Land Resource Study

25 The land capability classification of Sabah Volume 4 The Interior Residency and Labuan

Land Resources Division, Ministry of Overseas Development

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Land Resources Division, Ministry of Overseas Development
Tolworth Tower, Surbiton, Surrey, England KT6 7DY
1976

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The Land Resources Division of the Ministry of Overseas Development assists developing countries in mapping, investigating and assessing land resources, and makes recommendations on the use of these resources for the development of agriculture, livestock husbandry and forestry; it also gives advice on related subjects to overseas governments and organisations, makes scientific personnel available for appointment abroad and provides lectures and training courses in the basic techniques of resource appraisal.

The Division works in close co-operation with government departments, research institutes, universities and international organisations concerned with land resource assessment and development planning.

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Land capability classification, Interior Residency. Scale 1:250 000 (4 sheets) 50-9, 50-10, 50-14, 50-15.

Abstracts and keywords

ABSTRACT

This report contains a brief description of the physical and human environment of the Interior Residency and the island of Labuan (Sabah, Malaysia) covering some 18086 km^2 (6983 mi^2). The various resource surveys carried out in the area are noted and the methodology of the land capability classification which is based on these surveys is briefly outlined. This classification is shown on the 1:250 000 scale land capability classification map sheets enclosed with the report. The various resources are then separately described in some detail in simplified terms. Development opportunities in relation to the various land resources are outlined and attention drawn to conflicting resource potentials. General opportunities for land development are discussed bearing in mind land tenure, present land use, population and accessibility. In conclusion, recommendations are made for further studies to assist development planning. The report reveals that only approximately 10% of the land is suited for agriculture but that some 46% has a potential for commercial forestry.

RÉSUMÉ

Ce rapport contient une courte description de l'environnement physique et humain de la Résidence Interiéure et de l'île de Labuan (Sabah, Malaysia) qui s'étend sur quelque 18 086 km^2 (6 983 m^2). Les diverses études se rapportant aux ressources effectuées dans la région sont notées et un aperçu est donné de la méthodologie de la classification de la productivité potentielle qui est basée sur ces études. Les cartes de la productivité potentielle à l'échelle de 1:250 000 annexées au rapport montrent cette classification. Les diverses ressources sont ensuite décrites séparément de manière assez détaillée en termes simplifiés. Les possibilités d'exploitation par rapport aux diverses ressources terrestres sont esquissées et l'attention est attirée sur les potentiels contradictoires des ressources. Les possibilités générales d'exploitation des terres sont discutées en prenant en considération le régime foncier, l'usage actuel de la terre, la population et l'accessibilité. En conclusion, des recommandations sont formulées au sujet d'études ultérieures susceptibles de faciliter la planification de la mise en valeur. Le rapport indique qu'environ 10% des terres conviennent à l'agriculture et 46% à l'exploitation commerciale des forêts.

DESCRIPTORS FOR CO-ORDINATE INDEXING

Climate, geology, geomorphology, mineral resources, water resources, land capability, land resources, vegetation, forest resources, grassland, animal husbandry, game management, land tenure, demography, rural settlement, tourism, Sabah, Malaysia.

Glossaries

1. TECHNICAL TERMS

Alienated land	Land for which a title, lease or provisional lease has been issued
Annual licence	A licence to cut and extract timber from a specific area of land which is valid initially for a period no longer than one year
Field register	A list of land titles maintained by the District Surveyor which have not yet been entered in the central land register
Gazettement	The publication of a notice in the Government Gazette in this case referring to specific use of land for official purposes
Lease	A form of title to land
Licence agreement	An agreement giving the right to cut and extract timber from a given area of forest reserve for a period in excess of ten years
Native title	A form of title to land which can only be held by a native of the State
Provisional lease	A form of provisional title to land which gives the holder the right to occupy the land
Settlement scheme	A form of land development scheme where people are encouraged to settle on and develop areas of land. In return for developing the land, settlers are given the title to a small-holding and in addition may receive other benefits both in cash and kind
Sheet lalang	An extensive area of virtually pure *lalang (Imperata cylindrica)*
Special licence	A licence to cut and extract timber from a specific area of land which may be valid for a period of from one to ten years
Tamu ground	A place where rural markets are held
Village reserve	Land reserved for use by native villagers for various purposes and gazetted as such

2. MALAY WORDS COMMONLY USED IN PLACE NAMES

Batu	rock	Laut	sea
Besar	large	Padang	field
Bukit	hill	Pantai	beach
Gunong	mountain	Pangkalan	landing place
Hutan	forest	Pulau	island
Kampong	village	Sungai	river
Kechil	small	Tamu	rural market
Kuala	river mouth	Tanjong	cape
Ladang	clearing	Trusan	channel
		Ulu	upper reaches of river

3. COMMON (MALAY) AND BOTANICAL NAMES OF TREES

Api Api	*Avicennia* spp	Majau	*Shorea leptoclados*
Bakau	*Rhizophora mucronata*	Medang	*Lauraceae* spp. especially *Litsea*
Bangkita	*Rhizophora apiculata*		
Belian	*Eusideroxylon zwageri*	Melapi	*Anthoshorea* section of *Shorea*
Beus	*Bruguiera cylindrica*		
Bintangor	*Calophyllum* spp.	Mengaris	*Koompassia excelsa*
Binuang	*Octomeles sumatrana*	Merbau	*Intsia palembanica*
Buta Buta	*Excoecaria agallocha*	Nyatoh	*Sapotaceae* e.g. *Ganua, Madhuca, Palaquium, Payena* spp.
Durian	*Durio* spp.		
Gagil	*Hopea sangal*		
Geriting	*Lumnitzera* spp.	Obah suluk	*Shorea pauciflora*
Jelutong	*Dyera* spp.	Pengiran	*Anisoptera* spp.
Kapur	*Dryobalanops* spp.	Prepat	*Sonneratia alba*
Karai	*Meiogyne virgata*	Pulai	*Alstonia* spp.
	Mezzetia leptopoda	Putat paya	*Planchonia valida*
	Sageraea lanceolata also *Polyalthia* and other *Annonaceae*	Ranggu	*Koordersiodendron pinnatum*
		Red seraya	*Rubroshorea* section of *Shorea*
Kayu malam	*Diospyros* spp.		
Kedongdong	*Burseraceae* i.e. *Canarium* spp., *Dacryodes* spp., *Santiria* spp.	Resak	*Vatica* or *Cotylelobium* spp.
		Selangan batu	*Shorea* section of *Shorea*
Kembang	*Heritiera simplicifolia* and other spp. of *Heritiera*	Sengkuang	*Dracontomelon puberulum*
		Sepetir	*Sindora* spp.
Keranji	*Dialium* spp.	Melapi	*Anthoshorea* group of *Shorea*
Keruing	*Dipterocarpus* spp.		
Laran	*Anthocephalus chinensis*	Serungan	*Cratoxylum arborescen*
Layang layang	*Parishia insignis*	Takalis	*Pentace* spp.
Limpaga	*Azadirachta excelsa*	Tengar	*Ceriops tagal*
	Toona sureni and other *Meliaceae*	Urat mata	*Parashorea* spp.
		Yellow seraya	*Richetia* section of *Shorea*

4. COMMON (ENGLISH OR MALAY) AND BOTANICAL NAMES OF GRASSES AND FORAGE PLANTS

African star grass	*Cynodon dactylon*	Lalang	*Imperata cylindrica*
Buffalo grass	*Paspalum conjugatum*	Lotonosis	*Lotonosis bainesii*
Carpet grass	*Axonopus compressus*	Para grass	*Brachiaria mutica*
Centipede grass	*Ischaemium barbatum*	Paspalum	*Paspalum dilatatum*
Centro	*Centrosema pubescens*	Signal grass	*Brachiaria decumbens*
Coast grass	*Cynodon plectostachyus*	Siratro	*Phaseolus atropurpurens*
Guinea grass	*Panicum maximum*	Stylo	*Stylosanthes guyanensis*
Kazungulu	*Setaria sphacelata*	Suriname grass	*Bracharia decubens*

Parts 1-6

Part 1

Preface

This is the fourth and last of the volumes dealing with the land capability classification of the State of Sabah, Malaysia. The reports cover each of the residencies of the State and this volume deals with the Interior Residency which, for reporting purposes, includes the Labuan District. It is published with the permission of the Government of Sabah, to whom a draft was submitted in 1975.

Readers are referred to the introductory sections of Volume 1 for a history of the study, a description of the procedures used, the composition of the project team and a summary of findings.

The contributions and help given by the many persons and organisations involved in producing this volume are gratefully acknowledged; full details are given in the introduction to the four reports contained in Volume 1.

Part 2

Geographical background

LOCATION

The Interior Residency is situated in the south-western part of the State of Sabah (Text Map 4-1) and includes the larger islands of Labuan and Tiga together with some smaller islands. It has a relatively short coastline extending from Kimanis Bay in the north, along the Klias Peninsula to the State border with Sarawak in Brunei Bay in the south. The southern boundary of the residency is the international boundary with Kalimantan (Indonesia) while the western boundary is the inter-state boundary with Sarawak. It falls within latitudes 4^{o} 07'N and 5^{o} 56'N and longitudes 115^{o} 07'E and 117^{o} 08'E. Geographically the Interior Residency comprises the districts of Tambunan, Keningau, Beaufort, Kuala Penyu, Labuan, Tenom, Sipitang and Pensiangan, and has a total land area of approximately 18 086 km^2 (6 983 mi^2). The town of Keningau is the administrative centre of the residency while other towns of importance are Beaufort, Victoria (Labuan), Tenom and Tambunan. Labuan, for administrative purposes, is directly responsible to the State capital.

TOPOGRAPHY AND GEOLOGY

The outstanding topographical features of the Interior Residency are steep mountain ranges separated by intermontane alluvial plains. There are five mountain ranges i.e. the Crocker, Witti, Trus Madi and Meligan Ranges and the Kuamut Highlands, and five intermontane plains i.e. Tambunan, Keningau, Tenom, Sook-Dalit and Penawan together with the Crocker Plains on the seaboard. The main regions have been described by Collenette (1963) in his Physiographic Classification of North Borneo, which is used as the basis for this narrative. The regions which fall in the Interior Residency are shown on Text Map 4-2.

Pulau Labuan and Pulau Tiga are part of the Western Islands, formed mainly of alluvium, mudstones, siltstones, sandstones and shales. The northern tip of Labuan rises to 97 m (318 ft) while the highest point on Tiga is 107 m (350 ft).

The Klias Hills are marked by a series of low-lying ridges rising to 148 m (485 ft), composed of sandstones, siltstones and shales. These form the terminal portion of the Klias Peninsula. The remaining part consists of estuarine and peat swamps with some alluvial flats marking the course of the main rivers. This is the Klias Plain, the largest of the Crocker Plains. To the south, fringing the shoreline, is a smaller unit of the Crocker Plains.

Inland from the Klias and Crocker Plains are the Crocker Foothills. These are composed of the sandstones, siltstones, mudstones and shales of the Crocker Formation and above 300 m (1 000 ft) merge into the Crocker Range. The range is formed of strongly folded rocks of the Crocker Formation similar to those in the foothills, giving rise to steep mountainous country rising to 1 200-1 800 m (4 000-6 000 ft) and reaching 1 966 m (6 450 ft) on Gunong Lamaku at the southern end. The range is cut by the gorge of the Padas River in a north-easterly direction from Tenom to Beaufort.

The Meligan Range occupies the western border area between Sabah and Sarawak. It is rugged country with peaks generally in the region of 600 m-900 m (2 000-3 000 ft) though rising to 2 083 m (6 835 ft) on Muruk Miau close to the border. The range consists of interbedded quartz sandstones and shales which form regular ridges and valleys, and is characterised by well-formed cuestas of gently to steeply dipping sandstones.

The Witti Range comprises the mountains separating the upper Padas and the Talankai Valleys and the northern extensions as far as the Pegalan and Sook Rivers. It is built of the sandstones and shales of the Crocker Formation and the mudstones, greywackes and conglomerates of the Sapulut Formation. The two formations meet along the Witti Fault which runs in a north, north-easterly direction. The country is rugged with peaks varying from about 300 m-1 500 m (1 000-5 000 ft) with a maximum of 1 600 m (5 250 ft).

The Talankai Valley separating the Witti Range and the Kuamut Highlands drains south into Kalimantan. It cuts through the Sapulut Formation and is generally narrow with hills rising fairly steeply. At the northern end the valley floor is at an altitude of about 500 m (1 500 ft) falling to about 150 m (500 ft) in the south on the international boundary.

The Kuamut Highlands in the south-east corner of the residency are built of strongly folded rocks of the Labang and Sapulut Formations; mainly mudstones, sandstones, greywackes and conglomerates with limestone outcrops, which give rise to less rugged country with peaks over 1 200 m (4 000 ft) in places in the south close to the border but with a general height of 600-900 m (2 000-3 000 ft).

The Trus Madi Range comprises the mountains stretching from the Sook Plain in a north-easterly direction to the residency boundary. They are formed of argillaceous rocks of the Trus Madi Formation which have been subjected to mild regional metamorphism in the western part. The country is mountainous and rugged, reaching a height of 2 649 m (8 690 ft) on Gunong Trus Madi which is close to the eastern boundary, and with a number of peaks of 1 500-1 800 m (5 000-6 000 ft). The higher ground is deeply incised with steep gorges.

The Tambunan, Keningau and Tenom plains consist of terraces formed on alluvium that was deposited in steep sided valleys of the Western Cordillera, in some cases under lacustrine conditions. The alluvium is of variable texture and quite thick, and in all plains there are at least three terrace levels.

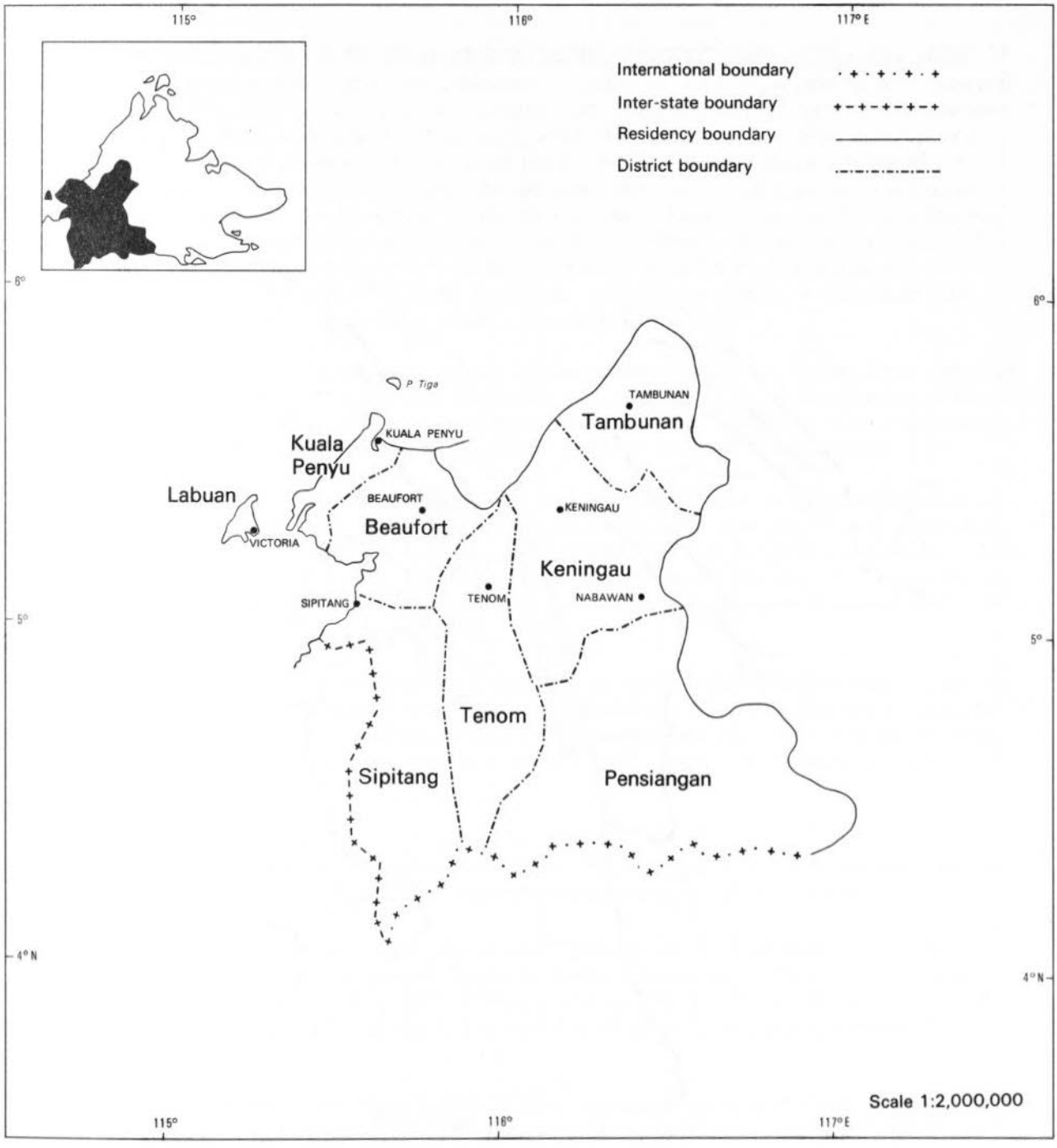
The Sook-Dalit Plain is the largest of the intermontane plains. The western and Dalit Section is dissected and formed on sandstones and shales. The eastern (Sook) section, however, lies on alluvium with a much gentler relief which is characterised by two main terrace levels.

The Penawan Plain is an area of alluvial deposition between the Witti and Maitland Ranges. The southern part drains south into the Talankai Valley while the northern part is drained by tributaries of the Labau River, which has deeply eroded the alluvium, and flows eastwards into the Kinabatangan.

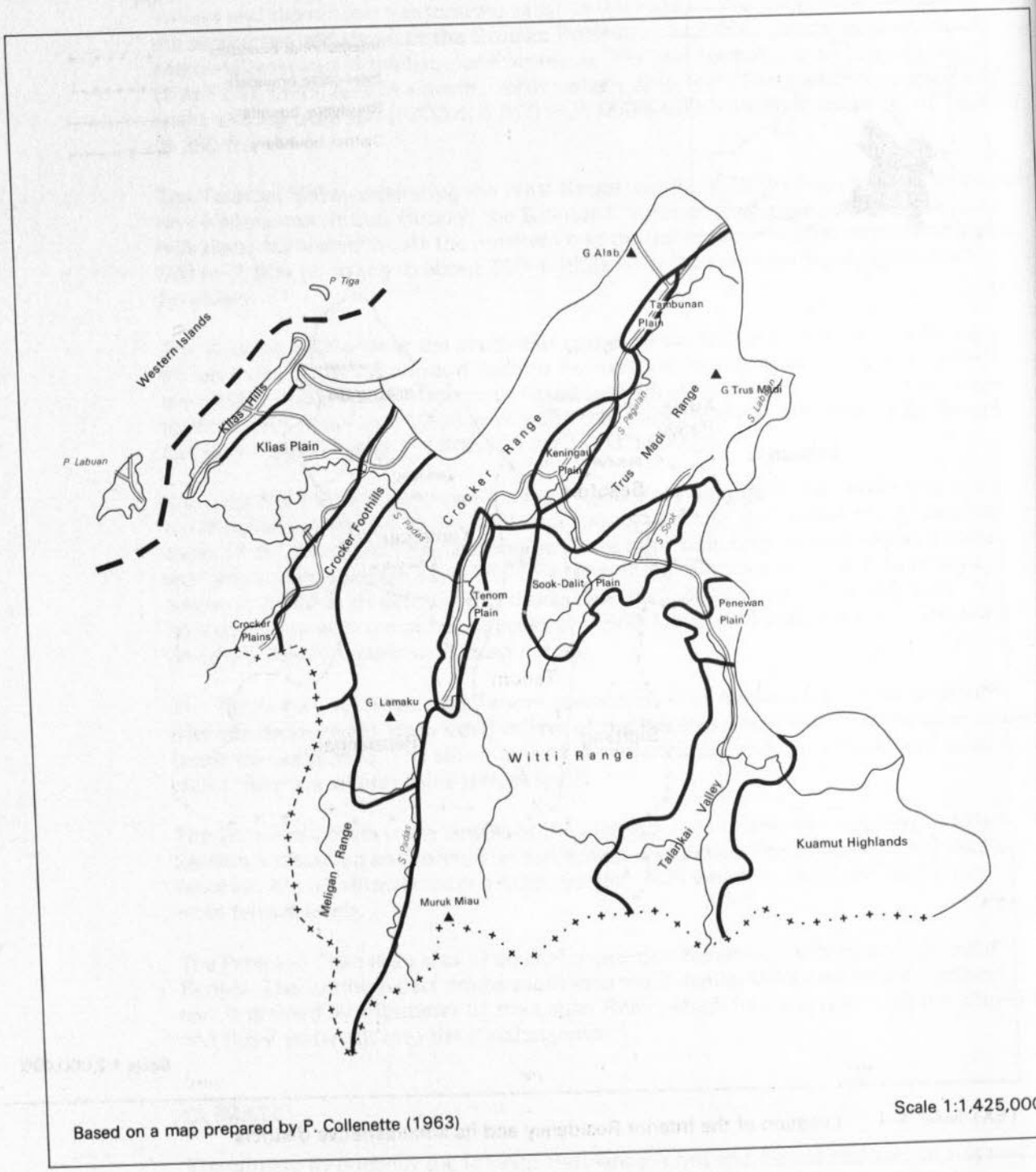
CLIMATE

The climate throughout the Interior Residency is hot and humid and two of Koppen's climatic zones, (see Koppen quoted by Trewartha, 1954) can be distinguished:

1. Land below 1 200-1 500 m (4 000-5 000 ft) experiences the tropical rain forest climate (Afi) where the monthly rainfall always exceeds 60 mm (2.4 in), the average temperature of the coolest month is higher than 18°C (64°F) and the range of temperature between the warmest and the coolest months is less than 5°C (9°F)



TEXT MAP 4-1 Location of the Interior Residency and its administrative districts



TEXT MAP 4-2 Physiography

Prepared by the Directorate of Overseas Surveys 19

2. Land above 1 200-1 500 m (4 000-5 000 ft) experiences the warm rainy climate (Cfi). This is defined as having no distinct dry season with no month receiving less than 30 mm (1.2 in) of rain and with the average temperature of the coolest month being below 18°C (64°F) but above -3°C (26°F) and the range of temperature between the warmest and the coolest month less than 5°C (9°F)

Rainfall

Text Map 4-3 shows the distribution of rainfall. The histograms are based on mean figures derived from data collected over a number of years; from year to year, however, there are often considerable fluctuations in monthly and annual rainfall. It can be seen that the first three months of the year, when the North-East Monsoon winds prevail, are in general the driest. At 14 out of the 21 stations shown February is the driest month. It will also be noted that the residency may be divided into two main zones based on mean annual rainfall. In the coastal lowland areas to the west of the Crocker and Meligan Ranges the mean annual rainfall varies from 2 500-4 000 mm (100-157 in). In the interior areas to the east of these ranges it varies from 1 500-2 300 mm (60-90 in). There is a third zone, ill-defined through lack of data, in the south-east where mean annual rainfall is 2 800-3 100 mm (110-122 in).

In the coastal lowland zone, rainfall, following the relatively dry first quarter, increases to a peak in May or June, then drops with the onset of the South-West Monsoon winds and increases again to reach a maximum in September to November. The wettest part of the year is therefore during the transition period between the monsoons.

In the interior zone the rainfall pattern is less clearly defined. The monthly variation is in most cases small and generally there are two peaks in the year. The first is in the period April to June, May being the wettest month at nine out of the twelve stations in the zone (Text Map 4-3). The second is in September to November. It appears that in this zone the monsoons play little part in determining the pattern of rainfall which is believed to be mainly convectional.

In the third zone in the south-east, mean annual rainfall is significantly higher than in the interior zone. Rainfall is heaviest in the months of April and May, the transition period between the monsoons. Apart from this peak period and the first two months of the year, which are relatively dry, there is little variation in monthly rainfall.

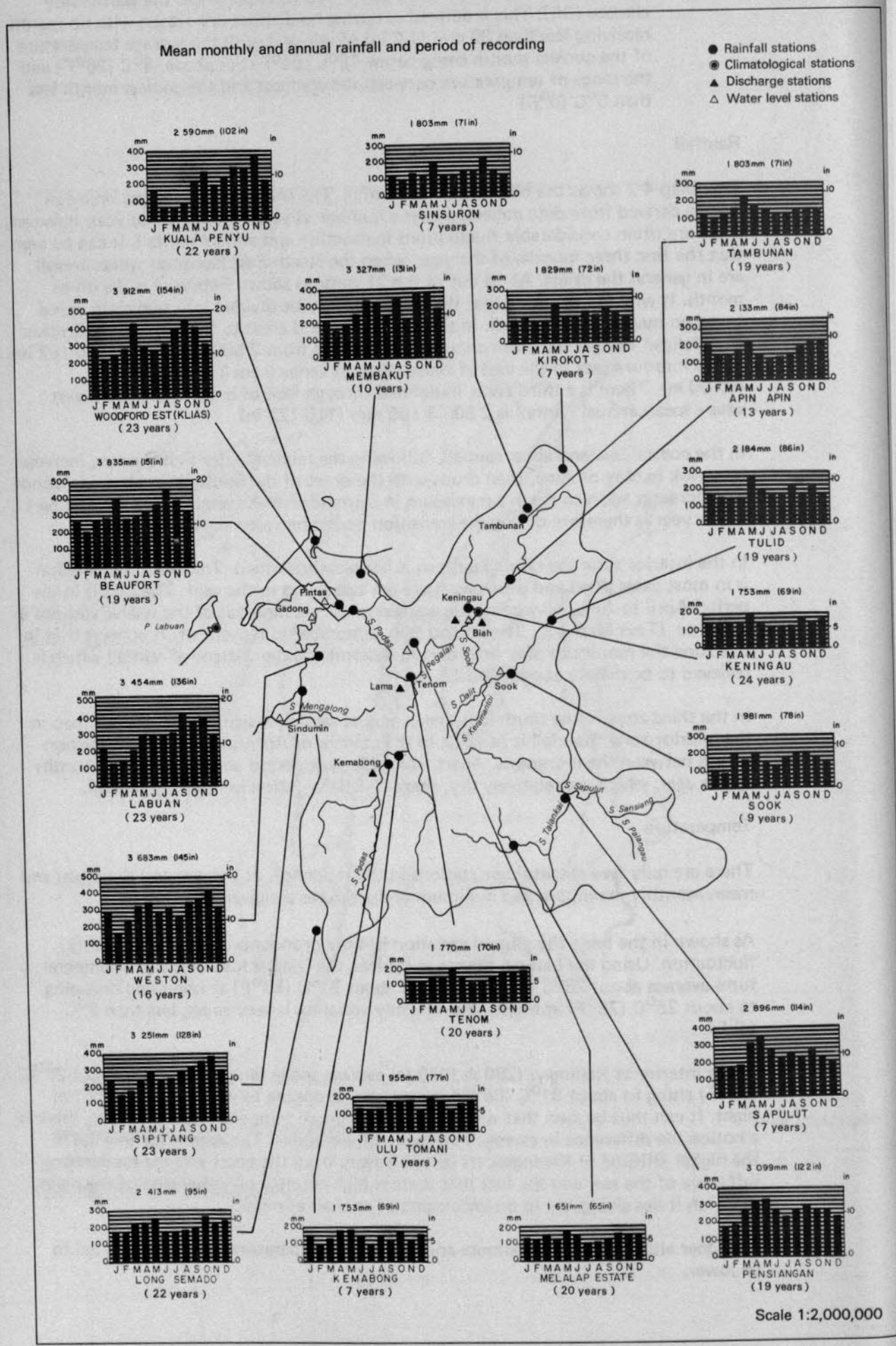
Temperature

There are only two climatologic stations in the residency, at Labuan and Keningau and mean monthly maximum and minimum temperatures are given in Table 1.

As shown in the table the diurnal variation is more pronounced than the monthly fluctuation. Using the Labuan figures as typical, the coastal lowlands shade temperatures average about 28°C (82°F) rising to about 31°C (88°F) at noon and dropping to about 25°C (78°F) at night. The monthly variation is very small, less than 2°C (4°F).

In the interior at Keningau (280 m (870 ft) average shade temperatures are about 25°C (78°F) rising to about 31°C (88°F) at noon but dropping to about 20°C (68°F) at night. It can thus be seen that while average maximum temperatures are similar, there is a noticeable difference in average minimum temperatures. The reason for this lies in the higher altitude of Keningau, its location away from the coast and the moderating influence of the sea, and the fact that there is high country on either side of the plain in which it lies giving rise to downcurrents of cool air at night.

At higher altitudes mean maximum and minimum temperatures may be expected to be lower.



TEXT MAP 4-3 Selected rainfall, climatological and hydrometric stations

TABLE 1 Monthly and annual mean daily maximum and minimum air temperatures °C (°F)

Station and altitude a.s.l.	Mean daily temp.	J	F	M	A	M	J	J	A	S	O	N	D	Annual average	Annual variation	Years of record
Labuan 30 m	Max.	29.8 (85.6)	29.9 (85.8)	30.7 (87.3)	31.4 (88.5)	31.3 (88.3)	31.1 (88.0)	30.8 (87.4)	30.8 (87.4)	30.7 (87.3)	30.6 (87.1)	30.3 (86.5)	30.3 (86.5)	30.7 (87.3)	1.6 (2.9)	16
	Min.	24.7 (76.5)	24.6 (76.3)	24.8 (76.6)	25.1 (77.2)	25.2 (77.4)	25.0 (77.0)	24.7 (76.5)	24.7 (76.3)	24.5 (76.1)	24.6 (76.3)	24.5 (76.1)	24.7 (76.5)	24.8 (76.6)	.7 (1.3)	
Keningau 285 m	Max.	30.1 (86.1)	30.6 (87.0)	31.1 (88.0)	31.4 (88.6)	31.2 (88.2)	31.0 (87.8)	31.0 (87.8)	31.0 (87.8)	30.9 (87.6)	30.7 (87.3)	30.5 (86.8)	30.3 (86.5)	30.8 (87.5)	1.3 (2.3)	9
	Min.	19.8 (67.7)	19.9 (67.8)	20.4 (68.7)	20.8 (69.4)	20.9 (69.6)	20.5 (68.9)	19.8 (67.7)	20.3 (68.5)	20.3 (68.5)	20.4 (68.8)	20.2 (68.4)	20.4 (68.8)	20.3 (68.6)	1.1 (1.9)	
Kundasan 1 290 m *	Max.	22.5 (72.5)	22.8 (73.0)	24.0 (75.2)	24.8 (76.6)	25.7 (78.3)	25.1 (77.2)	24.7 (76.5)	24.5 (76.1)	24.5 (76.1)	24.3 (75.7)	24.0 (75.2)	23.3 (73.9)	24.2 (75.6)	3.2 (5.8)	7
	Min.	15.1 (59.2)	14.6 (58.3)	15.2 (59.4)	15.5 (59.9)	16.2 (61.2)	16.6 (61.9)	16.5 (61.7)	16.1 (61.0)	16.3 (61.3)	16.2 (61.3)	15.9 (60.6)	15.2 (59.4)	15.8 (60.4)	2.0 (3.6)	
Kambarangan 2 220 m *	Max.	16.9 (62.4)	17.2 (63.0)	17.5 (63.5)	17.6 (63.7)	17.4 (63.3)	17.4 (63.3)	17.0 (62.6)	17.1 (62.8)	16.6 (61.9)	16.7 (62.1)	16.9 (62.4)	17.3 (63.1)	17.1 (62.8)	1.0 (2.8)	4
	Min.	10.9 (51.6)	11.0 (51.8)	11.1 (52.0)	11.3 (52.3)	11.7 (53.1)	11.6 (52.9)	11.5 (52.7)	11.4 (52.5)	11.3 (52.3)	11.4 (52.5)	11.3 (52.3)	11.5 (52.7)	11.3 (52.3)	.8 (1.5)	

* These two stations are not in the Interior Residency but data from them is included to provide information on mean temperature at higher altitudes.

VEGETATION

At present approximately 93.3% of the land in the residency is still covered with forest, of which undisturbed high forest accounts for some 65.2%, (36.3%) on land below 750 m (2 500 ft), 24.3% on land between 750 and 1 500 m (2 500 and 5 000 ft) and 2.7% on land over 1 500 m (5 000 ft). Freshwater swamp forest covers some 4.7%, secondary and disturbed forest, mainly regrowth following shifting cultivation,some 21.7% and other forest 0.6%. Of the remaining land approximately 1.6% is derived grassland and 1.2% current shifting cultivation. The balance is mainly used for more permanent forms of agriculture with rubber and rice the most important crops.

The natural vegetation of most of the area is tropical rain forest of one type or another with some mangrove forest developed on the coast. The greater part of the grasslands is believed to be relatively recently derived from high forest.

The forest with commercial prospects, which covers some 827 972 ha (2 045 942 ac) 45.7% of the land area, is more akin to the hill dipterocarp forest of Symington (1943), called by Fox (1972)'*selangan batu* forest', than to true lowland dipterocarp forest. Red seraya (species of the Rubroshorea group of *Shorea*) is the most common timber group followed by *selangan batu* (species of the shorea group of *Shorea*). *Urat mata* (*Parashorea* spp.), *keruing* (*Dipterocarpus* spp.) and yellow seraya (species of the richetia group of *Shorea*) are well represented but *kapur* (*Dryobalanops* spp.) is rare, likewise *belian* (*Eusideroxylon zwageri*).

A considerable proportion of this commercial forest in fact occurs above 800 m (2 500 ft); although in general at about this altitude the forest starts to become montane with a change in the floristic composition, a lowering of the canopy level and a marked drop in the volume of commercial timber. In the non-commercial montane forest, red and yellow seraya are generally the most common dipterocarps, though with a much lower volume than in the commercial forests, while *resak*, species of *Vatica* and *Cotylelobium*, dipterocarps of doubtful commercial value, become more common, though not abundant. In the montane forest species other than dipterocarps tend to account for a higher proportion of the commercial timber volume.

In the altitude zone 1 200-1 800 m (4 000-6 000 ft) the Oak/Conifer Forest of Fox (1972) is found on most of the mountains. This is a two layered forest with species of *Dacrydium, Podocarpus* and occasionally other conifers in association with various species of *Lithocarpus* and some *Castanopsis* and a thin understorey of other species. Above 1 500 m (5 000 ft) *resak* is more or less the sole representative of the Dipterocarpaceae.

Above about 1 800 m (6 000 ft) Ericaceous Forest (Fox, 1972) occurs. This is a one layered forest in which *Lithocarpus* spp, *Quercus* spp, *Eugenia* spp. and species of *Lauraceae* and *Sapotaceae* are common. This type of forest is found on Gunong Trus Madi in the summit area.

