AN OVERVIEW OF BIODIVERSITY IN MALAYSIA

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MANOKARAN, N. 1992. An overview of biodiversity in Malaysia. In this paper the status of biological diversity in the country is examined in the context of the forest ecosystem, wildlife, livestock, agricultural crops and aquatic flora and fauna. In so doing, the concept of biodiversity is discussed, and attention drawn to habitat loss and pollution as well as over-exploitation of biological resources over the last several decades. International cooperation in acquiring wild germplasm, especially of crop plants, is highlighted. Existing policies and legislations covering biological diversity are described. Finally, it is noted that key legislations for the protection of biological diversity are already in place but that what is required is effective implementation of these legislations.

Key words: Biodiversity - forest ecosystem - wildlife - livestock - agricultural crops - aquatic flora and fauna - policies and legislations

MANOKARAN, N. 1992. Pandangan menyeluruh tentang biodiversiti di Malaysia. Kertaskerja ini meneliti status biodiversiti di negara ini dan hubungannya dengan ekosistem hutan, hidupan liar, ternakan, tanaman pertanian serta akuatik flora dan fauna . Dalam hal ini, konsep biodiversiti dibincangkan dengan penekanan ke atas kehilangan habitat dan pencemaran, juga eksploitasi yang keterlaluan sumber biologi sejak beberapa dekad yang lepas. Kerjasama antarabangsa dalam mendapatkan germplasma liar, terutama pokok tanaman turut diketengahkan. Kertas kerja ini juga menyentuh polisi dan peraturan yang berkaitan dengan biodiversiti. Perlu ditegaskan, meskipun pada masa ini telah terdapat undang-undang dan peraturan bagi melindungi biodiversiti, apa yang lebih penting iaitu pelaksanaan yang berkesan bagi peraturan-peraturan ini.

Biological diversity - the concept

Biological diversity, or biodiversity, encompasses all species of plants, animals and microorganisms, and the ecosystems of which they are part. It is usually considered at three different levels, 'genetic diversity', 'species diversity' and 'ecosystem diversity'.

Genetic diversity is the diversity within species, as measured by the variation within genes. Such diversity covers distinct populations, or varieties, of the same species, as in rice, for example, or genetic variety within a population, which may be very high or very low.

Species diversity refers to the variety of living organisms on earth, variously estimated to be between 5 and 30 million or more, of which only about 1.4 million have been scientifically documented (Wilson 1988). Species richness on Earth today is the result of hundreds of millions of years of evolutionary history. Ecosystem diversity refers to the variety of the habitats, biotic communities and ecological processes in the biosphere.

While biodiversity is usually considered at the three different levels described, it essentially consists of three components (Figure 1). The compositional component consists of the genes, species and ecosystems as the basic units. The distribution of these units in time and space is structural diversity, and would include, among others, the vertical stratification in the tropical rain forest, the relative abundance of species, the age structure of populations and the pattern of communities in a region. When compositional and structural diversity change through land use or resource management, ecological processes or functional diversity such as nitrogen fixation, predation, and pollination and dispersal, changes. In the vast majority of these cases, the implications of these changes in functional diversity are poorly understood.

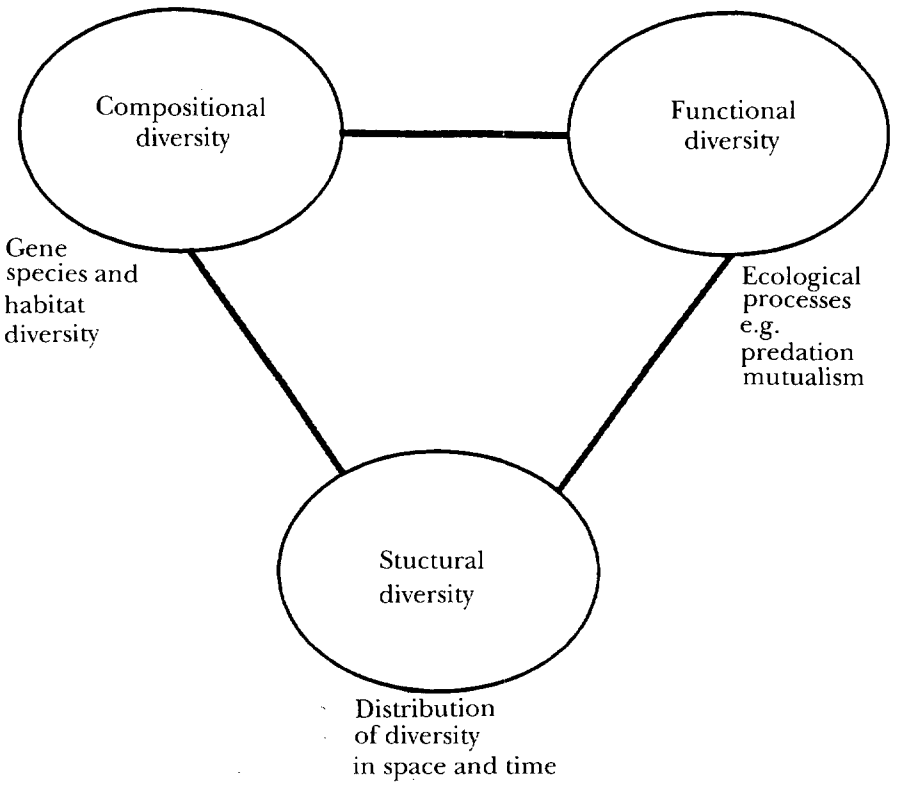

Figure 1. The various levels and components of biological diversity

An example of functional diversity is that of pollination of certain species of trees by bats, and this has been described in detail by Start and Marshall (1976) (Figure 2), and subsequently highlighted by Ng (1988). *Musa* (the wild banana), *Arenga* (an understorey palm), *Duabanga* (a medium-sized tree) and *Sonneratia*, the commercially unimportant mangrove species, are ever-flowering, and are pollinated by a species of bats, *Eonycteris spelaea*, throughout the year. This bat is an important pollinator of the durian (*Durio*, the valuable orchard fruit) and petai (*Parkia speciosa*,

