Plantations do however provide shade for the streams when the trees and palms are fully grown. Although the typical forest fish fauna is lost at the time of clearing and the streams are exposed to full sun for two or three years, there is evidence of extensive re-invasion of the plantations by forest fish when the shade has been re-established.

Therefore so long as a large proportion of the lowland agriculture consists of plantations of pains and trees, the prospects for the survival of the forest fish may seem fair. However, the scale of land clearing operations is growing, which means that the average distance separating the forest and old plantation reservoirs of fish and the bulk of the new plantations, which must be re-stocked from them when adequate shade is re-established, is growing also. Modern agricultural methods involve other risks to the fish, insecticides very toxic to fish, fertilisers causing excessive plant growth, herbicides killing water weeds and causing an oxygen demand, may all leach into streams; if terracing has been done well, the successful water conservation may dry out some streams, whereas poor terracing might permit soil erosion and silt contamination of streams and a variable water status of drought and flood. This situation might be alleviated if patches of undisturbed forest

are allowed to remain in the agricultural landscape as virgin jungle reserves or where the soil is locally unsuitable for cultivation as small parks, these will serve as centres for re-stocking. In general, agriculture based on resource conservation to prevent soil erosion, to maintain a steady water regime, to apply integrated pest control and to use more efficient methods of weed suppression and of fertiliser application, may give the best chance to the fish in the area.

The extension of rice cultivation, the construction of irrigation canals and the formation of mining pools have increased the habitats available to fish preferring sunlit water and they should flourish, if two hazards can be kept under control. The first is a wildly fluctuating water regime, which all good water conservation and utilisation schemes are designed to prevent. Secondly persistent or cumulative toxicity due to insecticides sprayed against pests of rice. There is hope of reducing rice-pests by breeding resistant varieties of padi and the discovery of alternative insecticides, which may be encouraged if joint rice cultivation with fish culture is recognised as an integrated means of staple food and protein production.

Over-collection

The island of Singapore has relatively few species of fish compared with Malaya. The main depletion in the fish fauna has been due to habitat (forest) destruction. However, during the last 30 to 40 years further losses in the native fish species to be found in Singapore have occurred. These are less easily attributed to further environmental modification, but there is strong evidence here - as elsewhere - that excessive collection by aquarists is responsible. Education of the aquarists through their clubs and encouragement to breed rare and attractive fish in captivity, instead of collecting them from the wild, provide the long term solution. Legislation and policing may assist meanwhile. Research on breeding and keeping of aquarium fish could be carried out in the universities and so bring the professionals and amateurs into fruitful contact.

Exotic escapes

Species introduced from other countries are called 'exotics' and those which become established in the wild are called 'escapes' from cultivation. Many plant weeds are exotic escapes and compete to the disadvantage of the native flora. The same can happen with fish, both ornamental species escaping from aquaria and edible species escaping from fish ponds. Game fish may be deliberately introduced for sport, but this has not been a success in Malaysia. Although exotics such as *Barbus semifasciolatus* (an aquarium fish) and *Tilapia mossambica* (a food fish of ponds) have escaped and multiplied in some areas,

it is not certain that they have damaged the chances of survival of indigenous rarities, which may be vanishing owing to the more general habitat destruction and pollution. Yet with so much wildlife in a precarious state, fish-lovers such as aquarists and specialists in fish-production should be on their guard against worsening the situation. Artificial fish ponds such as adapted mining pools and reservoirs are sometimes more easily managed so that exotic food-producing fish do not escape.

Legislation

Only the Giant Cyprinid, *Probarbus jullieni*, is considered to be a threatened species among Malaysian fish due to excessive capture for its flesh when on its spawning run up the great rivers of Pahang and Perak. As a result the reproduction of this never abundant fish is further curtailed by the growing human population. The only legislation to protect this and other fish prohibits fishing by means of explosives and restricts the use of the anaesthetic *tuba* root (of *Derris*) to the Royal prerogative. The enforcement of closed seasons when fishing is prohibited to enable the fish to spawn and the licensing of fishing to limit the catch - the latter is observed only in the Taman Negaran - will probably prove essential. Such regulation, like that for turtles, is often readily accepted by the local people if the purpose of increasing fish stocks is adequately explained and some priority in concessions is allowed them.

Future for Freshwater Fish

The urgent need is to eliminate pollution from Malaysian rivers. Urbanisation, industrialisation and land development all contribute in different ways to pollution. Experience in other countries has shown that it is never too early to prevent pollution. The other needs to protect Malaysia's freshwater fisheries and interesting fishlife are the preservation of a well mixed landscape, including many naturally and artificially shaded streams, and the formulation and. enforcement of legislate to regulate the harvest of fish to obtain the maximum sustained crop. This legislation must include close seasons, licensing, restriction on liberation of exotics of both ornamental and food fish.

Birdlife

Malaysia has an avifauna of more than six hundred species of birds. Some are resident the whole year round whereas others are migrants. The migrants may be further subdivided into those which only briefly visit on their passage from one place to another and those which spend part of the year here. The latter may again be subdivided into those which come here to nest and breed and those which come here to overwinter during the adverse season in

their breeding grounds. Some of these winter migrants come from as far distant as Siberia. Migrant birds pass through several countries and, especially for those species of economic value as food or importance as predators of pests, all the countries concerned have a mutual responsibility for their protection.

Some birds are found in every natural habitat in Malaysia from the coasts to the mountain tops. The sea birds are largely restricted to the coast; but some species such as the sparrows are found over a wide altitudinal range, wherever they can find man-made conditions. Birds are threatened in the same ways as other species, by destruction of their habitat and by accidental or deliberate killing more rapidly than they can reproduce. Habitat destruction is most serious if the species is strictly limited in range to a particular habitat in order to obtain food and cover, the situation is progressively worse the more specialised or restricted is the habitat. Since the lowland forest is the habitat which is liable to suffer the most widespread modification and destruction throughout Malaysia, its consequences for birdlife must be examined.

Preliminary studies indicate that less than 5 per cent of the local species increase in numbers and adapt to the new conditions when a predominantly forest area is cleared and displaced by agriculture or residential areas with gardens. Some birds of the forest have very specialised requirements, the Hornbills require large hollow trees to nest in and the Argus pheasants need an open floor in the forest for their courtship ritual. Even in forest managed according to the natural regeneration system inadequate old hollow trees may be left standing, because they are not growing economic timber, and the dense undershrub after opening the canopy may deny the pheasants their dancing ground. The altitudinal range of the lowland birds is not always known, the boundary between lowland and montane seems to be about 3000 feet (1000 m.) in East Malaysia, but it is probably lower in West Malaysia. It cannot be assumed that the birds can retreat upwards as the lowland forest disappears. Some birds may be limited to food available only in the lowlands, and all would have to compete for living space with the present incumbents. The - at least relative - increase in Macaques and other carnivorous arboreal animals in disturbed forest may militate against the nesting of some birds in managed productive forest. There is some hope that management might modify the upper-lowland and hill forests to carry a greater stocking of a few threatened large mammals, but the prospects are not bright to do the same for many different species of birds, too many to make the necessary individual ecological studies to make scientific management possible.

Neither are plantations with tree and palm crops a good substitute for forest in the case of most birds. A small number of species are abundant in the early open phase of rubber, but the avifauna is definitely poor in mature rubber, especially as

there is usually little undergrowth. Three species of parrots and four other birds have been reported eating oil palm fruit and are regarded as real or potential pests, a few more species tolerant of man-made habitats occur and in some cases birds of prey increase by feeding on rodents, but the overall contribution to preserving the typically forest avifauna is poor, because oil palm essentially supports larger populations of a reduced number of species. The retention of as much natural lowland forest as possible in reserves and parks must be encouraged and coupled with general conservation measures for the protection of birds. These general measures should be put into practice now before the problem is acute in Malaysia. In this way birds which are likely to become rare due to habitat destruction will be relieved of additional pressures which might cause their extinction before their critical condition is realised.

Birds as Food

Wildfowl and game birds are a traditional source of food throughout the world. The wild Malaysian Jungle Fowl is the ancestor of domestic poultry and with pheasants has always been trapped or shot by aborigines. Doves and other medium sized birds are also taken. While the bird population has been widely dispersed and relatively large compared with the human population, the light cropping or culling of these birds has had little-effect. However, as this situation changes as indicated the enforcement of further controls on licensing and limiting of catches, observance of closed seasons during the breeding months or even for several years when species are threatened, will become increasingly important.

A distressing feature of recent years in countries neighbouring Malaysia has been the modernisation of lamp and net methods of attracting and trapping migrant birds. Powerful pressure lamps and the fine 'mist' nets of nylon used by bird-banders have been brought into use. Thousands of birds of all species and size classes are trapped with a total kill during the migrations along the main flight paths. This has already led to noticeable reductions in some birds. Perhaps the best long term solution will be to provide the protein hungry people concerned with cheaper, more attractive and easily obtained meat. Malaysia must prevent the adoption of such techniques here and exercise influence in the interests of the region as a whole in halting this destruction of migrants, which are the heritage of many peoples.

Birds as a food resource includes their eggs and in the case of some swiflets their edible nests. The collection of edible nests is reasonably well organised and controlled in East Malaysia to allow adequate broods to be raised to maintain the

species. This provides a good example of how a natural resource can be both conserved and subject to controlled exploitation at the same time, preserving the wildlife and yielding a profit. More publicity might be given to these homegrown successful examples of conservation. Large scale collections of wild birds' eggs are local and rare in Malaysia, limited largely to a few sea birds, although constituting an added threat to the Megapode in East Malaysia.

In the currently developing situation it is desirable that all birdlife should be protected fully and that exceptions, that is when eggs or birds may be taken for food or destroyed as pests, should be defined as specific exemptions stating species, locality and season. Existing legislation in both East and West Malaysia affords considerable protection to many but not all birds; there are anomalies, but the main need for revision arises from the ordinances being framed for conditions now past, rather than for the likely future.

Birds and Agriculture

Birds are like insects in that the role of most in rural and agricultural life is beneficial, but a minority have become the specialised pests of crop plants. Studies of nesting activity in Malaysia shows a cycle from low at the end of the calendar year, rising rapidly to a maximum about the vernal equinox, falling somewhat to midsummer and then more markedly to the trough at the end of the year. This cycle in nesting activity is very similar to that in the intensity of solar radiation throughout the year and also to the variation in maximum temperature. These environmental factors may have a direct influence on the physiological behaviour of the birds or there may be an adaptation to parallel changes throughout the food chain. The rate of photosynthesis and plant growth in turn determining the secondary productivity of insects and that of the birds which feed upon them. Birds are certainly most active when hunting insects to feed their young. Certainly it would be unwise to under-estimate the benefit due to avian control of pests.

Birds of prey are almost entirely beneficial in the control of rodents. They occasionally take poultry and small or young farm animals if their normal food is in short supply during the breeding season. Farmers would do better to protect their stock from the birds of prey, which can then deal with rodents, rather than shoot the birds of prey and then risk poisoning their stock in attempts to control the rodents. Hawks and owls are often seen by day and night in the vicinity of batteries of poultry, but they cannot get at the fowls, but take rats which would otherwise endanger birds and eggs. Falconry has been suggested as an answer to the parrot problem in oil palm. Provided the birds of prey are not molested, agriculture increases the food available to them. Padi-growing extends the habitat of

some marsh birds, especially in East Malaysia.

Birds, like fish, are among the wildlife threatened by careless use of persistent insecticides. Other measures for the conservation of birds will retain their effectiveness if special and integrated methods of pest control are adopted in plantations. This applies particularly to the few cases where birds are themselves pests.

Death by Kindness, Ignorance, Neglect and Greed

The bird trade is a curious mixture of these ingredients. From ancient times there has been trade in bird skins, plumage and captive live birds. Some birds were exterminated by the demand for their plumage, but this aspect has now been brought largely under effective international control. Enforcement and prevention of evasion remain necessary. A close watch on new demands must be kept, for instance the new cottage and handicraft industry of making pictures out of plumage, not just from fallen feathers but from entire skins or wing plumage. At present common birds are used and - questions of humane killing aside - conservationists might do well to reserve their energies for more serious problems unless this creates a demand for the rarer of the more beautifully plumed birds.

The period of intensive collection of bird skins for scientific purposes is largely over as ornithology moves progressively from taxonomy to ecology and behaviour studies; cheap, versatile yet accurate colour photography facilitates the identification of rarities captured, which may be released after banding instead of being killed and sent to a museum. Stuffed birds have gone out of vogue as ornaments. Ivory from the casque of the Helmeted Hornbill is rare and valuable, other hornbills have been used also for decoration in East Malaysia. Although traditional, such usage should be restrained in view of the other pressures on this great bird of the forest canopy.

The demand for live birds grows. Some caged birds are kept as pets for their song, decorative effect or ability to imitate human speech. Where this leads to breeding and rearing in captivity, there is no conservation problem, indeed the experience gained may be of value in rescuing and multiplying the remnants of threatened species. At present only imported birds have been raised in captivity in Malaysia, specimens of local species are caught from the wild. If these are common species such as Mynahs and Doves, there may be objections on grounds of cruelty, but the species are not endangered by the practice. Comprehensive protective legislation should name those species it is permissible to capture and offer for sale, thus preventing the practice spreading to rarer birds.

Such legislation should be applied to the international traffic in wild birds. Zoos, pet shops and aviary displays are increasing their demands all over the world. The smaller and less well conducted travelling shows often have the greatest demand for the more spectacular rare birds as attractions. Poor conditions often result in brief lives and repeated demands for more exhibits. The wastage in capture and transport of these birds le high- Malaysia is not so greatly involved in this traffic as some other countries, mammals are more often the subject than birds in Malaysia. However, this is a situation which can rapidly deteriorate. The efforts of one country to stamp out this trade in the wildlife heritage can be easily undermined if neighbouring countries allow loopholes in shipment control or provoke jealousy by trying to corner the trade.

Capture for Release

The scientific study of bird migration and longevity depends much on banding (or ringing) by placing numbered aluminium bands on birds legs. The bird must be captured, handled briefly and gently to note its particulars, apply the band and release as soon as possible. Banding does not harm birds. Returns are obtained if the birds are recaptured (and released again), shot by hunters or found dead. Bird watching and banding is one of the most enjoyable and constructive hobbies known. The bird reports which appear regularly in the Malayan Nature Journal enable minor individual observations to be accumulated into a valuable whole.

Birds are captured and released for quite different reasons in Malaysia and more often in some neighbouring countries. It is a Buddhist belief that merit is acquired by the release of caged birds, which are bought from dealers for the purpose. Occasionally the cage birds released are aviary bred or imported birds, which are untrained to survive in the wild, find their own food, evade predators or seek shelter in city, garden or forest. Although birds may inherit more of their behaviour than mammals which seem to acquire more by learning, there is little doubt that released cage birds are at a disadvantage. In the case of wild birds caught by the dealers for sale and subsequent release, there is invariably a. sad history of injuries at capture, casualties during captivity, weakening due to wrong feeding, so that their chances of survival after release are poor, apart from frequent release in quite unsuitable environments. Although perhaps only a serious threat to wildlife if rarities are taken, this wanton destruction of life is not consistent with principles of conservation and it is detrimental to education in conservation to encourage this practice by default of criticism. At a time when the religious are re-examining their beliefs, one enquires respectfully if the purpose and function of this practice has not become distorted when birds are caught, caged, the

majority deprived of life and freedom, so that a few may be released?

The Need for Birdlife

The economic value of birds in pest control and food production has already been stated. The aesthetic value of birdlife is also important. Birds are appreciated more than other members of the animal kingdom for their real beauty and symbolism, their colouring, their song, their behaviour, their flight, their freedom. The scientific study, emotive appreciation and personal enjoyment of birds have already long transcended differences between east and west, rich and poor, and many other divisions in humanity. The national attitude towards birdlife and its protection is a measure of a people's advancement in conservation. At present the Peacock and indeed all Pheasants, the White-winged Wood Duck, the Rufus Headed Robin and Rueck's Blue Flycatcher are considered to be most seriously threatened in Malaysia, but there are many borderline cases, whose future will depend mainly on the verdict of public interest or apathy.

Mammals of the Land

Although many of the great mammals of the sea are threatened with extinction, Malaysia is not in a position to do much about them except for the Dugong discussed already, because the whales stray into Malaysian waters only rarely and Malaysia has no fleet of whalers. However, on the land there are about 200 species of mammals, some ox which are among the rarest and most severely threatened animals in the world. With the birds, the mammals enjoy the greatest popular appeal and interest, whether as big game, sources of food, working animals, pets or objects of curious observation in the wild or in captivity, because their behaviour is so similar to our own, we are fellow mammals. The problems of their conservation may be considered from two approaches, the general and the specific.

The general approach is to classify the 200 species of mammals wild in Malaysia according to their habitat and food, so that the groups most seriously threatened with a loss of cover or with starvation by the likely changes in land use in Malaysia can be recognised. Then it may be possible to make provision for them in advance of these changes and to start the necessary research to see how that provision can best be made. About half the Malaysian species of mammals live below 1,000 feet and both the number whose range extends upward from the lowlands and the total number at any altitude fall off progressively with greater elevation. A few species such as the Malaysian Mole are known only from the highlands. About half the mammals live in tall, undisturbed, primary forest, these are not exactly the same as those which live in the lowlands, although there are many species

in common between these two groups. About a quarter of the species live in disturbed forest, cultivated land, residential and urban areas, this group includes introduced species and agricultural pests.

Taking these two trends together we find that the majority of Malaysian mammals prefer to live in undisturbed, lowland forest. This is illustrated by counts of the number of species in primary forest, secondary forest and plantations, which were in the ratio 4 : 2 : 1. Although the two types of forest had many species in common, those in the cultivated areas were mainly different. There are several distinct layers in the undisturbed forest, which show their greatest development in the lowlands, each has a characteristic fauna. The largest class are the ground-dwellers, which are very diverse in size and feeding habits, small rodents and small cats, the peculiar Scaly Ant-Eater, all sizes of deer up to the large herbivores - including the largest of all, the elephant - and the big cats - including of course the Tiger. The middle-zone mammals do not attain such large sizes as the biggest terrestrial animals and are much better climbers, moreover they range beyond the middle-zone itself on to the ground and into the canopy, they include some rodents, the civets and the heavier monkeys. The canopy zone is inhabited by gibbons, leaf-eating monkeys, Slow Loris, squirrels and fruit-eating bats. Insect-eating bats hunt through the trees and some even above the trees. As the forest is progressively more severely disturbed, the canopy-dwellers are the first to go, then the terrestrial species typical of forest leaving the adaptable middle zoners until last, this is usually the stage of belukar or of tree-plantations, when a new ground fauna is evident, which alone persists if clearing is completed to lallang or padi fields.

One small minority group has been omitted from this general scheme, namely the aquatic mammals such as Otters, Water Shrew, Moonrat, Swamp Eat and the very rare Otter Musang. Some will probably survive in swamp forest uneconomic to drain, clear and plant and in other small niches. However, the otters may be lost from the lower reaches of all the larger rivers if the problem of water pollution is not solved. They may suffer too in agricultural areas if persistent insecticides build up in the food chain of life in streams.

The bulk of the lowland forest is destined to become agricultural land, thus the natural habitat of the majority of Malaysian mammals will be drastically reduced in area. For some strictly lowland species, that is those which live only below the 'steep land line' of the land-planners, wildlife or nature reserves in these areas will be the only solution. Such reserves may accommodate many of the smaller mammals, but the larger mammals - including all the most seriously threatened - need larger territories. An individual Orangutan needs 1½ square

miles of natural forest, 20 square miles is quoted for an elephant, although the viable unit is a herd of about 10 beasts, and a tigress with cubs needs 50 square miles. Fortunately there are prospects of managing reserves to carry heavier stockings in some cases, although there are risks of creating conditions in which epidemic disease may spread or famine may result in a bad year.. There are prospects of maintaining a representative population of most lowland mammals, particularly of the threatened species after they have been brought through the present critical period by protection in reserves, in the border zone left between the upper limit of cultivation at the 'steep land line' and the upper limit of approximately lowland climatic conditions at 1,000 or perhaps 2,000 feet elevation. This zone will probably consist of productive forest on relatively long rotation by natural regeneration with treatment and perhaps enrichment. It may also include plantations of exotic pines and eucalyptus, although the desirability of these essentially short rotation tree crops above the steep land line is dubious in view of soil erosion risks, apart from it being doubtful if plantations of exotic trees and indigenous wildlife will go well together. There is also a chance that if regeneration and enrichment were so successful in converting the productive forest to consist entirely of economic tree species, that the foresters would wish to exclude wildlife from feeding on them or that the food-plants of the animals would be found to have been eliminated.

At present the indications are that species typical of secondary growth, including some wild fig trees which figure prominently in the food of squirrels, leaf-eating monkeys and gibbons, are very common in the early phases of regeneration. Secondary growth does not vary so much with altitude as does primary. Secondary growth is the browse of medium and large herbivores, including both productive and threatened species. An increased stocking of deer and pig is likely in turn to give rise to a larger population of carnivores such as the big cats.

At least that is the hope. Whether or not this prospect can be realised, the opportunity will not be taken unless we are prepared for it. This means research now. Preferably joint research by foresters and wildlife conservators. In the earlier chapters quite definite recommendations were given to conserve soil and water. Integrated pest control is still emerging and the guiding principles are yet tentative, but - because of the obvious economic interest - research is in progress. Now that we have reached the protection of wildlife, the subject is even less developed, we can only indicate the need and allocate some priorities in the urgency of the different problems. Whether we regard this as an act of faith or belief in science, the results of research in nature conservation are likely to be as important and rewarding as those into natural resource utilisation.

Big Cats

The Tiger is the largest, the Leopard also called the Panther (both the spotted and black forms, of which the latter is more common in Malaya) is second largest and the Clouded. Leopard ranks third. All three occur in Malaya but only the last is found in East Malaysia. All three can spring and climb, but the extent to which they normally climb and hunt in the trees is in converse ratio to their weight; Tigers 300 1b (150 kg) hunt terrestrial prey such as wild pig, Leopards 100 1b (40 kg) take small deer and large birds (pheasants and jungle fowl) and the Clouded Leopard 50 1b (20 kg) feeds on monkeys as well as other birds and mammals, it is sometimes called the Tree Tiger. Their control of wild pig and monkeys is a valuable service to agriculture.

The threats to the big cats are threefold: loss of food rather than destruction of habitat, the fur trade and persecution for fear of attacks on domestic animals and man. The big cats can all go quite high into the hills and mountains, so that the alienation of lowland forest for agriculture does not deprive them of their only habitat, but it does reduce their range and what are probably their richest feeding grounds. If pig and deer are excluded from plantations of forest trees and heavily hunted in the productive forests, the food of the big cats may be reduced in the zone of timber crops above the 'steep land line' also. Until research is carried out, it is not possible to say what balances may be struck, but it should not be assumed that the deer, pigs and big cats must all go.

The fur trade has created a luxury demand for the Skins of big cats in their prime. Hunting and shooting them seems to be easier in countries with a more open terrain than the Malaysian forests, but if the big cats are exterminated in those countries the pressure will turn wherever any remain. The economics of luxury trade are such that the price is proportional to the rarity and the legal or illegal killing of Malaysian big cats will become more profitable. Once a rare animal is trapped or shot, it is rather academic whether it really was a cattle-killer, such pretended excuses are likely if the demand is great enough. Assuming that a hard-wearing nylon substitute fur is not acceptable, another alternative is to raise big cats in zoos, or even in parks. The Malaysian National Zoo has had considerable success in breeding tigers, it is worth looking into the economics of rearing them for their skins, because an excess of cubs has occurred occasionally. It may seem a mean act to rear a noble beast to kill it, although few raise the same objections about grand cattle, but it is better than maiming either to die lingering in the wild.