Peat swamp forest with *ramin* (*Gonystylus bancanus*), *jongkong* (*Dactylocladus stenostachys*) and *kapur* (*Dryobalanops rappa*) the most important species, occupies an area of some 650 km^2 (250 mi^2) on the Klias Peninsula with a small area of similar forest at Marintaman Mengalong Forest Reserve near Sipitang (Fox, 1972). This forest type is commonly bounded on the Klias Peninsula by areas of sago palm swamp with *Metroxylon rumphii.*

The forest vegetation of the Sook and Penawan Plains consists of Swampy Padang Forest, with *Hopea pentanervia* as an important species, in the lowlying parts, and Inland Dry Heath Forest, in which *Dacrydium elatum* is abundant, on the terraces (Fox, 1972). Where the forest cover has been removed and burnt, savanna conditions prevail, with *lalang* (*Imperata cylindrica*), bracken (*Pteridium* spp.) and *berungis* (*Baeckia frutesens*). Such open areas are also common on the Tambunan and Keningau Plains.

Tidal mangrove forest occurs round the coast though the total area is relatively small. Other vegetation types associated with specialised edaphic conditions do occur but are not extensive, e.g. heath forest on sandstone cuestas in the Meligan Range, and on Gunong Lamaku; *Dryobalanops rappa* forest on sandy terraces in the Mesapol Forest Reserve and Coastal Padang Forest with *Fagraea fragrans* and *F. elliptica* and similar land at Marintaman Mengalong Forest Reserve. (Plate 4-1).

SETTLEMENT AND POPULATION

The population, with towns and villages, is mainly concentrated on the seaboard, Labuan, and the intermontane plains, particularly Tenom, Tambunan and Keningau. This can be primarily attributed to the terrain and soils of those areas being able to support settled agricultural communities. Elsewhere the land is generally too steep or otherwise unsuited for permanent agriculture. Nevertheless other areas are sparsely populated with scattered small communities mainly engaged in shifting cultivation. In the Talankai Valley, particularly in the vicinity of Pensiangan and Agis, there is a relatively large community more or less dependent on shifting cultivation for a living.

The population of the residency including the Labuan District was, according to the 1970 census (Sabah, Malaysia, Dept. of Statistics 1973), 138 225 giving an average density of 7.6 per km^2 (19.8 per mi^2). However on Labuan, where 12.4% of the total population live, the average density is 177.8 per km^2 (460.6 per mi^2). The population is mainly rural with only 12.5% living in the main towns and townships as listed in Table 2. It will be noted from the Table that Victoria in the Labuan District has the largest population followed by Tenom. Table 2 gives a breakdown by districts and major community groups.

It will be seen from Table 2 that 82.2% of the population is indigenous with the Kadazan community group the largest. This group is reasonably well distributed throughout the residency with the exception of the Pensiangan District where it is hardly represented and the Sipitang and the Labuan Districts where numbers are small. In the Tambunan District over 96% of the population is Kadazan and in the Keningau District nearly 58.0%.

PLATE 4.1 *Dryobalanops rappa* forest in Mesapol Forest Reserve

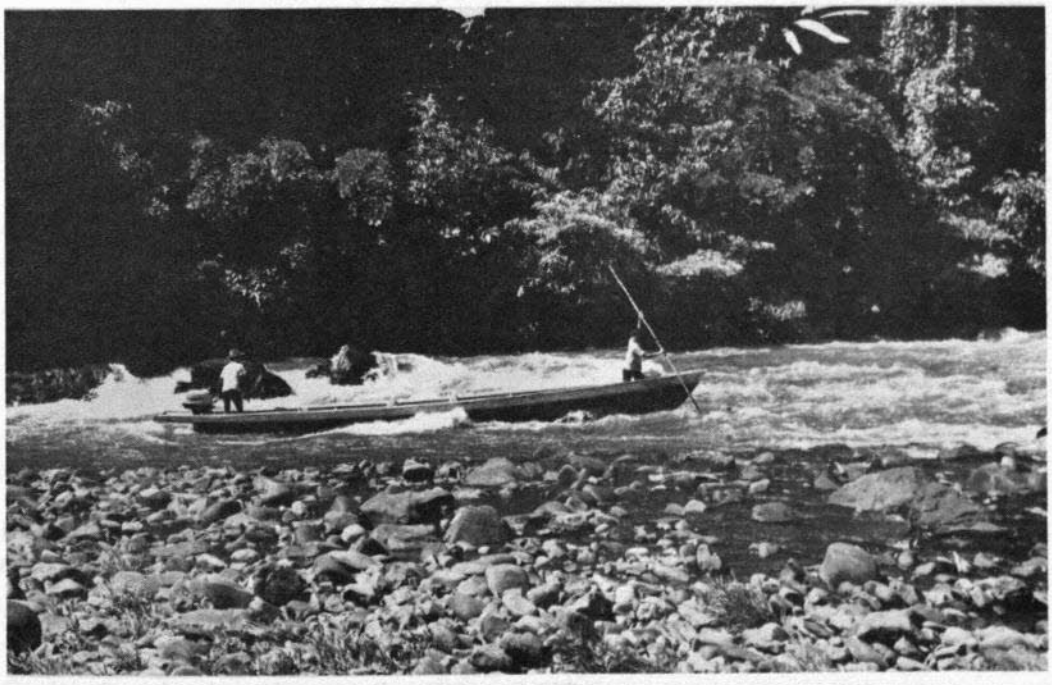


PLATE 4.2 Communications are difficult in the interior. River transport near Pensiangan

TABLE 2 Population by districts and major community groups

Community group	Kuala Penyu	Beaufort	Sipitang	Tenom	Pensiangan	Keningau	Tambunan	Labuan	Residency	
									Total	%
Kadazan	4 886	4 652	333	2 143	7	15 271	11 546	539	39 377	28.5
Murut	61	963	2 851	12 969	5 732	6 421	13	71	29 081	21.0
Bajau	914	276	19	141	1	330	21	93	1 795	1.3
Malay	73	480	36	599	0	83	8	4 410	5 689	4.1
Brunei	1 918	5 418	1 816	121	0	148	15	2 583	12 019	8.7
Kadayan	667	2 074	3 400	29	0	60	2	3 047	9 279	6.7
Bisaya	2 101	10 597	303	62	0	14	0	108	13 185	9.5
Other indigenous*	699	999	187	204	4	764	166	238	3 261	2.4
Total indigenous	11 319	25 459	8 945	16 268	5 744	23 091	11 771	11 089	113 686	82.2
Chinese	307	4 398	802	5 951	27	2 645	113	4 799	19 042	13.8
Indonesian	22	1 390	153	1 047	0	360	21	609	3 602	2.6
Others**	33	437	161	276	0	245	51	692	1 895	1.4
Total	11 681	31 684	10 061	23 542	5 771	26 341	11 956	17 189	138 225	100

* The most important community group is Sino-Native 2 807

** The most important community group is Indian 971

The Murut community group is the second largest, and is concentrated in the Pensiangan Tenom, Keningau and Sipitang Districts. In the Pensiangan District over 99% of the population is Murut and in the Tenom District over 55%.

Among the other indigenous groups the Bisayan, Brunei and Kadayan are the most numerous and are concentrated on the seaboard and poorly represented in the interior.

Of the non-indigenous community groups the Chinese is by far the largest and is third largest overall. This group is reasonably well distributed throughout the residency except for the Pensiangan and Tambunan Districts. The Chinese tend to be considerably more urban than other community groups and,as Table 3 shows, account for over 45% of the population in the main towns and townships. Other non-indigenous community groups are of little importance accounting for only 4% of the total population.

TABLE 3 Chinese community group in towns and townships

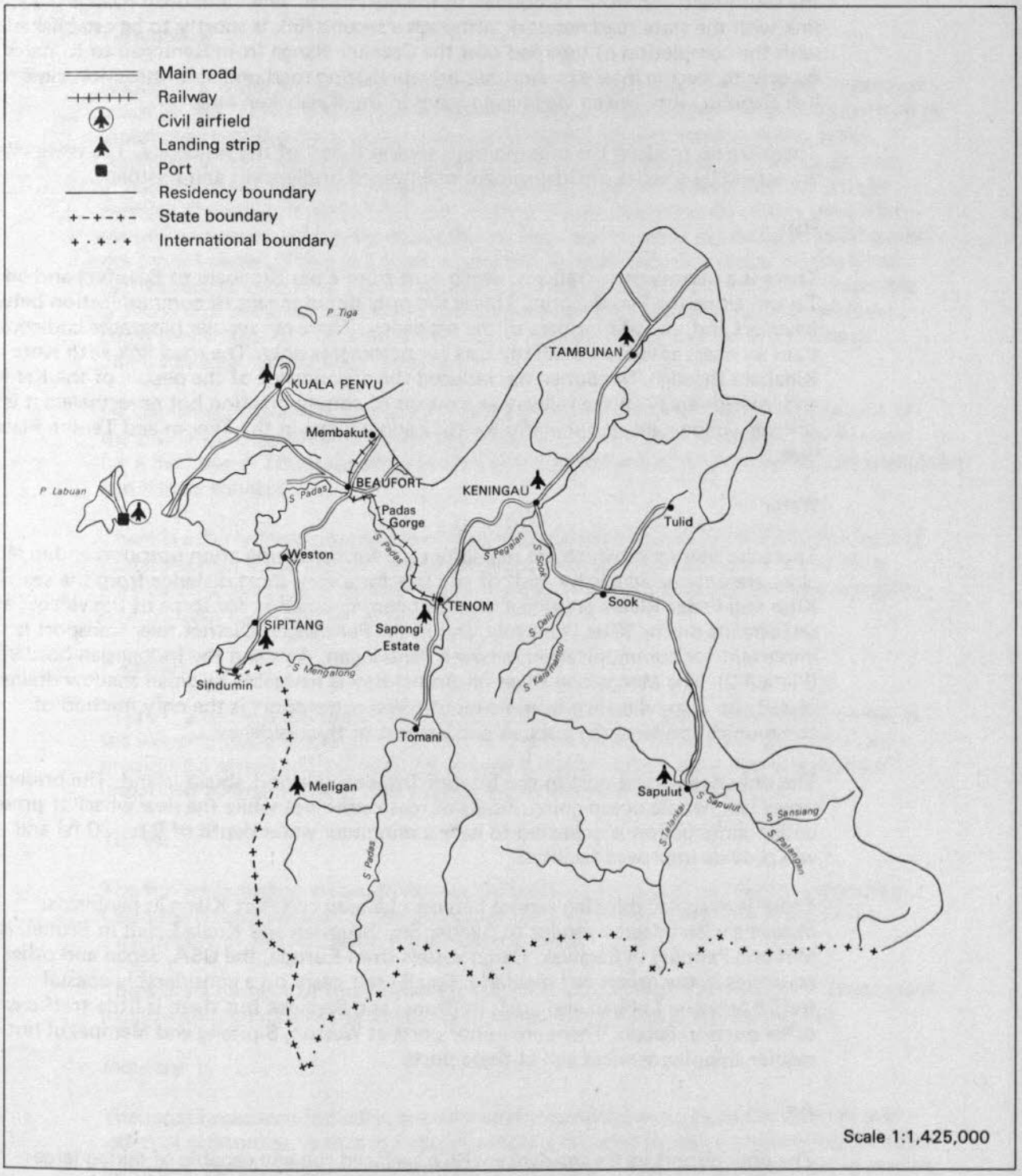
Town or township		Kuala Penyu	Beaufort	Sipitang	Tenom	Keningau	Tambunan	Victoria (Labuan)	Total
Total population		501	2 709	682	3 284	2 037	867	7 216	17 296
Chinese community group	Number	94	1 607	310	2 085	846	92	2 788	7 822
	Percentage	18.8	59.3	45.5	63.5	41.5	10.6	38.6	45.2

COMMUNICATIONS

The major feature of the communications system are shown in Text Map 4-4. There are two limited internal road networks with links to the West Coast Residency and a railway which runs to Kota Kinabalu. Water transport is little used though it is important as a means of communication between Labuan and the mainland. Road and rail transport provides the main external links though there are also sea and air communications.

Road

In all there are an estimated 887 km (551 mi) of roads maintained by the Public Works Department. Only a small proportion of these roads are sealed, the main exceptions being sections of the Keningau-Tenom road, and on Labuan which has a relatively



TEXT MAP 4-4 Communications

intensive road system. There is a road network of limited extent in the western seaboard area which links Beaufort with Weston, Sipitang and Sindumin in the south, Kuala Penyu and other settlements along the western coastline of the Klias Peninsula in the west and Membakut and the West Coast Residency in the north.

There is no road link east across the Crocker Range with Tenom, Keningau and the interior areas. On the eastern side of the Crocker Range there is a second road network, also of somewhat limited extent. This is centred on Keningau where three main roads meet: from Tomani and Tenom to the south-west; from Sapulut, Tulid and Sook to the south-east; and from Tambunan to the north-east. The Tambunan road is the sole link with the state road network, although a second link is shortly to be established with the completion of the road over the Crocker Range from Keningau to Kimanis by private logging interests. Another private logging road under construction aims to link Sapulut with Tawau via logging roads in the Kalabakan area.

There are no roads in the mountainous southern part of the residency. The main villages are served by a series of Government maintained bridle-trails and footpaths.

Rail

There is a narrow gauge railway which runs from Kota Kinabalu to Beaufort and on to Tenom along the Padas Gorge. This is the only direct means of communication between Beaufort and the interior part of the residency. There are regular passenger and goods train services, as well as small rail-cars for passengers only. The road link with Kota Kinabalu through Tambunan has reduced the dependence of the people of the Keningau and interior areas on the railway as a means of communication but nevertheless it is still very important, particularly for the people living in the Tenom and Tenom Plain area.

Water

There are few rivers which are regularly used for communication purposes and in all cases are only navigable by craft of any size for a very short distance from the sea. The Klias and Padas Rivers provide a means of communication for some of the villages and settlements on the Klias Peninsula, and in the Pensiangan District river transport is important for communication between Pensiangan, Agis and the Indonesian border (Plate 4-2). The Mengalong River on Brunei Bay is navigable by small shallow draught vessels for some distance from its mouth. Water transport is the only method of communication between Labuan and the rest of the residency.

The only deep-water port in the Interior Residency is on Labuan Island. The present wharf can handle ocean-going vessels of reasonable size while the new wharf at present under construction is expected to have a minimum water depth of 9 m (30 ft) and will provide improved facilities.

There is a regular shipping service between Labuan and Port Klang in peninsular Malaysia with a feeder service to Bandar Seri Begawan and Kuala Belait in Brunei, and Miri and Pending in Sarawak. Cargo vessels from Europe, the USA, Japan and other countries in the orient call regularly. Small craft carry on a considerable coastal traffic between Labuan and ports in Brunei and Sarawak but there is little traffic with other ports in Sabah. There are minor ports at Weston, Sipitang and Mempakul but no regular shipping services call at these ports.

Air

The only airport in the residency with a surfaced runway capable of taking large aircraft is on Labuan. There are regular services from here to Kota Kinabalu to connect with international flights and flights to other major towns in Sabah. There are also daily direct flights to Brunei, Miri, Bintulu, Sibu and Kuching. There are grass airstrips at Keningau and Sapulut with regular services to Kota Kinabalu using small piston-engined aircraft. Grass strips have been constructed at Tambunan, Sapong Estate (Tenom) and Meligan, but they are not regularly used and maintained.

ECONOMY

The economy is based on agriculture, with timber at present playing a minor role but likely to become increasingly important in the future. As much of the external trade is carried out through the port of Kota Kinabalu it is impossible to give meaningful figures for imports and exports. Labuan is an *entrepot* and a large proportion of its trade consists of importing and re-exporting mainly to Brunei and Sarawak. There is a very small volume of trade through the minor ports of Weston, Mempakul and Sipitang.

Agriculture

Agriculture is the mainstay of the economy with rubber and rice the most important crops (Wong, 1973). There is an extensive acreage of the former comprising both large estates and smallholdings and it is at present the most important external trade commodity. Wet rice is grown almost entirely on smallholdings, and although very important to the internal economy by providing food and a livelihood for a large number of people, it plays little part in the external economy. Coconuts are grown, mainly on Labuan and in the Kuala Penyu area, and copra is exported in small quantities from Labuan. There is a small pioneering oil palm industry based on the Klias Settlement Scheme, and Tenom supports a small cocoa-growing industry. Vegetable growing is of some importance in the economy of the Tenom Area, with produce being sold to markets outside the residency. Bananas are grown in the Sipitang/ Sindumin area for the Brunei market.

People living in the hilly and mountainous areas particularly in the southern part of the residency depend on subsistence agriculture, in the form of shifting cultivation, for a livelihood. The main crops are hill rice and tapioca with some maize and vegetables and a little tobacco.

There is a fairly large population of buffalo and cattle mainly on the Tambunan and Keningau Plains and animals, particularly buffalo, are regularly exported to Kota Kinabalu for the supply of meat. Likewise pigs bred in the Tenom area are regularly sent to Kota Kinabalu for slaughter.

Fisheries

There is a commercial prawn fishing industry based on Labuan which contributes to the external trade economy. Apart from this the fishing industry is on a small scale, providing a means of livelihood for people living along the coast and supplying an important source of food, thus playing a part in the internal economy.

Timber

The timber industry, although not very important at present, is rapidly expanding. Operations have started for the extraction of timber from extensive areas in the eastern part of the residency for the export trade.

There are a number of small sawmills scattered throughout the residency. These meet local requirements and the surplus is supplied to the Kota Kinabalu market.

Industry

The most important industry, and one which contributes to both the internal and external economies, is that at Labuan which is engaged in major engineering construction work for oil companies. Offshore oil exploration and production is being carried out along the continental shelf and a large tank farm is being constructed for the storage of oil prior to shipment. There are also boat building and repair industries at Labuan which are locally important.

There is a small oil palm mill in the Klias Peninsula and locally grown rice is milled for domestic consumption in a number of places. Apart from these there is no other industry concerned with the processing of agricultural produce.

Various light industries such as vehicle repairing, minor engineering works and furniture making exist to meet local demands.

Quarrying for roadstone is carried on near Sipitang in the hard sandstone of the Crocker and Meligan Formations.

Part 3

Survey and classification of resources

Part 3 reviews the various investigations of land resources leading to the systematic surveys recently undertaken, It describes how the results of these surveys have been used to produce a land capability classification, fully described in the monograph on *Land Capability Classification* (Sabah, Malaysia, State Department Planning Committee, 1973), parts of which are reproduced in the following text.

Survey and classification of specific resources

The first known scientific investigation was conducted as early as 1852. This was on the geology of Labuan Island and its neighbourhood (Wilson, 1964). The first known penetration into the interior proper, however, was in 1865 when a resident of the American settlement at Kimanis crossed the Crocker Range to Keningau. This part of the journey was to be next repeated in 1882 by F X Witti, an explorer whose main interest was minerals, who travelled onwards almost to Pensiangan before meeting his death (Collenette, 1965). The last part of the century saw increasing interest in the resources, particular by oil and agricultural enterprises.

The search for oil provided invaluable information on the basic geology, and continued until recent times. In the meantime, starting during the second decade of this century, Government initiated a land classification, the ultimate aim of which was 'to produce a map for the state at 2 mi to 1 in on which all areas of valuable forest are shown thereon as well as areas which can be thrown open for agriculture' (State of North Borneo, 1919). This goal was never reached, and very little information has survived.

GEOLOGICAL SURVEYS AND MINERAL RESOURCE GROUPS

Coal was discovered on Labuan in 1844 and a report on the geology of the area was made by J Motley in 1852 (Wilson, 1964). Few or no records are available on the observations made during the early journeys into the interior in 1865 and 1882. In 1889 there was renewed interest in the geology when the prospects for developing an oil industry were investigated on Labuan and the Klias Peninsula. For the next half a century geological survey was to be the almost exclusive province of oil interests. The Klias Peninsula was surveyed in 1908 (Wilson, 1964), the northern half of the inland part of the residency in 1914 (Collenette, 1965), the seaboard covering the Beaufort area to the Sarawak frontier in 1935 (Wilson, 1964) and, to complete the first reconnaissance, the southern half of the inland part in 1936 (Collenette, 1965).

The first overall account of the geology of all these areas was contained in a statewide report (Reinhard and Wenk, 1951). In the meantime there was renewed interest in coal, and the deposits on Labuan and near Weston were investigated in 1947 (Wilson, 1964).

Oil exploration interests again took an active part in investigating, in the 1950's, the geology of Labuan, Padas Valley and the Crocker Range and its adjoining areas (Wilson, 1964; Collenette, 1965).

1954 saw the start of survey operations in the residency by the newly instituted Geological Survey of the then British Borneo Territories. The Tambunan area was investigated as part of the Jesselton*-Kinabalu Survey together with a small part lying within the residency boundary to the west of Bongawan. This was followed by work in the Keningau-Pensiangan section, and by 1963 the geological survey coverage over the whole residency had been achieved with the completion of the Labuan and Padas Valley area. Text Map 4-5 shows the areas covered by the three component surveys. Areas 2 and 3 are mapped at the scale of 1:250 000, while 1:125 000 scale maps are available for Area 1 and also Labuan and nearby mainland on the Klias Peninsula.

During these surveys, sites of mineral deposits were recorded and this information, together with the results of the work undertaken by private prospecting companies, has provided the basis for determining the location, extent and value of the geological resources and their classification. In so doing, special emphasis has been placed on the occurrence of deposits which are workable by an open-cast system of mining, i.e. those which may have an appreciable long-term effect on the use of the land and thereby land capability. Four mineral resource groups are defined as follows:

Mineral Resource Group 1 Current mining land

Mineral Resource Group 2 Proven mining land, where economic mineral deposits have been ascertained as the result of geological prospecting

Mineral Resource Group 3 Possible mining land, where geological evidence of a cursory nature indicates that mineralisation of economic importance may occur

Mineral Resource Group 4 Land with no mining potential, where there is no evidence of mineral deposits

SOIL SURVEYS AND SOIL SUITABILITY (FOR AGRICULTURE) GROUPS

The first soil investigations were probably carried out by planters in the latter part of the 1890s with the opening up, by the newly constructed railway, of the seaboard and the interior for agriculture. For example, the Sook Plain was investigated in 1896 with a view to establishing estate agriculture there (Bower *et al*, 1972). Government might also have been involved in investigating the soils for agriculture, because Tregonning (1958) states that an official announcement was made in 1899 to the effect that the land next to the railway was suited for rubber.

It is apparent that the land classification work undertaken in the residency took very little account of agricultural aspects. The reports on its progress indicate that soil investigations were made in one area only, in 1921 near Mesapol, where 800 ha (2 000 ac) were pronounced suited for agricultural development (State of North Borneo, 1922).

The first important soil survey, that of the Keningau Plain covering some 260 km^2 (100 mi^2) was carried out during the period 1955-56 (Allen and Forster, 1956). During the next 13 years the soils in other areas were surveyed, mostly to discover land suited for rice cultivation. These were essentially *ad hoc* surveys and scanty records were made. No systematic pedological work was undertaken in the residency until 1969 when the soil survey of the Beaufort and Kuala Penyu Districts was started as part of the reconnaissance of the state. Soil maps were produced at the scale of 1:50 000. This was followed by similar work on the other parts of the residency, resulting in complete coverage by 1972. The results have been incorporated, together with those on the adjoining Kota Kinabalu, Penampang and Papar Districts, in the report on the soils of the south-west area of Sabah (Bower *et al.*, 1972; 1975). It should be noted that the latter report is accompanied by a soil map drawn to the scale of 1:250 000 which has been compiled from the 1:50 000 scale soil maps.

* now Kota Kinabalu

The 1:50 000 scale soil maps have not been published but they provide the basic data from which the soils have been classified into groups according to agricultural suitability. The steps involved are as follows. The basic 1:50 000 scale soil maps show the nature, location and extent of the soils; normally as soil associations but sometimes in more detail as soil families or soil phases. These maps form the basis for the soil suitability maps of the same scale which group the soils according to suitability for agricultural use. The suitability is assessed according to limitations to agricultural use associated with various soil characteristics. For the purpose of this classification it has been assumed that a moderate standard of agriculture can be practised, that is, one which is practical and within the capability of the average farmer.

Bower *et al.* (1972) employed the five soil suitability groups defined in Sabah (Sabah, State Development Planning Committee, 1973) and depicted on the 1:50 000 scale soil suitability maps of the residency used in the Land Capability Classification. In their revised report Volume 3 of *Land Resource Study 20, The soils of Sabah (1975),* Bower *et al.* used only three broad categories of soil suitability.

The five* soil suitability groups used here are:

Soil Suitability Group 1 Soils with no limitations to agricultural development

These are generally deep, permeable and well aerated soils with good reserves of moisture; and they are either well supplied with plant nutrients or readily responsive to fertilisers. They are developed on level or almost level land where the upper slope limit is 5^{o}. Having no limitations to agricultural development, the soils are capable of growing a wide range of crops.

Soil Suitability Group 2 Soils with few minor limitations to agricultural development

The limitations may include, alone or in combination: imperfect or poor drainage with a watertable occurring within 120 cm (48 in) of the surface for a significant proportion of the year, rock or similar impenetrable materials occurring between 50 cm (20 in) and 120 cm (48 in) of the surface, extreme coarse textures, or moderate slopes generally falling within the 5-15^{o} range which would not require any expensive form of anti-erosion control, or shallow peat deposits never more than 50 cm (20 in) in depth. Although a wide range of crops can be grown on such soils the choice is generally more restricted compared to Soil Suitability Group 1.

Soil Suitability Group 3 Soils with one serious limitation to agricultural development

This includes soils which are limited for agricultural development because they are on strongly sloping land in the 15-25^{o} range, soils on deposits of peat varying in depth from 50-120 cm (20-48 in), very poorly drained soils in which swamp conditions sometimes prevail, very poorly structured soils, or soils with a very restricted rooting space due to rocks at shallow depths,i.e. within 50 cm (20 in) of the soil surface, or soils showing acute plant nutrient deficiencies. To thrive on this group of soils crops must be specifically adapted to the adverse soil conditions. The group is therefore unsuited for diversified agriculture, and the success of any agricultural enterprise would depend on careful selection of crops and good management.

Soil Suitability Group 4 Soils with more than one serious limitation to agricultural development

This group would commonly include, for example, shallow soils developed on strongly sloping sites, or shallow soils with acute mineral deficiencies and strongly indurated subsurface horizons such as found in many podzols, very poorly drained and saline soils in which permanent swamp conditions prevail. These disadvantages greatly restrict the range and yield of crops, and result in a strong risk element for any agricultural enterprise even with a high standard of management.

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* In *Land Resource Study 20, The soils of Sabah* (Acres *et al.* 1975) only three categories of soil suitability were recognised. They broadly conform with the five groups described here and shown on the 1:50 000 scale suitability maps as follows: Category 1 ('suitable land') corresponding to Soil Suitability Groups 1 and 2. Category 2 ('marginal land') to Group 3, and Category 3 ('unsuitable land') to Groups 4 and 5. The more detailed five-tier system employed on the 1:50 000 scale soil suitability maps is considered more appropriate for the purpose of this report; inevitably, however, some differences in detail have resulted.

Soil Suitability Group 5 Soils with at least one very serious limitation to agricultural development

This would include soils developed on steeplands in which slopes greater than 25° predominate, extremely stony, rocky and boulder-strewn soils or bare rocks, soils with toxic levels of certain elements, and peat deeper than 120 cm (48 in). Agriculture on such soils would generally be inadvisable, or even impossible, but they may have a wide range of capability for forestry, hydrological or wildlife and conservation purposes.

NATURAL VEGETATION AND TIMBER RESOURCE GROUPS

The first recorded investigations on the forest cover were those carried out as part of the land classification. By as early as 1918,27 327 ha (67 526 ac) of mangrove had been surveyed (State of North Borneo, 1919). In 1919-21 interest was switched to the dry-land forest in the Sipitang Area, with 2 000-3 200 ha (5 000-8 000 ac) being covered in the Mengalong Valley (State of North Borneo, 1920) and 800 ha (2 000 ac) near Mesapol (State of North Borneo, 1922). A reconnaissance of the Tambunan bamboo forests was made in 1930 (State of North Borneo, 1931).

The first step towards undertaking a comprehensive forest inventory was proclaimed as early as 1948, when it was proposed that the vegetation cover should be mapped, largely as the result of the interpretation of aerial photographs, on standard 1:50 000 scale map sheets. Actual work in the residency was restricted to the period 1952-53, with a ground reconnaissance being made of the Keningau-Tambunan forests (Colony of North Borneo, 1953), and enumeration surveys of a number of small areas in the Sipitang and Beaufort Districts (Colony of North Borneo, 1954).

For the following seventeen years very little further work of this kind was undertaken, and it was not until 1971 that the Forest Department was to bring out the first systematic forest cover maps. These were based on the standard 1:50 000 scale topographic map sheets and covered the Beaufort and Kuala Penyu Districts. These maps provide the data on the forest resources for those districts in this report. In 1970-72 the whole of the residency was, as part of a statewide coverage, subjected to an aerial photographic survey and forest inventory; and the results, again on 1:50 000 scale maps, have provided the basis for the data used for the remaining part of the residency. The various surveys are shown in Text Map 4-6.

The various forest maps, and the *Forest Inventory Report* (Forestal International Limited, 1973) give an account of the location and extent of forest land, its type and size, and the volume of timber available for logging. All this information, except volume, is shown on the forest maps. Also shown are the terrain and drainage conditions of the land, factors important in timber extraction. The volume data are derived exclusively from the *Forest Inventory Report.* For land capability classification purposes the information relative to the timber production potential is rearranged in order to give an estimate of the present and future productivity of the land, and in so doing commercial aspects are brought in. In cases where the timber has been felled and records exist of the volume of timber realised, such figures are used to estimate the capability of the land. The rating employed relates essentially to the crown size and density of the trees and the volume of merchantable timber, and emphasis is laid on the inherent forest potential of the land. Crown diameter sizes are differentiated into large (over 18 m (60 ft)), medium sized (between 9-18 m (30-60 ft)), and small (less than 9 m (30 ft)). Eight timber resource groups are recognised (Sabah, Malaysia, State Development Planning Committee, 1973).

Timber Resource Group 1

This comprises the most productive forests and typically consists of trees with large crowns which are close together forming over 60% of the canopy; the commercial value is high and yields based on current standards can be expected to exceed 89 m^3 of commercial timber/ha (1 000 Hft^3/ac).

TEXT MAP 4-5 Geological surveys

TEXT MAP 4-6 Forest surveys

TEXT MAP 4-7 Alienation and gazettement mapping

Timber Resource Group 2

These forests contain either fewer trees with large crowns or consist of trees with medium-sized crowns which are close together. If composed of large crowns they form 30-60% of the canopy, if medium-sized over 90%. These are considered to be of average commercial value, and yields can be expected to be 62-89 m^3 of commercial timber/ha (700-1 000 Hft^3/ac).

Timber Resource Group 3

Forest areas contained in this group have a more open canopy formed by large to medium crowns, or if small crowns they are close together. Areas with large crowns have a density less than 30%, those with medium crowns 30-90%, and those with small crowns over 60%. By current standards such forests are considered to be marginally commercial, and may be expected to yield 35-62 m^3 of commercial timber/ha (400-700 Hft^3/ac).

Timber Resource Group 4

Here the forest canopy is generally open, consisting of a few trees with medium to small sized crowns. Such forests would not be considered of commercial value; yields of commercial timber based on present market trends would be expected to be below 35 m^3/ha (400 Hft^3/ac).

Timber Resource Group 5

The forests which form this group are non-commercial consisting of montane forests and forests on hills with soils derived from ultrabasic rocks, which because of their species distribution and small size are of no present commercial value. They might however be used for timber production in the future.

Timber Resource Group 6

This group comprises other non-commercial forests, which include coastal forests, freshwater swamp forests and areas of nipah (*Nipa fruticans*) all of which have no market value and no potential value in the foreseeable future.

Timber Resource Group 7

This group consists of mangrove forests which are commercially exploitable having a reasonable volume of pole-sized timber.

Timber Resource Group 8

This group covers forest plantations, previously logged immature forests for which timber yields cannot be predicted, and all non-forested land including cultivated, urban and derelict land.

HYDROLOGY AND WATER RESOURCES

A number of rainfall recording stations were established in the second and third decades of this century and these provide the earliest data. Hydrological studies, however, were started much later in 1959, with the recording of the level of the Sungei Sook at Sook. By 1964 similar recordings were being made at five other stations: at Keningau on the Pegalan, Sindumin on the Mengalong, at Tenom Lama and Gadong on the Padas, and at Pintas on the Sungei Klias. These studies were extended in 1968 when four gauging stations were commissioned: two on the Padas, at Keningau and Tenom Lama, and others on the Pegalan at Kemabong and the Sook at Biah. The location of the main hydrometric stations is shown in Text Map 4-3.

By 1968 rainfall data were being kept at 21 stations, with Keningau and Labuan recording a comprehensive range of climatological information.

Nippon Koei Co., Ltd. (1974) states in its report that the hydrology of the Sungei Padas has been subject to three separate studies concerned with harnessing its hydroelectric potential. The first was by the British Aluminium Co. in the 1950s in connection with a proposed aluminium refining plant at Sipitang. In 1963 the Snowy Mountains Hydroelectric Authority identified two sites in the Padas Gorge for hydroelectric generating purposes, with a smaller project up-river near Sapong. This was followed by a further study, by Lau and Partners in association with Kennedy and Donkin, who identified three points in the gorge which might be used for the purpose. The report by Nippon Koei, in addition to giving detailed recommendations on the construction of power-generating facilities, gives a general account of the hydrology of the Padas water-catchment area.

The information obtained as the result of these special consultancies, together with the basic data contained in the *Hydrological Records of Sabah* to 1968 (Sabah, Malaysia, Department of Drainage and Irrigation, 1970), forms the basis for the description of the water resources given later in this volume.

TOPOGRAPHY AND PLANIMETRY

The first part of the residency to be mapped topographically was the Padas-Pegalan Valley. This was in 1951 and, although not conforming to the standard quarter-degree sheet lines, was the forerunner of 1:50 000 scale mapping. This was shortly followed by a similar map for the Sipitang-Royoh area.

The first standard 1:50 000 topographic maps were published in the early 1960s. These were for the north, and the coverage gradually increased in extent southwards until, by 1970, the whole residency had been completed. These maps provide the basis for all the 1:50 000 scale mapping undertaken for both the Land Capability Classification and the various land resource maps.

LAND TENURE

The earliest known land record is for a government reserve at Beaufort in 1911, and the first title on land was in the form of a country lease, again at Beaufort, in 1914. In the following years a number of areas were alienated for agricultural purposes, the records being maintained at the Land Registry Office at Sandakan, then the state capital. This office was also responsible for gazetting land for specific government or communal purposes. The Padas River Forest Reserve was the first to be established, in 1920, and the first grazing and village reserve was gazetted at Tenom in 1929.

TABLE 4 The classification of the alienation and gazettement units

Land category	Alienation and gazettement units
Alienated land	Land alienated under leases and provisional leases, native titles and on field registers, settlement schemes, village reserves and areas proposed for alienation
Forest reserve	Land gazetted as protection, commercial, domestic, amenity, and mangrove forest reserves
Government reserve	Land allocated as state, airport, cemetery, educational, military, police station, quarry, tamu-ground, agricultural, veterinary, bird sanctuary and water supply reserves
Grazing reserve	Land allocated for communal pastoral purposes
Stateland	Land not allocated for government or private use

After World War II the land records were transferred and maintained at the Lands and Surveys Department headquarters at Kota Kinabalu. The task of systematically depicting the information on the standard 1:50 000 scale map sheets of the residency started in 1971 and was completed in 1974. The various stages involved are shown in Text Map 4-7, and the forms of alienation and gazettement shown on these maps are given in Table 4.

