INTERNATIONAL UNION FOR CONSERVATION OF NATURE AND NATURAL RESOURCES

Conservation Review of Tropical Rain Forests, General Considerations and Asia

by

T. C. Whitmore, IUCN Consultant

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A GENERAL CONSIDERATIONS

Scope of the review

The principal objectives of this review, are:

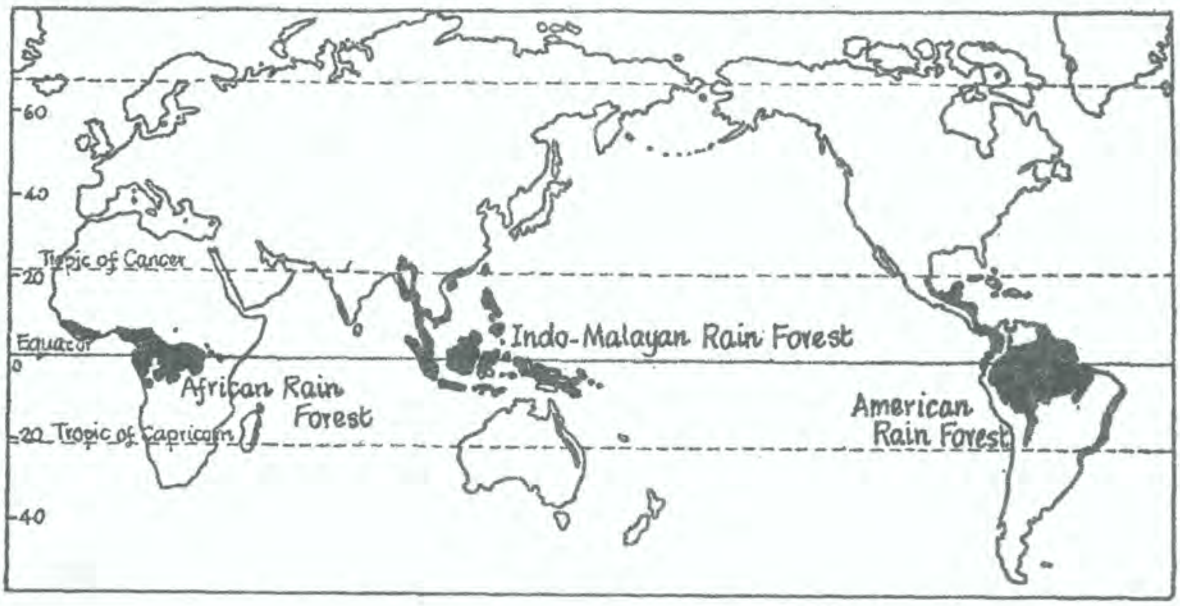
1. To prepare a description of the range of variation of tropical rain forest with maps showing the distribution of the various types.

2. To relate this description to the distribution of protected areas that at present afford effective protection.

3. To propose additional areas that may qualify for protection so as to ensure that the whole range of variation is afforded protection.

Each of the three tropical rain forest regions shown on the map (below) will be published separately and within them a report presented on each country. In this section consideration is given to matters pertinent to the whole review. It is followed by a section on Asia and the Pacific Region. Reports on Africa and Latin America will be issued separately later.

Distribution of tropical rain forest (Whitmore, 1975, Fig. 1.1).



Range of variation of tropical rain forest

Different sorts of rain forest can be recognized based on differences in structure and physiognomy. These sorts are called forest formations and they occur throughout the tropics despite the very substantial differences in flora between the different continents and between distant places within each continent.

Research on tropical rain forest has been mainly on a national or a regional basis and different systems of nomenclature have been developed in each of the three rain forest regions. These systems have the advantage of having been prepared as a result of aquaintance with the forests and therefore account for those kinds of forest which actually occur within the region.

For the purposes of this review of the state of and needs for conservation it is considered most useful to adopt one of these existing regional systems. It is not considered necessary or appropriate to attempt a review of the numerous systems of nomenclature which have been proposed, or to use one of the few global systems or to introduce a new global system. Some notes will be made in the African and Latin American reports on the extent to which the systems used differ from that used for Asia. The Asian system, which is essentially that introduced for the Indian Empire by Champion (1936) and modified by Burtt-Davy (1938) and Whitmore (1975), is the one preferred by the author.

Two world-wide systems of vegetation have recently been published. These are that introduced for the CT section of IBP by Fosberg (e.g. Fosberg 1967); and that introduced by UNESCO (1973a) to provide a framework of categories to be used in vegetation maps at scales $1:10^6$ or smaller. Neither of these new systems provides enough resolution or sufficiently precise definitions of the forest types recognized to be useful for present purposes.

Clapham (in preparation) is shortly to publish an assessment of "the specification and classification of vegetation types: a consideration of available methods and their suitability for various purposes, (with notes on) the special problem of tropical forests".

Tropical rain forest delimited against monsoon forests, subtropical rain forests and temperate rain forests

Tropical rain forest occupies climates which are perhumid or have only a slight dry season. Monsoon forest is a convenient term for those kinds of forest developed in places with a more marked dry season, where water is periodically seriously limiting to plants. The term was introduced by Schimper (1903). In his introduction to a discussion of these forests in Asia Whitmore (1975, chapter 12) states that "in general monsoon forests are of lesser stature than rain forests, with a lower biomass, and are deciduous to a considerable degree. The boundary against rain forest is often sharp, owing to the action of fire, rain forests often penetrating the monsoon formations as narrow strips of 'gallery forest' along water courses". Monsoon forests are very extensive on the Asian continent and in Africa. They are beyond the scope of the present review. Maps of climate can give useful assistance in delimiting the boundary between rain and monsoon forests.

At its latitudinal limits tropical rain forest merges into subtropical rain forest. Webb (1959) and Baur (1964) list structural and physiognomic differences from tropical lowland evergreen rain forest (*sensu* Burtt-Davy and this report, see B for definition and discussion) of which the principal ones are smaller predominant leaf size (notophyll not mesophyll *sensu* Webb 1959) and virtual absence of cauliflory and stilt roots. There are also floristic differences. Baur (1964) reported that subtropical rain forest is of limited occurrence, on fertile, well-drained soils beyond the tropics. He recorded it for eastern Australia (see also Webb 1959, as notophyll vine forest) and southern Brazil. The rain forests of south China and Taiwan, about which little is known, are possibly subtropical rather than tropical. New Caledonia is excluded from this review because its high forests are also believed by the author to be subtropical.

Some montane tropical rain forests have similarities in structure and physiognomy with temperate rain forests of, for example, southern Japan. There are also floristic similarities at family and, to a lesser extent, at generic level. There are substantial climatic differences between tropical mountains and the warm temperate zone, although rainfall and mean temperature are similar. For example, in the tropics the diurnal temperature range commonly exceeds the annual range, whereas in the temperate regions there is a marked annual cycle in climate and annual ranges exceed diurnal ones. For these reasons it seems preferable to distinguish tropical montane rain forests from temperate rain forests as separate formations, although they have sometimes been equated (e.g. by Baur 1964). Temperate rain forests are outside the scope of the present review.

World distribution of tropical rain forest

A map of the tropical rain forests of the world has been reproduced above. There are three great blocks.

The most extensive is the American rain forest, centred on the Amazon basin, extending to parts of the shores and islands of the Caribbean in the north and down the eastern Andean foothills in the south, and with outliers on the western slopes of the Andes and the Atlantic coast mountains. The extent of this forest is about 400×10^6 ha; it comprises about one-sixth of the total broad-leaf forest of the world (Pringle 1969).

The Asian (Indo-Malayan) rain forest is the second most extensive block and is estimated to cover about 250×10^6 ha (Pringle 1969). This extent is less than that of the American block, and the Indo-Malayan rain forest has been more extensively disturbed or destroyed by timber extraction. Rain forest occurs on many of the islands of the Pacific Ocean in Melanesia, Micronesia and Polynesia and these are included here.

The third block, the African rain forest, centred in the Congo basin and extending along the north coasts of the Gulf of Guinea and with outliers in Uganda, is the least extensive and the poorest in species. Pringle (1969) estimated that the evergreen and semi-deciduous forests of Africa cover 180×10^6 ha.

In addition there are a few relicts of rain forest remaining on the east coast of Madagascar and on the islands of Mauritius, Reunion, Rodriguez, and the Seychelles. These rain forests of the south Indian Ocean islands were never very extensive. They are included with the African forests in the present review.

Variation within the forest formations

It is now increasingly being realised that both the African and South American rain forests have been substantially reduced in area at dry periods during the Pleistocene, and have only recently expanded from small refugia to reach their present extent. By contrast there is no evidence that the Far Eastern tropical rain forest has been similarly decimated. This is probably because it lies centred on the Malay archipelago, a maritime rather than a continental setting and therefore less prone to desiccation. Furthermore, there are far more mountains in the tropical Far East than in tropical Africa or America and these have probably always had a wet climate and would therefore have provided a closer network of refugia than exists elsewhere in the tropics during any periods when the lowland climate did become drier.

The Far East rain forests are probably the richest in species of both plants and animals. On present evidence plants show a much greater degree of local endemism than elsewhere. Richness and endemism are likely to result, at least partially, from the greater stability of climate than elsewhere in the humid tropics. In Africa and Latin America there are now known to occur centres rich in endemic species, (F. White, H. Irwin, pers. comm.) probably representing Pleistocene refugia. In Africa these centres are superimposed on widespread forests throughout which there are a number of ubiquitous species.

It has already been noted that there are major floristic differences within the rain forest formations within each rain forest region as well as between the three regions.

In practice, conservation is likely to be organized on a national basis, and in this review the aim will be to discuss existing and potential protected areas to provide national networks which cover the main floristic variation within each forest formation. In a small State, such as Sarawak, one or a few reserves in each formation would be adequate, but in large nations, such as Brazil or Indonesia, complete geographic coverage must be aimed for and if centres rich in endemic species have been discovered the network should include them. Regional needs will also be kept in view. For example, mangrove forest comprises a fairly small number of species of very wide geographical range, and one need not for example advocate that each State in South East Asia should aim to set up a mangrove forest conservation area. Some discussion will be given in the introduction to the country reports on each region of the variation within it.

The network of reserves to be proposed will give full coverage to the natural regions proposed by Dasmann (1972, 1973). It differs from Dasmann's approach in that it is essentially pragmatic and avoids the necessity to attempt to establish and apply criteria whereby formal biotic regions and provinces can be defined and mapped. As Dasmann pointed out it is difficult to apply criteria without expert knowledge of a particular region.

The size of conservation areas

Conservation is not solely a matter of preserving samples of different vegetation formations. Conservation of species is of greater practical importance, because of their actual or potential utility to man.

Long-term conservation of species necessitates the conservation of adequate samples of populations to maintain the full genetic diversity and the breeding system, because species must be allowed to continue to evolve and to adapt, for example to secular climatic change. Most plant species in tropical rain forests occur at low density (see Whitmore 1971, 1973, for examples in Malaya). From this it can be concluded that complete conservation is only likely to be possible in large areas, and that a conservation policy is much better based on a few large areas than many small ones. Such a policy is also necessary for fauna conservation.

Floristic variation in a forest formation from place to place within a region is only the coarsest of a graded series of increasingly subtle modes of variation which are of interest to ecologist and silviculturist. These variations are discussed at length for lowland evergreen tropical rain forest by Whitmore (1975, chapter 15). Big reserves are more likely to conserve all patterns of variation than are small ones.

For rain forest plants there is really no practicable alternative to *in situ* conservation. *Ex situ* conservation of living plants is not practicable firstly because of the very large numbers of species involved; and secondly the difficulty of conserving adequate population samples to maintain genetic integrity and adaptability. The same problems apply to storage as seed. In addition very little is known about suitable storage conditions (some species appear to have so-called 'recalcitrant seeds', (see Whitmore 1975). Knowledge is also very scanty about population structure or breeding systems within even well-known commercially important rain forest species (e.g. the many South East Asian fruit trees of rain forest origin). Nothing at all is known about the majority of species.

Many plant species will probably survive even substantial disturbance of primeval tropical rain forest and its elimination from much of the land surface, though local endemics will disappear, and these are probably more numerous in tropical rain forest (especially in South East Asia) than in any other kind of vegetation. But the alteration to population structure and breeding behaviour and the loss of genetic diversity such interference entails will in the long-term alter the course of evolution. Animals are much less likely to survive decimation of primary rain forests than are plants.

There is no means at present to ascertain how big a population of a given plant species is adequate for conservation. Indeed there is no single or simple answer to this question. The guideline is to conserve a full sample of its genetic diversity and this can be attempted by conserving populations in the species' full range of habitats. Gene flow considerations suggest that contiguous habitats provide better chances for long-term conservation and continuing evolution. A crumb of comfort is provided by the comment that for out breeding, heterozygous species, which include many rain forest species (e.g. all or most Burseraceae, Meliaceae, Sapindaceae), population sizes need not be 'too large' (D. Zohary, pers. comm.).

Frankel (1974) gives a valuable review of the problems discussed in this section.

Criteria used in the selection of areas suitable for conservation

The conclusion drawn in the previous section was that tropical rain forest is best conserved in large areas. This review therefore mainly concentrates attention on establishing an adequate network of a fairly small number of large protected areas.

Many animals and plants could survive in forests managed for timber production, although these have different structure, age-class representation and proportions of species from virgin forests. Such areas are not included within the present review, though they should be considered within each nation as part of a national scheme of species' conservation if it is considered possible to provide the high degree of management which is necessary to make such multiple usage practicable. In particular, inviolate conservation areas (biosphere reserves in the terminology of MAB (UNESCO 1973b, 1974) are improved by a surrounding buffer zone of semi-natural forest, and in some cases this is likely to be essential to their survival and adequate functioning.

Research into management of tropical rain forests for multiple use, including investigation of the effects of present logging practices on animal and plant populations, has been neglected and should now be given high priority. The UNDP and FAO now have a number of nature conservation and wildlife management projects (see Appendix), and this and other topics of the present discussion could usefully be explicitly included within their remit.

Lowland tropical rain forest formations are under greatest threat because of the timber most of them contain and because of the potential of much of the land for agriculture. Mountain forests, especially on steep slopes, are less widely threatened. In South East Asia most of the remaining high rain forest is under logging licence. ECAFE (1974) estimated the remaining accessible lowland forests of Malaysia and the Philippines would be exhausted within a decade. The entire timber resources of the South East Asian tropical rain forests are unlikely to last beyond the end of the century (Whitmore 1975, chapter 19). Decisions taken in the next five to ten years i.e. by the mid-1980's, are likely to determine whether any large tracts of lowland tropical rain forest will remain, and in many countries (at least in South East Asia of which the author has personal knowledge) administrative decisions will need to be reversed if an adequate network of reserves is to be created, because licences to log will have to be rescinded. In countries where land remains unallocated the important requirement to conserve samples of natural forest needs to be remembered early in development planning, as has recently been powerfully argued by IUCN (Poore 1974).

The criteria for inclusion of a conservation area in the UN List of National Parks and Equivalent Reserves (1975) are not all appropriate for the purposes of the present review, as measures of legal status, access and staffing are included. Nevertheless, the UN List has provided a useful source for this review especially for countries for which information from other sources could not be obtained.

Plant species to be conserved

This review is based on the premise of total conservation of virgin forest ecosystems, and hence all the species they contain. Another approach, perhaps helpful in identifying priorities and in developing the case for conservation in individual countries, is to list the plant genetic resources, that is to say those plants of actual or potential benefit to man. This has been done for the territories dependent on Britain by Whitmore (1974) whose report for countries with rain forest has been utilised in preparing the present reveiw.

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Appendix

FAO Forestry Department projects in nature conservation and wildlife management as at 1 January 1975.

Source: FAO For. Dept. Field Staff List, January 1975. FO: MISC/75/1

Page	Position	Station	Months Duration
2	Africa, Regional/Inter-regional	Accra	12
5	Asia, Regional/Inter-regional	Bangkok	12
6	S.America, Regional/Inter-regional	Santiago	12
	C.America, Panama	Guatemala	12
7	Colombia		4
41	Dahomey	Cotonov	28
66	Indonesia: Manager	Bogor	24
	Wildlife biology	Bogor	12
	Nat. Parks, Tourism	Bogor	12
95	Nigeria: Wildlife Consultant	Ibadan Univ.	2
	Wildlife Training	Ibadan Univ.	2
105	Peru: Wildlife and Nat. Parks	Lima	4

The main forest formations of the tropical Far East (Whitmore, 1975; Table 10.1)

CLIMATE	SOIL WATER	LOCALITIES	SOILS	ELEVATION		FOREST FORMATION	
everwet	dry land	inland	zonal soils	lowlands to 1200 m		1 tropical lowland evergreen rain forest	tropical rain forests
				mountains	(750) ∧1200-1500m	2 tropical lower montane rain forest	
					(600) 1500 to 3000 (3350)m	3 tropical upper montane rain forest	
					3000 (3350)m to tree line	4 tropical subalpine forest	
			podzolised sands	mostly lowlands		5 heath forest	
			limestone	mostly lowlands		6 forest over limestone	
			ultrabasic rocks	mostly lowlands		7 forest over ultrabasic rocks	
		coastal				8 beach vegetation	
	water table high (at least periodically)	salt water				9 mangrove forest	
		brackish water				10 brackish water forest	
		fresh water	oligotrophic peats			11 peat swamp forest	
			eutrophic (muck and mineral) soils	almost permanently wet		12 a fresh water swamp forest	
				periodically wet		12 b seasonal swamp forest	
seasonally dry	moderate annual shortage					13 tropical semi-evergreen rain forest	
	marked annual shortage					14 tropical moist deciduous forest 15 other formations of increasingly dry seasonal climates	monsoon forests

B ASIA - GENERAL

The Tropical Rain Forest Formations in Asia

1.1 General The classification of formations used for Asia is that of Whitmore (1975). Definitions and occurrences of sections 1.2 - 1.13 are extracted from this source and the original should be consulted for further detail and references.

This classification is that of Burtt-Davy (1938) extended to include formations he omitted. The Burtt-Davy scheme is itself based on that of Champion (1936). It is a useful scheme in that, firstly, the descriptions are adequate to identify any forest to its formation, even on an incomplete description. Secondly, it is believed to be a comprehensive classification within which all the tropical rain forests of Asia can be accommodated.

The formations are listed on Table 1 which also groups them into a hierarchy based on soil and measures of water availability. They are defined in detail in the following sections. The principal characters are physiognomic and structural. These two groups of attributes are not always clearly identifiable with important habitats or environments. Therefore supplementary environmental terms are included in the names and occasionally in the definitions where this assists identification. The classification is therefore pragmatic rather than strictly systematic, in order to provide formations with names and characteristics which are meaningful and descriptive (cf. UNESCO, 1973). Extreme examples of this departure from a strictly structural/physiognomic classification are 'peat swamp forests' and 'forests on limestone'. In both these cases several different forests are brought together because of a common distinctive habitat.

1.2 Tropical lowland evergreen rain forest Key reference: Whitmore (1975) section 10.1

General description This is the most luxuriant of all plant communities and occurs under what are probably the finest dry-land growing conditions found anywhere in the world. It is a lofty, dense, evergreen forest 45 m or more high, only occasionally less, characterized by the large number of trees which occur together. Gregarious dominants (consociations) are uncommon and usually two-thirds or more of the upper-canopy trees are of species individually, not contributing more than 1 percent of the total number. This formation is conventionally regarded as having three tree layers; the top layer of individual or grouped giant emergent trees, over a main stratum at about 24 - 36 m, and with smaller, shade-dwelling trees below that. Ground vegetation is often sparse, and mainly of small trees; herbs are uncommon. Some of the biggest trees have clear boles of 30 m and reach 4.5 m girth, and may be deciduous or semi-deciduous without affecting the evergreen nature of the canopy as a whole. Boles are usually almost cylindrical. Buttresses are common. Cauliflory and ramiflory are common features. Pinnate leaves are frequent; laminae of mesophyll size predominate. Big woody climbers, mostly free-hanging, are frequent to abundant and sometimes also bole climbers. Shade and sun epiphytes are occasional to frequent. Bryophytes are rare.

All other rain forest formations differ from this in simpler structure, and in some cases in having fewer life-forms.

Within the tropical lowland evergreen rain forest there is a great deal of variation from place to place, mostly gradual and not sharply bounded. The most gross variation is a major difference between a western block, centred on the Sunda Shelf countries of Sumatra, Malaya, Borneo and Palawan and an eastern block centred on the Sulu Shelf, i.e. New Guinea and offshore islands to its west. These two blocks correspond to two regions of perhumid climate (see Whitmore, 1975 chapter 3) and are separated by a north to south belt of seasonally dry climates running down the western side of the Philippine archipelago, through Celebes to the Lesser Sunda Islands. Section 2.1 below gives further details. The western block has family dominance of the Dipterocarpaceae in the emergent stratum, and these forests are of greater height than any other broad-leaf tropical rain forests in the world. Frequently, several genera of dipterocarps (especially Anisoptera, Dipterocarpus, Dryobalanops, Parashorea and Shorea) and numerous species grow side by side. Malaya has 9 genera and about 160 species of dipterocarps, and Borneo 10 genera and about 270 species, with probably more awaiting discovery in Kalimantan. No other tropical rain forests anywhere in the world show such abundance and diversity of a single family of big trees. And, out of a total of 12 genera and about 470 species of Dipterocarpaceae in Asia, 10 genera and about 350 species are found on the Sunda Shelf. In the eastern block Dipterocarpaceae are only of local, limited occurrence.

Whitmore (1975 chapter 15) contains a full description of modes of variation within tropical lowland evergreen rain forest. These can be arranged roughly in a hierarchy of diminishing importance from geographical differences explicable in terms of historical plant geography, through variation caused by major disturbance (e.g. cyclone), to those related to topography and geology, with, at the bottom of the list and most subtle, those caused by differences in dispersal efficiency, phenology and soil differences within a topographically uniform site.

Habitat and distribution This is the predominant formation of the tropical Far East and occurs throughout the two great perhumid blocks, that is where water-stress is absent or only brief and intermittent, from sea level to 1200 m elevation or less and on dry-land sites where special soil conditions do not lead to its replacement by one of the formations described below. In the north west it reaches to about the latitude of the Malaysia-Thailand border but reappears as pockets in lower Burma, possibly on the Thailand-Khmer border around Chantaburi, along the south wall of the Himalaya in upper Burma and Assam, in the Andamans, in a small area of south west Sri Lanka, and in a narrow strip along the whole length of the western Ghats in peninsula India. In the east it reaches into Melanesia and possibly Micronesia, and Polynesia, but not Australia.

General floristics Tropical lowland evergreen rain forest has the greatest number of species of any rain forest formation. It is doubtful if any other vegetation type in the world exceeds it in this respect. This is partly due to the very large number of species of trees of all sizes, but also due to the extreme wealth of the other lifeforms present. Besides the Dipterocarpaceae, the western block is characterized by a rich, ground-layer palm flora of shade- and moisture-loving genera, principally Iguanura and Pinanga, and to a lesser extent by Areca, Nenga and Rhopaloblaste.

It is estimated that in Sarawak and Brunei there are between 1800 and 2300 species of trees of diameter $\geqslant$ 0.1 m in this formation, compared with only 849 in heath forest and 234 in peat swamp forest.

Man's impact The impact made by traditional cultures on this formation varies through the region. In much of Malaya and Sumatra man has had little effect until recent times, the Malay people being essentially coastal and riverine and the aborigines sparsely distributed except in the malaria-free hills where, as in Borneo and New Guinea also, shifting cultivation has transformed huge tracts to secondary forest. Within the last century plantation agriculture has made extensive inroads notably in Sumatra and Malaya. The dipterocarp forests have become one of the world's major sources of hardwood timber, especially since the end of the Second World War, and exploitation is taking place at an ever-increasing pace. Exploitation has also begun in the less valuable forests of the eastern block.

1.3 Tropical semi-evergreen rain forest Key reference: Whitmore (1975) section 10.2.

General description Semi-evergreen rain forest is a closed, high rain forest in which the biggest trees sometimes attain large size. It includes both evergreen and, in the top of the canopy, deciduous trees, in an intimate mixture but with a definite tendency to gregarious occurrence. Deciduous trees may comprise up to one-third of the taller trees, though not all are necessarily leafless at the same time. The number of species is high but less so than in evergreen rain forest. Buttresses continue to be frequent and occur in both evergreen and deciduous species. Bark tends to be thicker and rougher and cauliflory and ramiflory rarer. The stature tends to be slightly less than evergreen rain forest and the emergents to occur as scattered individuals which are sometimes rare. Big woody climbers tend to be very abundant. Bamboos are present. Epiphytes are occasional to frequent and include many ferns and orchids.

Habitat and distribution Tropical semi-evergreen rain forest forms a belt between evergreen rain forest and moist deciduous forest. It occurs in places where there is regular annual water-stress of at least a few weeks' duration. This can be due to particular soil conditions as well as to rainfall regime, and a mosaic of the three formations may occur at their mutual boundaries. It follows that no precise delimitation of the extent of this formation from climatic data is possible. Tropical semi-evergreen rain forest is of very limited extent in the Far East compared to evergreen rain forest. It forms the extension of tropical rain forest into eastern Australia where it occurs north of 21°S and detailed work has been done on its interdigitation with other formations of suboptimal sites. It also occurs marginally to evergreen rain forest in southern peninsular Thailand (see Whitmore 1975 section 12.3, Fig. 12.4), in Indo-China, Burma, the Andamans, Sri Lanka, and the Indian subcontinent. We have little detail on its extent within the Malay archipelago, though presumably it bounds the zone of monsoon climates which runs south from the Philippines to the Lesser Sunda Islands, and it occurs, possibly extensively, in New Guinea in rain-shadow areas.

General floristics In the Kra isthmus there is a slight decrease in total number of species of Dipterocarpaceae in the semi-evergreen rain forest compared to the evergreen rain forest to its south; some are characteristic of one formation or the other. Characteristic species of semi-evergreen rain forest also occur in suitable sites within the evergreen rain forest. For example, a small island of semi-evergreen forest occurs surrounded by evergreen forest in central Malaya in Taman Negara in the intermontane valley of the upper Tembelin river, in the rain-shadow of both monsoons and on riverine, alluvial soils. This forest is markedly deciduous in the regular early-year drought and contains much *Tetrameles nudiflora*, a species mainly of monsoon climates. *Anisoptera oblonga*, a dipterocarp of the semi-evergreen and deciduous dipterocarp forests of continental Asia, also occurs in the upper Tembeling basin.

Man's impact The forests of this formation have been logged in the Kra isthmus and in eastern Australia, so that only small virgin fragments now remain. The most valuable commercial semi-evergreen rain forest stand is of a colline variant, namely, the mixed broad-leaf *Araucaria* forest of the Bulolo-Watut valleys in New Guinea.

Because of the dry season, semi-evergreen rain forest and its secondary forest derivatives are more easily destroyed by fire than is evergreen rain forest, and therefore this formation is more easily replaced by open grassland (principally of *Imperata cylindrica*, alang alang, cogon, kunai or lalang), sometimes with scattered, fire-resistant trees. The extensive area around Bulolo in New Guinea is an example of such a replacement.

1.4 Subtropical rain forest To the north of Malesia in south China and on Taiwan and Hainan, and to the south east in Australia tropical lowland evergreen rain forest and tropical semi-evergreen rain forest merge into subtropical rain forest.

The main distinctions (Baur, 1964; Webb, 1959) are smaller average leaf size (notophyll sensu Webb predominating rather than mesophyll sensu Webb), while cauliflory and stilt roots are virtually absent. Buttressing may be common.

Webb (1959) described the Australian rain forest formations in detail and mapped their occurrence. Only the forests north of 21°S are considered by him to be tropical rain forest. There does not appear to be a sufficiently detailed account of rain forest in China to ascertain whether the rain forest there is subtropical, tropical evergreen or both (the account in Whitmore, 1975 sections 1.1 and 10.1, based on Wang (1961) is equivocal on this point).

1.5 Heath forest Key reference: Whitmore (1975) section 10.3

General description On soils derived from siliceous parent materials which are inherently poor in bases, and commonly coarsely textured and freely draining, evergreen rain forest is replaced by heath forest and this is strikingly different in flora, structure, and physiognomy.

"Even the botanically inexperienced casual wanderer will notice the change when he enters the kerangas forest from the lowland dipterocarp forest, not only because of the change in species (with which he may not be familiar) but also because of the striking difference in the structure, texture and whole colour of the forest. In the lowland dipterocarp forest the entire growing space is loosely and evenly filled with green foliage and the general impression is of a sombre but fresh green. In the kerangas forest the storey formed by large saplings and small poles predominates and forms a tidy and orderly but forbidding phalanx which is dense and often difficult to penetrate. The canopy is low, uniform, and usually densely closed with no trace of layering. Single emergents may occur and usually indicate extreme site conditions. Brown and reddish colours prevail in the foliage of the upper part of the canopy and the sun fills the forest with a rather bright light of reddish-brown hue which in spite of the dense canopy appears to be considerably brighter than the light in the lowland dipterocarp forest with its higher and more irregular vegetation" (Brunig, writing on the heath forest at Bako National Park, Sarawak).

To this description must be added that there are more trees with small leaves than in evergreen rain forest and many leaves are distinctly sclerophyllous (that is, thick and leathery); deciduous species are absent. The ground commonly has a bryophyte cover. Trees of large girth are rare; buttresses are smaller, but stilt roots commoner. Big woody climbers (including climbing palms) are rare, but slender, wiry, independent climbers frequent. Epiphytes are frequent and photophytes occur nearer the ground than in evergreen rain forest. Myrmecophytes are abundant, in the more open and stunted heath forests. Amongst the herbs the insectivores Drosera, Nepenthes, and Utricularia may also be common in open places. On aerial photographs the flat canopy is highly distinctive due to its pale tone and its very fine texture which results from tree-crown structure and small leaf sizes. Species with leaves held obliquely vertical may be common.

The streams draining areas of heath forest are tea-coloured by transmitted light, and opaque black by reflected light owing to the presence of colloidal humus. They are usually acid, and with a low oxygen content.

Heath forest is easily degraded by felling and burning to an open savanna of shrubs and scattered trees over a sparse grass and sedge ground layer; this is often called padang, from the Malay word for an open space. The secondary succession is a slow-growing community of xeromorphic shrubs and trees, quite lacking those species of Macaranga, Mallotus, etc., which are so characteristic of secondary evergreen rain forest.