the most important jungle fruit) when these flower only during certain times of the year. Thus wholescale clearance of mangrove areas, and with that of *Sonneratia*, could adversely affect populations of this bat as its diet is nectar and pollen from the flowers of the tree species it visits. This in turn could have repercussions on the fruit yields of durian and petai.

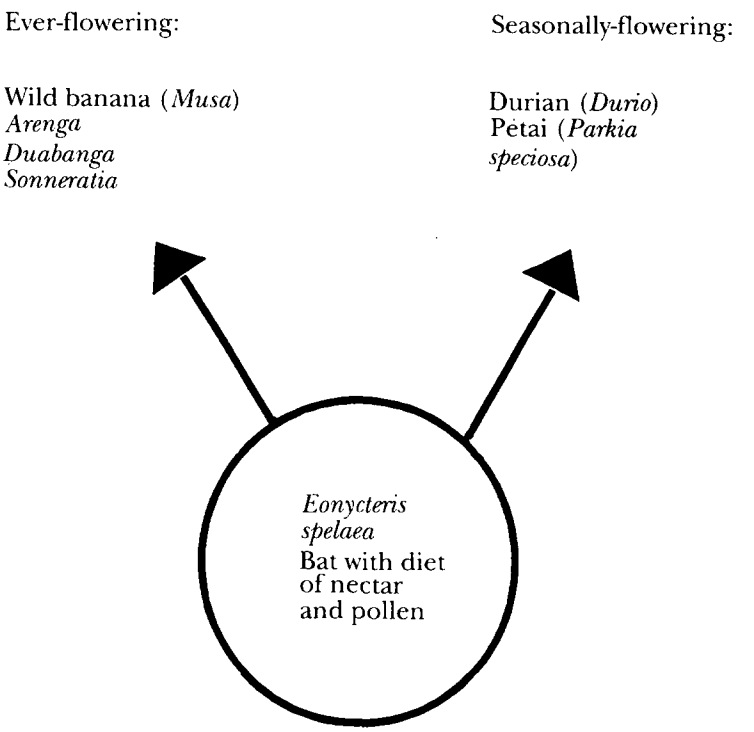

Figure 2. Functional diversity - feeding habit of bat leading to pollination of ever-flowering plants and seasonally - flowering fruit trees (adapted from Start & Marshall (1976))

Where is biodiversity concentrated?

Species richness increases from the poles to the equator, reaching its peak in tropical forests and coral reefs.

Forests now cover 3,625 million *ha* or 27.7% of the total ice-free land area of the world (FAO 1991). Of this total forest area, 25.4% is covered by boreal forests, 21.2% by temperate forests, and 53.4% by tropical forests.

Of the about 14% of the earth's land surface covered by tropical forests, 5-7% is covered by tropical moist forests with the remaining covered by tropical dry forests. Tropical moist forests are estimated to contain more than half the species in the entire world biota.

Loss of species

There is no accurate account of the loss of species and this loss may occur even before species are discovered. An estimate indicates that since the year 1600, 724 known species have become extinct (McNeeley *et al.* 1991). Another estimate places the potential loss of biodiversity at 15,000 to 50,000 species per year from the 1990s onwards, due mainly to tropical deforestation (Reid & Miller 1988).

The main causes of loss of species have been identified as;

* habitat loss, degradation and fragmentation;
* over-exploitation by commercial harvesting, logging, fishing and hunting;
* pollution;
* introduction of exotic species;
* climate change.

The main cause of species loss is habitat loss. For the period 1981-1990, the annual rate of deforestation of closed and open tropical forests was estimated to be as high as 16.8 million *ha* (FAO 1991).

Biological diversity in Malaysia

The forest types of Peninsular Malaysia were described by Symington (1943) and further elaborated upon by Wyatt-Smith (1964). This classification, shown in Table 1, applies to Sabah and Sarawak as well.

Table 1. The rain forest types of Malaysia (adapted from Symington (1943) and Wyatt-Smith (1964)

Climatic climax forest	Edaphic forest
Lowland dipterocarp forest	Heath (or Kerangas/Kerapah) forest
Hill dipterocarp forest	Forest over limestone
Upper dipterocarp forest	Forest over ultramafic outcrops
Montane oak forest	Beach stand vegetation
Lower ericaceous forest	Mangrove forest
Montane subalpine vegetation	Brackish-water forest
Semi-evergreen seasonal forest	Peat swamp forest
	Fresh-water swamp forest
	Seasonal swamp forest

The forest habitats are home to a wide array of plants, animals and micro-organisms. Species diversity increases with the inclusion of fresh water and marine environments, such as coral reefs, coastal waters, estuaries, montane streams, and lakes. Species diversity in Peninsular Malaysia, as shown in Table 2, exemplifies that for the whole of Malaysia.