GAME AND RECREATIONAL RESOURCES

Very little has been published on the game resources even though some of the earliest collections were made well over a hundred years ago. These were undertaken by inhabitants of the newly established settlement on Labuan and the work was closely associated with the British Museum. It was carried out intermittently, mainly by H Low from 1848 to 1877 and J Motley 1850 to 1854 (Medway 1965).

The first important collection of mammals, however, was to await 1928 when a Raffles Museum Expedition was based at Royoh on the Padas Gorge (Davis, 1962).

After World War II interest was largely centred on Trus Madi. R E Ebel collected there in 1953, and the Cambridge University North Borneo Expedition studied the animal life of the mountain in 1956 (Medway, 1965).

This information, together with the checklists in Davis (1962) and Medway (1965), provides the basis for the information on the game resources contained in this report.

Little or no attention has been given to the recreational resources. The knowledge which is available is contained later in this report.

PRESENT LAND USE

Even though a census of the main agricultural crops was undertaken in 1961, the first comprehensive survey of land use was only made in 1972. This survey was based on the interpretation of the aerial photographs taken as part of the Forest Inventory. The results are incorporated in a report for the residency (Wong, 1973), and maps drawn to the scale of 1:50 000, 1:250 000 and 1:500 000 have been compiled. The information is presented according to the form recommended by the International Geographic Union with the identification of individual crops as they occur. The present land use categories, ranging from the most intense use to the least intense, are:

Category 1 Urban and associated land

Category 2 Horticultural land

Category 3 Permanent crops, commonly tree crops in plantations and orchards

Category 4 Shifting cultivation

Category 5 Permanent improved pasture

Category 6 Natural grassland

Category 7 Forest land

Category 8 Swamp, marshland and wetland forests

Category 9 Unused land

The land capability classification

This section is devoted to describing how the results of the various surveys and investigations described in the previous account are processed in order to arrive at a land capability classification. The classification employed is that of the *Land Capability Classification* (Sabah State Development Planning Committee, 1973) and is based on the earlier work undertaken in Peninsular Malaysia (Panton, 1966).

Factual economic data concerning land use are not available and the approach to land capability therefore rests on the basic assumption, which is supported generally in practice throughout Malaysia, that mining is more profitable than agriculture and that both are more profitable than forestry.

The groupings involved in the classification essentially indicate the most profitable use to be made of the land. It is an attempt to interpret and express to the best advantage current knowledge on its use, and as new experience is acquired revision will be needed. The classification is based solely on the probable economic gains which can be obtained from the land under the level of management in common practice, and not necessarily upon current usage. Such factors as accessibility, social benefit, the pattern of land ownership and current land use, although affecting decisions about development, do not influence the grading. The system employed does not attempt to indicate the specific nature of the resource type, i.e. nature of the mineral reserve, agricultural and forest crop.

LAND CAPABILITY CLASSES

The various natural resource groups are interpreted into five land capability classes, and these are set up so that land having the greatest number of theoretical alternative uses, but probably giving the highest monetary return on development, is in Class I and land having the least number of uses is in Class V, with the number of uses becoming progressively smaller between these two classes. This indicates, for example, that although recreation and wildlife areas can be established theoretically in all five classes, the optimum use of the land will depend on the existence of adequate levels of minerals, or its agricultural crop potential or timber exploitation capacity, always in that order of importance, thus determining the form of land use which is likely to provide the maximum economic benefit. It should be noted that the Class I land in the residency possesses a mining potential only; agricultural and forestry prospects on such land are low. The five classes are defined thus:

Class I **Land with a high potential for mineral development**

Class II **Land with a potential for agriculture with a wide range of crops**

Class III **Land possessing a moderate potential for agriculture with a restricted range of crops**

Class IV **Land with no mining or agricultural potential, but a potential for forest resource exploitation and best suited for this purpose**

Class V **Land with no potential for mining, agriculture or forest resource exploitation and is generally best suited for conservation or recreational purposes**

LAND EXPLOITATION UNITS

Any one area of land may have one or more resources which may be economically exploitable. It follows, therefore, that on broader scale natural groupings of land occur with similar qualities and uses, each having the same kinds of natural resource potential. These are defined as land exploitation units and are essentially complementary to and fall within the five land capability classes which have been recognised. Falling in a lower order in the classification, these units serve the purpose of providing a comprehensive range of information on the capability of the land, and thus any alternative

uses. The overall recommendation, however, as to the future use of the land is defined at the land capability class level. The relationship between the resource groups and the other elements employed in the classification is set out in Table 5. Each unit has a land capability class connotation followed by a suffix indicating the assigned land exploitation unit. The following land exploitation units are recognised:

Unit 1A Land possessing a high potential for mineral development and therefore best suited for mining

Unit IIA High potential for agriculture only

Unit IIC High potential for agriculture and a marginal potential for timber exploitation

Unit IID High potential for agriculture and also a possible mining potential

Unit IIIA Moderate potential for agriculture

Unit IIIB Moderate potential for agriculture and also a high potential for timber exploitation

Unit IIIC Moderate potential for agriculture and also a marginal potential for timber exploitation

Unit IIID Moderate potential for agriculture and also a possible mining potential

Unit IIIF Moderate potential for agriculture, a marginal potential for timber exploitation and also a possible mining potential

Unit IVA High potential for timber exploitation only

Unit IVB Marginal potential for timber exploitation only

Unit IVC High potential for timber exploitation and a possible mining potential

Unit IVE Productive mangrove resources only

Unit VA Little or no potential for agriculture or forest resource exploitation, and best suited for protective or recreational purposes

Unit VB Little or no potential for agriculture or forest resource exploitation, but with a possible mining potential

TABLE 5 The relationships between resource suitability groups, land capability classes and land exploitation units

Land capability class	Land exploitation unit	Resource suitability groups*		
		Mineral	Soil	Timber
I	IA	1-2	4-5	4-6, 8
II	IIA	4	1-2	4-6, 8
	IIC	4	1-2	3
	IID	3	1-2	4-6, 8
III	IIIA	4	3	4-6, 8
	IIIB	4	3	1-2
	IIIC	4	3	3
	IIID	3	3	4-6, 8
	IIIF	3	3	3
IV	IVA	4	4-5	1-2
	IVB	4	4-5	3
	IVC	3	4-5	1-2
	IVE	4	4-5	7
V	VA	4	4-5	4-6, 8
	VB	3	4-5	4-6, 8

*For definitions see previous text.

These units are recognised in order to provide a framework for developmental planning of the resources of the land. This then lends itself with ease to multiple land-use planning which will be of future importance, because alternative choices of land-use must always be considered from time to time and frequently from one region to another owing to changes occurring in the economic or social structure.

CARTOGRAPHY, AREA MEASUREMENT AND DATA TABULATION

Using 1:50 000 scale topographic maps as a base, the information obtained from the surveys is correlated by overlaying the various maps so as to enable the boundaries of the land exploitation units to be drawn. In this way the basic land capability maps are compiled. The land exploitation units are shown on 1:50 000 scale maps, and are grouped together as land capability classes on the 1:250 000 scale maps which are published with this report. The land capability maps also show the main geographical features. The location of present and potential quarry sites are shown on the 1:50 000 scale maps. The different land categories are shown in various colours on the maps.

In order to assist land development planning at the local administrative level all the 1:50 000 scale thematic, topographic and land tenure maps are arranged to cover each district. Twelve loose bound volumes are produced for each, with all the materials lying flat. These provide the minimum essential information for local planning, and copies are held at the main district and headquarter offices of the relevant departments for that purpose.

All area measurement was made in acres on the 1:50 000 scale maps using dot-counting planimeters. Translucent copies of the present land use maps were superimposed on the land capability maps, and the various forms of land use were measured with the land exploitation units and alienation and gazettement categories. Sheet acreages were first tabulated, and cumulative totals were then compiled to arrive at the district and then residency figures. The acre figures were then converted to hectares. This should be kept in mind when reading the various tables.

Part 4

The resources and their distribution

As most of the residency is mountainous and rugged, and formed on sedimentary rocks almost devoid of minerals of economic importance, its land resources are of far less importance than those of the east coast (see volumes 1 and 2 of this *Land Resource Study*). The land suited for agriculture is generally confined to narrow stretches along the seaboard, and on parts of the interior plains. Extensive areas of forest have been destroyed by shifting cultivators, and much of the commercial forests which remain are located in poorly accessible inland areas. There are extensive tracts of grassland on some of the interior plains on which attempts are being made to establish a beef industry. The high rainfall and steep terrain contribute to an important, but little used, water resource base. The residency is not particularly well endowed with game and recreational land resources, and the coal on Labuan is the only known mineral of economic importance.

A general account of the types, extent and location of the land resources is given below.

Mineral resources

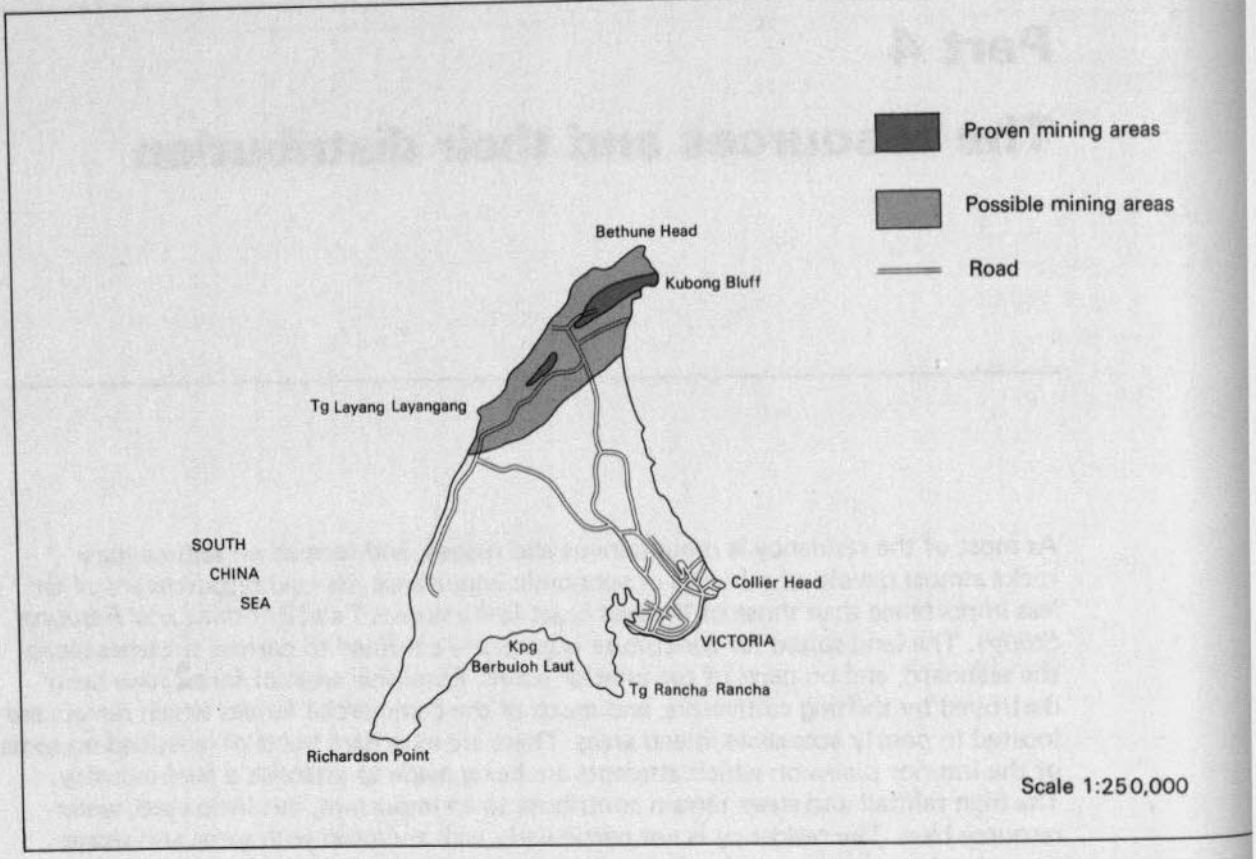
Of the five residencies in Sabah, the Interior Residency is unique in having no known metalliferous mineral deposits. In other parts of the state geological surveys and prospecting have revealed that mineralisation of economic interest is mainly related to the occurrence of igneous rocks; and it will have been noted during the description of the geology that such rocks do not occur in this residency.

The country rocks are predominantly lithic successions of sandstones, mudstones and shales, and so far coal is the only mineral of importance which has been discovered. The deposits constitute the only proven (Mineral Resource Group 2) and possible (Group 3) mining resource, and this has been largely deduced from previous mining operations carried out in the Labuan Coalfield.

Coal

The occurrence of coal has been known for a considerable period of time and deposits were mined on Labuan for sixty years. Text Map 4-8 shows that the coalfield covers an area of 1 641 ha (4 060 ac) over the northern part of the island. The following account is largely based on the description made by Wilson (1964) of the geology and mineral resources.

Four coal seams are known to occur. They are interbedded with sandstones and shales, vary in thickness from 0.6 m (2 ft) to 3.4 m (11 ft) and are inclined generally between 15 and 35°. Analyses have shown the coal to be lignitic or sub-bituminous.



TEXT MAP 4-8 The Labuan Coalfield

D.O.S. 3238 Bn

Prepared by the Directorate of Overseas Surveys 19

The proven reserves (Group 2) have been mapped in two small areas which together total some 184 ha (456 ac). Their adjoining lands have been designated as possible for mining (Group 3), and cover 1 457 ha (3 604 ac).

The coal was worked at a number of places, with some temporary stoppages, from 1846 to 1911. Production at its peak in 1896 was 45 715 t (46 449 lgt), although the total marketed from the field is thought to have been no more than 442 290 t (450 000 lgt). The reserves remaining to a depth of 600 m (2 000 ft) have been estimated at around 8 857 800 t (9 000 000 lgt).

Low quality coal has been known to occur near Weston since 1886. It is found in shallow seams and lenses, but the amount available is thought to be small, probably only a few tens of thousand tons.

Soil resources

The physiography has been described in Part 3 of this volume, and it will have been noted that it is dominated by a number of mountain ranges and the swamps of the Klias Plain. The soils are therefore generally poor in quality and those suited for agriculture are restricted to the low hills and riverine tracts of the seaboard and parts of the interior plains. Such soils occupy a small proportion of the residency, as can be seen from Table 6 where Soil Suitability Groups 1, 2 and 3 comprise only 10.3%, some 183 438 ha (453 280 ac).

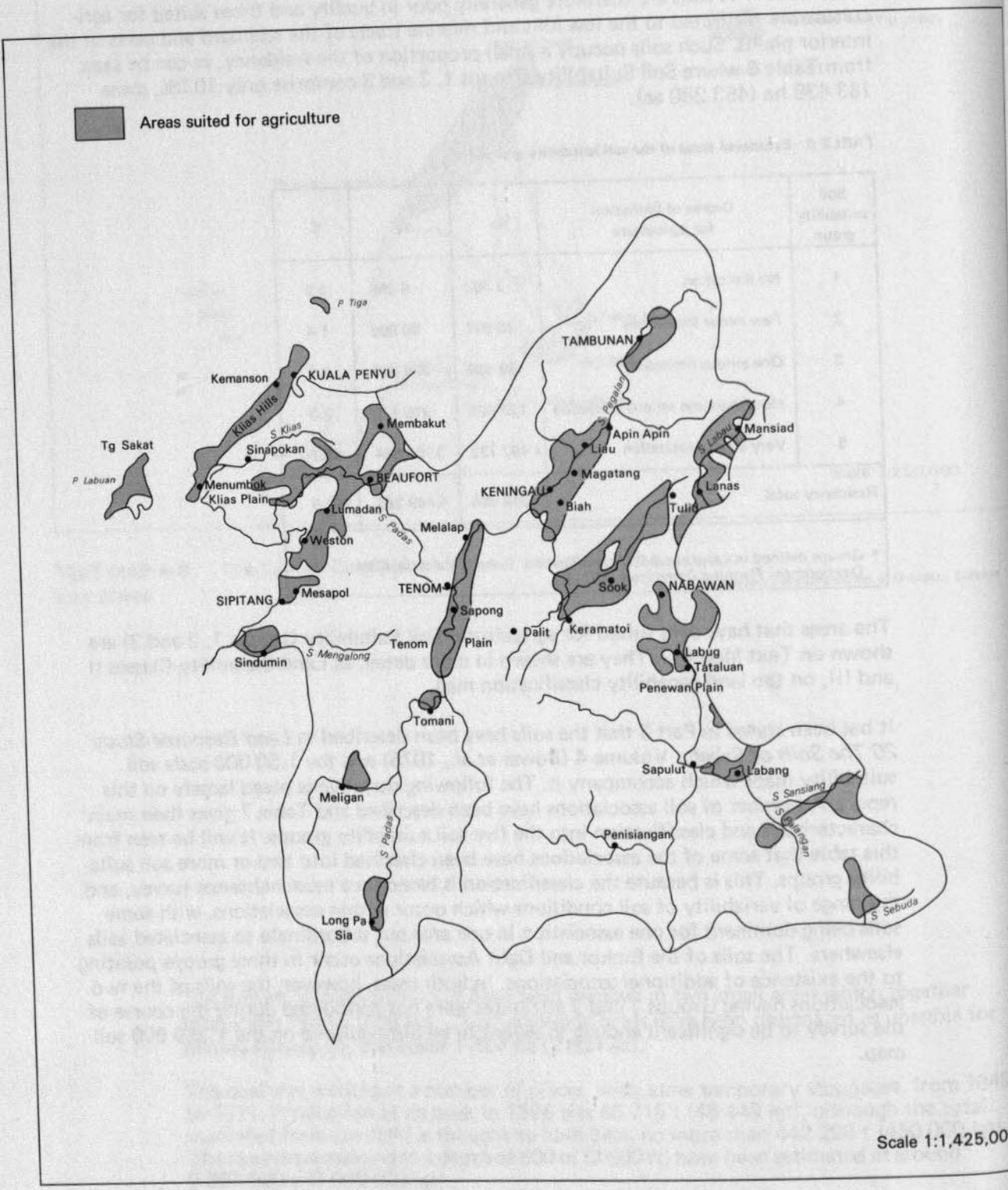
TABLE 6 Estimated areas of the soil suitability groups*

Soil suitability group	Degree of limitation for agriculture	ha	ac	%
1	No limitation	3 382	8 358	0.2
2	Few minor limitations	20 597	50 895	1.4
3	One serious limitation	159 459	394 027	8.7
4	More than one serious limitation	127 526	315 120	7.0
5	Very serious limitation	1 497 722	3 700 864	82.7
Residency total		1 808 686	4 469 264	100.0

* Groups defined in *Land capability classification* (Sabah, Malaysia, State Development Planning Committee, 1973)

The areas that have soils suited for agriculture (Soil Suitability Groups 1, 2 and 3) are shown on Text Map 4-9. They are shown in more detail, as Land Capability Classes II and III, on the land capability classification map.

It has been stated in Part 3 that the soils have been described in *Land Resource Study 20 The Soils of Sabah,* Volume 4 (Bower *et al.*, 1975) and the 1:50 000 scale soil suitability maps which accompany it. The following narrative is based largely on this report. A number of soil associations have been described and Table 7 gives their main characteristics and classification into the five soil suitability groups. It will be seen from this table that some of the associations have been classified into two or more soil suitability groups. This is because the classification is based on a reconnaissance survey, and the range of variability of soil conditions which occur within associations, with some soils being dominant for one association in one area but subordinate to associated soils elsewhere. The soils of the Binkor and Dalit Associations occur in three groups pointing to the existence of additional associations. In both cases, however, the soils of the two associations having Groups 1 and 2 attributes were not considered during the course of the survey to be significant enough in extent to be distinguished on the 1:250 000 soil map.



TEXT MAP 4-9 Areas suited for agriculture (Soil Suitability Groups 2 and 3)

TABLE 7 Soil suitability classification and soil associations

Soil suitability group	Soils		Soil association
	Landform	Parent material	
1	Terraces	Alluvium	Binkor
2	Gently sloping hills	Sedimentary rocks	Dalit
		Mudflows and sedimentary rocks	Kretam
	Terraces	Alluvium	Binkor
	Meander belts		Tuaran
3	Strongly sloping hills	Sedimentary rocks	Dalit
			Kalabakan
		Alluvium	Sinarun
	Terraces		Binkor
			Brantian
	Valley floors and terraces		Labau
	Meander belts		Tuaran
	Floodplains		Kinabatangan
	Freshwater swamps		Sapi
	Stranded beaches	Calcareous sand	Usukan
4	Strongly sloping hills	Sedimentary rocks	Dalit
	Terraces	Alluvium	Kepayan
			Sook
	Tidal swamps		Weston
	Stranded beaches	Siliceous sand	Tanjong Aru
5	Mountains and steeplands	Sedimentary rocks	Serudong Maliau Crocker Lokan Trus Madi Gomantong
	Freshwater swamps	Peat and alluvium	Sipitang
			Klias

SOIL SUITABILITY GROUP 1 NO LIMITATION

Group 1 soils have only been recognised on the Tenom Plain (see Plates 4.3 and 4.4) where they have been mapped as the Binkor Association. They occur on low terraces formed from slightly raised alluvium. These terraces are generally flat to gently sloping and are occasionally cut by small streams.

The soil parent materials are relatively recent deposits of medium textured alluvium. Even though the alluvium has been derived from sandstones and shales the nutrient status of these soils on the Tenom Plain is in the medium range, reflecting the youthful nature of the alluvium and a low degree of weathering and leaching.

Drainage in the soils of the Binkor Association is generally poor but on the Tenom Plain imperfect to well drained conditions prevail which distinguish these soils in the area from those of the association in other parts. Poorly drained localised areas do occur imposing localised minor limitations for agriculture.

These soils are restricted to a continuous 2 000 ha (5 000 ac) terrace running north from Tenom Town to Melalap and about 400 ha (1 000 ac) to the south of Sapong.

PLATE 4.3 Good growth of cocoa, under *Gliricidia* shade, on Group 1 soils on the Tenom Plain

PLATE 4.4 Rubber cultivation on Group 1 soils on the Tenom Plain

SOIL SUITABILITY GROUP 2 ONE OR MORE MINOR LIMITATION

Soils with minor limitations for agriculture are associated with a number of low hills and terraces in the Klias Hills and the Tenom Plain. The limiting factors may be due to topographic or drainage features.

Soils developed on gently sloping hills

Group 2 soils found on this type of terrain have only been recognised on the Klias Hills and the neighbouring Pulau Tiga. The hills are formed by two distinctive materials. Pulau Tiga and a part of the nearby mainland are characterised by a series of volcanic mud effusions which have formed hills about 80 m (250 ft) high, while further to the south in the Klias Hills the occurrence of relatively soft mudstones, and shales with subordinate sandstone beds,are marked by a series of low hills rarely more than 30 m (100 ft) in amplitude.

The volcanic mudflows are composed of clay with fragments of sandstone and shale and the soils are predominantly fine textured and deep, although rock rubble is frequently encountered at depth. These are well structured soils which have levels of plant nutrients adequate for most agricultural crops. The profiles investigated have been described as being imperfectly drained which is not considered to be a limiting factor as far as agricultural development is concerned. The only limitation recognised is that due to the slopes on which the soils are developed. These are normally in the 5-15^{o} range, which is a minor limitation. These soils are of very limited extent, with 500 ha (1 300 ac) being mapped on Pulau Tiga and 300 ha (700 ac) near Kuala Penyu.

A minor limitation due to slopes in the 5-15^{o} range is also recognised in the soils developed from the sedimentary rocks. Otherwise they are suited for a wide range of agriculture crops, being predominantly deep, fine textured with moderate to strong structural aggregation, and at least moderate levels of plant nutrients.

These soils have been described by Bower *et al.* (1972) as the Dalit Association. The modal slope for this association is given as 15-20^{o}, which is considered to be a serious limitation; whilst in the Klias Hills it will have been noted the slopes vary from 5-15^{o}. It will be seen, therefore, that most of the soils mapped as the Dalit Association have been classified as Group 3, and some as Group 4.

The Group 2 soils of the Dalit Association described above occupy an area of about 4 000 ha (10 000 ac) on the line of low hills running from Sinapokan to Menumbok.

Soils developed on terraces

The Group 1 soils of the Binkor Association have already been described and it will have been noted that they are restricted to the Tenom Plain. At the southern end of the plain, however, poor drainage conditions prevail and this imposes a minor limitation for agriculture. Otherwise the soil conditions are similar to those of the Group 1 soils. 800 ha (2 000 ac) only have been mapped.

Soils developed on meander belts

Group 2 soils developed on meander belts are restricted to the Tenom Plain where they form continuous tracts of land adjacent to the Pegalan and Padas Rivers. They have been mapped as the Tuaran Association over an area of 6 000 ha (15 000 ac). These are deep alluvial soils ranging from coarse textured levee deposits to loams, silts and clays away from the river banks; medium textures predominate. Drainage conditions likewise vary, from freely draining in the coarse levee deposits to very poor in the finer textured and lower lying areas away from the river banks. The modal drainage class however, is considered to be poorly drained; a minor limitation for agriculture. Otherwise these soils can be considered to be amongst some of the best in the residency. Even though they may be covered by flood-waters every few years,inundation is never long and the waters rapidly recede leaving deposits of fresh alluvium, thereby periodically replenishing their plant nutrient levels.

SOIL SUITABILITY GROUP 3 ONE SERIOUS LIMITATION

The Group 3 soils described in the Interior Residency are of wide variety and developed on a distinctive range of landforms and parent materials. The limiting factors found in these soils are due to shallowness, or a strongly sloping land surface, or drainage.

Soils developed on strongly sloping hills

Derived from sedimentary rocks

These are composed of sandstones, mudstones and shales. These rock types vary in proportion from place to place, but generally shales appear to be dominant in the east of the Pensiangan District and sandstones elsewhere.

They have been mapped by Bower *et al.* (1972) as the Dalit and Kalabakan Soil Associations, the latter being restricted to the shale formations to the east of Pensiangan. The Group 2 soils of the Dalit Association have already been described. The main difference with these soils is the terrain, the hills being higher with amplitudes up to 80 m (250 ft) with some as much as 150 m (500 ft) and slopes in excess of 15°, sometimes up to 25°.

The terrain therefore restricts the use of these soils more than any other feature, and constitutes a serious limitation. An additional, but minor, limitation occurs with the soils of the Kalabakan Association which are moderately shallow, bedrock normally occurring within 100 cm (40 in) of the surface. The main occurrences are given in Table 8.

TABLE 8 The major occurrences of Group 3 soils developed on strongly sloping hills and derived from sedimentary rocks

Region	Area	Extent	
		ha	ac
Crocker Foothills	Beaufort–Weston	9 800	24 000
	Sipitang	5 300	13 000
	Beaufort–Membakut	8 500	21 000
	Membakut	4 500	11 000
Western Islands	Labuan	4 900	12 000
Kuamut Highlands	Ulu Sebuda	4 000	10 000
	Ulu Sansiang	3 300	8 000
	Ulu Palangan	1 600	4 000
Talankai Valley	Labang	3 600	9 000
Sook-Dalit Plain	Dalit	1 600	4 000
Witti Range	Tenom	800	2 000

Derived from alluvial deposits

Strongly sloping hills formed by alluvial deposits are common to all the interior plains except for the Sook-Dalit Plain. They are also common in the Labau Valley. The hills constitute strongly dissected terrace remnants with amplitudes of relief of 30-60 m (100-200 ft). Slopes are generally in the 15-25° range but the summit areas may sometimes be flat. The alluvial deposits overlie sandstones and shales which can be exposed in places by the removal of the alluvium.

The soils are deeply developed, and medium soil textures predominate although high pebble contents are characteristic for the north-eastern flanks of the Keningau and Tenom Plains. These are old leached soils and the plant nutrient levels are low. They will, however, respond readily to fertilisers and, because of this, the nutrient status is not considered to be a serious limitation to agriculture. Here again the strongly sloping terrain influences the grading into Group 3. Their main occurrences are given in Table 9

TABLE 9 **The major occurrences of Group 3 soils developed on strongly sloping hills and derived from alluvial deposits**

Region	Area	Extent	
		ha	ac
Tenom Plain	Melalap to Tomani	8 500	21 000
Witti Range	Lanas	6 100	15 000
	Mansiad	5 300	13 000
Penawan Plain	Pandewan	4 500	11 000
Keningau Plain	Keningau	3 200	8 000
	Liau to Apin Apin	2 800	7 000
	Biah	1 200	3 000

Soils developed on terraces

These include the poorer areas of the Binkor Association, the Group 1 representatives of which have already been described, and the soils of the Brantian Association. The terraces have flat to rolling surfaces which, particularly with those of the Brantian Association, may be locally dissected giving rise to short flanking slopes generally less than 15°. They are widespread along the seaboard and interior plains and valleys.

The terraces are formed by deposits of old alluvium and are of extremely variable texture and may be very pebbly. The soils are accordingly very variable; but the modal profile would be well drained, deeply developed, and medium textured with moderately developed structural aggregation. They have been subject to strong leaching processes, and this is particularly marked in some small scattered areas with soils composed of almost sterile bleached sands, which are generally podzols. Accordingly, the plant nutrient levels of these soils are in general low, imposing a serious limitation to agricultural development. Other limiting factors which may occur include a high pebble content, local poorly drained areas, extremely coarse textures and topographic limitations on the flanking slopes of the Brantian terraces. These factors are, however, never extensive enough or of sufficient seriousness to affect the Group 3 rating of the two associations. The main occurrences are given in Table 10.

TABLE 10 **The major occurrences of Group 3 soils developed on terraces**

Region	Area	Extent	
		ha	ac
Sook-Dalit Plain	Keramatoi to Tulid	17 000	42 000
Keningau Plain	Keningau	9 300	23 000
	Liau to Apin Apin	4 000	10 000
	Magatang	1 200	3 000
Crocker Foothills	Mengalong Valley	3 600	9 000
	Sipitang	400	1 000
Penawan Plain	Nabawan	3 200	8 000
	Pandewan	1 200	3 000
Klias Hills	Kuala Penyu	3 200	8 000
	Belanot	800	2 000
Tenom Plain	Sapong	2 800	7 000
	Melalap	400	1 000
Meligan Range	Meligan	2 000	5 000
	Long Pa Sia	1 200	3 000
Witti Range	Lanas	2 000	5 000

Soils developed on valley floors and terraces

In the interior, most of the floodplains of all the main rivers have been mapped as the Labau Association, in which discontinuous low alluvial terraces flank the floodplains, especially along narrow valleys. The river courses are marked by low levees and small islands and, particularly on the Keningau and Tambunan Plains, may be braided. Short term flash flooding is a common feature.

The alluvial deposits are very variable, ranging from sands and pebble beds on the Tambunan Plain and parts of the Keningau Plain to moderately fine to medium textured material on the Sook-Dalit Plain, the southern portion of the Keningau Plain and parts of the Talankai Valley.

The soils are correspondingly variable, with coarse textured soils developed on the sandy and pebbly alluvium of the levees and eyots, while further away from the river banks the texture usually becomes progressively finer and drainage conditions deteriorate, frequently becoming very poor. It can therefore be seen that any one of two serious limitations may operate at any one place. These are coarse textures and very poor drainage which, combined with the minor flooding problem, seriously restrict their suitability for agriculture. Their main occurrences are given in Table 11.

TABLE 11 The major occurrences of Group 3 soils developed on valley floors and terraces

Region	Area	Extent	
		ha	ac
Keningau Plain	Keningau to Apin Apin	5 300	13 000
Sook-Dalit Plain	Dalit to Keramatoi	3 600	9 000
Tambunan Plain	Sinsuron to Tambunan	2 400	6 000
Talankai Valley	Labang	1 600	4 000
	Sapulut	400	1 000
Kuamut Highlands	Ulu Sansiang	1 200	3 000
Tenom Plain	Sapong	800	2 000
Penawan Plain	Labug	800	2 000
	Pandewan	400	1 000
	Tataluan	400	1 000

Soils developed on meander belts

Soils of the Tuaran Association, which are developed on meander belts, have been described earlier under Soil Suitability Group 2. These, it will have been noted, have only one minor limitation, that is being predominantly poorly drained. Areas of the same association have also been mapped with even poorer drainage conditions, to such an extent as to impose a serious limitation to agricultural development. Otherwise the soil conditions appear similar to those described during the earlier account on the Group 2 representatives.

By far the most extensive area lies adjacent to the Padas and Klias Rivers in the Beaufort area, where the alluvium is associated with extensive peat swamps. Some 12 900 ha (32 000 ac) have been mapped in that area. About 3 300 ha (8 000 ac) also occur under similar conditions in the Membakut area. The other major occurence is along the upper reaches of the Padas River just after it enters the Tenom Plain, which covers 1 100 ha (2 600 ac).

Soils developed on floodplains

These are associated with the larger rivers of the seaboard. The soils are predominantly very poorly to poorly drained, generally constituting a serious limitation to agriculture.

Soil parent materials are mainly medium to fine textured alluvium. In some places the riverine alluvia overlie old beach sands and sometimes peat deposits.

Without their inferior drainage these soils would be suited for most agricultural plants, being deep, stoneless, medium to fine textured and with moderate levels of plant nutrients. An account of their general distribution is given in Table 12.

TABLE 12 The major occurrences of Group 3 soils developed on floodplains

Region	Area	Extent	
		ha	ac
Klias Hills	Kuala Penyu to Sinapokan	2 400	6 000
	Belanot	400	1 000
	Kemansan	400	1 000
Crocker Plains	Mesapol	1 200	3 000
	Sindumin	1 200	3 000
	Sipitang	400	1 000
Klias Plain	Lumadan	1 200	3 000
	Weston	400	1 000

Soils developed in freshwater swamps

In some low-lying tributary valleys, mainly between the tidal swamps and hills, small areas of backswamps are to be found. These are never extensive, a total of just over 500 ha (1 300 ac) only being found in the residency. By far the largest areas are on Labuan but, even so, only 200 ha (600 ac) have been mapped on the island.

The soils are very poorly drained, and swamp conditions prevail except during exceptionally dry periods. They are formed predominantly of medium to fine textured alluvium although very localised peat deposits may occur. Otherwise they have the same general characteristics as the related floodplain soils.

Soils developed on stranded beaches

These consist of coral and shell debris in the form of stranded ridges and swales. The soils consist of calcareous sand, and the soil drainage depends on the local topography, poor in the swales and generally imperfect on the strand crests. Otherwise, being developed on an easy terrain and endowed with high levels of plant nutrients, they afford a favourable medium for most agricultural crops. They are, however, of very limited extent, covering a total of just under 900 ha (2 200 ac) only in the residency. These are mainly restricted to a number of beaches near Kuala Penyu and on Pulau Tiga and Labuan.

SOIL SUITABILITY GROUP 4 MORE THAN ONE SERIOUS LIMITATION

Soils developed on strongly sloping hills

Extensive areas of the Dalit Association have been mapped in the interior as Soil Suitability Group 4. This is attributed to topography and nutrient status imposing two serious limitations. It will have been noted that other areas of the association have been classified as Group 2 in the Klias Hills and Group 3 in other parts of the residency.

Apart from the low level of nutrients reported in the Group 4 representatives the soils and topography are similar to those described for the Group 3 representatives. It is, however, important to appreciate that the soils have been mapped on a reconnaissance level only and more detailed investigations might possibly reveal that the low fertility which has been attributed to these soils may not be so serious; in which case they would more fittingly be placed in Group 3. The main occurrences are given in Table 13.