Habitat and distribution Kerangas is an Iban term for land-carrying forest which, when cleared, will not grow hill rice. The term Heidewald was used in the first major description of the formation by Winkler for south Borneo and translated as heath forest by Richards in his important study of the formation in north Sarawak. Heath forest develops mainly over coarse siliceous deposits which give rise to podzolized soils. The greatest extent of heath forest in the Far East is in Borneo where it occurs around much of the coastline on raised terraces of poorly consolidated coarse, sandy, marine, and riverine sediments left stranded by the fluctuating sea-level of the late Pleistocene. Similar but less extensive terraces which also bear or once bore heath forest occur along the south coasts of Thailand and Khmer; in Malaya extensively down the east coast as parallel strips separated by swampy hollows and on the west coast in north Perlis and near Satun (Setul) across the Thai border and also at Tanjong Hantu, Perak; on east coast Sumatra; extensively on the islands of Bangka and Billiton; on the Karimatas, Anambas, and Natunas; and in south west Sri Lanka. Coastal heath forest has been extensively converted to secondary savanna (padang) maintained by grazing and burning; for example, on the whole of the east coast of Malaya only two small semi-natural stands of heath forest remain, at Jambu Bongkok and Menchali.

In Borneo, lowland heath forest also occurs extensively inland, mainly on sandstone plateaux and cuesta formations. In Sarawak, Brunei, and Sabah it is usually on the dip slopes in hilly country, where sandstone beds lie close and parallel to the surface. The scarp slopes carry evergreen rain forest on less stable, continually rejuvenating soils. This catenary complex, frequently completed by the type of evergreen rain forest known as empran along rivers has been described from Sarawak, Brunei and Sabah (see Whitmore, 1975 p. 132) and probably occurs also in Kalimantan. It occurs on the Dulit range in north east Sarawak, which is the site of Richards' classic studies. Interdigitation also occurs on flatter sites similarly correlated with differences in soil.

In parts of Sarawak (and probably elsewhere in Borneo), mainly inland, podzolic soils become temporarily, to more or less permanently, waterlogged because of imperfect subsoil drainage or because the hard pan in the soil forms an impermeable layer. The forest is here known as kerapah, an Iban term denoting swampy conditions. In structure and physiognomy this is heath forest, though some species are particularly common in these sites. The summit plateau of Gunung Panti in south Malaya carries heath forest over a waterlogged soil developed over sandstone, which is perhaps comparable to kerapah forest, otherwise there is no record of kerapah from outside Borneo. It is equally curious that extensive stands of inland heath forest have also not been recorded elsewhere. In Malaya, for example, the extensive outcrops of siliceous sedimentary rock in the lowlands east of the Main Range carry evergreen rain forest. Hills along the east coast from the Gunung Besar massif northwards to south Trengganu have dense stands of the fan palm Livistona saribus which Wyatt-Smith believed to be associated with the drying effect of strong winds plus poor, shallow soils. Some quartz dykes and quartzite ridges in Malaya carry a low stunted heath forest; they only cover a tiny area; comparable sites and forests have been described in Brunei.

Small areas of inland heath forest are reported from Bangka, Billiton, central Celebes, and west New Guinea. In the area of the Star Mountains in central New Guinea they are all on river terraces, some of which have impeded drainage, and some of which carry Agathis labillardierei forest. The apparent absence of extensive areas of inland heath forest from the huge land mass of New Guinea serves, if it is confirmed by more thorough studies, to emphasize even further the uniqueness of Borneo in this respect.

General floristics Concerning heath forest in general, Brunig has estimated that in total there are 849 species of tree (428 genera) in the heath forests of Sarawak and Brunei; of this total 220 species also occur in lowland dipterocarp rain forest. For example, many of the Dipterocarpaceae of the Sarawak heath forest are found in evergreen rain forest, and these are found mainly in the most favourable heath forest sites. There are also 146 species common to both heath forest and peat swamp forest (Brunig, 1973), including several big timber trees. There is no species known which occurs both in peat swamp forest and lowland dipterocarp rain forest but not also in heath forest. Heath forest also has some species in common with upper montane rain forest.

Myrtaceae are a prominent family in heath forest. A much-commented-on feature is the abundance of genera with an Australian centre of distribution.

The striking difference in flora of heath forest from lowland evergreen rain forest was found to be as equally marked amongst the mosses as the trees on Mt. Dulit, Sarawak.

Man's impact Heath forest soils are too infertile and acidic for traditional agriculture and quickly become degraded. Areas which have been cultivated are seen today as open sandy savannas, as along the Malayan east coast. These savannas, and the patches of trees and forest with which they are interspersed, have a recreational value there, as also at the Bako National Park, which will be increasingly appreciated as man becomes ever more an urban animal in the decades ahead. The cultivation of pineapples is a successful venture on heath forest soils around Kuching.

Heath forest, if carefully managed, can provide a continuing source of timber. Selective felling has been practised at Menchali in Malaya since early this century and is recommended for the remaining small areas on the east coast of Malaya. Re-establishment after clear-felling and burning might be possible if care is taken and has been suggested for Sarawak to produce crops for domestic timber, poles, and firewood.

There is unlikely to be much demand in land development schemes for conversion of heath forest areas to agriculture. If foresters can discover economic means of growing tree crops on these poor sandy soils this will help to relieve pressure on the remaining areas of the other more mesic and species' rich rain forest formations.

1.6 Forest over limestone Key reference: Whitmore (1975) section 10.4

General description and occurrence Craggy limestone hills form a striking part of the landscape in many parts of the tropical Far East. Limestone landscapes (karst) whether of the tower (karstkegel) or cockpit kind provide a diversity of habitats and soils which have been fully analysed by Anderson, describing Sarawak:

1. The alluvial soils at the base of limestone hills, although derived from other rocks, are under the influence of run-off water and erosion from the limestone.

2. The base of cliffs and ravines in the hills, sometimes with small scree slopes of limestone boulders. The nature of this habitat in Sarawak is complicated because ravines have formed along igneous intrusions. It is here and in deep soil pockets on ledges and in sink holes that most of the few Dipterocarpaceae associated with limestone occur.

3. The limestone slopes have a dense, irregular forest with trees clinging precariously, their roots penetrating to great depths in crevices. Sheer cliffs bear scattered shrubs and a characteristic herb flora, amongst which Gesneriaceae are prominent, many of which resist dry periods by reversible desiccation of the tissues.

4. The summits of the limestone hills provide a peculiar habitat. There is a deep mat of peat-like humus, held together by tree roots and anchored by them to the limestone pinnacles underneath. This soil is acidic and in Sarawak the low forest it supports has affinities with lowland heath forest. This habitat resembles heath forest in both its deficiency in plant nutrients and also in its free draining status, which implies that periodic water-stress most probably occurs.

Limestone is known to occur at high elevations in New Guinea and also in the Gunung Mulu National Park in Sarawak on Gunung Api and Gunung Benarat, both of which rise to over 1200 m. In Sarawak the montane limestone habitats are similar to those of lower elevation. On the less precipitous pinnacles there is about 0.6 m of peat and a low forest which has distinct similarity to that on the adjacent sandstone mountain Gunung Mulu.

Recently emerged pericoastal limestone platforms are another limestone habitat, with widespread small occurrences in both Malesia and the Melanesian archipelagos. In the Solomons little floristic difference was detected in this habitat from lowland rain forest further inland.

<u>General floristics</u> The various habitats of karst limestone in Sarawak, and probably elsewhere, have distinctive floras, and overall limestone vegetation is rich in endemics. The fullest study has been in Malaya.

Of 747 species recorded on limestone there 195 (about 26 percent) are in Malaya confined to it, and of these about 130 (67 percent) are endemic to the country. Of those found on limestone but not confined to it 80-100 species are cremnophytes (crevice plants) rather than calcicoles; they always inhabit rocky sites but appear indifferent to the nature of the rock upon which they grow. Some 50 of the species confined to limestone in Malaya are species of monsoon Asia to the north, and most of these are restricted to the extensive limestone outcrops of the far north west in Perlis, Kedah, and the Langkawi Islands. It would appear that they penetrate south into the perhumid tropical zone only in the periodically dry limestone habitats where alone they can compete successfully.

<u>Man's impact</u> Most forest on karst limestone has no commercial value, though some very showy herbs (especially Balsaminaceae, Begoniaceae, and Gesneriaceae) deserve greater attention from horticulturists. <u>Agathis</u> on limestone in Celebes (Malili) and on Waigeo, and <u>Nothofagus</u>

on karst pinnacles and doline rims in east New Guinea are exceptions. The forest is sometimes destroyed by deliberate burning by tin and gold prospectors in Malaya and Sarawak. The forest on the high limestone mountains Api and Benarat in Sarawak is occasionally damaged by fire which according to local observations is started by lightning (api = fire). After fire the ground may remain bare for many years before a slow succession of bryophytes and ferns re-establishes, and then, in litter and soil pockets, a shrub flora. Earliest man probably made greater use of limestone areas, living in caves; both Java and Sarawak (Niah) have extensive fossil and subfossil remains.

1.7 Forest over ultrabasic rocks Key reference: Whitmore (1975) section 10.5

General description and occurrence There is much variation in forest structure, physiognomy and floristics over ultrabasic rocks, ranging from forests which are very similar to evergreen rain forest to others which are highly distinctive.

Along the north coast of Waigeo Island and of New Guinea to its east (for example, along the northern foothills of the Cycloop mountains) is a belt of low shrubby vegetation, open in places and sharply bounded against tall lowland evergreen rain forest. This vegetation coincides exactly with red-purple soils derived from ultrabasic rocks.

In the Solomons the most distinctive lowland forest formation is that found over ultrabasic rocks. It is sharply demarcated from adjoining forest. Geologists have mapped the extent of the ultrabasics from aerial photographs, on which this forest formation is easy to see.

In west Malesia the forest over ultrabasic rocks is often much less distinctive. Ultrabasic rocks near Raub, east of the main range in Malaya, carry a high forest, with the structure and physiognomy of lowland evergreen rain forest, and the same is true of the ultrabasic hill north east of Ranau in Sabah at the foot of Mt. Kinabalu, where the tallest tree, in a forest which included several dipterocarps, was 54 m and a deep soil had developed. Meijer has noted that the dipterocarp species found over lowland ultrabasics in Sabah were quite different from those of different adjacent rocks, but that the same species occur in Brunei and Sarawak over other soil parent materials. Elsewhere in the lowland of Sabah, especially on shallow soils, a low forest tending to heath forest in structure and physiognomy has been recorded, and pure stands of Casuarina nobilis occur on islands in Darvel Bay, on Malawali, and on Bangi Island.

Although near Ranau forests on ultrabasic do not differ in structure or physiognomy from contiguous forests on different rock this is not the case nearby higher on the slopes of Mt. Kinabalu. For example, the trail to the summit enters an area of ultrabasic rocks at about 2400 m from an area of sandstone, and there is a sudden decrease in canopy height. Many species reach their lowest elevation on the mountain here. A similar sharp change occurs on the east ridge of Mt. Kinabalu at about the same elevation.

1.8 Beach vegetation Key reference: Whitmore (1975) section 10.6

General description, floristics and habitat There are two kinds of beach vegetation. Along accreting coasts, where new sand is being continuously deposited, the initial stage of beach vegetation is the pes caprae association, a low herbaceous plant cover over a broad sand strand, of which most members are creeping plants with long, rooting stolons or stems. Most of these species are confined almost or entirely to this habitat and are pantropical in distribution; some are rare in Malesia. Minor differences in composition reflect the origin of the sand, which may be from quartz, andesite (blackish in colour), or derived from coral and therefore calcareous.

Seedlings of beach trees, including coconuts from water-borne fruits, are found in the older part of the association, notably of the wind-dispersed Casuarina equisetifolia, itself a pioneer species which forms pure stands and is unable to regenerate on the litter carpet of its dead, fallen photosynthetic twigs.

On the beach wall, that is, the low (0.5 m - 1 m) ridge at the inland margin of the sand beach, the second vegetation type, the Barringtonia association, is found. (This falls within the tropical littoral woodland formation of Burtt-Davy 1938). On abrading coasts, where off-shore sea conditions ensure that no sand is being accumulated or that sand is being removed, this association is found without the pes caprae carpet in front, instead the narrow beach is inundated each flood-tide, and is shaded by the low-set, wide-branched crowns of trees of this association, commonly with their trunks lying out over the beach, and with the lowest branches often damaged by sea-water. As erosion continues trees are uprooted and crash down seaward. The width of this seaward forest fringe is seldom more than 25-50 m, and on rocky, steep shores it is confined to a very narrow strip. Inland it merges with lowland rain forest. Its composition is very uniform throughout Malesia, and many species extend from the coast of Africa through Malesia far into the Pacific (the so-called 'Indo-Pacific strand flora'); some indeed are pantropical. It is found in both perhumid and seasonally dry regions. Many species have seeds or fruits adapted to water-dispersal. Locally one or other species may become dominant, but a mixed association is more usual. The trees are sometimes loaded with epiphytes, among which are many ferns and orchids. Amongst the commonest are: Barringtonia asiatica, Calophyllum inophyllum, Casuarina equisetifolia, Cocos nucifera, Cycas rumphii, Guettarda speciosa, Heritiera littoralis, Hernandia nymphaeifolia (peltata), Hibiscus tiliaceus, Messerschmidia argentea, Morinda citrifolia, Pandanus tectorius, Pongamia pinnata, Premna corymbosa, Scaevola taccada, Terminalia catappa and Thespesia populnea.

On small, low, coral islands the Barringtonia association may form the principal forest type. Pisonia grandis is especially common on small off-shore islets and is absent from the beach forest of the large islands; this has been ascribed to its needing guano, so that its occurrence is restricted to that of off-shore bird colonies.

There is no sharp demarcation between beach vegetation of sandy and rocky coasts, mangrove forest of muddy coasts, and brackish-water forests, because intermediate habitats occur and, furthermore, many coastlines are unstable and the nature of deposition subject to change. A few species are found in more than one vegetation type, notably Hibiscus tiliaceus, and, on the Sunda shelf, the big clump-forming nibong palm Oncosperma tigillarium.

Man's impact The Barringtonia association has been severely damaged over much of the Far East, but still survives extensively on the islands of the western Pacific. It is usually replaced by planted coconut groves under which are either grasses or ferns.

1.9 Mangrove forest Key references: The ecology of the Malayan mangrove forests, including a study of the complex zonation of different communities, is fully described in a classic monograph by Watson; their fauna (especially the invertebrate fauna) is elegantly covered by Berry and their birds by Nisbet. Van Steenis has described mangrove ecology for the whole of Malesia, and McNae for the whole region of the Indian Ocean. Richards and Chapman give reviews for all the tropics. The specialised physiological mechanisms which enable mangrove species to tolerate salt-water conditions have recently been investigated by Scholander et al. and Atkinson et al. These references are cited in full in Whitmore (1975), section 11.1.

General description, floristics and habitat Mangrove forest is well-known, its flora does not change much through the region (for the minor differences see Hou, 1958). It is best developed on muddy, accreting coasts.

Man's influence This was the first forest formation to be brought under intensive silvicultural management in Malaya, as a valuable source of firewood, charcoal, and cutch for tanning and of poles for piling and scaffolding; all uses except the last have markedly declined in recent years. Management has now run through several complete felling and regrowth cycles. Mangrove forest is an important resource elsewhere in the region, especially in the more densely inhabited western part of Malesia. Besides plant products mangrove is an important source of fish, prawns and crabs and some open water species also have their breeding grounds in mangrove forest.

There is a modern and developing industry to utilise mangrove wood as a raw material for rayon manufacture, for which purpose the felled logs are chipped and shipped to Japan. Careful silvicultural management is necessary to ensure that enough mother trees are left standing for a new forest to develop, and that forest bordering creeks are left intact to minimise the risks of erosion.

Much of the mangrove forest of the coasts of Vietnam has been completely or almost completely destroyed by chemicals sprayed from the air. This has eliminated the mangrove as an important source of wood, wood products and food. Regeneration is sparse or absent, presumably due to the absence of a seed source.

A mangrove forest is being created artificially by planting on the west coast of Bougainville on a new muddy delta, formed of the spoils washed down to the coast from the copper mine. Steps toward artificial regeneration are perhaps called for in Vietnam.

1.10 Brackish water forest Key reference: Whitmore (1975) section 11.2

The inland edge of the mangrove and the upper tidal limit of estuaries carries a forest with a number of distinctive species amongst which *Nypa fruticans* is important. This palm forms extensive pure stands mainly along water courses and as far east as New Britain, with scattered outliers extending to the Solomons and in the Marianas.

1.11 Peat swamp forest Key reference: Whitmore (1975) section 11.3 which is principally a summary of the detailed researches of Dr. J.A.R. Anderson.

Habitat and distribution The peat swamp forest formation is of a very special type and with a rather restricted flora. The soil is peat, which may be defined as a soil with organic matter showing a loss on ignition greater than 65 percent. Tropical peat is usually acid with a pH usually less than 4.0. The surface of a peat swamp is not subject to flooding and is normally markedly convex. The peat is usually at least ½ m deep, and depths up to 20 m have been recorded. There is a solid, fibrous, sometimes soft crust over a semi-liquid interior containing large pieces of wood, and the colour is commonly reddish-brown. The only incoming water is from rain, which is *ipso facto* extremely mineral deficient. The drainage water is black by reflected light and tea-coloured by transmitted light and is highly acid.

Lowland peat swamp forest is very extensive in east Sumatra, on both coasts of the Malay peninsula, and in Borneo. It is apparently absent from east New Guinea despite the very great extent of fresh-water swamp vegetation there which is described in the next section; but it occurs in the southern part of west New Guinea. There is some peat in the southern Philippines but not in the drier north west. The total extent of peat swamp forest in Indonesia is estimated to be 17×10^6 ha, in Sarawak (where it occupies 12.5 percent of the land area) 1.5×10^6 ha, and in Malaya about 0.5×10^6 ha.

General description Peat swamps characteristically have a domed surface, as do peat bogs of temperate climates, and have a stilted water table higher than that of the surroundings. The forests growing on most of the peat swamps in the region have evidence of concentric zones, the innermost one being a forest of stunted trees, commonly of markedly xeromorphic aspect.

Zonation is very marked in the peat swamp forests of Sarawak and Brunei. Peat swamp forests occupy nearly the entire coastline of these two countries. The biggest single swamp, on the Maludam peninsular, stretches 64 km inland from the mangrove forest fringe and covers 1070 sq. km. These forests and those of north west Kalimantan are unique in the presence of Shorea albida, whose range extends from the mouth of the Kapuas river south of Pontianak to the Tutong river in Brunei. This dipterocarp plays a major role in the swamp forest communities, and no species is known to play the same part elsewhere.

In Sarawak and Brunei there exists a catena of forests from the edge to the centre of each peat swamp. Anderson has divided this into six types (phasic communities) which are moderately sharply distinct in structure, physiognomy, and flora. Not all types are developed everywhere. The first type is found on the periphery, more or less confined to the outer steeper slopes of the dome surface. The last two types have formed only on the most highly developed swamps, which occur in the middle and upper reaches of the Baram estuary. Tea-coloured streams navigable by small boats penetrate the outermost community for several kilometres. The sequential pattern of forest types represents, in brief, a change from an uneven-canopied high forest, similar in structure and physiognomy to lowland dipterocarp evergreen rain forest but with fewer species per unit area, a lower canopy (36-42 m), and fewer stems per unit area, to a similar forest (type 2) but dominated by enormous trees of Shorea albida. This is followed by an even-canopied high forest (type 3) in which Shorea albida is the sole dominant, which in turn is replaced by a dense, even-canopied forest (type 4) with a xereromorphic and stunted aspect and in which few trees exceed 1.8 m girth. This type is itself succeeded, towards the centre of some of the Baram swamps, by a very dense pole-like forest (type 5) with a low canopy in which few trees exceed 0.9 m girth, and finally by an open savanna woodland (type 6) which shows a high degree of stunting and xeromorphism and in which only two species exceed 0.3 m girth.

The Malayan peat swamp forests are less highly developed than those of Sarawak and Brunei; all of them carry mixed swamp forest, type 1. On the west coast the huge trans-Perak swamp is not domed, and river levées still protude in parts. The Langat swamp in Selangor is domed. These swamps lie over stiff clay which is generally above sea-level, and in which diatoms of the mangrove environment were found at Telok in Selangor, now lying several kilometres inland. The west coast of Malaya is sinking and it is possible that this has prevented development of forests comparable to the inner zones elsewhere. The only sign of concentric zonation is at Hutan Melintang in south Perak where Shorea ulginosa increases from 4.8 per hectare near the margin to 30-51 per hectare 2-4 km inland, in one area as poles only, reminiscent of S. albida.

On the east coast the peat has formed over sand behind coastal sand spits, and is most extensive between the Pahang and Rompin rivers where the coastline is advancing rapidly.

Pollen analysis of peat cores from swamps of the Baram delta in Sarawak has shown that the catenary sequence of forest types represents a succession in time. At the base of the cores stiff clay was reached at 13 m depth, overlain by mangrove, then a Campnosperma coriaceum-Cyrtostachys lakka-Salacca conferta association followed by the six communities in order. The whole succession was shown by radio-carbon dating to have formed over 4500 years. It was possible also to show that the coastline of the Baram delta has been advancing over that period at a mean rate of 9 m/year. The average rate of accumulation of peat was 0.3 m/year, and it was distinctly faster in the early years (475 mm/year at 10-12 m depth, 223 mm/year at 0-5 m). This serves to explain the 'inverted-plate' shape of the bog surface; the rapid initial formation of peat results in the steep sides (slopes of 0.2-0.6 m/km), the slow later rate accounts for the almost flat central bog plain.

The peat swamps have a biconvex shape, and the lower surface owes its concavity to the deposition of alluvium at the margins by the bordering rivers. It is noticeable that the peat swamps furthest from the coast, which are the oldest, are the thickest and most markedly lens-shaped.

It is thought that peat formation is probably initiated at the inland margin of mangrove swamp because the high sulphide and salt content of the underlying clay is toxic to the micro-organisms which would normally decompose falling plant debris. It may also be significant that in Java, where the rivers drain base-rich volcanic soils, there are no peat swamps, whereas in Sarawak, Brunei, and elsewhere peat swamps have formed, the rivers drain relatively mineral-poor hinterlands: but much of Java is seasonally dry and that may be more important.

General floristics Again, this has been studied in greatest detail in Sarawak and Brunei. Most of the tree families of lowland dipterocarp evergreen rain forest are found in peat swamp forest; exceptions are Combretaceae, Lythraceae, Proteaceae, and Styracaceae. Palms are poorly represented and only occur in the peripheral communities. There are probably very few species restricted to peat swamp forest. The greatest similarity with lowland dipterocarp forest is in the peripheral mixed swamp forest (type 1), where drainage is best and the peat soil more fertile than furtherin. By contrast, species in the swamp centre are largely those found also on poor, frequently podzolized heath forest soils, and to some extent on soils degraded by erosion and leaching after destruction of the primary forest cover. In total, 146 tree species have been recorded in both heath and peat swamp forest. Eleven of the fifteen species of Dipterocarpaceae recorded in peat swamp forest have also been recorded in heath forest. Adaptations to the specialized habitat conditions of peat swamp forest include prominent pneumatophores.

In Malaya there are floristic differences between the west and east coasts. Overall, the forests have the same economic species as the Sarawak mixed swamp forest, except that some are absent. The Malayan peat swamps are a very valuable timber resource. Their floristic poverty compared to dry-land forest means that the timber produced is of relatively uniform quality, and yields are very high - up to 61 tonne/ha. Natural regeneration of all sizes is excellent, and the first managed rotation should have even higher yields with minimal silvicultural treatment. Only *Gonystylus bancanus* and *Tetramerista glabra* are not found naturally regenerating in virgin forest. As in Sarawak, the fast-growing *Shorea* spp. and *Cratoxylum arborescens* predominate in regrowth forest.

In the forest on the Paneh peninsula of Sumatra the central zone is a dwarf forest dominated by *Tristania*. In south Sumatra and east Borneo *Tristania obovata* and *Ploiarium alternifolium* are dominant.

Man's impact Peat swamp forest is an extremely valuable forest resource which, because the land is in the main totally unsuitable for agriculture, is likely to remain as part of the forest estate. Peat swamp forest will therefore become relatively even more important in the future than it is today as progressively more and more of the dry lowlands are brought into agricultural use.

Shallow peat has been converted to pineapple (in Johore) or rubber plantations. Peat over 3 m thick cannot be successfully brought into agricultural use, and there is no doubt that it should remain under forest. Andriesse (1974) reviews the possibilities of claiming peat land for agriculture.

In Sarawak peat swamp forest is the main source of timber which itself is the main export commodity of the State. The first type to be exploited, from about 1945, was the peripheral mixed swamp forest. *Gonystylus bancanus* is the most valuable species by far although it was at first unmarketable and was left behind in the forest to be poisoned. More recently, since about 1961, the *Shorea albida* consociation has come to be exploited. Seedlings and saplings are very rare, but are occasionally seen in gaps. Poles are absent. This is the forest type, more than any other, which is prone to extensive damage from wind and lightening. No species other than *S. albida* has the ability to reach the canopy top of this type. Unless they occur over established seedlings or saplings, gaps apparently remain open until a S. albida fuiting year, when they are colonised, and the seedlings grow very fast up into trees, the characteristic very light timber being a sign of this rapid growth. It is impossible to delay felling until after a seed year, which is only about once a decade, and regeneration of this forest type presents major problems. S. albida regeneration is generally negligible in forest type 2, which has a denser middle and lower canopy than type 3, but 64,800 seedlings per hectare were recorded after a heavy seed year. The canopy is less liable to serious wind damage, and complete gaps rarely form. Natural regeneration of S. albida in this forest type appears distinctly rare. After felling, the species of type 1 regenerate.

In forest type 4 natural regeneration of Shorea albida and of two other common big trees of this community, is mainly vegetative, by suckers or coppice shoots. S. albida trees of all girths are present and saplings and poles are more frequent than elsewhere. This forest type has no value for timber, but with its high volume per hectare and low extraction costs has potential as a source of pulp or chip wood.

It has recently been estimated that the total timber rescurce of S. albida in Sarawak, allowing for 50 percent defect, is about 8×10^6 tonne.

In Brunei a project is under consideration to clear-fell much of the Belait peat swamp forest for chips. This includes forest types 2, 3 and 4. At present no means is known of ensuring that high forest regenerates and it is feared much of the area may become covered by low shrubby vegetation.

1.12 Fresh-water and seasonal swamp forest Key reference: Whitmore, (1975) section 11.4

General description and habitat The soil surface of land covered by the fresh-water swamp forest formation is regularly to occasionally inundated with mineral-rich, fresh-water of fairly high pH, and the water level fluctuates, thus allowing periodic drying of the soil surface. A few centimetres of peat or much soil may occur, but these forests are not to be confused with peat swamp forest, which have deep peat and are more or less entirely dependent on rain as the water source. A very shallow peat layer usually has little effect on the species' composition of fresh-water swamp forest.

The environment, including the soils, is extremely heterogeneous (see Burnham in Whitmore, 1975 section 9.10). The floristic composition and the structure of the vegetation also varies enormously from floating grass mats (in the Bornean lakes and believed to be a fire-climax) and open sedge or grass plains (especially in New Guinea), to pandan or palm swamp (also especially extensive in New Guinea), and to scrub and forest. In Malaya, for example, fresh-water swamp forest varies from a low scrub with scattered 20-30 m tall trees to a forest similar in structure to that of mixed species' peat swamp forest. Stilt roots, knee roots, and sinuous plank buttresses are present but infrequent. Where flooding is brief the forest approaches lowland evergreen rain forest in composition, via an intermediate formation which may be designated seasonal swamp forest. The distinctive riparian forests of the middle reaches of rivers in Sarawak, which are known as empran, fall into this intermediate category.

Distribution The greatest extent of the fresh-water swamp habitat is where the biggest rivers are, that is, on the continent in Indo-China, Thailand, and Burma (especially the Mekong and Irrawaddy) and in New Guinea (especially the Fly and Sepik), but the habitat occurs throughout the region, associated with river valleys and, except where the coasts are very steep, also with alluvial coastal plains. Fresh-water swamp forest is not restricted to the wettest climates; it is found also in seasonally dry parts of New Guinea and in east Java.

General floristics The enormous range in habitat and vegetation is coupled to great diversity in floristic composition. Fresh-water swamp forest is not distinct, at family and genus level, from that of dry-land lowland forest of the same region. Some species are confined to swampy sites; many others grow also on dry land.

There is a distinct tendency to gregariousness in primary fresh-water swamp forest, and to species' poor associations or even to consociations. Throughout New Guinea *Campnosperma brevipetiolatum* occurs in pure or nearly pure stands and the sago palm, *Metroxylon sagu*, also occurs in huge stands; in some places these two species grow together. Fresh-water swamp forest in narrow depressions in the heath forest of east coast Malaya, which receive very acid water, has floristic affinity with peat swamp forest.

Of particular interest is the occurrence along the north coast of Papua of pure stands of 48 m tall *Casuarina* aff. *cunninghamiana* as a pioneer species on swampy alluvial fans, resulting from destructive floods, and standing high over a mixed species forest 30 m tall.

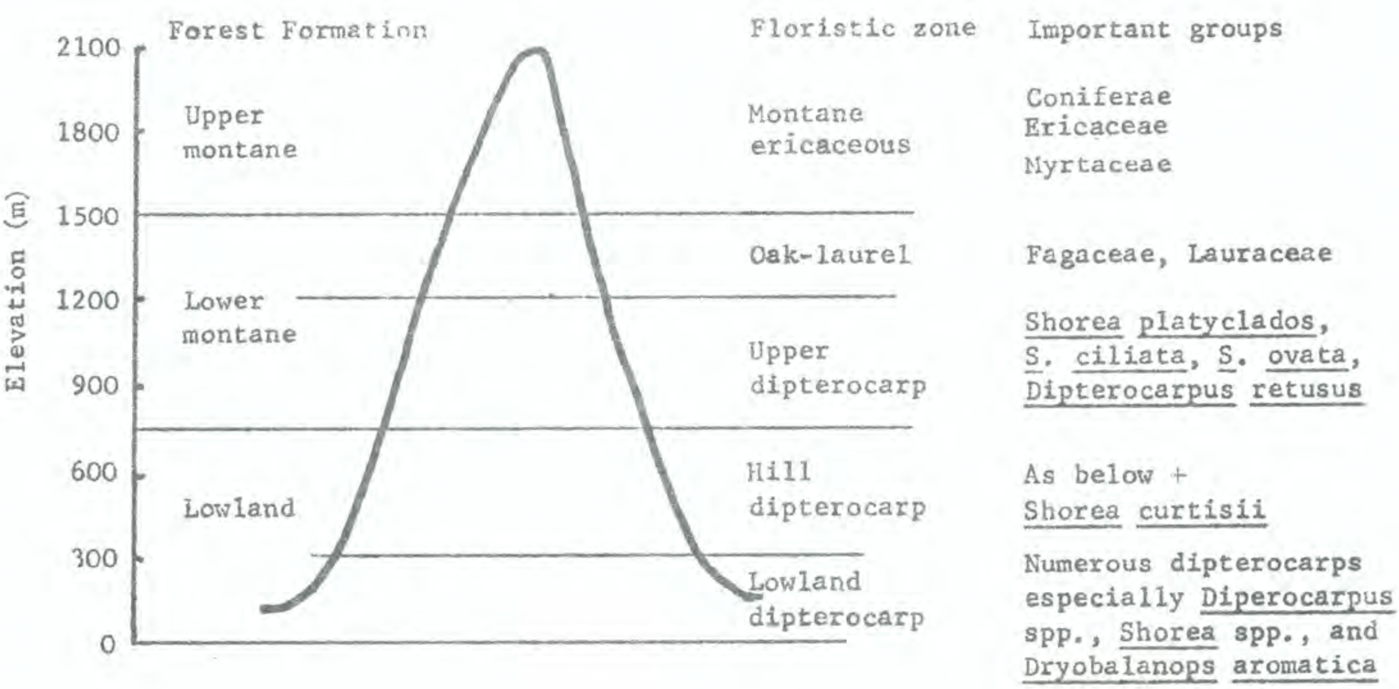
Some pure stands of single tree species undoubtedly have a secondary origin. Throughout the region, especially in south Sumatra, Malaya, south and south east Borneo, and New Guinea there occur forests of *Melaleuca kajuputi* (plus several other *Melaleuca* species in New Guinea). This grows as an understorey tree in primary swamp forest and becomes gregarious after repeated burning, owing to its production of root suckers and coppice shoots. Big *Melaleuca* trees have thick, loose, corky bark which affords protection against fire. Sloughed bark and other litter accumulates on the ground and becomes highly inflammable in dry weather. In Malaya mature Melaleuca forest has a 21 m high canopy and trees reaching 1.2 m girth. Extensive pure stands of Macaranga pruinosa and Campnosperma coriaceum in Malaya, of same-size trees and an even canopy top, are believed to represent stages in a secondary succession back to mixed swamp forest after clearing.