Table 2. Species diversity in Peninsular Malaysia (from Cranbrook (1988))

Plant/animal group	Number of species
Flowering plants	8000
Ferns	500
Fungi	300
Mammals	203
Birds	616
Snakes	141
Frogs	93
Lizards	>80
Butterflies	1022
Moths	>5000*
Other insects	>20000*
Other invertebrates	>10000*

* estimates

The richness of the flora is reflected in results of recent studies. For example, in the Pasoh Forest Reserve, a lowland dipterocarp forest, 820 species in 294 genera and 78 families were enumerated in a 50-*ha* plot of all trees ≥ 1 *cm* diameter at breast height (Kochummen *et al.* 1990). The species number is almost one third of the total number of tree species found in Peninsular Malaysia. Seventy-six species of trees in the plot are known to bear edible fruit (Saw *et al.* 1991).

There is a high level of endemism in the flora. In Peninsular Malaysia, where more studies have been carried out, Ng *et al.* (1990) found that 746 species out of 2,830 tree species (26.4%) are endemic to the Malay Peninsula. Kiew (1990) calculated that in herbs, endemism in large genera with more than 40 species in *Sonerila* (Melastomataceae), *Argostemma* (Rubiaceae), *Didymocarpus* (Gesneriaceae) and *Begonia* (Begoniaceae) ranges between 87% to 96% of the species.

Just as in other parts of the tropics, much of our biological diversity awaits investigation, understanding and documentation. A complete inventory of all fauna and flora may never really be possible, nor a proper understanding of all other aspects of biological diversity. The best that one could hope for in attempting to evaluate the status of biodiversity in the country is to determine the status of the various ecosystems that harbour species diversity. In the case of domesticated flora and fauna, the emphasis would be on the status of breeding and conservation activities, if any. In taking this approach, biological diversity is discussed in the context of the forest ecosystem, wildlife, livestock, agricultural crops and aquatic flora and fauna.

The forest ecosystem

The extent

The total land area of Malaysia is 32.86 million *ha.* Of this forests account for 18.40 million *ha* (Table 3) (Ministry of Primary Industries Malaysia 1991). Dipterocarp forests, alluvial and peat swamp forests combined, and mangrove swamp forests constitute 86.4%, 10.3% and 3.3% respectively of the forested area.

It appears that the total area of other forest types, described in Table 1, has been included in that of the dipterocarp forests. It is uncertain as to how much non-

dipterocarp forest is on steepland, beginning with montane oak forest at about 1200 *m* a.s.l. About 15% of the forests is classified as Protective Forest (Table 4), and this presumably includes part of the upper dipterocarp forest as well.

Table 3. Distribution and extent of major forest types in Malaysia in 1989 (million *ha*)

Region	Land area	Dipterocarp	Swamp	Mangrove	Total forested land
Peninsular Malaysia	13.16	4.94	0.46	0.11	5.51
Sabah	7.37	3.93	0.19	0.32	4.44
Sarawak	12.33	7.04	1.24	0.17	8.45
Total	32.86	15.91	1.89	0.60	18.40

Source: Ministry of Primary Industries Malaysia, 1991

In accordance with t he National Forestry Policy 1978, and the National Forestry Act 1984, 12.73 million *ha* of forests have been designated as the Permanent Forest Estate. The Permanent Forest Estate consists of 9.99 million *ha* of Productive Forest, for timber production in perpetuity, and 2.74 million *ha* of Protective Forest, for the protection of watersheds and the environment (Table 4).

Table 4. Permanent Forest Estate in Malaysia in 1989 (figures in million *ha*)

Region	Protective Forest		Productive Forest		Total			Percentage of total land area
	Virgin	Logged	Virgin	Logged	V	L	V+L	
Peninsular Malaysia	1.90	-	0.44	2.40	2.34	2.40	4.74	36.0
Sabah	0.35	-	0.75	2.25	1.10	2.25	3.35	45.5
Sarawak	0.49	-	2.71	1.44	3.20	1.44	4.64	37.6
Total	2.74	-	3.90	6.09	6.64	6.09	12.73	38.7

Source: Ministry of Primary Industries Malaysia, 1991

A total of 1.39 million *ha* of forest have been set aside for the conservation of biological diversity (Table 5). This includes a network of national parks, and wild life sanctuaries and nature reserves. About 330,000 *ha* are within the Permanent Forest Estate and the remaining 1.06 million *ha* outside of it.

Since its inception in 1950, 125 pockets of virgin forests, known as Virgin Jungle Reserves (VJRs), totalling 110,624 *ha* have been established. These, varying in size from 3 to 1600 *ha* each, and representing various forest types, were established to serve as permanent nature reserves and natural arboreta, as controls for comparison with harvested and silviculturally treated forests, and as undisturbed natural forests for general ecological and botanical studies. In Peninsular Malaysia 77 VJRs covering 22,325 *ha*, and in Sabah, 48 VJRs covering 88,299 *ha*, were established, with none in Sarawak. Many are now isolated in a sea of agricultural development. How many of these still remain, and in what form, is uncertain.