The fate of maimed animals reminds us of the persecution of the big cats on behalf of villagers who fear for their cattle.

This problem has been fully discussed in an earlier section on the borders of cultivation and the control of wild pig and similar pests. We need only recapitulate that the big cats are excellent natural controls of mammalian pests, and injury to the big cats in ill considered attempts to trap or shoot them is the main cause of them becoming cattle-killers or. even man-eaters.

The immediate future for the big cats may seem assured. However, the three factors mentioned could together cause a very rapid deterioration in their chances of survival. Since each factor separately is quite likely, continual effort will be necessary to preserve the present situation, reverse the tendancy and improve the status of these animals.

Primates

The primates include the Treeshrews, Slow Loris, Monkeys and Apes, including Man, Among the objects of conservation is the preservation of the environment fit for Man to live in and to retain his sanity. In this sense the whole of this book is about the conservation of that one primate. However, whether we regard the protection of Man from himself as an object or a by-product of nature conservation, we can deal here only with the wild relatives of the Naked Ape. The similarity of the more advanced primates to ourselves has led to an enormous demand for them as pets, performers in circuses, exhibits in zoos and as the subjects of medical (including space) research. The primates are considered to be among the more difficult animals to breed in captivity, whether this is truly so or because insufficient effort has been made by zoos to provide suitable conditions for healthy breeding stock to court, mate, bear and rear their young remains to be seen, (zoos are organised for display, we would not expect our human relatives to raise a family under these conditions, how can you make a promise of a private room for the confinement to an ape?). The fact remains that the great demand for captive primates is met by capture of wild animals and not by breeding in captivity.

In some cases adult monkeys and apes are caught, but often they are difficult to catch and handle. The majority of Gibbons and Orangutan are taken as babies by shooting the mother and picking up the helpless orphan. It sometimes happens that a mother ape is accidentally killed when a tree is felled for example, when taking care of the surviving infant is commendable; but far more often this is an excuse to account for possession, because killing of these animals protected by law is a punishable offence. Thus the acquisition of one young captive ape is nearly always at the cost of one adult breeding female, which left in nature might bear more, in addition to reducing the future wild population by the animal actually acquired. In the hands of the average hunter, dealer or shipper this is the start of a history of malnutrition and infectious disease which eliminates

up to 90% of the young captives before they reach their final destination. Almost invariably animals rescued from the trade- are found in cramped, dirty quarters suffering from dysentry and infested with worms and vermin. Even in the best zoos some apes are delicate subjects, for instance gibbons are very susceptible to water-borne diseases, perhaps because in their natural tree-top existence they do not come into contact with streams; bare, hygenic cages on the other hand prove frustrating for these intelligent animals.

The progressive disturbance of primary forest leads first to the disappearance of the canopy-dwellers among which the Orangutan, Gibbons and Leaf-Eating Monkeys are found. Thus the Malaysian Apes are among the most sensitive to habitat modification. The White-handed Gibbon is mainly a lowland species, whereas the other Gibbons - especially the Siamang - are found in the hills. Any productive forest involves operations likely to disturb the canopy-dwellers, whether in the lowlands or in hill forest. Thus the best prospects for the survival of these apes in productive forest is if there is a mosaic of forest at different stages of the regeneration cycle so that they do not have to move too far to find suitable canopy, when one portion is due for timber extraction and passes again into the open or disturbed phase. Whether or not a fair stocking can be maintained in this way in productive forest will depend on freedom from other pressures such as poaching.

Orangutan

The Orangutan is the largest ape in Malaysia, second only to gorillas in the world. Fully grown Orangutan are about the stature of a man, but thicker built and weighing more than all except the most obese humans. Although shy, retiring and inoffensive by nature, they are powerful and can seriously injure those who molest them in captivity. The Orangutan is one of man's closest living relatives in the world today. Probably . for this reason the Orangutan is in great demand. In modern times its range has been limited to Borneo and Sumatra, where its habitat is being reduced by land clearing and forestry operation. The combination of these forces has resulted in the Orangutan being placed on the short list of species most severely threatened with extinction in the world today.

The threat was realised by the Sarawak Museum and by the Forest Department in Sabah. Research was initiated in Sarawak and continued in Sabah when a Game Branch was set up as part of the Forest Department. These efforts are co-ordinated by OURS (Orang-Utan Recovery Service) under the auspices of the IUCN Survival Service Commission. OURS has arranged financial support and the co-operation of the Malaysian National Zoo in Kuala Lumpur, as well as playing a leading role in reform and enforcement of

legislation not only in the countries of origin of the animals, (Indonesia and East Malaysia), but in the centres of distribution and shipment such as Singapore. IUCN (International Union for Conservation of Nature and Natural Resources) seeks the co-operation of IUDZG (International Union of Directors of Zoo-logical Gardens) to ensure that zoos do not accept illegally acquired animals such as Orangutan. The aspects of the work of OURS are reviewed in turn.

All young Orangutan taken illegally or orphaned by genuine accident must be handed over to the authorities in East Malaysia, where no permits to shoot or capture these totally protected animals are issued. The authorities may confiscate all Orangutan found in West Malaysia or Singapore which have not been legally acquired with an export permit from their country of origin. These confiscated animals may be held temporarily in such places as the National Zoo, almost invariably they are in urgent need of veterinary care. The policy of OURS is to send as many Orangutan as possible to a centre where they can be nutured and trained to re-adapt to life in the wild, whither they will be returned by being given progressively greater freedom. Only those Orangutan which are deemed to have become completely unsuitable for rehabilitation to a wild existence, will be exported legally to zoos and similar institutions, preference being given to those which have been successful in breeding Orangutan or other primates in captivity. These potential recipients have provided the financial support.

One of the most conspicuous human features is the care of their young and training of them to obtain their future livelihood. The other apes differ from us only in that this period of dependence is shorter, although still a matter of years. It is for this reason that young Orangutan cannot be turned loose immediately in forest, apart from the risks of recapture by poachers or of dying from diseases picked up during captivity, they would starve or soon fall victim to predators. The preliminary research was at Bako National Park, Sarawak, and the present centre is in Sepilok Forest Reserve, Sabah. The young animals are kept in clean quarters, fed regularly with a balanced diet and regularly examined and treated medically. They are exercised daily under gentle supervision and encouraged to climb trees with progressively greater freedom in their 'open zoo'. Eventually it is hoped to release groups of Orangutan retrained to jungle life in strict sanctuaries, one of which may be established in the Upper Segama area. The Sepilok area is also protected in this sense. Some animals may have been in captivity too long during their normally formative years to re-adjust, these are those destined for zoos if they do not respond to their opportunity to return to the wild.

Research is still needed at every stage to assist the young Orangutan to recuperate, retrain and return. The mode of life of the Orangutan in the wild, its food and habitat requirements, are still inadequately known. The best chance of survival must be given to the released and remaining wild Orangutan and their future protection assured. The activities of OURS, whose authors would agree that only a start has been made in what is needed, given some idea of the immense effort needed in the enactment and enforcement of legislation, organisation of funds, staff and research, and provision of adequate, suitable, permanent, fully protected sanctuaries which must be made to save an endangered species.

The Big Herbivores

A herbivore is an animal of vegetarian diet, the big ones are ungulates, that is hooved animals, the family to which cattle, horses, sheep and goats belong. The three large herbivores discussed here, Elephant, Rhinoceros and Wild Cattle (Seladang in West and Banteng in East Malaysia) are the largest wild land mammals in South East Asia, indeed only domestic cattle and buffalo - some of which have run wild - rival the smaller wild cattle (Banteng) in size. All three are hunted and shot at for various reasons, the Elephant to protect agricultural crops and less frequently as licensed big game to provide ivory and other trophies, the wild cattle are poached for their meat and the Rhinoceros are the biggest prize of all for the poachers because every part, especially the horn, is believed to have almost magical - but actually non-existent - medicinal, tonic and aphrodisiac properties for which the superstitioue are willing to pay heavily.

All three require large amounts of herbage as fodder, the Elephant feeds preferentially on bamboos, palms and secondary growth in disturbed forest, the Rhinoceros feeds on belukar shrubs as far as is known, but the Wild Cattle prefer coarse grasses and scrub typical of jungle clearings. Under natural conditions these essentially secondary types of vegetation occur scattered throughout the primary rain forest in patches damaged by storm or landslip or where old dead trees have fallen, the more open grass and scrub being found on river banks and in the abandoned clearings of old aboriginal settlements. Thus in nature they need large territories or beats over which they wander to browse. They need recourse to water and to salt-licks. Other forms of cover are probably needed for resting and breeding. Under present day conditions of forest clearance for land development and settlement of aborigines, the large herbivores are being driven from their traditional home and are becoming concentrated along the margins of cultivation where their preferred food of grasses and other secondary vegetation is found in abundance,

This exposes them to poachers and brings them into conflict with agriculture.

The only encouraging aspect of this situation is that the management of secondary vegetation to produce an abundance of grass, scrub and belukar is already fairly well known or can easily be improved by relatively short term and simple studies, (conversely it would be a very tall order if we had to restore the primary forest). Some progress has been made along these lines for the encouragement of Banteng in the Udjong Kulon Nature Reserve in Java. Agriculturalists are rather good at establishing these conditions by accident and neglect. It would be possible by design in wildlife management. This opens up several possibilities.

Firstly managed areas to provide more abundant food, fertilised if necessary and enriched with artificial salt licks, should support a much higher stocking. The animals should be less inclined to wander away. This concentration can be located somewhere that access is difficult for poachers (and from where they cannot easily escape undetected with the spoils) and altogether better protection can be afforded by the game wardens. Where food and total protection are afforded, the breeding rate often increases and wild animals become much tamer. The tameness is an important point in the later stages of development of such reserves, because it means that casual visitors such as tourists have a much better chance of seeing and photographing some of these large animals. As far as possible these protected, managed areas should be in the centre of parks and game reserves, so that there is a large buffer zone surrounding them. Attractive as this idea is, there are problems and risks.

Although the necessary research on management does not appear to be exceptionally difficult or to require a very long time to obtain results, so far it has not been started at all in Malaysia - beyond a few observations on feeding habits. Next the animals have to be got from where they are now into the now managed reserves. Where there is a nucleus of the animals as in the National Park (Taman Negara) of West Malaysia, the management can be started where they are causing as little disturbance to the animals as possible. However, usually it will be necessary to move small, threatened groups which do not form viable breeding units over quite long distances of terrain difficult due to hills, rivers, roads and human obstructions.

Publicity has been given of late to field immobilisation techniques in which a dose of combined tranquiliser and anaesthetic is shot into the animal by means of a gun firing a syringe loaded as a dart. After a brief period of panic and frantic effort the animal is subdued, comitose or asleep and can be guided or manhandled by tackle into a crate and carried off to its new home. In practice it is essential to have a veterinarian

experienced in the technique in charge, also for the dose to have been accurately assessed and correctly delivered. There has been one case of shooting a tiger in the eye with such a so-called mercy gun in Malaysia (the tiger had to be killed defeating the object of the exercise). Too small a dose and the animal may damage itself in its panic, too large and it may never recover. The savanna plains of Africa, where the technique was developed, are very different from the thick swamps into which some of our few surviving Rhinoceros have retreated. A large animal immobilised in a swamp may have drowned or recovered and got away - perhaps to collapse later from injuries in some inaccessible place - before it had been extracted by the handling team. If these methods have a place here, the Seladang might be the best first subjects after suitable trial on domestic cattle (for instance when the Veterinary Department need to inoculate an intractile bull).

Another risk is the development of epidemic disease in these artificial concentrations of wild animals. This is a risk which must be taken, because in most cases the rare beasts are exposed to even greater risks of destruction at present. Nevertheless this danger may be anticipated by having more than one such reserve, managed or situated under slightly different conditions if possible, and with access to the best veterinary advice available in the event of trouble arising, so that diagnosis and action may be prompt. If the managed park is a great success and the stock multiplies to too high a density for the health of the population or to threaten other wild life, then culling or cropping will be necessary. At the present time this is not a problem, but it may be necessary to ensure that the game wardens have the necessary powers if it is ever necessary for them to apply such measures.

Elephant

The Asian or Indian Elephant is the world's heaviest land mammal, it is wild in West Malaysia and has escaped and run wild in parts of East Malaysia. There are about 500 in Malaya, it is no longer found in the most developed states of Selangor, Negri Sembilan and Malacca. Its density seems to peter out with progressively higher penetration into the hills, so large an animal must find difficulty in very steep places. On a steep portion of a rubber estate the elephants used to steady themselves by curling their trunks around the trees conveniently placed in orderly rows 22 feet apart. Elephant occur above the 'Steep land line' in Malaya but probably do not ascend in great numbers above the lowland dipterocarp forest type.

Although at present in fair numbers, the elephant numbers are falling quite rapidly, mainly because no one has

devised any other way of dealing with alleged crop raiders than by shooting a few. Even so it is hoped that substantial numbers will survive in Upper Perak, the National Park and perhaps other reserves throughout the country,

Seladang

There are, hopefully, more than 300 of these Wild Cattle left in Malaya (the Banteng is extinct in West Malaysia except perhaps for a few strays from the small stock surviving in South Thailand). However, these 300 are widely scattered and about 100 of them are faced with fairly rapid destruction of their favoured valleys, salt licks and mineral streams by flooding for hydro-electric and irrigation schemes.

The more lowland parts of the National Park and some other areas would seem ideal for managed reserves of Seladang. An attempt might be made to convert some to range cattle under partial domestication. The related Indian Gayal has been bred under such conditions. Ecological studies have begun and it is urgent that some constructive action be taken for these threatened animals.

Banteng

This is found in East Malaysia (where the Seladang is absent). Relatively little is known of its status. Perhaps because grassland has taken over from shifting cultivation quite high up in the hills of Sabah, e.g. on plateaux at 4,000 feet (1,200 m), Banteng have been reported at quite high levels as well as in valleys. Also the Banteng browses on leaves of shrubs and low hanging branches as well as grazing on grass.

Rhinoceros

The Javan One-Horned Rhinoceros was once found in Malaya, but what was probably the last one was shot in 1932. The entire world stock of this species is in Udjong Kulon Nature Reserve at the extreme western tip of Java in Indonesia.

The Sumatran Two-Horned Rhinoceros is the only species left in Malaysia. There are probably 20 individuals left in Malaya and a few may yet survive in Sumatra and Sabah. This species is definitely on the very verge of extinction, poached for its horn, denied living space and split up into small groups and solitary individuals. Although it enjoys legal protection, the penalties if caught, are still low compared with the possible profit to the poachers (the penalties are higher in Sabah than Malaya where they are ridiculously low), anyway poachers hope to get away without getting caught, and whether they are caught or not, the damage is done, a rare animal is dead. The first

need is to strengthen the Game Department so that adequate personnel are available to actually protect the known groups by-patrolling the reserves.

Valuable preliminary field studies have been made indicating its wide range from the swamps to the hills and food preferences. If protection is provided and funds and personnel follow, building on this foundation and showing a sense of urgency, it is possible that Malaysia will be able to save the Sumatran Rhinoceros as the Indonesians are doing for the Javan Rhinoceros.

Other Herbivores

The medium sized herbivores, Tapir (restricted to Malaya and Sumatra with related species in South America), Sambur Deer and Serow are all threatened to some degree. The Tapir fortunately goes quite high into the hills (4,000 ft. 1,200 m.) but its geographical range is contracting. It is now extinct in Borneo, although prehistoric remains have been found there. The Serow inhabits rocky limestone, but this is being quarried and the vegetation burnt. The Sambur Deer had suffered a decline, but a close season of some years followed by careful control of hunting is showing promising signs of restoring a good stocking with healthy age and sex structure. Therefore the largest herbivores are neither the only threatened species nor the only ones something can be done to save.

CHAPTER SIX

NATIONAL PARKS AND NATURE RESERVES

The idea of a National Park for the nation's recreation and to preserve the best of its scenic beauty is readily associated with that of a reserve to protect wildlife for the enjoyment of future generations. There are various immediate, practical reasons for maintaining a particular area undisturbed, for instance because it is a catchment important in the control of the water regime and the prevention of soil erosion in a large river basin. Undisturbed areas are needed as controls in experiments and studies in forestry and hydrology and on. the processes of soil formation and biological evolution. The preservation of the native fauna and flora for beneficial purposes such as animal and plant breeding, pest control and phytochemical investigation is another function of such reserves both now and in perpetuity. These areas become the natural centres for open-air recreation, the enjoyment of which is part of the heritage of all citizens and for which tourists and holidaymakers are willing to pay, so reversing the flow of money from the rural areas and the country. These parks and reserves can often be located on land which is unsuitable for other purposes, although combining several of the functions mentioned above and discussed at length in the earlier chapters.

In this chapter the planning, location, staffing, administration, management, legislation and public use of national parks, nature reserves and similar areas will be discussed rather than the need for such areas, because the various reasons for creating and maintaining them have already been detailed. National parks and the successful preservation of characteristic wildlife within them are a great source of national pride and satisfaction. Failure to assure adequate provision is a constant source of regret. All over the world this generation must assume its responsibilities in bequeathing the heritage it has received in a viable condition for the use and enjoyment of future generations. The greater pressures which threaten wildlife today are a measure of the sense of fulfilment which will be the reward of those who attempt and achieve these objects. In a new national and international, professional sense, none but the brave deserve the fair.

Past, present and proposed reserves differ in size, particular purpose and regulation. In general it is intended that the public should have access and should be able to follow those activities which do not harm the wildlife and other features protected in the reserve or which do not impair their enjoyment by other people. In certain circumstances, such as the breeding sites of rare birds, the exclusion of the general public is the only way to ensure that no harm or. disturbance to the wildlife defeats the object of the conservation programme; hopefully the status of the rarity will improve and the restrictions

may be relaxed for the benefit of an educated and appreciative public, but meanwhile certain strict sanctuaries will be required, which may be islands or similar isolated places, but more often will be an inner part of a larger park with normal access. Although undisturbed natural conditions are usually characteristic of national parks, there are cases where management is necessary to allow a greater stocking to be carried or conditions for breeding to be improved. Therefore portions of nature reserves may be modified under the control of the wardens.

Some types of reserves, especially some existing bird sanctuaries, contain very little natural vegetation; in the areas concerned birds and other wildlife are declared to be totally protected, this is to enable them to continue to use their favoured breeding grounds, examples include wet-padilands in Sabah, hill stations and a golf course in Malaya. In the case of fully protected birds (fully protected in the legal sense, not always alas in fact) which it is illegal to harm, kill or capture at any time of year in any part of the country, the whole country is in effect a reserve for them even if not very rigorously maintained. Therefore the legislation for the general protection of wildlife will be considered with that of the more definitive reserves.

Legislation

Wildlife is protected in Malaya, Sabah and Sarawak under Ordinances passed in 1955, 1963 and 1958 respectively. Their provisions cannot be described in detail and are not exactly the same in all three territories. Broadly they provide for animals (mainly mammals and birds are specified) to be classified as Totally Protected, Licensed or Game Animals and the rest. Those totally protected cannot be harmed, shot, trapped or kept in captivity. The Licensed or Game animals may be hunted or taken as cage birds for example during certain seasons and in certain places as specified on purchase of a license. The rest are not protected, except that wanton cruelty to vertebrates is usually punishable. It is permissible to kill even totally protected animals in defence of human life, crops or property. The onus is on the person killing such an animal to prove the justification. This leaves an obvious loophole in the law - the animal might be enticed on to the owner's property with the intention of killing it - the correct enforcement and interpretation of the law must rely upon the sympathy of the court, whether with the animal victim or the hunter (perhaps represented as a starving farmer) and will ultimately depend upon public opinion.

The penalties also vary between States and in some cases are unrealistically small by comparison with the profit of poaching or the incalcuable value of a rare animal. These laws also control the trade in wild life and their products, alive and

dead, by licensing taxidermists and dealers in game, skins, pets and cage birds. Lax enforcement of the law leads first to loss of revenue in licenses, thin loss becomes permanent if the game animals are exterminated by illicit hunting and trapping. Thus lack of enforcement leads to loss of wildlife, which is lost to everyone including the hunter, the poacher, the game warden and the ordinary citizen. So neglect leads to another extinct species, which is shameful in an enlightened society. Therefore to conserve both the wildlife and the revenue it can raise, proper observance and enforcement of the law are essential. Therefore the law must be amended to prevent abuses and the Game Departments (or equivalent authorities) must be adequately staffed and trained, so that the law may be properly implemented with the support of the government and people.

The first Game Reserve in Malaysia was gazetted in 1902, various game reserves, wildlife reserves, bird sanctuaries and national parks have been created since. Taman Negara, Malaya (formerly known as the King George V National Park) was formed in 1938. Bako National Park followed in Sarawak in 1957 and the Kinabalu National Park was constituted in Sabah in 1963. The three national parks were made under different ordinances. The various other reserves in Malaya were made as specific gazette notifications in most cases. Some have been rescinded and alienated for other purposes by further gazette notifications. In only the minority of cases have any staff been provided to patrol, watch and manage the reserves. The purpose of some of the reserves has been ill-defined and consequently they have been poorly managed for conservation. Some reserves have been to protect game animals mainly for the hunt.

New enactments are in preparation for West Malaysia. It is desirable that general legislation covering all parks, reserves and sanctuaries be drawn up using the best examples from East and West Malaysia and other countries as models. The practice of separate ordinances and notifications for each reserve has led to unfortunate, inadvertent omissions from the regulations of some of them. In some cases the Game Department and serious students are prohibited from making necessary collections for identification. However, undoubtedly the weakest feature of the existing legislation in West Malaysia is the ease with which reserves can be alienated by gazette notification and converted to other uses. It is essential that in future those reserves which are to be retained and the new reserves to be created should all be established by Acts of Parliament, so that their status would remain inviolate unless changed by another Act of the highest authority.

Location

In the attached table and accompanying notes the names and extent of the National Parks and similar reserves in

Malaysia are given. Those listed in the table are areas which are still almost entirely in their natural condition. The existing reserves cover 6.1, 1.1 and 0.02 percent of the total land areas of Malaya, Sabah and Sarawak respectively. A few reserves or parts of them in Malaya have ceased to serve any useful purpose and should be rescinded, especially as they would be better managed as forest reserves or converted to agriculture.

The respective authorities in East and West Malaysia (the Game Department in Malaya with the assistance of a Colombo Plan Advisor) have drawn up recommendations for adjustment of some existing reserves and proposals for new reserves. These are also given in the table. If these recommendations were . implemented in their entirety, the reserves and parks would cover 9.9, 3.6 and 0.75 percent of the land area in Malaya, Sabah and Sarawak. This proportion may seem large in the case of Malaya, but more than 20% of the country is more than 1,000 ft. (3000 m) above sea level and the amount above the 'steep land line' is even more. The 10% in existing and proposed reserves has been selected to occupy mainly uncultivatable land, where wildlife reserves, catchment areas and national parks are the best land use and will provide employment for people where otherwise ther would be none.

The smaller reserves and sanctuaries are mentioned in the notes. A new name of National Nature Monument is proposed for some of these in Malaya. This name has gained currency in many countries to mean small National Parks and Reserves which have been dedicated to preserve unique features or the best examples in the nation's characteristic wildlife and scenery. Batu Caves is an obvious choice for inclusion in this class, it has a rich flora on the limestone hill and an interesting cave fauna including some 'living fossils', it also has cultural significance, it is one of the few natural attractions in the environs of the capital city, much of the hill has been gazetted as a reserve for the public recreation since 1930, but without any definition of the protection to be afforded to the wildlife, the caves or the public, because parts have been rescinded and are now being blasted.