Man's impact Fresh-water swamp forest has in general a lower timber-stocking than dry-land lowland rain forest as well as problems of access, and is consequently of low commercial value. Exceptions are some of the pure stands of species, either primary or secondary in nature. The Campnosperma forest of north east Malaya are utilized as a source of timber for match splints, and the Malayan Melaleuca swamps are repeatedly cut for firewood and charcoal (Wyatt-Smith, 1963) as are those of Indonesia, for example, round Bandkarmasin in south Kalimantan. A few of the New Guinea Campnosperma stands have been harvested. The vast sago palm swamps of New Guinea provide the prime food of the local inhabitants. Over much of its range, and especially on the Asian continent, fresh-water swamp vegetation has been destroyed and replaced by rice paddies or, to a lesser extent, by rubber plantations, and only tiny vestiges of the former forest remain.

1.13 Montane forest formations Key reference: Whitmore, (1975) chapter 16

General description As one climbs a tropical mountain one successively encounters forests of different structure, physiognomy and flora (see appended Table and Figure from Whitmore, 1975).

Vegetation zones on the main mountains of Malaya.
(Whitmore, 1975. Fig. 16.1)



Characters used to define the principal montane forest formations
(Whitmore, 1975. Table 16.1)

Formation	Tropical lowland evergreen rain forest≠	Tropical lower montane rain forest	Tropical upper montane rain forest
Canopy height	25-45m	15-33m	1.5-18m
Emergent trees	Characteristic, to 60(80)m tall	Often absent, to 37m tall	Usually absent, to 26m tall
Pinnate leaves	Frequent	Rare	Very rare
Principal leaf size class of woody plants≠	Mesophyll	Mesophyll	Microphyll
Buttresses	Usually frequent and large	Uncommon, small	Usually absent
Cauliflory	Frequent	Rare	Absent
Big woody climbers	Abundant	Usually none	None
Bole climbers	Often abundant	Frequent to abundant	Very few
Vascular epiphytes	Frequent	Abundant	Frequent
Non-vascular epiphytes	Occasional	Occasional to abundant	Often abundant

≠ Included for comparison
≠ Following Raunkiaer

The most dramatic change, partly so because it usually occurs sharply over a short distance, is from mesophyll-dominated forest with an uneven, billowing canopy surface to microphyll-dominated forest with a lower, flattish canopy surface, the trees more slender, usually with gnarled limbs and very dense subcrowns. This latter formation is called upper montane rain forest. It is encountered first on knolls and narrow ridge crests with mesophyll forest occupying the valleys, saddles, and broader crests. Upwards it comes to clothe the entire landscape. It is as clearly distinctive on aerial photographs or from an aeroplane as to the traveller on foot.

Upper montane rain forest is frequently only 10 m tall or less (range 1.5-18 m), and its shorter facies are sometimes called elfin woodland. On outlying spurs and on isolated peaks upper montane forest occurs at lower elevations than on big mountain massifs. In these sites it abuts directly onto tropical lowland evergreen rain forest, for example, on Mts. Belumut and Ophir and on Kedah Peak in Malaya; on Mt. Tinggi on Bawean, Mt. Ranai on Natuna; smaller mountains of the Solomon archipelago; and ridges in the plain of the Fly river in south New Guinea. By contrast, on all major mountains there is an intermediate formation, lower montane rain forest, below the upper montane rain forest and which itself merges downwards with lowland rain forest, usually through a broad ecotone.

Lower montane differs from lowland rain forest in having a lower canopy (15-33 m against 25-45 m), with fewer, smaller emergent trees. Fewer trees are buttressed and the buttresses are much smaller, big woody climbers are usually absent, vascular epiphytes are abundant (as opposed to frequent), and cauliflory is much less common and so are species with compound leaves. We do not yet know the reasons for these differences. They are diagnostic when considered in toto although not individually striking, and forests of intermediate nature occur in the ecotone. It is interesting to note that Burtt-Davy (1938) placed lower montane rain forest as a sub-formation of lowland evergreen rain forest.

There is, in general, an increase in cloudiness with elevation on tropical mountains. Above the level where a cloud cap prevailing develops on any particular mountain, conditions are for much of the time very moist. Here bryophytes (mostly hepatics and filmy ferns) develop luxuriently, and may swathe tree boles and crowns in great festoons, as well as lying thickly underfoot. The bog moss Sphagnum sometimes occurs as one of the ground mosses. This eerie vegetation is called mossy forest, and it is most commonly found as a facies of upper montane rain forest, though mossy lower montane rain forest is known, for example, in the Solomons, and even mossy lowland rain forest occurs, patchily in damp canyons and more extensively in extremely wet climates such as on the Santa Cruz Islands (where rainfall is over 6000 mm/year).

'Mossiness' is often better developed in saddles, through which the moisture-laden air blows, than on adjacent ridges. Mossy forest is better developed in west than east Java, its luxuriance declines in parallel with the increasingly dry climate eastwards. In the Lesser Sunda Islands, east of Java, where the climate is even drier, no mossy forest is found in the mountains, the only sign of the cloud zone in east Timor, for example, is the occurrence of epiphytic beards of the lichen Usnea.

Upper montane rain forest is commonly very short and dense on knolls and sharp ridge crests, the saddles between carrying a much taller forest yet of indentical floristic composition. This variation is to be compared with that found at lower elevations where upper montane forest on knolls alternates with lower montane in the saddles. At still lower elevations lower montane forest itself exhibits similar variation with topography. In addition, as a further stunting effect, on many mountains in Malaya a narrow zone at the upper-most limit of lower montane forest is shorter than the main part, and similar stunted lower montane forest actually covers a few summits, for example, of Gunung Mandi Angin (1436 m).

Tropical montane forests are more extensive in the Far East than in either Africa or Latin America and considerable research has now been undertaken in them to elucidate plant-climate-soil relationships. This is fully reviewed by Whitmore (1975).

Zonation in New Guinea On the biggest mountains of the region, the huge cordillera which runs the length of New Guinea and which has several peaks over 4000 m high, the forest zones attain their greatest altitudinal extent. The ecotone between the lowland and lower montane forest formations is at about 1500 m, and upper montane forest is found from about 3000 m upwards.

Zonation occurs in the lowland rain forest, especially between plains and foothill forest. For example, in the former Pometia pinnata is the most important timber species, locally with Intsia palembanica; in the latter Anisoptera thurifera and Hopea spp. form a widespread association on ridges. Zonation within lower montane rain forest also occurs and has now been elucidated in a number of places. For example in the Wabag-Tari area of the Highlands, which is probably fairly typical, 'oak' forest is prevalent at 900-2250 m containing much Castanopsis acuminatissima. Upwards, 2100-2700 m 'beech' (Nothofagus) forest prevails as multi-species stands on ridges either as discrete groves or continuous tracts. Interspersed with the beech forest, and best developed in valleys, is a mixed forest of about 40-50 species in about as many families. This gives way abruptly upwards at above 3000 m to upper montane rain forest which has a distinct and poorer flora besides its structural and physiognomic distinction. On the great New Guinea cordillera the upper montane rain forest can itself be divided into two rather distinct floristic zones; the 'cloud forest' at 3000-3300 (3350) m and the 'lower subalpine forest' at 3300 (3350)-3550 (3600) m. On the highest mountains a third zone has been distinguished: the 'upper subalpine forest' which lies between 3500 (3600) m and 3900 (3950) m on Mt. Wilhelm. This forest is 4.5 m tall and has even smaller leaves preponderant, namely nanophylls. The subalpine forest formation is represented on the bigger mountains of Sumatra and Java at the uppermost limits of forest by a forest with low, dense canopy containing a strong microtherm element in the flora but does not apparently occur elsewhere in the Far East. Comparable forests occur on the highest peaks of the Andes.

Zonation elsewhere in the region On the smaller main mountain ranges of Malaya (few peaks over 1800 m) zonation is much compressed in comparison with New Guinea. The formations do not extend so high, and there is not so much variation with elevation within them.

Mt. Makiling in the Philippines has zones similar to those on a small Malayan mountain. On the big mountains of Sumatra and Java (with some peaks over 3000 m but none over 4000 m) zonation is intermediate between New Guinea and Malaya and the lower limit of upper montane rain forest is at about 2000 m.

Forest zonation occurs in seasonally dry as well as perhumid climates and mountain monsoon forests are known. For example on many of the mountains in Java upper montane forest is periodically burned. After a mild fire there is much regeneration from stumps; more frequent fire increases the abundance of grasses, and ultimately savanna develops. The only tree which is favoured by burning is Albizzia lophantha. Mossy forest is less often burned, which is hardly surprising. At lower elevations burning leads to the replacement of lower montane forest with Casuarina junghuhniana forest or savanna. Pinus and Araucaria in our region both occupy seasonally dry sites in the lower montane zone. Intermontane valleys, as in the Barisan range of Sumatra and the main ranges of New Guinea, are drier than the outer slopes. There are extensive seasonally dry montane forests in Thailand, Burma and Indo-China.

Zonation summarized In summary, three major and parallel changes in forest structure and physiognomy with increasing elevation can be observed. First, there is a decrease in stature and in biomass; the giant emergents of the lowlands are absent from lower montane rain forest, and there is a further decrease in stature to upper montane and subalpine forest. This progressive diminution has sometimes been referred to as a three-layered forest being replaced by a two-layered and ultimately by a one-layered one, which is an evocative but rather crude description of the change. Secondly, leaf size decreased. Thirdly, there is an increase in the amount of epiphytes, especially of bryophytes and fimly ferns. There are also parallel changes in flora.

The tree line and beyond The altitudinal limit of tree growth is only reached on a few of the biggest mountains of New Guinea where it lies at about 3720-3840 m. Near its upper limit forest occurs as a low subalpine type as described above. Most if not all of these highest mountains have a short, very dry spell each year during which the mountain-top alpine vegetation is usually burned by native hunting parties, for it is the habitat of small mammals. Over large areas subalpine forest remains as patches in fire-climax alpine grassland, and fire-resistant woody plants stand as isolated survivors. The altitude at which the tree limit occurs is further complicated by the occurrence of grassland in so-called 'frost-pockets' in hollows and along valley floors below the climatic tree line. Frost-pockets and hollows have also been reported from the highest mountains of Java.

Alpine vegetation above the tree line is a complex, edaphically determined mosaic of dwarf shrub heath, short alpine grassland, moss tundra, and fern meadow. Many of the genera are mainly temeperate in their distribution. Precipitation may fall as snow above about 4000 m, and the line at which snow permanently lies is slightly above 4500 m, only a few peaks in west New Guinea reach above it.

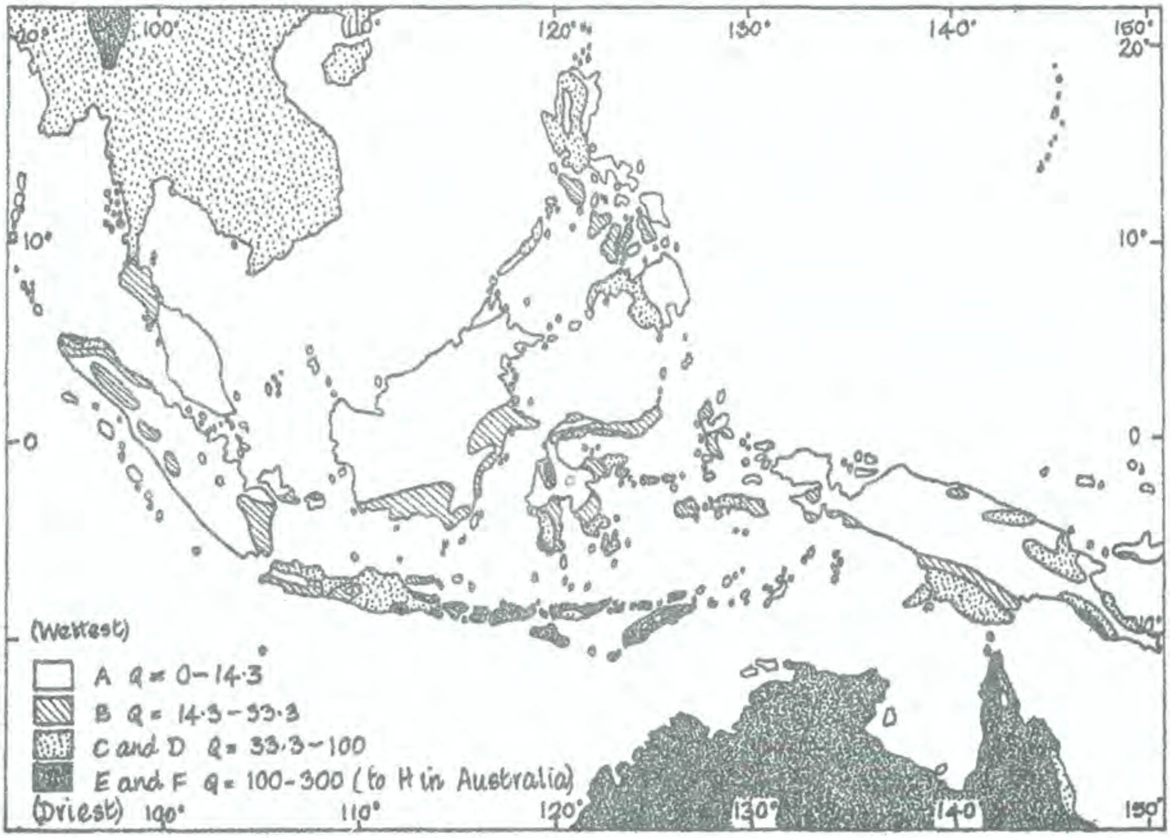
Outside New Guinea no other mountains in the region extend above the climatic tree line. The uppermost slopes of the numerous high, active volcanoes in Indonesia are bare due to a continual supply of ash, lava and other ejectaments. Some montane forests have been converted to fire-climax savanna.

The montane floras The changes in forest structure and physiognomy with elevation are paralleled by equally striking changes in floristic composition which are, as far as we at present know, also generally gradual within the lowland and lower montane forest formations; abrupt to upper montane and then, in New Guinea, abrupt again to the subalpine forest. At the broadest level of generalisation, families of predominantly tropical distribution (megatherms) are restricted, or almost restricted, to elevations below about 1000 m. These include Anacardiaceae, Burseraceae, Capparidaceae, Combretaceae, Connaraceae, Dilleniaceae, Dipterocarpaceae, Flacourtiaceae, Marantaceae, Myristicaceae, and Rhizophoraceae.

Conversely, a number of families of predominately temperate distribution (microtherms) and numerous genera are only found above about 1000 m. Some of these have affinities in the north hemisphere (e.g. Ranunculus), others in the south (e.g. Gunnera).

The upper montane and heath forest formations compared Upper montane and heath forest have many features of structure and physiognomy in common. Some species also occur in both formations. The forest canopy of both formations is rather even, dense, and commonly with a high albedo (of pale colour on aerial photographs). Trees have dense crowns, microphyll is the predominant leaf size, and the leaves tend to be held obliquely vertical, often closely placed on the twigs. The plant community of both formations is of low biomass in comparison with others. Paths made by animals or travellers remain open for a long time, and many species have hard, dense wood--two factors which suggest that growth rate is slow. Big woody climbers are absent or rare in both formations. Analysis for Malaya and Brunei of species distributed in heath and or upper montane forest indicate that some species are either megatherm or microtherm in requirement (cf above) whilst others are responding to features of the environment common to both heath and upper montane forest. Whitmore (1975, sections 10.3, 16.5, 16.6) summarizes current evidence on the relative importance of seasonal water stress and oligotrophy as the major limiting environmental factor in these formations.

Rainfall types of the tropical Far East based on wet/dry period ratios (Q) (Whitmore, 1975, Fig. 3.1)



The Tropical Rain Forest Formations in Asia Mapped

Two maps of the Malay archipelago present useful regional summaries of forest and forest environment.

2.1 Climatic map based on the index of Schmidt and Ferguson This climatic index is described in detail in Whitmore (1975), section 3.2. A series of climates are defined with progressively more dry months per year, from type A, perhumid and non seasonal through, (in the archipelago) to type F. The adjacent map shows the distribution of these climates.

The Schmidt and Ferguson climatic types closely reflect vegetation where this is known, in contrast to both the Köppen and Thornthwaite indexes (see Ho, 1962) which match very poorly. For example the inter-montane valley of the Barisan range in Sumatra is depicted as having a slightly seasonal climate (type B). The range of *Pinus merksuii* in Sumatra includes this valley. Both in Sumatra and the Philippines as well as on the continent this species occurs in B and C type climates and avoids type A, the non seasonal perhumid climates. *Imperata* grassland is extensive around Palembang and the map shows that there is a dry season during which burning is possible, The sequence of vegetation and species on the south east peninsula of Celebes from Ujung Pandun (Makassar) north to Malili is closely reflected by the sequence of climatic types.

The map therefore can be used to give a good indication of the general distribution of rain forest and of monsoon forests. The two great blocks of tropical rain forest centred on the Sunda and Sulu shelves respectively are clearly depicted. Monsoon forests and savannas and grasslands derived from them occur mainly in a belt running south through west Philippines and east Celebes, as well as in the Lesser Sunda Islands, parts of the Moluccas, and in Java as a wedge on the north coast diminishing westwards.

2.2 The UNESCO (1958) vegetation map This map, at 1:5 million, should be read in conjunction with this report. In the adjacent table the legend has been amended to give a nomenclature to the forest types depicted, in line with the rest of this report.

A source of confusion is that the man-influenced vegetation types shown on the map (secondary forest, wet rice-fields, dry fields, plantations and areas left clear and unlabelled) are each derived from several different naturally occurring formations. This tends to obscure correlations between this map and the map of climate-types reproduced above. There are several other limitations:

(1) Forests over limestone and ultrabasic rocks are not shown at all, nor are the various montane forest formations depicted. High mountain alpine grassland is shown for west but not east New Guinea.

(2) Lowland evergreen rain forest and semi-evergreen rain forest are not shown separately.

(3) The seasonally dry climates mapped by Schmidt and Ferguson are reflected in some degree on the UNESCO map by grasslands, savannas and teak forest. But monsoon forest is more extensive than shown in both east New Guinea and the Philippines.

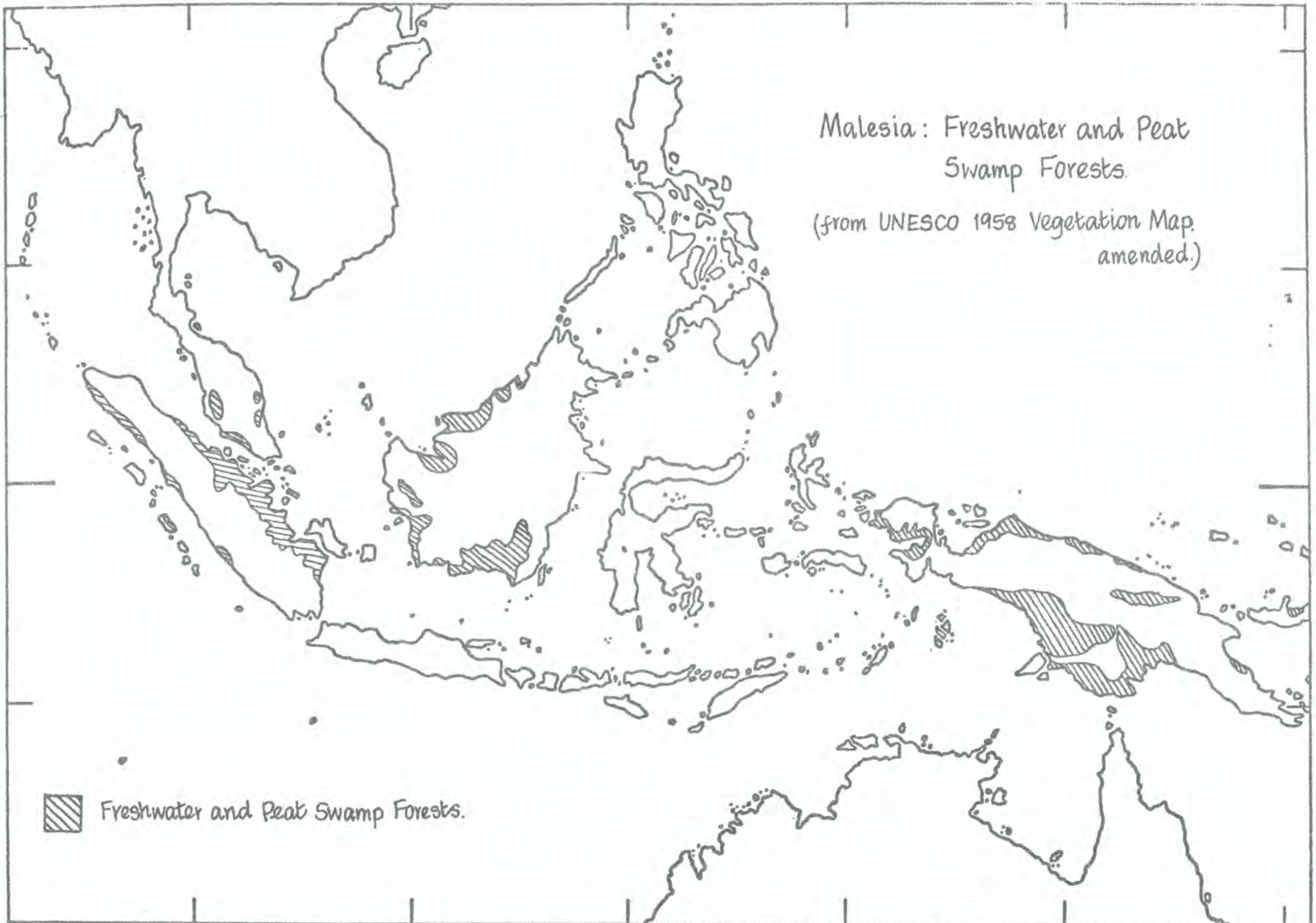
(4) The extent of Agathis forest is only very crudely shown, and this type is omitted from east New Guinea and New Britain.

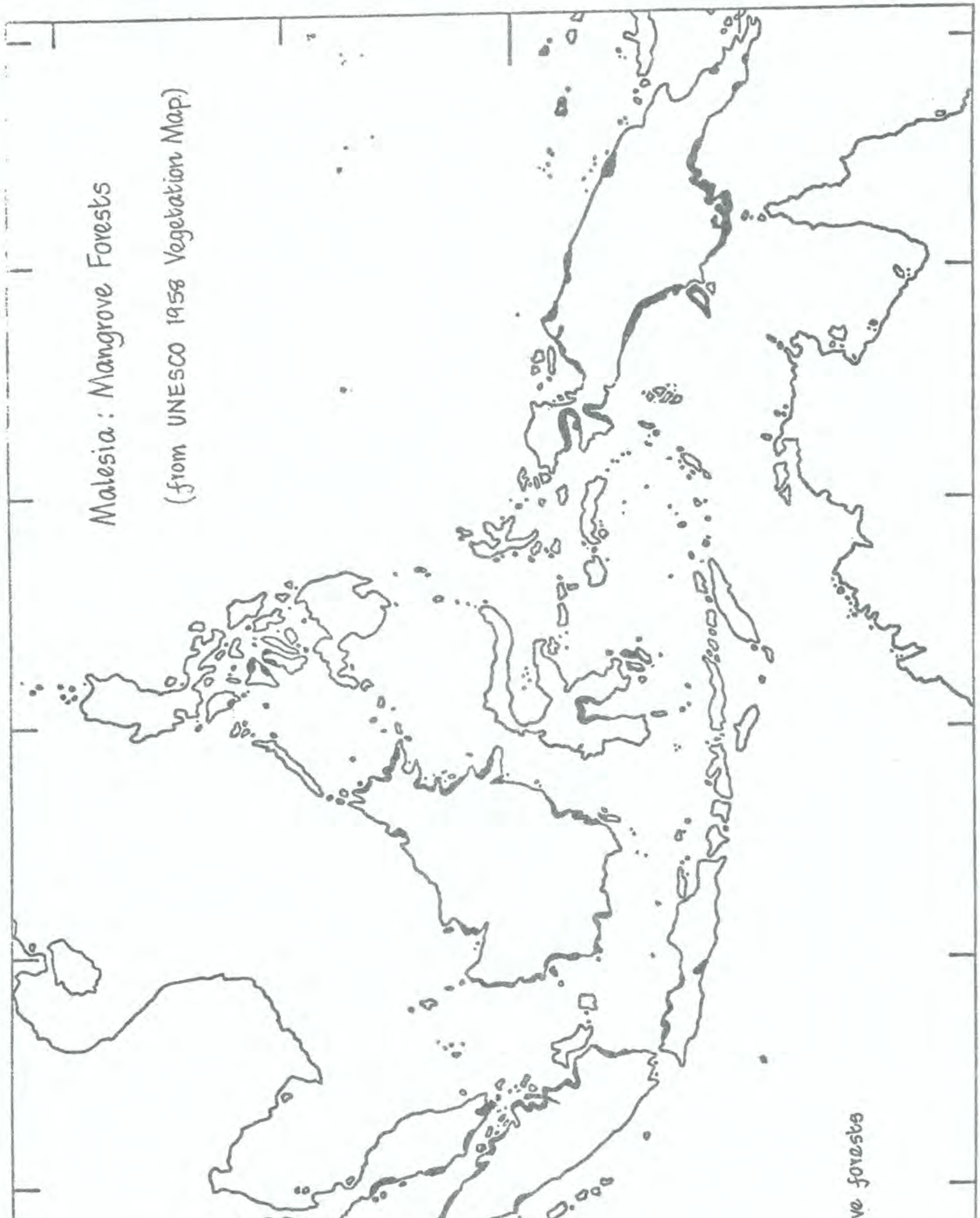
The gaps within the belt of dipterocarp rain forest on the map correspond very roughly with the occurrence of high mountains.

The map is especially valuable in depicting the location and extent of mangrove forest and swamp forest both of which are accurately shown. The two adjacent maps, copied from the UNESCO map, show the extent of these kinds of forest.

Amended legend to the UNESCO 1958 map

UNESCO number and name		Corresponding formation in this report where different
1.	Rain forest)	tropical lowland evergreen
2.	Dipterocarpaceous rain forest)	rain forest plus semi- ever-
3.	Agathis rain forest)	green rain forest
4.	Borneo Ironwood rain forest)	
5.	Casuarina forest	derived from a montane monsoon forest type
6.	Pinus forest	derived from semi-evergreen rain forest or monsoon forest
7.	Freshwater swamp and peat forest	
8.	Sago swamp forest	
9.	Mangrove forest	
10.	Secondary forest	ex several formations
11.	Savannas)	mainly derived from monsoon
12.	Grassland)	forests
13.	Alpine grassland	
14.	Monsoon (or seasonal) forest	
15.	Teak forest	a monsoon forest type
16.	Wet rice-field	mainly derived from fresh-water swamp forest
17.	Dry fields	derived from several formations
18.	Plantations	derived from several formations


Malesia: Freshwater and Peat Swamp Forests.
(from UNESCO 1958 Vegetation Map. amended.)
Freshwater and Peat Swamp Forests.


Malesia : Mangrove Forests
(from UNESCO 1958 Vegetation Map)
Mangrove forests

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C ASIA - COUNTRY REPORTS

I AUSTRALIA - CHRISTMAS ISLAND

Christmas Island, 320 km south of the Sunda Straits, is administered by Australia. It is of volcanic origin with much coral limestone and is an important source of phosphate which has been mined for many years. The area is 135 sq. km and the maximum elevation c. 210 m. Rainfall is 2000 mm per annum.

The flora is of Malesian affinity with 20-30 endemic species. Several different rain forest communities have been described (Mitchell, 1974). Most of the forests have been or will be destroyed by mining, but Mitchell states that small pockets will remain and these are important as bird breeding grounds. Regeneration after mining is very slow, especially on areas mined in early years by hand because the degree of extraction was higher then than now.