TABLE 13 The major occurrences of Group 4 soils developed on strongly sloping hills

Region	Area	Extent	
		ha	ac
Sook-Dalit Plain	Dalit to Keramatoi	45 300	112 000
Trus Madi Range	Apin Apin to Sook	15 800	39 000
Crocker Range	Keningau	2 800	7 000
Penawan Plain	Labau to Pandewan	2 800	7 000

Soils developed on terraces

A number of terraces occur, both on the seaboard and the interior plains, which are marked by sandy soils. Two soil associations belonging to Soil Suitability Group 4 have been mapped on these terraces, the Kepayan and Sook Associations.

The soils of the Kepayan Association are predominantly podzols, consisting essentially of layers of white, almost sterile, sand which may reach a thickness of well over 3 m (10 ft), e.g. on Labuan. The normal thickness is 30-60 cm (1-2 ft) and overlies dark, frequently hard horizons. The underlying alluvium is generally composed of sand on the coastal terraces, and is fine to medium textured inland. Soil drainage is variable but mainly poor.

The Sook Association has been mapped on the Sook-Dalit and Penawan Plains. In this association the terraces have been incised by a number of shallow stream channels which have given rise to numerous low-lying depressions in which swamp conditions prevail. Podzols occur on both the terrace tops and depressions, although the most common soil is composed of poorly drained coarse textured alluvium. This is very impoverished and the soils in many ways resemble the podzols with which they are closely associated.

It will be seen, therefore, that the factors seriously limiting these soils with regard to agriculture are the low plant nutrient status and coarse texture. Shallowness, due to the presence of an indurated layer, and very poor drainage may be additional serious limitations in certain areas. The main occurrences are given in Table 14.

TABLE 14 The major occurrences of Group 4 soils developed on terraces

Region	Area	Extent	
		ha	ac
Sook-Dalit Plain	Sook-Tulid	18 600	46 000
Penawan Plain	Penawan	3 200	8 000
	Pandewan	400	1 000
Crocker Foothills	Sipitang	1 600	4 000
	Mesapol	800	2 000
	Beaufort	800	2 000
	Weston	800	2 000
Tambunan Plain	Tambunan	800	2 000
	Sinsuron	400	1 000
Western Islands	Labuan	800	2 000
Keningau Plain	Liau	400	1 000
	Biah	400	1 000
Witti Range	Lanas	400	1 000

Soils developed in tidal swamps

These are most extensive in the deltas, although much of the coastline is marked by narrow strips of such soils.

Being close to sea-level they are very poorly drained, and periodic flooding by tidal waters frequently gives rise to saline soil conditions. The salinity and very poor drainage give rise to two serious limitations. In addition, extensive areas may contain high levels of sulphur; and it is likely that in many cases attempts to reclaim such land by draining will result in excessively high acidity levels. Agricultural development is not, therefore, recommended. The main areas are given in Table 15.

TABLE 15 The main occurrence of Group 4 soils developed in tidal swamps

Region	Area	Extent	
		ha	ac
Kilas Plain	Padas Delta	28 800	71 000
	Kuala Penyu	2 400	6 000
Western Islands	Labuan	1 200	3 000
Crocker Plains	Kuala Mengalong	400	1 000

Soils developed on stranded beaches

These are related to the Group 3 stranded beach soils, but they differ mainly because of the mineralogy of the parent material; in this case the sands are composed of almost pure quartz.

The beaches include both those of the present day and older features in the form of strands and swales some 1-3 m (3-9 ft) above sea level. Because of the low-lying nature of these beaches the soils are affected by fluctuations in groundwater level. Those in the swales are usually poorly drained to swampy, while on the ridges the soils may be well drained.

Being composed of quartz the plant nutrient status is low which, together with the extreme coarseness, imposes two serious limitations for agriculture. An additional serious limitation may occur when very poor drainage prevails in the depressions. Their main distribution is given in Table 16.

TABLE 16 The main occurrences of Group 4 soils developed on stranded beaches

Region	Area	Extent	
		ha	ac
Klias Plain	Kuala Penyu to Membakut	4 900	12 000
Klias Hills	Tj. Sakat to Tj. Nosong	800	2 000
Western Islands	Labuan	800	2 000

SOIL SUITABILITY GROUP 5 VERY SERIOUS LIMITATION

Soils developed on mountains and steeplands

These largely cover the areas of high elevation and relief, the Crocker, Meligan, Trus Madi and Witti Ranges, and the Kuamut Highlands. They are not, however, restricted to the mountain chains. Smaller zones generally as a series of ridges are to be found in the Crocker Foothills and the Talankai Valley. In all they cover by far the greatest proportion of the residency, some 1 367 400 ha (3 379 000 ac), or 76%.

Topographic factors, more than any other, impose a very serious limitation to agriculture. Slopes are generally in excess of 25°, the maximum normally considered permissable for farming. In addition to the physical difficulty of cultivating such slopes, accelerated soil erosion is likely to be extreme on clearing the natural vegetation cover for agriculture. Further, these lands comprise the catchments of all the main rivers, and large scale disturbance of the watersheds would result in very serious flood problems on their plains.

These soils are very variable, tending to be shallow and their characteristics largely depend on the nature of the parent rock materials.

Soils developed in freshwater swamps

A number of freshwater swamps are marked by deep peat development. The most extensive of these occur adjacent to the main rivers adjoining the coastal swamps. Less extensive areas are found in depressions on some seaboard terraces and in two high altitude synclinal basins in the Meligan Range.

The formation of the peat can be directly attributed to the accumulation of vegetative matter in stagnant, extremely acid, swamp waters. The peat is usually more than 1.2 m (4 ft) in depth, which is considered to be a very serious limitation to agriculture. In general it is formed from woody material. Strongly acid in reaction and with low levels of plant nutrients together with its waterlogged nature it affords a very poor medium for the growth of agricultural plants. These soils are not, therefore, recommended for agricultural development. The main peat swamp areas are given in Table 17.

TABLE 17 The main peat swamp areas

Region	Area	Extent	
		ha	ac
Klias Plain	Klias Plain	60 700	150 000
Meligan Range	Ulu Pa Sia	1 600	4 000
Crocker Plain	Sindumin	1 200	3 000
Crocker Foothills	Kuala Mengalong	800	2 000
	Sipitang	400	1 000

Forests and their timber resources

INTRODUCTION

Approximately 1 622 000 ha (4 009 000 ac), (92.2%) of the land area is still forested and 70.7% of this is undisturbed high forest. Of the balance 23.5% is secondary and disturbed forest, mainly regrowth following shifting cultivation while the remaining 5.8% is swamp forest including freshwater, mangrove and nipah with a small amount of transitional and beach forest. Approximately 691 000 ha (1 707 000 ac) of undisturbed high forest occurs on land below 750 m (2 500 ft), a further 439 000 ha (1 085 000 ac) on land between 750 m (2 500 ft) and 1 500 m (5 000 ft) and some 49 000 ha (121 000 ac) on land above 1 500 m (5 000 ft). Of this forest approximately 828 000 ha (2 046 000 ac) is considered to be commercial of which some 202 000 ha (500 000 ac) occurs on land above 750 m (2 500 ft).

In composition much of the undisturbed high forest is closer to the hill dipterocarp forest of Symington (1943), i.e., the *selangan batu* forest of Fox (1972) than to the lowland dipterocarp forest of the east coast. In general this type of forest with its relatively high proportion of *selangan batu* extends up to an altitude of about 750 m (2 500 ft). Usually at about this altitude structure and species composition begin to change, the average volume of commercial timber falls and the forest becomes montane. This is a gradual change and the actual altitude range over which it occurs varies from place to place depending on topography, locality, soil and other factors. However, in view of the fairly extensive area of commercial forest occurring above 750 m (2 500 ft) it would appear that at least in some places the change to montane forest takes place at a rather higher altitude than 750 m (2 500 ft).

Although the *selangan batu* forest is heterogenous with a great variety of species the relative proportions of the main commercial timber groups are fairly uniform throughout the forest with dipterocarps accounting for 70%-90% of the volume of commercial timber. However total commercial volume does vary quite considerably particularly between forest on flat lowland and on steep higher land, the latter generally having a higher total commercial volume and a higher volume of dipterocarps.

On account of low volume, species composition and location, montane forest in general has little commercial value and is classed as non-commercial. The same applies to upper montane forest i.e. forest above 1 600 m (5 000 ft) where the volume of commercial timber is very low.

The secondary forest which follows shifting cultivation generally contains few if any elements of the original dipterocarp flora and it exhibits considerable variation in composition and structure depending on age, altitude and other factors. Very little if any of it has any commercial value at present.

Approximately 833 800 ha (2 060 300 ac) of stateland, forest reserve and alienated land carry forest which is considered to be commercial or having a commercial potential with an expected yield of the preferred dipterocarp species in excess of

35 m^3/ha (400 H ft^3/ac). Of this area some 79 900 ha (197 400 ac) carry Timber Resource Group 1 forest with an expected yield of more than 89 m^3/ha (1 000 H ft^3/ac), a further 600 400 ha (1 483 700 ac) carry Group 2 forest with an expected yield of 63-89 m^3/ha (700-1 000 H ft^3/ac), while approximately 150 000 ha (370 800 ac) carry Group 3 with an expected yield of 35-63 m^3/ha (400-700 H ft^3/ac). There is a relatively small area of some 3 400 ha (8 400 ac) which has been logged and is therefore assumed to have a commercial potential but cannot be classified into the three groups because information on the yield obtained is not available. Approximately 28 900 ha (71 500 ac) of the undisturbed high forest on land below 750 m (2 500 ft) is at present considered non-commercial since the expected yield of preferred dipterocarp species is less than 35 m^3/ha (400 H ft^3/ac). Much of the commercial forest whether in forest reserve or on stateland is already under licence or has been assigned and will be licensed in due course. However extensive areas are inaccessible with steep and difficult terrain and it is likely to be some years before they can be logged.

Some 236 700 ha (585 000 ac) in the altitude zone between 750 and 1 500 m (2 500-5 000 ft) carry non-commercial montane forest while approximately 49 000 ha (121 000 ac) above 1 500 m (5 000 ft) carry non-commercial upper montane forest.

Other types of forest, mainly freshwater swamp forest and non-commercial mangrove forest including nipah swamp, which have no commercial value in the foreseeable future, total approximately 84 400 ha (208 600 ac). Productive mangrove forest covers an area of some 8 800 ha (21 800 ac).

The areas carrying commercial dipterocarp and productive mangrove forests are shown in Text Map 4-10.

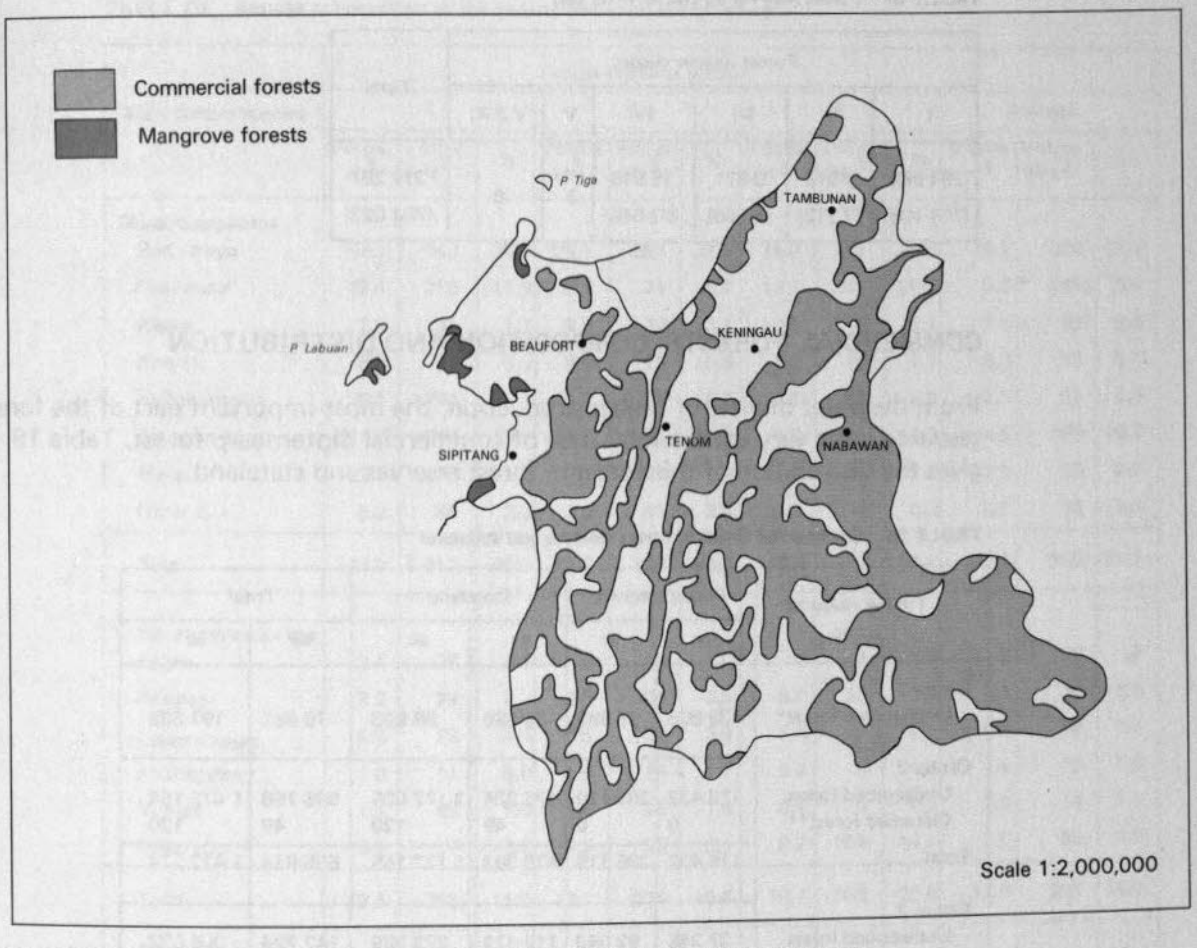
The volume figures given in the various tables in this section are average cubic metres per hectare (m^3/ha) and equivalent hoppus cubic feet per acre (H ft^3/ac). Volumes unless otherwise indicated include all timber with a basal diameter greater than 51 cm (20.1 in), i.e. a girth of 1.6 m (5 ft 3 in) measured over bark at a height of 1.3 m (4.3 ft) or above buttress, to a top diameter of 46 cm (18 in), i.e. a girth of 1.4 m (4 ft 8 in) over bark or point of branching, whichever is the lower. They are derived from the *Sabah Forest Inventory* data (Forestal International Limited, 1973), with allowances for inaccessibility (15%), defect (15%) and breakage during logging (10%). They may therefore be regarded as recoverable volumes. Their accuracy is of the order of ± 15% with 95% probability (Udarbe, 1974). It should be noted that the *Sabah Forest Inventory* was based on aerial photographs taken over the period November 1969 to September 1971 and therefore no account has been taken of exploitation, or any other action resulting in changes to the forest cover, subsequent to the latter date.

The yield parameters used in defining Timber Resource Groups 1, 2 and 3 only refer to the main species and timber groups of the Dipterocarpaceae i.e. red seraya, urat mata, kapur, keruing, yellow seraya, melapi and selangan batu.

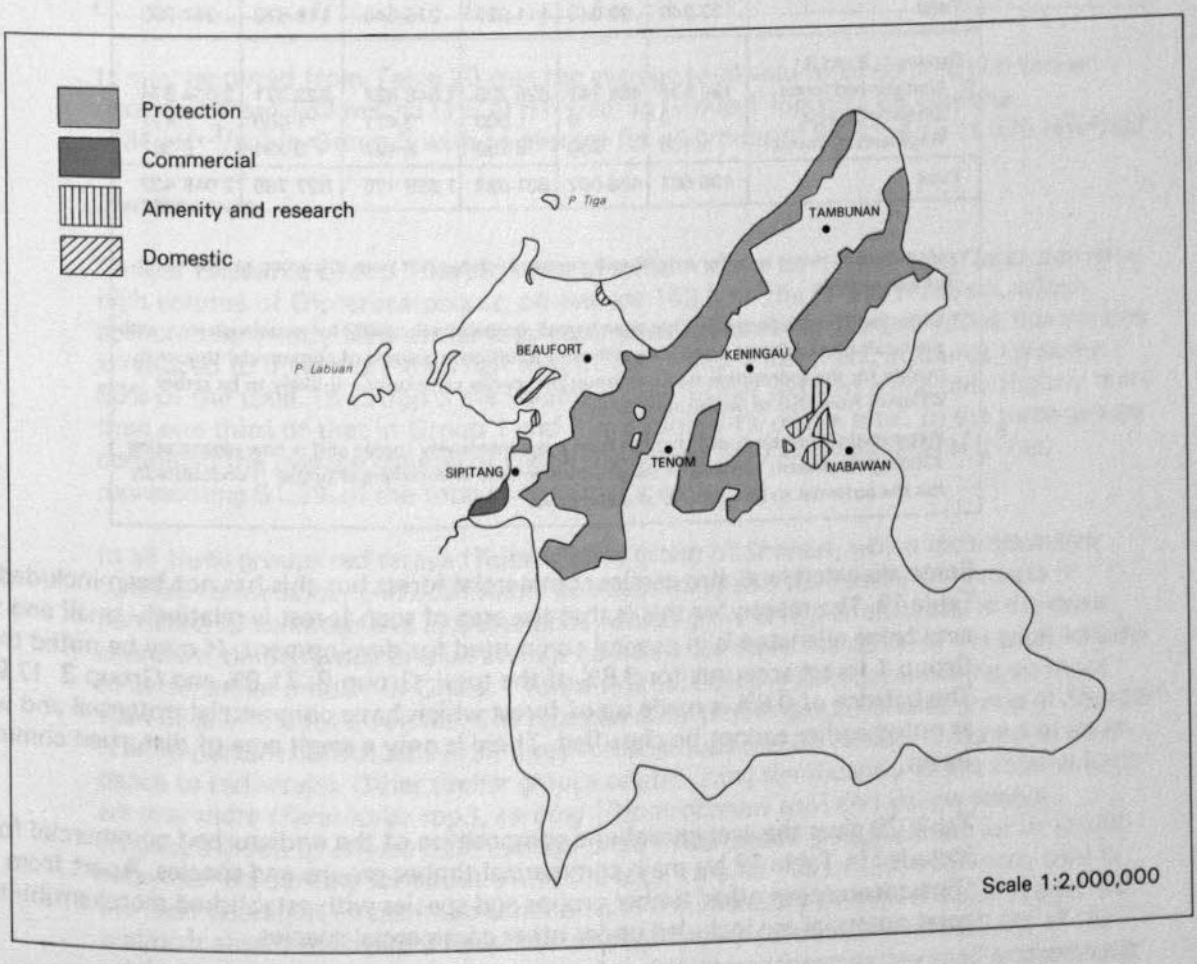
The scientific and vernacular names of the main trees are given in the Glossaries.

Of the land area of the residency 17.5% is constituted as forest reserve of various classes and forms part of the permanent forest estate. The approximate location of these forest reserves, except for those too small to be shown, and their class is given on Text Map 4-11 while Table 18 gives their distribution by classes. The forest reserves are classified as follows:

Class I	Protection forest reserves
Class II	Commercial forest reserves
Class III	Domestic forest reserves
Class IV	Amenity forest reserves
Class V	Mangrove forest reserves
V.J.R.	Virgin jungle forest reserves



TEXT MAP 4-10 Commercial forests and productive mangrove forests



TEXT MAP 4-11 Forest reserves

D.O.S. 3238 Bq

Prepared by the Directorate of Overseas Surveys 1976

TABLE 18 Forest reserves by classes in ha (ac)

Forest reserve classes						Total
I	II	III	IV	V	V.J.R.	
284 982 (704 198)	2 919 (7 212)	3 871 (9 565)	25 515 (63 048)	0	0	317 287 (784 023)

COMMERCIAL FORESTS: COMPOSITION AND DISTRIBUTION

From the point of view of timber production, the most important part of the forest resource is the very considerable area of commercial dipterocarp forest. Table 19 gives the distribution of this forest in forest reserves and stateland.

TABLE 19 Commercial forest in forest reserves and stateland

Timber resource group	Forest reserves		Stateland		Total	
	ha	ac	ha	ac	ha	ac
Group 1 Undisturbed forest*	39 896	98 585	39 985	98 803	79 881	197 388
Group 2 Undisturbed forest Disturbed forest**	119 432 0	295 119 0	476 334 49	1 177 035 120	595 766 49	1 472 154 120
Total	119 432	295 119	476 383	1 177 155	595 815	1 472 274
Group 3 Undisturbed forest Disturbed forest	37 248 0	92 043 0	110 476 951	272 989 2 351	147 724 951	365 032 2 351
Total	37 248	92 043	111 527	275 340	148 675	367 383
Groups 1, 2 and 3 Undisturbed forest Disturbed forest Regenerating forest†	196 576 0 105	485 747 0 260	626 795 1 000 3 289	1 548 827 2 471 8 127	823 371 1 000 3 394	2 034 574 2 471 8 387
Total	196 681	486 007	631 084	1 559 425	827 765	2 045 432

* Undisturbed forest is, as far as is known, forest which has not been disturbed by any form of exploitation

** Disturbed forest is forest that has been logged, probably selectively for certain species, with the result that while the stand may still carry a sufficient volume of commercial timber to qualify for the appropriate resource group the species composition is likely to be rather different from that of undisturbed forest

† Regenerating forest is forest that has been more intensively logged and is now regenerating Although at present carrying an insignificant volume of commercial timber it undoubtedly has the potential to be classified as commercial

Some alienated land also carries commercial forest but this has not been included in Table 19. The reason for this is that the area of such forest is relatively small and the land being alienated is in general committed for development. It may be noted that Group 1 forest accounts for 9.6% of the total, Group 2 71.9% and Group 3 17.9%. The balance of 0.6% is made up of forest which has a commercial potential and which as noted earlier cannot be classified. There is only a small area of disturbed commercial forest.

Table 20 gives the average volume composition of the undisturbed commercial forest included in Table 19 by main commercial timber groups and species. Apart from Dipterocarpaceae other timber groups and species with established merchantibility and good potential are included under other commercial species.

TABLE 20 Average composition of the undisturbed commercial forests

Main timber species	Timber resource group											
	1			2			3			Average		
	Vol/ha m^3	Vol/ac Hft^3	%	Vol/ha m^3	Vol/ac Hft^3	%	Vol/ha m^3	Vol/ac Hft^3	%	Vol/ha m^3	Vol/ac Hft^3	%
Dipterocarpaceae												
Red seraya	57.2	642	35.1	29.1	327	31.6	15.8	177	24.2	29.7	334	31.2
Urat mata	19.4	218	11.9	6.2	70	6.7	13.1	147	20.2	9.0	101	9.4
Kapur	2.8	31	1.7	2.9	32	3.1	0.7	8	1.1	2.5	28	2.6
Keruing	8.6	97	5.3	9.8	110	10.6	1.7	19	2.7	8.3	93	8.7
Yellow seraya	26.1	294	16.0	5.9	66	6.4	5.8	65	8.9	8.2	92	8.6
Selangan batu	21.7	244	13.4	14.7	165	15.9	9.3	105	14.3	14.5	163	15.2
Melapi	2.5	28	1.5	2.1	23	2.2	1.8	20	2.7	2.0	23	2.2
Other spp	5.2	58	3.2	3.6	41	3.9	0.2	2	0.3	3.2	35	3.3
Total	143.5	1 612	88.1	74.3	834	80.4	48.4	543	74.4	77.4	869	81.2
Other commercial spp												
Belian	2.6	29	1.6	.9	10	1.0	0	0	0	.9	10	.9
Medang	2.2	24	1.3	3.2	36	3.5	5.0	56	7.6	3.4	38	3.6
Leguminosae	6.9	78	4.3	3.5	39	3.8	1.4	15	2.1	3.5	39	3.7
Kedongdong	1.0	11	0.6	1.6	18	1.7	0.7	8	1.1	1.4	15	1.5
Nyatoh	1.7	19	1.0	1.3	15	1.5	0.4	5	0.7	1.2	14	1.3
Other spp	5.1	57	3.1	7.6	86	8.1	9.2	104	14.1	7.5	85	7.8
Total	19.5	218	11.9	18.1	204	19.6	16.7	188	25.6	17.9	201	18.8
Total all spp	163.0	1 830	100	92.4	1 038	100	65.1	731	100	95.3	1 070	100

It may be noted from Table 20 that the average total volume of commercial timber decreases from 163 m^3/ha (1 830 H ft^3/ac) in Group 1 forest to 65.1 m^3/ha (731 H ft^3/ac) in Group 3 with an average for all groups of 95.3 m^3/ha (1 070 H ft^3/ac).

Dipterocarps

Timber Resource Group 1 forest, most of which occurs on hilly or steep land, carries a high volume of Dipterocarpaceae, on average 143.5 m^3/ha (1 612 H ft^3/ac), which accounts for nearly 90% of the total commercial volume. In Group 2 forest this volume is reduced to little more than half that of the Group 1 forest and accounts for some 80% of the total. In Group 3 the volume is still further reduced being only slightly more than one third of that in Group 1 and forms some 74% of the total. In the three groups combined the average volume of Dipterocarpaceae is 77.4 m^3/ha (869 H ft^3/ac) representing 81.2% of the total commercial volume.

In all three groups red seraya (Rubroshorea group of *Shorea*), which includes *majau* (*Shorea leptoclados*) and *obah suluk* (*S. pauciflora*), also the heavier red serayas in particular *S. venulosa* and *S. platyclados*, which grow at higher altitudes, is the most abundant timber group and on average accounts for more than 31% of the total volume of commercial timber. In Group 1 forest it is particularly abundant making up more than 35% of the total volume. The *selangan batu* timber group (Shorea group of *Shorea*) is an important constituent in all three forest groups and on average is second in abundance to red seraya. Other timber groups contributing significantly to the total volume are *urat mata* (*Parashorea* spp.), *keruing* (*Dipterocarpus* spp) and yellow seraya (Richetia group of *Shorea*). On average these three timber groups are similar in abundance,each accounting for about 9% of the total volume. *Kapur* (*Dryobalanops* spp) is the least abundant of the more common and commercially preferred dipterocarps and is almost absent in Group 3 forest. On average it only accounts for some 2.6% of the total volume. Included in the 'other species of Dipterocarpaceae' are *gagil* and *selangan* (*Hopea* spp), *pengiran* (*Anisoptera* spp) and *resak* (*Vatica* and *Cotylelobium* spp).

Other commercial species

Species other than Dipterocarpaceae, which are considered to be commercial or have commercial potential, account for between 11.9% (Timber Resource Group 1) and 25.6% (Group 3), of the total commercial volume, and on average 18.8%. Compared with the Dipterocarpaceae the actual volume of these species varies much less between the Groups.

In general the volume of individual species and timber groups is not high and on average only two timber groups, namely *medang* (*Lauraceae* spp other than *belian*) and Leguminosae, contribute more than 1.5% of the total commercial volume. Even so both these groups comprise a large number of species and even genera, and the volume of individual species and genera will in general be very small. As far as individual species are concerned the two species of *Eusideroxylon* comprising *belian* are likely to be the most abundant on average. In the forests of the Interior Residency, *mengaris* (*Koompassia excelsa*) is not nearly so common as it is in the forests of the east coast residencies and has not therefore been shown separately; it is included in Leguminosae.

The group, 'other spp.', includes *jongkong* (*Dactylocladus stenostachys*), *ramin* (*Gonystylus* spp.), *binuang* (*Octomeles sumatrana*), *karai* (*Annonaceae* spp.), *kembang* (*Heritiera* spp.), species of Sterculiaceae other than *Heritiera*, *laran* (*Anthocephalus chinensis*), *kayu malam* (*Diospyros* spp.), *limpaga* (*Meliaceae* spp.), jelutong (*Dyera* spp.), *durian* (*Durio* spp.), *ranggu* (*Koordersiodendron pinnatum*), *pulai* (*Alstonia* spp.), *putat paya* (*Planchonia valida*), *bintangor* (*Calophyllum* spp.), *serungan* (*Cratoxylum arborescens*), *takalis* (*Pentace* spp.), *sengkuang* and *layang layang* (Anacardiaceae spp. other than *rengas* and *ranggu*).

Although all the other commercial species are considered to have established merchantability or at least good potential, many are not at present utilised. The generally low unit area volumes make them unattractive for the export market, and lack of information about their properties and uses, or difficulty in conversion and handling make them unpopular for local use. In the case of some timber groups and in particular with medang, most of the trees belong to the understorey and many do not often reach the minimum size for consideration as commercial timber by current standards. However, if timber with smaller basal and top diameter limits were considered commercial then the volume available would be considerably larger.

TIMBER RESOURCES OF THE FOREST RESERVES

It will have been noted from Table 19 that a considerable part of the commercial forest occurs in forest reserves which have been classified according to their main functions. The timber resources of the different classes of forest reserve are now considered in more detail.

Class I Protection forest reserves

There are six protection forest reserves covering a total area of some 284 982 ha (704 198 ac). The location of these reserves is shown on Text Map 4-11. The main reason for maintaining forest cover on most of these areas is the protection of water catchments and the prevention of soil erosion on steepland, though in some cases conservation of a special type of flora is the main reason. The reserves together with the main reasons for their establishment are listed below.

1.	Gunong Lamaku	To protect the headwaters and catchment areas of rivers and streams flowing off the steep mountainous terrain of the southern-most part of the Crocker Range and minimise erosion of unstable soils

2.	Crocker Range *	To protect the headwaters and catchment areas of the various rivers flowing off the eastern flank of the central part of the Crocker Range with the object of reducing flooding and minimising soil erosion
3.	Trus Madi *	To protect the catchment areas and headwaters of the various tributaries of the Pegalan, Sook and Labau rivers with the object of reducing flooding and minimising soil erosion
4.	Mount Mandalom	To protect the catchment areas and headwaters of tributaries of the Sook and Padas rivers with the object of reducing flooding and minimising soil erosion
5.	Sianggau	To conserve an area of considerable ecological and botanical interest containing a variety of vegetation types including a small area of virgin peat swamp forest
6.	Pulau Tiga	To conserve and protect the flora of the island

Commercial forests in the Class I reserves

Some 64.6% of the area of protection forest carries commercial timber stands and these have been classified accordingly. Details are given in Table 21.

TABLE 21 Distribution of Timber Resource Groups 1, 2 and 3 in the Class I, Protection forest reserves

Timber resource group	ha	ac
1	39 588	97 823
2	111 666	275 930
3	35 255	87 117
Total	186 509	460 870

Although this forest is classified as commercial on the basis of the expected yield of timber the forest should not really be considered commercial since in general logging should not be allowed in protection forest. However in some areas restricted and carefully controlled exploitation may be permitted. The average composition of the forest in Groups 1, 2 and 3 is given in Table 22.

Table 22 shows that the Group 1 forest carries a high average volume of commercial timber, with dipterocarps making up 88.7%. Most of this forest occurs on steepland below 750 m (2 500 ft). Some 60% of Timber Resource Group 2 forest occurs on hilly land below 750 m (2 500 ft) while the other 40% occurs on steepland above 750 m (2 500 ft). Group 3 forest mainly occurs on steepland below 750 m (2 500 ft). Taking the three groups together the average total commercial volume is 102.3 m^3/ha (1 149 H ft^3/ac) with dipterocarps accounting for 82.3%.

In all three forest groups red seraya timber is the most abundant, on average accounting for nearly 32% of the total volume. *Selangan batu* is an important timber especially in Group 2 forest and on average is the second most abundant making up some 14.6% of the total volume. Other important timbers are *urat mata*, yellow seraya and *keruing*, which for all groups combined account respectively for 10.8%, 9.4% and 7.2% of the total volume. It is of interest to note that Group 3 forest carries a considerably larger volume of *urat mata* than Group 2 and that while *keruing* is relatively abundant in Group 1 and 2 forest, there is very little in Group 3. *Kapur* is not common in any group but in Group 3 it is so rare that the volume is almost too small to be recorded.

*Substantial areas of these reserves fall within the boundary of the West Coast Residency, which has been reported in Volume 3.

TABLE 22 Average composition of the undisturbed Group 1, 2 and 3 forests in Class I reserves

Main timber species	Timber resource group									Average		
	1			2			3					
	Vol/ha m^3	Vol/ac Hft^3	%	Vol/ha m^3	Vol/ac Hft^3	%	Vol/ha m^3	Vol/ac Hft^3	%	Vol/ha m^3	Vol/ac Hft^3	%
Dipterocarpaceae												
Red seraya	51.5	578	32.4	31.2	350	33.2	15.7	176	24.1	32.6	366	31.9
Urat mata	21.3	240	13.4	6.2	70	6.6	15.3	171	23.5	11.1	124	10.8
Kapur	3.0	34	1.9	2.9	32	3.0	.1	1	.1	2.4	27	2.3
Keruing	11.4	128	7.2	8.0	90	8.5	1.2	14	1.9	7.4	83	7.2
Yellow seraya	23.7	266	14.9	5.7	64	6.1	6.4	72	9.9	9.7	109	9.4
Selangan batu	9.4	218	12.2	15.1	169	16.0	9.7	109	15.0	15.0	168	14.6
Melapi	2.9	33	1.8	2.1	23	2.2	2.1	23	3.2	2.2	25	2.2
Other spp.	7.8	87	4.9	3.6	41	3.9	.1	1	.1	3.8	43	3.7
Total	141.0	1 584	88.7	74.8	839	79.5	50.6	567	77.8	84.2	945	82.3
Other commercial spp.												
Belian	.8	9	.5	.8	9	.9	0	0	0	.7	8	.7
Medang	2.1	24	1.3	3.8	43	4.0	5.4	61	8.3	3.7	42	3.7
Leguminosae	6.6	74	4.2	3.4	38	3.6	.6	7	1.0	3.6	40	3.5
Kedongdong	.9	10	.6	1.8	20	1.9	.6	7	1.0	1.4	15	1.3
Nyatoh	2.0	23	1.2	1.4	16	1.5	.1	1	.1	1.3	15	1.3
Other spp.	5.6	62	3.5	8.0	90	8.6	7.7	87	11.8	7.4	84	7.2
Total	18.0	202	11.3	19.2	216	20.5	14.4	163	22.2	18.1	204	17.7
Total all commercial spp.	159.0	1 786	100	94.0	1 055	100	65.0	730	100	102.3	1 149	100

The proportion of other commercial species in the total commercial volume varies from 11.3% in Group 1 to 22.2% in Group 3 forest with an average of 17.7%. However the actual volumes show relatively little variation compared to the volumes of Dipterocarpaceae. The only two timbers which contribute more than 20% of the total volume in any forest group are *medang* and Leguminosae. The greatest volume of the former is found in Group 3 and of the latter in Group 1 forest. The volumes of the other timber groups and species are insignificant. There is a very small area, 16 ha (40 ac), of productive mangrove forest.

Non-commercial forest in the Class I reserves

Dipterocarp forest on land below 750 m (2 500 ft) with an expected yield of less than 35 m^3/ha (400 H ft^3/ac) covers some 10 000 ha (24 700 ac). Non-commercial montane forest on land between 750 m (2 500 ft) and 1 500 m (5 000 ft) covers approximately 53 890 ha (133 160 ac) while upper montane forest on land above 1 500 m (5 000 ft) covers approximately 16 650 ha (41 140 ac). The average volume composition of montane and upper montane forest is given in Tables 23 and 24 respectively. Average figures are also given for the currently non-commercial species; *berangan, mempening* and *obah* which become relatively abundant in montane and upper montane forest, particularly *mempening* in the latter.