When Malaysia has the system of National Parks and nature reserves which its people and wildlife deserve, their future development for the conservation of wildlife and the provision of recreational amenities for their visitors must be assured.

Amenities

The present National Parks all provide some amenities to visitors. At Bako, Sarawak, these consist mainly of paths or trails

to enable the places of interest and natural beauty to be reached easily; there is a camping site and some accommodation. In the Kinabalu National Park, Sabah, there is a path leading right to the summit 13,455 ft (4104 m) - the highest between the Himalayas and New Guinea - with hut accommodation lower down and camping sites at suitable intervals all the way. Visitors may obtain pamphlets describing the more interesting wildlife which are likely to be seen. Taman Negara, Malaya, has several bungalows for visitors and a number of trails near the park headquarters. The path to the summit of Gunong Tahan 7,186 ft (2193 m) - the highest peak in Malaya which is within the park - is difficult for the ordinary visitor to follow. Rod and line fishing is allowed, but hunting of birds and animals is not permitted. There are hides by salt-licks, where it is sometimes possible to see and photograph Seladang and other wildlife.

However, many visitors to Malaysia's national parks are disappointed to see very little wildlife, this is particularly so in the Taman Negara, Malaya, where they expect to see Seladang at least and perhaps Tapir, Elephant and Deer. This disappointment discourages others from visiting and suggests to some that the park is failing in its purpose. The main reason why wild cattle are not more regularly seen is that the few remaining herds have become very nervous. Their present grazing grounds are near villages on the boundary of the park where they are molested by poachers. Total protection is an essential for wildlife, especially cattle and deer, to become tame enough for visitors to get close to them taking only normal precautions not. to scare them. Therefore the development of totally protected areas deeper in the park, which can be managed to increase the amount of fodder and to provide artificial salt-licks, watering places and cover, will serve two main purposes:- the preservation of the wildlife, and the provision of a spectacle for visitors.

Trails are necessary in every type of park, sign-posted as appropriate. Underwater trails for skindivers or vantage points for glass-bottomed boats should be indicated in submarine parks. Female turtles are very shy when they first come ashore to lay their eggs. Suitable shelters may be provided so that visitors may view in comfort without disturbing the turtles. Taman Negara already has some hides near salt-licks, this facility can be extended in various ways, for example in bird sanctuaries and similar areas. In swamps such as Tasek Bera, the hides must be approached either by boat or by raised pathways. A pioneer example of a platform high up in tree in Malayan rain-forest has revealed the fascinating world of the tree canopy, including various apes and many colourful birds, most of which are more active' by day than by night in contrast to the fauna of the forest floor. Naturally tourists will want something more secure than a ladder to climb up to their observation perch, but towers with stairways or even lifts at suitable locations should prove rewarding, both aesthetically to the visitors and financially to the operators.

Paths serve a dual function, they give access and also they guide and gently discipline the visitors. The casual tourist seldom strays far from the prepared route. As a result he is less likely to get lost and he is less likely to disturb features, plants and animals better left alone. One of the problems in Batu Caves for example is that there are no paths and all visitors to the Dark Cave get their footwear muddy. If there were dry paths which took them where they could see the spectacles without bringing them near to the feature themselves, the tendency of many visitors to damage the stalactites, mark the walls and to behave inconsiderately might be much reduced by the inconvenience of leaving the clean, safe and easy paths.

Suitable notices along the routes through the parks can draw the attention of the visitors to points of interest. These will be part of a much larger system of instruction through various media to stimulate interest in wildlife, pride in the. national parks, intelligent appreciation, responsible behaviour and general enjoyment. Illustrated notices, leaflets and guide books are well tried methods which will always find a place, but descriptions recorded on tape and films or filmstrips shown either at park headquarters or in schools or on television in advance preparation for a visit will play an increasing role. Museum displays at park headquarters help too. Finally the value of well trained guides versed in their subject among the park personnel, wardens and rangers to share enthusiastically their knowledge and so help others Can never be over-estimated. This intensifies the satisfaction of career staff as well as of visitors.

Other amenities, which are necessary in national parks or close to national nature monuments, include accommodation and refreshment facilities. There is need for a range from simple hostels, camp and picnic sites to hotels and restaurants suitable for the more elderly, comfort-loving tourists from overseas who can afford to pay more. The pride in their country developed among youth by spending holidays out of doors in national parks is a far better long-term investment than the immediate gains in tourists' money, attractive as the latter may be. Many other national characterisitcs may be dispalyed for tourists or encouraged among youth in association with national parks. For example typical local food and genuine national dishes, well prepared but served in a traditional manner prove an enjoyable experience which is frequently lacking in the more common types of tourist resort. Youth camps and hostels provide an agreeable background for the spontaneous enjoyment of national sports, songs and dances, so perhaps relieving racial tensions.

The provision of these amenities provides work for rural people. In many countries the local handicrafts - sometimes utilizing natural materials - sold in association with national parks are more pleasing artistically, more faithful to local

designs and useful than the stereo-typed souvenirs sold in towns, at airports and hotels all over the world. The considerations should always be kept subsidiary to the main purposes of national parks which are to conserve wildlife, natural resources and beauty. Nevertheless, national parks can be developed as profitable enterprises and as centres for the revival of national pride, traditional crafts and pastimes.

Sport

Wherever there are suitable lakes or rivers, parts can usually be set aside for swimming and sometimes for boating. Controlled fishing by rod and line can often be allowed as an attraction without disturbing the wildlife as a whole. However, hunting, even licensed and strictly controlled, requires very careful consideration. Hunting by aborigines using their traditional primitive traps and weapons, such as bows and arrows, blow-pipes and darts, may be regarded as part of the natural complex and there is a case for protecting their ancestral rights to hunt game for food by such methods, which are not a serious threat to most endangered species. However, such concessions must be carefully supervised that potentially more destructive methods such as steel traps, luring with power lamps, and firearms are not substituted for the primitive, more skillfull means of limited effect. Moreover new demands for wildlife taken by aborigines, such as captive animals for dealers or trophies for tourists, cannot be allowed to erode the purpose of nature protection. In other words, hunting by aborigines must forfeit any special concessions and become subject to the same universal controls if their hunting ceases to be aboriginal.

The concessions to aborigines must be carefully defined, both within and without national parks. Owing to the reduced area available to wildlife and aborigines due to modern land development, there can be no concessions at all for the hunting of totally protected animals which are endangered species 01 for any hunting at all in the strictest wildlife sanctuaries for the preservation, breeding and rehabilitation of threatened animals, because freedom from all disturbance is essential in these areas. Often the aborigines who have lost their hunting rights may be found new employment as game wardens and park rangers.

Aborigine's hunting rights constitute a special case wherever practised. Usually conventional hunting and shooting must be prohibited in national parks and nature reserves. Normally animals should be taken only on other land, for example forest reserves or in agricultural areas, under licence and with proper respect to close seasons and the age and sex limitations placed on the number of animals which may be killed. If a national park or wildlife reserve is successful in raising and maintaining a heavy stocking of pig, deer or even wild cattle, these may well develop a situation where selective culling is necessary to maintain a desirable age and sex composition of the animal populations. This culling can provide much needed meat especially as protein is one of Malaysia's most important growing dietary deficiencies. Sale of meat will yield revenue.

This revenue may be further increased by licensing the culling to private hunters, however, this can be a dangerous procedure in national parks. There is a greater risk with private hunters that ordinary visitors may be injured or killed than is so when only game wardens are employed. Moreover, there is a risk of undermining the principles of administering reserves by allowing progressively greater disturbance of all the wildlife as well as the game and by hunting gradually obtaining greater significance than wildlife conservation. The emphasis may change to managing the park primarily to raise game for hunting instead of protecting wildlife for ordinary visitors to see and enjoy. Therefore, although the extra revenue may be attractive, it would be better to organize the park in the interest of the majority of visitors and to raise revenue by other means without undue reliance on hunting licences.

The experience gained in management of game, including culling, in national parks and nature reserves may well be used profitably in the maintenance of maximum meat production in forests and other areas, where the shooting may more reasonably be licensed to hunters. In this way, the national parks become the outdoor laboratories to increase the exploitation of this natural resource. They are the laboratories for many other experiments in ecology and natural history; this service to students, amateur and professional, trainee and expert, is one of the great public amenities of nature reserves.

Administration

The planning of a national park system and the management of nature reserves to preserve the wildlife and landscape of Malaysia for enjoyment by the people will require a changed emphasis in the functions of the Game Department in West Malaysia and an expansion of the activities of the appropriate authorities throughout Malaysia. Hitherto, various authorities have been concerned with conservation in the different states of Malaysia, primarily the Game Department in Malaysia - although previously more attention has been given to the destruction of supposedly dangerous animals - and the Forest Department and Department of Irrigation and Drainage have been important in conservation of habitats and water resources. In Sabah, the recently formed Game Branch is part of the Forest Department, whereas in Sarawak the small National Park and the Turtles Board have arisen through the agency of the Museum. Marine turtles are under the protection of the Fisheries Department in West Malaysia. Although uniformity of organization and legislation in all states of Malaysia might improve efficiency by reducing confusion, such uniformity of the government agencies concerned is less important than ensuring that the best features of previous experience, research, organization and legislation in all states of Malaysia and indeed elsewhere are combined and applied throughout the country.

A comprehensive system of national parks, nature reserves and wildlife conservation requires staff of various kinds knit into one organization. The central administration must undertake the overall planning of the service and the routine arrangements of staff recruitment, training, promotion, leave and social security and of financial matters, both regular expenses - including the staff's pay – and the costs of development. The higher administration under the director and chief conservators is responsible to the government and for liaison with other departments, museums, institutes, universities, schools and private organizations such as the Nature Society. Inevitably, even an "outdoor" department requires office work to draw up policies, programmes, estimates and reports. The government requires a careful account of expenditure and revenue. It is advisable for an assessment to be made of indirect revenue from tourist accommodation, sales and services by local people to visitors. This helps to maintain a true perspective of the contribution of national parks to the country's economy.

The field staff, usually divided into senior staff called wardens and junior staff called rangers, have several duties. Firstly, they are responsible for enforcing observance of the legislation concerning wildlife throughout the country as well as in the national parks. The parks, reserves and sanctuaries must be patrolled sufficiently frequently to exclude poachers. Where licensed shooting and fishing are allowed, there must be checks that the proper fees are paid and restrictions on the kill or catch in size or season are obeyed. Sometimes farms, animal dealers and ordinary residences must be visited, armed with a warrant if necessary, to recover animals which it is prohibited to keep in captivity or for sale. Secondly, the field staff must maintain the parks and manage the wildlife. This includes clearing paths, erecting and repairing bridges, signposts and hides as far as the physical amenities are concerned. The management of wildlife will require censuses of their numbers, modification of the habitat for example by cutting shrubs, culling too large or over-aged populations, as well as the general protection of the wildlife. Occasionally, the field staff may be called upon in their traditional duty as the destroyers of crop-raiding, cattle-killing and other dangerous animals, alternatively a special control officer may be appointed to apply the best methods in each case. The field staff may also act as guides and instructors for visitors to the parks, or this role may be deputed to specially trained staff.

The field staff are professionals but not necessarily scientists. A scientific or research branch is necessary to investigate improved methods of conserving wildlife and raising its productivity where appropriate. The research branch must keep a constant watch on the stocking of important species as reported in the censuses by the field branch, in order to interpret the effect of management methods and to be alert to any threat due to either a dangerous decline in numbers, perhaps caused by disease, or to an excess which might exhaust the food supply. The research branch must be prepared to advise the field branch what to do in these circumstances or know how to design a suitable investigation if the problem is a new one.

The research staff will usually have had advanced training at university or institutional level in biology, ecology, wildlife management or veterinary science. Research is needed to save rare species, to increase stocking in parks, to enable visitors to enjoy wildlife without disturbance, to control wildlife humanely where they are pests of agriculture especially by deterring rather than by destroying them. Immobilization techniques need study so that rare animals can be moved safely, this might be applied to securing pest animals for zoos or moving them where they can do no harm instead of killing them. The minimal areas for the survival of biological communities, plant and animal species, the movements of migrants, breeding seasons and many other ecological problems must be investigated, some of which have been mentioned elsewhere in this volume.

Central research stations are needed, at least one each in East and West Malaysia. The central research stations will require various laboratory and library facilities, but it may be necessary to supplement these by access to the more extensive facilities available in universities and other research institute, for example in agriculture, forestry and medicine. Therefore, the central research stations must probably be located near state and federal capitals or other centres of learning. They should not be too far distant from the administrative headquarters, or better combined with them. However, many of the actual experiments must be carried out in the parks and reserves. Therefore, parts of the parks may be set aside for research and in any case appropriate accommodation for research work and staff must be provided in each park. Sometimes a room as an office in park headquarters and a room to sleep in at the hostel are all that is necessary if the investigations can be handled by occasional visits by the research officer. In other cases, one or more research officers in permanent residence with a branch laboratory attached may be necessary.

The national park service and wildlife conservation department should provide two types of instruction. Firstly to train their own personnel in particular the rangers, and secondly to educate the general public to understand wildlife and enjoy natural beauty, so leading to a greater appreciation and respect for their value. Departmental training should include both theory taught in a school set up in conjunction with the research station and practice demonstrated in the parks and reserves themselves. The education of the public is threefold, firstly by visits to schools, universities, nature societies, rotary clubs and other groups where films and exhibits may be shown and talks given, secondly by publications and provision of material to mass media, radio, television and the press, and finally by assisting the public to learn about nature in the parks, either by static displays, signposts and descriptions which every casual visitor may use or by guided tours and courses more appropriate for larger groups especially of young people. Education in the enjoyment of wildlife and pride in the country, leading to an understanding of the need to conserve natural resources and to save the environment from pollution, is vital for the future of the national park service, the nation itself and all mankind. Therefore, at least one education and

public relations officer, who has specialized in these subjects, is needed and in time an education branch, independent under the director or in conjunction with the research branch, will probably prove essential.

The national parks and wildlife conservation service will eventually offer careers to a wide range of staff with different backgrounds and levels of education. Aborigines, the traditional dwellers in the forests and hills where most of the parks will be situated, will find more congenial work than perhaps the towns afford. There will be need for guides, boatmen, cooks, rangers, wardens, scientists and many others. Eventually, the departments concerned may rise from their relatively minor status at present to take pride of place in service to the nation.

CHAPTER SEVEN

CONCLUSIONS

This volume opens with an account of the climate in Malaysia showing that two great renewable natural resources - sunshine and rain - are relatively abundant. The high potential productivity due to plentiful sunshine can only be realized by the wise use of water. As well as using the water in agriculture, industry and for domestic needs, it must be safely conveyed to the sea without Causing floods or eroding away the soil.

The soil is the medium in which most of our crops are grown and so obtain the bulk of our food. The soil is a natural resource, renewable under wise management but easily lost if misused. The allocation of land for various uses - different kinds of agriculture, forestry, mining, catchment or wilderness - according to its soil type and topography so that the most suitable areas are utilized for each purpose is one of the basic steps in national planning and conservation practice. However, after correct allocation it is still necessary to actively preserve the soil from erosion. Several practical measures have been discussed following a review of the main soil types in Malaysia.

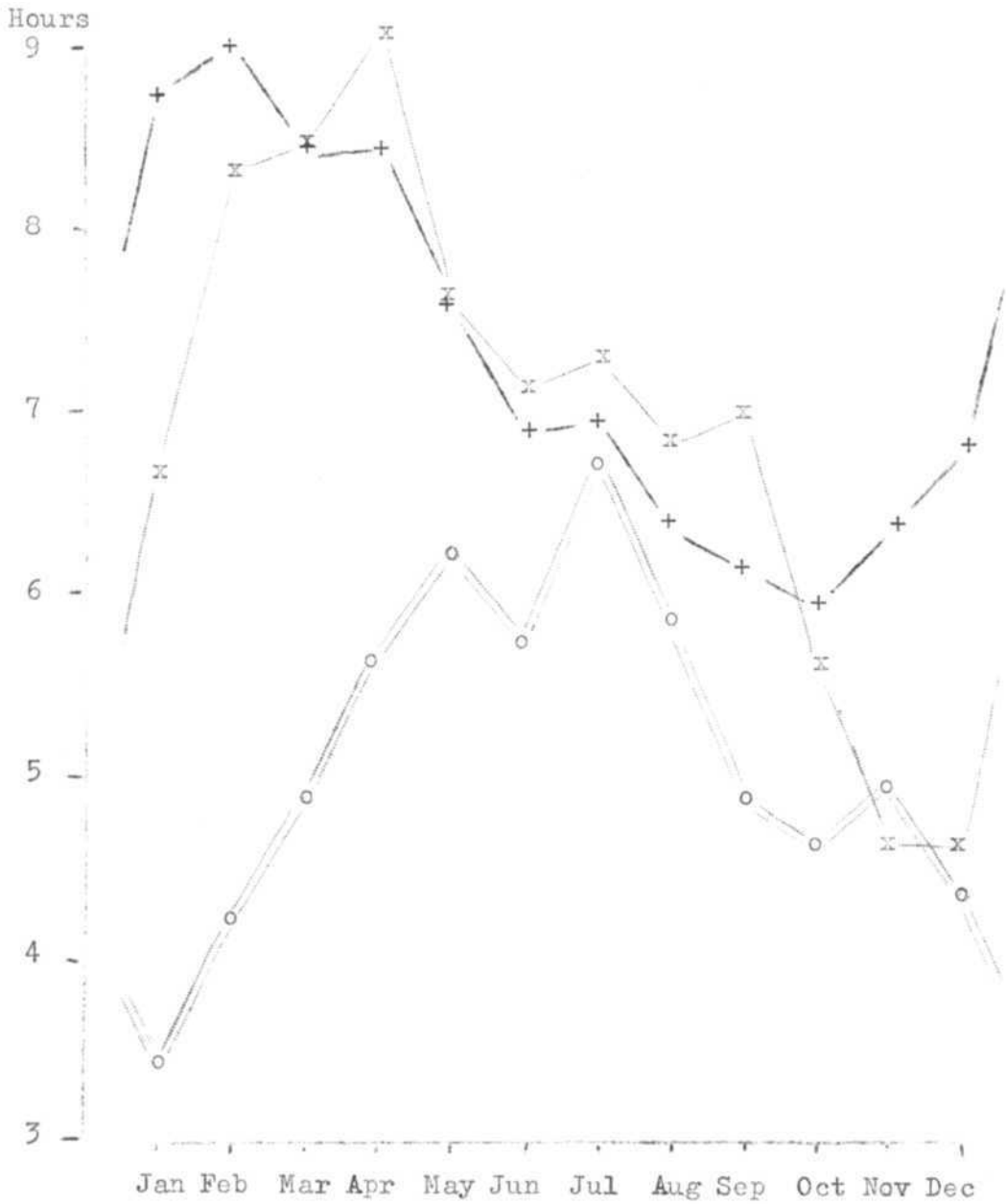
Agriculture is the means of using sunshine, rain, soil, plants and animals to produce most of our food. These individual components must be conserved and the system as a whole kept in balance. Modern weapons against pests - weeds, fungal diseases, insects and other animals which compete with the crops or with man in his consumption of them - consist of powerful chemicals. Their use does not only restore the balance in favour of man and his crops, but owing to their power and persistence - especially of some insecticides - may cause widespread effects which overthrow the balance and create new problems. Therefore, integrated methods of pest control are sought, which combine less dangerous chemicals with natural biological control and cultural modifications. These integrated methods may prevent resistance to pesticides appearing, which is a serious disadvantage of many synthetic chemicals, through the variety of attacks launched on the pests. Natural biological controls and resistance to pest and disease reveal a contiunuing dependence of agriculture on wildlife resources.

Thus the conservation of agriculture itself depends in part on the conservation of wildlife. There are known, and also presumably as yet unknown, natural resources of significance in medicine and pure science, which can only be saved by the preservation of as wide a range as possible of species of living things in their natural habitats and biological communities. The latter are reviewed as characterized by their typical natural vegetation. The wildlife is considered by the main habitats in turn, mentioning those species which seem to be most seriously threatened with extinction and the causes for their critical condition such as habitat destruction, pollution, over-collecting and excessive hunting.

Finally, the needs to conserve water, preserve wildlife, retain beautiful scenery and to provide for the growing requirements of an increasingly urban population to have some wilderness areas for recreation, relaxation and enjoyment are brought together in a review of Malaysia's present system of national parks, nature reserves and legislation to protect wildlife and proposals to improve these in future. National parks and nature reserves can be developed with suitable amenities and so become valuable assets, primarily to conserve the landscape, soil, water and wildlife, and in addition to provide revenue from tourists, work for local people, recreation for youth and sometimes meat by hunting and fishing, and finally to assist in education and nation building.

The development of national parks and wildlife conservation in Malaysia will come about by national planning. In West Malaysia, land utilization is planned through the Land Capability Classification, which is a branch of the Economic Planning Unit in the Prime Minister's Department. The Malaysian National Committee for the International Biological Programme (IBP) has also been established under the auspices of the Land Capability Classification. The IBP has seven sections, of which that for the Conservation of Terrestrial Biological Communities (Section CT) is concerned here. The Malaysian CT committee consist of representatives of the following organizations responsible for various aspects of conservation or interested in its promotion: the Economic Planning Unit and the government Departments of Agriculture, Forest, Game, Irrigation and Drainage, Museums, the School of Biological Sciences, University of Malaya, the Malaysian Scientific Association and the Malayan Nature Society. The Department of Fisheries is concerned with marine conservation and is thus not on the committee for terrestrial conservation. Important contributions to conservation in plantations have been made by the Rubber Research Institute and by the private research stations. The corresponding bodies in East Malaysia have been active in the cause of conservation, in particular the Forest Departments and the Museums, the Sarawak Museum being one of the older institutions of this nature in Malaysia. The Sabah Society promotes studies of all cultural and natural historical subjects in Sabah including conservation. The Botanic Gardens and National Museum, Singapore, have always taken an interest in conservation of the whole region although not situated in Malaysia itself.

The leading position of the Economic Planning Unit (Prime Minister's Department) in Land Capability Classification, its participation in the IBP, CT Section and the arrangement for a Colombo Plan specialist to visit and advise on national parks and wildlife conservation in West Malaysia, are all indications of favourable circumstances for the adoption of progressive proposals in these respects. There is of course vigorous competition for various areas of land between rival potential uses and for the funds available to finance utilization and conservation. Nevertheless, despite the very large areas which have been, are being and will be converted to agriculture, there are good prospects that well prepared cases for conservation will be incorporated in the national plans. In Malaysia, as in many other parts of the world, it is not merely a question of lobbying the government to legislate measures for conservation and to vote funds for development of national parks, but for all who believe in the principles of conservation to assist in preparing a reasoned case and in encouraging the people as a whole to understand and implement conservation as an expression of pride in their homeland and in order to hand on to future generations a heritage of beauty, interest and enjoyment in an unpolluted environment.