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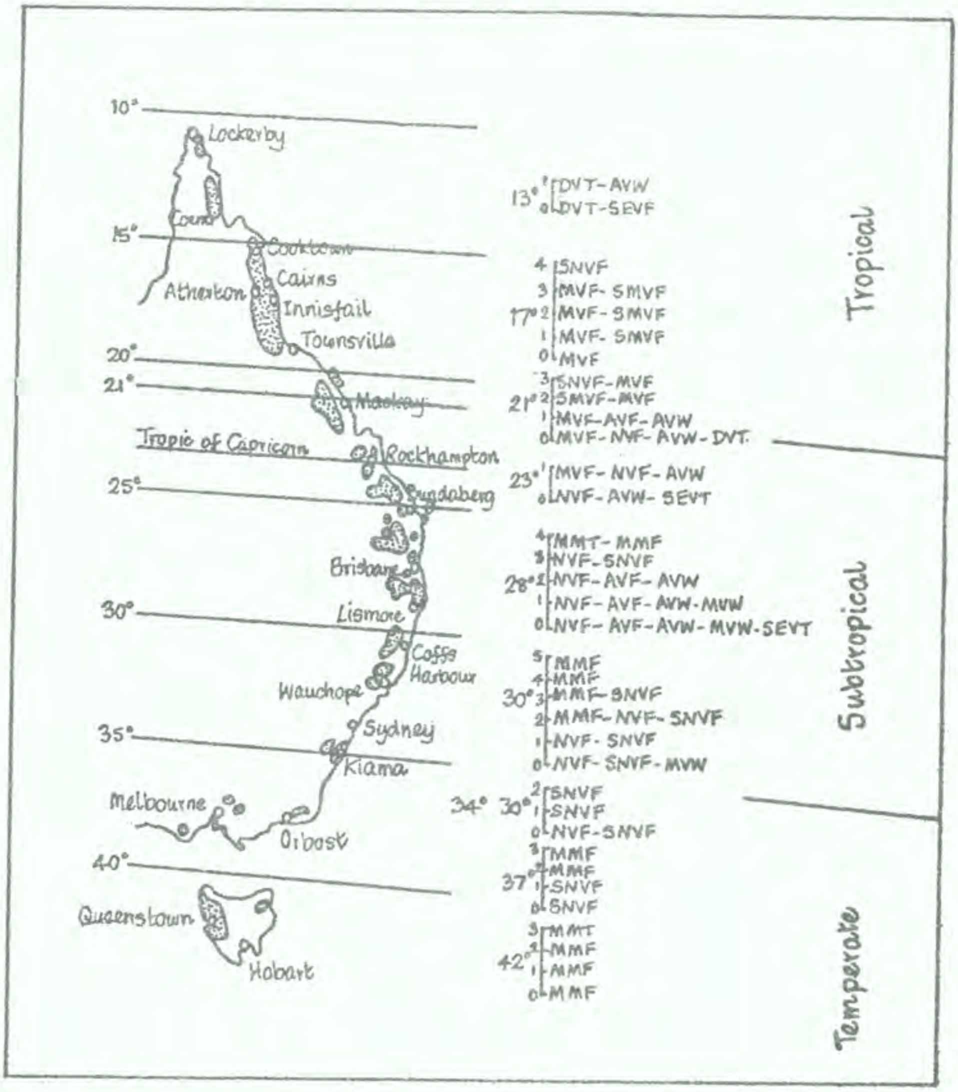
II AUSTRALIA - QUEENSLAND

1. Occurrence of tropical rain forest formations Key reference: Webb (1959)

   Webb defined and mapped tropical, subtropical and temperate rain forest in Australia and proposed a complicated physiognomic-structural scheme of nomenclature for subformations which is used in Australia but has not been taken up elsewhere.

   Tropical rain forests are found north of 21°S on the mountains which lie along the east coast of Queensland, see attached map (Webb, 1959, Fig. 1).



(Webb, 1959, Fig. 1) Rain forest distribution in Australia in terms of latitude and altitude. The numbers on the vertical scale represent thousands of feet altitude (305 m = 1000 ft.).

The forests north of 21°S are named and equated to formations used in this review as follows:

	Webb	Us
MVF	Mesophyll vine forest	semi evergreen rain forest
SMVF	simple mesophyll vine forest	lower montane rain forest
SNVF	simple notophyll vine forest	upper montane rain forest
MMT	microphyll mossy thicket	upper montane rain forest
(SEVF)	(semi-evergreen mesophyll vine forest)	(monsoon forest)
(DVT)	(deciduous vine thicket)	(monsoon forest)
(AVW)	(Araucarian microphyll vine woodland)	(monsoon forest, or marginal to semi-evergreen rain forest)

About 30 major floristic types of rain forest are recognized by Webb (pers. comm.).

The tropical evergreen rain forest formation does not occur in Australia.

Much of the forest at low and medium elevations has been selectively logged for up to nearly a century, some areas repeatedly.

The north Queensland rain forest is of world interest especially because of its high concentration of primitive, relict, taxonomically isolated species and genera.

2. Conservation

Several areas have recently been declared National Parks, but so far none in the Cape York peninsula.

Only about half of the major floristic types are included in existing reserves. Some land remains in private ownership (for example an important example of SEVF at Weymouth Holding in the Cape York peninsula), the rest is crown land and is mainly held as state forests or timber reserves. Presumably, as elsewhere, high rugged mountain peaks still carry essentially virgin forest and are unlikely to be threatened.

Rain forest conservation has to be considered with conservation of monsoon and sclerophyll forest. The juxtaposition of these different formations has been the subject of close study by Webb and his collaborators.

Douglas (1975) has reviewed the pressures on the remaining temperate, subtropical and tropical rain forests of Australia. He points out how European attitudes to them have changed since the continent was discovered. Different groups view the forests in different ways, often yet to be reconciled, and frequently in need of modification in the national rather than a purely local interest.

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III BANGLADESH

1. Occurrence of the rain forest formations

See the report for India, and the map attached thereto.

Bangladesh lies almost entirely in the zone of tropical semi-evergreen rain forest, with a narrow belt of evergreen rain forest along the hills inland from Chittagong and a very extensive block of mangrove forest (tidal forest of Champion 1936) at the mouths of the Ganges.

2. Existing areas affording effective protection

Both reserves in the UN List (2nd edition, 1971) probably contain rain forest. (It should be noted that these reserves have been dropped from later editions of the List because of inadequate protection.)

(a) The Chittagong Hill Tracts National Park (No. 1, p.377, UN List) lies in an area of evergreen or semi-evergreen rain forest on Champion's map. The area is 25,900 ha, the elevation c. 360 m, and the relief undulating. The UN List records teak as a common tree, which implies the existence of a monsoon forest not a rain forest (see Whitmore, 1975 chapter 12).

(b) Madhurpur National Park (No. 2, p.379, UN List). 10,360 ha, below 200 m elevation, a thickly forested plain traversed by rivers and canals. This lies within semi-evergreen rain forest on Champion's map. The area is inhabited, and it is likely the forest is extensively disturbed.

3. References

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IV BRITISH SOLOMON ISLANDS PROTECTORATE

The Protectorate covers the Solomon archipelago, (except Bougainville and Buka) the Santa Cruz archipelago and outlying islands, principally Ontong Java, Rennell and Bellona. The attached map lists the principal localities mentioned in this review.

1. Occurrence of the rain forest formations

The Land Resource Division, Ministry of Overseas Development, London, has in preparation a soils and vegetation survey with maps of much of the Protectorate (Hansell and Wall, 1976). A general introduction to the vegetation was given by Whitmore (1969). Compared to Malesia the Solomons are very poor in species. There is little regional differentiation within the archipelago, little local endemism, and indeed little endemism in general. The climate of most of the archipelagos is very wet indeed and with no regular detectable dry seasons. Brookfield and Hart (1966) characterise it as tropical oceanic. Epiphytes (including many aroids) and climbers are luxuriant, in marked contrast to most Malesian forests. Mountain soils on Kolombangara were found to be excessively leached even by tropical standards (Lee, 1969).

1.1 Lowland evergreen rain forest This is the predominant formation and clothes most of the lowlands. It is much disturbed by man, earthquake or cyclone. Disturbance is probably the pre-eminent factor determining different floristic types of lowland rain forest (Whitmore, 1974). *Agathis macrophylla*, restricted to Ndeni and Vanikolo (Santa Cruz archipelago) is the single most important tree species. It has considerable plantation potentiality, possibly greatest in the whole genus.

1.2 Forests of seasonally dry areas The north coast of Guadalcanal in the shadow of the high Kavo range is a rain shadow area, and this extends to parts of the Nggela islands further north and possibly to the extreme south east tip of Santa Ysabel. Gallery forest, savanna and grassland are the main vegetation types in this rain shadow. A few species have their only Solomon localities in this area (Whitmore, 1969).

1.3 Limestone Limestone occurs mainly as narrow pericoastal bands of geologically. Recent raised fringing reefs. Coral limestone variously impure and variously uplifted occurs also inland. There are a few karst towers (e.g. the sacred mountain Tatuve on Guadalcanal) and on north Choiseul an inpenetrable area of cockpit country. The important timber tree *Campnosperma brevipetiolatum* seems to be a calcifuge. A few other species (e.g. *Celtis* spp., *Pometia pinnata*, *Vitex cofassus*) are abundant on coral but not exclusively so and may be basicolous rather than calcicolous.

1.4 Ultrabasics Ultrabasics are extensive and have been mapped from the distinctive uniform forest canopy (as seen on air photographs) commonly dominated by *Casuarina papuana*. Only four species are known which are restricted to this substratum. Whitmore (1969) gives fuller details and a map.

1.5 Freshwater and seasonal swamp forests These occur as small coastal and riverine blocks. *Terminalia brassii*, of current interest as a plantation species in Papua-New Guinea, is locally gregarious.

1.6 Mangrove forests These are extensive and reach 30 m tall. *Nypa* is here at its eastern limit, and is nowhere common.

1.7 Beach forests These are extensive, many in pristine condition in contrast to the more populous islands of Malesia.

1.8 Peat swamp and heath forest Are unknown.

1.9 Montane forest Montane forests show very strong elevational compression. Upper montane forest commonly abuts directly on to lowland rain forest. The floristic element (notably Fagaceae) which is an important component of Malesian lower montane rain forest is largely absent. Whitmore (1975, chap. 16) gives evidence to suggest zonation with elevation in the Solomons is largely determined by the very wet climate. On Vanikolo, which is quite excessively wet (rainfall c. 6000 mm p.a.) even lowland rain forest has some montane features.

2. Existing areas affording effective protection

Land tenure, as in New Guinea, is a complex issue and vacant land always has a customary owner. Present day population density is low, and villages are mainly coastal on most islands, though signs abound of former habitations inland.

(a) An area of disturbed rattan-infested lowland forest interspersed with grassland lying just inland from the capital Honiara on north Guadalcanal and in the Kavo range rain shadow is a National Park. It suffers encroachment by shifting cultivators and is freely visited by townspeople who hunt and cut firewood. This area is unrepresentative of the Solomons as a whole. It was heavily fought through in the Pacific War 1942-3.

(b) The Lawrence Valley inland from the settlement Peou on Vanikolo, Santa Cruz archipelago contains the main unlogged stands of *Agathis macrophylla* on the island, and four observation plots established in 1956.

(c) A few of the 221.5 acre observation plots established on Kolombangara in 1964 are included in an area at Shoulder Hill on the north east of the island which Levers Pacific Timbers have agreed not to log. This area abuts on to the central mountainous part of Kolombangara which lies above the elevation at which commercial timber occurs.

3. Proposed Conservation Areas

The poor flora and monotonous uniformity of the Solomons forests lead to the conclusion that a few conservation areas would suffice to maintain samples of the different forests and species.

(a) The most important tree on a world scale is Agathis macrophylla, endemic to the two main islands of the Santa Cruz archipelago. It has been virtually logged out from Vanikolo so that only the Lawrence Valley stand remains as a sample of pristine Agathis forest, but is abundantly regenerating: the genetic diversity is probably fully maintained. The Ndeni stands are now being logged. There is an urgent need to ensure conservation of a representative tract on this island.

(b) The other feature of general importance of the Solomons and Santa Cruz rain forests is the strong compression of altitudinal forest belts. On most islands the primary lowland forests have been destroyed. Kolombangara is unusual in possessing a fine sweep of primary forest from near the shore to the summits at over 1500 m. The Forest Department has before it proposals for conserving a belt of forest, preferably on the west coast at either Sandfly Harbour or Merusu Cove in order to include a set of the observation plots set up in 1964. The land is held by local people. South, east and north Kolombangara are held by Levers and the forests have been or are being logged. The details of this proposal are in Whitmore (1974, sect. 9.42).

(c) Consideration should be given to conserve samples of mangrove, beach and ultrabasic forest, and possibly of the forest on the coral islands Rennell or Bellona.

(d) The Land Resource Division report (Hansell and Wall, 1976; 1 above) includes the following proposals for conservation:

(i) Guadalcanal: The Upper Lungga catchment area is entirely forested and unpopulated. As it is possible that the Lungga River will be used in the future for water storage and hydro-electric power it is advisable that the entire middle and upper Lungga catchment be declared a protected forest area.

(ii) New Georgia Islands: The island of Tetepare is virtually unpopulated and unused. It is suggested that except for the western extremity the whole island be designated a nature reserve. (This carries coastal, beach, mangrove? and lowland rain forest.)

Kolombangara provides ideal conditions for studying changes in soil and vegetation with increasing altitude on the same soil parent material. It is recommended as a matter of urgency in view of the timber exploitation taking place that a segment of natural forest from the sea to the crater summit be chosen as a biosphere reserve.

(iii) Santa Ysabel: The many small islands in the extreme west are uninhabited and unused. It is suggested that Ghaghe, Popa and adjacent small islands be declared a protected nature reserve. (These carry coastal and beach rain forest.)

(iv) Rennell: Is large and has a small population. The island also has an unusual and varied ecology. It is recommended that a part of the eastern rim and lake be declared a nature reserve.

(v) The unpopulated islands of the Duff Group (Santa Cruz archipelago) merit conservation.

4. Extent to which existing and proposed reserves include the different formations

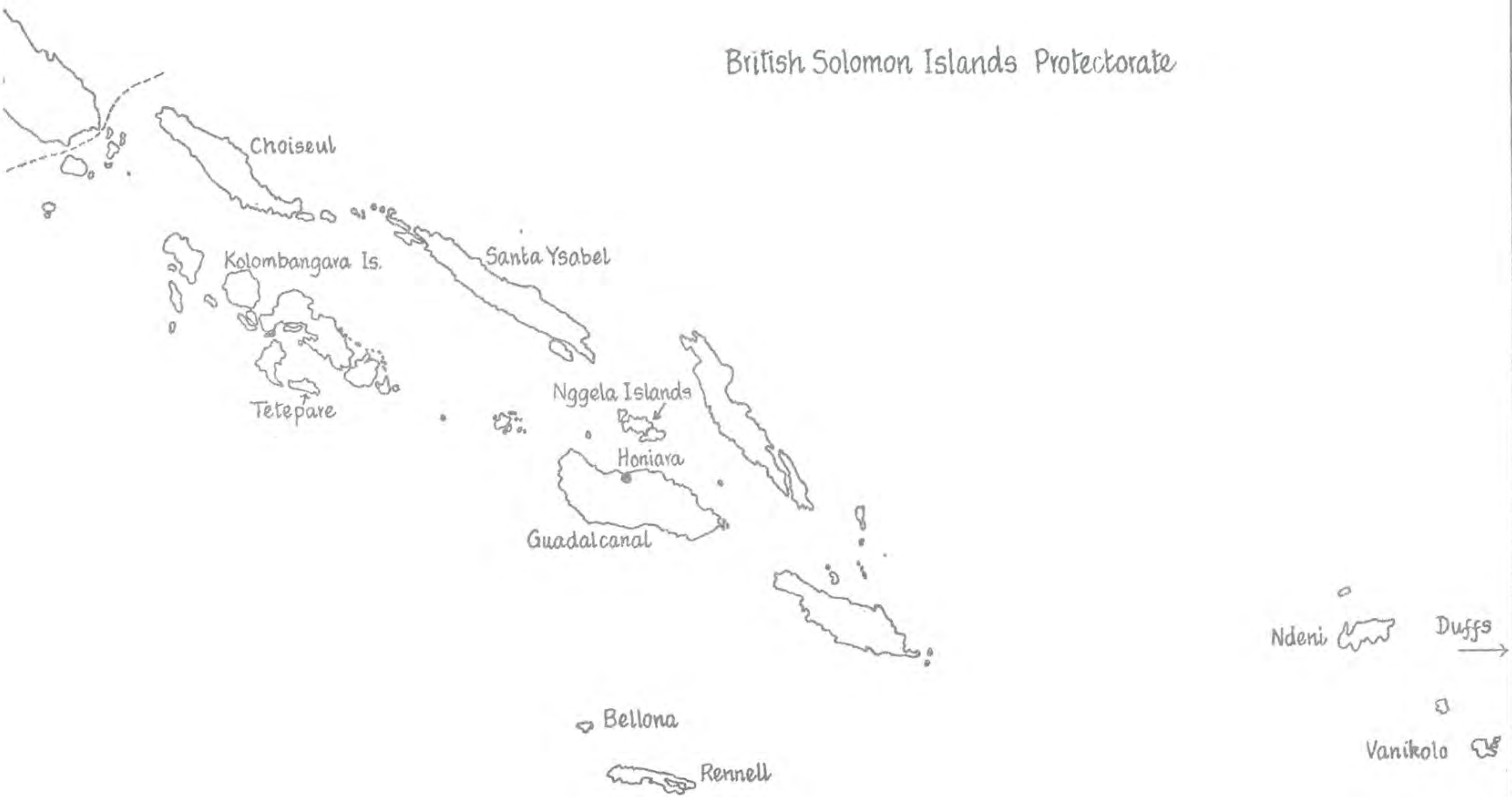
The network of reserves mentioned in 2 and 3 would encompass all forest types.

5. Matters for urgent action summarized

The Ndeni *Agathis* forests and Kolombangara elevational catena are the most important features which should be conserved in the Protectorate. They are also the two forests currently under greatest likelihood of disappearance by current logging concessions.

J.M. Diamond (*in litt.*) emphasizes the importance of the Solomons' avifauna. Many species have evolved different races or subspecies on adjacent islands, notably in the New Georgia Islands. These were discovered in the thirties by Mayr on the Witney Expeditions and have become classic examples of speciation cited in textbooks. Kolombangara, highest and second largest of the New Georgia Islands has the richest assemblage. Conservation of a substantial block in the centre of the island plus a corridor to the coast is essential in order to retain a big enough area for all these species to continue to coexist.

Diamond also emphasizes the current danger to Rennell island. This is the world's largest raised coral island. It has for its size a very large fauna, rich in endemics. There is a proposal currently under consideration to mine bauxite and also to remove much of the forest cover for wood chips. The latter would have a serious effect on the terrestrial fauna and vegetation. Rennell is a remote island whose people have little contact with the outside world. They live surrounded by forest and in equilibrium with it. They utilise the forest as a source of food and building materials. Urgent and careful consideration needs to be given to the long-term harm likely to be done if extensive forest clearance were to be permitted.


British Solomon Islands Protectorate
Choiseul
Santa Ysabel
Kolombangara Is.
Tetepare
Nggela Islands
Honiara
Guadalcanal
Bellona
Rennell
Ndeni
Duffs
Vanikolo

6. References

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HANSELL, J.R.F. and WALL, J.R.D. 1976. Land resources of the Solomon Islands. Vol. 1 Introduction and recommendations. Land Resource Study 18. Land Resource Division, Overseas Development Administration, Foreign and Commonwealth Office, Tolworth.

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V BRUNEI

1. Occurrence of the rain forest formations

Brunei has a very rich flora indeed, resulting from her position in the heart of the Sunda shelf, and has examples of most of the rain forest formations.

1.1 Tropical lowland evergreen rain forest is widespread throughout the interior. The mixed dipterocarp forests are probably more species-rich than anywhere else. Of Dipterocarpaceae Brunei has 9 genera, 151 species (Borneo 10:270; Malaya 9:160; Sunda shelf 10:350; all Asia 12:470).

1.2 Heath forest occurs along much of the coast line on Quaternary terraces, in places degraded to savanna with bare sand patches. Inland heath forest occurs in smaller patches on sandstones interdigitated with shales which carry evergreen rain forest. *Agathis* is locally dominant especially on the coast.

1.3 Beach vegetation has been largely degraded.

1.4 Mangrove forests occur at the mouths of the main rivers and around the shores of Brunei Bay. They are inhabited by Proboscis Monkey.

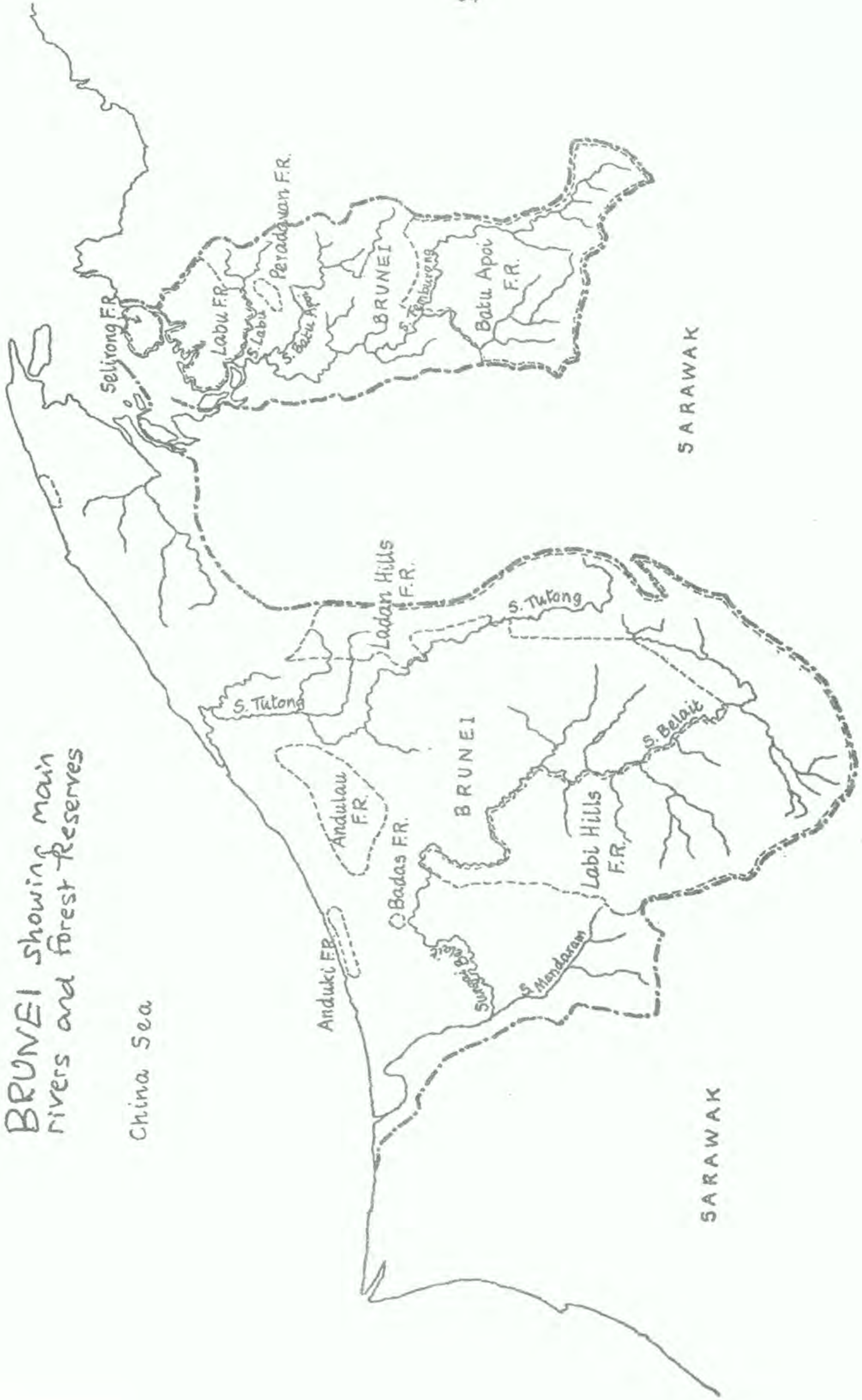
1.5 Peat swamp forest occurs in a big block south of Seria. It is dominated by *Shorea albida* and shows a complex zonation of communities. Some has been logged. Small river-valley peat swamps occur elsewhere and the Sungai Tutong carries the northern most *Shorea albida* forest.

1.6 Lower montane forest occurs on a few higher peaks, and

1.7 Upper montane rain forest is of even more restricted occurrence, mainly on Gunung Pagong, Ulu Temburong.

2. Existing areas affording effective protection

Forest reserves are shown on the attached map. Brunei has a small population and earns enough from her oil field. Present policy is to exploit the forests to meet internal demand but not to allow export. Much of the Andulau forest reserve and part of several others have been exploited but the forests of the 'Belait rim' and Ulu Temburong remain intact. There is a natural arboretum at Sg. Liang, Andulau F.R. of *c.* 80 acres.


BRUNEI showing main
rivers and forest Reserves
China Sea
Anduki F.R.
Andulau F.R.
Badas F.R.
Badas
S. Mendaram
Labi Hills F.R.
S. Belait
BRUNEI
S. Tutong
Ladan Hills F.R.
S. Tutong
SARAWAK
Selirong F.R.
Labu F.R.
S. Labu
S. Batu Apoi
Peradayan F.R.
BRUNEI
S. Temburong
Batu Apoi F.R.
SARAWAK

3. Proposed conservation areas

3.1 Bukit Peradayan, Temburong is under consideration as a National Park by the Forest Department. This is a small sandstone plateau bearing heath forest with lowland rain forest on the scarps. It is very easy to reach.

3.2 The whole of Ulu Temburong (i.e. Batu Apoi Forest Reserve) should be also considered. This is an uninhabited area of jumbled steep ridges and mountains, with few currently commercial stands of timber except on the west face of the Belalong ridge. Lowland and the montane rain forest formations are represented. Access is difficult.

4. Adequacy of existing and proposed areas

Bukit Peradayan would conserve inland heath forest and Ulu Temburong lowland and montane evergreen rain forest. Mangrove, peat swamp and heath forest are not included.

5. References

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HUNTING TECHNICAL SERVICES LTD. 1969. Government of the State of Brunei: Land Capability Survey. 3 vols. Borehamwood.
WHITMORE, T.C. 1974. Plant genetic resource survey (Dependent and Associated Territories). Ministry of Overseas Development. 88 pp. mimeo.

VI BURMA

The account of rain forests in Burma has been revised and updated in Whitmore and Grimwood (1976) to be published by IUCN.

VII CHINA AND TAIWAN

There is not enough published information from which to decide whether the residual rain forests of the south China coast line, Hainan and Taiwan are tropical or subtropical or both (see section B, 1.2). Nothing has been ascertained about their conservation status.

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VIII FIJI

1. Occurrence of the rain forest formations

No detailed ecological survey has been made but Berry and Howard (1973) of the British Land Resources Division have made a forest inventory of the three main islands Viti Levu, Vanua Levu and Kandavu, which includes general notes on the vegetation plus a detailed stratification of the forest into numerous types grouped into 9 major classes. The classes are based on appearance on aerial photographs, on land form and on strip enumerations. Agriculture and soils have been surveyed by the same Division and a report is in preparation by R.N. Jenkin and A. Lesslie entitled Land Resources of the Main Islands of Fiji.

The Fiji islands in general carry tropical rain forest on the south eastern sides which are exposed to the south east trade winds and have a more or less perhumid climate, and grassland, savanna and dry forests on the north west slopes, which are seasonally dry. The uppermost slopes and summits (which reach c. 1,735 m) carry montane rain forest types.

Beach forest has been largely replaced by plantations. Mangrove forest occurs. There are no records of heath, peat swamp or fresh-water swamp forest or of ultrabasic rocks. There is some cockpit limestone. Most of the islands are of volcanic rock.

Between 1900 and 1967 twenty eight hurricanes visited the archipelago. Berry and Howard only observed small areas of forest showing clear signs of wind damage. South east Viti Levu is especially prone to hurricanes.

The forests show clear signs that there were much bigger populations in the interior in the past, probably prior to 1820 when the sandalwood trade began. Village sites correlate with poor forest or patches of open woodland.

As in the New Hebrides, Hawaii and Seychelles exotic pioneer species, not indigenous ones, dominate secondary forest.

The flora is not rich. Many of the minor forest types of Berry and Howard are distinguished by their floristics and are to some extent related to relief. Conifers (Agathis vitiensis, Dacrydium, and Podocarpus) are common in some forests, especially at high elevations and, together with Calophyllum, are noticeably absent from secondary stands.

2. Existing Conservation Areas

The U.N. List of National Parks and Equivalent Reserves (2nd edn.) lists two for Fiji (pp. 200, 201).

(a) Ravilevu or Taveuni Nature Reserve on the fourth biggest island Taveuni, not covered by the Berry and Howard report. Constituted 1959, area 3,972 ha, highest elevation 600 m, lying in mountainous country. Taveuni has continuously heavy rainfall, the wettest of the seven regimes recognized by Fitzpatrick, Hart and Brookfield (1967). It is likely that this reserve is entirely forested, and because of its very wet climate (cf. Solomon Islands) shows strong elevational compression of forest formations, so includes montane as well as lowland types.

(b) Nandarivatu Nature Reserve on Viti Levu. Constituted 1956 and 1958, area 1,674 ha, highest elevation Mount Tomanivi (Victoria) 1,735 m, tallest peak in the islands. The reserve consists of three separate areas 2 - 9 km apart of 1,308, 276 and 90 ha area, situated within strictly supervised Nandarivatu-Nadada Forest Reserve. The area is very mountainous.

This area almost certainly has a perhumid montane climate, but to its north and west is a zone with a three month dry season which might occur in the reserve especially if it contains low elevation areas of north to west aspect.

It can be surmised that the reserve contains montane forest types, probably lowland rain forest, and possibly monsoon forest largely degraded by fire to savanna.

(c) The U.N. List excludes 20 Forest Reserves of which the largest is 11,160 ha on Taveuni island. Low elevation forests are managed for production, montane ones are protective.

3. Proposed Conservation Areas

Professor A. C. Smith, who has a prolonged and extensive aquaintance with Fiji and whose new flora is approaching publication, reports (*in litt*.) that the following areas should be considered for conservation.

(a) Southward of Mount Tomanivi lies the central plateau of Viti Levu, an area 30-50 km long and broad, with no villages, few trails and little disturbed. Rainfall is heavy. Fine upland forest remains. The Nandiravatu reserves are small and extension into this plateau warrants consideration.

(b) Part of the southern watershed of Vanua Levu, namely the entire Wainunu and Yanawai river basins and perhaps including part of the northwards draining Ndreketi river, an area of *c*. 50 x 30 km and including some of the least known and least explored lowland rain forest in Fiji.

(c) Consideration should also be given to the slope north of Natewa Bay, essentially all of Vaturova and Sanggani Tikinas. This area has still quite undisturbed rain forest and includes the high points of the island.

In addition A. L. Dahl reports (*in litt*.) that the following areas have been proposed as rain forest conservation areas in a National Trust report, but that there is no immediate prospect of establishment. These areas are all on Viti Levu, their size was not stated.

Mount Voma and surroundings, Namosi (lowland rain forest with interesting ferns).

Rama-Korobaba, Suva (lowland rain forest with endangered parrot finch).

Nausori-highlands (gymnosperm-dominated forest).