Table 5. Areas under national parks and wildlife and bird sanctuaries in Malaysia in 1989 (figures in million *ha*)

Region	National parks	Wildlife and bird sanctuaries+	Total
Peninsular Malaysia	0.43	0.31	0.74
Sabah	0.25	0.14	0.39
Sarawak	0.08	0.18	0.26
Total	0.76	0.63	1.39

Source: Ministry of Primary Industries Malaysia, 1991

\+ A total of 190,000 *ha* in Peninsular Malaysia and 140,000 *ha* in Sabah are located in the Permanent Forest Estate

The remaining 4.61 million *ha* of forest outside of the Permanent Forest Estate are designated as Stateland Forests. These are earmarked for conversion, over a period of time, to agriculture and other land use.

Policy /legislations

The National Forestry Policy 1978, applicable to Peninsular Malaysia, provides for the classification of forests as Protective, Productive and Amenity Forests. This is further embodied in the National Forestry Act 1984 which is deemed to apply throughout Malaysia. As land matters are constitutionally the rights of the states, major decisions such as gazettement and degazettement of forest reserves are within the powers of the State government. A number of other Federal legislations complement and support the National Forestry Act. These include:

- Water Enactment 1920
- Land Conservation Act 1960
- National Land Code 1965
- Protection of Wildlife Act 1972
- National Parks Act 1980
- Environmental Quality Act 1974

The Water Enactment provides guidelines for the maintenance of riparian strips or river reserves, but these are not strictly enforceable.

The Land Capability Classification, introduced between 1963 and 1976, ranks mining to be of highest priority, followed by agriculture, and then only forestry and other uses. Major land use changes, with consequent impact on biological diversity, have resulted from the application of the Land Capability Classification.

Under the Environmental Quality Act, an environmental impact assessment is prescribed for activities that affect forest. This includes activities involving conversion of forests to other land use as well as to logging in areas greater than 500 *ha* or in catchment areas.

Land use and forests

i) Conversion of dipterocarp forests to agricultural land

Significant conversion of lowland forests to other land use began with a significant increase in tin mining activities in the western parts of the Malay Peninsula in the middle of the nineteenth century, and the beginning of plantation cultivation of rubber (*Hevea brasiliensis*) at the start of the nineteenth century. With rubber prices having dropped sharply in the world markets in the 1960s, lowland forests were cleared further for the planting of oil palm (*Elaeis guineensis*) in order to diversify the economy.

Forest conversion to agriculture, mainly oil palm and rubber, intensified during the period 1971 to 1990, when government-supported land development schemes were established, mainly in Peninsular Malaysia. A total of 1.64 million *ha* of lowland forests, representing up to 20% of the forested area in the Peninsula, were cleared to resettle about 4% of the population (WWF 1992). This emphasis on agricultural development led to decline in poverty but at considerable environmental cost. Following the path taken in Peninsular Malaysia, the expansion of land development schemes for oil palm by the Federal Land Development Authority (FELDA) has been in Sabah since the mid 1980s.

Over the period 1970 to 1989, forested land for the whole of Malaysia had been reduced by 5.39 million *ha* or 22.7% (Table 6). Reduction was 31.4% for Peninsular Malaysia, 29.9% for Sabah and 10.5% for Sarawak. Almost all the forests cleared were lowland forests, the largest reservoir of genetic variation of dipterocarp trees, the largest and most important timber group of the country and of the Southeast Asian region.

Table 6. Proportion of forested land in Malaysia in 1970+ and in 1989*

Region	Land area (million *ha*)	Forested land (million *ha*)		Proportion (%) of forested land in	
		1970	1989	1970	1989
Peninsular Malaysia	13.16	8.03	5.51	61.0	41.9
Sabah	7.37	6.33	4.44	86.0	60.2
Sarawak	12.33	9.44	8.45	76.6	68.5
Total	32.86	23.79	18.40	72.4	56.0

\+ Source: Annual Reports of Forest Departments of Peninsular Malaysia, Sabah and Sarawak
* Source: Ministry of Primary Industries Malaysia, 1991

Building of dams has led to loss of natural forest habitats. It is estimated that well over 100,000 *ha* of forested land have been submerged to date (Tho 1990). In Sarawak, Marajan and Dimin (1989) estimated from an analysis of a 1985 Landsat imagery that a total of 3.5 million *ha* (28.4% of the total land area) in Sarawak had been affected by shifting cultivation.

ii) Mangrove forests

As at 1989, about 600,000 *ha* of mangrove forests remained (Table 3), with 70% as forest reserves and the remaining as stateland forest (Ong *et al.* 1992). Ong *et al.* (1992) note that over the period 1980 to 1990, mangrove forest reserves had been reduced by about 12%, mainly through conversion to agriculture and shrimp culture, and by reversion to stateland mangrove status. In the state of Selangor alone, 35% of mangrove forests were converted to mainly oil palm and coconut plantations over the last 15 years.

Chan (1984) reported that between 1970-79, more than 75% of the logged mangrove forest in the Matang area in Perak required enrichment planting. Declining productivity of the mangrove forest, to 60-70% of the original capacity, implied decrease in the food supply of mangrove dependent organisms. Of the present total mangrove area, only 0.3% in Peninsular Malaysia, 0.2% in Sarawak and 1.3% in Sabah are protected.

The importance of the mangrove ecosystem is well known. Mangroves, besides providing wood, are feeding and nursery grounds for fisheries, and are the habitats of several of our important commercial fishes and prawns. They are also an important nutrient source, through leaf litter decomposition, for organisms in the adjacent deeper waters and hence serve as an important link in aquatic food chains (Odum & Heald 1972).

iii) Swamp forests

Swamp forests, both peat and freshwater alluvial, accounted for 10.3% of the total forested land in 1989. They are important habitats for wildlife, besides being a source of timber. Together with the mangrove forests and other water bodies such as rivers and lakes, they form the wetlands important for migratory species.