MONTHLY VARIATION IN MEAN HOURS BRIGHT SUNSHINE PER DAY (1957-61)

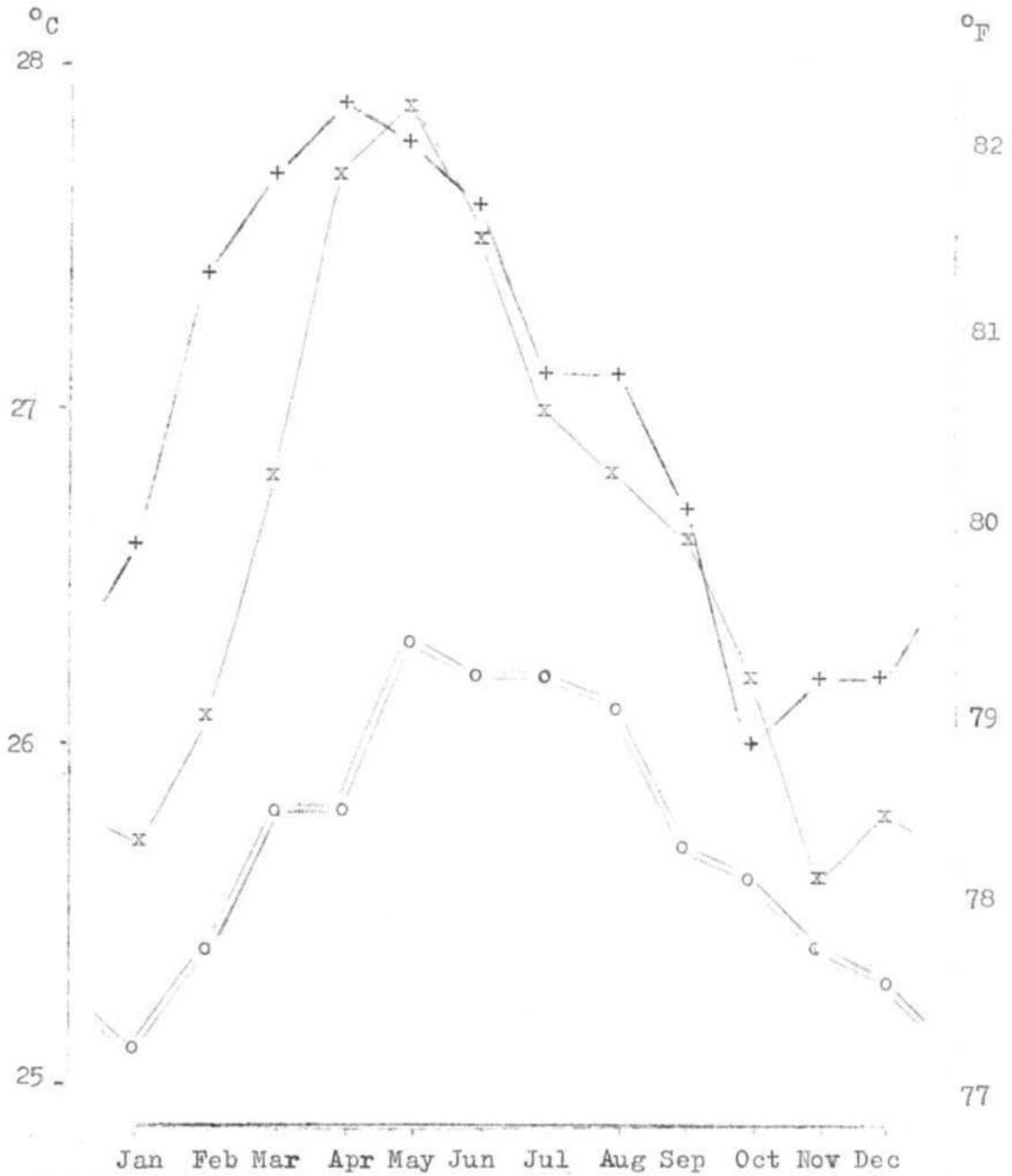
+ — + = ALOR STAR 6° 12' N, West Coast Malaya, cycle in advance

x — x = KOTA BHARU 6° 10' N, East Coast Malaya, two months later

o — o = KUCHING 1° 29' N, Sarawak, cycle latest of all in year

Other lowland stations in Malaysia show similar variation in solar radiation throughout the year according to whether they lie on an east or west coast.

Figure 1.



VARIATION IN MONTHLY MEAN TEMPERATURE (1957-61)

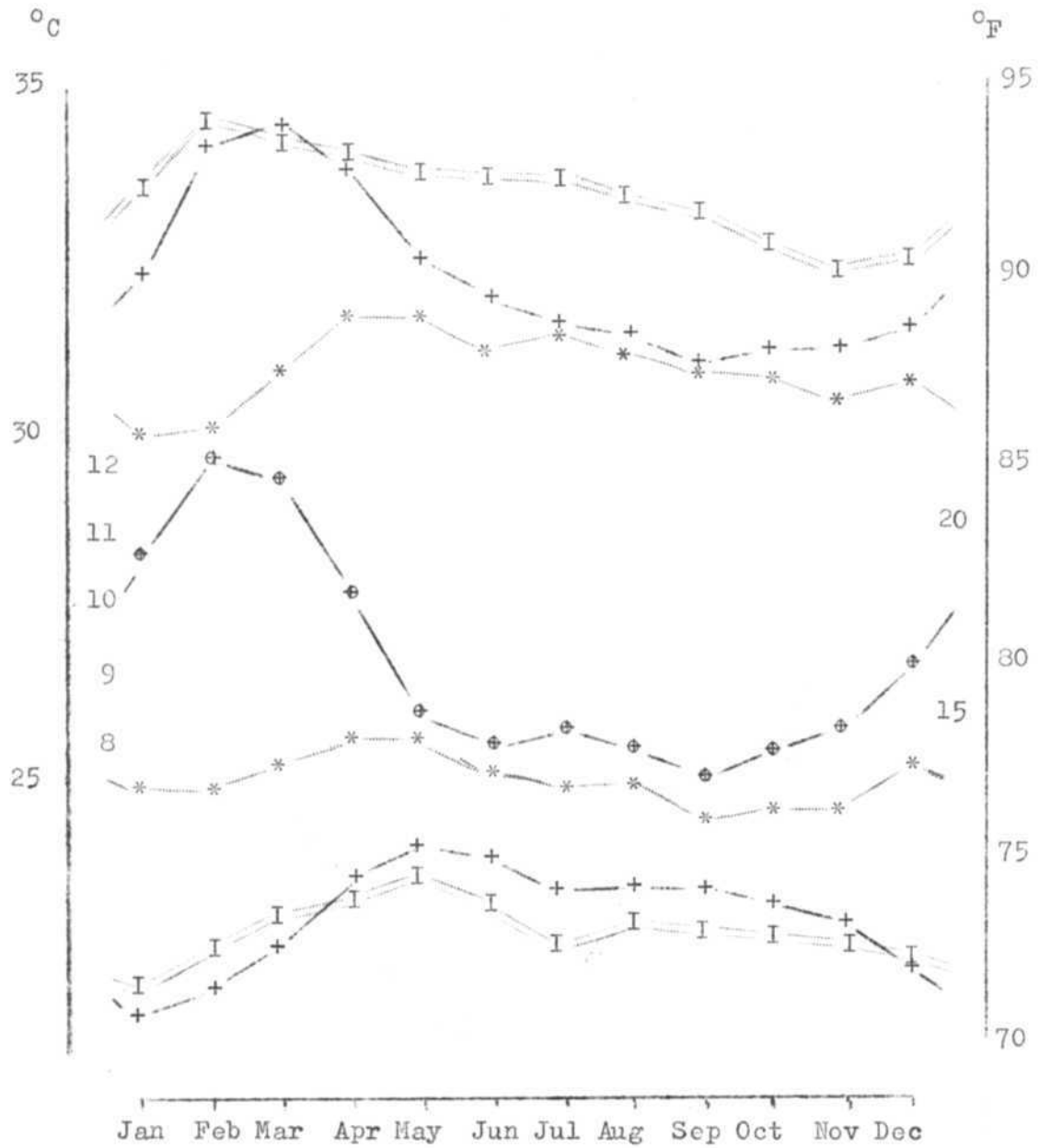
+ —— + = ALOR STAR 6° 12' N, west Coast Malaya

x —— x = KOTA BHARU 6° 10' N, east Coast Malaya

o —— o = KUCHING 1° 29' N, western Sarawak coast

Most lowland stations in Malaysia show mean temperature cycles like those at Alor Star and Kota Bharu - a little behind the sunshine cycles. Most are intermediate between the examples illustrated here.

Figure 2



MONTHLY VARIATION IN MEAN MAXIMUM AND MINIMUM TEMPERATURES (1957-61)
Upper and lower curves respectively, outer scales

+ —— + = ALOR STAR 6° 12' N, cycle of maximum temperature slightly later than that of sunshine, minimum lagging behind later

I ═══ I = IPOH 4° 34' N, inland west coast Malaya, wide daily range

* —— * = LABUAN 5° 18' N, island off Borneo, narrow diurnal range

MONTHLY VARIATION IN MEAN DIURNAL TEMPERATURE RANGE (1957-61)
Central curve and inner scales

⊕ —— ⊕ = ALOR STAR 6° 12' N, similar cycle to that for sunshine

Figure 3

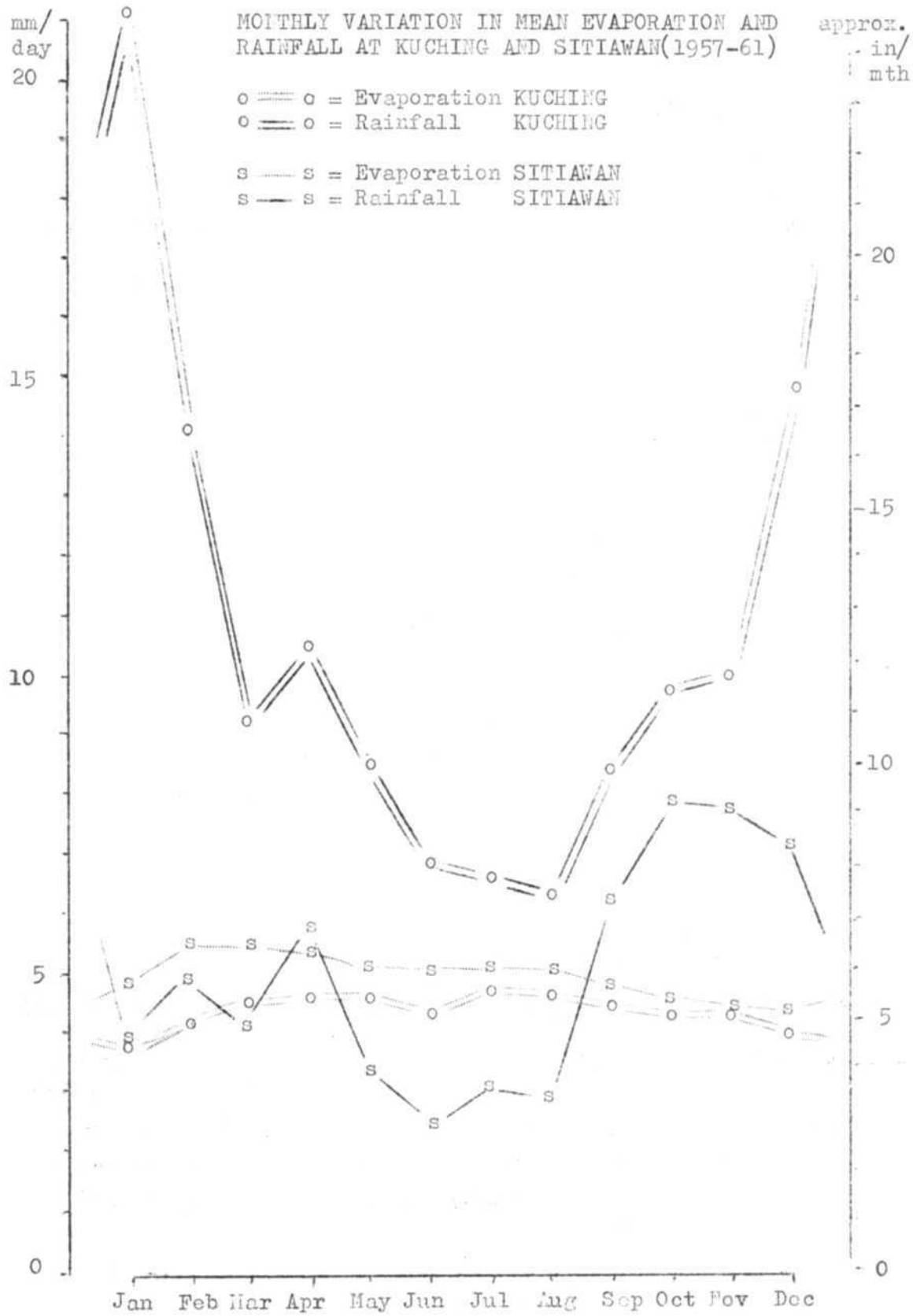

MONTHLY VARIATION IN MEAN EVAPORATION AND RAINFALL AT KUCHING AND SITIAWAN(1957-61)
o = o = Evaporation KUCHING
o = o = Rainfall KUCHING
s = s = Evaporation SITIAWAN
s = s = Rainfall SITIAWAN
mm/day
approx. in/mth
20
15
10
5
0
20
15
10
5
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

Figure 4

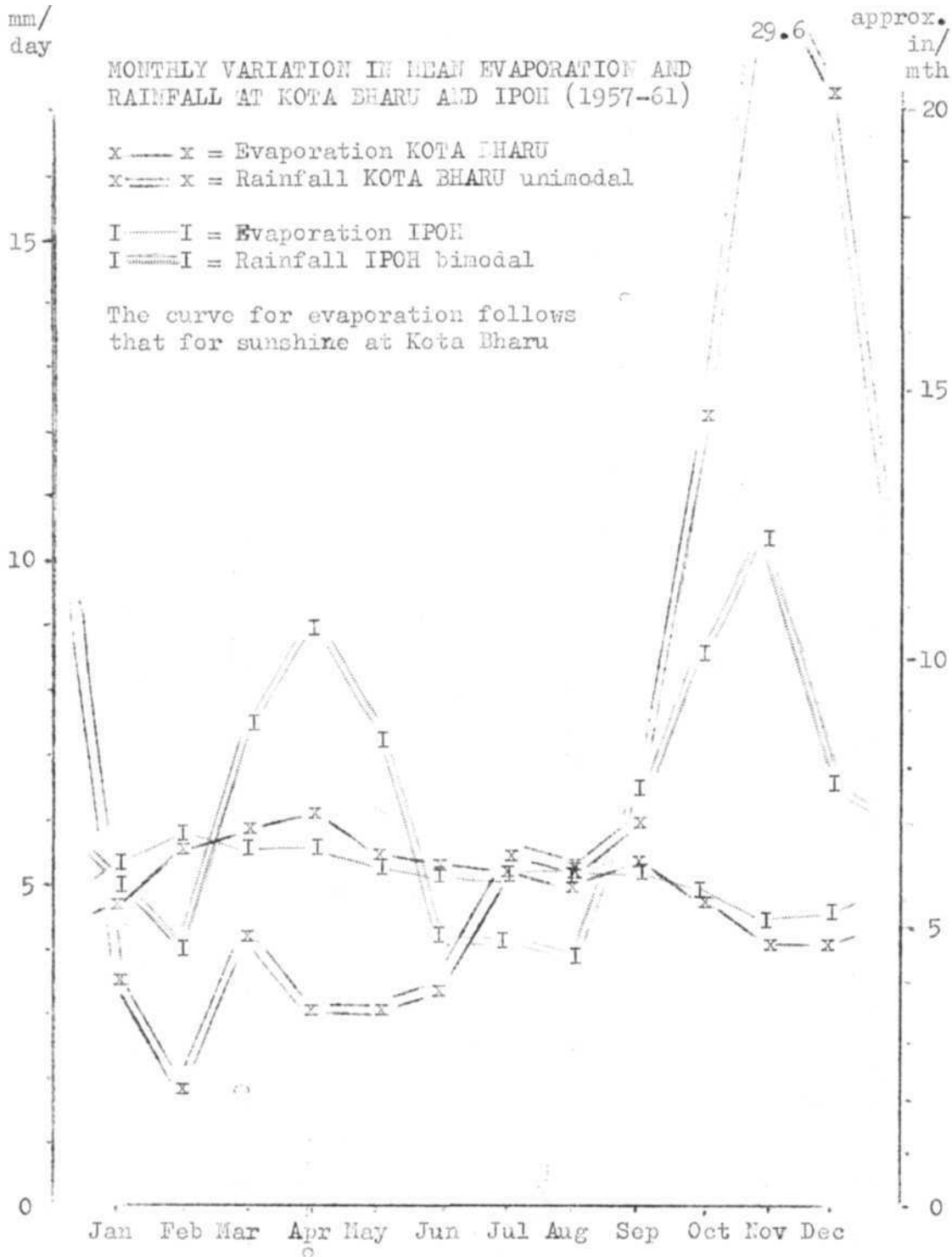

mm/
day
approx.
in/
mth
29.6
MONTHLY VARIATION IN MEAN EVAPORATION AND
RAINFALL AT KOTA BHARU AND IPOH (1957-61)
x —— x = Evaporation KOTA BHARU
x = x = Rainfall KOTA BHARU unimodal
I —— I = Evaporation IPOH
I = I = Rainfall IPOH bimodal
The curve for evaporation follows
that for sunshine at Kota Bharu
0
5
10
15
20
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

Figure 5

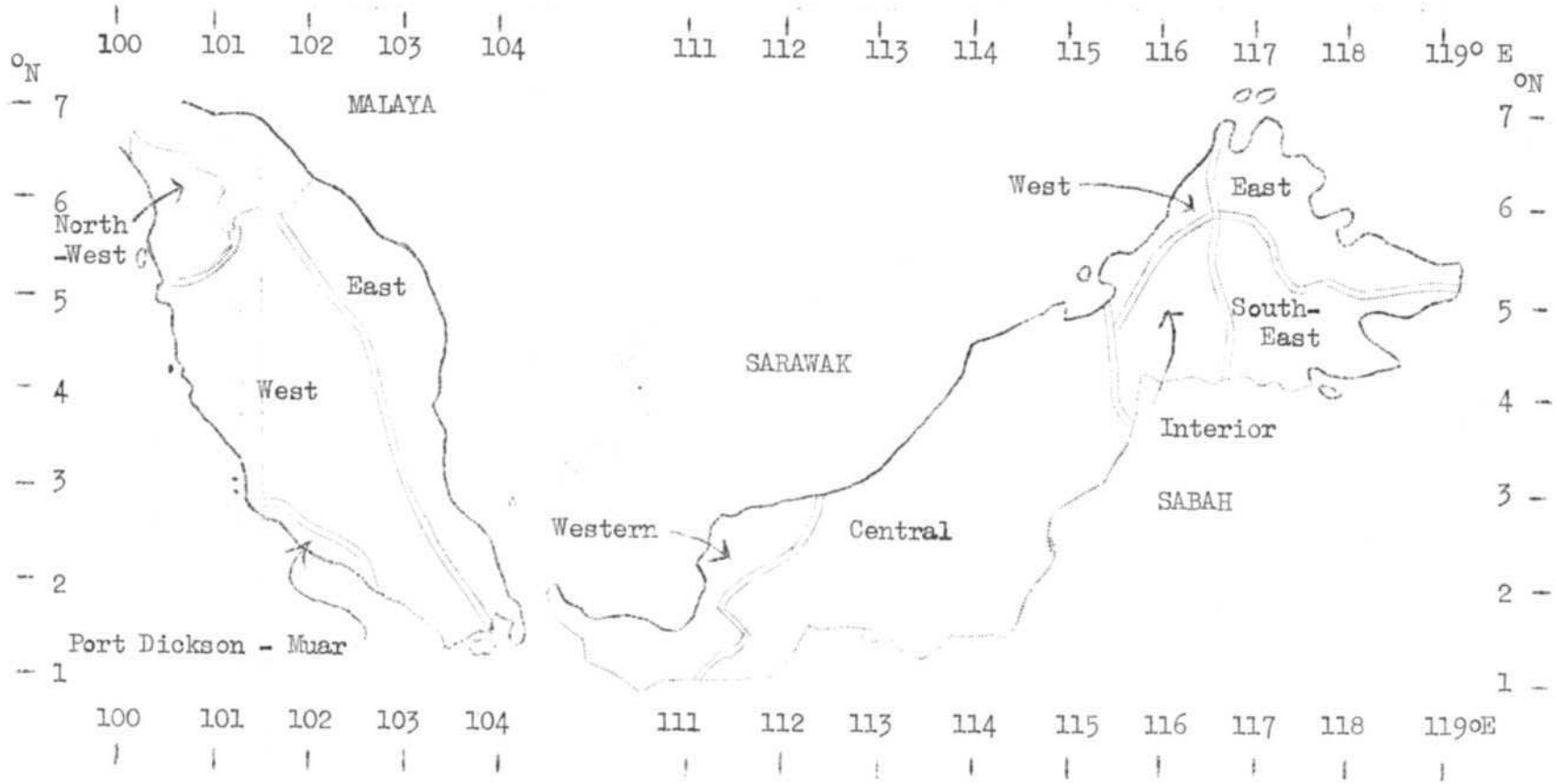
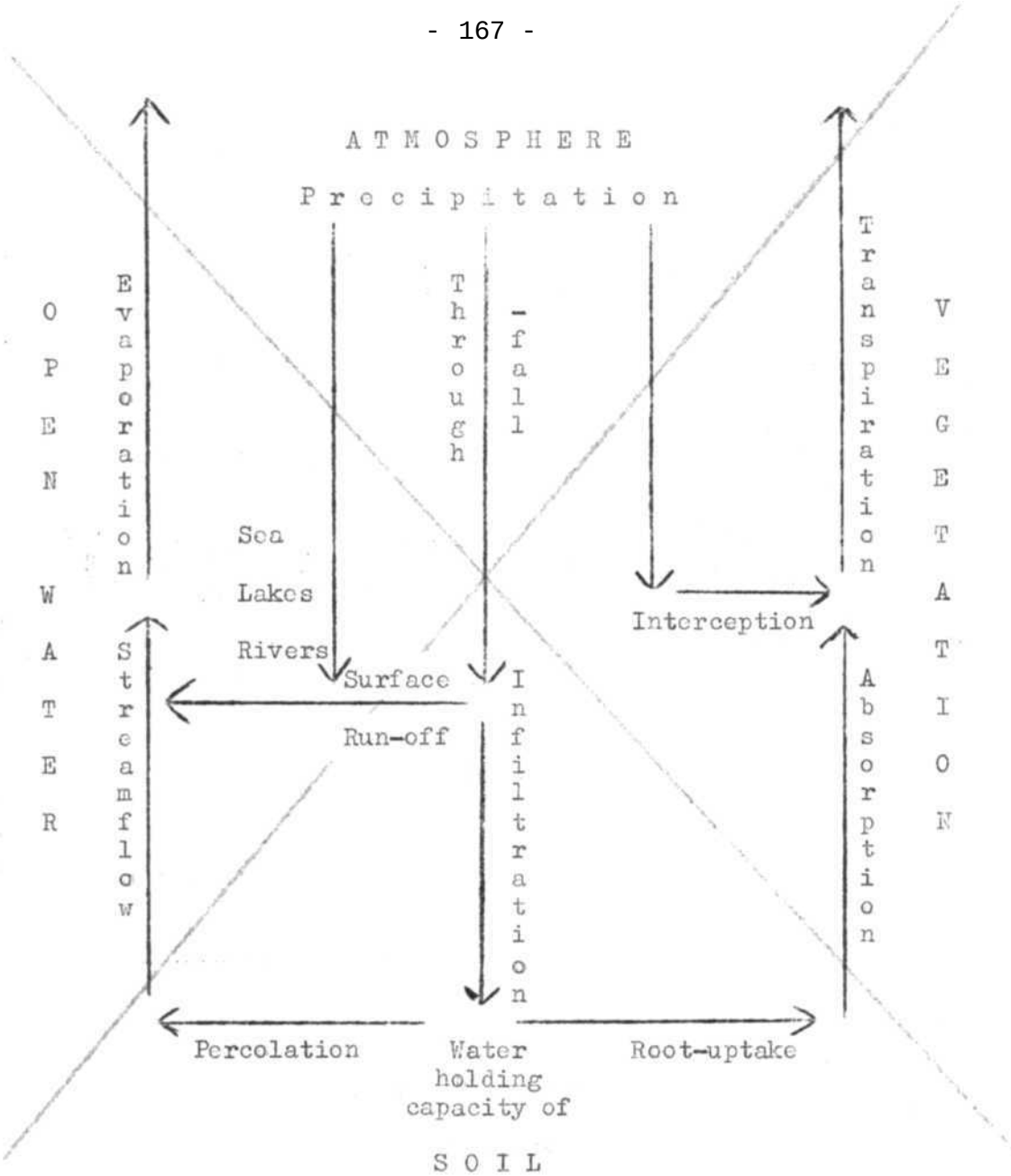
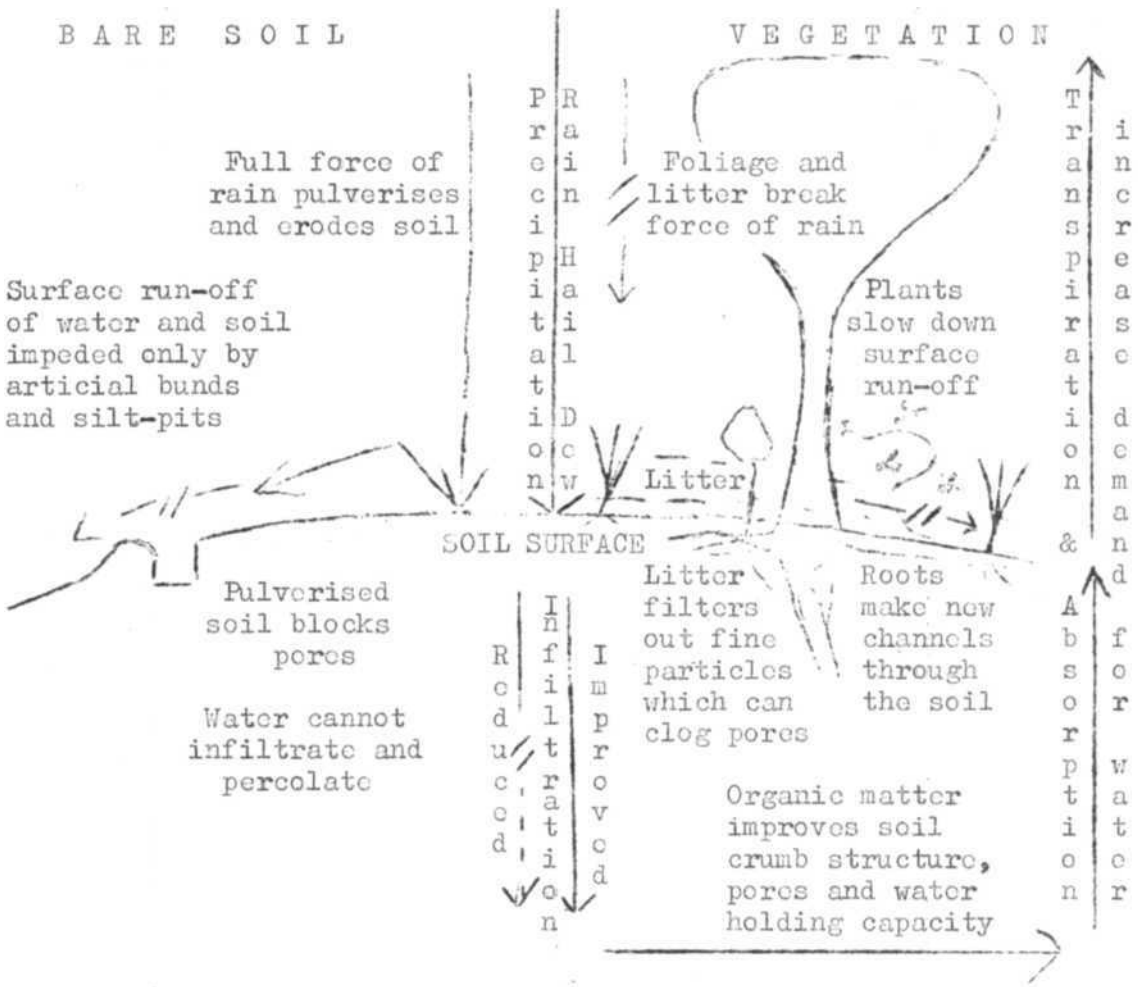