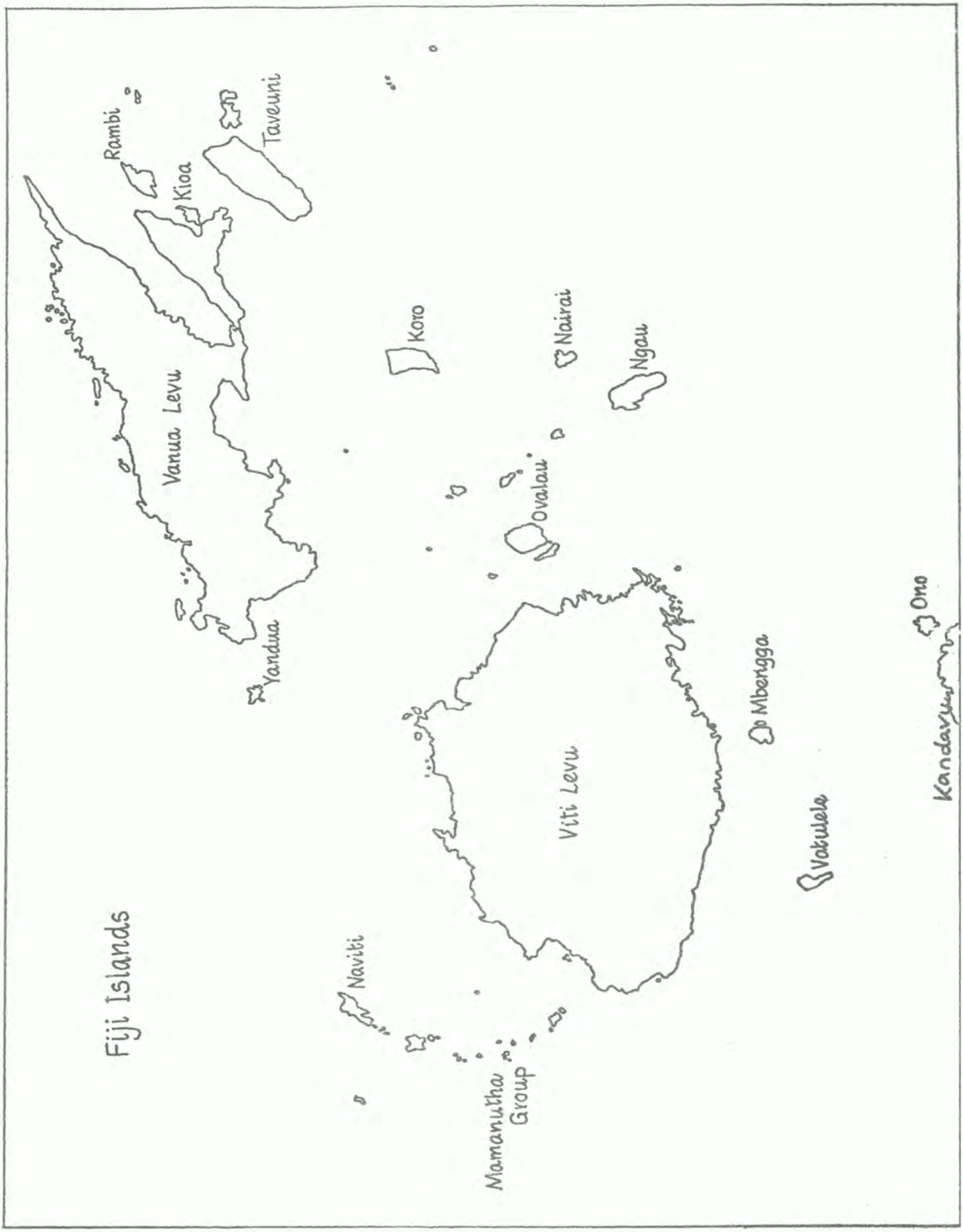
Nadrau-Plateau (lowland rain forest grading to dry low forest and grassland, with bog *Goniocladus* palm, and Talasiga vegetation).

Nakauvadra (*Pandanus* forest).

Dreketi (gymnosperm forest with *Cycas*).

4. Adequacy

Montane forests are perhaps adequately conserved in protective forest reserves and the two existing parks. Lowland and beach rain forest is probably inadequately represented in existing reserves, but would be adequately conserved if the additional areas pinpointed by Professor Smith were included. Mangrove forest is at present unrepresented, but may occur in the Smith proposed areas.


Fiji Islands
Vanua Levu
Rambi
Kioa
Taveuni
Koro
Nairai
Ngau
Ovalau
Yandua
Viti Levu
Mbengga
Ono
Kandavu
Vatulele
Naviti
Mamanutha
Group

5. Conservation education

In Fiji it is included as a project in the World Wildlife Fund rain forest campaign.

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IX INDIA

1. Occurrence of the rain forest formations

Champion (1936, see also Champion and Seth 1968) defined and described the forest types of India (present-day India, Pakistan, Bangladesh and Burma), and provided the basis for the scheme of formations of Burtt-Davy (1938) used by Whitmore (1975) and in the present survey.

The rain forest formations in these countries are:

(a) Tropical lowland evergreen rain forest, called tropical wet evergreen forest by Champion, and

(b) Tropical semi-evergreen rain forest, called tropical semi-evergreen forest by Champion.

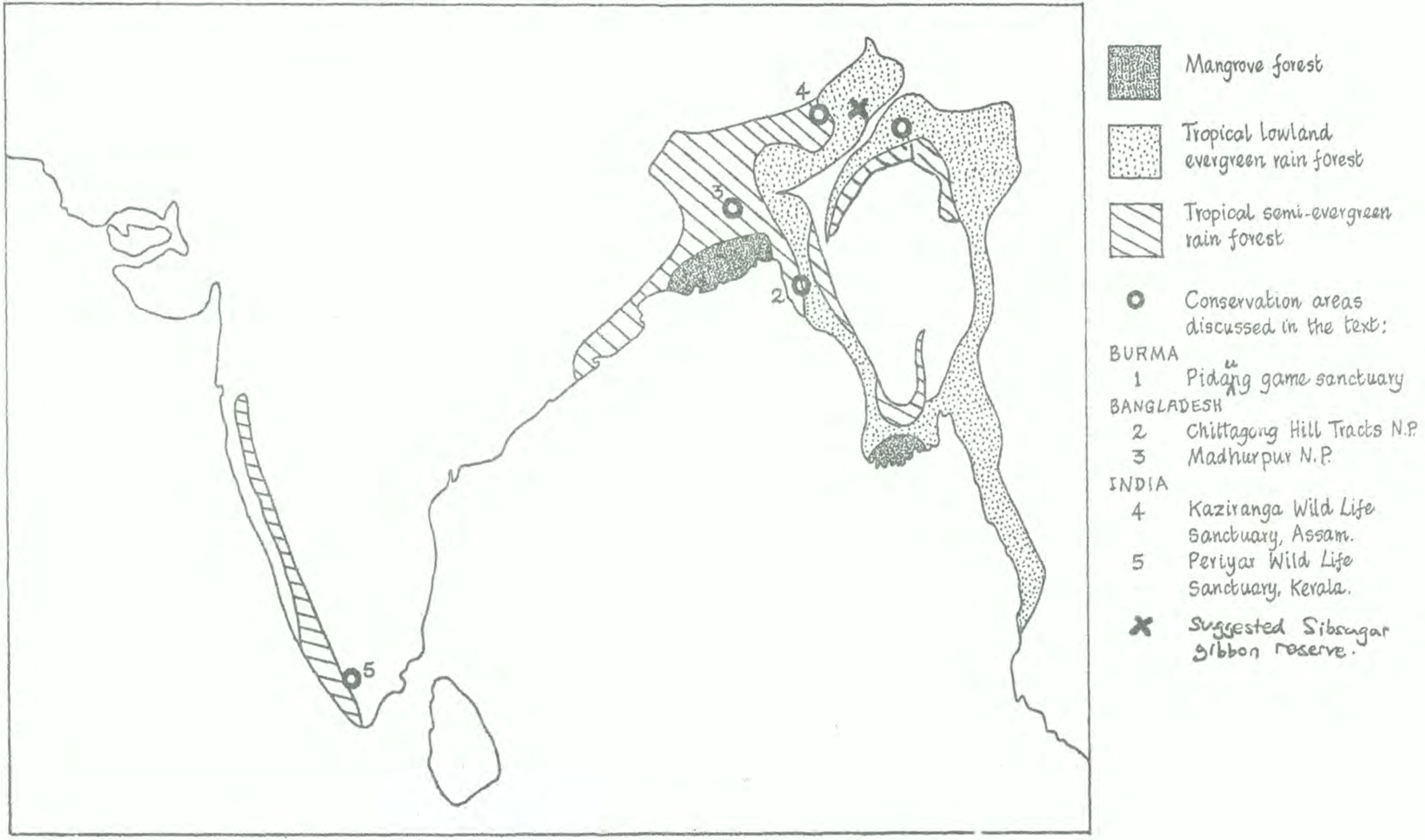
In both formations different floristic types were described from different parts of the country.

In India these types are restricted to the Andaman Islands (possibly the Nicobars too), the Himalayan foothills in Assam and a narrow belt along the western Ghats, as is shown on the attached map. Montane rain forests occur in the western Ghats (Blasco 1971).

Part of the big block of mangrove forest at the mouths of the Ganges lie within India.

2. Existing areas affording effective protection

On the map are superimposed the two national parks and equivalent reserves included in the U.N. List (2nd edition 1969) which probably contain tropical rain forest. (The various subtropical types recognised by Champion are beyond the scope of the present survey, they are represented at least marginally in 1. Manas, 13. Corbett, and 14 Jaldapara reserves.)



base vegetation map: frontispiece of Champion (1936), simplified.

(a) Kaziranga Wild Life Sanctuary, Assam (no. 2, p. 261 in the U.N. List). 42,994 ha, elevation c. 75 m, south bank of the Brahmaputra river, largely covered in herbage. This reserve lies in an area Chamption maps as containing both evergreen and semi-evergreen lowland rain forest. Any forest which exists in the reserve will be a riverine or swamp type.

(b) Periyar Wild Life Sanctuary, Kerala (no. 5, p. 262 in the U.N. List). 77,000 ha, elevation 914-1828 m; forested hills and valleys and grassy plains and semi-evergreen rain forest formations on Champion's map. At higher elevations it must include lower and possibly upper montane rain forest too.

3. Proposed Conservation Areas

In 1972 a suggestion was made to the Assam Forest Department that a forest reserve in Sibsagar district should be officially designated as a hoolock gibbon reserve (D.J. Chivers pers. comm.).

The author has inadequate knowledge to propose additional areas and has been unable to ascertain whether there are areas not in the U.N. List which conserve tropical rain forest. In particular, the recently created Tiger Reserves need to be investigated, and also whether there are forest reserves in the Andaman or Nicobar islands which act or could act as conservation areas.

WWF/IUCN as part of the current rain forest conservation programme propose to identify potential conservation areas in the western Ghats (Wildlife, 1975, p. 371).

4. Adequacy of reserves

The reserves listed above do not cover the full range of forest types described by Champion (1936).

5. References (*: not seen)

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X INDO CHINA

The account of rain forests in Indo China has been revised and updated in Whitmore and Grimwood (1976) to be published by IUCN.

XI INDONESIA

1. Occurrence of the rain forest formations

All the forest formations listed and described in section B. (Asia - General) occur in Indonesia. Some notes on occurrence were given in that section and are amplified in Whitmore (1975). The UNESCO (1958) Vegetation Map annotated in B.2.2, also gives a general impression of forest types in Indonesia. The location of reserves which include adequate samples of natural or near natural forest for conservation are shown on the adjacent map.

Indonesia is such a vast country that there are substantial floristic differences within it and a network of conservation areas of the different forest formations is needed to give geographical coverage.

2. Existing Areas Affording Effective Protection

The number of nature reserves is about 160 and their total area about 3.8×10^6 ha. These reserves include strict nature reserves, wildlife sanctuaries, recreation areas and hunting parks. A few are very small. Basjarudin (1974) gives an annotated list. The United Nations List of National Parks (2nd ed. 1969) contains a second list, shorter because of the criteria adopted, not all of which are relevant to the present survey.

The present survey is based on the list published by Basjarudin and his numbers are retained. The following table is a summary. It is followed by notes on individual reserves.

LIST OF NATURE RESERVES IN INDONESIA
CONTAINING MAINTAINABLE SAMPLES OF RAIN FOREST

(based on Basjarudin 1974)

	No.	Name	Size (ha)	No. in UN 1969 list	notes
A.	JAVA				
	Banten				
	1	Pulau Panaitan	17,500	-	off W.coast
	2	Ujung Kulon	39,120	1	W.peninsula
	3	Ranca Danau	2,500	5	W.coast
	Bogor				
	8	Telaga Warna	23	-	nr. Bogor
	9	Dungus Iwul	9	-	N.coast
	10	Yanlappa	32	-	N.coast
	Sukabumi				
	11	Sukawayana	33	-	
	14	Cikepuh	10,000	-	
	Cianjur				
	19	Cibodas-Gunung Gede	1,040	7	
	20	Takokak	50	25	
	22	Ciogong	1,000	-	
	23	Salastri	1,000	-	
	25	Telaga Patengan	150	-	
	Bandung				
	26	Cigenteng + Cipanji	2 + 3	26	
	29	Malabar	8	-	
	30	Papandayan	844	10	

No.	Name	Size (ha)	No. in UN 1969 list	notes
Garut				
32	Leuweung Sancang	2,157	-	
Banjar				
34	Pananjung Pangandaran	457	-	
Banyumas				
36	Nusa Kambangan Barat	928	8	
Wonosobo (Banjarnegara)				
39	Telaga Ranjang Dringu	?	-	
40	Gunung Pangonan - Telaga Sumurup	?	-	
41	Telaga Warno (Pengilon)	?	-	
42	Dieng High Plateau	85	-	
Jepara				
58	Gunung Celering, G. Muria	1,300	-	
Surabaya (Pasuruan)				
65	Arjuno Lalijiwo	580	11	
Malang				
68	Laut Pasir Tengger	5,250	3	
71	Pulau Sempu	877	9	
Jember				
73	Nusa Barung	6,000	2	
Bondowoso				
77	Kawah Ijen	2,560	4	
78	Yang High Plateau	15,000	-	
79	Baluran	25,000	-	
80	Meru - Betiri	60,000	-	
Banyuwangi				
81	Banyuwangi Selatan	62,000	-	
Bawean				
82	Bawean (Pulau Noko, Pulau Nusa)	15	-	

No.	Name	Size (ha)	No. in UN 1969 list	notes
B. SUMATRA				
Aceh				
86	Serbojadi	300	27	
87	Kluet	20,000	-	
88	Gunung Leuser	416,500	-	
Langkat				
89	Mt. Wilhelmina (Langkat)	200,000	-	
Tapanuli				
95	Dolok Saut	39	33	
Jambi				
96	Berbak	190,000	-	
Riau				
100	Kerumutan	120,000	-	25m alt.
103	Taluk	120,000	-	25m alt.
104	Bangkinang	150,000	-	25m alt.
105	Sungai Rangan	80,000	-	location not ascertained
106	Sei (Sungai) Siak Kecil	25,000	-	25m alt.
Agam				
110	Rimbo Panti	3,500	13	
Solok/Kerinci				
115	Gunung Indrapura (Kerinci)	12,530	12	
Bengkulu				
116	Despatah	0.3	-	*Rafflesia arnoldii*
117	Dusun Besar	1,155	34	
119	Bengkulu	2,148	-	
124	Cawang	3.2	-	*Rafflesia arnoldii*
Lampung				
120	South Sumatra I	356,800	-	
123	Mt. Krakatau	2,500	14	

No.	Name	Size (ha)	No. in UN 1969 list	notes

C. KALIMANTAN

None of the following big reserves in Kalimantan is in the UN List. The reserves in Kutei and Singkawang are so close to each other that the following locations, provided by Kartinawarta (*in litt.*) are given in addition to showing them on the map:

128	110°7'-110°22'E; 1°6'-1°23'N
129	109°46'-110°20'E; 0°32'-0°57'N
130	(?) 103°1'-109°6'E; 0°32'-0°57'N
131	110°8'-110°22'E; 2°32'-2°38'N
134	116°30'E; 0°10'N
136	116°2'-116°22'E; 0°2'-0°14'N
136A	115°3'E; 0°32'-1°13'N
137	114°52'-115°14°E; 0°2'-0°14'N
139	115°3'E; 0°32'-1°13'N

Singkawang

No.	Name	Size (ha)	No. in UN 1969 list	notes
127	Mandor	2,000	36	
128	Mt. Palung	30,000	-	
129	G. Pocapa (Nyadin Becapa)	10,000	-	increased to 40,000 ha
130	Pasir Panjang (Raja Pasi)	10,000	-	
131	Batu Jurung	10,000	-	

Sampit

No.	Name	Size (ha)	No. in UN 1969 list	notes
132	Sampit	205,000	-	
133	Bukit Raya	105,000	-	

Kutei

No.	Name	Size (ha)	No. in UN 1969 list	notes
134	Padang Luwani	5,000	-	
135	Kutei	*c.*200,000	-	
136	G.Putih	70,000	-	
137	Sungai G.Ratah	100,000	-	
138	Meratus Ulu	200,000	-	
139	(Pleihari) Tanah Laut	50,000	-	

Kartinawarta (*in litt.*) reports that 136 and 137 have been replaced by 136A Long Bangun 300,000 ha.

D CELEBES

Menado

No.	Name	Size (ha)	No. in UN 1969 list	notes
140	Gunung Tangkoko, Batuangas	4,446	16	

	No.	Name	Size (ha)	No. in UN 1969 list	notes
	Makasar				
	145	Bantimurung	10	39	
E.	BALI				
	147	West Bali	20,000	-	
F.	LESSER SUNDA ISLANDS				
	151	Mt. Rinjani	40,000	-	
G.	MOLUCCAS				
	156	Gunung Api	80	41	
H.	IRIAN JAYA				
	157	Mt. Lorentz	40,000	-	

In addition Kartinawata (1974) reports that in April 1974 an additional 1.3×10^6 ha in Irian Jaya were approved by Government.

As nature reserves as follows:

x	Kelapan-Komoran (Frederik-Hendrik) Islands	250,000	-
y	Pegunungan (Mountains) Cycloop	47,000	-

Notes on the Nature Reserves

A. JAVA

1. Pulau Panaitan. A low island, vegetation believed to have been entirely destroyed by the Krakatau eruption. Lowland inland and coastal regrowth rain forest.

2. Ujung Kulon. W.peninsula of Java. Partly destroyed by the Krakatau eruption but with older ('virgin') forest above 200 m elevation. Important for animals, especially banteng and Javan rhinoceros. Lowland regrowth rain forest.

3. Ranca Danau. Freshwater swamp forest, but very disturbed, around a crater lake. A bird sanctuary.

8. Telaga Warna. Lower montane rain forest, just below summit of Puntjak pass south of Bogor, a tiny relict fragment, currently being destroyed. See Hambali and Soejipto (1974).

9. Dungus Iwul and 10. Yanlappa. The last fragments of lowland west Javan inland rain forest, with dipterocarps; being depleted by firewood collectors.

11. Sukawayana. A tiny fragment of south coast forest, being logged.

14. Cikepuh. South west lowlands. No information.

19. Cibodas-Gunung Gede. The famous and important reserve above the Cibodas mountain botanic garden, of lower and upper montane and sub-alpine rain forest. Subject of numerous research studies which are summarized in van Steenis (1972). Currently this reserve is being damaged at its lower elevations by firewood gatherers and shifting cultivators (see Flora Malesiana Bulletin 27, 2183-8,1974).

20. Takokak. Probably with good remnant montane forests.

22. Ciogong. South coast lowland forest with banteng, deer, tiger etc.

23. Salastri. South coast vegetation.

25. Telaga Patengan. 1000-1500 m, lower montane forest; type locality of many of Koorders' species. Under pressure from local people, and being logged.

26. Cigenteng + Cipanji. 1300-1600 m. Lower montane forest. (Present status unknown).

29. Malabar. 1400-2300 m. Upper montane rain forest.

30. Papandayan. Volcanic crater plus surrounds. 1800-2600 m. Upper montane and subalpine rain forest and alpine grassland. Liable to frost. An important type locality, much studied.

32. Leuweung Sancang. Lowland forest on south coast, some still primary. Banteng etc.

34. Pananjung Pangandaran. Lowland forest on south coast. Rafflesia. Banteng. A much-frequented beauty spot under severe recreational pressure.

36. Nusa Kambangan Barat. The only good Javenese mangrove forest; also coastal forest and Rafflesia. Prison camp.

39. Telaga Ranjang Dringu. A lake on the Dieng plateau. Central Javan montane forest. Elevation over 2000 m.

40. Gunung Pangonan Telaga Sumurup and 41. Telaga Warno (Pengilon). Dieng plateau, swamp vegetation.

42. Dieng High Plateau. 2500-2600 m. Some montane forest.

58. Gunung Celering, G.Muria. Seasonal mountain rain forest; to 1602 m.

65. Arjuno Lalijiwo. A big active volcano reaching 3500 m. Superb forest. Heavy population pressure. A dried (Lentinus) mushroom industry is centred on these forests.

68. Laut Pasir Tengger. Volcanic sand dunes at 2100-2500 m. Alpine grassland, heaths.

71. Pulau Sempu. To 375 m. Primary lowland forest.

73. Nusa Barung. To 3.3 m. Coastal forest. Many animals.

77. Kawah Ijen. A crater lake at c. 2250 m., surrounded by east Javan dry upper montane forest and grassland.

78. Yang High Plateau. Vegetation as 77.

79. Baluran. Dry lowland forest, probably a monsoon forest formation. Many animals.

80. Meru-Betiri. An area of east Javan south coast superb lowland rain forest (with a similar palm flora to that of west Java). Javan tiger.

81. Banyuwangi Selatan. Lowland rain forest, logged in the 13th and 14th centuries.

82. Bawean Island. Lowland rain and monsoon coastal forest. No detailed information.

B. SUMATRA

86. Serbojadi. Orang utan, Rafflesia. Lowland forest; possibly within the Bandar Aceh dry zone.

87. Kluet. A big area of Aceh, about which nothing was ascertained, except that it contains orang utan and Rafflesia, but presumably rain forest, and probably containing montane types.

88. Gunung Leuser. A huge, ruggedly mountainous area in north west Sumatra from 300 m elevation to 3466 m (G. Leuser summit). Includes lowland evergreen, lower montane, upper montane and subalpine forest formations and alpine grasslands, but all on very steeply hilly land. The reserve is butterfly-shaped, bisected by the gorge-like Alas valley through which runs a road. The flora is very rich, and so is the fauna, which includes orang utan, Sumatran rhinoceros and tiger. A sawmill has recently been established on the edge of the reserve.

G. Leuser has been the location of several recent zoological and botanical studies by European and Indonesians. These are summarized by Jacobs (1974) and include work by Dr. F. Kurt a Swiss zoologist (1971), by Mr. & Mrs. Rijksen, who established a centre to re-habilitate confiscated orang utan, and by Dr. & Mrs. Wilde of the Rijksherbarium, Leiden, who collected plants. In the Netherlands a Gunung Leuser committee has been formed which coordinates research, management and financing in agreement with WWF and the Indonesian Government, the last represented by Dinas PPA. The G. Leuser reserve does not meet the UN criteria, in terms of access, accommodation and staff so is not in the UN List.

89. Mt. Wilhelmina (Langkat). Another huge area of N. Sumatra, about half the size of G. Leuser, and also not in the UN List. Similar in its vegetation and importance. This reserve is currently under rapid erosion from logging.

95. Dolok Saut. 1800 m. Pinus merkusii over Gleichenia. It is important that population sample(s) of this important conifer are conserved to maintain its genetic diversity.

96. Berbak. East coast. Mangrove, peat swamp and brackish water forest formations. Illegal transmigration to this area from Celebes is taking place and forest is being felled. Animals will become endangered.

100. Kerumatan. Peat swamp forest, 25 m altitude.

103. Taluk. Lowland rain forest plus some dry fields, 25 m altitude.

104. Bangkinany. As 103 plus some secondary forest, 25 m altitude.

106. Sungai Siak Kechil. As 103 but near the east coast peat swamp forests, 25 m altitude.

110. Rimbo Panti. Elevation to 200 m, in the Sumatran rift valley. Rather dry lowland forest, poor in species, much dispersed. Hot springs in the middle.

115. G. Indrapura (Kerintji). The highest mountain in Sumatra, 3800 m, and an active volcano. Contains all the montane rain forest formations and alpine grassland plus vegetation influenced by solfataras. The reserve now includes G. Tujuh, a crater lake surrounded by superb forests which are better than on Indrapura itself. Rumour has it that from 1975 this area is to be used for breeding Sumatran rhinoceros (J. Dransfield pers. comm.).

116. Despatah + 119. Bengkulu + 124. Cawang. West coast lowland to lower montane forest. A bigger reserve is needed here to include all of these. This is discussed further in section 3 below as area D.

117. Dusun Besar. 750-1500 m, a lake with surrounding *Hanguana* swamp and swamp forest.

120. South Sumatra I. Superb lowland and hill rain forest. Under great pressure from loggers.

123. Mt. Krakatau (islands).

C. KALIMANTAN (Details on 128-131, 134, 136, 136A, 137, 139 provided by Kartinawarta, *in litt.*).

127. Mandor. To 1250 m. Heath forest. Proboscis monkey.

128. G.Palung. Swamp to mountain forest, to 1116 m altitude.

129. G.Becapa. Now extended to 40,000 ha. Lowlands to mountains, 1392 m.

130. Pasir Panjang (Raja Pasi). Lowland forest, some secondary. (Coastal)

131. Batu Jurung. Swamp forest. (Coastal, probably peat swamp forest and possibly within the range of *Shorea albiela*: T.C. Whitmore.)

132. Sampit. Peat swamp forest with *Agathis* and heath forest interdigitated. All/most has been logged.

133. Bukit Raya. To 2278 m elevation. Lowland and some mountain rain forests. Only reserve in Schwaner mountains. Important.

134. Padang Luwani. Heath (*Tristania*) forest.

135. Kutei. This huge reserve in north east Kalimantan was established in 1936 mainly to conserve orang utan and rhinoceros. The following notes are a brief synopsis of the report (with maps) of a four week survey in 1970 by Reksodihardjo, Anderson & Phung (1974). In 1969 about one third of the area, 100,000 ha, forming the coastal area was excised for logging. The forest contains lowland rain forest, rather poor in dipterocarps but very rich in *Eusideroxylon zwageri*, Borneo Ironwood, developed on alluvium. This is the only big Borneo Ironwood forest left on the island. Ridges on the western side are rich in the fan palm *Borassodendron borneensis*. The forest is primary except for small areas of shifting cultivation on the west and disturbed forest along some rivers where there has been illegal hand logging. The area has a somewhat drier climate than average for Kalimantan, Bontang, formerly within the reserve, averages 1983 mm p.a., with July and August averaging less than 100 mm. The forest might therefore be of the semi-evergreen rain forest formation not evergreen. Apart from pressures to release additional areas for logging, which can be expected, there had also been prospecting for oil in the vicinity of

the reserve and also within the north east part of the reserve by P.N. Pertamina. The team recommended northern, southern and western extensions to compensate for the lost area, and noted that orang utan were apparently uncommon and might have been more concentrated in the excised eastern coastal area.

136. G.Putih. Lowland swamp forest (probably peat swamp: T.C. Whitmore).

136A. Long Bangun. Lowland forest.

137. G.Ratah. Lowlands to 100 m altitude.

138. Meratus Ulu. South east slopes of the Meratus mountain chain. Lowlands to 1500 m, therefore including lowland and montane forests. May include karst limestone (e.g. G. Serampakah) and ultrabasic as both kinds of rock occur in the Meratus mountains. Parts of this south east corner of Borneo are slightly seasonally dry, and lowland semi-evergreen rain forest might be included and so might seasonally dry montane, limestone and ultrabasic formations.

139. Pleihari Tanah Laut. Lowland forest.

D. CELEBES

140. G.Tangkoko, Batuangas. At the extreme north east tip of Celebes. A volcano, 1370 m. Lower slopes with dry (? monsoon) forest, wetter upwards with a mossy upper montane forest on the summit. Important for animals (anoa, babirusa, and a megapode and Celebes black monkey).

145. Bantimurung. Karst limestone, 150-170 m, in a seasonally dry climate. Celebes ape.

E. BALI

147. West Bali. Extensive forest ranging from open savanna to wettish hill forest.

F. LESSER SUNDA ISLANDS

151. Mt. Rinjani. Presumably this reserve includes Casuarina junghuhniana forest plus seasonally dry montane types.

G. MOLUCCAS

156. Gunung Api. A volcanic islet in the Banda group reaching 650 m. A bird sanctuary. Presumably includes coastal (? mangrove) forest. Lower slopes bear savanna. The upper slopes are influenced by volcanic eruptions but might bear montane monsoon forests showing altitudinal compression.

H. IRIAN JAYA

157. Mt. Lorentz. High mountain forests up to the snow line at 4700 m.

x Kelapan-Komoran Islands. Mangrove and freshwater swamp forests.

y Cycloop mountains. Lowland to montane rain forests.

3. Proposed Conservation Areas

These areas are shown on the map which accompanies this report.

A. JAVA

A. Cibarengkok. West Java near the south coast. Lowland rain forest, hill facies, and lower montane rain forest, largely virgin, being logged in parts. To lie within a 20,000 ha Forest Reserve.

B. Halimum. A mountain complex in west Java, the water catchment area of part of the north coast rice-plain. Largely virgin lower montane to upper montane rain forest, total area c. 70,000 ha. A forest reserve; access has recently been improved and logging is now commencing. Dr. M. Jacobs (Leiden) has made a conservation proposal concerning this area to the World Wildlife Fund.