Much of the swamp forest had been cleared for conversion to agriculture during the last 25-30 *y*. Timber extraction often leads to lowering of the water table and consequently to further changes in the ecosystem. Peat swamp forests are mostly gazetted as forest reserves, and are under-represented as protected areas.

Logging issues and biological diversity

The tropical rain forests are stratified into several vertical layers (Richards 1952). The five layers in the dipterocarp forest consist of the emergent layer of large trees, up to a height of 45 *m* or so, the canopy layer at a height of about 30 *m*, the understorey layer at about 15 *m* height, the shrub layer up to 5 *m* height, and the herbaceous layer at ground level. This stratification has provided a diversity of niches for animals as well as plants. The niches may be separated from each other not only in space but also in the time of activity. Thus there are animals that are either diurnal or nocturnal or are both diurnal as well as nocturnal.

The tropical rain forest is therefore a highly complex ecosystem of flora and fauna. Interactions between the flora and fauna through the food web, and especially through pollination of flowers and dispersal of seeds, help to maintain the forest. Harvesting of

the forest for timber disrupts the interaction between the various communities, the degree of disruption depending on the intensity of logging. Whitmore's (1984) summary of various studies indicate that light selective logging does not totally disrupt mammal and bird communities, and that many species recover their numbers, and some are benefited. In such logging activities, relict patches of intact forest play a vital role as refuges during logging for some mobile species.

Under management systems prescribed for the dryland forests in Peninsular Malaysia, Sabah and Sarawak, harvesting is selective. Residual trees are expected to form the next crop in specified time periods. Up to 1989, about 85% of the Productive Forest in Peninsular Malaysia, 75% in Sabah and 35% in Sarawak had already been logged (Table 4). It is estimated that by the end of this decade no primary forest areas will remain in the Productive Forest of the Permanent Forest Estate in Peninsular Malaysia, and by the early part of the next decade in Sabah as well.

The issues of overlogging and illegal logging have been highlighted in the press from time to time. These issues have been brought into even greater focus now with the Federal Government determined to stamp out these practices once and for all. These logging activities, by their very nature, are highly destructive to the environment. In addition, logging operations in forest concessions, whose licensees are powerful figures, are also known to be overly intensive and therefore highly destructive as well. The logging activities just described, the extent of which is uncertain, disrupt the structural and functional diversity - the effect of badly damaging the vertical structure of the forest is to greatly reduce the diversity of niches available and therefore of the great diversity of life forms. The ground surface, so badly exposed now, suffers erosion from torrential rains that are common in the tropics. This is particularly acute since much of the timber harvesting is now in hill forests.

While little is known of the biological diversity and the ecological processes at and below the soil surface in the forests of the tropics, soil organisms through their activities, are known to breakdown litter, mix organic matter, release nitrogen in the ammoniacal form and help to maintain the porosity of the soil. Disruption of such ecological processes through severe soil loss resulting from the logging activities just described causes irreversible damage to the system as the forest becomes degraded.

Studies by Shallow (1956), Leigh and Low (1973) and Abd. Rahim *et al.* (1988) have shown that the sedimentation rate in forested areas is well below the 1 $t\ ha^{-1}\ y^{-1}$ standard of UNESCO. Another study by DID (1986) of the Sg. Tekam catchment in the state of Pahang showed that the sedimentation rate in the streams was 6.60 $t\ ha^{-1}\ y^{-1}$ during the first year after logging.

Wildlife

The decline

The status of conservation of wildlife in Peninsular Malaysia, Sabah and Sarawak has been summarised by the IUCN (Anonymous 1988a, 1988b).

In Peninsular Malaysia, much of the rich diversity in fauna is altitudinally restricted to the lowlands. Even species which range from the lowlands to the upper montane zones such as the tiger, elephant, rhinocerous and pig-tailed macaques, occur

naturally at higher densities in the lowlands. The intensification of forest conversion to agriculture beginning in the early 1970s has had an impact on their population levels.

The Sumatran rhino, which occurs in small number at several locations in the Peninsula, has a viable breeding population only in the Endau-Rompin forests. Just as the Javan rhinocerous became extinct in the Peninsula in 1932 due to illegal poaching, the Sumatran rhino is in danger of meeting the same fate.

The tiger population in the Peninsula has dwindled to about 250 from about 3500 in the early 1950s. The seladang (gaur or wild cattle) population is down to about 480 individuals scattered across several reserves. About 700 elephants remained in 1982, scattered over several states. Other species of mammals listed as threatened by IUCN include the dhole (wild dog), leopard, clouded leopard, golden cat, marbled cat, flat-headed cat, horseshoe bat, Malay tapir and serow (mountain goat).

In Sabah and Sarawak, the diverse flora supports an equally diverse fauna with a high level of endemism. Habitat loss in Sabah has been high. Excessive hunting has led to some faunal populations being at risk in both the states. In Sarawak, shifting cultivation activities have been detrimental to wildlife.

Policy/legislations

The Protection of Wildlife Act 1972 provides for the establishment of wildlife reserves or sanctuaries. The Taman Negara Enactment, of Pahang (1939), Kelantan (1938) and Trengganu (1939), led to the establishment of Taman Negara, or the National Park, for the protection of indigenous flora and fauna. The National Parks Act 1980 has yet to see the creation of a new national park.