Figure 6 RAINFALL REGIONS OP MALAYSIA



The hydrological cycle or the circulation of water on the Earth

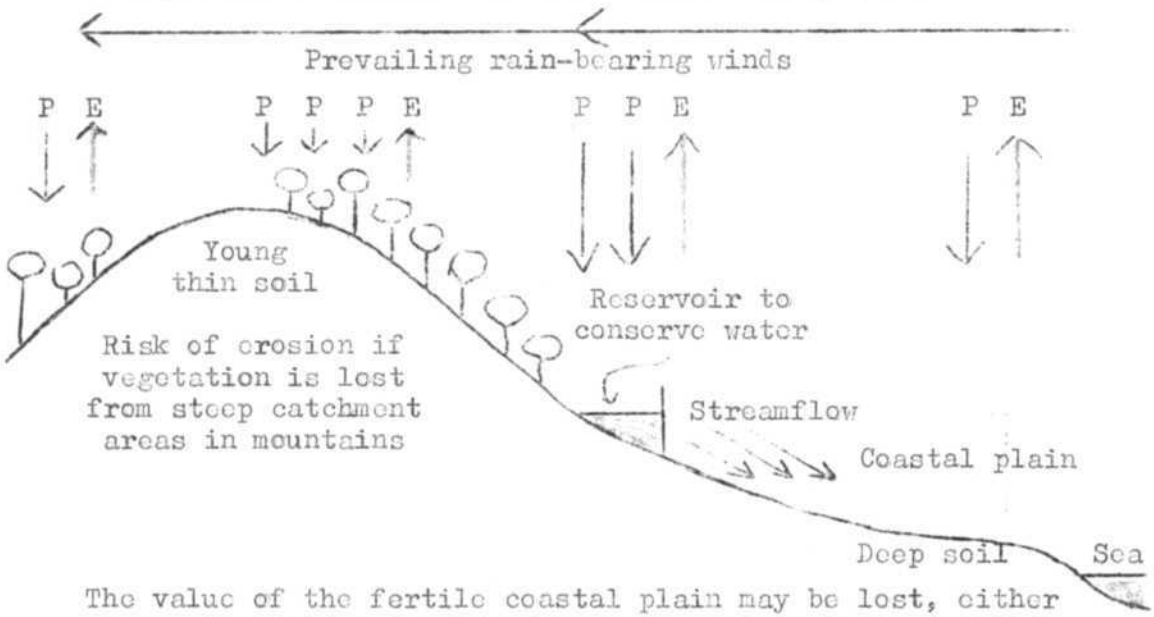
Figure 7



Comparison of the effects of bare soil and vegetation on the rates of infiltration, run-off and erosion

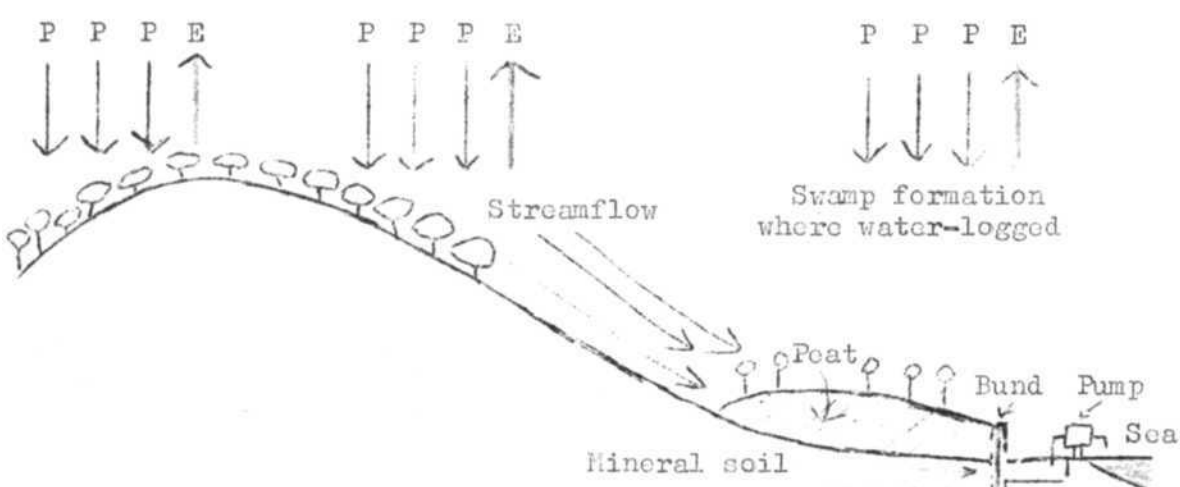
Figure 8

A TYPICAL 'HYDROLOGICAL LANDSCAPE' IN MALAYSIA WHERE THE PRECIPITATION (P) EXCEEDS THE EVAPORATION (E) ON THE WINDWARD SIDE OF THE MOUNTAINS, BUT PRECIPITATION BALANCES EVAPORATION IN THE FERTILE COASTAL PLAIN



The value of the fertile coastal plain may be lost, either by flooding if riverflow becomes uncontrollable, or due to seasonal shortages of water, if the excess in the hills is not conserved. Protection of soil by vegetation is needed in the hills to control the flow and conserve the water.

MALAYSIAN HYDROLOGICAL LANDSCAPE WITH AN EXCESS OF PRECIPITATION (P) OVER EVAPORATION (E) THROUGHOUT



Swamp formation occurs in the coastal plain, clearing the peat down to the mineral soil level may give rise to problems of drainage and flood prevention owing to the excess water falling on and flowing into the area Either use pumps and bunds or retain forestry usage.

Figure 9

PROFILE OF A RENGAM SERIES SEDENTARY
SOIL DERIVED ON SITE FROM GRANITE

A_1 Topsoil stained dark by organic matter for 3 cm under forest, deeper under cultivation

A_2 Brownish-yellow sandy clay loam, some mica, subject to leaching

B_2 Gradual transition, mottled yellow-red, at 1 - 2 m depth, to pale red, accumulation zone

B_3 Mixed soil and rock fragments

C Weathered parent rock, granite, sometimes decay of rock evident to as deep as 10 m.

PROFILE OF A SELANGOR SERIES COASTAL ALLUVIAL SOIL

A_1 Topsoil stained dark brown with organic matter upto depth of 10 cm

A_2 Dark grey brown silty clay, friable where aerated by roots, subject to leaching

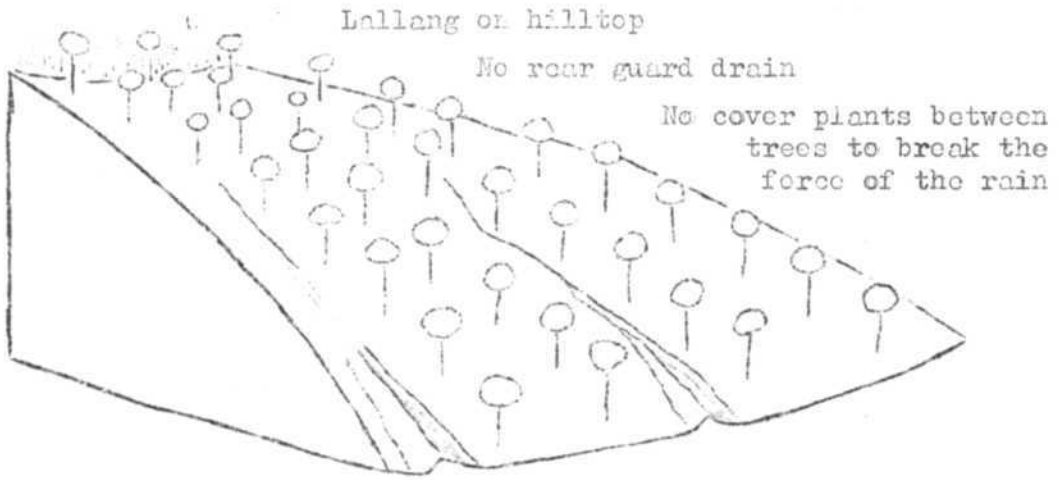
B_2 Yellow and rusty brown mottling at 60 cm depth, clay, poor structure, accumulation zone

C Blue grey slimy, silty marine clay, water-logged from depth of 1 m unless drained, smells of sulpherous products.

SOIL PROFILE DIAGRAMS TO SHOW THE HORIZONS IN TWO COMMON SOILS

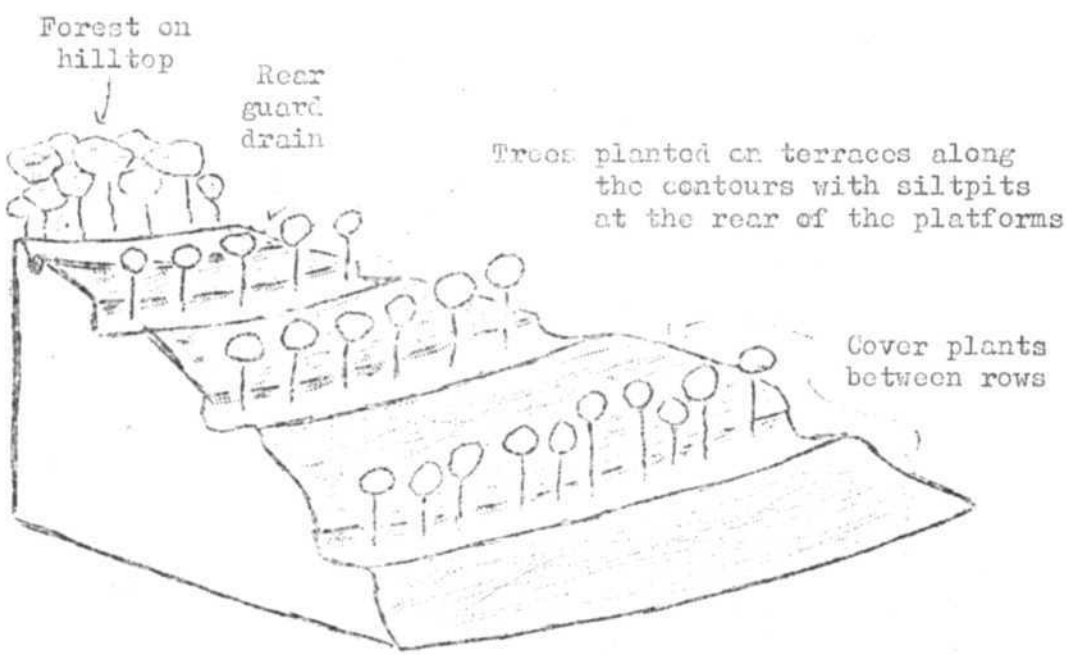
Figure 10

AN UNPROTECTED PLANTATION ON A HILL SLOPE LOSING WATER AND SOIL



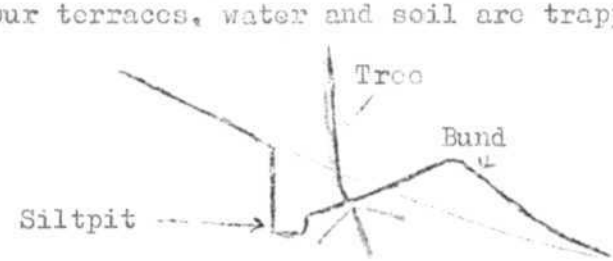
Tree rows run up and down hill, water runs unimpeded downhill scouring out gullies and carrying off topsoil

A PLANTATION ON A HILL SLOPE USING METHODS TO SAVE SOIL AND WATER



The force of the rain on the soil surface is broken by the cover plants, the flow of water downhill is broken at regular intervals by the contour terraces, water and soil are trapped by siltpits.

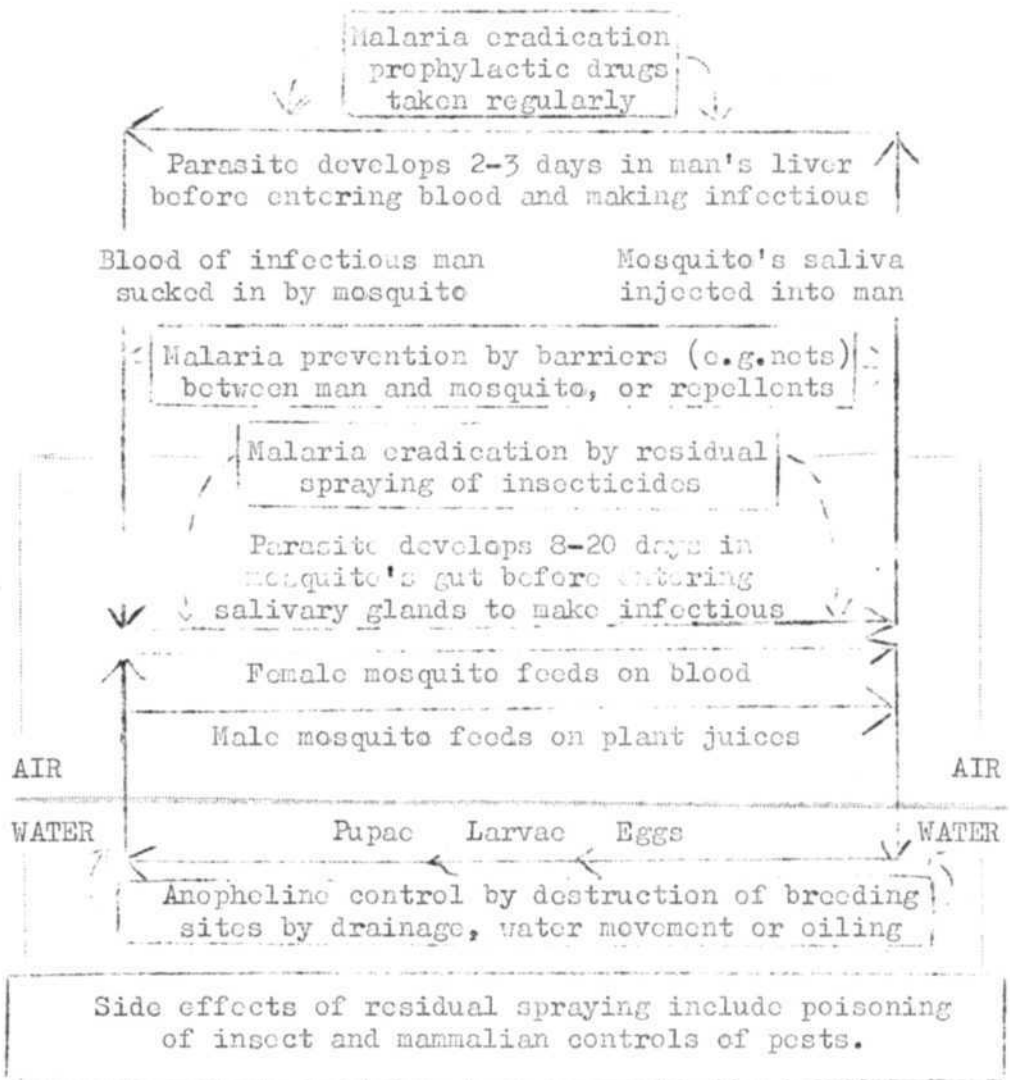
Detail of terrace



EROSION CONTROL

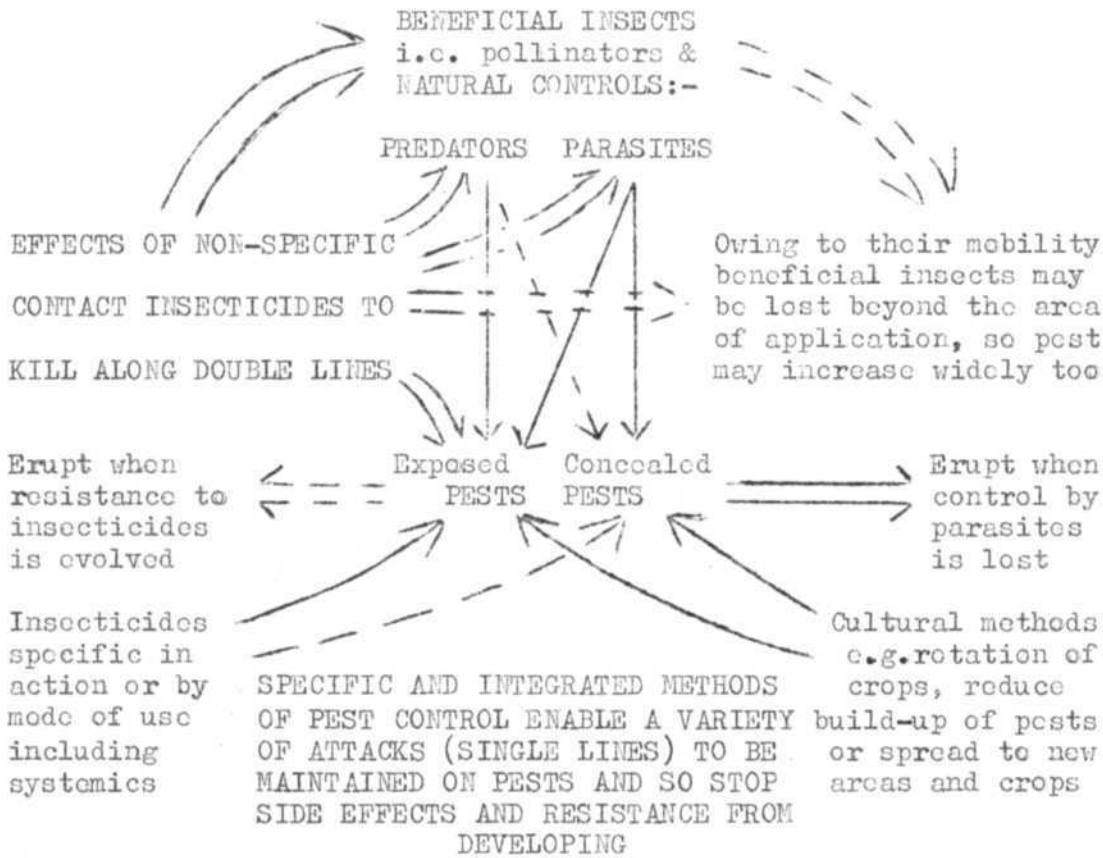
Figure 11

MALARIA IS SPREAD IN MAN BY THE COMBINED LIFE CYCLES OF THE PARASITE (PLASMODIUM) AND OF THE VECTOR (ANOPHELINE MOSQUITO)



Malaria prevention has used barriers, repellents and protective clothing to protect humans from mosquito bites and to prevent infection of either anopheline or human by the other. Anopheline control destroyed or made unsuitable the mosquito breeding sites Malaria eradication attacks the parasite with prophylactic drugs in man and with destruction in the vector by residual spraying of insecticides, which are effective during the incubation of the parasite within the mosquito. The residual insecticides may have side effects by poisoning predators and parasites of pests