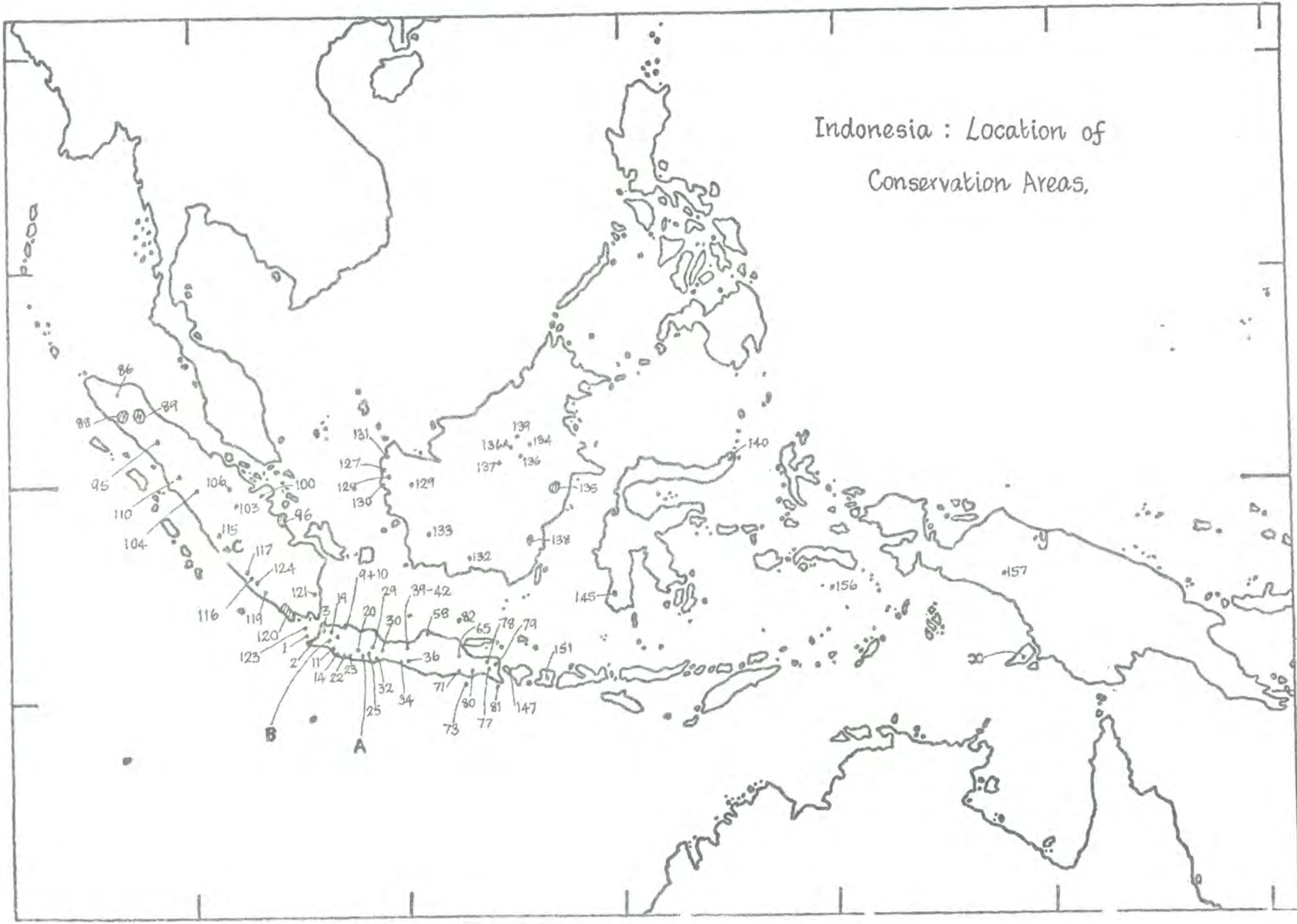
B. SUMATRA

C. Tapan-Sungai Penuh road. Pinus merkusii forest. This is the most accessible stand of the southernmost (Kerintji) population of the three separate Sumatran populations of P. merkusii, and the only one to occur south of the equator. Cooling (1968) gives details. The Pinus is associated with Agathis, which is unique. The flora is very rich. Tiger are present.

D. Bengkulu. South west Sumatra, on the hills inland from Bengkulu town. About 50,000 ha of virgin rain forest. Elevation 300-2500 m, running from the hill facies of lowland evergreen rain forest to montane forests. The former is very rich in dipterocarps, including huge trees and in palms. There has been patchy logging and shifting cultivation in parts by the local people. Within this area occur the small existing reserves listed above, 116 Despatah (0.3 ha), 119 Bengkulu (2148 ha) and 124 Cawang (3.2 ha).

4. Adequacy of Existing and Proposed Reserves

The network of reserves described above appears to the author to give reasonable geographic coverage to the whole of Indonesia except central and south eastern Celebes which is still largely covered with high rain forest, and except Irian Jaya.


Indonesia : Location of
Conservation Areas.
86
88
89
95
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116
119
120
123
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2
3
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9+10
29
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39-42
58
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78
79
11
14
22
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32
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There are few reserves in mangrove forest. Freshwater swamp forest is apparently poorly represented outside Irian Jaya. Heath forest is apparently only represented in 132 (Sampit) 127 (Mandor) and 134 (Padang Luwai) all in Kalimantan.

There is a great concentration of reserves in Java where human population is very dense. Many are small and the degree to which they still remain relatively or completely undisturbed needs to be ascertained. This is the reason why two additional areas A. Cibarengkok and B. Halimun are mentioned for Java.

5. Matters for urgent action summarized

(a) There has been an enormous enlargement of the timber industry in Indonesia since the late 1960s, because of the political stability of the Suharto government. Numerous large concessions have been allocated, and most of the commercial (i.e. lowland) rain forests of the nation are now under licence. Nature reserves have come under pressure. For example, Way Kumbas, 130,000 ha of lowland rain forest in south Sumatra, has been entirely excised (Meijer 1974), one third of Kutei has been excised, and a sawmill built on the edge of the Gunung Leuser reserve. The security in perpetuity of the existing reserves is not yet entirely assured. An overall review of the status of each reserve is probably desirable, followed by preparation of a revised list based on existing and proposed reserves. There is currently a lull in the rate of logging, but when world trade picks up again the industry will recover.

(b) Cibodas-Gunung Gede, (No. 19) Gunung Leuser (No. 88) and Kutei (No. 135) are three important reserves which are in different ways currently being or likely soon to be damaged, as was detailed in section 2 above.

6. Acknowledgements

Much of the detailed commentary of section 2 was provided by: Dr. J. Dransfield. To him also are due the proposals in section 3. Dr. K. Kartinawata kindly ascertained the location of some of the reserves described by Barjarundin, and provided notes on some of these.

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XII MICRONESIA AND POLYNESIA

The conservation status of tropical rain forest in Micronesia and Polynesia was reported to the author in a letter from A. L. Dahl (South Pacific Commission) as follows:

American Samoa - No protected forest areas, and the little remaining primary forest is continually being reduced. One atoll reserve (Rose).

Cook Islands - No protected areas, but aid in establishing national parks has been requested. An eventual park in part of central Rarotonga is therefore a possibility.

French Polynesia - Two excellent reserves recently established on Tahiti:

Mount Marau, over 1,000 ha of montane rain forest-cloud forest. (i.e. lower and upper montane rain forest.)

Presqu'île, over 2,000 ha, including several complete and almost inaccessible valleys of riverine and lowland rain forest.

Several other reserves under consideration, including other parts of central Tahiti, and a drainage basin on Raiatea.

Detailed proposals have been made for the Marquesas by the Antenne du Museum National d'Histoire Naturelle to supplement the three small reserves established there in 1971, but even if these were to be established, the prospects of effective enforcement are slim for the time being.

Gilbert and Ellice - No rain forest. (For species cultivars which need conservation see Whitmore 1974.)

Guam - No significant undisturbed vegetation.

Nauru - No reserves.

Niue - Complete system of reserves in legislation presently being considered, including 160 ha virgin forest still under tapu (Huvalu Forest).

Tonga - No forest reserves at present, although suggestions have been made of a forest park on 'Eua.

Trust Territory (Micronesia) - Some studies have been made but no action has been taken.

Western Samoa - A detailed IUCN survey has proposed a complete series of national parks and reserves protecting the major forest types but the report has not yet been accepted by the Government. Legislation has recently been passed permitting the establishment of parks and reserves, but lack of resources will make progress slow.

References

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XIII NEW HEBRIDES CONDOMINIUM

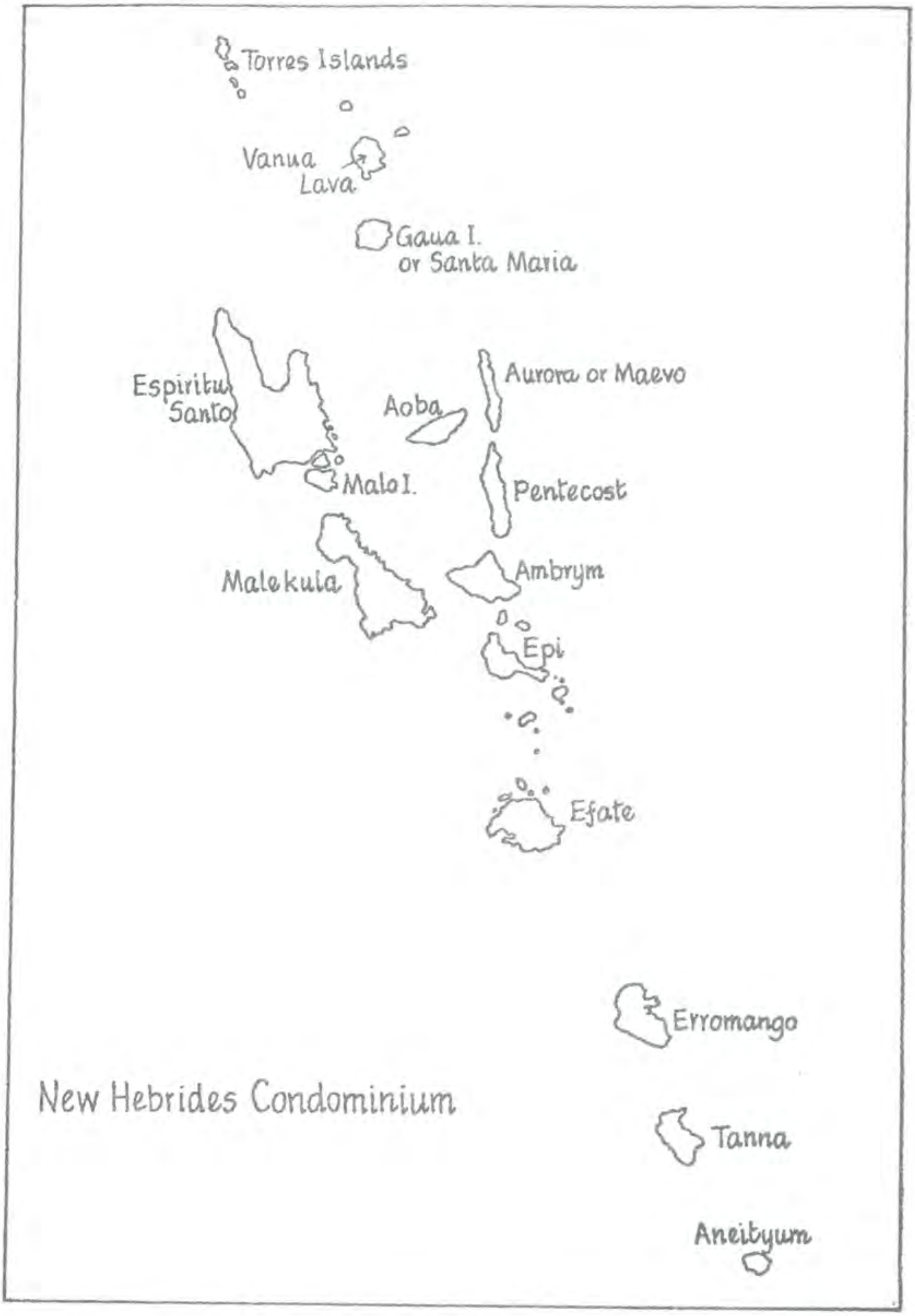
A map of the archipelago is attached.

1. Occurrence of the rain forest formations

Nothing has been published on the forest types of the New Hebrides except the detailed account of Erromango island by Johnson (1971). Corner and Lee (1975) review various aspects of biology.

The flora of the New Hebrides, like that of the Solomons to their north, is essentially Malesian but poorer in families, genera and species. The New Hebrides flora is markedly poorer than that of the Solomons. Generic endemism is low. Too little critical work has yet been undertaken to say how many species are truly endemic. The New Hebrides do not have *Ficus* sect. *Pharmocosycea* or the primitive family Winteraceae, and this may be because they are recently evolved islands, not a Gondwanaland fragment.

The vegetation is a low dense scrub or a low forest interspersed with scrub and grassy patches, and has few species per unit area. On the biggest mountains there is the usual zonation to lower and upper montane forest with increasing elevation. Santo Peak and Taburemesana on Santo reach 1800 m.


Torres Islands
Vanua Lava
Gaua I. or Santa Maria
Espiritu Santo
Aoba
Aurora or Maevo
Malo I.
Pentecost
Malekula
Ambrym
Epi
Efate
Erromango
New Hebrides Condominium
Tanna
Aneityum

The only extensive tall forest is that dominated by the New Hebridean kauri Agathis obtusa. The densest stands (now partially logged) were on south east Erromango. Fairly dense forests remain on south west Erromango, on the southern slopes of Mount William, north Erromango. Kauri also occurs on Aneityum (largely logged-out) and (apparently as a rare tree) on Santo. On Erromango Calophyllum neo-ebudicum is an abundant associate of kauri. Castanospermum australe occurs on Santo (and elsewhere ?) as groves of tall trees set in the widespread low scrub. Otherwise tall trees are rare.

The reason for the great extent of low scrub lies undoubtedly in part in the prevalence of cyclones throughout the archipelago, and possibly owes something also to the activities of the formerly dense native population.

In many places the primary vegetation has been invaded, following destruction or serious disturbance, by exotic pioneer species for example Leucaena leucocephala, Mimosa invisa, Lantana camara and Cassia fistula. This must reflect the lack of aggression of indigenous pioneers (e.g. Macaranga, Mallotus) in competition, and is in marked contrast to the Solomons. It is a feature of the islands of Fiji, Hawaii and Seychelles also.

Fire-climax grassland and savanna occur in the extreme south east of Santo and on west Efate, Erromango and Tanna, which are in the lee of the south east Trades, seasonally dray and therefore with seasonally inflammable vegetation.

2. Conservation

No conservation areas exist and the only one which has been proposed is the south west stand of Agathis on Erromango.

3. Urgent Action Required

Conservation of an adequate sample of the population of Agathis obtusa is desirable. This species, with A. macrophylla of the Santa Cruz archipelago to the north, is probably the most important in the whole genus for development as a plantation tree, and Agathis is potentially one of the most valuable tropical conifers for plantation use.

4. References

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XIV PAPUA NEW GUINEA

1. Occurrence of the rain forest formations

1.1 General. The study of rain forest ecology is not so advanced as in countries of western Malesia and until recently there has been an absence of wide scale accounts of the vegetation of Papua New Guinea.

Van Royen (1963) in a mimeographed account, now long out-of-print, gave a mainly floristic description of the vegetation of the whole island of New Guinea. A long series of reports of small areas has been prepared by the Land Resources and Regional Survey branch of CSIRO (see Whitmore 1975, appendix). These include chapters on forestry and vegetation. Authorship varies and the reports are difficult to correlate. Recently Paijmans (1973) produced a smaller scale description and map covering the Papuan peninsula, and (1975) has produced a vegetation map of the whole of Papua New Guinea in 4 sheets at a scale of 1: 10^6 plus explanatory notes. There is also a vegetation map plus brief notes by Robbins in Ford (1974). Johns (1972) has an account of the vegetation. There is considerable inconsistency of nomenclature of forest formations between these various reports and with names used outside Papua New Guinea, and detailed correlations remain to be attempted except that Grubb and Stevens (1975) have reviewed most of the work on mountain forests.

Papua New Guinea contains sizeable areas of seasonally dry climate at both low and high elevations, notable in the south west adjacent to Irian Jaya and in the intermontane valleys of the central cordillera.

Generally speaking, the exact length and intensity of the dry season and the limits of occurrence of dry climates are not known but the CSIRO reports include available figures for the areas they cover. The climatic map shows the approximate extent of seasonally dry climates. The drier ones coincide with the occurrence of monsoon forests and savanna, beyond the scope of the present review.

1.2 Lowland evergreen rain forest and semi-evergreen rain forest. The exact boundaries between these formations are not known, as just described, and complex interdigitation probably occurs because of local rain shadow effects.

Lowland rain forest is extensively disturbed in Papua New Guinea by human interference. The maps of Paijmans (1975) show the wide extent of this disturbance, surprisingly greater than in forests of eastern Malesia; see also White (1973).

Possibly in Papua New Guinea there is greater uniformity amongst at least the big trees over large areas than in the Sunda shelf dipterocarp rain forests but data on distribution patterns within these forests have not been published, so that there are no precise observations on regional differences or centres of endemism or richness.

Dipterocarps are only locally common, and are absent from or rare in huge tracts. Whitmore (1975, chap. 15) gives details.

Specht, Roe and Boughton (1974) state that these rain forest formations 'contain the core of the vertebrate fauna'.

1.3 Heath forest. This is apparently (and unaccountably) absent from Papua New Guinea.

1.4 Forest over limestone. Karst limestone is uncommon. Massive limestone masses occur. There are records of distinct sorts of forest on limestone.

1.5 Forest on ultrabasics. Ultrabasic rocks occur throughout Papua New Guinea at low and high elevations. Paijmans (1975) and von Royen (1963) note distinctive forests.

1.6 Beach vegetation. It is of widespread occurrence.

1.7 Mangrove forest. The forest is very extensive, see the UNESCO vegetation map.

1.8 Freshwater and seasonal swamp forest. These are vey extensive in the lowlands, see the UNESCO vegetation map. Numerous structural and floristic types have been described. Small pockets of swamp forest occur in the mountains, in one type conifers are common (Paijmans 1975).

1.9 Peat swamp forest. It has not been recorded, despite the extensive, detailed surveys which have been made of the swamp forests.

1.10 Mountain forests. The biggest mountains of south east Asia are in New Guinea, and mountain forest types here occupy their greatest altitudinal range. Above the lower montane and upper montane formations a subalpine forest formation is well developed. Within all these formations several distinct altitudinal belts occur differing primarily in floristics. Grubb and Stevens (1975) attempt a synthesis of the numerous, scattered, fragmentary accounts and Whitmore (1975) and section B.1.13 of the present review describe these forests in a regional context.

The mountains are not uniformly perhumid but the extent to which differences in forest occur in the various seasonally dry mountain climates is not known. It is likely that *Araucaria* is restricted to seasonally slightly dry lower montane climates (Whitmore 1975, chap. 14).

Much mountain forest has been destroyed by shifting cultivation up to about 2600 m (above which conditions are too cold) and much is disturbed or depleted. Much more has been converted to grassland or savanna by fire, and in many places fire is believed to determine the tree line. Frost pockets are another feature limiting forest occurrence.

2. Existing Areas Affording Adequate Protection

Most of the land is under native tenure, even where uninhabited. In this the situation differs from countries further west, in which vacant land commonly belongs to the State, and the consequences for forest use and land development are profound.

Only three national parks exist. In addition timber rights are owned by or leased to Government over other areas but these have minimal importance for conservation.

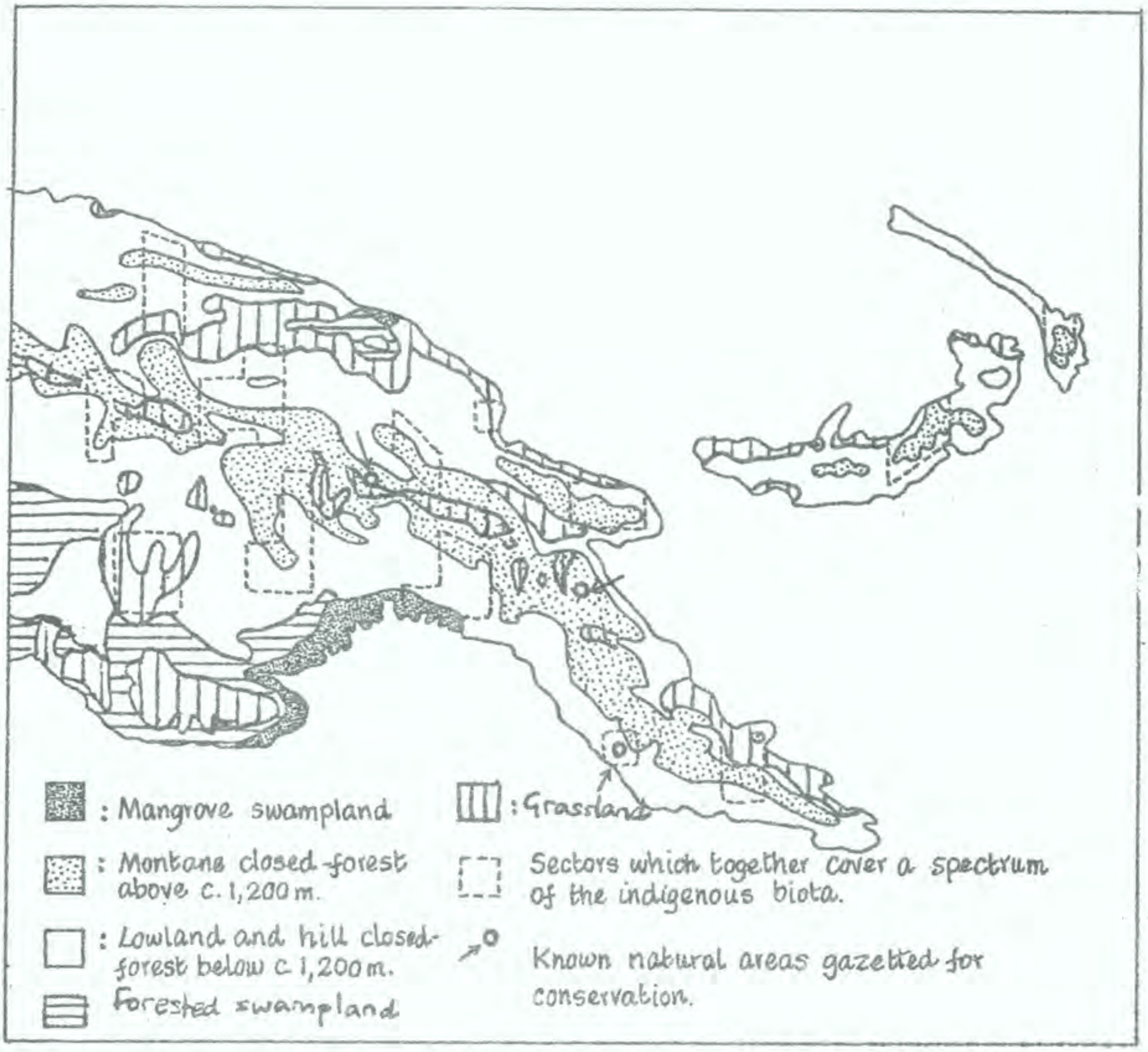
(a) Varirata (Wariarata) National Park. Papua, north of Port Moresby and accessible by road, 1060 ha, centred on 9°25'S; 147°18'E and ranging from 120-1065 m elevation. Rain forest occupies less than one third of this Park. It merges into savanna (one third), partly as tongues of gallery forest. One quarter to one third of the vegetation is considered secondary, and most of the rain forest shows signs of substantial disturbance.

(b) McAdam National Park. 2080 ha, 670-1980 m elevation, bordered by the gorge between Wau and Bulolo, Morobe district. Tribute mining occurs along the river, there are native gardens within the Park which has been policed by rangers since March 1975. The vegetation is lower montane forest, some with *Araucaria*.

(c) Mount Wilhelm. 840 ha of the upper slopes along the track to the summit; on lease, with more under negotiation. Ideally this Park should be extended northwards through the uninhabited forested slopes down to the Ramu river at 330 m. A hut, formerly property of the Australian National University, lies within this Park.

3. Proposed Conservation Areas

The adjacent map from Specht, Roe and Boughton (1974) shows the main vegetation types of Papua New Guinea and areas within which it would be reasonable to attempt to establish a series of conservation areas designed to encompass a representative range of vegetation types, covering both the various forest formations and also in different floristic regions. It should be noted that, because the high mountain spine runs roughly west to east, these areas lie across the 'grain' of the country and so include transects of altitudinal types.
The areas have been chosen to lie in regions of low population. Specht, Roe and Boughton (1974) also briefly summarize existing National Park legislation.



Prime desiderata from a total list of 66 proposed conservation areas of the National Parks Board of Papua New Guinea are:

(a) Talelele islands. Off north New Britain. Mangrove and lowland coastal (plus beach ?) forest.

(b) Lake Dakataua. North end of Willaumez peninsula, New Britain. Lowland evergreen rain forest surrounding the Lake, c. 16,000 ha.

(c) Mount Gallosuelo. North east New Britain, an extinct/dormant volcano north of the Nakanai plateau. This would help conserve the catchment area for a hydro-electric scheme based on Lake Hargy. Lowland (plus lower montane ?) forest, c. 23,000 ha.

(d) Mount Bosavi. South of the southern Highlands, a sparsely populated area with a big altitudinal range (30-2450 m), the western most area in the map above. Lowland to upper montane forests.

(e) Parari/Kikori/Tarima rivers. Papuan gulf. Lowland swamp forests, mangrove forest. A hydro-electric scheme has been proposed for the Pariri river.

4. Extent to which existing and proposed reserves include the different formations

The existing areas, of which only the first two are held freehold, are manifestly inadequate.

Reserves established within the zones shown on the map would probably give adequate minimal conservation to the biota of mainland Papua New Guinea, New Britain and New Ireland. Area(s) on Bougainville should also be considered.

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XV PENINSULAR MALAYSIA

1. Occurrence of the rain forest formations

A vegetation map based on but simplified from that of Wyatt-Smith (1962) is attached. The principal existing and proposed conservation areas and large-scale land development schemes are shown on a second map.

The appendix to Whitmore (1975) lists several papers on forest types in Malaya.

1.1 Lowland evergreen rain forest. This is the principal rain forest formation of dry land in the lowlands. The map gives some indication of regional variation. Since 1962 there have been substantial excisions for comprehensive land development schemes, namely Jengka triangle, Pahang Tenggara and Johore Tenggara. The main remaining substantial area of low flat to gently undulating uninhabited country is just north of Taman Negara (the National Park) in the Ulu Aring and Ulu Lebir. A new road across the Main Range near the Thai border will make accessible for logging the foothill forests, on the east side these still are very little disturbed though on the west in Ulu Perak this is not the case. ECAFE (1974) reported that Peninsular Malaysia would exhaust the lowland timber resource from all remaining accessible lowland forests within a decade.

1.2 Semi-evergreen rain forest. Restricted to the far north west, north Kedah, Langkawi Islands and Perlis. All or nearly all altered to a biotic climax Schima-bamboo forest, described in detail by Symington (1943) and maintained by intermittent cultivation and fire. Certain species indicative of seasonally dry climate occur also in the upper Tembeling basin in Taman Negara, ressumably because this is a dry intermontane basin. Details are given by Whitmore (1975, sect. 10.2). Other seasonally dry areas are known to exist (see maps in Dale 1959, 1960)* notably the area around Jelebu in which the Pasoh I.B.P. rain forest site lies. No floristic or structural/physiognomic indications have been detected correlated with these areas.

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* the map in Gaussen, Legris and Blasco (1967) contradicts those of Dale. The latter are probably to be preferred.

1.3 Heath forest. Heath forest occurs on recent unconsolidated sands down much of the east coast. It has been virtually all degraded to padang i.e. open grassland or savanna. A small area of forest remains at Jambu Bongkok, Trengganu, and another, selectively managed for timber for most of this century at Menchali, south Pahang. On the west coast a tiny area of high heath forest remains at Tanjong Hantu, Dindings, Perak.

Inland tiny fragments of heath forest occur scattered through the country on quartz and quartzite outcrops. The summit of Gunung Panti in Johore bears a swamp over sandstone and is probably to be equated to swampy heath-forest, kerapah, of Sarawak (see section B.1.5 above and Whitmore, 1975, sect. 1.3).

Lesong Forest Reserve in south west Pahang, over sedimentary rock and with from the air a very uniform canopy of trees with rather small crowns, might approach heath forest. Investigations have not been made. This area is within the Pahang Tenggara development scheme.

The Gunung Besar massif on the Johore/Pahang border and coastal hills northwards to south Trengganu have forest with abundance of the fan palm *Livistona saribus* and might be considered a variant of heath forest.

1.4 Forest over limestone. Karst towers are common in Malaya south to Selangor. The map gives some indication of their distribution. Two small limestone outcrops were detected in Johore in the late sixties.

1.5 Forest over ultrabasic rocks. This occurs in the eastern foothills of the Main Range south west of Raub. Tiny pockets remain interspersed with rubber plantations.

1.6 Beach vegetation. This occurs between heath forest and the sea, and on rocky offshore islands. Most has been extensively disturbed or destroyed. A substantial tract still remains apparently more or less intact south of Mersing in east Johore.

1.7 Mangrove forest. The main forests are on the west coast, see the map. This formation has been under intensive silvicultural management for many years.

1.8 Peat swamp forest. Extensive forests occur on both west and each coasts, see the map. These forests which differ somewhat between the two coasts have been described in B, I, 1.11. The west coast peat swamps especially have been progressively logged for many years now.

1.9 Freshwater and seasonal swamp forest. These also are shown on the map. The area in south east Johore has a flora and fauna with many endemics and the flora has Bornean affinities. It is now realized, subsequent to work by Kepong in east Malaya 1965-72, that the Bornean floristic element is not confined to this small pocket, *pace* the line on the map (Whitmore, 1973).

1.10 Lower montane rain forest. This occurs extensively along the Main, Bintang and east coast mountain ranges.

The lower floristic zone is being logged wherever it contains adequately dense stands of big dipterocarps, notably *Shorea platyclados*. The upper floristic zone (oak-laurel forest) is of no current commercial value and has only been substantially destroyed around Cameron Highlands (for firewood) and to a smaller extent at Fraser's Hill, Maxwell's Hill and Genting Highlands.

1.11 Upper montane rain forest. This, likewise, is extensive along the main mountains where it has only been disturbed or destroyed in small patches around the hill stations. It also occurs at lower elevation on isolated mountains, notably Kedah Peak, Mount Ophir and Gunung Belumut. This is not a *Massenerhebung* effect. It is analysed by Whitmore (1975, chaper 16).

2. Existing Areas Affording Effective Protection

Within the present definition discussed in section A, General Considerations, the only existing conservation area is Taman Negara, 1677 square miles (4343 sq. km), as it alone is large and affords complete protection to virgin high forest.

The case for the conservation in perpetuity of Taman Negara was argued in detail in Ho, Soepadmo and Whitmore (1971) and data were brought together on geography, geology, the forests, the fauna and the flora (*loc. cit.* pp. 196-201). Taman Negara covers 4 per cent of the country. It includes lowland evergreen and semi evergreen, lower montane and upper montane rain forest, a few limestone karst towers and some seasonal swamp forest. Amongst dry land habitats it lacks only an area of high elevation granite.

At present dams are bieng constructed on the Sungei Tahan and Sungei Tembeling in the south east. These will cause local damage, make access much easier and alter the character of some of the grandest and most accessible scenery in the Park.

Taman Negara is not an ideal shape for conservation of animals with extensive ranges as it has a narrow waist in the centre which is traversed east to west by the watershed of the north and south flowing rivers. It should either be extended on its northern and south central boundaries, which could be done in compensation for the land which will be lost by flooding when the two dams are completed. Or, alternatively, adjacent land should remain under forest as a buffer zone when (soon) land development approaches from the south and later the north. Such forest could be managed productively provided the requirements of fauna were met.