Sabah has its own conservation legislation. The national parks in Sabah were gazetted as state parks in 1984 to avoid confusion with national parks that would be gazetted under the federal National Parks Act 1980.

Sarawak also has its own legislation concerning conservation. The National Parks Ordinance (1956), the Wildlife Protection Ordinance (1958) and the Forests Ordinance (1954) allow for the gazettement of national parks and wildlife sanctuaries and reserves.

Protected areas

The existing national park in Peninsular Malaysia, and those in Sabah and Sarawak, were established under the provisions of state legislations. The National Park in Peninsular Malaysia, Taman Negara, covers an area of 434,300 *ha*, with 57% being in Pahang, 24% in Kelantan and 19% in Trengganu, and with 58% lowland forest below 300 *m* a.s.l. and the rest hill and upper dipterocarp forests between 300 to 1200 *m* a.s.l. (Anonymous 1971). Illegal logging has been reported in the National Park in recent years.

The proposed second national park at Endau-Rompin, reduced in size from its originally proposed 87,000 *ha* to 24,281 *ha* through logging, has yet to be gazetted. The state governments of both Johor and Pahang now want the areas to be state parks rather than a national park (Leong *et al.* 1992).

The existing protected areas in Sabah and Sarawak are about half and one-third in total area respectively of that in Peninsular Malaysia. In all three regions, three major habitat types, mangrove forests, peat swamps and freshwater swamps, important for wildlife including migratory birds, are quite unprotected by any sizeable protected areas.

Livestock

The status

One of the more recent summaries of genetic resources of livestock or farm animals is that of Mukherjee (1979). Farm animals are categorised as indigenous and non-indigenous.

Malaysian jungle fowls, wild pigs, swamp buffaloes, Kedah-Kelantan cattle and local goats (Kambing katjang) are considered true indigenous animals of Malaysia. Other farm animals such as L. I. D. cattle, Kelantan sheep, local Chinese pigs, Canton type chickens, some local ducks and geese, and local Bronze turkeys are also termed indigenous. This is because over the generations their habitats perhaps modified their genome to a considerable extent for their adaptation to the new environment, and the gene frequencies within each of the populations might have been stabilised a long time ago.

Non-indigenous animals are mainly breeding chickens, pigs, cattle and goats which have been imported into this country from all over the world. Importation of these animals has enriched the gene pool of the different species considerably.

Mukherjee (1979) observed that a great deal of information on the distribution, population numbers and productive performance of the various breeds, strains and varieties of different domestic animals now exists in Government and private farms in Malaysia. However, he noted that much of the information is not readily available to planners, administrators and research workers involved in animal production because most of the data are unpublished.

Policy/legislation

The National Agricultural Policy 1984, which has just been revised, provides for the development of food production. Included in this category are lifestock products such as meat, dairy and poultry, as well as fish and aquaculture.

Crop genetic resources

Policy/legislation

The National Agricultural Policy 1984 sets out guidelines for agricultural development up to the year 2000. The Policy, which categorises Malaysian agriculture into two classes, food production and industrial crop production, has just been revised.

The status

Crop genetic resources consist of indigenous as well as introduced materials. Indigenous crop genetic resources require conservation while introduced crop genetic resources require broadening of the genetic base. Our major economic crops such as rubber, oil palm, pepper and cocoa are introduced.

Biodiversity of crop genetic resources is best discussed in terms of conservation and broadening of the genetic base. Arasu (1975, 1985), Mak *et al.* (1979), Zakri (1986) and Zakri *et al.* (1989) have discussed this subject in detail. The main points, especially from Zakri *et al.* (1989), are summarised here.

i) Rice

Germplasm collection of rice (*Oryza sativa*) started before 1950 (Chen 1983), and at present the germplasm collection stands at 6082 accessions. About one half of the total collection comprises indigenous varieties, which have been collected from remote areas where farmers continue to plant part of their paddy land with traditional varieties along with improved strains. The remainder of the collection originates from 29 different countries. The International Board for Plant Genetic Resources (IBPGR) has, and is, assisting in the activities to broaden the genetic base.

ii) Rubber

Most of the present planting materials of rubber (*Hevea brasiliensis*) are derived from a small collection of 22 seedlings brought from Brazil (Wycherley 1968, Subramaniam & Mohd. Noor Ghani 1975). The genetic base of the germplasm is therefore narrow. This situation is further exacerbated by the plantings of a few selected, high yielding clones which lack resistance to the South American leaf blight.

To enlarge the genetic base, the Rubber Research Institute Malaysia (RRIM) participated in the International Rubber Research Development Boards's (IRRDB) wild collection expedition to the Amazon Basin in 1981. Another collection expedition to the Amazon Basin is being finalised now.

iii) Oil palm

The genetic base upon which the breeding populations of oil palm (*Elaeis guineensis*) in Southeast Asia are based is extremely narrow (Hartley 1976). Expeditions to West and Central Africa to collect wild germplasm were organised during the last two decades. An expedition to Nigeria was jointly organised by the Malaysian Agricultural Research Development Institute (MARDI) and the Nigerian Institute for Oil Palm Research (NIFOR) in 1973 (Rajanaidu 1985). Subsequently, further collections were carried out in Cameroon, Zaire, Tanzania and Madagascar, and in Central and South America for wild germplasm of the related *E. oleifera* (Rajanaidu 1985).

iv) Cocoa

The cocoa (*Theobroma cacoa*) crop in the country is of narrow genetic base (Arasu 1975). Recently MARDI imported a wide range of new genetic material from Brazil, and the present accessions stand at 400 (Arasu 1985).