It is interesting to note that if the basal and top diameter limits for the timber groups and species of the montane forests are reduced respectively to 35.8 cm (14.1 in) and 30.5 cm (12.0 in), then the total volume of timber from all commercial species rises to 52.5 m^3/ha (590 H ft^3/ac) and that of Dipterocarpaceae and other commercial species to respectively 21.9 m^3/ha (246 H ft^3/ac) and 30.6 m^3/ha (344 H ft^3/ac). Also if in the upper montane forest the basal and top diameter limits are similarly reduced, then the

total volume of timber from all commercial species rises to 21.0 m^3/ha (236 H ft^3/ac) and the volume of Dipterocarpaceae and other commercial species to respectively 1.9 m^3/ha (22 H ft^3/ac) and 19.1 m^3/ha (214 H ft^3/ac).

TABLE 23 Average composition of montane forest in forest reserves and stateland

Main timber species	Vol/ha m^3	Vol/ac Hft^3	%
Dipterocarpaceae			
Red seraya	8.4	94	28.4
Urat mata	1.4	16	4.7
Kapur	0.2	2	0.7
Keruing	0.2	2	0.7
Yellow seraya	2.7	31	9.3
Selangan batu	0.4	4	1.3
Resak	1.2	14	4.1
Other spp.	0.3	3	0.8
Total	14,8	166	50.0
Other commercial spp.			
Nyatoh	6.3	70	21.1
Medang	2.7	31	9.3
Leguminosae	2.4	27	8.0
Kedongdong	0.1	1	0.3
Others	3.3	37	11.3
Total	14,8	166	50.0
Total all commercial spp.	29.6	332	100.0

Important non-commercial species of timber size are as follows:

	m^3/ha	Hft^3/ac
Berangan (*Castanopsis* spp.)	2.0	23
Mempening (*Lithocarpus* and *Quercus* spp.)	1.8	20
Obah (*Eugenia* spp.)	2.3	26

TABLE 24 Average composition of upper montane forest in forest reserves and stateland

Main timber species	Vol/ha m^3	Vol/ac Hft^3	%
Resak	1.6	18	15.9
Nyatoh	2.8	32	28.0
Medang	2.6	29	25.5
Kedongdong	1.0	11	9.6
Others	2.1	24	21.0
Total all commercial spp.	10.1	114	100.0

Important non-commercial species of timber size are:

	m^3/ha	Hft^3/ac
Berangan	0.7	7
Mempening	11.2	125
Obah	2.1	24

In the protection reserves other non-commercial forest, mainly freshwater swamp forest, covers some 301 ha (745 ac), while secondary forest following shifting cultivation and other non-forest and non-productive land (rock and scrub) covers some 17 770 ha (43 900 ac).

Class II Commercial forest reserves

The object of the Class II, Commercial forest, reserves is the supply of timber and other forest produce to meet the general demands of trade and industry. As indicated in Table 18 there are only 2 919 ha (7 212 ac) of this class of reserve in the residency and there is in fact only one such reserve, the Marintaman Mengalong Forest Reserve, which occupies a coastal strip in the extreme south-west corner of the residency as shown in Text Map 11.

Commercial forests

Despite its classification as a commercial forest reserve there is no commercial forest in the Marintaman Mengalong Forest Reserve but there are 49 ha (120 ac) of potentially productive mangrove forest.

Non-commercial forests

The non-commercial forest in the Marintaman Mengalong Forest Reserve comprises the following: beach forest 36 ha (90 ac), freshwater swamp forest 1 030 ha (2 546 ac), regrowth after shifting cultivation 575 ha (1 421 ac), cultivation both shifting and permanent 234 ha (577 ac), grassland 962 ha (2 378 ac) and non-productive land 32 ha (80 ac).

Class III Domestic forest reserves

The object of domestic forest reserves is to supply timber and other forest produce for local requirements. There are 3 871 ha (9 565 ac) of domestic forest reserve in the residency comprising the Klias Forest Reserve and part of the Sungei Damit Forest Reserve, which lies on the coast on the boundary between the Interior and West Coast Residencies, as shown in Text Map 11.

Commercial forests

There is no commercial forest but there are 23 ha (56 ac) of productive mangrove forest in that part of the Sungei Damit Forest Reserve falling in the Interior Residency.

Non-commercial forests

The non-commercial forest comprises freshwater swamp forest 3 675 ha (9 081 ac), regrowth after shifting cultivation 69 ha (170 ac) and transitional forest 60 ha (148 ac). There are also small areas of shifting cultivation, swamp and non-forested land.

Class IV Amenity forest reserves

The main reasons for the constitution of these reserves are to provide areas for local amenity and for research and arboretum work. There are four amenity forest reserves in the residency with a total area of 25 515 ha (63 048 ac). The locations of the larger ones are shown in Text Map 4-11 and details of the resource groups are given in Table 25.

The Mesapol Forest Reserve is of considerable ecological and botanical interest as it carries a stand in which *kapur barus* (*Dryobalanops aromatica*), an uncommon species in Sabah, is abundant. In the Sook Plain Forest Reserve, which includes over 4 200 ha (10 400 ac) of grassland, research is being carried out on the establishment of plantations of fast growing exotic species on such land. This grassland is not natural but has been derived from high forest by regular burning. The Kampong Hindian and Nabahan Forest Reserves comprise small areas of productive and non-productive mangrove forest, transitional forest and freshwater swamp forest.

TABLE 25 Timber resource groups in Class IV, Amenity forest reserves

Forest reserve	Timber resource group														Total	
	1		2		3		4		5		6		7			
	ha	ac	ha	ac	ha	ac	ha	ac	ha	ac	ha	ac	ha	ac	ha	ac
Kampong Hindian	0	0	0	0	0	0	0	0	254	627	290	716	52	129	596	1 472
Mesapol	0	0	0	0	28	70	0	0	0	0	0	0	0	0	28	70
Nabahan	0	0	0	0	0	0	0	0	169	417	169	418	0	0	338	835
Sook Plain and extension	308	762	7 766	19 189	1 965	4 856	2 941	7 267	571	1 412	0	0	11 002	27 185	24 553	60 671
Total	308	762	7 766	19 189	1 993	4 926	2 941	7 267	994	2 456	459	1 134	11 054	27 314	25 515	63 048

Commercial forests in Class IV reserves

It may be noted from Table 25 that only some 39% of the area of amenity forest reserves carries commercial forest. The average composition of this forest in terms of the volume of commercial timber is given in Table 26.

It will be seen from the table that the average volume of commercial timber varies from 162.4 m^3/ha (1 824 H ft^3/ac) in Group 1 forest with dipterocarps accounting for 86.1% of the total to 66.7 m^3/ha (749 H ft^3/ac) in Group 3 forest in which dipterocarps account for only 56.4% of the total volume. For Groups 1, 2 and 3 combined the average total volume is 90.0 m^3/ha (1 010 H ft^3/ac with dipterocarps accounting for 79.4%.

TABLE 26 Average composition of commercial forest in Class IV, Amenity forest reserves

Main timber species	Timber resource group									Average		
	1			2			3					
	Vol/ha m^3	Vol/ac H ft^3	%	Vol/ha m^3	Vol/ac H ft^3	%	Vol/ha m^3	Vol/ac H ft^3	%	Vol/ha m^3	Vol/ac H ft^3	%
Dipterocarpaceae												
Red seraya	45.6	512	28.1	24.2	272	26.0	15.9	179	23.9	23.2	261	25.8
Urat mata	8.9	100	5.5	7.5	84	8.1	.7	8	1.1	6.2	70	6.9
Kapur	.9	10	.6	4.3	48	4.6	2.2	25	3.3	3.8	42	4.2
Keruing	29.6	333	18.2	15.7	177	16.9	6.4	71	9.5	14.3	161	15.9
Yellow seraya	22.6	254	13.9	5.4	61	5.9	2.4	27	3.6	5.4	60	6.0
Selangan batu	30.1	338	18.5	15.1	170	16.3	9.5	107	14.2	14.5	162	16.1
Melapi	.9	10	.6	2.4	27	2.5	.2	2	.3	1.9	21	2.1
Other spp.	1.2	13	.7	2.8	31	3.0	.3	3	.4	2.2	25	2.4
Total	139.8	1 570	86.1	77.4	870	83.3	37.6	422	56.4	71.5	802	79.4
Other commercial spp.												
Belian	3.0	34	1.9	1.4	16	1.5	0	0	0	1.2	13	1.3
Medang	1.1	13	.7	1.8	20	1.9	2.5	29	3.8	1.9	21	2.1
Leguminosae	8.8	99	5.4	4.1	46	4.4	4.9	55	7.4	4.3	49	4.8
Kedongdong	1.6	18	1.0	1.1	12	1.1	1.2	13	1.8	1.1	12	1.2
Nyatoh	1.9	21	1.2	1.3	15	1.4	2.4	27	3.6	1.5	17	1.7
Jongkong	0	0	0	0	0	0	5.7	64	8.5	1.1	13	1.3
Jelutong	.9	10	.6	1.8	20	2.0	2.8	32	4.2	2.0	22	2.2
Serungan	0	0	0	.1	1	.1	4.7	52	7.0	1.1	12	1.2
Other spp.	5.3	59	3.1	4.0	45	4.3	4.9	55	7.3	4.3	49	4.8
Total	22.6	254	13.9	15.6	175	16.7	29.1	327	43.6	18.5	208	20.6
Total all commercial spp.	162.4	1 824	100	93.0	1 045	100	66.7	749	100	90.0	1 010	100

Table 26 shows that red seraya is the most abundant timber in all three timber resource groups and on average makes up some 25% of the volume of commercial timber. *Selangan batu* and *keruing* are important constituents of all three groups and on average both account for some 16% of the total. *Urat mata* and yellow seraya both contribute a significant volume on average but in Group 3 forest neither is common, more especially *urat mata.*

Among the other commercial species the only timber group or species which in total accounts for a significant volume is Leguminosae. However in Group 1 forest the volume of *belian* is significant while in Group 3 *jongkong* is the fourth most abundant timber and probably the most common individual species; *serungan* is also quite abundant and the volume of *jelutong* is significant. Because of the peculiar abundance of these latter three species in Group 3 forest they have been treated separately in Table 26 and not included with 'other spp.' as elsewhere.

The presence of significant volumes of *jongkong* and *serungan*, typical freshwater swamp forest species, in Group 3, is interesting in that it suggests that this forest, with its relatively small proportion of Dipterocarpaceae, is in places transitional to freshwater swamp forest.

There are approximately 460 ha (1 130 ac) of productive mangrove forest included in the amenity forest reserves.

Non-commercial forests in Class IV reserves

There are some 2 940 ha (7 260 ac) of dipterocarp forest with an expected yield of commercial timber of less than 35.6 m^3/ha (400 H ft^3/ac). Transition forest and non-commercial swamp forest cover some 990 ha (2 450 ac). Secondary forest, the regrowth following shifting cultivation, covers some 6 050 ha (14 950 ac) while current cultivation both permanent and shifting accounts for another 560 ha (1 380 ac). Grassland which occurs only in the Sook Plain Forest Reserve and its extension totals some 4 280 ha (10 580 ac) and there are 160 ha (400 ac) of non-productive land.

Mangrove forests in the forest reserves

There are no Class V, Mangrove forest, reserves in the residency. However there are a total of approximately 546 ha (1 350 ac) of productive mangrove forest in other forest reserves and the average volume composition of this forest is given in Table 27.

Bakau and *bangkita* are the most important commercial species as they are preferred for chipping for pulp and for many other uses e.g. piling, building poles, firewood and charcoal. *Beus* and *tengar* are also acceptable for chipping and for some other uses. Other mangrove species have little merchantable value at present apart from *geriting*, which is used for salt water piling.

TABLE 27 Average composition of the productive mangrove forests in forest reserves

Species	Vol/ha m^3	Vol/ac H ft^3	%
Bakau (*Rhizophora mucronata*)	17.4	195	26.5
Bangkita (*Rhizophora apiculata*)	21.6	243	32.9
Beus (*Bruguiera spp.*)	3.8	43	5.8
Tengar (*Ceriops tagal*)	1.3	14	2.0
Api Api (*Avicennia* spp.)	1.9	21	2.9
Buta Buta (*Exoecaria agallocha*)	.8	9	1.2
Geriting (*Lumnitzera* spp.)	.1	1	.1
Other species	18.8	212	28.6
Total	65.7	738	100

Volume figures are derived from *Sabah Forest Inventory* data (Forestal International Limited, 1973). Volumes are calculated on the basis of gross stem volume inside bark of all trees 9 cm (3.5 in) diameter i.e. 28 cm (11 in) girth and larger, measured over bark at 70 cm (27 in) above stump height, which is 61 cm (24 in) above ground level or top of stilt roots, to a top diameter of 5 cm (2 in) i.e. 16 cm (6.3 in) girth inside bark. Stem volumes include any merchantable pieces of branchwood of 1.2 m (4 ft) or longer. An allowance of 11.3% has been made for defect.

TIMBER RESOURCES OF THE STATELANDS

In the statelands there are very extensive areas of undisturbed dipterocarp forest both commercial and non-commercial. Considerable areas of virgin dipterocarp forest have been destroyed by shifting cultivation giving rise to non-commercial secondary forest, but up to the present there has been very little exploitation by logging. Other non-commercial forest includes freshwater swamp forest, montane and upper montane forest.

There is a relatively small area of productive mangrove forest and a larger area of non-productive mangrove forest. The various types of forest, particularly those of commercial importance, are discussed in the following text.

Commercial forests in the statelands

As shown in Table 19 the area of commercial forest on stateland amounts to some 631 084 ha (1 559 425 ac). Most of this is undisturbed and the areas of disturbed and regenerating forest are relatively very small. The average composition of the undisturbed forest in terms of commercial timber volume is given in Table 28.

TABLE 28 Average composition of undisturbed commercial forest on stateland

Main timber species	Timber resource group									Average		
	1			2			3					
	Vol/ha m^3	Vol/ac Hft^3	%	Vol/ha m^3	Vol/ac Hft^3	%	Vol/ha m^3	Vol/ac Hft^3	%	Vol/ha m^3	Vol/ac Hft^3	%
Dipterocarpaceae												
Red seraya	62.7	705	37.6	29.2	328	31.5	15.8	177	24.3	28.6	322	31.1
Urat mata	17.6	197	10.6	6.3	71	6.8	12.7	142	19.5	8.1	91	8.8
Kapur	2.6	29	1.5	2.9	33	3.1	.9	10	1.4	2.5	28	2.7
Keruing	5.9	66	3.5	10.1	114	10.9	1.8	20	2.8	8.4	94	9.1
Yellow seraya	28.6	321	17.2	5.9	66	6.4	5.6	64	8.6	7.3	82	8.0
Selangan batu	23.8	267	14.3	14.7	165	15.9	9.2	103	14.1	14.2	160	15.4
Melapi	2.1	23	1.2	2.1	23	2.3	1.7	19	2.6	2.0	22	2.2
Other spp.	2.7	31	1.6	3.6	40	3.9	.2	3	.3	3.0	33	3.2
Total	146.0	1 639	87.5	74.8	840	80.8	47.9	538	73.6	74.1	832	80.5
Other commercial spp.												
Belian	4.3	48	2.6	.9	10	1.0	0	0	0	.9	11	1.0
Medang	2.2	24	1.3	3.0	34	3.2	4.9	55	7.5	3.4	38	3.7
Leguminosae	7.2	81	4.3	3.5	39	3.8	1.5	17	2.3	3.4	38	3.7
Kedongdong	1.1	12	.7	1.6	17	1.7	.7	8	1.1	1.4	16	1.5
Nyatoh	1.3	15	.8	1.3	15	1.4	.5	6	.8	1.2	13	1.3
Other spp.	4.7	54	2.8	7.5	84	8.1	9.6	107	14.7	7.6	86	8.3
Total	20.8	234	12.5	17.8	199	19.2	17.2	193	26.4	17.9	202	19.5
Total all commercial spp.	166.8	1 873	100	92.6	1 039	100	65.1	731	100	92.0	1 034	100

It will be noted from Table 28 that the average total commercial volume decreases from 166.8 m^3/ha (1 873 Hft^3/ac) in Group 1 forest to 65.1 m^3/ha (731 Hft^3/ac) in Group 3 forest with an average of 92.0 m^3/ha (1 034 Hft^3/ac). In Group 1 forest dipterocarps account for some 87.5% of the commercial volume. This proportion decreases to 73.6% in Group 3 forest with an average of 80.5%. In all three forest groups red seraya is easily the most abundant timber accounting for as much as 37.6% of the commercial volume In Timber Resource Group 1 and on average 31.1%. *Selangan batu* is important in all forest groups and on average accounts for 15.4% of the commercial volume. Others contributing significantly to the commercial volume are *keruing, urat mata* and yellow

seraya, which are of similar average abundance,each accounting for 8-9% of the total volume. *Kapur* is not very important in any group.

Among the other commercial species the only two timber groups which on average contribute any significant volume are *medang* and leguminosae. The former is most abundant in Group 3, the latter in Group 1. In Group 1 forest there is a reasonable volume of *belian* but in Group 2 there is much less and in Group 3 there is too little to be recorded. The volume of the other timber groups is insignificant both on average for the total and in individual timber resource groups.

Non-commercial forests in the statelands

There are some 16 100 ha (39 800 ac) of undisturbed dipterocarp forest with an expected yield of commercial timber of less than 35.6 m^3/ha (400 Hft^3/ac). Non-commercial montane and upper montane forests cover respectively some 183 000 ha (452 300 ac) and 32 330 ha (79 900 ac). The average volume composition of these two latter types of forest is given in Tables 23 and 24 in the earlier section on protection forest reserves. Non-productive mangrove forest covers approximately 18 500 ha (45 750 ac), freshwater swamp forest with an expected yield of commercial timber of less than 35.6 m^3/ha (400 Hft^3/ac) 32 600 ha (80 600 ac), transitional forest 2 390 ha (5 900 ac) and beach forest 200 ha (500 ac). There are some 292 800 ha (723 500 ac) of secondary forest being regrowth following shifting cultivation.

Mangrove forests in the statelands

There are approximately 8 167 ha (20 181 ac) of productive mangrove forest comprising some 7 731 ha (19 103 ac) of commercial mangrove and some 436 ha (1 078 ac) of logged mangrove. Most of this forest occurs in and around the estuaries of the Klias and Padas rivers. The average volume composition of the commercial mangrove forest is given in Table 29.

TABLE 29 Average composition of the commercial mangrove forests on stateland

Species	Vol/ha m^3	Vol/ac Hft^3	%
Bakau (*Rhizophora mucronata*)	24.9	280	29.5
Bangkita (*Rhizophora apiculata*)	42.2	474	49.8
Beus (*Bruguiera* spp.)	2.9	33	3.4
Tengar (*Ceriops tagal*)	1.3	14	1.5
Api Api (*Avicennia* spp.)	3.5	39	4.1
Buta Buta (*Excoecaria agallocha*)	1.2	13	1.4
Geriting (*Lumnitzera* spp.)	.1	1	.1
Other species	8.6	97	10.2
Total	84.7	951	100

The commercial mangrove forests on stateland contain a considerably greater volume per unit area of commercial wood than those in the forest reserves and there is a much larger proportion of the two most important species, namely *bakau* and *bangkita*. This can be seen by comparing Tables 27 and 29.

Water resources

The climate has been discussed, and the rainfall at selected stations is given on Text Map 4-3. It will have been noted that three broad rainfall zones can be recognised: the seaboard and western flanks of the coastal ranges with a mean annual rainfall of about 2 500-4 000 mm (100-157 in), the rain-shadowed eastern slopes and interior plains with 1 500-2 300 mm (60-90 in) and the south-east with 2 800-3 100 mm (110-122 in). Rainfall on the western side of the Crocker and Meligan Ranges may be much higher than recorded, because the stations are sited in the Crocker Foothills and if an allowance is given for the usual rise in rainfall with increasing altitude many parts can be expected to have around 5 100 mm (200 in).

It will also have been noted that the rainfall pattern follows seasonal peaks, April - June and September - November in the west and interior, and during April - May in the south-east.

Bower *et al.* (1972) in their account of the soils have shown that January - April is the most likely period for 'dry' months, that is with less than 60 mm (2.4 in) of rain (Trewartha, 1954). June-September is an additional 'dry' period for the interior plains. They have also shown that the frequency of the dry periods coupled with the relatively low annual rainfall can result in serious drought conditions on the interior plains. On the Crocker and Meligan Ranges, however, all months can be expected to be wet.

Rainfall can be intense and Bower *et al.* (1975) have shown that over 100 mm (4 in) of rain in one day have been recorded at most of the stations, with some maxima in excess of 200 mm (8 in). They have also shown that the frequency and intensity are higher on the western side of the Crocker Range. Loss of water by evaporation is high but decreases with altitude. Data on evaporation are available for one station only, Keningau, where the annual average is 1 797 mm (70.8 in) (Bower *et al.* 1975) which, it should be noted, is slightly in excess of the 1 753 mm (69 in) average rainfall recorded for that station.

Thus it can be expected that in the highlands, particularly those of the Crocker and Meligan Ranges, where infiltration rates are not excessive and where precipitation is the highest and evaporation is the lowest, considerable amounts of water are available as surface runoff and stream and river flow is continuous. Except for particularly small catchment areas, therefore, plentiful and reliable surface water supplies can be expected.

SURFACE WATER AND IRRIGATION

The Witti Range forms the main watershed; drainage to the west being into the South China Sea and to the east the Celebes Sea. It forms the upper catchments of the two largest river systems, the Padas and the Talankai.

TABLE 30 The main river basins

River basin	Area		
	km^2	mi^2	Main catchment
Padas	7 815	3 017	Crocker, Meligan, Witti and Trus Madi Ranges
Talankai	5 957	2 300	Witti Range and Kuamut Highlands
Mengalong	648	250	Crocker Range
Membakut	252	97	Crocker Range
Lakutan	224	86	Crocker Range
Bukau	213	82	Crocker Range

Details of the main river basins are given in Table 30. It should be noted that the Talankai runs into an adjoining region of Indonesia before reaching the sea, and this account is restricted to the Sabah part.

Comprehensive stream-flow and related data are available for the Padas Basin only, although some water level records are available for the Mengalong and Klias Rivers. Such water level records are of little value for overall hydrological purposes and it will be seen, therefore, that very little is known of the water resources of the rivers except for those of the Padas Basin. The following account on the Padas is largely based on the report by Nippon Koei Co Ltd (1974).

Most of Padas Basin is protected by a dense forest cover. Shifting cultivation is common to some parts, particularly in the Witti Range; and most of the plains are, or have been, cultivated and are now covered by low vegetation.

The Padas river system is by far the largest and most important with a catchment area of 7 815 km^2 (3 017 mi^2) and with a river length of each of its three main tributaries, the Padas, Pegalan and Sook, of 208 km (130 mi). All three after rising in the mountains and flowing swiftly in their upper courses, enter the interior plains where the rate of flow decreases. This is particularly marked on the Sook and Tenom Plains. After leaving the Tenom Plain the main river cuts through the Crocker Range along the Padas Gorge. Below the Gorge the Padas broadens into a wide floodplain which runs through the swamps of the Klias Plain, and ultimately joins the sea.

The Padas Gorge is about 48 km (30 mi) long and is flanked by high mountains, some rising to over 900 m (3 000 ft) above the river. The gradient is steep and the river drops some 170 m (550 ft). A number of rapids mark the first and steepest sector, particularly below its entrance above Pangi where it drops some 90 m (300 ft) in 5.6 km (3½ mi).

The catchment above the Gorge is estimated to be 7 715 km^2 (2 980 mi^2) and its mean annual rainfall 1 730 mm (68 in). Table 31 gives the details of the discharge of the Padas and its three main tributaries above this point. Flow is variable, e.g. the maximum flood recorded for Padas at Tenom Lama is 934 cumecs (33 000 cusecs) whilst the minimum dependable flow is probably in the region of 40 cumecs (1 400 cusecs).

TABLE 31 Catchments and average discharge of the Padas and its tributaries

River	Station	Catchment		Average discharge rate	
		km^2	mi^2	cumecs	cusecs
Padas	Tenom Lama	7 715	2 980	193.7	6 840
	Kemabong	3 190	1 227	116.2	4 105
Pegalan	Keningau	1 319	823	53.1	1 878
Sook	Biah	1 684	650	23.9	844

The river system normally carries a fairly heavy load of suspended material, particularly along its main course and the Sook. The quantity is probably directly proportional to the rate of runoff, ranging from 1-777 ppm. The annual sediment yield at Tenom is estimated to be 222 t/km^2 (566 lgt/mi^2).

Although there are no records, the floodplains of the basin above the gorge are reputed to be inundated for short periods most years. The flooding does not, however, appear to pose a serious problem overall. Below the gorge flooding is far more frequent and serious. The data available for Beaufort (McCarthy, 1974) for 1957-1973 show that the Padas rises over its banks many times a year and for any month one can expect a flood at least once in every two or three years.

Even though it is the second largest in the residency, very little is known of the Talankai Basin. Its extent and location is given in Table 30. It is mainly mountainous and forested although some areas are periodically used for shifting cultivation. Flow along its main course is fairly rapid and the long term average discharge is probably in excess of 300 cumecs (1 000 cusecs) along most of its length.

PLATE 4.5 Recently commissioned padi irrigation scheme near Sindumin

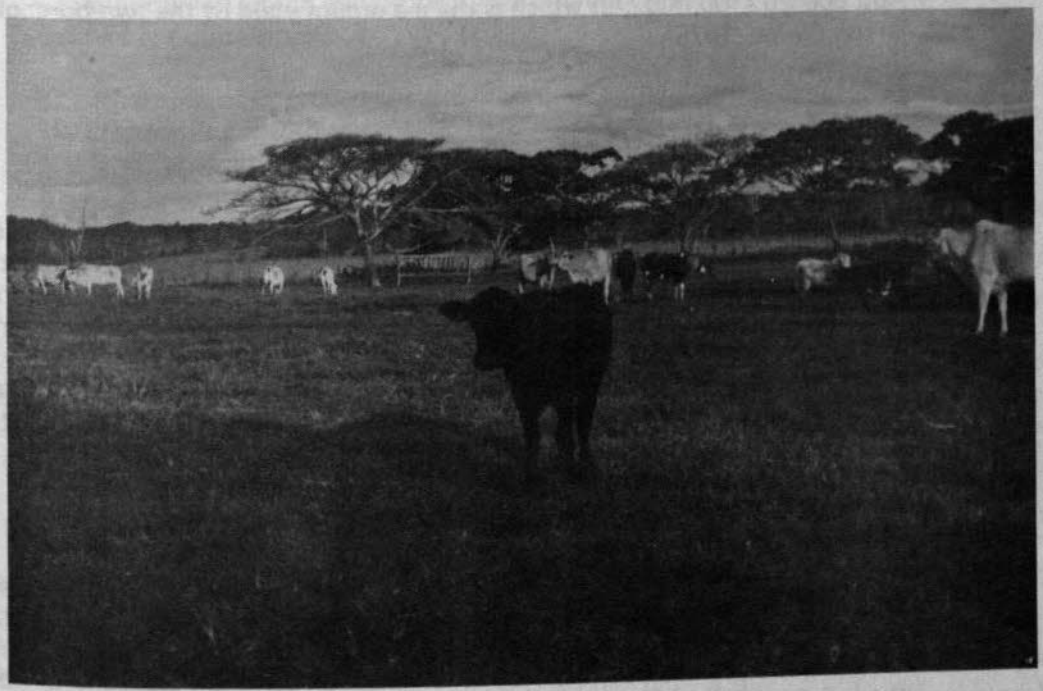


PLATE 4.6 Cattle grazing on improved pastures on the Sebrang Cattle Station, Keningau

The other main rivers, the Mengalong, Membakut, Lakutan and Bukau, all drain the western flanks of the Crocker Range. Their catchments are mainly forested and relatively small. The hydraulic gradients are steep and stream-flow rapid. They discharge onto alluvial plains before reaching the sea, but flooding is rare and of short duration, except in low-lying areas under tidal influence.

The water catchments in the Klias Hills and Western Islands are small and most are incapable of providing sustained yields, stream flow being intermittent.

The extensive swamps of the Klias Plain hold very considerable reserves of water. Much of the plain is covered by a very thick mantle of peat which holds many times its volume of water. Very little, however, is known about the quality of the water, but it is likely to be extremely acid and has a high proportion of organic colloids.

Even though primitive methods of irrigation have probably been employed since early times, particularly in the Tambunan area, properly organised development using modern technology stems from recent years, and there are a number of government-run schemes in operation throughout the residency. The oldest and largest is that of Bunsit-Bingkor on the Keningau Plain. It became fully operational in 1961 and serves some 2 023 ha (5 000 ac). The water is drawn from the neighbouring Baiayo River across which a low barrage has been constructed. The minimum flow of the river has been estimated at 5.66 cumecs (200 cusecs) which is considered by Allen (1956) adequate to irrigate 4 856 ha (12 000 ac). Large irrigation schemes i.e. in excess of 202 ha (500 ac), are operational at Apin Apin, Sindumin (see Plate 4.5) and Tunggul Tinggi near Mesapol. Smaller schemes exist at Ulu Tomani, Biah, Limbawang and Pulai Menang.

GROUNDWATER

The country rocks of the populated parts of the residency generally are of low porosity and permeability and hold small reserves of water. With ample surface water supplies in most parts there has generally been little interest in developing underground resources. The small and irregular flow of the streams on Labuan and near Kuala Penyu is insufficient to meet the potable water requirements of the two towns, which are obtained from boreholes. The aquifers are in alluvial deposits. The known reserves on Labuan amount to a yield of 1 818 000 l/d (400 000 g/d), all of which is being used (Thomas, 1971), whilst Kuala Penyu draws some 273 000 l/d (60 000 g/d) out of the 455 000 l/d (100.000 g/d) which is the maximum yield of the two boreholes currently in use (Wilde, 1975).

Grazing resources

There are fairly extensive areas of natural grasslands scattered throughout the residency with the largest continuous areas in the Sook and Keningau Plains. The natural grasses afford very poor pastures but with increasing interest in beef production in recent years these grasslands have attracted attention as possible grazing areas. However, much of the grassland occurs on soils which are either not suited for agriculture or only suited for restricted agriculture and the area developed on soils suited for diversified agriculture is relatively small. The potential of much of this land for grazing is at present uncertain.

PRESENT GRAZING LAND

The buffalo and cattle population of the residency was estimated in 1970 at 27 500 and 6 480 respectively (Sabah, Malaysia Department of Agriculture, 1971), though it is thought that these figures are rather on the high side. There is little established grazing for the buffalo and cattle many of which graze on common grass and scrubland round the kampongs and in the padi fields after the rice crop is harvested. There are only a few small to medium sized cattle farms where there may be some improved grazing.

The natural grasslands generally afford only poor grazing with *lalang* (*Imperata cylindrica*), the dominant species. Locally extensive areas of sheet *lalang* are regularly burnt to stimulate young regrowth for grazing. This young regrowth is of some nutritional value but it rapidly loses this as it matures and becomes almost inedible. In some grassland areas bracken (*Pteridium* spp.) is common and in others the straits rhododendron (*Melastoma* spp.) is widespread. In Sipitang and Beaufort Districts centipede grass (*Ischaemium barbatum*) which is of some value for grazing, does occur naturally in places but it is not found in Tenom, Tambunan and Keningau Districts. The buffalo in the Beaufort District are mostly found in the stateland of the Klias Plain.

There are only 1 722 ha (4 256 ac) of gazetted grazing reserves of which less than 25% is grassland. Table 32 shows the areas of improved pasture, grassland and other land use in the grazing reserves by land capability classes. However there are other areas of stateland which are by customary right regularly used for grazing and though not gazetted as grazing reserves should, for practical purposes be regarded as such.

TABLE 32 The grazing reserves, their land capability and present use

Land capability class	Improved pasture		Grassland		Other land use		Total	
	ha	ac	ha	ac	ha	ac	ha	ac
II	0	0	17	42	97	241*	114	283
III	3	8	260	641	491	1 213*	754	1 862
IV	0	0	7	18	66	164	73	182
V	15	36	128	317	638	1 576**	781	1 929
Total	18	44	412	1 018	1 018	3 194	1 722	4 256

* Mostly high forest and scrub forest

** Mostly swamp, marshland and wetland forest with some high forest and scrub forest

It will be noted from Table 32 that little more than 1% of the area is improved pasture, that the area of Land Capability Class II land is relatively small and that most of this is still covered by forest, and also that a large part of the Class III and V land is either forested or swampy. While most of the Class V land is probably of very little use for grazing purposes there are some 600 ha (1 500 ac) of Class III land where slope is not a limitation and which will probably be suitable for grazing. Most of the grazing reserves are quite small.

The total area of improved pasture according to the *Present Land Use Survey* (Wong, 1973), based on information as at 1970, is not large and its distribution by land tenure and land capability class is given in Table 33. Since 1970 there has been an increase in the land improved for grazing. The most recent estimate made by Bacon (1975) is that out of a total of 684 ha (1 690 ac) which are fenced, 158 ha (390 ac) have been planted with fodder crops.

The species which have been mainly used for improving pastures are the legume stylo, (*Stylosanthes guyaensis* var 'Schofield') and the grasses, suriname grass (*Brachiaria decumbens*) and African stargrass (*Cynodon plectostachyus*). Other species have been tried but without much success. The suitability of the various pasture grasses and legumes have been investigated at the government cattle station at Sebrang, Keningau, (Plate 4-6). This station has, for the past eleven years, held a key position in research into pasture improvement and other aspects of animal husbandry, for both residency and state.

TABLE 33 Distribution and land capability of improved pastures

Land capability class	Alienated land		Stateland		Grazing reserves		Total	
	ha	ac	ha	ac	ha	ac	ha	ac
III	19	48	45	111	3	8	67	167
V	15	36	0	0	15	36	30	72

POTENTIAL GRAZING LAND

Natural grassland covers approximately 28 282 ha (69 887 ac) and its distribution by land categories and suitability for improvement is shown in Table 34. From the table it can be seen that only some 9.7% (2 667 ha (6 589 ac) are inherently suited for grazing (Land Capability Class II). Of the 11 814 ha (29 194 ac) of land of medium suitability (Class III) some will probably be suited for grazing where slopes are not too steep but the production of good pasture may require a considerable input of fertiliser. It is likely that little, if any, of the land with poor suitability (Class V) will be suitable for grazing.

It will be noted from Table 34 that a large proportion of the land inherently suited for grazing is either alienated land or stateland and is thus readily available for development for grazing. Development of this land for grazing will involve the eradication of *lalang* and the introduction of forage crops to replace it and provide improved pastures. In places clearing and slashing may be required to reduce the amount of shrubby vegetation and fencing will of course be necessary. Experience has shown that concentrated and continuous grazing of *lalang* in fenced paddocks will greatly reduce its vigour and result in somewhat improved pasture.