3. Proposed conservation areas

A graded series of areas of different sizes of conservation area and with different degrees of protection and multiple usage has recently been proposed by the Malayan Nature Society (Anon. 1974). The map from this paper is reproduced here and some of the principal areas are also drawn on to the 1962 vegetation map which is appended. Several of the proposed areas approach the present terms of reference or are necessary to complete a network of reserves in Peninsular Malaysia and are therefore mentioned here.

Reference must also be made to the chain of reserves proposed to conserve the fauna made by Stevens (1968).

Endau-Rompin Proposed National Park. This spans the Johore/Pahang border. Its area approaches that of Taman Negara. It lies centred on the Gunung Besar massif which contains a substantial area of flattish upland on sedimentary rocks and bearing a poorly-stocked forest approaching heath forest in composition. The northern part is within the Pahang Tenggara development area. The southern part lies within the huge Endau Wildlife Reserve in Johore.

Logging has penetrated this proposed Park from several directions, and much of the valuable timber has already been removed, destroying thereby much or most of the species-rich and very grand lowland dipterocarp forest. The upper ends of the valleys which penetrate from the north and west contain(ed) at low elevation red meranti-keruing forest which is probably the richest (and commercially valuable) floristic type. All efforts should be made to include part of this type within the Park after it has been precisely located. There is a region to the Park's south floristically uniquely rich in Calophyllum (if any has survived logging), a sample should be included in the Park.

This proposed Park contains much forest approaching heath forest in composition (and therefore of little timber interest and on land of low potential for agriculture), and possibly runs into freshwater and/or peat swamp forest at its eastern edge. These swamp formations certainly should be included within the Park.

Sungkai Wildlife Reserve. (Perak; 24 sq. km). This and the following Wildlife Reserves are forseen by the Malayan Nature Society to be compatible with multiple land use.

This area contains lowland evergreen rain forest.

Krau Game Reserve. (W. Pahang, c. 520 sq. km). A large and important area, still largely (entirely ?) under virgin evergreen rain forest with Gunung Benom in the north which rises to over 1500 m and has a fine sweep of lower and upper montane rain forest (described by Whitmore 1972) and Kuala Lompat Game Ranger station in the south east, centre of detailed studies in primate ecology since 1968 (Chivers, Hunt and associates).

The fauna on G. Benom was studied on a 1967 British Museum (Natural History) expedition. For further details see Whitmore (1975, sect. 16.7), Stevens (1968) gives additional data on fauna.

This reserve complements Taman Negara in that G. Benom is a granite mountain and high level granite is the major habitat type missing from the Taman Negara.

Gunung Belumut Wildlife Reserve. (North Johore; c. 230 sq. km). Gunung Belumut, c. 990 m, is an isolated mountain showing upper montane forest at unusually low elevation and contiguous with lowland rain forest (for details see Whitmore 1975, chap. 16). It lies within the Endau-Kota Tinggi (West) Game Reserve. Stevens (1968) proposed the steep, shallow-soiled upper slopes plus upper part of the valley to the east as a wildlife reserve to act as a refuge for animals from the lowlands as these are converted to agriculture. Belumut lies on the east boundary of the northern part of the Johore Tenggara land development area.

Sungei Nenggiri Wildlife Reserve. (Kelantan; 370 sq. km). This area contains karst limestone set in lowland evergreen rain forests on both granite and sedimentary rocks.

Grik Wildlife Reserve. (Ulu Perak; 520 sq. km). Poor quality lowland evergreen rain forest or possibly partly semi-evergreen rain forest. There are many salt licks and much game. Land development schemes are proposed in this region.

Belum Wildlife Reserve. (Ulu Perak, Thai border; 2150 sq. km). A currently inaccessible area now uninhabited (except by terrorists and troops) of lowland evergreen and/or semi-evergreen rain forest. The area is near the lake which will be formed on completion of the Temengor dam on the Sungei Perak and to the new east west highway. It is very rich in game. The forest is mostly of poor quality and is in part secondary.

Ulu Muda Wildlife Reserve. (Kedah; 1150 sq. km). Catchment area for a big irrigation scheme, west slopes Bintang range, disturbed evergreen/semi-evergreen rain forest, hill facies. An area with much game.

Telok Peat Swamp Virgin Jungle Reserve (Selangor). An area of a few square kilometres of west coast peat swamp forest, now surrounded by plantations, with peat too deep to warrant clearance. The area is important for teaching, is the type locality for several plant species and far more accessible than any other remaining high peat swamp forest.

Pulau Tioman (east of Pahang). A small mountainous island with virgin forest inland from the cultivated coastal plain.

Gunung Panti (south Johore). Unique with kerapah forest on the summit and an extremely rich highly endemic flora on the evergreen rain forested slopes, now largely logged. Also important as a tourist centre. To the east lies seasonal swamp forest, (see below).

Finally, special mention must be made of the tiny patch of virgin forest surrounded by logged forest at Sungei Menyala (Negri Sembilan) where observation plots of inestimable global value have been maintained since 1947/49, and the other similar plot at Bukit Lagong (Kepong, Selangor).

4. Extent to which existing and proposed reserves include the different forest formations

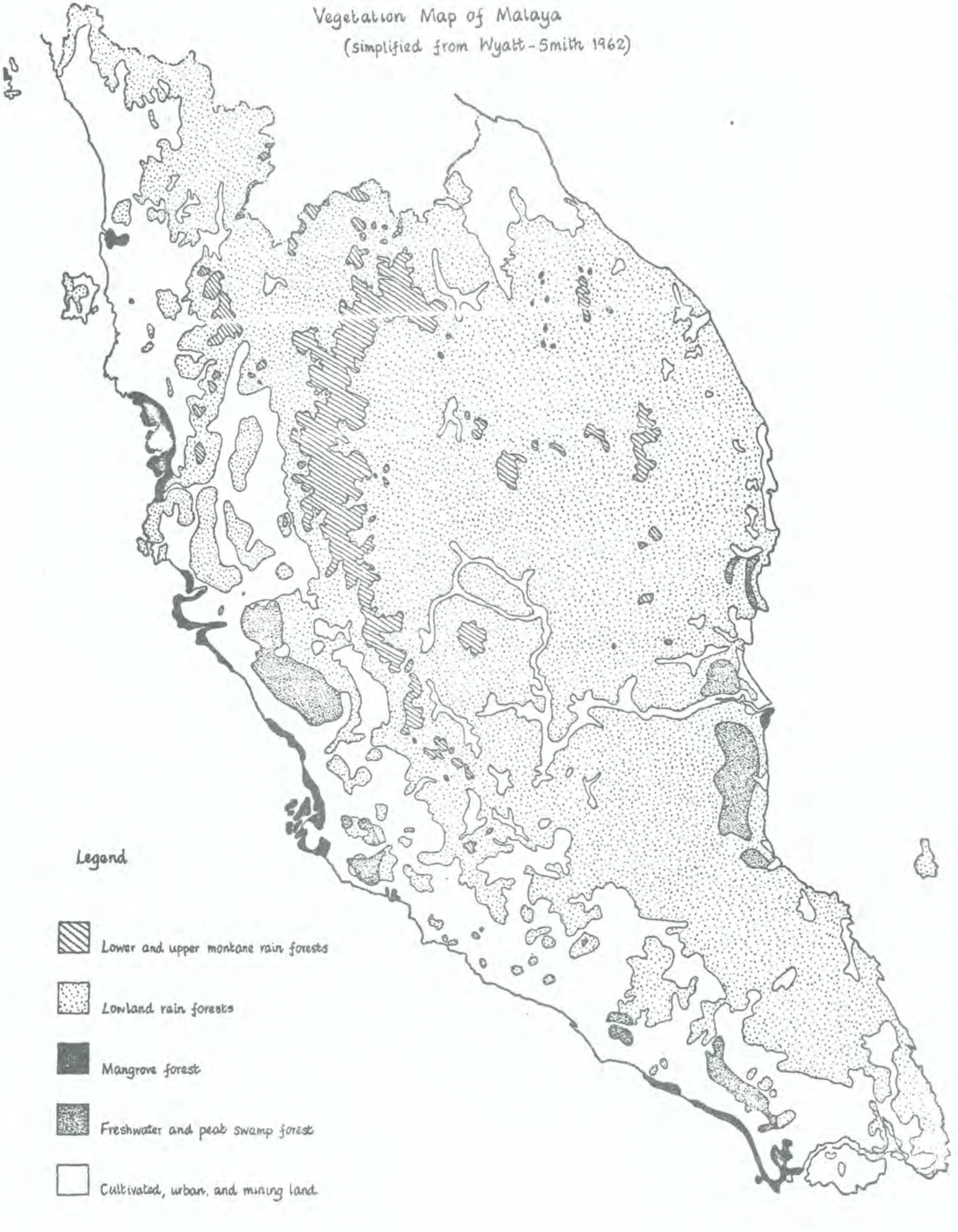
Lowland evergreen and semi-evergreen rain forest. The chain of reserves in (3) above cover the country and more or less encompass the range of floristic variation. Consideration is needed of the extent to which multiple use in the proposed Wildlife Reserves is compatible with vegetation/flora.

Lower montane forest. Not under severe pressure except where there are stands of upper dipterocarp forest (sensu Symington 1943, see Whitmore 1975, chap. 16). The existing proposed and existing reserves protect this.

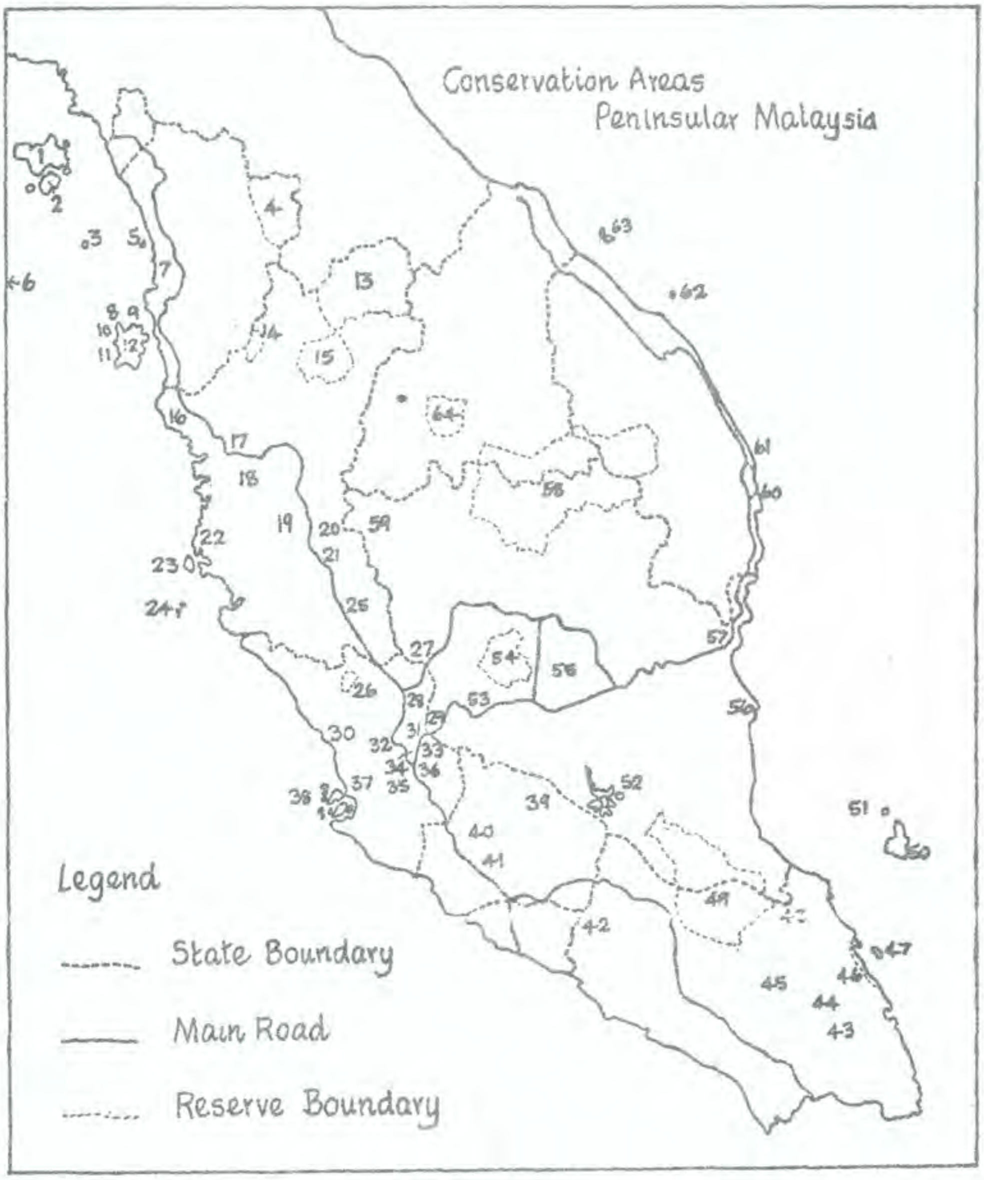
Upper montane forest. Represented in reserves but not under threat except possibly the low elevation occurrence on G. Belumut which would however come within the proposed wildlife reserve.

Heath forest. This has nearly all been seriously disturbed or destroyed. The three remaining small coastal patches (Tanjong Hantu, Jambu Bongkok and Menchali) are all in forest reserves. The quart/quartzite ridges are partly in forest reserves; those near population centres are under recreation pressure. Gunung Panti is too disturbed to be classed as a reserve within the present terms of reference but its unique plateau kerapah forest and unique flora plus its tourist importance demand that it should remain forested.

Vegetation Map of Malaya
(simplified from Wyatt-Smith 1962)




Conservation Review:
Peninsular Malaysia
6
5
4
Taman Negara
2
A
B
1
3
C
D
Major Proposed Conservation Areas
1 Endau/Rompin National Park
2 Krau Game Reserve
3 Belumut
4 Sungai Nenggiri
5 Belum
6 Ulu Muda
Land Development Areas
A Jengka Triangle
B Pahang Tenggara
C
D
Johore Tenggara



1. Pulau Langkawi
2. Pulau Dayang Bunting
3. Pulau Lembu, P. Kacha, P. Paya, P. Segantang
4. Ulu Muda
5. Pulau Bunting
6. Pulau Perak
7. G. Jerai (Kedah Peak)
8. Muka Head
9. Batu Feringgi
10. Pantai Acheh
11. Penang Mangroves
12. Penang Hill
13. Belum
14. Ulu Selama
15. Grik
16. Kuala Gula
17. Maxwell's Hill
18. G. Bubu
19. Batu Gajah
20. G. Gajah & G. Tempurong
21. G. Bujang Melaka
22. Segari
23. Pulau Pangkor
24. Pulau Rumbia, P. Lalang P. Buloh
25. Sungkai
26. Sungei Dusun
27. Frasers Hill
28. Bukit Kuta
29. G. Ulu Kali
30. Kuala Selangor
31. Ulu Gombak
32. Templer Park
33. Klang Gates
34. Batu Caves
35. Bukit Lanjan
36. Bukit Nanas (Weld Hill)
37. Meru
38. Pulau Ketam
39. Pasoh
40. G. Berembun
41. G. Angsi
42. G. Ledang
43. G. Panti
44. Ulu Sedeli & G. Semalayang
45. G. Belumut
46. Mersing Coast
47. P. Sibu
48. Sg. Emas
49. Endau-Rompin N.P.
50. P. Tioman
51. P. Tulai
52. Tasek Bera
53. Karak
54. Krau
55. G. Senyum
56. Pahang Tua
57. Beserah
58. Taman Negara
59. Cameron Highlands
60. Bt. Bauk
61. Dungun
62. P. Bidong Laut
63. Perhentian
64. Nenggiri

Forest over limestone. The Sungei Nenggiri reserve plus others listed in Anon. (1974) will conserve adequate karst limestone, which is not under pressure (except Batu Caves and Bukit Takun near Kuala Lumpur) and falls below our reference size of reserve.

Forest over ultrabasics.

Beach vegetation. The east Johore coast has been considered for recreation *cum* nature reserve in development plans for Johore Tenggara but falls outside present terms of reference.

Mangrove forest. All substantial tracts are under silvicultural management.

Peat swamp forest. Telok is an important reserve though too small to be viable or adequate in the long term. The west coast forests are probably all being logged. Part of the east coast area south of Pekan with low timber content is being considered as a reserve within the Pahang Tenggara land development scheme. See also proposal above at Endau/Rompin National Park.

Freshwater swamp forest. See proposal above at Endau/Rompin National Park. East of G. Panti seasonal swamp forest of low stature and timber content and now largely/entirely logged has an extremely rich flora with many endemic species.

5. Matters for Urgent Action Summarized

(a) The possibilities of compensatory extension at Taman Negara and constituting of a managed-forest buffer need urgent investigation.

(b) The valleys which penetrate the Endau/Rompin proposed National Park should be included and therefore not be logged.

(c) Much of the Krau Game Reserve should probably be retained under virgin forest.

(d) Sungei Menyala virgin jungle reserve needs securing from continuous agricultural threat.

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XVI PHILIPPINES

1. Occurrence of the rain forest formations

Three factors make it difficult to make any precise statement on the occurrence today of rain forests in the Philippines.

(1) A belt of seasonally dry climates runs down the western side of the Philippine archipelago. This is approximately shown on the map of Schmidt and Ferguson climatic types (see section B.2.1) on which clear areas are type A, perhumid, hatched are type B and shaded are type C/D, of progressively more marked dry season.

(2) The Philippines have been the main source of log exports from the whole of Malesia for most years since the Second World War.

(3) The Philippines have a population of c. 50 million which is increasing by 3.7 per cent a year.

It appears that no map or comprehensive account of different vegetation types in the Philippines has ever been prepared of sufficient detail for the purposes of the present report. The six sheet Soil Cover Map at a scale of 1: 10^6 dated 1964 (Domain Use Division, Bureau of Forestry, Manila) recognises only five vegetation types, commercial forest, non commercial forest and brushland, cultivated land, cogon (Imperata) and open land, and marsh or swamp. Moreover, the extent of commercial forest has substantially decreased since this map was prepared.

The seasonally dry climates of the western side of the archipelago once supported monsoon forests, now substantially altered and largely degraded by fire, cultivation and grazing to savanna or grassland. Monsoon forests are outside the scope of the present survey. Between them and the lowland evergreen rain forests of the east coast once must have lain a belt of lowland semi-evergreen rain forest, but apparently it has never been identified or mapped. Montane forest formations of perhumid and slightly seasonal climates must also occur, variously disturbed, their distribution affected by local rain shadow effects as well as regional climate.

(a) The lowland evergreen and semi-evergreen rain forests are rich in dipterocarps and in stature are amongst the tallest tropical rain forests in the world. See Whitmore (1975) for further details. Except on Palawan they are subject to intermittent damage by cyclones, more frequently in the northern islands. This is likely to have had a profound effect on structure and species composition, which has not been fully elucidated. Whitmore (1975) discusses the evidence. These dipterocarp forests have now been substantially eliminated by logging followed by settlement, sometimes illegally, by landless peasants (kaingeneros).

The rain forests of the Philippines thus now cover a much smaller area than formerly, and are still being rapidly felled and eliminated. Logs have been one of the major exports of the country, but, with effect from 1975 and in an attempt to reduce the rate of felling by increasing the percentage utilisation and to increase the value of the exports, only processed timber (sawn lumber, veneer, plywood) can be exported.

(b) Freshwater and peat swamp forests are absent, according to the UNESCO (1958) Vegetation Map.

(c) Mangrove forest is of limited extent.

(d) Karst and massive limestone occurs, and will be mentioned further below.

(e) The author has seen ultrabasic outcrops supporting a low, uniform canopy, small-crown forest on Palawan south of Puerto Princessa and Agathis growing in 'normal' lowland rain forest on ultrabasics near the border of Davao City and Bukidnon provinces in Mindanao.

(f) Lower and upper montane rain forest is widespread. Some areas will be mentioned further below. In addition there is probably a substantial tract along the high Sierra Madre mountains which run along the east coast of Luzon north from a little south of the latitude of Manila.

(g) Subalpine forest probably occurs on a few very high peaks.

2. Existing Areas Affording Effective Protection

In 1974 the UNDP/FAO project in north Luzon on Training in Multiple-Use Forest Management appointed for three months an expert wildlife consultant Major I.R. Grimwood, formerly Head of the Game Department, Kenya. Grimwood was able to make a general survey of the national parks, to visit several of the more important ones and to review the status of wildlife conservation in the Philippines. The following account is largely based on his report (Grimwood 1975). Grimwood emphasised that his comments and conclusions can only be regarded as tentative in the extreme because he was only able to visit a few parks and had difficulty obtaining information about others.

There are some 66 national parks in the Philippines, more than exist in any other country of similar size. The definition, however, is different from that internationally accepted, as a considerable number are recreation areas or are designed to protect historical sites or monuments. Many are relatively small. Few meet the criteria for inclusion in the U.N. List.

The national parks face several serious problems: their boundaries are not marked, so entry is unrestricted and hunting and forest-produce collecting not controlled. This creates a wrong impression amongst the public at large. Shifting cultivators have moved into most parks, though sometimes only peripherally. Some Government departments appear ignorant of what a national park really is as townships (barrios) have been formally declared within several and timber leases have been granted in others. The field staff are few in number and have little training.

In 1972 the independent Parks and Wildlife Office was merged into the forest department as one of seven devisions of what is now the Bureau of Forest Development. Field officers of the Office are now subordinated to and under the orders of their respective District Forest Officers. The head of the Parks and Wildlife Division has no executive control but may merely be called on for advice. Grimwood makes a series of recommendations to improve the situation.

A few large parks and some smaller ones were created to conserve wilderness areas and the former are considered in detail by Grimwood and here. Their location is shown on the accompanying map.

Luzon

(a) Mt. Arayat National Park (Grimwood 1975, p. 29). 3700 ha. A volcanic cone 450-600 m high, forested except on its lower slopes, arising abruptly from the heavily settled rice plain of central Luzon. Arayat lies in a seasonally dry climate zone, but probably itself has a higher and better distributed rainfall than the plain. A small mountain such as this either carries lowland rain forest to its summit or has a cap of upper montane rain forest whose lower edge is determined by the level of prevalent cloud (see Whitmore 1975 chap. 16).

(b) Quezon National Park (Grimwood 1975, p. 29). 980 ha. Virgin lowland dipterocarp forest at 120-240 m, possibly of the semi-evergreen, not the evergreen formation judging from the Schmidt and Ferguson climate map. The Park also includes a 'spectacular limestone ridge' reaching 390 m which presumably has a distinctive forest type and flora. It is bisected by a road.

(c) Aurora Memorial National Park (Grimwood 1975, p. 30). 3,000 ha, 60 km long and up to 3 km wide, covering the crest and flanks of an east west running range of hills, traversed from end to end by a road. The forests are virgin and clothe the steep slopes from 600 m down to c. 100 m on both sides. The forests to the south have been damaged, but to the north are still more or less virgin as far as the horizon. On both flanks, however, timber concessions have been granted up to the Park boundary. Wildlife is plentiful. The District Forest Officer in charge has recently put forward a proposal for selective logging to 60 m from the road for 'stand improvement'. Grimwood strongly advocates strengthening and enlarging this Park. It lies near the east coast and probably carries lowland evergreen dipterocarp rain forest showing influence of cyclone damage.

(d) Mt. Mayon National Park (Grimwood 1975, p. 31). 5,500 ha. Upper slopes of the 2,400 m Mayon volcano, which is active and last erupted in 1968. The lower slopes are settled and the forests have been logged to the commercial limit, 600-750 m. The undemarcated park boundary lies above the settlements and includes all the forest. Above the commercial (lowland evergreen dipterocarp) zone up to 1,200 m is a belt of mossy upper montane rain forest (see Whitmore 1975, chap. 16 and Mt. Arayat above), and above that tall talahib grass as far as the steep, bare cinder cone at 2,000 m. The rainfall is very high. This Park has both scenic and scientific value.

Mindoro

This island has a strongly seasonal climate and carries monsoon forest, now largely degraded to savanna. In 1970 the Mt. Iglit-Mt. Baco

National Park of 120,000 ha and also two Game Reserves of 44,500 ha and 15,000 ha were created to save from extinction the endemic Tamaraw (Anoa mindorensis). Monsoon forest conservation is beyond the scope of the present survey.

Mindanao

(e) Mt. Apo National Park (Grimwood 1975, p. 33). 73,000 ha, covering what is left of the forests of the volcanic Mt. Apo massif, 2953 m tallest in the nation. The forests have been destroyed up to 750-900 m. Mindanao has a very tall kind of lowland dipterocarp forest, and is only infrequently struck by cyclones. The flora is rich in species. The climate is perhumid. Lowland evergreen, lower montane and upper montane rain forest must all be well represented. Subalpine rain forest probably occurs too. There are several endemic animals and it is a centre of concentration of the endangered Monkey Eating Eagle, whose long term survival depends on the continuing existence of a large tract of rain forest. A proposal has recently been made and endorsed by the Directorate of the Bureau of Forest Development to reduce to 13,000 ha the National Park and release the rest for logging and settlement. There are already an estimated 30,000 illegal settlers within the Park and a township. Fortunately these are believed to be mainly in the periphery. Grimwood makes detailed proposals for restructuring the Park.

Panay

(f) Bulabog-Putian National Park (Grimwood 1975, p. 34). 900 ha, 40 km north of Iloilo City and a popular resort. A forest-covered limestone hill rising to about a hundred metres above an intensively cultivated plain. There is an edible birds' nest cave near the summit and a phosphate mining concession has been granted.

Palawan

This island lies on the Sunda Shelf, and differs in flora and fauna from the rest of the Philippines. The whole island is a game reserve. Population density is lower than elsewhere and great tracts of lowland rain forest remain, though all or most have been let out on logging concessions and several are being felled. Shorea is absent. Dipterocarpus (apitong) is the commonest big tree. The climate is wholly seasonally dry (the Schmidt and Ferguson map reproduced here is now known to be incorrect) and the lowland forest probably belongs to the semi-evergreen rain forest formation, with upper montane rain forest on the highest peaks (1,500-2,000 m), probably with a belt of lower montane rain forest between, on at least the bigger mountains.

(g) St. Paul Underground River National Park (Grimwood 1975, p. 34). 3,000 ha on the west coast, including spectacularly eroded limestone rising to 1,410 m at Mt. St. Paul. The sea frontage to the west is stony hillsides carrying low scrub. There are small patches of lowland dipterocarp forest where three beaches lie between these hills and the sea. There is an extensive area of lowland dipterocarp forest contiguous to the Park to its north, believed to be under license though logging has not yet started. Almost all the large animals of Palawan are reported to occur in this locality. This Park has outstanding potential as a tourist and conservation area but extension to the north is essential.

3. Proposed Conservation Areas

Luzon

(a) An area of upper (and lower ?) montane rain forest in north central Luzon has been proposed for conservation to replace the Mt. Data National Park, whose forests have been destroyed by settlers. This would also conserve several little-known endemic rodents. It would encompass Mts. Pulog, Panatoan and Tulog. It is discussed by Grimwood (1975, p. 21), following a suggestion by Dr. M. Jacobs, Leiden, Mt. Pulog (2880 m) is the highest peak in Luzon. The uppermost slopes may carry subalpine forest.

(b) Grimwood (1975, p. 26) also recommends the conservation of the watershed forests of the Pampanga river basin and reports that quite extensive natural dipterocarp forests remain on its eastern side.

(c) Consideration would be given to conservation of part of the Sierra Madre mountains. Jacobs and Mendoza (1968) gave some details of access and extent of logging.

4. Adequacy of existing and proposed areas

The areas discussed in (3) and (4) would give skeletal coverage to the main rain forest formations, except that apparently no ultrabasic areas are included. The network is probably inadequate to conserve the genetic diversity of all plant species, including for example the important tree Agathis, though this is nominally afforded protection by a ban on felling. The network would give minimal conservation of rain forest fauna.

5. Matters for urgent action summarized

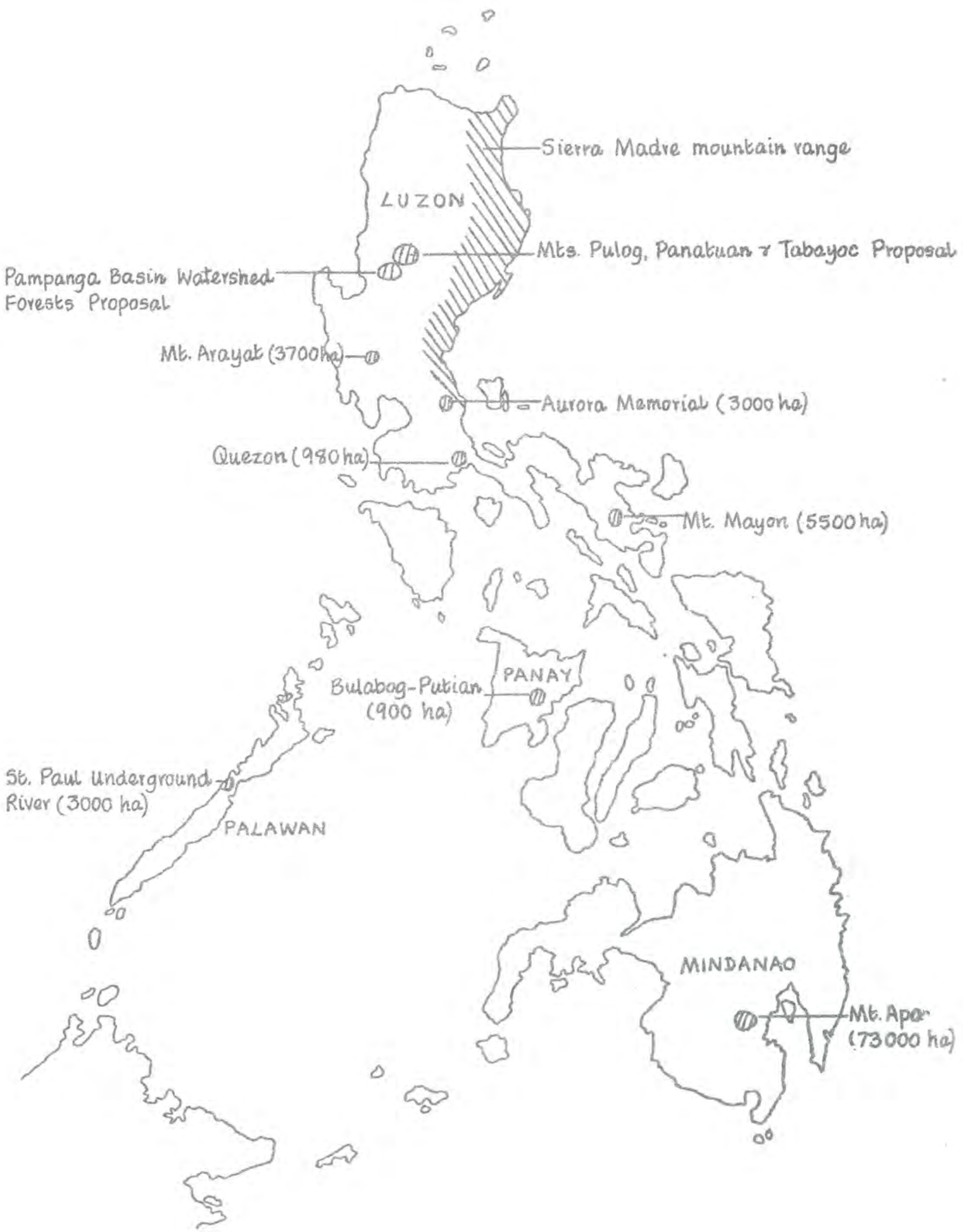
(a) The subordination of all park and wildlife affairs to forestry is very unsatisfactory.