v) Coconuts

Malaysia is located within the centre of diversity of the coconuts (*Cocos nucifera*) (Whitehead 1976). However, the coconut germplasm in this country is being indirectly eroded through massive replanting programmes under the Coconut Smallholders Development Scheme beginning 1963 and the increasing rate of industrial development. Coconut germplasm is being collected by MARDI (Jamadon & Misbah 1984).

vi) Fruits

The Indo-Malaysian forests are regarded as one of the major centres of diversity and origin, and therefore as gene pool, of many important crop plants, including fruit tree species (Harlan 1970, Li 1970, Zohary 1970, Frankel 1975, Soepadmo 1989). Loh (1975) lists more than 100 species of fruit trees under cultivation in Malaysia. Of these, only the pineapple is grown on a commercial scale, and the breeding material for this crop is limited to three or four highly heterozygous clones (Arasu 1975). Cultivation of the others are in smallholdings. Loss of natural habitats is leading to genetic erosion of many of these fruit crops such as the citrus and citrus relatives.

vii) Root and tuber crops

The notable crops under this grouping are cassava (*Manihot esculenta*), keladi (*Colocasia* sp.), yams (*Dioscorea* spp.) and sweet potato (*Ipomoea batatas*). Conversion of forests for agricultural and land development purposes is considered to have led to erosion of wild species, primitive cultivars and genetic variability of these crops (Ghani-Farah 1989).

viii) Food legumes

Groundnut (*Arachis hypogaea*), soybean (*Glycine max*) and long bean (*Vigna sesquipedalis*) are some of the food legumes of significance in the country. Cultivation is, however, not large, and cultivars have been introduced from outside for adaptation to local environments or as parents for making crosses (Yap & Wong 1982).

Aquatic flora and fauna

The aquatic environment includes both maritime and riverine waters. 'Maritime waters' of Malaysia refers to areas of the sea adjacent to Malaysia, both within and outside Malaysian fisheries waters and includes estuarine waters or waters of the mouth of the river. 'Riverine waters' means the waters of any river, lake, stream, pond or such other waters, whether natural or man-made.

The aquatic flora and fauna of Malaysia have been poorly documented. Under this circumstance, therefore, the most logical manner in which to evaluate the status of this component of the biodiversity is to evaluate the status of the habitat itself, and of the fisheries industry.

Policy/legislations

The principal legislations for the management of fisheries come under the Fisheries Act 1985, and the Exclusive Economic Zone (EEZ) Act 1984. The Fisheries Act provides for the conservation, management and development of maritime and estuarine fishing and fisheries in Malaysia and of turtles and riverine fishing. There is provision under this Act for the establishment of marine parks for the protection of aquatic flora and fauna, and the protection of breeding grounds and habitats of aquatic life. Under the EEZ Act 1984, any written law relating to fisheries shall be applicable to the exclusive economic zone which is the area extending two hundred nautical miles beyond from the baseline of the territorial sea.

Riverine flora and fauna

That the inshore waters of Malaysia were overfished had been known since the late 1960s. In reviewing the state of fisheries in Malaysia, MIER (1990) noted that there was a drastic decline in the quantities of riverine fish available for sale between 1971 and 1975 in Peninsular Malaysia, declining from over 1000 *t* in 1971 to less than 200 *t* in 1975. Since then, MIER (1990) notes, the resource has further deteriorated.

Environmental pollution is considered to be one of the major factors for the decline in the riverine fisheries. Out of 86 rivers surveyed over the period 1985-89, 39 rivers (or 41%) in Malaysia were classified as grossly polluted, and these cannot sustain fish or any other form of aquatic life while many others are moderately polluted, severely reducing the fish stocks (Anonymous 1992a).

MIER (1990) ascribed severe river pollution to the discharge of organic wastes into rivers, and the siltation of river systems. The organic wastes include sewage, oil palm mill effluents and rubber factory effluents. Siltation is mainly through deforestation, poor logging practices, mining activities and urbanisation. Extensive use of pesticides in oil palm and rubber plantations as well as other agro-based industries ultimately find their way into rivers and cause fish mortality either directly or via the food chain.

Marine flora and fauna

The marine environment of Malaysia supports a rich and diverse assemblage of life ranging from microscopic floating plants and animals collectively known as plankton, to actively swimming animals like fish, turtles and marine mammals which are collectively known as nekton (Salleh & Wan Portiah 1992). Phytoplankton like diatoms and algae form the base of food chains in the sea to support plant-feeders which in turn support the carnivores. The zooplankton include copepods, segestid shrimps, and arrow worms together with the young planktonic stages of barnacles, crabs, prawns, molluscs and fish. Other algae (such as seaweeds) and sea grasses are other plant life in the sea. Beds of seagrass occur in shallow waters, and being extremely productive, form an important ecological niche for sea organisms.

The coral reefs, such as those of Pulau Payar near Pulau Langkawi off the west coast, and of Pulau Redang, Pulau Tinggi, Pulau Besar and Pulau Tioman off the east coast,

are a group of complex shallow water ecosystem that is among the most productive of all natural ecosystems, whether terrestrial or marine. The reefs encompass many habitats and are suitable breeding and nursery grounds for a large variety of marine life including fish, cuttlefish, squids, sea urchins, giant clams, sea cucumbers, and many other large and small organisms. For this reason the coral reefs are sometimes referred to as the tropical forest of the ocean.