TABLE 34 Alienation and gazettement of the natural grassland and its suitability for pasture improvement

Suitability for improved pastures*	Stateland		Forest reserves		Government reserves		Grazing reserves		Alienated land		Total	
	ha	ac	ha	ac	ha	ac	ha	ac	ha	ac	ha	ac
Good	597	1 475	1	3	461	1 138	17	42	1 591	3 931	2 667	6 589
Medium	5 807	14 350	1 814	4 482	148	366	259	641	3 786	9 355	11 814	29 194
Poor	8 590	21 227	1 902	4 699	225	555	128	317	2 916	7 205	13 761	34 003

* This is based on a rating for agricultural development

Good = diversified agriculture (Land Capability Class II)

Medium = restricted agriculture (Land Capability Class III)

Poor = not suited for agriculture (Land Capability Class V)

In addition to the natural grasslands there is a potential for developing improved pastures on land at present under forest. Because of the need for relatively flat terrain such development would be restricted mainly to Class II land of which there are a total of some 9 070 ha (22 410 ac). The greater part of this land is alienated or stateland and thus should be readily available for development. Of course, development for grazing might well conflict with development of other forms of agriculture.

Game resources

It will have been noted in Part 3, when the various investigations carried out on the game resources were discussed, that relatively little work of this nature has been undertaken. There has been no formal survey and the published information is very sparse, largely the work of Davis (1962) and Medway (1965) on the mammals of North Borneo and Borneo respectively. These are themselves, in the case of the Interior Residency, mainly based on the collections and notes made by nineteenth century residents on Labuan, the 1928 expedition to Rayoh in the Padas Gorge, and Trus Madi in 1956.

The natural ecosystem has been evolved in the primordial forest which, in Borneo, 'is perhaps the most favourable environment for plant and animal life' (Davis, 1962). Human settlement and agriculture have, however, destroyed large areas of the high forest. This has considerably modified the animal population and some species have been particularly affected. For example, in 1856 herds of *temadu* (wild cattle) were described as being plentiful on the Klias Hills (St. John, 1862). These herds have long

since been exterminated and reports of the animal are very rare and restricted to the remote mountains. On the other hand some species, e.g. of pig and deer, may have increased in numbers following the destruction of the high forest. Similar to the other parts of Sabah, the general picture is probably one of a decreasing wildlife population, with some species being restricted to the most remote undisturbed forests.

Very little information is available on the birds and reptiles, but the mammals are reasonably well documented, some 53 species being positively identified and a further 20 species, because of their common occurrence in neighbouring parts of Borneo, can be considered to be plentiful in the residency.

MAMMALS

In common with other regions in Borneo, the Interior Residency has probably one of the richest primate fauna in the world. About 17 species occur, 13 of which are specifically mentioned as being recorded within the residency boundary by Davis (1962) and Medway (1965). The largest and rarest is the orang utan, very small numbers of which are still likely to survive in the south-west in the isolated parts of the Meligan and Witti Ranges, and in the south-east in the upper reaches of the Sapulut Valley. The Sunda Island gibbon has been reported at Rayoh and on Trus Madi and it is probably common to all the undisturbed forests. Monkeys are plentiful in all parts, from the coasts to the high mountains, and fairly common as large tribes in both plantations and forests. They are represented by a number of species which are listed in Table 35, which also includes the other primates, the tree shrews. Many of these are nocturnal and arboreal, and therefore rarely seen.

Pig and deer are the main game animals and are an important source of food for some rural communities. The bearded pig is probably the most common and widespread, being found from beach to mountain top. Large numbers occur, for example, above 2 400 m (8 000 ft) on Trus Madi (Bryant, 1956), and are plentiful on Pulau Tiga. Three deer species have been described and are listed in Table 35. The sambar is the largest, most uncommon and highly prized by hunters. It is now mainly restricted to the more remote areas as solitary individuals or pairs. The barking deer and the mouse deer are also essentially non-gregarious, but they appear to be more common and widespread, frequenting both high forest and low vegetation associated with shifting cultivation.

The sumatran rhinoceros and the *temadau* or wild cattle have fallen as the most serious victims of the hunter. Trus Madi for a long time had the reputation of having a rhinocerous population. They undoubtedly existed but have not been sighted in recent decades. Medway (1962) reports the animal being seen in the Upper Padas area in 1946, and this is the most recent documented evidence. The Upper Padas area is the only one reputed for *temadau*. Judged by St. John's account of its numbers on the coast in 1856, the animal has suffered considerably at the hands of the hunter and might now be close to extermination.

Six species of carnivores have been described, and a further three are likely to occur. Of these the Malaysian bear and the otters are probably of most interest. The forests of the upper part of the Padas Valley also appear to be a sanctuary for the bear. The small-clawed otter (*Aonyx cinerea*) is probably widespread in the riverine areas, but the hairy-nosed otter (*Lutra sumatrana*) is likely to be less common, having been described only from the Mengalong Valley (Medway, 1965).

The squirrels are very numerous, are predominantly arboreal, and perhaps the commonest of the mammals. Thirteen species may be present; nine have been positively identified, two of which are flying squirrels.

There are a great number of bats; Davis (1962) and Medway (1965) list ten species. The most interesting is the large flying fox, the world's biggest. It is hunted but remains plentiful, large flights being a fairly common sight on the coast.

The asiatic elephant has been reported once, in the Pensiangan area (Medway, 1965). This is outside its normal geographical range and might well have been a rare wanderer from neighbouring Kalimantan. Elephant can be considered to be all but absent from the Interior Residency.

TABLE 35 The important and more common mammals

Sambar deer	*Cervus unicolor brookei*
Barking deer	*Muntiakus muntjak pleiharicus*
Lesser mouse deer	*Tragulus javanicus*
Bearded pig	*Sus barbatus barbatus*
Sunda Island gibbon	*Hylobates moloch*
Crab-eating macaque	*Macaca fascicularis*
Grey leaf monkey	*Presbytis aygula hosei*
Maroon leaf monkey	*Presbytis rubicunda*
Sunda Island leaf monkey	*Presbytis aygula*
Common treeshrew	*Tupaia glis*
Mountain treeshrew	*Tupaia montana*
Lesser treeshrew	*Tupaia minor*
Slender treeshrew	*Tupaia gracilis*
Large treeshrew	*Tupaia tana*
Pentail treeshrew	*Ptilocercus lowii*
Moonrat	*Echinosorex gymnurus*
Large flying fox	*Pteropus vampyrus*
Island flying fox	*Pteropus hypomelanus tomesi*
Giant squirrel	*Ratufa affinis*
Red giant flying squirrel	*Petaurista petaurista*
Mountain giant rat	*Rattus infraluteus*

REPTILES

Turtles are known to frequent the shoreline and have been seen in large groups in the sea between Pulau Tiga and Kuala Penyu. They are the most important reptiles and are protected under the Fauna Conservation Ordinance (Colony of North Borneo No. 11 of 1963). They are known to nest on some beaches on the Klias Peninsula, and de Silva (1974) reports that green turtle (*Chelonia mydas*) have been known to lay eggs on Labuan. The eggs are edible and are much sought after by collectors. There has been no estimate made of the number of turtles but it is reasonable to assume that it is declining.

Crocodile (*Crocodilus porosus)* have been reported in the Padas and Pegalan on the Tenom Plain, where they have been known to prey on humans. Their distribution is probably widespread but, because of hunting, their total population is likely to be small and rapidly decreasing. The monitor lizard (*Varanus salvator*) is known to occur in a number of places, and in spite of hunting is probably a common animal throughout the residency, particularly along the rivers.

Snakes are rarely seen but a large number are likely to occur. Most are not poisonous and are harmless. There are no details available.

BIRDS

Apart from a very brief account contained in the report of the Cambridge University expedition to Trus Madi (Bryant, 1956), there has been no known published account on the bird life of the residency. It is reasonable to assume, however, that it has very much in common with that of the West Coast Residency. This has been reported on in Volume 3 and the reader is referred to that text for further details.

The most common game birds are snipe (*Capella megala* and *C. stenura*), which are migrants from the northern winter. In season, large numbers are to be found on the Keningau Plain. Pigeon are plentiful and are probably the most hunted of the birds.

Recreational land resources

The residency is not particularly well endowed with land suited for recreational purposes. There are high altitude areas in the mountains which may have some potential, some beaches and a few places which are scenically attractive and interesting.

The value of land in the mountains for recreational purposes is greatly enhanced when it is at an altitude which is high enough to provide a significantly cooler climate. This is considered to be the case with land above 1 200 m (4 000 ft) as at this altitude the maximum day temperature can be expected to be below 23°C (75°F) and lower than 18°C (65°F) at night. There are fairly extensive areas of such land with access ranging from reasonably easy to very difficult.

The only part of the coastline where there are attractive beaches and seas that are usually clear and clean is the western shoreline of the Klias Peninsula. While there are sandy beaches along the coastline between Weston and Kuala Mengalong and on Labuan and neighbouring small islands the seas in this area are in common to all of Brunei Bay, subject to periodic discoloration.

Away from the highlands and coastline there are a few places which, because of their particular scenic attraction or historic interest, merit particular attention.

HIGH ALTITUDE AREAS

In that part of the Crocker Range which falls in the Interior Residency there are a total of some 19 500 ha (48 300 ac) of land above an altitude of 1 200 m (4 000 ft). The largest block of such land lies in the northern part of the residency on the eastern side of the range. The heavy precipitation is however likely to detract somewhat from the attraction of these high altitude areas for human settlement and recreation. Rainfall is particularly high and low cloud and afternoon mists are common. Access to this area is provided by the main highway from Kota Kinabalu to Tambunan which crosses the range close to Gunong Alab. An almost unbroken chain of land above 1 200 m (4 000 ft) continues in a south-westerly direction along the crest of the range as far as Lingan. From this point to the southern end of the range there are only isolated patches of land above 1 200 m (4 000 ft) most of which are quite small. However in the vicinity of the headwaters of the Pampang and Liawan Rivers there is an area of some 2 000 ha (5 000 ac) access to which may be gained from the road which timber interests are building across the range to link Keningau with Kimanis.

In the Trus Madi Range there are some 33 600 ha (83 000 ac) of land above an altitude of 1 200 m (4 000 ft), in one compact block, rising to 2 649 m (8 690 ft) at the summit of Trus Madi. Access to the whole of this area is very difficult and it can only be reached by walking. The nearest road is that from Tambunan to Ranau and it is unlikely that road access will improve in the foreseeable future.

Elsewhere in the residency there are small areas of land above 1 200 m (4 000 ft) but most of these apart from being small in extent are remote and inaccessible.

BEACHES AND ISLANDS

Moderately to gently shelving sandy beaches occur along almost the whole length of the western shoreline of the Klias Peninsula. The beaches are of reasonable quality and the seas in the area are generally clean and clear. Where the old road from Kuala Penyu to Menumbok runs close to the sea access to the beaches is easy but where it leaves the

coast and runs inland access is a little difficult. However this road is likely to fall into disrepair and become unusable as it is being replaced by a new road which in no place runs close to the sea. It is thus likely that in the near future access to most, if not all, of the beaches will not be easy.

There are scattered beaches along the coast between Weston and Kuala Mengalong though of rather poor quality being generally dirty and shallow shelving, there are also beaches on Labuan and the neighbouring small islands of Kuraman and Rusukan, some of which are quite good. However all these beaches which are washed by the seas of Brunei Bay may suffer the disadvantage that their waters are subject to periodic discoloration which considerably reduces their attraction for recreational purposes.

AREAS OF SCENIC ATTRACTION

The gorge of the Padas River where it flows through the Crocker Range has steep forest-clad hills and swiftly moving turbulent water. This combination has considerable scenic attraction and the area is considered to have potential for recreational purposes. The railway which runs alongside the river provides easy access and a means of viewing the scenery.

The Tambunan Valley is scenically attractive with its terraced padi fields, swiftly flowing clear streams, bamboo clad hills and back-drop of high mountains. The remains of Mat Salleh's Fort, which is of historic interest, act as a focal point for the area. Access is provided by the main road from Kota Kinabalu to Tambunan and on to Keningau which runs through the valley.

The valley of the Labau River between Lanas and Mansiad is scenically attractive with the clear, swift flowing river and pleasant, peaceful, rural areas. Access is provided as far as Lanas by a dirt road from Tulid.

In the Batu Tunggul area some 16 km (10 mi), south-east of Sapulut, there are a number of limestone outcrops with caves. At present access is difficult as the road from Keningau only goes as far as Sapulut.

Part 5

Opportunities for resource development

Part 5 is primarily concerned with the main resource development opportunities which exist in the residency. At the same time it provides broad guidelines for further investigations and studies which are thought necessary to assist proper implementation planning. Any discussion on future development would not be complete without considering the course of events which have given rise to the present land use and alienation and gazettement pattern.

HISTORY OF LAND DEVELOPMENT

In common with the other parts of the north-west coastline of Borneo, the Interior Residency appears to have had a long history of immigration and trade with the outside world. As early as the seventh century A.D. the Chinese T'ang Empire had established trading links. This contact with the Asian mainland was to continue for the next thousand years. In the meantime the neighbouring Kingdom of Brunei was to rise in power and gain suzerainty of the coastline and lower reaches of the rivers. Brunei itself was subject to much external influence; in addition to that of Chine it had, successively, close links with the Buddhist Srivijaya Empire of Sumatra, the Hindu Majahpahit Empire of Java, and later Malacca (Whelan, 1970).

Even though these contacts with the outside world undoubtedly brought about many cultural, social, political and commercial changes they probably had little effect on the general pattern of land use; with villages on the coast and main rivers engaged in fishing and small scale cultivation, and scattered semi-migratory communities inland sustained by hunting and shifting cultivation. There was no large scale development but a small surplus was produced for trade. For example, Whelan (1970) cites that the commodities listed in 1526 for export from Brunei included, amongst other things, rice, sago, pepper and fish. Much of these were undoubtedly shipped from the residency to Brunei together with jungle produce such as rattan and wax.

The history of modern development in the residency can be considered to start with the Anglo-Brunei treaty of 1846 which resulted in Labuan being ceded. The island was almost unpopulated and undeveloped, having 'one of the finest forests in the Far East' (St. John in Whelan, 1970). From the start the prime interest was coal mining, and this was to be the mainstay of the economy for many years. Land development on the island was slow and frequently stagnant, even though favourable reports on its agricultural potential had been made. Motley as early as 1852 stated, in his report on the geology, that 'occupying at least three-fourths of the whole island, is a fine and deep yellow loam, excellently adapted for nearly all tropical cultivations' (Motley, 1852). There was very little positive response to such eulogy. Even though land titles were being issued in the 1860s, and much of the land was taken up at an early date, there was never any large-scale agricultural development on the island. Agriculture was largely the work of smallholders and remains so today.

With the establishment of a settlement on Labuan closer attention could be given to the neighbouring mainland; and early inhabitants such as H.Low and J.Motley made important journeys through parts of the seaboard noting various aspects of its resources and natural history. The first recorded penetration of the interior was in 1865-6 from Kimanis to Keningau, and by the early 1880s other places had been visited, including Tambunan and the country to the south (Whelan, 1970). Slowly there evolved a picutre of what lay behind the coastal ranges.

With the start of Chartered Company rule in 1882 government control was to spread from the north. The Klias Peninsula was bought from the Sultan of Brunei in 1884. This was to be followed by a number of similar purchases, and by 1901 all the land making up the present day residency had been acquired (Whelan, 1970).

For some time the economy remained based on its traditional agricultural produce, mainly rice and sago. This was to be supplemented in the early 1890s by tobacco, marking the start of estate-type agriculture. Although the plantations were never extensive, the tobacco boom of the period probably more than anything else served to focus interest in developing land on the mainland. With this in mind the Chartered Company embarked in 1896 on a programme of railway construction. This was to end in 1905, by which time Beaufort was linked to Weston to the south, Kota Kinabalu (then Jesselton) to the north and Melapap via Tenom to the east; and tobacco was being grown on a commercial scale on the Padas, below Beaufort and near Tenom.

The construction of the railway coincided with the arrival of a new plantation crop, rubber. This was first introduced into Sabah in 1899 and successfully tested at a newly established government garden in Tenom (Tregonning, 1958). For some time before this however, the tobacco industry was in decline and with the advent of such a new promising crop many of the estates were converted to rubber. By 1905 commercial production of tobacco in the state had virtually ceased, but rubber was being planted in economic quantities and a number of estates were established along the newly constructed railway line. Beaufort and Tenom, the sites of which were uninhabited before the arrival of the railway, quickly became important centres for the rubber industry. The spate of clearing and planting was interrupted by the 1914-18 War, and continued at a slower but still significant pace afterwards. By 1917 14 095 ha (34 828 ac) had been planted in Sabah (Tregonning, 1958), the greater part of which was concentrated in the Beaufort area, much as widespread smallholdings.

At the same time coconuts became an important crop though cultivation was somewhat scattered, with a few small estates on Labuan, and along the western coastline of the Klias Peninsula. The Klias Plain continued to be an important producer of sago and its export continued to be of economic significance; to such an extent that in 1925 Government attempted to make a concerted but abortive effort to organise the crop on an industrial basis. The immediate postwar period saw other failures in the public sector's endeavour to diversify development. As part of a campaign to increase wet-rice cultivation an experimental farm was set up in 1919 near Keningau. This was to be abandoned in 1926. Similarly a cattle station was established near Tenom in 1921 with the view to establishing a beef industry. This was also to fail in 1926 (Tregonning, 1958).

During this time however, Government was having far greater success in establishing an effective administrative system. By 1934 district posts existed at Beaufort, Mempakul, Sipitang, Keningau, Tenom, Tambunan and Pensiangan (Whelan, 1970); the whole of the residency was under effective Government control. Beaufort soon became the main centre of the rubber industry, but during the 1930s there was very little increase in the total acreage of the crop (Tregonning, 1960); however there has been considerable replanting in the last few decades.

Unlike in other parts of Sabah, the timber industry has had a negligible effect on the overall development pattern. Mainly because of extraction difficulties logging has largely been restricted to meet local demands. The first known commercial operations

started in the 1960s in the Beaufort area. These were later extended to the Sipitang hinterland, and a large enterprise has been established recently to exploit the considerable timber resources lying to the east of the Sook and Penawan Plains.

New developments in the agricultural sector since the establishment of the rubber industry have been the advent in the 1960s of the oil palm as a pioneer commercial crop on the Klias Peninsula (Plate 4-7) and cocoa as an equally recent crop, in this case on the Tenom Plain.

Throughout this long history of land development the main imprint on land use has been that of shifting cultivation (see Plate 4-8). This, more than anything, has resulted in the destruction of much of the primordial forest, and as a result much of the commercial forests have been lost. Shifting cultivation, however, plays little or no role in a cash economy, and the main export product which has sustained the residency for most of its history has been rubber. This, and to a lesser degree, the cultivation of other crops such as coconuts and rice, has resulted in extensive areas of the seaboard and some of the interior plains being alienated for agriculture.

PRESENT LAND USE AND ALIENATION AND GAZETTEMENT

The 1970 *Present Land Use Survey* (Wong, 1973 b) has confirmed the extent of the shifting cultivation. It follows a rotational system with cropping periods interspersed with periods of fallow marked by scrub forest growth. About 6.4% of the residency is used in this fashion; this is greater than the total area under more permanent agricultural crops, which amounts to 85 072 ha (210 215 ac), 4.7% of the land. Most of the agricultural development is concentrated on the areas of relatively easy access on the seaboard and some of the interior plains, particularly in the Beaufort, Kuala Penyu and Tenom Districts. This is illustrated by Text Map 4-12. Over 93% of the land remains forested, (see Figure 4-1).

Table 36 gives the data on present land use for each district. It shows that most (62%) of the cultivated land is under permanent crops. Wong (1973 b) indicates that rubber is the most extensive with 40 751 ha (100 697 ac), which represents almost 48% of the total agricultural land. A considerable proportion (44.5%) of this rubber is moribund or neglected, and therefore unproductive. This particularly applies to the Sipitang and Beaufort Districts. Wong (1973 b) has also shown that most of the rubber in the residency is grown on smallholdings.

Rice is the most important annual crop, a total of 13 125 ha (32 432 ac) (Wong, 1973 b) being grown as wet padi mainly on the Keningau and Klias plains. There are some 22 374 ha (55 287 ac) of dry land rice grown on a shifting and loosely rotational basis in conjunction with such crops as tapioca, maize, yams, sweet potatoes and tobacco.

Sago is the next most extensive crop, for which the 1970 *Present Land Use Survey* gave a figure of 2 634 ha (6 509 ac), with most of this growing semi-wild in scattered groves in the swamps of the Klias Plain. About 2 468 ha (6 098 ac) are used for coconut cultivation, mainly in the Klias Hills and on Labuan, with very little in the interior. Bananas are an important cash crop on the Tenom Plain where 433 ha (1 070 ac) are grown (Wong, 1973 b). Cocoa is a rapidly expanding crop on the Tenom Plain; the 1970 estimate was 274 ha (678 ac), while the 1975 figure is likely to be considerably larger. Oil palms are virtually restricted to the Klias Plain and are not extensive, covering a total of 700 ha (1 729 ac) (Wong, 1973 b).

PLATE 4.7

Oil palms cultivated on the Klias Plain. The lodging is due to the poor anchoring substratum afforded by the mixed alluvial and peat soils. Klias Settlement Scheme

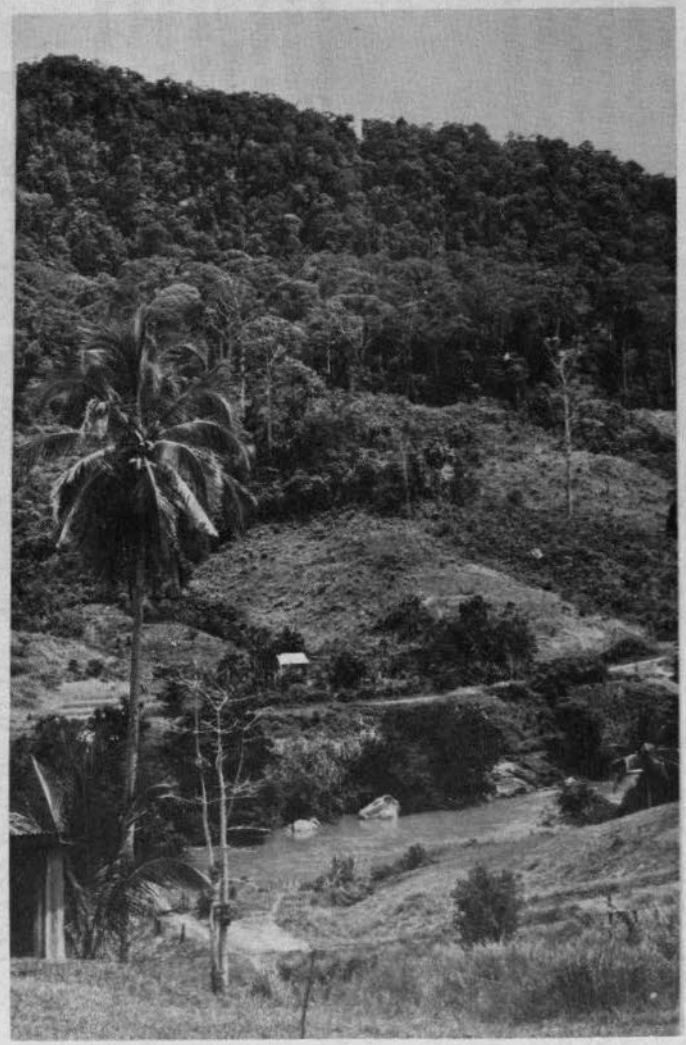


PLATE 4.8

Traditional land-use pattern in the interior, with shifting cultivation on the lower slopes. Talankai Valley, Sapulut

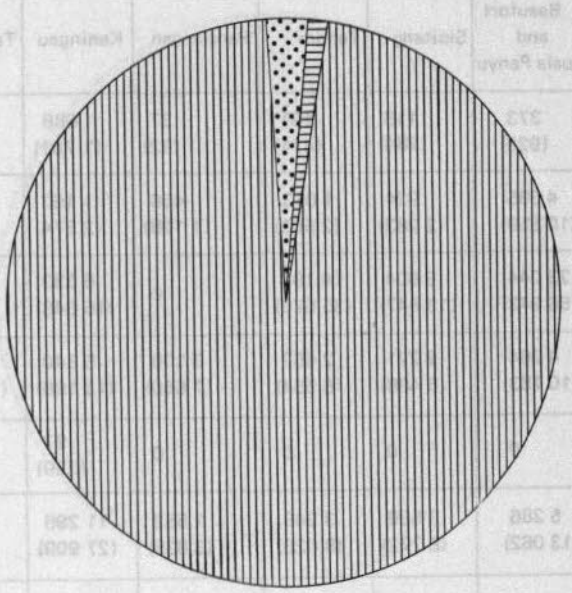
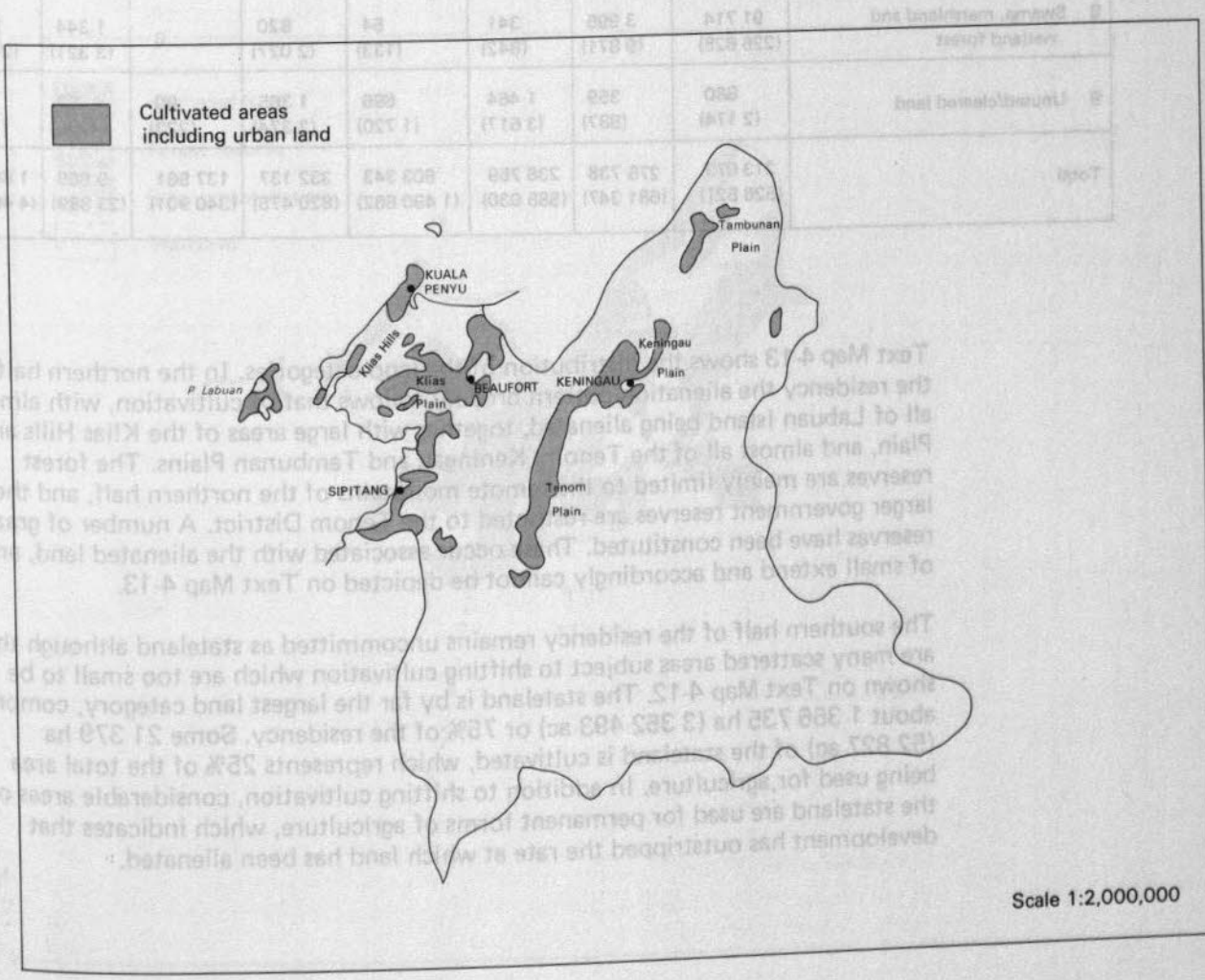


FIGURE 4-1 Present land use



TEXT MAP 4-12 Cultivated areas including urban land

Prepared by the Directorate of Overseas Surveys 1976

TABLE 36 Present land use by districts in ha (ac) (1973)

Major present land use category	District							Total residency
	Beaufort and Kuala Penyu	Sipitang	Tenom	Pensiangan	Keningau	Tambunan	Labuan	
1 Urban and associated land	373 (923)	115 (284)	191 (471)	37 (92)	688 (1 701)	110 (271)	381 (942)	1 896 (4 684)
2 Horticulture	4 395 (10 859)	924 (2 283)	1 013 (2 503)	456 (1 128)	1 163 (2 874)	804 (1 988)	821 (2 028)	9 576 (23 663)
3 Tree, palm and permanent crops	23 044 (56 943)	5 604 (13 847)	14 193 (35 070)	0	6 333 (15 648)	1 199 (2 963)	2 653 (6 555)	53 025 (131 026)
4 Shifting cultivation	4 364 (10 783)	2 221 (5 488)	2 652 (6 554)	3 100 (7 660)	5 340 (13 196)	4 134 (10 215)	563 (1 391)	22 374 (55 287)
5 Improved permanent pasture	0	0	0	0	97 (239)	0	0	97 (239)
6 Grassland	5 286 (13 062)	3 550 (8 772)	3 248 (8 026)	1 552 (3 835)	11 295 (27 909)	3 261 (8 057)	895 (2 211)	29 086 (71 872)
7F Forest	72 303 (178 662)	249 324 (616 079)	196 201 (484 814)	578 000 (1 428 238)	282 322 (697 619)	116 390 (287 599)	1 274 (3 147)	1 495 815 (3 696 158)
7S Scrub forest	10 720 (26 490)	9 646 (23 836)	17 456 (43 133)	19 448 (48 056)	22 714 (56 127)	11 973 (29 585)	1 649 (4 074)	93 606 (231 301)
8 Swamp, marshland and wetland forest	91 714 (226 625)	3 995 (9 871)	341 (842)	54 (133)	820 (2 027)	0	1 344 (3 321)	98 268 (242 819)
9 Unused/cleared land	880 (2 174)	359 (887)	1 464 (3 617)	696 (1 720)	1 365 (3 374)	90 (223)	89 (220)	4 943 (12 215)
Total	213 079 (526 521)	275 738 (681 347)	236 759 (585 030)	603 343 (1 490 862)	332 137 (820 475)	137 961 (340 901)	9 669 (23 889)	1 808 686 (4 469 264)

Text Map 4-13 shows the distribution of the land categories. In the northern half of the residency the alienation pattern broadly follows that of cultivation, with almost all of Labuan Island being alienated, together with large areas of the Klias Hills and Plain, and almost all of the Tenom, Keningau and Tambunan Plains. The forest reserves are mainly limited to the remote mountains of the northern half, and the larger government reserves are restricted to the Tenom District. A number of grazing reserves have been constituted. These occur associated with the alienated land, are of small extend and accordingly cannot be depicted on Text Map 4-13.

The southern half of the residency remains uncommitted as stateland although there are many scattered areas subject to shifting cultivation which are too small to be shown on Text Map 4-12. The stateland is by far the largest land category, comprising about 1 356 735 ha (3 352 493 ac) or 75% of the residency. Some 21 379 ha (52 827 ac) of the stateland is cultivated, which represents 25% of the total area being used for agriculture. In addition to shifting cultivation, considerable areas of the stateland are used for permanent forms of agriculture, which indicates that development has outstripped the rate at which land has been alienated.