(b) All the areas listed in (2) need to be demarcated and policed.

(c) Extension of Aurora National Park and rescinding of licences to log are urgently required.

(d) Mt. Apo National Park is of vital importance as the flora, vegetation and fauna reserve for the important biota of Mindanao. The

THE PHILIPPINES



proposal to reduce it to 20 percent of its present area needs investigation and then argued confutation.

(e) The extent of the licence to mine phosphate in Bulabog-Putian National Park needs study then possibly reduction.

(f) The St. Paul Underground River National Park Palawan needs extending into the commercial forests, under logging licence, to its north.

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XVII SABAH

1. Occurrence of the rain forest formations

No vegetation map has been published and only fragmentary accounts of the different formations. Of these Fox (1972) is the longest.

1.1 Tropical lowland evergreen rain forest. The only big remaining tracts are on the east coast where a very tall, species-rich dipterocarp forest is being rapidly logged. This is perhaps the grandest lowland evergreen rain forest in the world, in terms of stature, though slightly less rich in species than similar forests in Malaya and Sumatra and with dipterocarps more predominant amongst the big trees. The dipterocarp forests of southern Philippines, now largely disappeared, are the most closely comparable. State policy was formerly to manage these forests on a 70 year rotation to produce a sustained yield mainly on a few big long-term timber concessions. Recently the policy has changed and now the forests are being rapidly felled to produce maximum immediate revenue. Government through the

Foundation now plays an important role in the logging industry. The west coast forests have been largely logged or replaced by shifting cultivation.

Floristic types have been described by Fox (1972); and Menritt (1967) is the results of forest inventory, classification and mapping undertaken by Canadian consultants.

1.2 Tropical semi-evergreen rain forest. The occurrence of this formation in Sabah has not been demonstrated. The Schmidt and Ferguson climatic map (see section B.2.1) shows areas of mildly seasonally dry climate, on the east coast logging is often undertaken in a dust cloud (rarely so in Malaya), and the Sook plain is believed to be a disclimax grassland originating from a catastrophic fire in 1914 (Cockburn 1974).

1.3 Heath forest. This occurs coastally and inland. Inland it is frequent as part of a catena of vegetation associated with the interlying sandstones and shales of the Belait geological formation and occurs on sandstone plateaux.

1.4 Limestone. There are a few karst hills, some with caves inhabited by the swiftlets which produce edible birds nests.

1.5 Ultrabasics. These are widespread at low elevations and also occur at high elevations (Kinabalu). Forest structure and floristics are diverse, varying from distinctive to being very similar to lowland evergreen rain forest. Several dipterocarps are recorded as restricted to lowland ultrabasics in Sabah and are found on quite different rocks in Sarawak (see Whitmore 1975).

1.6 Beach vegetation. It is extensive on the mainland and offshore islands. The degree to which it remains pristine or nearly so has not been ascertained.

1.7 Mangrove forest. Widespread, see UNESCO map (B, 2.2 above). Currently being exploited for chips in Sandakan bay and around Tawau. If felling controls are observed, to leave unlogged forest along channels plus mother trees, this intensive utilization is probably sustainable. If excessive felling occurs there is the danger of eliminating seed sources and therefore delaying regrowth or of the regeneration of non-commercial mangrove species.

1.8 Freshwater and seasonal swamp forest. Widespread but not in extensive stands. Fox (1972) gives some details.

1.9 Peat swamp forest. It is of limited occurrence, mainly in the south west near Brunei where it has been largely logged, and also as small, valley peat swamps on the east coast.

1.10 Montane forests. Lower montane and upper montane forest are widespread on Trus Madi, the Crocker Range and Mount Kinabalu. Kinabalu also has subalpine forest. The flora of this mountain is very rich indeed with many endemics as well as microtherms of both north and south hemisphere affinity and also has a rich representation of different forest types on different rocks and sites. Corner (1964) contains a selection of papers on aspects of the biology of Kinabalu, see also Ho and Poore (1966) and, for a succinct description of vegetation and flora, Meijer (1971).

2. Existing areas affording effective protection

(a) Kinabalu National Park was created in 1964 as an area of 690 square kilometres centred on and surrounding Mount Kinabalu (4104 m), highest mountain between the Himalaya and New Guinea. Since then 26 sq. km have been excised on the eastern flanks for the Mamut copper mine, compensated by the new Mount Templer extension of 93 sq. km on the northern side. 90 percent of this Park lies above 900 m elevation. The boundary is at 150 m on the north and 1350 m on the south but dropping to 510 m in the south east near Ranau. All montane forest types are included, and some hilly lowland evergreen rain forest in the north which includes banteng (*Bos javanicus*) and orang utan, but because the mountain dominates the Park it is considered to be inadequate as a conservation area for lowland animals. It is estimated that the Mamut copper deposit will last for 25 years; no more copper has yet been found. Both low and high elevation ultrabasic rocks and forests occur within the Park.

(b) Pulau Gaya, Tungku Abdul Rahman National Park is an island of 3596 ha, offshore from the capital Kota Kinabalu. Created in 1974. Contains beach forest and coastal associations of lowland evergreen rain forest in a near-pristine state. The flora has an interesting Philippine element.

(c) Kabili-Sepilok forest reserve. 4050 ha, close to Sandakan, adjacent to the new forest research centre. This forest has mostly been logged in the past. It contains seasonal swamp forest and the catena of heath forest and floristic associations of evergreen (? semi-evergreen) rain forest associated with the Belait geological formation. It is an important centre of continuing forest ecological and silvicultural research, summarized by Fox (1973) and contains an orang utan rehabilitation centre.

3. Proposed Conservation Areas

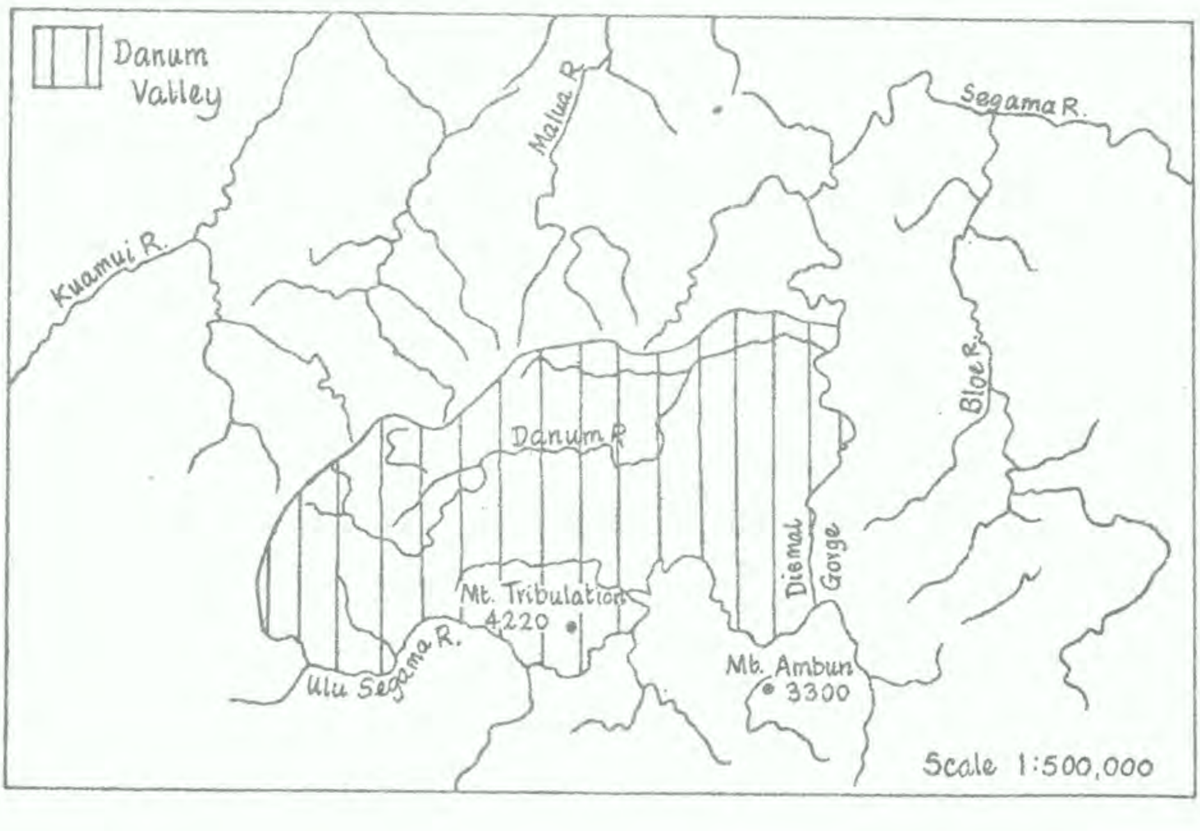
The three existing areas do not adequately cover the forests of Sabah. A very comprehensive series of proposed conservation areas has been prepared by the National Parks Board and is now being considered by government. These areas can be divided into two groups.

Group A. These areas meet the criteria of being large, together they constitute a minimal network.

(a) Danum Valley. The Danum is a tributary of the Segama. This is a little known area of 61,659 ha enclosed by high country. It lies in the very important and very species-rich east coast lowland evergreen rain forest type and includes mountain forests on the slopes of Mount Tribulation. It is centred on 117°60'E, 5°W, is very inaccessible, and is in the heart of the Ulu Segama forest reserve, surrounded by land which is unsuitable for agriculture and therefore likely to remain permanently under forest.

The Ulu Segama forests contain a concentration of orang utan (MacKinnon 1971). Sumatran rhinoceros are believed to occur. There is a wealth of other animal life. Ulu Segama forest is currently being logged. Most of the area is licensed to the Sabah Foundation for logging. The proposed reserve is considered a minimal area for orang utan conservation.

The main Segama River catchment area, showing the position of the Danum Valley.



(b) Klias Peninsula. An area of 350 sq. km in the south west of Sabah, bordering Brunei Bay, deltas of the Padas and Klias rivers. Two separate blocks have been identified as potential conservation areas, the Klias sector, 36,000 ha, to the north of Brunei Bay and the Merintaman Menggalong sector, 3,500 ha, east of the Bay. The former is mainly mangrove forest including big areas of Nypa. Inland it merges through disturbed brackish water swamp forest to large open grassy padangs maintained by buffalo grazing. The latter is more varied, it contains a ridge reaching 117 m elevation, and includes peat swamp forest (similar to the anomalous Lawas peat swamp forest of adjacent Sarawak, see Whitmore 1975, chap. 11.3) which is otherwise virtually absent from Sabah, heath forest and lowland evergreen rain forest (now very sparse on the west coast) as well as mangrove forest. World Wildlife Fund, Malaysia, recently sponsored a 10 day survey (Wells, Marshall and Lowry 1975), which saw 7 mammals, 108 birds and 2 reptiles in 10 days. The mangrove forests are important for fish and their spawn.

Group B. These proposed areas complete a network of reserves for Sabah:

West coast

(c) Crocker Range forest reserve, water catchment area for the west coast, much shifting cultivation, many animals eliminated by hunting. Lowland evergreen and montane forest formations (rising to 1500 m).

(d) The Padas Gorge cuts the Crocker Range and is highly scenic. Banteng have been reported.

The Department of Agriculture Land Capability Classification project have identified several areas suitable for recreation, amenity and conservation on the east coast. Those of possible forest conservation potential are as follows:

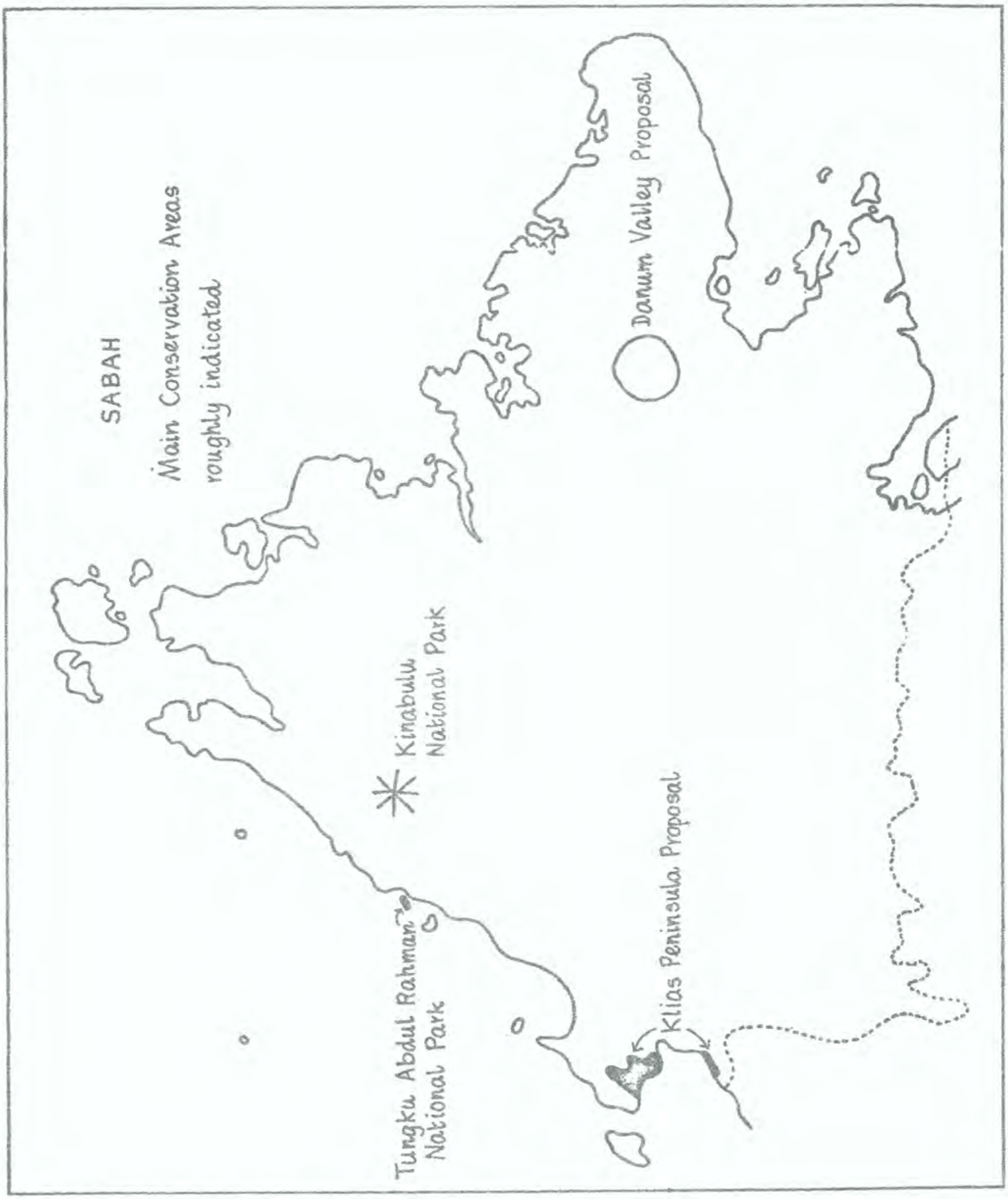
Sandakan Residency

(e) Meliau range, rising to 1,335 m.
(f) Mount Trus Madi eastern slopes, rising to 2,653 m.
(g) Mount Tawai, an igneous plateau rising to 1,340 m.
(h) Maliau basin; Belait geological formation, reaching 1,524 m.
(i) Gomanton karst limestone hill.
(j) Berhala island at mouth of Sandakan harbour.
(k) Turtle Islands off the east coast (owned by Government).

Tawau Residency

(l) Mount Silam. An ultrabasic hill of 870 m near Lahad Datu, with compressed zonation of elevational forest types.

(m) In addition near Tawau parts of the Tawau Hills and Ulu Kelumpang forests have been suggested.


SABAH
Main Conservation Areas
roughly indicated
Danum Valley Proposal
Kinabulu
National Park
Tungku Abdul Rahman
National Park
Klias Peninsula Proposal

5. Matters for Urgent Action Summarized

The Group A areas (Danum valley and Klias Peninsula) in section (4) need urgent investigation. In the latter quarrying of low grade limestone is being done, and suggestions have been made to establish a wood chip factory on Labuan island to exploit Brunei Bay mangrove forests.

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XVIII SARAWAK

1. Occurrence of the rain forest formations

An outline map (modified from Forest Distribution and Licensing Map, Forest Industries Development Project 1974) is attached.

1.1 Tropical lowland evergreen rain forest. This occurs throughout the interior. Topography is very rugged, though hills are low. There has been extensive destruction by shifting cultivation, along the rivers (see map). There is only one working logging concession, near Kapit, Rejang, but the UNDP/FAO Forest Industries Development Project has identified eight large areas (units) within which it is hoped to stimulate rational high intensity utilisation, and there are several other big areas under licence.

1.2 Lower and upper montane rain forest. It is mainly restricted to the eastern boundary where it runs due north-south.

1.3 Heath forest. As in Brunei this occurs inland on sandstones in small patches in a catenary sequence with lowland rain forest which lies on the interbedded shales. There are also inland areas (e.g. Usun Apau plateau) on siliceous igneous rocks. Coastal heath forest occurs in the south west.

1.4 Forest on limestone. Karst limestone occurs at low elevations south of Kuching and at Niah and at high elevations around Gunung Mulu.

1.5 Mangrove forest. This is found mainly round Kuching and in the Rejang delta, see the map.

1.6 Peat swamp forest. This is very extensive, see the map. It consists of domed peat bogs with a sequence of up to six forest types in most of which Shorea albida is an important component. The ecology has been very thoroughly investigated by Dr. J.A.R. Anderson. Whitmore (1975, chap. 11) gives a summary of his findings and references to his publications. Peat swamp forest is the main current source of lumber. The single most valuable species is Gonystylus bancanus, ramin. There are still several silvicultural problems which hinder work on growing a new crop. There will be others if it is decided to fell forest for wood chip production.

1.7 Beach vegetation. This is scanty because most of the coastline is swamp (see the map).

2. Existing areas affording effective protection

2.1 Bako National Park. 2712 sq. km, created 1957. A rocky headland on the coast north of Kuching. Mainly heath forest partly degraded but also with small areas of evergreen rain forest, freshwater swamp forest, riverine peat swamp forest, beach vegetation and mangrove. Ashton (1971) gives a good summary description.

2.2 Niah National Park. 31.3 sq. km, created November 1974, mainly because of the important archaeological sites in caves in karst limestone. This karst tower complex is surrounded by freshwater/peat (?) swamp forest. The World Wildlife Fund proposes to 'promote protection' as part of its tropical rain forest conservation programme (Wildlife 1975, 371).

2.3 Lambir Hills. 69.4 sq. km, 4th Division. Mixed dipterocarp lowland rain forest.

3. Proposed Conservation Areas

Government has under consideration the following National Parks:

(a) nearly constituted:

3.1 Gunung Mulu. 528.4 sq. km, 4th/5th Divisions centred on 4°10'N; 114°50'E. Creation of this important large Park awaits final ratification of the necessary legislation by the Federal government in Kuala Lumpur. This area includes all the major vegetation types of Sarawak including high elevation limestone (1650 m). The altitudinal range is 60-2340 m.

(b) being constituted:

3.2 Pelagus Rapids. 20.7 sq. km, 7th Division. Adjacent to these the biggest rapids on the Batang Rejang. Lowland rain forest and inland heath forest including its swamp facies known locally as kerapah (Baillie 1970). There has been much illegal intrusion recently. The flora, along the rapids is of great interest, especially for *Didesmandra* and gesneriads.

3.3 Matang. 225 sq. km, 1st Division. This is a mountain dominating the Kuching skyline and is locus classicus of several plant species because Beccari worked there for a period. It is a water catchment and declaration of a Park involves negotiations with the P.W.D. Lowland rain forest and lower montane forests are included.

3.4 Loagan Bunut. 51.8 sq. km, 4th Division. This covers the whole catena of peat swamp forest, types and a lake.

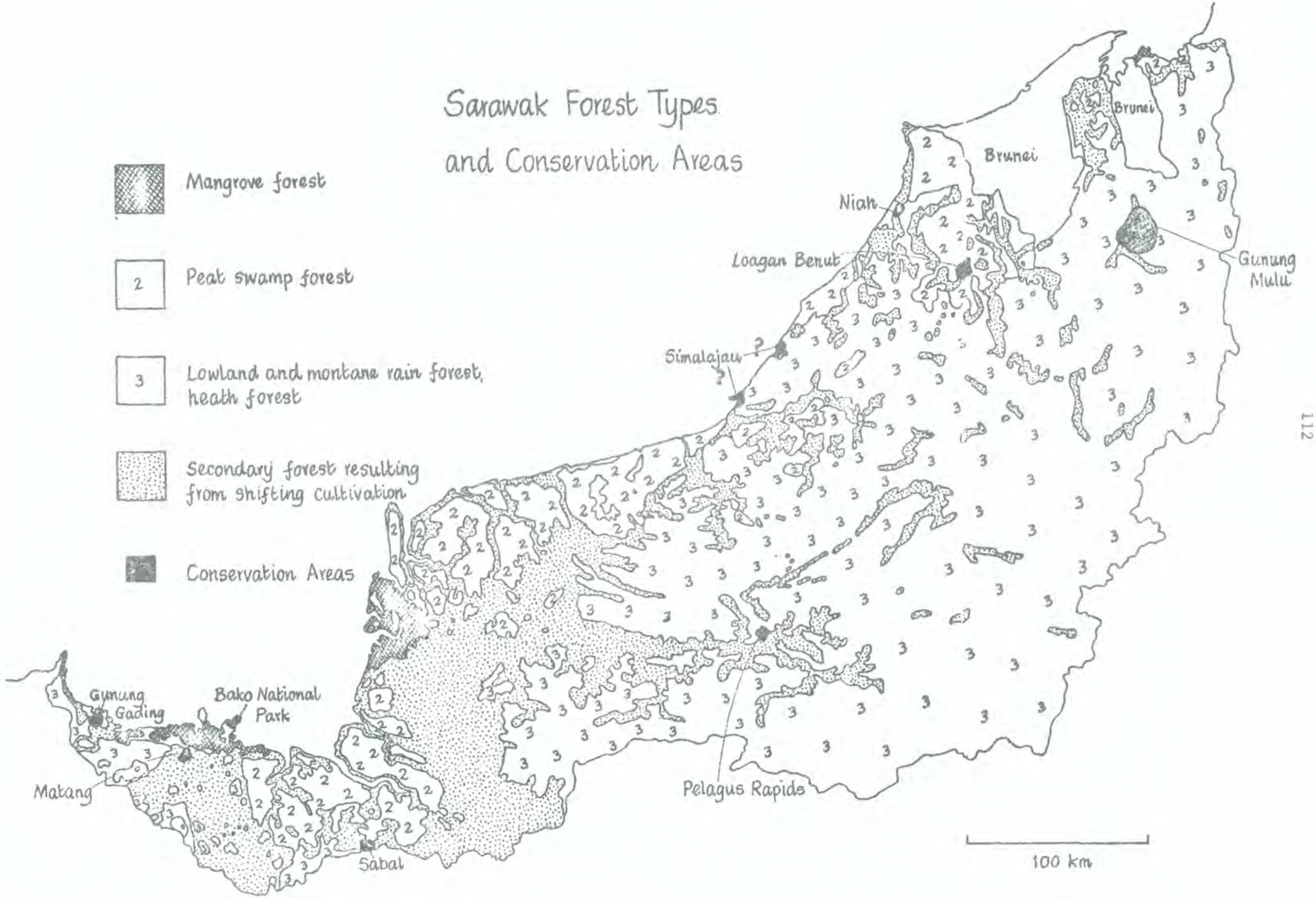
3.5 Gunung Gading. 33.6 sq. km, 4th Division. This includes lowland and lower montane rain forest. It is of particular interest because it is one of the largest of the few granite outcrops in Sarawak and has a rich flora.

3.6 Similajau. 38.8 sq. km, 4th Division. Coast, heath and lowland rain forest are included.

3.7 Sabul. 12.9 sq. km, 1st Division. This includes lowland rain forest, with an interesting flora of palms and herbs on the summit scarp.

4. Adequacy of existing and proposed areas

The coverage appears adequate except possibly for mangrove forest (3.1 only).


Sarawak Forest Types
and Conservation Areas
Mangrove forest
2
Peat swamp forest
3
Lowland and montane rain forest, heath forest
Secondary forest resulting from shifting cultivation
Conservation Areas
Brunei
Brunei
Niah
Loagan Benut
Simalajau
Gunung Mulu
Pelagus Rapids
Gunung Gading
Bako National Park
Matang
Sabal
100 km

5. Matters for urgent action summarized

5.1 The proposed reserves 3.1-3.7 need to be firmly established in time to be written into the State land use development plan.

5.2 A vegetation map and development plan is needed for Gunung Mulu, which is one of the most important Parks on the Sunda shelf.

6. References

ASHTON, P.S. 1971. The plants and vegetation of Bako National Park. Malay. Nat. J. 24, 151-62.

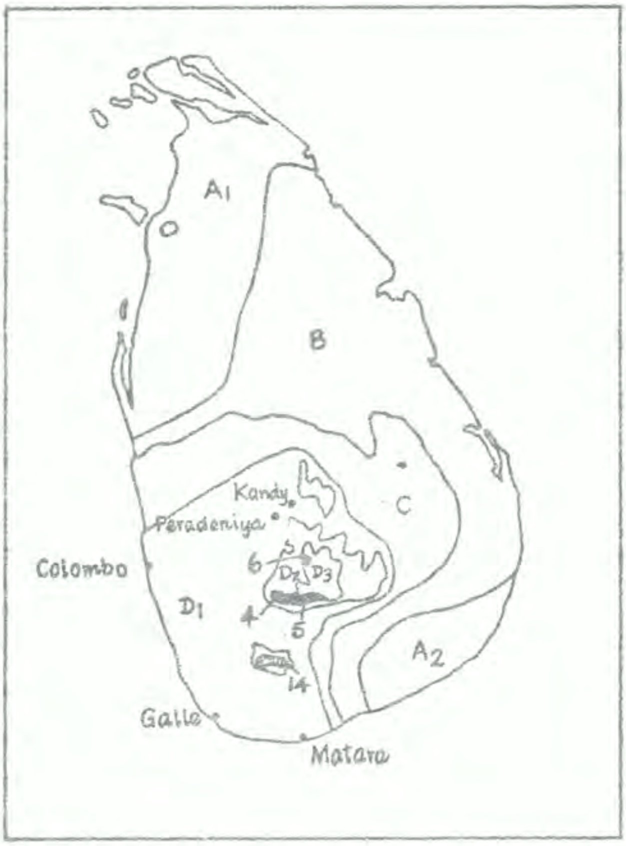
BAILLIE, I.C. 1970. Report on a reconnaissance soil survey of the Pelagus protected forest 3rd Division. Soil Survey Report F 2, Forest Department, Kuching.

WHITMORE, T.C. 1975. Tropical Rain Forests of the Far East. Oxford.

XIX SRI LANKA

1. Occurrence of the rain forest formations

Rain forests are restricted to the south west of the island. On the map below (from Cruz 1973) D = rain forest and grassland, D1 = below 3,000 ft, D2 = 3,000-5000 ft, D3 = over 5,000 ft. Most of the endemic animal species inhabit zone D, 25% of them are confined to the upper montane zone D3. Half of the endemic plant species are also restricted to the wet zones and 'more are found at the lower elevations than on the hills' (Cruz 1973).



Map showing rain forest and conservation areas in Sri Lanka.

1.1 Tropical lowland evergreen rain forest plus a drier facies (probably semi-evergreen rain forest) are both described in some detail by Holmes (1958) and mentioned by Andrews (1961). Emergents reach 125 ft, and are mainly dipterocarps; the continuous canopy is at about 90 ft. All Ceylonese dipterocarps except one are endemic. Andrews says this formation is restricted to ridges in the Sabaragamuwa area to 3,000 ft elevation and notes that it is the best timber producing forest. It is not known to what extent this forest remains virgin.

1.2 Lower montane rain forest is recorded by Andrews (1961) for 3,000-5,000 ft, and is probably equivalent to D2 on the map.

1.3 Upper montane rain forest is recorded by both Holmes (1958) and Andrews (1961) at over 5,000 ft, and is probably equivalent to D3 on the map.

1.4 Mangrove forest probably occurs round part of the coast.

2. Existing Areas Affording Effective Protection

Peak Wilderness, Horton Plains, Hakgala Strict Natural Reserve and Sinharaja Forest 4,5,6 and 14 on the map above all lie in the perhumid rain forest bearing region, but they are only 6% of the total reserved area of 3,850 sq. km, all the remaining 94% lie within the dry zone. Hakgala is an area of 1,100 ha and lies at about 1,000 m (U.N. List 2nd edn. 1971). Crusz says that Sinharaja forest is perhaps the only true primary tropical rain forest in the country and is 'almost a relict biome' from which timber extraction has recently begun.

3. Proposed Conservation Areas

3.1 Mt. Haycock, Hiniduma Kande, has been proposed (Crusz 1973). This peak reaches 650 m, lies north of Galle, is the highest point of the humid region, and is still forested.

3.2 Andrews (1961) recommended that all forests over 5,000 ft should be conserved.

4. Adequacy of Existing and Proposed Areas

No judgement is possible on the evidence available.

5. Matters for Urgent Action

The status of Sinharaja forest should be assessed as a matter of urgency in view of the reported logging.

6. References (*: not seen)

ANDREWS, J.R.T. 1961. A Forest Inventory of Ceylon (Hunting Survey Corporation Ltd., Canada). Government Printer, Ceylon.

CRUSZ, J. 1973. Nature conservation in Sri Lanka (Ceylon). Biol. Conserv. 5, 199-208.

HOLMES, C.H. 1958. The broad pattern of climate and vegetation distribution in Ceylon. In Symp. Humid Tropics Veg. UNESCO, Paris.

*MUELLER DOMBIOS, D. & SIRISENA, V.A. 1967. Climate Map of Ceylon, (revised 1968). Ceylon Survey Department.

XX THAILAND

The account of rain forests in Thailand has been revised and updated in Whitmore and Grimwood (1976) to be published by IUCN.