The coral reef community in Malaysia is considered to be one of the most diversified in the world. In the waters of the Bodgaya group of islands off the coast of Semporna, Sabah, for example, a total of 466 species of macro invertebrates (excluding hard corals) and 265 species of fish, including 36 species of butterfly fish, have been observed.

The total fisheries production, consisting of marine coastal fisheries, or inshore coastal fisheries, and offshore fisheries increased steadily from 481,641 *t* in 1984 to 951,307 *t* in 1990 (Anonymous 1992b). The marine coastal fisheries, which include finfish, prawn and shellfish resources, are distributed more densely in a relatively narrow but productive inshore coastal zone.

Annual fisheries statistics for the period 1970-1990 indicate a drop in catch per unit effort of many commercial fish landed from the inshore coastal areas (Anonymous 1992b). During this period fishing intensity increased, and a few commercial species had almost disappeared from some localities. In contrast, there was increase in catch of other commercial species, especially the invertebrates such as the prawns, squids and cuttlefish.

Besides increased intensity of fishing, pollution channelled from industry and agriculture into costal waters, had also led to the decrease in catch of many commercial fish species. The Environmental Quality Report 1990 (Department of Environment 1991), in fact, notes that Malaysian coastal/marine water "is still contaminated with oil and grease, faecal coliform and suspended solids, and that activities such as land development, agriculture and high population density were among the main causes of water pollution."

The coral reefs, the breeding and nursery grounds of a large variety of marine life, have been facing degradation due to human terrestrial activity. Sedimentation is one of the major problems facing coral reefs and while no quantitative information exists, there is little doubt that deforestation, agricultural and forestry practices, exploitation of mangroves, and the dumping of terrestrial and marine effluents and sewage have adversely affected the coral reefs of the nation. This is because coral polyps are sensitive organisms that need optimum water conditions to survive. In addition, coral reefs are threatened by illegal harvesting of coral and other reef life for sale to aquarium wholesalers. Such activities are widespread off the east coast.

To date 22 offshore islands and the surrounding marine waters have been identified and proposed for the establishment of marine and state parks. Some of these have already been gazetted. The aim in establishing these parks is to protect, conserve and manage representative marine ecosystems in perpetuity. However, as states have jurisdiction over the islands and the federal government over the living resources in the sea, resort development approved on some of the islands has resulted in the discharge of sediment load into the ocean leading to coral reef damage.

Conclusions

In the drive towards alleviating poverty, agricultural areas expanded quite considerably, mainly for industrial crops, particularly in Peninsular Malaysia. This expansion was at the expense of pristine lowland forests, including wetlands, the storehouse of a large reservoir of biological diversity. The environmental cost has also included reduction in wildlife populations. The expansion in agricultural areas continues, primarily for the industrial crops, oil palm and rubber, and in Sabah mainly.

While biological diversity is completely lost with conversion of forests to other uses, over-intensive timber harvesting operations lead to breakdown in structural and functional diversity, leading to forest degradation in the long run. Overlogging and illegal logging activities are highly destructive and these have occurred regularly in recent times but the extent of this is uncertain. The Government is now taking measures to put an end to all these activities once and for all. Such measures should include strict compliance of licensees with procedures laid down for the harvesting of timber in the designated concessions.

Forested areas have been set aside for the protection of biological diversity and the environment, and these amount to almost 21% of the total forested land. However, some key habitats such as mangrove forests and swamp (peat and freshwater) forests are underrepresented as protected areas. Globally, there is continuing debate as what proportion of the tropical forest needs to be totally protected, as the functioning and maintenance of this ecosystem is poorly understood.

The gene pools of livestock and crop genetic resources have benefited from germplasm obtained from outside the country. While in livestock this has been achieved by the importation of certain animals, in crops this has been achieved through the cooperation of international agencies such as the IBPGR, IRRDB, NIFOR, the International Council for Development of Underutilised Plants (ICDUP) and the Society for Advancement of Breeding Researches in Asia and Oceania (SABRAO). Loss of forested areas, mainly lowland forests to agricultural development in particular, has led to loss of wild relatives and to genetic erosion of some of the crop plants.

Pollution of the riverine habitat from discharge of organic wastes from industrial activities, silt from forest clearance, poor logging practices, mining activities and urbanisation, and pesticides from industrial crop plantations and other agro-based industries have adversely affected riverine fisheries. This is an indication that riverine biological diversity has been affected as well.

Such pollution channelled into coastal waters has adversely affected catches of several commercial fish, the catches being affected also by overfishing. Coral reefs off our coasts, the habitat, and breeding and nursery grounds for a large variety of marine life, are highly susceptible to such pollution. The extent to which coastal marine biological diversity has been affected is, however, not known. That in a period of only ten years till 1990, mangrove forest reserves, another habitat and feeding and nursery ground for fisheries and an important link in aquatic food chains, had been reduced by 12%, is further indication that our marine biological diversity is greatly at risk from changes that may have serious long-term implications.

Protection of the environment is central to the issue of protection of biological diversity. There are in existence key legislations such as the Environmental Quality Act 1974, and others that have been mentioned in this paper. What is required now is effective implementation of these legislations and the necessary resources made available to achieve this. The Government has already made it clear that it intends to stamp out activities in the forestry sector that are against effective forest management practices . This same approach in all other sectors concerning and affecting biological diversity will ensure that biodiversity is protected, managed and utilised sustainably.

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