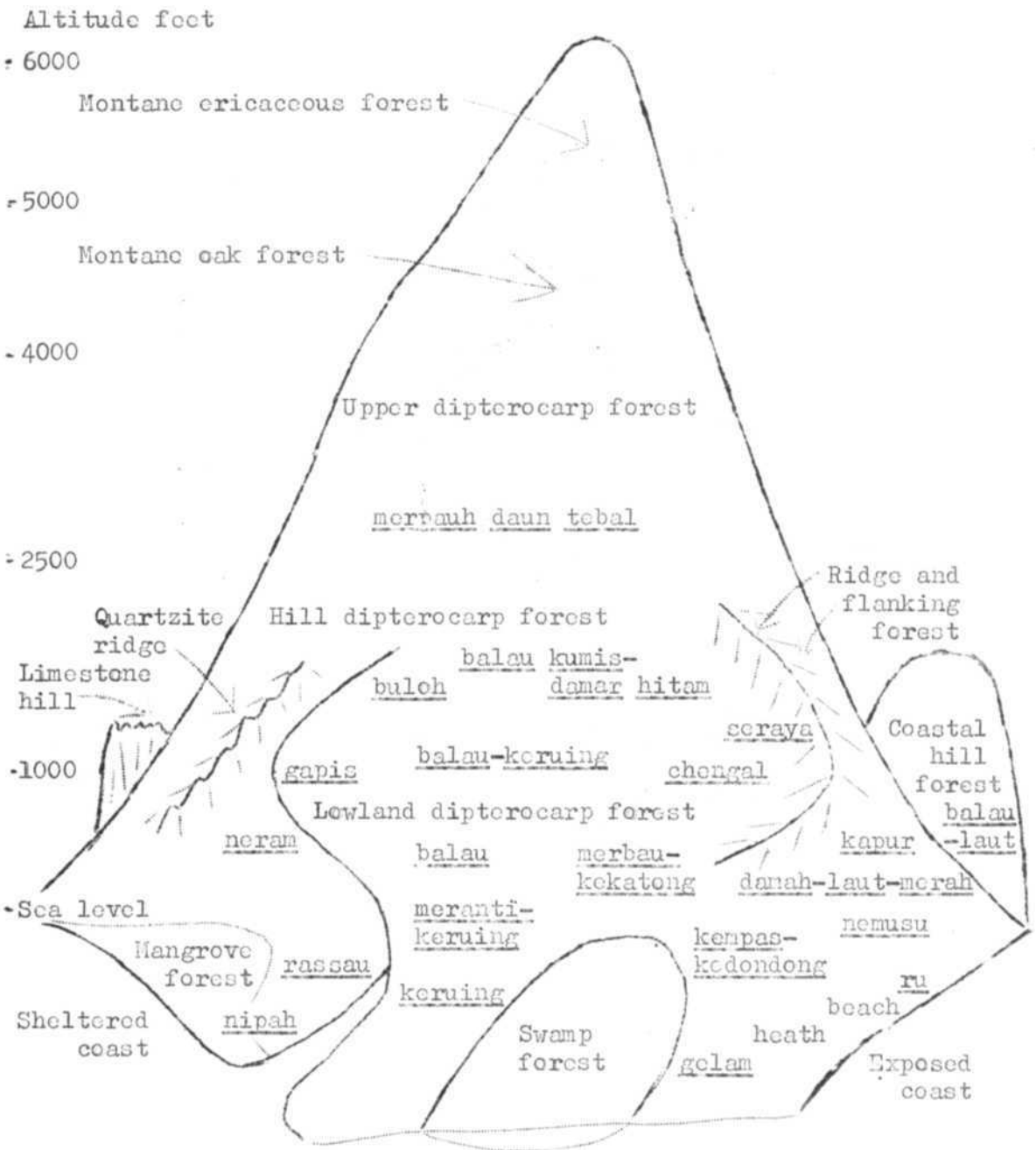
Figure 12



Natural controls, especially by parasites which hunt for the host to feed their larvae upon, are the most potent defence against concealed pests. Specific and integrated approachs allow natural controls to continue alongside chemical and cultural methods. A further undesirable effect of persistent non-specific insecticide is to taint food crops or to poison other preeators at a higher level of the food-chain.

COMPARISON OF INSECT PEST CONTROL METHODS

Figure 13

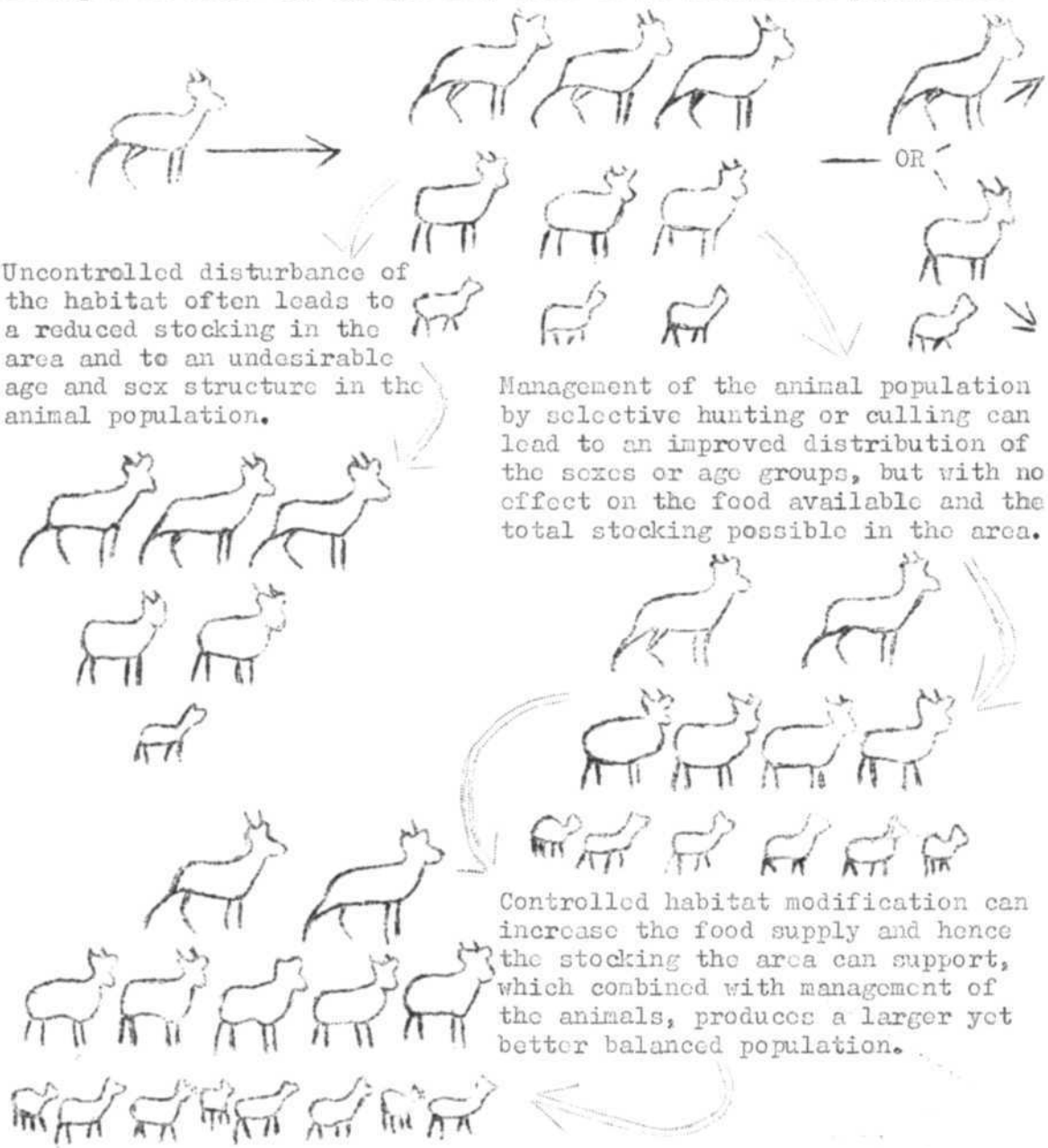


A SIMPLIFIED DIAGRAMMATIC AND SCHEMATIC REPRESENTATION OF THE ECOLOGICAL DISTRIBUTION OF SOME FOREST TYPES IN WEST MALAYSIA

Figure 14

PRINCIPLES OF STOCKING AND MANAGEMENT

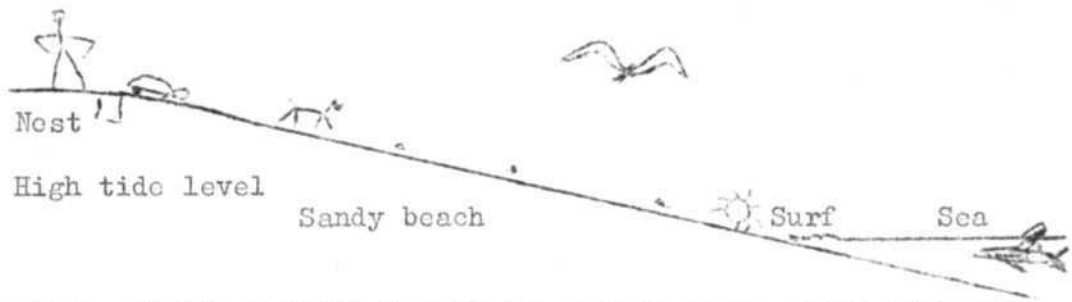
When an area carries the stocking of animals which the food available will support, the introduction of more animals dependent on the same food supply must be balanced in time by the departure or death of an equivalent number or mass of animals to restore the correct stocking. Attempts to overstock an area may lead to an unbalanced population.



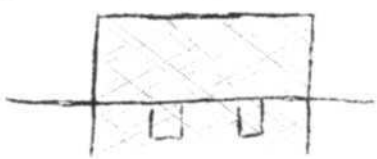
The symbols represent respectively:- old or male animal, mature or female animal, and young animals. These diagrams should not be taken too literally, but rather as illustrating possible applications of stocking principles and wildlife management in reserves and parks.

Figure 15

TURTLE NESTS, HATCHERIES AND RELEASES

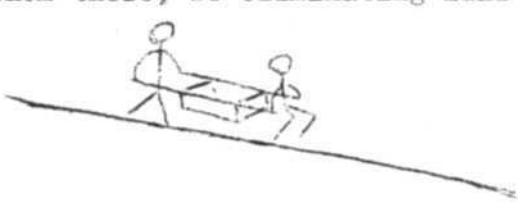


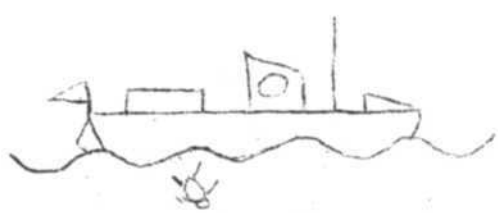
In nature, female turtles lay their eggs in nests above high tide level on sandy beaches. The eggs may be collected by humans. When the hatchlings emerge and make their way down the beach to the sea and out into deep water, they may be taken by such predators as:- dogs, crabs, seagulls and sharks. In all hatchery schemes some of the eggs collected are placed in a hatchery protected from birds and animals by wire netting around and over the nests, buried at the edges. The schemes differ in the manner in which the hatchlings are released.

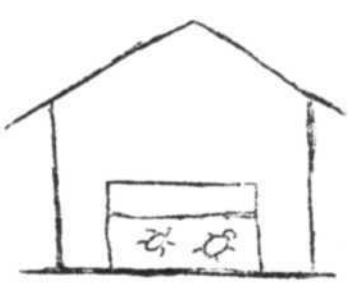


The simplest and most natural method, seldom used, is to let the hatchlings make their own way down the beach under the protection of an escort. This should ensure imprinting if it is essential for the female's return to nest on the beach.

Another method is to carry the young hatchlings as soon after emergence as possible out to deep water by boat and to release them there, so eliminating land predators and pounding by surf.







A further variation is to keep the hatchlings in tanks on land until they have consumed the yolk-sacs and may be more agile swimmers or divers, before release in deep water at sea.

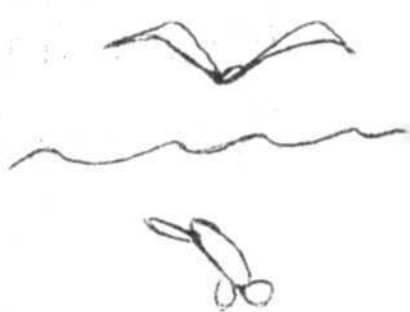


Figure 16

POLLUTION OF WATER

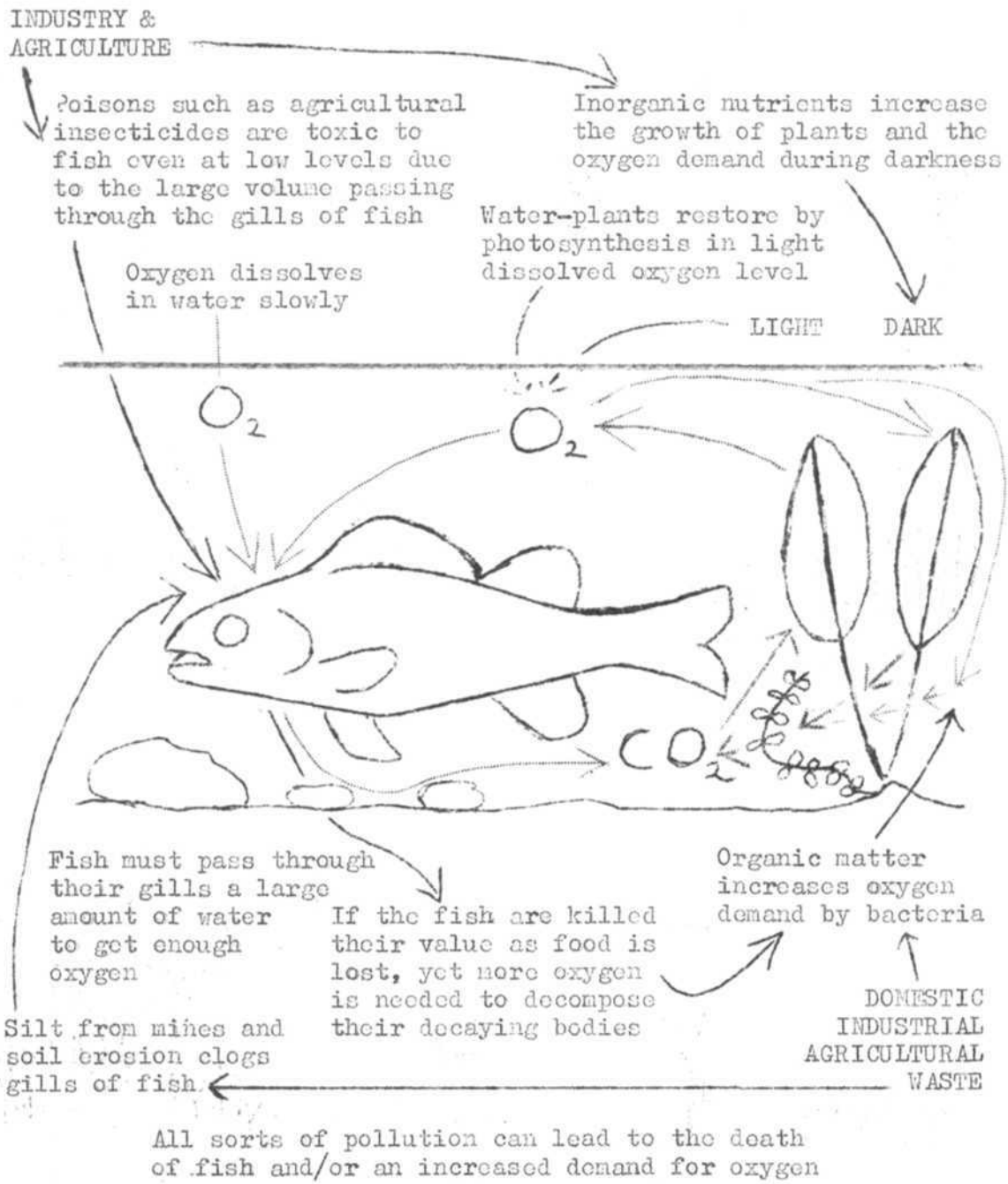
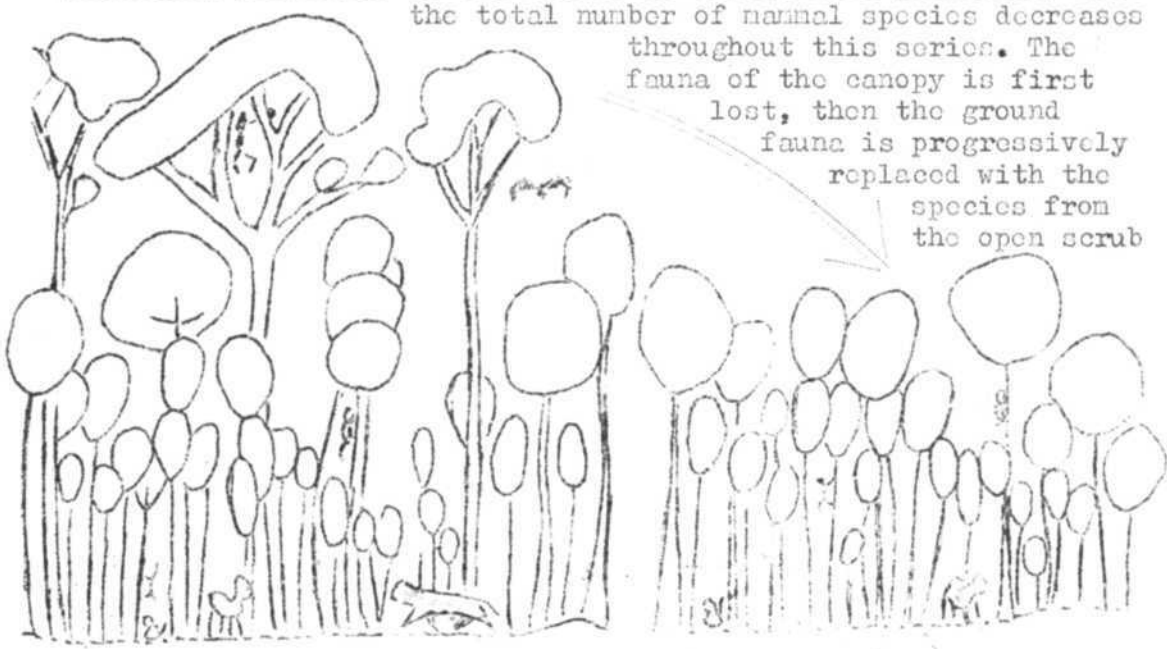


Figure 17

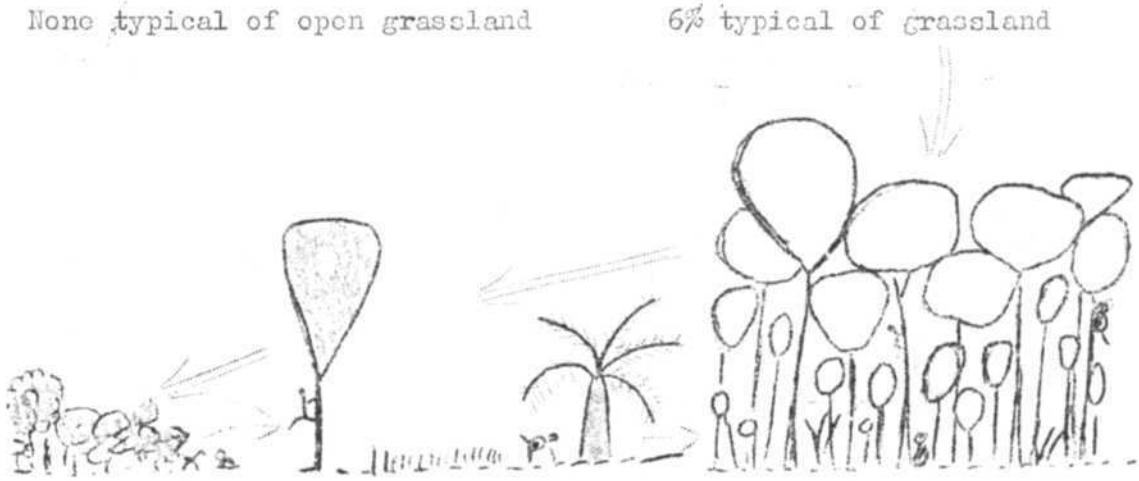
FAUNAL CHANGES WITH DISTURBANCE AND CLEARING OF FOREST

The relative proportion of the total mammal fauna typical of open conditions increases as the degree of disturbance increases, but the total number of mammal species decreases throughout this series. The fauna of the canopy is first lost, then the ground fauna is progressively replaced with the species from the open scrub



Primary Lowland Dipterocarp Forest
Total number of Mammal Species = 76
None typical of open grassland

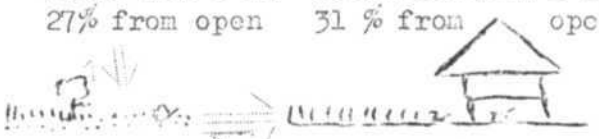
Disturbed Lowland Forest
Total No. of Mammals = 32
6% typical of grassland



Scrub
Total No. = 11
27% from open

Rubber and Oil Palm
Total Mammals = 13
31 % from open

Secondary Forest
Total Mammals = 11
9% typical of open



Grass
Total No. = 7
43% from open

Lallang (man-made)
Total No. = 4
100% from open

Figure 18

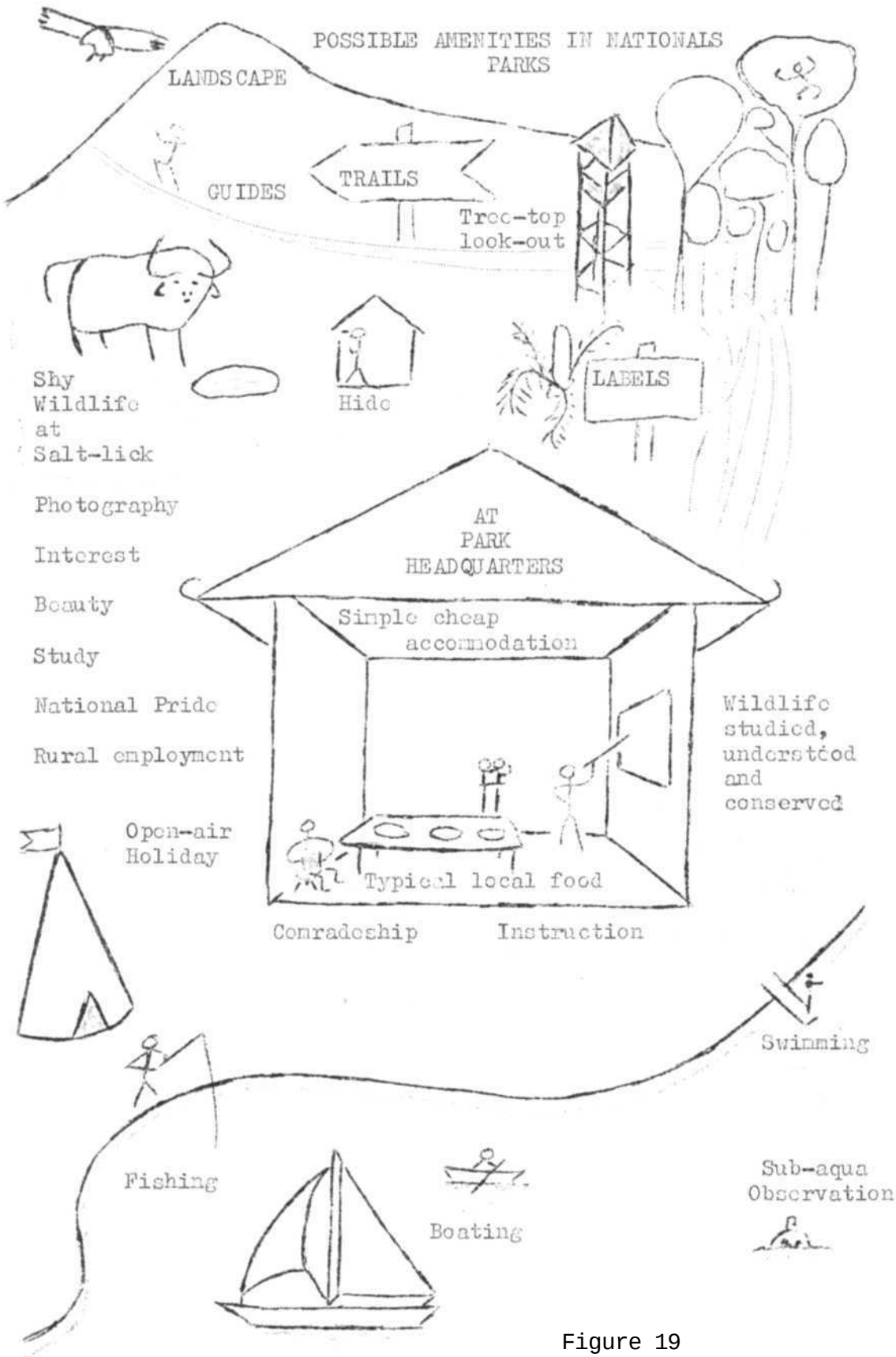

POSSIBLE AMENITIES IN NATIONALS PARKS
LANDSCAPE
GUIDES
TRAILS
Tree-top look-out
Shy Wildlife at Salt-lick
Hide
LABELS
Photography
Interest
Beauty
Study
National Pride
Rural employment
AT PARK HEADQUARTERS
Simple cheap accommodation
Wildlife studied, understood and conserved
Open-air Holiday
Typical local food
Conradeship
Instruction
Swimming
Fishing
Boating
Sub-aqua Observation

Figure 19

FUNCTIONS OF NATIONAL PARK AND WILDLIFE SERVICE

This schematic organisation of the functions of the National Park and Wildlife Service is only one of many possible arrangements, whichever is adopted, the organisation should be flexible and permit of as much exchange of information, staff and services between the different branches. In all dealings with the public, the assistance the service can give must be emphasised.