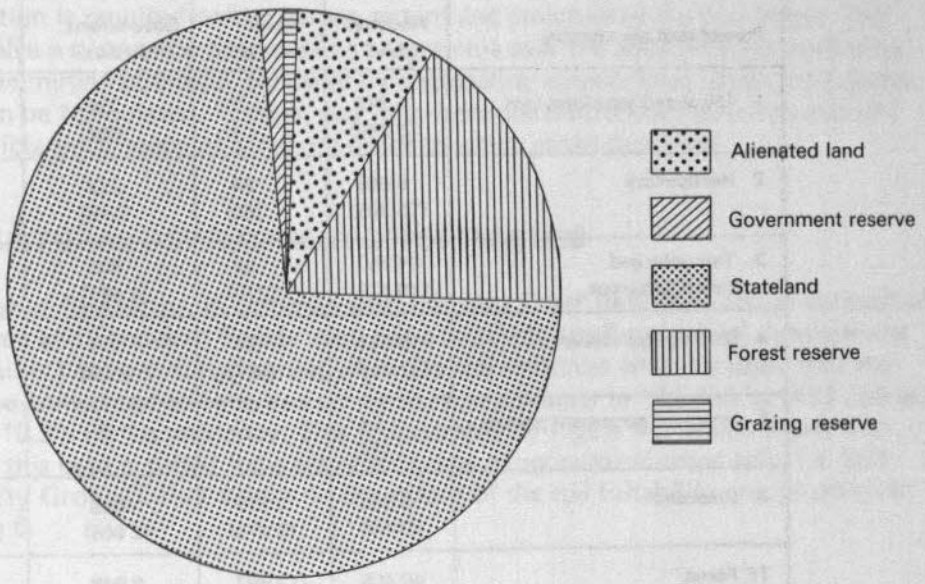
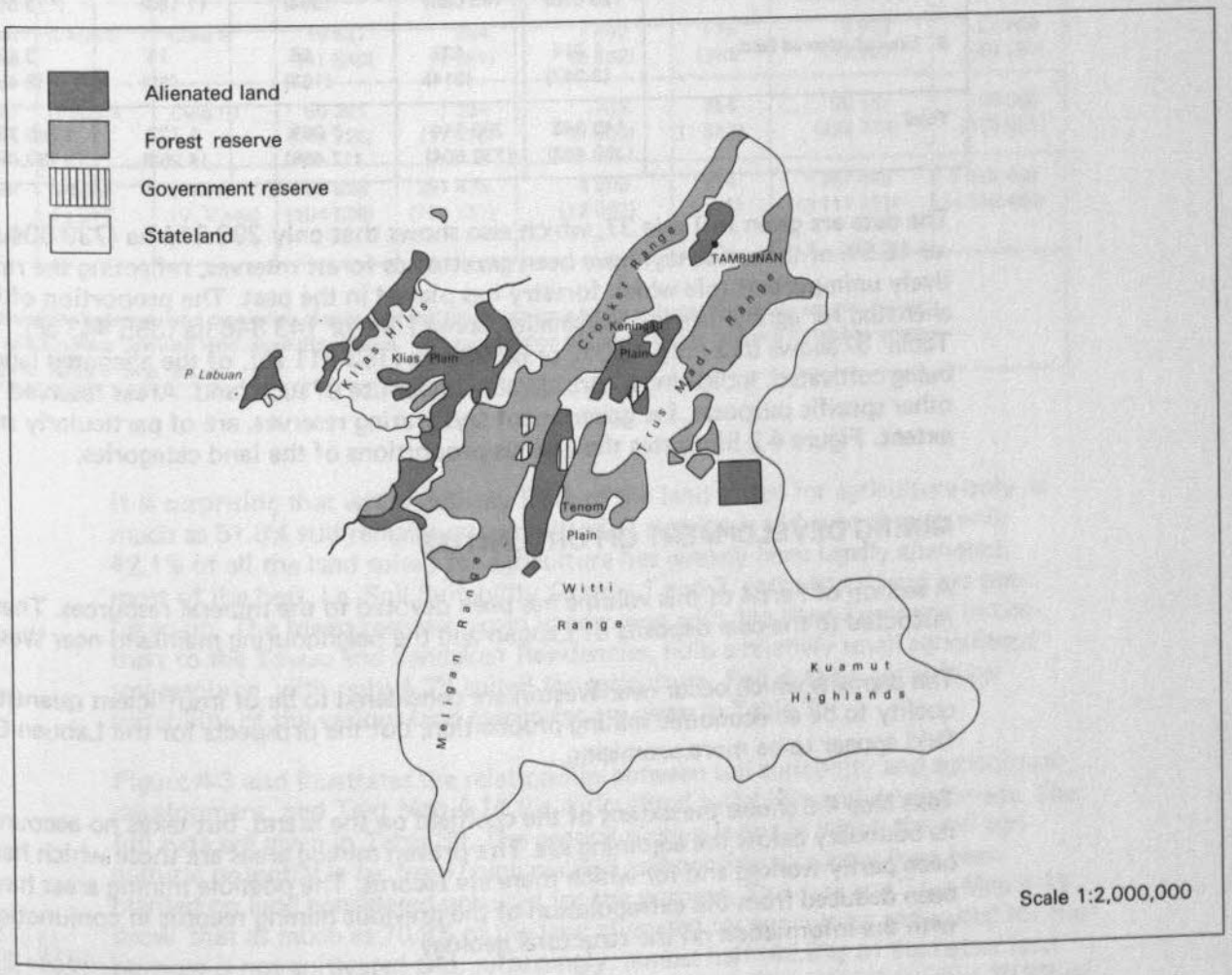


FIGURE 4-2 Alienation and gazettement



TEXT MAP 4-13 Distribution of the land categories

D.O.S. 3238 Bs

Prepared by the Directorate of Overseas Surveys 1976

TABLE 37 Present land use within the land categories in ha (ac)

Present land use category	Land category				
	Alienated land	Forest reserve	Government reserve	Grazing reserve	Stateland
1 Urban and associated land	1 319 (3 259)	2 (4)	228 (564)	20 (50)	327 (807)
2 Horticulture	6 558 (16 205)	24 (60)	222 (549)	39 (96)	2 733 (6 753)
3 Tree palm and permanent crops	44 750 (110 578)	85 (210)	603 (1 491)	56 (139)	7 531 (18 608)
4 Shifting cultivations	10 944 (27 044)	154 (381)	174 (429)	31 (78)	11 070 (27 355)
5 Improved permanent pasture	34 (84)	0	0	18 (44)	45 (111)
6 Grassland	8 353 20 640	3 915 (9 673)	836 (2 066)	412 (1 018)	15 570 (38 475)
7F Forest	40 405 (99 840)	273 697 (676 306)	3 948 (9 755)	186 (459)	1 177 579 (2 909 798)
7S Scrub forest	19 798 (48 920)	4 278 (10 570)	849 (2 097)	464 (1 147)	68 218 (168 567)
8 Swamp, marshland and wetland forest	10 371 (25 626)	17 032 (42 086)	143 (354)	483 (1 193)	70 239 (173 560)
9 Unused /cleared land	1 314 (3 247)	127 (314)	66 (163)	13 (32)	3 423 (8 459)
Total	143 846 (355 443)	299 314 (739 604)	7 069 (17 468)	1 722 (4 256)	1 356 735 (3 352 493)

The data are given in Table 37, which also shows that only 299 314 ha (739 604 ac), or 16.5% of the residency, have been gazetted as forest reserves; reflecting the relatively unimportant role which forestry has played in the past. The proportion of land alienated for agriculture is even smaller, some 7.9% or 143 846 ha (355 443 ac). Table 37 shows that only 43.3%, or 62 286 ha (153 911 ac), of the alienated land is being cultivated, indicating a considerable under-use of such land. Areas reserved for other specific purposes, i.e. government and grazing reserves, are of particularly small extent. Figure 4-2 illustrates the various proportions of the land categories.

MINING DEVELOPMENT OPPORTUNITIES

A section of Part 4 of this volume has been devoted to the mineral resources. These are restricted to the coal deposits of Labuan and the neighbouring mainland near Weston.

The deposits which occur near Weston are considered to be of insufficient quantity and quality to be an economic mining proposition, but the prospects for the Labuan Coalfield appear to be more promising.

Text Map 4-8 shows the extent of the coalfield on the island, but takes no account of its boundary below the adjoining sea. The proven mining areas are those which have been partly worked and for which there are records. The possible mining areas have been deduced from the extrapolation of the previous mining records in conjunction with the information on the structural geology.

Wilson (1964) has indicated that, although requiring verification, the reserves in both the proven and possible mining areas are likely to be well in excess of 8 857 800 t (9 000 000 lgt). Before mining is again attempted, however, considerably more information is required on the nature, extent and structure of the coal seams. This will involve a systematic deep-drilling programme over the areas indicated as having a possible mining potential, followed by engineering surveys from which production plans can be formulated. Further, any long-term planning should take into account the possible occurrence of off-shore deposits which might be mined.

AGRICULTURAL DEVELOPMENT OPPORTUNITIES

The Interior Residency, in common with the West Coast Residency and in contrast to the Tawau and Sandakan Residencies, has a relatively small agricultural development potential. It has been stated earlier when the soil resources were discussed that the total area considered to be suited for agriculture amounts to 183 438 ha (453 280 ac), or only 10.3% of the residency. This is illustrated by Figure 4-3, which shows that most of this land is suited for a restricted range of agricultural crops only, i.e. Soil Suitability Group 3. Full details on the extent of the soil suitability groups are given in Table 6.

TABLE 38 Suitability of the land categories for agriculture in ha (ac)

Agricultural suitability	Soil suitability	Land capability	Land category					Total
			Alienated land	Forest reserve	Government reserve	Grazing reserve	Stateland	
Diversified agriculture	Group 2	Class II	16 827 (41 580)	644 (1 591)	1 442 (3 562)	115 (283)	4 952 (12 237)	23 980 (59 253)
Restricted agriculture	Group 3	Class III	60 391 (149 225)	7 234 (17 876)	732 (1 809)	754 (1 862)	90 157 (222 779)	159 268 (393 551)
Not suited for agriculture	Groups 4 and 5	Classes IV, V and I	66 628 (164 638)	291 435 (720 137)	4 896 (12 097)	854 (2 111)	1 261 626 (3 117 477)	1 625 439 (4 016 460)

The relationships between land capability classes, soil suitability groups and agricultural suitability are also shown. The full relationships between land capability classes, land exploitation units and all the resource suitability groups are shown in Table 5 on p. 26.

It is surprising that with relatively little of the land suited for agriculture only as much as 51.8% still remains uncommitted as stateland; and even though only 42.1% of all the land suited for agriculture has already been legally alienated, most of the best, i.e. Soil Suitability Groups 1 and 2, agricultural land has been taken up. The forest reserves, again in common with the West Coast and in contrast to the Tawau and Sandakan Residencies, hold a relativly small agricultural soil resource, with only 4.3% suited for agriculture. Full data on agricultural suitability of the various land categories are given in Table 38.

Figure 4-3 also illustrates the relationship between soil suitability and agricultural development, and Text Map 4-14 the agricultural suitability and development. The full data are given in Table 39. The general picture is one in which the full agricultural potential is far from being realised and considerable areas have been planted on land considered unsuited for the purpose. The data and Text Map 4-14 show that as much as 70.9% of the land alienated for agriculture and suited for the purpose is not cultivated and, surprisingly, almost half (49.9%) of the better land i.e. Soil Suitability Groups 1 and 2, is not being used. They also show that 39.8% of all the land being used for agriculture is not considered suited for the purpose; this

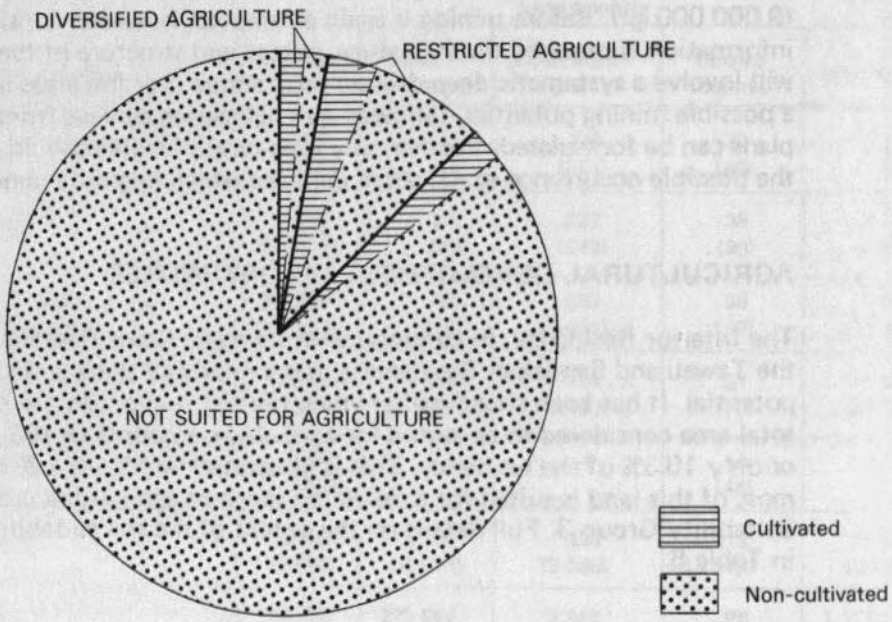
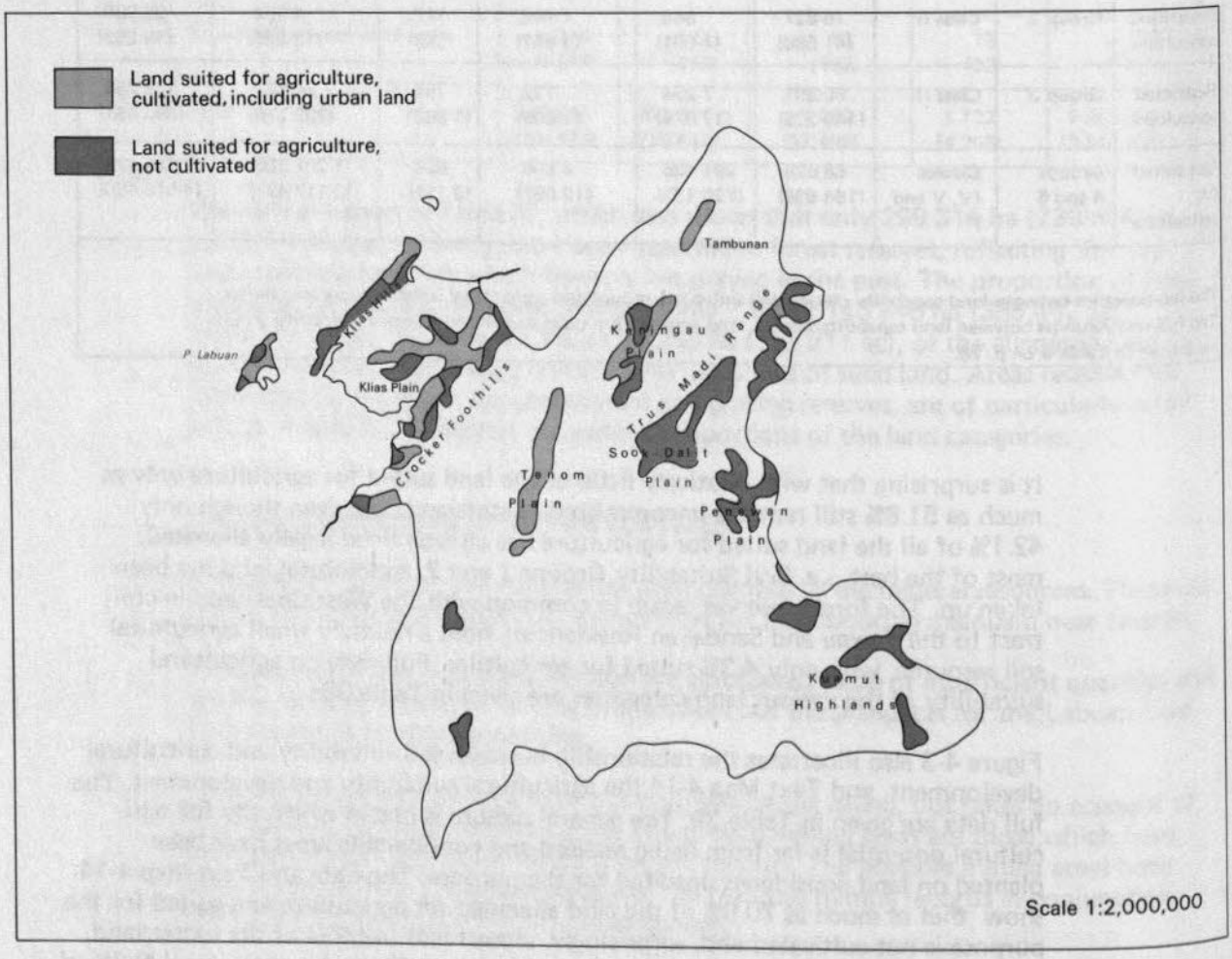


FIGURE 4-3 Land suitability and agricultural development



TEXT MAP 4-14 Areas suitable for agriculture, and the extent of their development

Prepared by the Directorate of Overseas Surveys 1976

is largely due to rubber, now mostly moribund, having been planted on stateland. It is also disturbing to find that 31.4% of the shifting cultivation occurs on land considered unsuited for agriculture; in this case mainly on mountains and steeplands.

TABLE 39 Present land use and agricultural suitability

	Major present land use category	Agricultural suitability					
		Diversified agriculture		Restricted agriculture		Not suited for agriculture	
		ha	ac	ha	ac	ha	ac
1	Urban and associated land	153	378	1 112	2 747	631	1 559
2	Horticulture	1 196	2 956	5 456	13 483	2 924	7 224
3	Tree, palm and permanent crops	9 514	23 510	22 232	54 936	21 279	52 580
4	Shifting cultivation	1 157	2 860	12 217	30 187	9 000	22 240
5	Improved or rotational crops	0	0	68	167	29	72
6	Grassland	2 668	6 593	11 812	29 188	14 606	36 091
7F	Forest	3 900	9 637	75 926	187 614	1 415 988	3 498 907
7S	Scrub forest	4 602	11 371	22 807	56 356	66 197	163 574
8	Swamp, marshland and wetland forest	568	1 403	6 212	15 351	91 487	226 065
9	Unused/cleared land	221	545	1 433	3 542	3 289	8 128

The course taken to develop the agricultural soil resource will depend on a number of factors; the most important of which include access and communications. But the first consideration should ideally be the legal status of the land, with land already specifically allocated for agriculture, i.e. the alienated land and grazing reserves being first considered, then stateland, followed by forest and government reserves. Also, in conjunction with the legal status of the land its agricultural suitability should be considered. Hence, when considering the various land categories the first choice would be the Group 1 soils, followed by Group 2 and then Group 3. These considerations are treated accordingly in the following text.

Alienated land

Text Map 4-15 shows the distribution of the alienated land, its suitability for agriculture and whether it is cultivated or not.

The choice of land for agriculture in the past has been generally poor, and a great number of titles have been issued on land not considered suited for agricultural development. Further, much of the suitable land which has been alienated is not being cultivated. Figure 4-4 illustrates the general situation, and the data on agricultural suitability and the land use of the alienated land are given in Table 40.

The data given in Table 40 show that some 35 398 ha (87 469 ac) remain uncultivated; which represents a significant opportunity for further agricultural development in the residency. The main areas of such land, i.e. alienated and suited for agriculture but not cultivated are shown on Text Map 4-15. These areas are easily accessible being close to the main road system. They include some 700 ha (1 700 ac) of the Soil Suitability Group 1 soils in the Tenom area described earlier, about 6 100 ha (15 000 ac) of Group 2, and approximately 28 700 ha (70 800 ac) of Group 3 soils. It should be noted that virtually all the Group 1 soils have been alienated.

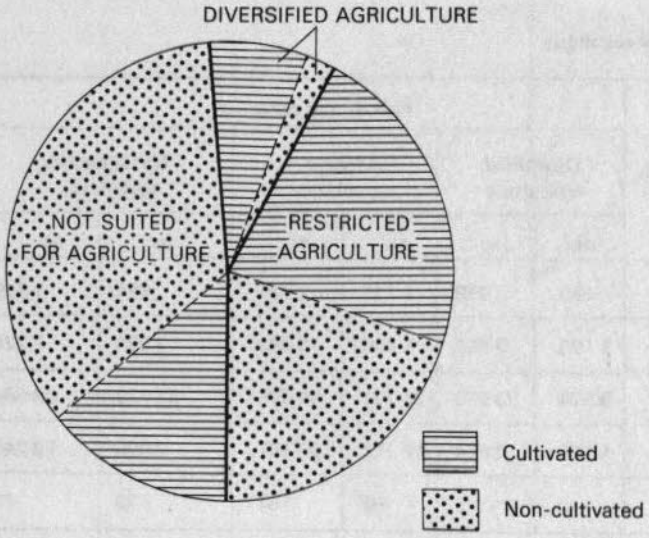


FIGURE 4-4
Soil suitability of the alienated land and its agricultural development

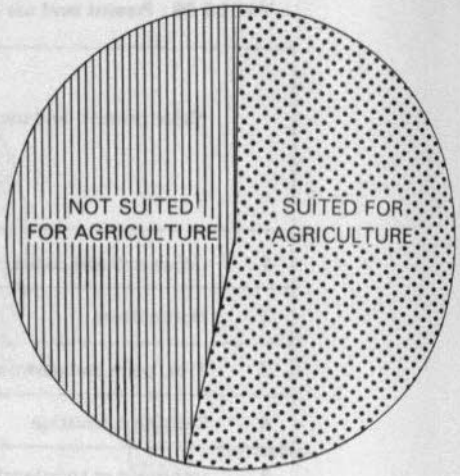
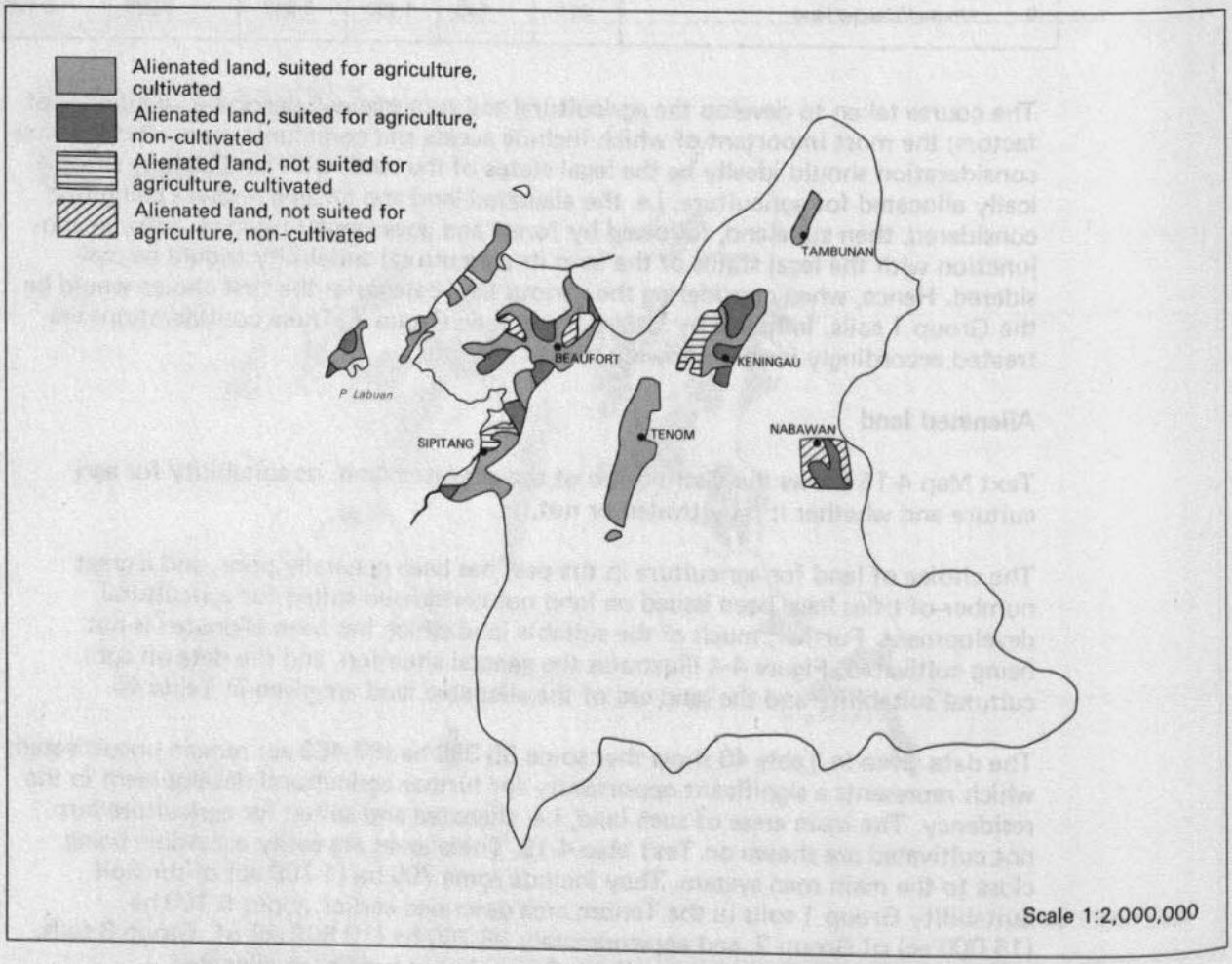


FIGURE 4-5
Suitability of grazing reserves for agriculture



TEXT MAP 4-15 Alienated land, its suitability and agricultural development

Prepared by the Directorate of Overseas Surveys 1976

TABLE 40 Present land use and agricultural suitability of alienated land in ha (ac)

Agricultural suitability	Present land use category												Total
	Cultivated					Non-cultivated							
	2	3	4	5	Subtotal	1	6	7F	7S	8	9	Subtotal	
Diversified agriculture	913 (2 256)	8 232 (20 341)	930 (2 298)	0	10 075 (24 895)	127 (315)	1 591 (3 931)	1 459 (3 605)	3 144) (7 768)	304 (752)	127 (314)	6 752 (16 685)	16 827 (41 580)
Restricted agriculture	3 957 (9 779)	19 172 (47 374)	8 596 (21 240)	19 (48)	31 745 (78 441)	876 (2 164)	3 783) (9 349)	11 601 (28 666)	8 831 (21 822)	2 981) (7 367)	573 (1 416)	28 646 (70 784)	60 391 (149 225)
Not suitable for agriculture	1 688 (4 170)	17 346 (42 863)	1 419 (3 506)	15 (36)	20 467 (50 575)	316 (780)	2 979 (7 360)	27 345 (67 569)	7 823 (19 330)	7 085 (17 507)	614 (1 517)	46 161 (114 063)	66 628 (164 638)
Total	6 558 (16 205)	44 750 (110 578)	10 945 (27 044)	34 (84)	62 287 (153 911)	1 319 (3 259)	8 353 (20 640)	40 405 (99 840)	19 798 (48 920)	10 371 (25 626)	1 314 (3 247)	81 559 (201 532)	143 846 (355 443)

TABLE 41 The degree of development of alienated land suited for agriculture in the main agricultural regions

Agricultural region	Cultivated		Non-cultivated		
	ha	ac	ha	ac	%
Sipitang	1 010	2 500	1 400	3 450	58.0
Kuala Penyu	4 770	11 790	6 320	15 620	57.0
Keningau Plain	6 470	15 980	5 920	14 640	47.8
Labuan	3 380	8 350	2 710	6 700	44.5
Sindumin	1 750	4 330	1 300	3 200	43.3
Beaufort	12 700	31 380	9 120	22 540	41.8
Tenom Plain	8 830	21 810	4 670	11 540	34.6
Tambunan Plain	2 360	5 840	460	1 150	16.5

Table 41 gives the data illustrating the problem of under-use of the alienated land in the main agricultural regions. Sipitang and Kuala Penyu are proportionally the worst with well over half not cultivated, although Beaufort has by far the greatest area which could be developed. The data confirm that there is very little scope for extending the agricultural holdings on the Tambunan Plain.

Grazing reserves

It will have been noted when the alienation and gazettement was discussed, that the grazing reserves are of particularly small extent. They occupy an aggregate total of 1 723 ha (4 257 ac) only. It can be seen, therefore, that even if all of this land was developed the increase would not have any overall significance. The development prospects are further limited by that fact that only 52% is considered suited for agriculture. This is illustrated by Figure 4-5.

The grazing development potential of these reserves is discussed in a later section, and it will be seen that they are generally poorly sited for the purpose. The prospects for general agricultural development are better, and consideration should be given to planting tree or arable crops on areas of the grazing reserves which are unsuited for grazing. The relevant data are given in Table 42. Some 630 ha (1 556 ac) of Group 3 soils could be considered in this way.

TABLE 42 Present land use and land capability of grazing reserves

Present land use category	Land exploitation unit									
	IIA		IIIA		IVB		IVE		VA	
	ha	ac	ha	ac	ha	ac	ha	ac	ha	ac
1	1	3	19	47	0	0	0	0	0	0
2	2	4	34	84	0	0	0	0	3	8
3	5	12	49	122	0	0	0	0	2	5
4	5	12	19	48	0	0	0	0	7	18
5	0	0	3	8	0	0	0	0	15	36
6	17	42	259	641	0	0	7	18	128	317
7F	6	16	111	274	6	16	0	0	62	153
7S	74	184	239	591	36	90	4	10	110	272
8	4	10	6	15	16	40	3	8	453	1 120
9	0	0	13	32	0	0	0	0	0	0
Unit total	115	283	754	1 862	59	146	15	36	780	1 929

Stateland

Even though only 7.0% is considered suited for cultivation the stateland holds over half (51.8%) of the agricultural soil resources of the residency therefore, of all the land categories, it has the greatest potential for development.

Figure 4-6 illustrates the proportion suited for agriculture, and Table 43 gives the data on land use and land capability. From the table it can be seen that out of a total of 95 108 ha (235 016 ac), some 4 952 ha (12 237 ac) are suited for a diversified form of agriculture (Land Capability Class II) and 90 156 ha (222 779 ac) for a more restricted range of crops (Class III).

The stateland holds a significant proportion of the agricultural holdings, amounting to some 21 584 ha (53 335 ac) or 25.4% of all the cultivated land in the residency. Thus, over a quarter of the farming is being carried out on land to which titles have not been issued. This is undertaken almost entirely by native farmers who, however, do have customary rights to cultivate such land. These rights are respected by government and development planning will have to conform to this view. This will be relatively simple in cases where the strategy involves the improvement of present holdings, but in cases of developing large individual land units, e.g. plantations, considerable problems may arise. This extensive use of the stateland can be attributed mainly to two factors: that the issue of land titles is not keeping abreast of settlement and development, and that shifting cultivation is almost exclusively practised on such uncommitted land. Much of it, however, is on steepland not recommended for agriculture which, although not to be condoned, does not materially affect the overall prospects for agricultural development of the stateland. About 9.6% of the stateland with soils suited for agriculture is being used for the purpose. It will be seen, therefore, that significant development opportunities remain: 3 736 ha (9 232 ac) of Soil Suitability Group 2 and 82 215 ha (210 570 ac) of Group 3, a total of 85 951 ha (219 802 ac).

Text Map 4-16 shows the location of the main areas of stateland with a potential for further agricultural development, and the following gives a more detailed account of the various development opportunities which exist in terms of the Group 2 and Group 3 soils which are not cultivated.

TABLE 43 Present land use and land capability of stateland in ha (ac)

Present land use category	Land capability class and land exploitation unit												
	I	II		III				IV				V	
	IA	IIA	IIC	IIIA	IIIB	IIIC	IIID	IVA	IVB	IVC	IVE	VA	VB
1	0	8 (20)	0	165 (407)	0	0	0	0	0	0	0	154 (380)	0
2	0	170 (420)	0	1 383 (3 418)	3 (8)	8 (21)	0	120 (296)	7 (18)	0	11 (27)	1 030 (2 545)	0
3	0	868 (2 145)	4 (10)	2 836 (7 008)	7 (18)	9 (23)	4 (10)	137 (339)	43 (106)	0	11 (26)	3 611 (8 923)	0
4	0	166 (411)	0	3 413 (8 433)	47 (115)	21 (52)	0	304 (752)	140 (346)	0	0	6 979 (17 246)	0
5	0	0	0	45 (111)	0	0	0	0	0	0	0	0	0
6	0	594 (1 469)	4 (10)	5 655 (13 974)	87 (214)	66 (162)	0	406 (1 004)	134 (331)	4 (10)	30 (74)	8 589 (21 223)	2 (4)
7 F	3 (8)	1 678 (4 147)	61 (151)	17 896 (44 221)	35 227 (87 048)	7 218 (17 836)	0	555 836 (1 373 471)	154 204 (381 042)	0	25 (62)	405 422 (1 001 800)	5 (12)
7S	6 (14)	1 123 (2 774)	3 (8)	11 745 (29 022)	546 (1 348)	296 (731)	4 (10)	3 464 (8 561)	1 350 (3 335)	0	764 (1 887)	48 908 (120 852)	10 (25)
8	0	219 (542)	0	2 440 (6 029)	90 (223)	114 (282)	0	1 617 (3 995)	2 783 (6 876)	0	11 198 (27 670)	51 763 (127 907)	15 (36)
9	0	53 (130)	0	726 (1 793)	79 (196)	27 (66)	0	379 (936)	81 (200)	0	38 (94)	2 041 (5 044)	0
Unit total	9 (22)	4 880 (12 058)	72 (179)	46 303 (114 416)	36 086 (89 170)	7 759 (19 173)	8 (20)	562 263 (1 389 354)	158 743 (392 254)	4 (10)	12 076 (29 840)	528 498 (1 305 920)	31 (77)
Class total	9 (22)	4 952 (12 237)		90 156 (222 779)				733 087 (1 811 458)				528 530 (1 305 997)	

Soil Suitability Group 2 in stateland

Most of the Group 2 soils of the stateland occur on the Klias Hills as scattered enclaves in alienated tracts. The individual areas are generally small and rarely more than 400 ha (1 000 ac) in extent. They are located mainly along the gently sloping low hills between Sinapokan and Menumbok and the soils are derived from the mudstones, shales and sandstones which comprise the country rocks. The total area assessed is 1 400 ha (3 400 ac). The occurrences are shown in more detail on the separate land capability classification map.

Communications in the area have been fairly difficult, relying largely on water access, by sea on the west and along the Klias River to the east, although the Kuala Penyu to Menumbok jeep track has served as a somewhat tenuous link with the main road system. The situation, however, is rapidly improving with the construction of a major highway which will run through the area from north to south. This road will improve considerably the prospects for development, both for the stateland areas and also the alienated land which remains uncultivated.

The remaining stateland with Group 2 soils awaiting development is found in even smaller individual areas, rarely more than 40 ha (100 ac) or so, usually associated with alienated areas and, because of their smallness, the course of development of both the stateland and alienated land would be closely inter-related.

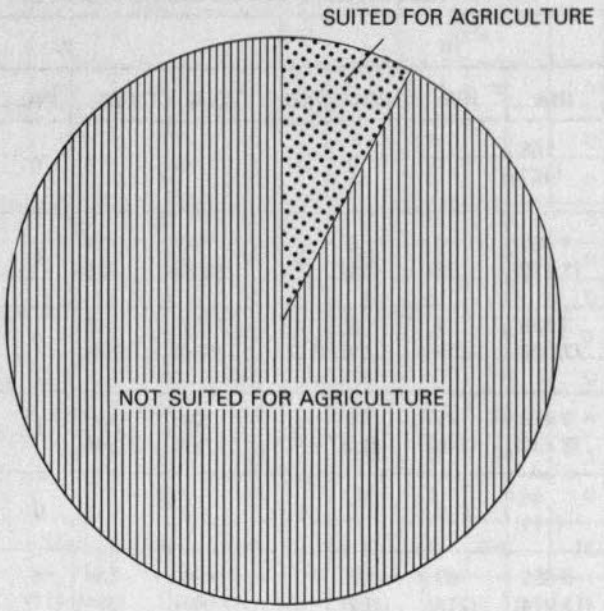
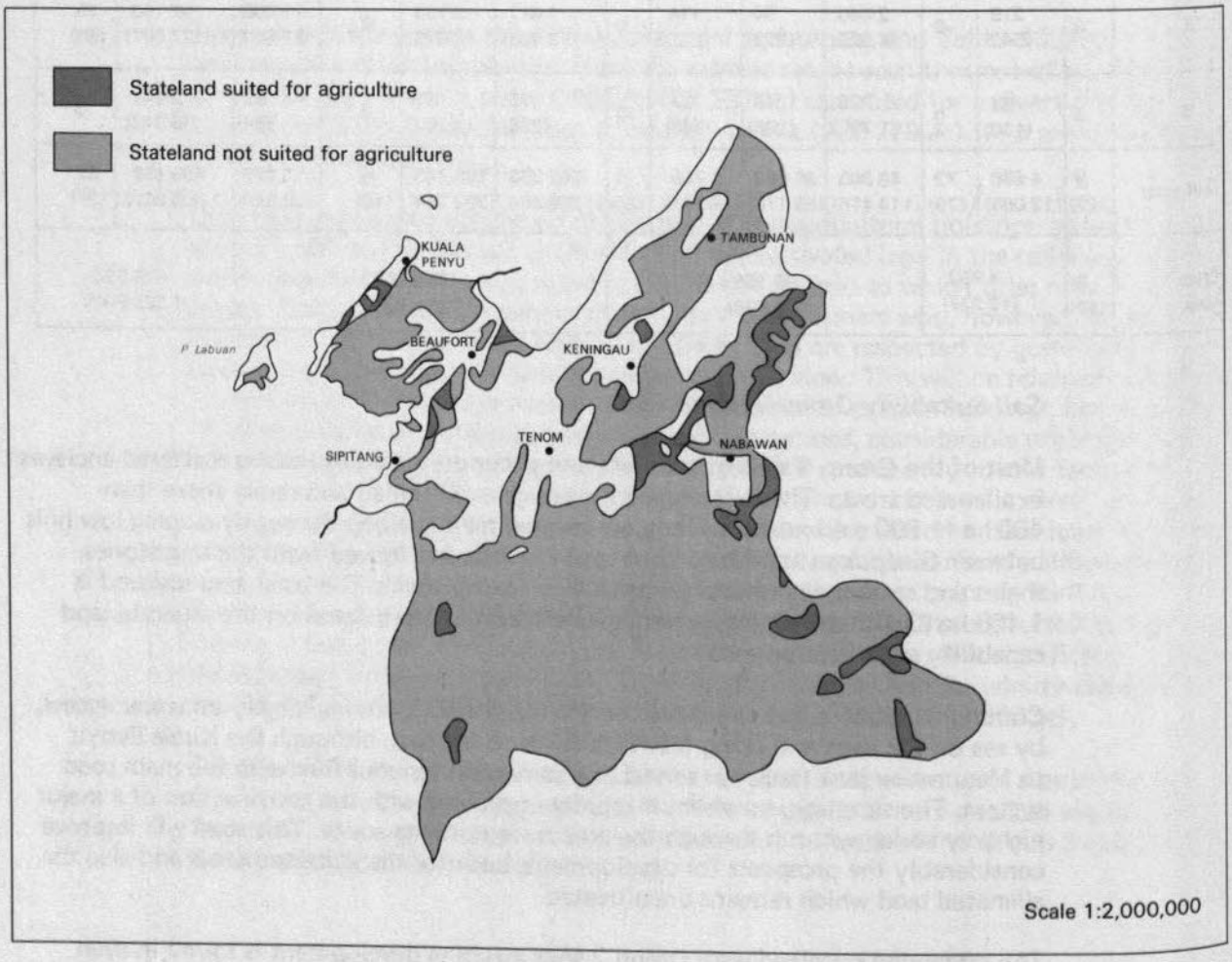


FIGURE 4-6 Suitability of stateland for agriculture



TEXT MAP 4-16 Suitability of stateland for agriculture

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Soil Suitability Group 3 in stateland

It will have been noted in the foregoing pages that the Group 3 soils in the stateland hold the greatest potential for agricultural development in the residency, and that some 82 215 ha (210 570 ac) are available for the purpose. The main areas are given in Table 44 and on the separate land capability classification map.