Figure 20

National Parks and Similar Nature Reserves in Malaysia

	Name		Area in Sq. miles
West Malaysia (Malaya) Total Area 51,000 sq.miles			
Existing reserves, retention recommended	Bukit Kutu		7½
	Mersing (1)		72
	Sungei Dusun		17
	Sungkai		9½
	Taman Negara		1,677
Existing reserves adjustment recommended, see note (2).	Gunong Blumut (3)	(311)	87½
	Krau	(213)	252
	Sungei Endau (4)	(392)	291
Existing reserves closure recommended (5)	Chior	(17)	
	Segamat	(120)	
New reserves proposed (6)	Belum		830
	Grik		262
	Segari		5½
	Selama		86
	Sungei Emas		61
	Sungei Nenggiri		143
	Tasek Bera		63
	Ulu Muda		445
	Ulu Trengganu		450
Total		(2,836)	4,759
Other Reserves (7)		(284)	309
Grand Total		(3,120)	5,068
East Malaysia, Sabah Total Area 29,000 sq.miles			
Existing reserve	Kinabalu		275
New reserve proposed	Ulu Segama		700
Other reserves (8)		(51)	57
Grand Total		(326)	1,032
East Malaysia, Sarawak Total Area 48,000 sq.miles			
Existing reserve	Bako		10½
New reserves proposed (9)	Gunong Gading		13
	Gunong Mulu		239
	Lambir		16
	Loagan Bunut		20
	Matang		8½
	Niah		15
	Pelagus Rapids		20
	Sabal		5
	Simalajau		15
	Sungei Dalam		2
Grand Total		(10½)	364

Figures in brackets refer to notes on page 182.

Table 1

Notes on National Parks and similar nature reserves in Malaysia.

(1) Mersing, this is at present called the eastern section of the Endau-Kota Tinggi wild life reserve.

(2) these reserves have portions which no longer serve any function in conservation and would be better alienated for other purposes, these reserves also have adjacent to them land which would more appropriately be included, the change from the present area (in brackets) to the proposed area allows for both types of adjustment.

(3) Gunong Blumut, this is at present called the Western Section of the Endau-Kota Tinggi wild life reserve.

(4) Sungei Endau, this is at present called the Endau-Kluang wild life reserve.

(5) these reserves are no longer managed in the interest of conservation, although their present status prevents proper management according to their most appropriate land use, the animals - which these reserves were created to protect - have already gone.

(6) these proposed reserves are all situated in areas where the steep-ness of the land or poor soil conditions, and the presence of endangered wildlife, make this the best land use combined in many cases with catchment protection.

(7) these other reserves, mainly bird sanctuaries, currently at Batu Gajah, Bukit Sungei Puteh*, Cameron Highlands, Fraser's Hill, Klang Gates, Kuala Selangor, Pahang Tua, Port Dickson*, Pulau Sibu island group, Royal Selangor Golf Club, Templer Park and Weld Hill, Kuala Lumpur, are small areas (except that at Cameron Highlands accounting for 265 of the total 248 sq. miles) and include large proportions which no longer bear natural vegetation; the proposed increase in area of 25 sq. miles is accounted for by expansions at Kuala Selangor and Templer Park, with additions of National Nature Monuments at Batu Caves, Batu Feringgi, Dungun (for turtles), Gunong Gajah, Kuala Gula and Trengganu Islands. (Those marked * could well be closed and the Cameron Highlands reserve contracted).

(8) these other reserves consist of bird sanctuaries at present, several islands and 50 sq. miles of farmland at Kota Belud; the proposed additions include Pulau Gaya (scenery and marine life) and other areas for recreational areas and flora protection.

(9) Gunong Mulu, Lambir, Niah and Sungei Dalam are in process of constitution, the others have been approved in principle, the final site has yet to be decided for Loagan Bunut; these proposed parks include as far as possible every type of primary vegetation in Sarawak and several of the most magnificent stretches of. scenery, including some of the largest limestone massifs (totally unsuitable for agriculture) in humid equatorial South East Asia and Niah (one of the principal archaeological sites in the world).

BIBLIOGRAPHY

ALFRED, E.R. (1968) Rare and Endangered Fresh Water Fishes of Malaya and Singapore. Conservation in Tropical South East Asia. IUCN Pub. New Series No. 10 - Morges, Switzerland, pp. 325-331.

BALASINGHAM, E. (1968) Turtle Conservation in Malaya. Conservation in Tropical South East Asia. IUCN Pub. New Series No. 10 - Morges, Switzerland, pp. 321-323.

Bird Report: 1962 Malayan Nature Journal (1963) 17 pp. 123-144.

Bird Report: 1963 Malayan Nature Journal (1964) 18 pp. 134-168.

Bird Report: 1964 Malayan Nature Journal (1965) 19 pp. 160-194.

Bird Report: 1965 Malayan Nature Journal (1967) 20 pp. 59- 80.

Bird Report: 1966 Malayan Nature Journal (1968) 21 pp. 34-50.

Bird Report: 1967 Malayan Nature Journal (1968) 21 pp. 185-200.

BULLOCK, J.A. (1965) The Ecology of Malaysian Caves (and a Note on the Faunistic List from Batu Caves). Malayan Nature Journal, 19, pp. 57-64.

CAREY, I.Y. (1962) Methods of Cultivation among the Kelantan Temiar Symposium on the Impact of Man on Humid Tropics Vegetation. Goroka, New Guinea, 1960, UNESCO, pp. 207-214.

CONWAY, G.R. (1968) Crop Pest Control and Resource Conservation in Tropical South East Asia. Conservation in Tropical South East Asia. IUCN Pub. New Series No. 10 - Morges, Switzerland, pp. 159-163.

HARRISON, J.L. (1968) The Effect of Forest Clearance on Small Mammals. Conservation in Tropical South East Asia. IUCN Pub. New Series No. 10 - Morges, Switzerland, pp. 153-158.

HARRISON, J.L. (1964) An Introduction to the Mammals of Sabah. Sabah Society, Kota Kinabalu.

HARRISON, J.L. (1966) An Introduction to the Mammals of Singapore and Malaya. Singapore Branch, Malayan Nature Society, Singapore.

HARRISSON, B. (1968) Conservation Needs of the Orarig-Utan. Conservation in Tropical South East Asia. IUCN Pub. New Series No. 10 - Morges, Switzerland, pp. 294-295.

HARRISSON, B. (1968) OURS The Orang-Utan Recovery Service - Two Years of Activity 1963/1965. Conservation in Tropical South East Asia. IUCN Pub. New Series No. 10 – Morges, Switzerland, pp. 296-298.

KENNEDY, J.S. (1968) The Motivation of Integrated Control, Journal of Applied Ecology, pp. 492-499.

Malaysian Caves Issue. Malayan Nature Journal, 19, part 1.

McCLURE, H.E. (1968) Some Problems concerning Endangered Birds in South-Eastern Asia. Conservation in Tronical South East Asia. IUCN Pub. New Series No. 10 - Morges, Switzerland, pp. 307-311.

McCLURE, H.E. (1966) Flowering, Fruiting and Animals in the Canopy of a Tropical Rain Forest. Malayan Forester, 29, pp. 182-203.

McCLURE, H.E. and HUSAIN b. HAJI OSMAN (1968) Nesting of Birds in a Coconut-Mangrove Habitat in Selangor. Malayan Nature Journal 22, pp. 18-28.

MEIJER, W. (1965) A Botanical Guide to the Flora of Mount Kinabalu. Symposium on Ecological Research in Humid Tropics Vegetation, Kuching, Sarawak, 1963 UNESCO, pp. 325-366.

MEIJER, W. (1968 A Botanist's View on the Use of Arboricides in Forestry in Sabah. Conservation in Tropical South East Asia. IUCN Pub. New Series No. 10 - Morges, Switzerland, pp. '64-167.

MELLANBY, K. (1967) Pesticides and Pollution. New Naturalist Series No. 50, Collins, London.

MOHD. KHAN b. MOMIN KHAN (1968) Deer Biological Data, 1967. Malayan Nature Journal 21, pp. 159-164.

PANTON, W.P. (1963) Topography, Geology and Soils. Malayan Forest Records No. 23, Part II, Chapter 2.

PANTON, W.P. (1968) Land Capability Classification in the States of Malaya, Malaysia. Conservation in Tropical South East Asia. IUCN Pub. New Series No, 10 - Morges, Switzerland, pp. 71-74.

PROWSE, G.A. (1968) Pollution in Malayan Waters. Malayan Nature Journal 21, pp. 149-158.

SANDOSHAM, A. (1965) Malariology with special reference to Malaya. University of Malaya Press, Singapore.

SILVA, G.S. de (1968) The East Coast Experiment. Conservation in Tropical South East Asia. IUCN Pub. New Series No. 10 - Morges, Switzerland, pp. 299-302.

SMYTHIES, B.E. (1968) The Birds of Borneo, Second Edition. Oliver and Boyd, Edinburgh and London.

SPEER, W.S. (1963) Report to the Government of Malaysia on Soil and Water Conservation. Food and Agriculture Organisation of the United Nations . Report No. 1788, Rome.

STEVENS, W.E. (1968) The Rare Large Mammals of Malaya. Malayan Nature Journal, 22, pp. 10-17.

STEVENS, W.E. (1968) Habitat Requirements of Malayan Mammals. Malayan Nature Journal, 22, pp. 3-9.

STEVENS+ W.E. (1968) The Conservation of Wildlife in West Malaysia. Ministry of Lands and Mines, Seremban, Malaysia.

TALBOT, L.M. and M.H. Eds. (1968) Conservation in Tropical South East Asia. IUCN Pub. New Series No. 10 - Morges, Switzerland.

WOOD, B.J. (1969) The Extent of Vertebrate Attacks on the Oil Palm in Malaysia. Progress in Oil Palm, Incorporated Society of Planters, Kuala Lumpur, pp. 162-184.

WYATT-SMITH, J. (1963) Manual of Malayan Silviculture for Inland Forests. Malayan Forest Records, No. 23.

WYATT-SMITH, J. and WYCHERLEY, P.R. Eds. (1961) Nature Conservation in Western Malaysia, 1961. Malayan Nature Journal, Special Issue.

WYCHERLEY, P.R. (1967) Rainfall Probability Tables for Malaysia. Rubb. Res. Inst. Plant. Manual 12.

WYCHERLEY, P.R. (1967) The Batu Caves (Malaysia) Protection Association. Studies in Speleology 1, pp. 254-261.

GLOSSARY

(Most technical words and phrases are defined where they first occur in the text, but the more frequently used terms and some which have given difficulty are included for easy reference in this glossary, which cannot be exhaustive for all matters relating to conservation and allied topics.)

ADAPTATION

A change in a living organism which enables it to function more efficiently or improves its chances of survival in a particular environment. Adaptations may be physiological, temporary and limited to the individuals exposed to a change in environment or may become genetically fixed, of evolutionary significance and characteristic of populations such as races, varieties, species or larger groups.

ADVECTION

Horizontal movement of air and the associated lateral transmission of heat.

ALGAE

Simple plants lacking vascular tissues. Sometimes each individual consists of one cell only. The reproductive organs consist of one cell only in the forms with many cells in each individual plant. They carry out photosynthesis although the green pigment chlorophyll may be obscured by others of different colours. Most occur in damp or aquatic habitats, the marine algae are called seaweeds.

ALIEN

A species which is not native in the area or country concerned, but has its natural range of distribution elsewhere, whence it has been deliberately introduced or accidentally carried.

ALLUVIUM

Material transported by water to the site where it is deposited and develops into soil

AMINO-ACID

An organic compound with a basic amino group (NH_2), which in all naturally occurring amino-acids is attached to the carbon atom adjacent to the acidic carboxyl group (COOH), another group forming the remainder of the compound. Amino-acids are joined together in chains to form proteins. Green plants can make all the necessary amino-acids, but most animals must be supplied with several amino-acids ready made.

ANNUAL

In the temperate regions, an annual plant means one which germinates, grows, flowers, fruits and died all in one season of less than a year. The essential feature is that it dies after setting seed, which holds true in the tropics also, although the life cycle is often very short and sometimes - in rather few cases - very long as in the so-called Century Palm.

ANTIBIOTIC

A substance secreted by a living organism which inhibits the growth of - sometimes killing - other kinds of organisms. In many well known medical examples the antibiotics are produced by fungi and suppress bacteria.

AQUARIST

A person who keeps an aquarium, which is a glass tank or similar enclosure, in order to keep aquatic animals (those which live in water) in captivity.

ARID

Very dry owing to inadequacy of rain; in contrast to humid conditions such as those which prevail in Malaysia.

ARTIFICIAL

Made or applied by man, not by nature, for example artificial fertilisers or manures are mineral nutrients quarried or manufactured and added to the soil.

ASSIMILATE

To take simple nutrients into an organist and build them into more complex substances. Used as a noun to mean the substances assimilated, especially the products of carbon assimilation by photosynthesis.

AVIFAUNA

The bird population of a locality or region.

BACTERIA

Microscopic living organisms, each consisting of one cell only. A few bacteria can carry out photosynthesis by means of a pigment somewhat different from the chlorophyll of green plants. Most bacteria must obtain their energy from other sources by decomposing organic matter or as parasites of other organisms, especially as the causes of diseases in animals. Some are important in the fixation and circulation of nitrogen in the soil.

BAGWORMS

The larvae of moths which encase themselves with plant and soil debris, thus perhaps affording some protection against contact insecticides. Bagworms are normally controlled by natural predators and parasites, but these are more susceptible to contact insecticides than the bagworms.

BAMBOO

Members of the grass family with woody stems. Most are large in size compared with other grasses, but not as tall as forest trees. Bamboos may establish local dominance by forming dense thickets, from whose edges new shoots extend rapidly to shade out tree seedlings. The young shoots of some bamboos are edible.

BASALT

An igneous rock formed by the solidification of volcanic lava, relatively rare in Malaysia.

BELUKAR

A Malay word referring to secondary vegetation of mainly woody plants, shrubs, trees and lianes. Belukar is not as tall as primary forest and usually contains few timber trees of commercial value. The undergrowth in belukar is often very dense, especially at the edges where light penetrates obliquely almost to the ground. It is belukar in such circumstances - rather than primary forest - which has earned the reputation of "impenetrable jungle" where "paths are overgrown again over night" at least as far as the non-swamp vegetation of the humid tropics is concerned.

BIOTIC

Of or due to living organisms, especially to indicate those factors in the environment or ecosystem due to the effects of the living organisms present. Human activity is one of the most powerful biotic influences; the significant natural biotic factors include micro-organisms in the soil, the vegetation, grazing animals, predators and parasites. Also applied to a kind of climax.

BIRD BANDING

The American usage for bird ringing as it is called in England. A light metal band embossed with a number and return address is fixed around the bird's leg. A band of the correct size moves freely without hurting the bird. Banding of nestlings is possible because the lower part of a bird's leg does not increase in thickness after fledging. The details of the bird are recorded against the band number. Bird banding is a fascinating hobby. All interested should learn how to handle and identify the birds and to apply the bands correctly. Bands can only be obtained from the proper authorities in each country, which are seldom government departments, where training is also available. All bands found in Malaysia may be sent to the Malayan Nature Society, P.O. Box 750, Kuala Lumpur, giving details of how and where the bird bearing it was found.

BOUNDARY RAIN

Precipitation caused by the uplift of moisture-laden air where wind streams impinge upon each other or against a stationary mass of air.

BRACKISH

Of water salt to the taste yet with a lower content of salt than that in seawater, brackish water is usually formed by a mingling of fresh and seawater, but may arise from salt springs.

CARBOHYDRATE

Compounds consisting of carbon, hydrogen and oxygen only, the last being in the same ratio as in water, general formula Cx(H20)y. Sugars, starch and cellulose are well known examples. Cellulose is the main structural material in plant cell-walls. Cellulose is broken down by bacteria in the soil and in the rumen and blind-gut of some mammals. Carbohydrates, especially starch and sugars, are among the most common sources of energy in the food of animals and the metabolism of all living organisms.

CARNIVORE

An animal (also a very few plants) which feeds on flesh, especially members of the Carnivora, an order of mammals whose teeth are adapted to eating flesh including the bears, cats, civets, dogs, otters, weasels and allies.

CAVE

A hollow space underground formed by a rockfall or by erosion. Some naturalists restrict the definition to those caves with access for wildlife. Most, but not all, caves in Malaysia have been hollowed out in limestone formations by the action of water.

CHLOROPHYLL

A green pigment found in most plants, which enables light energy to be trapped and made available for photosynthesis. Several forms of chlorophyll are known, they are compounds of carbon, hydrogen, magnesium, nitrogen and oxygen.

CLIMATIC

Of or due to the weather conditions throughout the year, especially to indicate those factors contributing to the environment or eco-system arising from the intensity of or variation in meteorological conditions. Applied also to a kind of climax vegetation.

CLIMAX

The type of vegetation which would finally cover a particular area after sufficient time (sometimes as much as centuries) to attain a stable composition in equilibrium with the environmental factors, that is the typical natural vegetation in the undisturbed condition. The climax for a large area such as a whole country, or a region sharing similar climatic conditions, is called the climatic climax, because it is determined mainly by the climate. It is rain forest throughout Malaysia. However, locally soil conditions such as poor drainage in swamps or lack of fertility on heaths prevent the full development of the climatic or regional climax, and the climax obtained is called an edaphic climax, because the soil is the main limiting factor.

CLIMAX (Contd)

The attainment of the climatic climax may be prevented or it may be converted into another type of vegetation and maintained in this condition by the activity of animals, including man and his specialised ways of interfering with the environment such as spreading fires and in recent times pollution. A climax due to animals, for example over-grazing following the loss of predators, is called a biotic climax. The climax resulting from repeated burning is sometimes called a fire climax, but it is also an example of a biotic climax.

COLLAR

The portion of a tree where the root and shoot join at approximately ground level mentioned in the discussion of root disease.

COLLUVIAL

Soil developed by the mixing together of material washed or fallen down to the foot of a slope with material weathered on site.

COMMUNITY

A general term in ecology to indicate different species living together in the same place affecting each other by their mutual relationships. A community may be a unit in a larger community. A community may be independent of adjacent communities or be linked with them. Some ecologists define different types of communities and classify them using special terms for the units at different levels.

CONDENSATION

The change of a substance from the vapour state to the liquid, especially of water vapour into water drops.

CONE-SHELL

The beautiful and much sought-after shell of Conus and related marine gasteropod molluscs.

CONTOUR

A line drawn on a map or which may be traced on the ground to join points of equal height above sea level. A path, terrace, ditch or siltpit which follows the contour is therefore level.

CONVECTION

The vertical movement of air (or other fluids) and the associated upward transmission of heat. (For convectional rain see instability rain.)

CORAL

The rocky mass formed from the calcareous external skeletons of colonies of simple animals (Coelenterates) and/or the animals themselves. Coral forms only in shallow, warm seas where the fringing reefs are an important habitat and protection of the coast.

CULL

To pick out, especially to select for removal or destruction, to kill particular individuals from a population, to eliminate unhealthy or over-aged surplus stock.

DERIVATIVE

Of communities and vegetation which have been derived from the climatic climax by modification of the habitat usually through biotic factors.

DETERGENT

A dissolved agent which detaches contaminants (dirt, fungal parasites, etc.) from the solid substratum (article to be cleaned, host tissues, etc.) by modification of their respective surface properties without dissolving the contaminant. Detergents are used in domestic and industrial cleaning, some pesticides contain detergents; large amounts of cleaning detergents in rivers can lead to eutrophism, excessive froth due to lowered surface tension and damage to some organisms.

DEW

Water drops condensed on the surface of plants, the soil and other terrestrial objects.

DIPTEROCARP

A tree of the family Dipterocarpaceae, named after the type genus Dipterocarpus which has two-winged fruits, although other members of the family have different numbers of wings on the fruit. Many Dipterocarpaceous trees yield commercially valuable timber, although much Malaysian timber comes from trees of other families. Dipterocarp forest refers to forest in which Dipterocarp trees constitute a larger proportion of the timber and/or the tall, emergent trees overtopping the rest than do those of any other single family.

DISPLAY

Animals, especially birds, showing striking features with appropriate Movements and sometimes sounds to convey messages concerning courtship, protection of territory, etc., to members of the same species.

ECOLOGY

Study of the relationships of living organisms (animals and plants) with each other and with their environment, especially the study of natural communities.

ECOSYSTEM

A recognisable, self-sufficient biological community characterised by the vegetation and associated animal population arising in the particular environment. An ecosystem consists of the habitat and the living organisms it supports. The main factors contributing to an ecosystem are classified as biotic, climatic and edaphic.

EDAPHIC

Of or due to the soil, its biological, chemical, physical and topographical features, especially those factors in the ecosystem or the environment attributable to the soil. The biological features of the soil, mainly the micro-organisms living in the soil, are largely determined by its chemical and physical characteristics including aeration and drainage, also by the vegetation and the climate for instance the rainfall and temperature. The biological features of the soil may be considered as biotic and/or edaphic. Thus fine, absolute classification is impracticable because all factors interact.

ENCEPHALITIS

Inflammation of the brain.

ENDEMIC

Of plant and animal species whose natural distribution is limited to a particular area, for instance a country, a hill or an island, probably the place of origin. Also of diseases which occur repeatedly in a particular area, although not necessarily the place of origin.

ENTERITIS

Inflammation of the intestines.

ENVIRONMENT

The conditions surrounding an organism, especially the external physical, chemical and biological circumstances in which it lives. (The internal environment refers to the conditions of the fluids surrounding individual cells and organelles within an organism, which is an important concept in physiology but it does not directly concern conservation and ecology.)

ENZYME

A protein which acts as a catalyst, that is it speeds up greatly certain chemical reactions although it is only present itself in very small amounts. Enzymes are made only by living organisms.

EPIDEMIC

Of a disease caused by a parasite, which shows a relatively large and very rapid increase in the number of cases.

EPIPHYTE

A plant which uses another as a support without drawing any nutrients from the latter's living tissues and without contact with the ground. An epiphyte may be contrasted with a parasite, which obtains nutrients from its host, and with a climber which is rooted in the soil.

EQUATORIAL

Of the region about the equator and of the typical climate and vegetation prevailing there. Characterised by rainfall in excess of evaporation, lack of marked seasonal variation such as a long dry spell and by high temperatures in which diurnal variation exceeds seasonal; rain forest is the typical vegetation or climax in the lowlands. Most of Malaysia is equatorial in this sense; the equatorial belt lies within 5 to 10 degrees on either side of the equator.

EQUINOX

When the sun is vertically overhead at noon at the equator and the day and night are both 12 hours long everywhere throughout the world. The first equinox each year falls about 21 March and the second about 22 September, these are called respectively the spring or vernal and the autumnal equinoxes following the usage established in the northern temperate region.

EROSION

The act of wearing away material or the condition of being worn away, especially the wearing away of rock and soil by water and wind including abrasive particles carried by them.

ESCAPE

An alien which has run wild after introduction for rearing in captivity or by cultivation.

ESTUARINE

Of an estuary, which is the mouth of a river where tidal influences are felt and at least some saltwater penetrates.

EUTROPHIC

Of waters rich in dissolved mineral nutrients and highly productive of organic matter: a state of excessive eutrophism may lead to exhaustion of the dissolved oxygen.

EVOLUTION

The process of new forms of living organisms arising by gradual change through successive generations so that species, which now differ, are descended from common ancestors. Genetic mutations and recombinations produce forms adapted to survive better, especially if there are concomitant changes in the environment. Evolution by natural selection resulting in the survival of the fittest or best adapted was propounded in 1858 by Charles Darwin and Alfred Russel Wallace, the latter formulated his views while studying wildlife in the Malay Archipelago including East Malaysia.

EXOTIC

Alien (popularly exotic is reserved for the more bizarre aliens or indeed anything out of the ordinary, but any foreign species is exotic, whereas natives are not).

FAUNA
The animal population present in a particular place or during a given epoch.

FERN
Spore-bearing, vascular green plants usually in damper habitats.

FISH-TAGGING
A method of marking fish to study their movements and longevity, primarily a tool for research in fisheries and migration, but it may become a scientific hobby for skin-divers in a parallel manner to the enlistment of amateur ornithologists as bird-banders.

FLORA
The plant population present in a particular place or during a given epoch. As well as referring to the plants themselves, a flora may indicate species lists or manuals for the identification of the plants in a country. The Flora Malesiana Foundation is preparing a series of volumes to describe the flora of the Malesian region, which includes Malaysia.

GAME
Animals hunted or pursued for sport. Game animals are legally defined in the appropriate legislation.

GENETIC
Due to heredity, the transmission of characters from one generation to the next.

GILLS
The respiratory organs of aquatic animals, gills have a large surface area due to many folds; dissolved gases and other substances diffuse across the fine membranes separating the external water and the many internal blood vessels.

GREEN PLANTS
Plants containing chlorophyll and able to carry out photosynthesis.

HABITAT
The place where an organism lives, its environment.

HERBICIDE
A chemical which kills plants, especially those considered to be weeds, restricted by some to non-woody species.

HERBIVORE
An animal which eats plants.

HIDE
A structure to conceal an observer, photographer or hunter of wild animals from them, sometimes called a blind in American usage.

HUMUS

Decaying organic matter, mainly of plant origin, in the soil.

IGNEOUS

Of rocks formed by solidification of molten material.

IMPRINTING

A form of learning in animals, usually early in life, whereby the manner in which a particular action is first carried out or in which a particular stimulus is first presented, determines the future response in a situation concerned with that action or stimulus. If all young animals of a given species share the same experience, they all become imprinted in the same way, so that the response become the behaviour characteristic of the species. The ability to be imprinted is inherited, but the resultant behaviour is not inherited or instinctive. Animals may be abnormally imprinted by exceptional experience giving rise to atypical responses and behaviour. Learning by imprinting is stable and difficult to unlearn or modify.

INFILTRATION

The entry of water into the soil through pores, instead of running off over the surface.

INSECTICIDE

A chemical to kill insects, especially those which are pests or transmit disease. Insects are invertebrate animals with jointed bodies, typically three pairs of legs in the adult and a hard external skeleton. Insecticides are poisons and their action cannot be confined to harmful pests and insects alone, instructions to reduce risks to operators, domestic animals and wildlife should be carefully followed.

INSTABILITY RAIN

Due to surface heating and convection currents moisture laden air continues upward into cool air where condensation into rain occurs often as thunderstorms.

INSTINCT

Specific behaviour patterns which are inherited responses to stimuli, not learned.

INTRODUCTIONS

Aliens deliberately imported and encouraged to run wild.

INTRUSION

Igneous rock which solidified before reaching the earth's surface, often located between other formations.

INVERTEBRATE
An animal without a backbone, that is which is not a vertebrate.

KARST
A type of limestone landscape in which drainage of water through the rock has produced dissected, steep sided hills, often riddled with hollows and caves, with thin infertile soil.

LAC INSECTS
Of the family Coccidae, which includes also scale insects and mealy bugs, most are pests of crop plants although seldom very damaging: the true lac-insect Coccus lacca produces shellac and cochineal in India.

LALLANG
The Malay name for the grass Imperata cylindrica and for areas dominated by almost pure stands of this grass, which may establish a biotic fire climax.

LARVA
A young, active stage of an animal which differs distinctly in form from the adult.

LEARNING
Process by which an animal comes to behave in response to stimuli as a result of its past experience.

LEGUME
The bivalved fruit pod characteristic of the family Leguminosae; popularly any plant in this family, e.g. beans, peacock flowers and rain trees. Many, but by no means all, leguminous plants have in nodules on their roots symbiotic bacteria able to fix atmospheric nitrogen. This is known in plants of other families also.

LEPTOSPIROSIS
A tropical fever due to infection by leptospirochaetes, usually considered to be bacteria but classified by some as protozoa (primitive, one-celled animals).

LIANA
Woody climbing plant.

LIMESTONE
A rock consisting of at least half calcium carbonate, the remainder often being magnesium carbonate with smaller amounts of siliceous and other mineral matter. Usually formed by sedimentation of calcareous animal shells or from coral.

LITTORAL
Strictly the seashore between high and low tide levels; also the land and sea adjacent to this zone.

MALARIA

Fevers caused by infection with protozoa called Plasmodium. Areas, where the disease is endemic, and the Anopheles mosquitos, which transmit it, are sometimes called malarial.

MANAGEMENT

Refers in conservation to the modification of the habitat or treatment of the wildlife in order to promote heavier stocking or the survival of particular species.

MEALY BUG

A scale insect of the Coccidae which has a mealy or waxy covering, sometimes pests of crops.

METABOLISM

The chemical processes of a living organism.

METAMORPHOSIS

Change of form. In animals from larva to adult for example. Of rocks altered by great heat or pressure (occasionally by solution and recrystallisation).

MIGRANT

An animal which migrates, that is members of the species move regularly and systematically between two (or more) definite, separate areas. For example, the annual movements of birds such as the Siberian Thrush and Blue Robin which breed in central Asia and winter in Malaysia, or the regular spawning runs up the great rivers of Malaya of the Giant Cyprinid fish.

MITES

Invertebrate animals related to the spiders, some are parasites.

MONSOON

Seasonal winds, whose prevalent direction depends on the time of year, affecting very extensive areas between the tropics. Of the climate and vegetation characteristic of these regions where the seasonal monsoon-born rains alternate with dry spells.

MOSQUITO

Insect with aquatic larvae, the female adults are blood-sucking and transmit a wide range of diseases.

MOSS

Common name for Musci; green plants reproducing by spores from sex organs consisting of many cells lacking highly differentiated vascular tissue, found in damp places.

MOTH

Insects with two pairs of wings and feathery antennae, adults often feed on nectar and larvae on plants or organic remains.

MULCH

Material, often vegetable matter, laid over the soil.

MUTATION

A sudden change in a hereditary factor, which may be transmitted to the next generation and become expressed as a change in the colour, structure, function or behaviour of the living organism.

NATIVE

Born in a country, naturally occurring there, not introduced.

NATURAL

Of vegetation which has not been modified by man or animals under human control.

NEMATODE

Roundworm, unsegmented, pointed at both ends. Some nematodes are free-living in soil or water, many are parasites of crop plants and animals, especially of vertebrates; most are minute but a few gut parasites of mammals are fairly large.

NICHE

A habitat of limited extent or occurrence, because it is dependent on an exceptional combination of factors to which few species are well adapted; niche is less commonly used in ecological writings today.

NITROGEN FIXATION

Formation of organic compounds of nitrogen using the atmospheric gas as the source by the agency of blue-green algae or of bacteria, either free-living in the soil or symbiotic with green flowering plants (e.g. many Leguminosae).

NUCLEIC ACID

A large chain of nucleotides, each of which consists of three components, namely a sugar with 5 carbon atoms, phosphoric acid and a base containing nitrogen. DNA (Deoxyribonucleic acid) has 2-deoxy-D-ribose as the sugar with thymine, cystoscine, adenine and guanine as the bases. RNA (Ribonucleic acid) has ribose as sugar and uracil instead of thymine with the other 3 bases. DNA transfers genetic information from one generation of cells or of individual living organisms to the next. RNA translate the information of the DNA into enzymes to effect it in the metabolism and development of the cell or organism.

NUCLEUS

In a cell of a living organism, a body containing most of genetic material inherited from the previous generation, which can be stained characteristically. In rain formation, the small particles about which condensation takes place.

NUTRITION

The provision of food to living organisms, simple substances to green plants but more complex compounds to animals. Balanced nutrition means that the nutrients are supplied in approximately the same proportions as they are required, whereas deficits or excesses of one or more nutrients indicate unbalance.

OIL PALM

Elaeis guineensis. A palm introduced from West Africa to Malaysia, from whose fruit oil is expressed, the acreage planted with oil palm in Malaysia has increased greatly since 1960.

ORCHID

A plant of the family Orchidaceae, characterised by laterally symmetrical flowers, several of whose parts are strongly modified especially as adaptations to ensure cross pollination by particular insects. The pollen is in sticky masses. The seeds are very small like powder. Many orchids are tolerant of temporary drought. The Orchids are a very-popular group with hbrticulturalists because of the striking colours and forms of many; some are scented; few have any use except as ornamentals, the best known exception yields vanilla, but it is not native in Malaysia.

PANEL

Of a rubber tree, the part of the trunk which is tapped, the exposure of the inner bark tissues renders them liable to infection.

PARASITE

A living organism which obtains its nutrients from the living tissues of another living organism, the latter is known as the host. An obligate parasite has no other way of nutrition, a facultative parasite has alternative methods for instance as a saprophyte, a partial parasite obtains part of its food only from its host.

PATHOGEN

A parasite which causes disease.

PEAT

Soil consisting entirely of plant remains, usually formed under water-logged conditions, but sometimes where mineral nutrients are in very limited availability, peat formation is most rapid under very wet, infertile conditions.

PERENNIAL

A plant which grows for many years and flowers and fruits several times during its life.

PESTICIDE

A chemical to kill unwanted living things whether plant or animal.

PHOTOSYNTHESIS

The synthesis of carbohydrates from water and carbon dioxide by plants using the energy of sunlight absorbed by the green pigment chlorophyll.

PHYTOGEOGRAPHIC

Of the distribution and range of plants throughout the world.

PIONEER

Of the first vegetation colonising a bare area at the beginning of a succession.

PLANKTON

The floating or drifting flora and fauna of lakes and the sea, usually individually microscopic living organisms.

PODSOL

A heavily leached type of infertile soil with a thin covering of organic matter, a deep profile of almost pure siliceous material, usually grey-white sand, and a hardpan of accumulated iron and other compounds beneath.

POLLUTION

The act, state or material of defilement, especially the poisoning of the environment so that it is less suitable or quite unfit to support life. Water and air are most susceptible to pollution. Freshwater is already affected widely in Malaysia. Coastal waters may be involved soon if preventive action is not taken. Locally, there is atmospheric pollution and aerial deposits obscure vegetation and poison the topsoil, especially where heavy applications of pesticides are made. The whole world is at risk to radioactive pollution, although Malaysia is as yet less seriously affected.

PRECIPITATION

All the water which reaches the earth from the atmosphere. Nearly all the precipitation in Malaysia is as rain, although dew and hail also occur. In other regions, snow and hoar frost occur too.

PREDATOR

An animal which preys on others, especially by hunting, killing and eating them. The hunting aspect introduces an element of selective pressure tending to promote the survival of the fittest predators and to eliminate the least fit among the prey.

PRIMARY

Of vegetation which is natural, undisturbed by man and his animals, any stage in the natural succession from pioneer to climatic (or edaphic but not biotic) climax.

PROTEIN
Complex organic compound consisting of a chain or chains of amino-acids.

PULVERISE
To reduce to a fine powder.

QUARTZ
A hard crystalline form of silica.

QUARTZITE
An impervious rock of metamorphosed sandstone consisting of quartz cemented by finer silica.

RADIATION
The emission of energy as rays, electromagnetic waves or particles. Solar radiation is the heat and light of sunshine. Radiation from radio-active sources can cause mutations and kill at high levels.

RAPTORE
Birds of prey which hunt by day.

RESISTANCE
The ability of living organisms to withstand infection by parasites or poisoning by toxic chemicals. The resistance of plants to diseases saves great expenditure on alternative methods of protecting crops. The wild flora is the natural reserve of resistance. The acquisition of resistance to chemicals by adaptation in insects and by pathogenic micro-organisms constantly erodes the effectiveness of pesticides, drugs and antibiotics.

RUBBER TREE
Hevea brasiliensis. Introduced from Brazil to Malaysia in 1876/7, rubber is obtained in the latex flowing from the cut bark; more than 4 million acres (1.6 million hectares) have been planted in Malaysia. A classic example of a crop which has been more successful in plantations in other countries than its origin, where its performance is limited by diseases.

SAPROPHYTE
A plant (usually a bacterium or a fungus) which obtains its nutrients in solution from decaying, organic matter, so circulating the materials of dead plants and aminals.

SATURATION
State of the air, when it contains the maximum amount of water vapour possible in stable equilibrium at the ambient temperature.

SCALE INSECT
Of the family Coccidae, the female is stationary on the host plants and has a covering of scale, some are pests.

SEAWEED
Marine alga, brown, green or red.

SECONDARY
Of vegetation in any stage of development after disturbance or modification by man.

SEDENTARY
Of soil formed from material weathered on site.

SEDIMENTARY
Of rocks formed by the deposition of suspended material from water.

SEED
A propagule developed from an ovule fertilised by a pollen nucleus and consisting of an embryo surrounded by protective coats and sometimes provided with additional food material. The seed-plants (Spermatophyta) are considered to be the most highly evolved and provide most of the dominant land-plants in the world today.

SILT
Fine material suspended in or deposited from water. Of pits (ditches) following the contours which arrest water flowing down-hill and allow the silt to settle out instead of being carried away.

SOCIAL
Of a species of insect, whose members live together in an organised or cooperative society or family unit consisting of larvae and adults within a common shelter.

SOIL
The material covering the surface of the earth in which plants may root; the soil consists usually of rather loose particles of weathered rocks with organic admixtures, especially plant remains.

SPECIES
A natural unit in the classification of living organisms, a number of individuals whose characteristics lie within a defined range of variation. A species is often defined as a group of individuals which breed among themselves but are unable to reproduce with those outside the group; however, this criterion is difficult to determine in most actual cases and is found not to apply fully in many of those in-vestigated, although the arrangement of the species described on other grounds is seldom altered for this reason. Nevertheless, despite differences of opinion whether two or more species should be "lumped" as one or one species "split" into several, there is general agreement on species in practice. For instance, most groups of plants or animals which share one common name in the local vernacular language correspond to species, each of which is given a scientific name of two Latin words.

SPORE

An initially single-celled reproductive body of a plant, which is not the product of sexual fusion. Spores are usually detached from the plant and distributed, sometimes in very large numbers. In the simplest plants the spores may give rise directly to new individuals, but in the more advanced plants, the spores develop into multicellular bodies which produce the sex cells, in the seed-plants only the male spores (i.e. the pollen) are dispersed.

STALACTITE

A mineral column hanging from the roof of a cave or over-hanging rock, which consists of material - usually calcium carbonate - deposited from water dripping down and evaporating from the column.

STALAGMITE

A mineral column building up from the floor of a cave or similar place by crystallisation of marble, i.e. calcium carbonate or other material from water dripping onto it. A stalactite and stalagmite may join to form a pillar. Stalagmite is sometimes used of the marble encrusted on cave walls and floors.

STEEP LAND LINE

An important concept in Land Capability Classification in Malaya, the contour above which the land is mostly steep with shallow soils liable to erosion if exposed and below which the slopes are more gently, the soil deeper and the land more suitable for agriculture. The actual elevation of this contour varies from place to place.

STOCKING

The population of an animal which an area will support. The population may be measured in numbers, e.g. head of cattle, or in total body weight of the population.

STRAND

Shore of sea, estuary or lake.

SUBSOIL

The partially weathered material lying beneath the soil and merging with the parent material below. This vague, popular term is replaced in scientific descriptions of soil profiles by the "C horizon".

SUCCESSION

The progressive sequence of vegetation which develops from the colonisation of an area to the climax, edaphic or climatic in which a natural succession culminates. The succession in a particular environment is called a sere.

SUPER-SATURATION
The unstable and hence usually temporary condition of the air containing more water vapour than that required to saturate it,

SWAMP
Low-lying, wet land where the water-table is always close to and often somewhat above the soil surface.

SYMBIOSIS
The living together of dissimilar organisms (at least of different species and usually of different groups entirely) in close association to their mutual benefit. The lichens consist of an intimate mixture of fungi and algae; other examples of symbiosis include nitrogen-fixing bacteria in nodules on leguminous plants, cellulose-decomposing bacteria in the gut of herbivorous animals, algae in corals, food and protection arrangements of sea-anemones and hermit crabs.

TERMITES
Social insects of the order Isoptera, found mainly in hot countries, called "white ants" because of their superficial appearance. Termites feed on cellulose and other plant material, only a minority are parasites of living trees or at least eat the dead wood of living trees and so bring about their collapse, most live on plant remains including constructional timber. In natural, tropical vegetation termites consume vast amounts of plant debris and play an important role in the circulation of nutrients.

TICKS
Blood-sucking mites which can transmit diseases.

TOPOGRAPHY
The description of a place, especially the shape of the superficial features.

TOXIC
Poisonous, especially of naturally occurring poisons secreted by bacteria or found in plants and animals.

TRACE
Of elements and nutrients essential to a living organism but only required in very small amounts, their concentration in tissues may be measured in parts per million compared with the major elements expressed usually as percentage (parts per hundred).

TRAP-DOOR SPIDERS
A group of primitive spiders with jointed abdomens, they line their nests with silk and cover them with a hinged lid.

TROPICAL

Of the region between the tropics of Cancer and Capricorn (respectively 23 ½ degrees north and south), sometimes referring to areas beyond these latitudes where similar climate and vegetation prevail. The tropical region includes the equatorial[1] region. Tropical is used generally to indicate those features which are found throughout the whole region (including the equatorial) notably the high annual mean temperature and rainfall. Tropical is less frequently contrasted with equatorial to indicate the conditions close to the tropics themselves, especially the marked seasonal variation in rainfall, but monsoon (monsoonal) is a less confusing usage for the climate and vegetation in these parts where a definite dry spell alternates with the rains.

UNGULATES

Hooved mammals, mostly herbivorous and living in herds.

VERTEBRATE

An animal With a backbone (fish, amphibia, reptiles, birds and mammals).

VIRUS

A sub-microscopic body able to multiply in a host organism, usually evident due to the resultant disease, and consisting of nucleic acid with a covering of protein, sometimes with fat as well. Some viruses have been obtained as crystals. No free-living viruses are known. Viruses have some properties accepted as typical of living organisms and other properties which are not. The debate whether they are living or not depends on the definition of life and which criteria are considered typical. Viruses cause many dangerous diseases of man and animals and economic losses of crops; a few have potential as parasites - natural controls - of insect and mammalian pests.

VITAMIN

Organic compounds required in trace amounts by a living organism and essential to its health and normal functions, but which the organism is unable to make for itself and must obtain from the environment usually as food. Most animals and many fungi have vitamin requirements, but most green plants have none, because although they need the same compounds to function, they can make them from simple nutrients for themselves.

WATER-TABLE

The level of water in the soil, below which all the pores are filled with water. The water-table rises and falls with the rainfall, drainage and evaporation of water. The water-table may be above the soil surface during floods or in water-logged swamps.

WEED

A plant growing where some human does not want it, especially if it is competing with crops or detracting from planted ornamentals. Not all weeds are aliens, but many which are introduced grow very rapidly free from the pests and diseases in their country of origin.

WILDFOWL

Game-birds especially of wet places.

WILDLIFE

All living things except those cultivated or kept by man at any given place; the natural flora and fauna.

YEASTS

Single-celled fungi able to carry out fermentations and to produce various vitamins.

ZONATION

The formation of zones, belts or strips of different types of vegetation associated with variation in the environment. The zonation of the earth is by latitude from the frigid zones near the poles to the torrid zone of the tropics and equator. Altitudinal zonation is found on mountains. Littoral vegetation shows zonation according to the depth and frequency of inundation, the development of the soil, elevation and drainage. Zonation occurs along river banks and around lakes.

Acknowledgements

After suggesting that I should write this Manual, Mr. E.J.H. Berwick, O.B.E., Secretary General of IUCN has been a continual source of encouragement and assistance. The principal references from which material has been obtained are given in the bibliography. I am particularly grateful for information obtained from papers, letters and verbal communications from Mr. R.A. Allbrook, Dr. J.A.R. Anderson, Dr. E. Balasingham, Dr. I.Y. Carey, Mr. G.L. Carson, Mr. G.R. Conway, Prof. J.L. Harrison, Mr. and Mrs. T. Harrisson, Dr. D.S. Johnson, Mr. K.T. Joseph, Mr. M.K. Mohd. Khan, Dr. H.E. McClure, Lord Medway, Mr. H.T. Pagden, Mr. W.P. Panton, Dr. G.A. Prowse, Prof. A. Sandosham, Dr. W.E. Stevens and Mr. B.J. Wood.