TABLE 44 Main areas of Group 3 soils occurring in the stateland

Region	Area	Soils		Extent	
		Landform	Parent material	ha	ac
Sook-Dalit Plain	Keramatoi to Tulid	Terraces	Alluvium	11 300	28 000
		Valley floors and terraces		3 200	8 000
	Dalit	Strongly sloping hills	Sedimentary rocks	1 600	4 000
Witti Range	Lanas		Alluvium	6 100	15 000
	Mansiad			5 300	13 000
	Lanas	Terraces		2 000	5 000
Crocker Foothills	Ulu Membakut	Strongly sloping hills	Sedimentary rocks	4 700	11 000
	Beaufort to Weston			1 800	4 500
	Mengalong Valley	Terraces	Alluvium	1 800	4 400
Kuamut Highlands	Ulu Sebuda	Strongly sloping hills	Sedimentary rocks	4 000	10 000
	Ulu Pelangan			1 600	4 000
	Ulu Sansiang			3 200	8 000
		Valley floors and terraces	Alluvium	1 200	3 000
Talankai Valley	Labang	Strongly sloping hills	Sedimentary rocks	3 600	9 000
	Sapulut	Valley floors and terraces	Alluvium	1 600	4 000
				400	1 000
Keningau Plain	Keningau	Terraces		2 000	5 000
	Liau to Apin Apin			1 200	3 000
	Keningau to Liau	Valley floors and terraces		800	2 000
Meligan Range	Meligan	Terraces		2 000	5 000
	Long Pa Sia			1 200	3 000
Klias Plain	Gadong	Meander belts		1 600	4 000
	Suasa			800	2 000
Tenom Plain	Southern end	Strongly sloping hills		1 600	4 000
Penawan Plain	Pandewan	Terraces		1 200	3 000
		Valley floors and terraces		400	1 000
	Labug			800	2 000
	Tataluan			400	1 000

The greatest potential for development exists on the Sook-Dalit Plain. There, the prospects are particularly favourable, being served by a system of roads which make the a area accessible to the more densely populated Keningau, Tambunan and Tenom Plains and also the communities of traditional shifting cultivators in the Labau Valley to the east. The full development of the plain, however, will depend on further road construction. The western end in particular is not easily accessible and, to facilitate development, a road will be required from Sook to Keramotoi, a distance of some 13 km (8 mi). Although generally uninhabited, parts of the plain are sparsely populated and, although titles have not been issued, are held under customary rights by the local communities.

The problem of these customary rights to land is likely to be more significant, as far as development is concerned, in the neighbouring Lanas and Mansiad areas of the Labau Valley. It will be seen from Table 44 that they contain a considerable soil resource, which together with the communities of shifting cultivators offer a substantial opportunity for agricultural expansion. Lanas is accessible by jeep-track from the neighbouring Sook-Dalit Plain. Ultimately the road will have to be improved and extended to the Mansiad area to the north in order to open up those potentially important areas for agriculture.

Although not having available individual areas as extensive as the Sook-Dalit Plain and the Labau Valley, those in the Crocker Foothills probably have the best prospects for early development. This is because they lie close to the road system and the relatively highly populated areas of the seaboard. The potential of the Mengalong Valley, however, will only be fully realised with the construction of some 32 km (20 mi) of road, which will link with the Sindumin-Sipitang road system, and open up the upper reaches of the Valley.

Of the area listed on Table 44 and falling in the Pensiangan District, those on the Penawan Plain and the Talankai Valley are, at present, reasonably accessible. This is by the newly constructed road from Keningau to Sapulut, and on to the Labang area by river, a distance of some 16 km (10 mi). As these are alrady minor centres of population they would serve as nuclei for future development. The other areas of importance which lie to the east, in the Witti Range, are completely inaccessible and are not populated. Their prospects for development can be considered as being very remote.

It has already been noted that most of the Tenom and Keningau Plains have been alienated; but a few significant areas of Group 3 soils remain legally uncommitted as stateland as shown on the separate land capability classification map and Table 43. But whether all these remain so for in such highly populated and accessible areas is unlikely. Their development will be intimately associated with that of the large areas of alienated land with which they occur, and which are shown on Table 41 as being non-cultivated.

A similar situation is likely in the Gadong and Suasa areas of the Klias Plain, and it is considered highly unlikely that such relatively large areas of alluvial soils still in 1975 remain completely uncommitted.

Land of reasonable extent suited for agriculture in the Meligan Range is restricted to the the Meligan and Long Pa Sia areas. Both are centres of small populations and parts are already being farmed, mainly with dry-land rice. There is ample room for the greater production of conventional crops but marketing would be a problem because of the remoteness of the areas. Even though a jeep track has recently been constructed for some miles southwards from the nearest road-head at Kuala Tomani, this will have to be improved and extended considerably to provide any worth-while assistance to development in the two areas. Since the distances involved are considerable, Meligan being some 27 km (17 mi) from Kuala Tomani and Long Pa Sia 48 km (30 mi), and the terrain is difficult, such a road would not appear economically justifiable in the foreseeable future.

Forest reserves

Very little of the land gazetted as forest reserves is suitable for agriculture. This is illustrated by Figure 4-7. The total area is estimated as 7 878 ha (19 467 ac), or 2.6% of the 299 314 ha (739 604 ac) occupied by the forest reserves. Table 45 shows that almost all (91.8%) of the land suited for agriculture is Class III land, i.e. suited for a restricted range of agriculture only.

TABLE 45 Forest reserves present land use and land capability in ha (ac)

Present land use category	Land capability class and land exploitation unit								
	II		III			IV			V
	IIA	IIC	IIIA	IIIB	IIIC	IVA	IVB	IVE	VA
1	0	0	0	0	0	0	0	0	2 (4)
2	8 (20)	0	5 (12)	0	0	4 (9)	0	0	8 (19)
3	3 (8)	0	11 (28)	0	0	2 (6)	2 (6)	0	66 (162)
4	0	0	59 (145)	5 (12)	12 (29)	30 (74)	1 (3)	0	48 (118)
5	0	0	0	0	0	0	0	0	0
6	1 (3)	0	1 704 (4 211)	17 (43)	92 (228)	192 (475)	6 (14)	0	1 902 (4 699)
7F	616 (1 521)	0	2 542 (6 281)	792 (1 958)	454 (1 122)	161 496 (399 059)	10 877 (26 877)	0	96 919 (239 488)
7S	11 (28)	1 (2)	841 (2 078)	55 (137)	60 (149)	501 (1 239)	85 (210)	0	2 722 (6 727)
8	3 (8)	0	338 (835)	163 (402)	68 (167)	10 871 (26 863)	382 (943)	510 (1 260)	4 698 (11 608)
9	0 (1)	0	4 (10)	8 (19)	4 (10)	45 (110)	0	0	66 (164)
Unit total	643 (1 589)	1 (2)	5 504 (13 600)	1 040 (2 571)	690 (1 705)	173 142 (427 835)	11 353 (28 053)	510 (1 260)	106 430 (262 989
Class total	644 (1 591)		7 234 (17 876)			185 005 (457 148)			106 430 (262 989)

The main areas of the forest reserves which are suited for agriculture are shown on Text Map 4-17.

Soil Suitability Group 2 in forest reserves

These are virtually restricted to the Pulau Tiga Forest Reserve and cover the three gently sloping hills formed by volcanic mudflows on the Island. Their extent is assessed at 500 ha (1 300 ac), which is hardly large enough to sustain an agricultural community of any importance. Other factors which would inhibit settlement and development on the island are the shortage of potable water supplies and communications; the nearest mainland port being Kuala Penyu, which is 18 km (11 mi) distant.

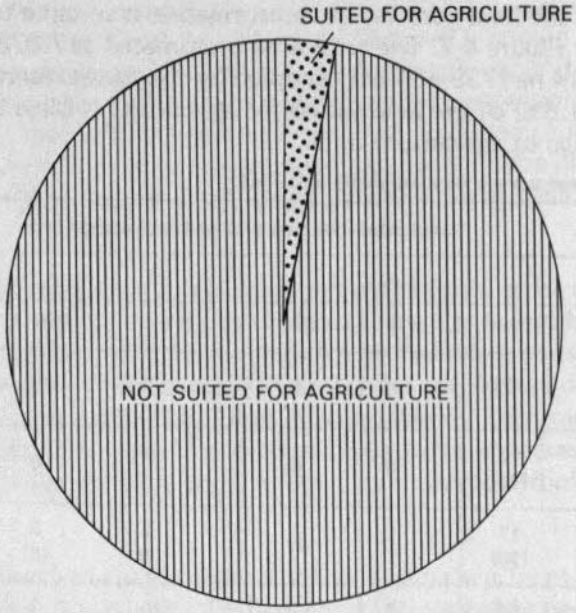
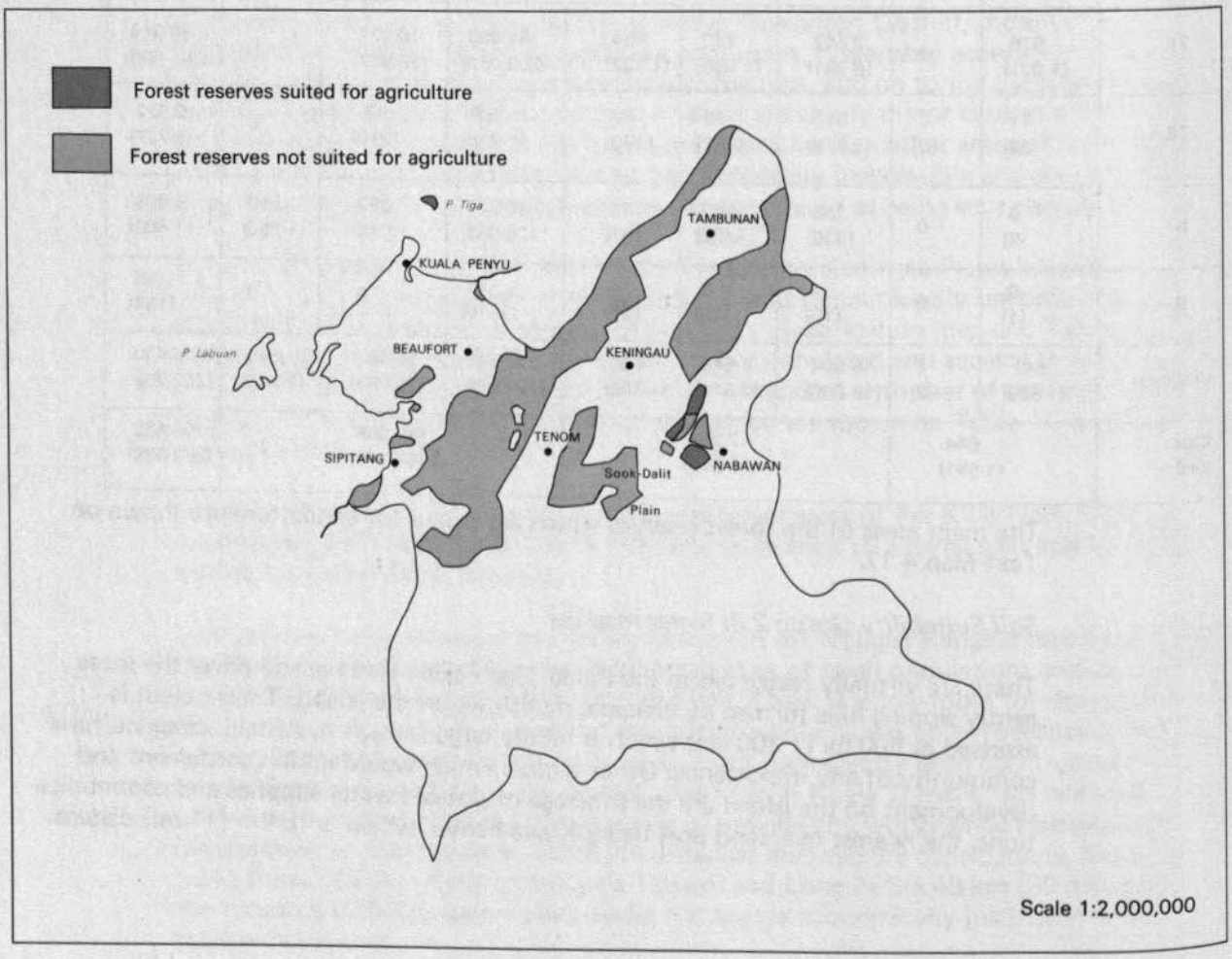


FIGURE 4-7 Suitability of forest reserves for agriculture



TEXT MAP 4-17 Suitability of forest reserves for agriculture

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Soil Suitability Group 3 in forest reserves

These comprise some 7 234 ha (17 876 ac), of which 5 828 ha (14 400 ac) are estimated to occur in the Sook Plain Forest Reserve. The balance occurs in a number of other forest reserves as small, scattered tracts, which are rarely more than a few hundred acres in size and, therefore, not worthy of special mention in this report. The soils in the Sook Plain Forest Reserve are developed on alluvial terraces. The areas are easily accessible and any agricultural development planning for the Sook Plain should take into account their possible excision from the Reserve.

Government reserves

The government reserves occupy a relatively small part of the residency, covering about 7 068 ha (17 465 ac) only. Table 38 shows, however, that a significant proportion of the reserves are suited for agriculture, totalling some 2 174 ha (5 371 ac) or 30.7%; 1 442 ha (3 562 ac) suited to diversified forms of agriculture, and 732 ha (1 809 ac) for more restricted forms.

TABLE 46 Government reserves present land use and land capability in ha (ac)

Present land use-category	Land capability class and land exploitation units									
	I	II		III		IV			V	
	IA	IIA	IID	IIIA	IIID	IVA	IVB	IVE	VA	VB
1	0	16 (40)	0	52 (129)	0	0	0	0	160 (395)	0
2	0	103 (256)	0	57 (141)	0	8 (20)	0	0	53 (132)	0
3	0	397 (980)	6 (14)	121 (299)	22 (54)	3 (8)	0	0	52 (128)	3 (8)
4	0	56 (139)	0	46 (113)	0	0	0	0	72 (177)	0
5	0	0	0	0	0	0	0	0	0	0
6	2 (4)	461 (1 138)	0	145 (358)	3 (8)	1 (3)	0	0	225 (555)	0
7F	0	80 (197)	0	78 (192)	6 (16)	2 396 (5 920)	87 (215)	0	1 290 (3 189)	10 (26)
7S	5 (14)	237 (587)	8 (20)	159 (394)	30 (74)	36 (88)	2 (6)	5 (12)	360 (890)	5 (12)
8	0	37 (91)	0	3 (31)	0	0	0	6 (14)	88 (218)	0
9	0	40 (100)	0	0	0	1 (2)	0	0	25 (61)	0
Unit total	7 (18)	1 428 (3 528)	14 (34)	671 (1 657)	61 (152)	2 445 (6 041)	89 (221)	11 (26)	2 325 (5 745)	18 (46)
Class total	7 (18)	1 441 (3 562)		732 (1 809)		2 545 (6 288)			2 343 (5 791)	

Table 46 summarises the present land use and capability of the government reserves. More than half (59.7%) of the land suited for agriculture is not cultivated. The rest, however is largely being developed for agricultural research and demonstration purposes, particularly on the Tenom Cocoa Research Station and the cattle station at Sebrang.

It can be seen, therefore, that the potential for agricultural development in the government reserves is very limited. Almost all the land suited for agriculture occurs on government-run stations.

FORESTRY DEVELOPMENT OPPORTUNITIES

The forest resources of the Interior Residency are very considerable and there are extensive areas of undisturbed dipterocarp forest which may be classed as commercial on the basis of the expected yield. However topography and inaccessibility do impose fairly general constraints on the development of these resources. While large scale exploitation of the dipterocarp forest has only just started it appears likely that it will greatly expand in the future and forestry and forest industries will play an increasingly important role in the economy of the residency.

As has been noted in Part 4, extensive areas of commercial forest both in stateland and forest reserve have been licensed for logging or assigned with licences to be issued in due course. It is thus likely that in the normal course of events considerable areas of forest will be logged in the foreseable future. However inaccessibility and severe terrain do impose constraints on logging over quite large areas and the possibility of overcoming these constraints is dependent on a number of factors. None of the forest is at present managed on a sustained yield basis.

A large part of the commercial forest occurs either in protection forest reserves or on steepland where the forest cover should be maintained, preferably undisturbed, for soil and water conservation. The need to protect steepland in important catchment areas does impose a constraint on the development of the forest resources. It means that exploitation will have to be more carefully controlled than in less rugged areas and that in some places it may have to be completely prohibited. The steep nature of the terrain makes logging of the forest more difficult and in places impossible, while lack of communications particularly in the southern part of the residency greatly increases the cost of exploitation. All things considered the deveopment of the forest resources presents many problems but it seems likely that in time these will all be overcome.

The area of forested land which is suitable for agriculture as well as having a forestry potential is relatively very small. Most of the land carrying commercial forest is not suited for agriculture mainly on account of the steepness of the terrain. (See Plates 4-9 and 4-10).

Development of the available forest resources is dependent on two major factors:

(1) The legal status of the land

(2) The suitability of the land for agriculture

In the case of (1.) the order of priority for development will be forest reserves, statelands, government reserves and alienated land. In the case of (2.) priority will be given to land more suited for forestry than the various forms of agriculture i.e. Land Capability Class IV land first followed by Class III and then Class II. Class V land with no known potential for either agriculture or forestry is not considered to offer any opportunity for economic development. However, a large proportion of this Class V land is relatively steep and covered with secondary forest following shifting cultivation. The prospects for commercial forestry on such land will depend on allowing the forests to regenerate over a very long period of time with the hope that adequate stands of timber can be obtained. The alternative would be plantation forestry i.e. the cultivation of trees for wood. In any case this land is best suited for forestry and, with this in view, it is suggested that the greater part of it should be constituted as forest reserve.

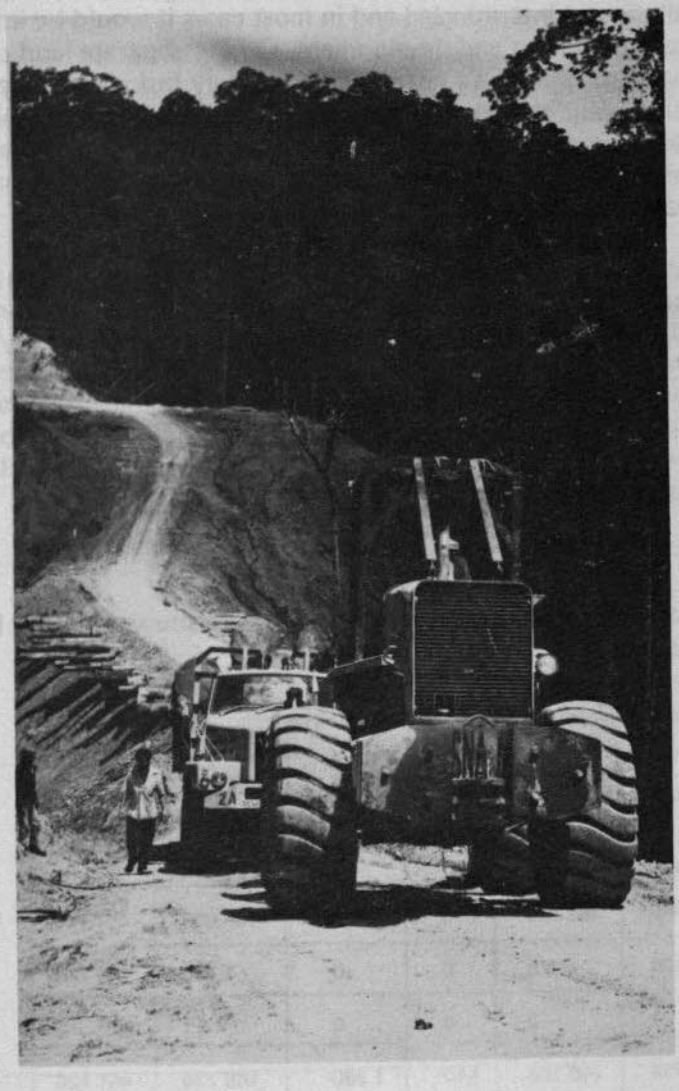


PLATE 4.9

Logging road in the Witti Range. The long haulage distances greatly increase the cost of exploitation

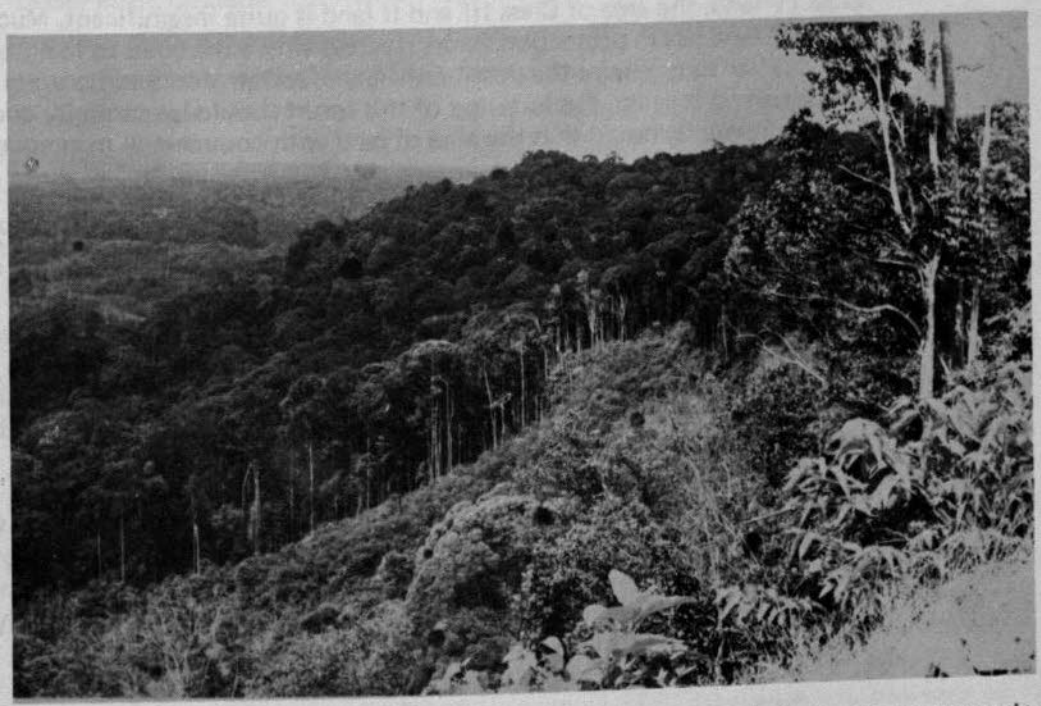


PLATE 4.10 Commercial forest on steepland near Mesapol. The terrain imposes severe restrictions to logging, and the soils are very prone to erosion

In this section of the report, Timber Resource Groups 1, 2 and 3 are grouped together and treated as one category, Commercial forest, while Group 7, Productive mangrove forest, is dealt with separately. The reason for this is that in any forest, Groups 1, 2 and 3 are generally found intermingled and in most cases it would be impractical to consider separate exploitation and development. On the separate land capability classification map these groups are not shown separately but as one category, Land Class IV which also includes mangrove forest. As Groups 4, 5, 6 and 8 are not considered to have any commercial potential in the foreseeable future areas classified as such are not considered to have any immediate forest development opportunities and accordingly are not discussed further.

Data have been derived from two sources: Forest Department mapping prior to 1970 and the Forest Inventory afterwards. Both were based on the interpretation of forest types from aerial photographs and form the basis for the land capability classification mapping and data contained in Table 47 and 48. Table 19, however, is based on the expected yield from different forest strata using the Forest Inventory stock tables which were compiled from data obtained by physical sampling of the forest. It should therefore be noted that the areas of Timber Resource Groups 1, 2 and 3 given in Table 19 differ from those given in Tables 47 and 48.

Forest reserves

Forest resource development areas in forest reserves are shown on Text Map 4-18 and summarised in Table 47.

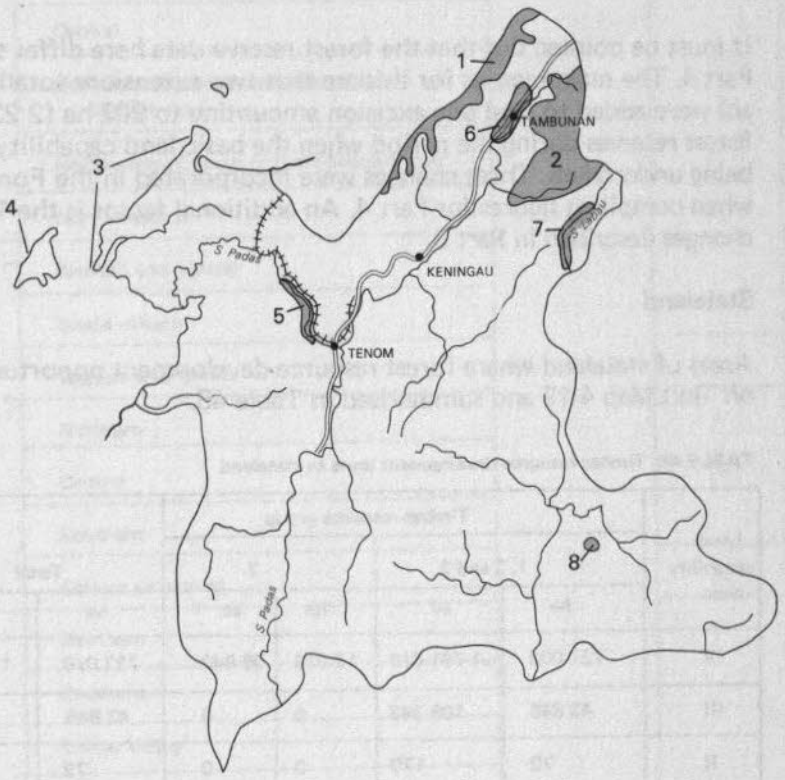
TABLE 47 Timber resource development areas in forest reserves

Land capability class	Timber resource group				Total	
	1, 2 and 3		7			
	ha	ac	ha	ac	ha	ac
IV	184 493	455 888	510	1 260	185 003	457 148
III	1 730	4 276	0	0	1 730	4 276
II	1	2	0	0	1	2
Total	186 224	460 166	510	1 260	186 734	461 426

By far the greater part of the land in forest reserves with a forestry potential is Class IV land; the area of Class III and II land is quite insignificant. Much of the Class IV land lies in protection forest reserves where the need to maintain adequate forest cover to minimise the possible danger of soil erosion and flooding is a severe constraint on logging. Exploitation of this forest should be carefully and strictly controlled. It will be noted that the area of land with commercial mangrove (Group 7) is very small indeed.

The area of land with a commercial forest potential amounts to some 62% of the total area in forest reserves. The balance comprises Class II and III land with no commercial timber potential (2%) and Class V land (36%). Of the land with no forest potential approximately 89% is covered with undisturbed non-commercial dryland forest much of which is montane or upper-montane, while a further 4% carries undisturbed non-commercial swamp forest. The balance comprises secondary forest, mainly regrowth following shifting cultivation 3%, grassland 3%, and other non-forested land.

Much of the Class V land is steep and mountainous, where forest cover should be maintained for protection purposes to minimise flooding and soil erosion. In places where forest cover is inadequate there may be possibilities of establishing forest plantations of suitable indigenous or exotic species which, with carefully controlled exploitation, could be harvested.



Scale 1:2,000,000

Area	Main Purpose of Conservation
1 Crocker Range, land above an altitude of 1,220m (4000ft)	Recreation, amenity, fauna and flora
2 Trus Madi Range, land above an altitude of 1,220m (4000ft)	Recreation, amenity, fauna and flora
3 Beaches along the west coast of the Klias Peninsula	Amenity and recreation
4 Beaches on Labuan	Amenity and recreation
5 Padas Gorge	Amenity and recreation
6 Tambunan Valley	Amenity and recreation
7 Labau Valley	Amenity and recreation
8 Batu Punggul	Amenity, recreation and flora

TEXT MAP 4-20 Suggested conservation areas

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The areas of grassland, most of which are on flat and undulating terrain in the Sook Plain, have of necessity been classified as Timber Resource Group 8. However experimental work on the establishment of forest plantations of fast growing species, which has been in progress for some five years, does indicate that there may be opportunities for the development of forest plantations on these grassland areas. Species which have been tried include *Pinus caribaea* var. *hondurensis, Pinus oocarpa* and *Eucalyptus deglupta,* (Philippine and New Guinea strains). Of these species the Philippine strain of *Eucalyptus deglupta* shows considerable promise while the *Pinus caribaea* is growing quite well.

It must be pointed out that the forest reserve data here differ somewhat to that in Part 4. The main reasons for this are that two extensions totalling 21 826 ha (53 932 ac) were added to, and one excision amounting to 902 ha (2 230 ac) deducted from forest reserves during the period when the basic land capability classification was being undertaken. These changes were incorporated in the Forest Inventory data used when compiling figures for Part 4. An additional factor is the 1:50 000 scale mapping changes described in Part 3.

Stateland

Areas of stateland where forest resource development opportunities occur are shown on Text Map 4-19 and summarised in Table 48.

TABLE 48 Timber resource development areas in stateland

Land capability class	Timber resource group				Total	
	1, 2 and 3		7			
	ha	ac	ha	ac	ha	ac
IV	721 003	1 781 618	12 076	29 840	733 079	1 811 458
III	43 845	108 343	0	0	43 845	108 343
II	72	179	0	0	72	179
Total	764 920	1 890 140	12 076	29 840	776 996	1 919 980

A very considerable area of stateland has a potential for forestry, and the greater part of this area (94.4%) is Class IV land which is not suited for agricultural development. The balance amounting to approximately 43 909 ha (108 500 ac) is Class II and III land (mainly the latter) which has a moderate potential for agricultural development. There is relatively little land with a potential for productive mangrove forest. The large area of Class IV land provies an excellent opportunity to expand the area of forest reserves. However, much of this land is steep and dissected and in mountainous country where adequate forest cover should be maintained for protection purposes. In such areas this requirement will be a constraint on the exploitation and development of the forest resource. Table 49 lists the major areas of stateland suited for forestry. The balance of the land with a forestry potential is in relatively small scattered patches and tracts as shown on the land capability classification map. Class IV land is marked on the the map but class II and III land with a forest potential is not delineated.

As noted in Part 4 there are considerable areas of non-commercial montane and upper-montane forest and secondary forest. While these areas may have no potential for commercial forestry maintenance of forest cover is in many cases most important for protection purposes. With this in mind it is recommended that the greater part of these areas should be included in protection forest reserves. As in the case of the forest reserves where forest cover is inadequate for protection purposes it may be possible to establish forest plantations of indigenous or exotic species, which with carefully controlled exploitation could be harvested.

TABLE 49 Major areas suited for forestry in stateland

Region	Area	Forest potential	Land capability class	Approximate extent	
				ha	ac
Witti Range	Upper reaches of Padas river	Commercial forest	IV	29 700	73 400
	Central southern*			19 900	49 200
	Central			153 600	379 600
	North-eastern, south and west of Sook-Sapulut road			19 200	47 400
	North-eastern, north of Sook-Sapulut road			10 700	26 500
	North-western			4 900	12 000
Kuamut Highlands	Western and central			158 500	391 700
	South eastern			15 800	39 000
	Western and central*		III	10 200	25 300
Talankai Valley	Northern		IV	30 400	75 100
	Central			36 900	91 200
	Southern			23 400	57 800
	Eastern extremity		III	3 500	8 700
Meligan Range	Northern		IV	25 700	63 500
	Southern			37 100	91 700
Trus Madi Range	Labau Valley			12 900	31 800
	North and east of kampongs Tiong and Tulid			4 700	11 700
	South-east of Keningau			15 900	39 300
	East of Tambunan*			4 300	10 700
	Labau valley*		III	5 700	14 000
Crocker Range	Upper reaches of Membakut River*		IV	2 200	5 500
	South-east of Beaufort*			6 700	16 600
	Kotar			4 400	10 800
	South of Tenom			3 300	8 200
	Upper reaches of Mengalong River*			3 500	8 700
	South of Gunong Lamaku			18 300	45 200
Sook-Dalit Plain	South and west of Kampong Sook*		IV	23 000	56 800
			III	3 600	8 800
Penawan Plain	Penawan Plain*		IV	7 700	19 000
			III	4 300	10 700
Crocker Foothills	South-east of Sipitang*		IV	6 900	17 000
Klias Plain	North of Beaufort-Kuala Penyu road	Freshwater swamp forest		3 600	9 000
	Klias River estuary	Mangrove forest		6 600	16 200

* Comprise a number of separate areas

It should be mentioned that since the compilation of the data for this report proposals have been put forward for extensive forest reserves, (Martyn, 1973), including some 2 169 km^2 (837 mi^2) of protection forest reserves and 3 938 km^2 (1 520 mi^2) of commercial forest reserves.

Government reserves

The areas in government reserves with commercial forest resources are summarised in Table 50.

TABLE 50 Forest resource areas in government reserves

Land capability class	Forest resource group				Total	
	1, 2 and 3		7			
	ha	ac	ha	ac	ha	ac
IV	2 534	6 262	11	26	2 545	6 288
III	0	0	0	0	0	0
II	0	0	0	0	0	0
Total	2 534	6 262	11	26	2 545	6 288

Some 1 900 ha (4 700 ac) of the Class IV land occurs in two blocks of land on the north side of the Padas Gorge. This land was reserved for the purpose of providing timber for the state railway. There is a possible opportunity for developing it further for that purpose but the terrain is steep and there is a need to maintain some forest cover for protection. The balance of the Class IV land is in small scattered patches and will mostly be required for purposes other than forestry.

Grazing reserves

The area in grazing reserves with a commercial forest resource is negligible amounting to only 59 ha (146 ac) of Timber Resource Group 3 and 15 ha (36 ac) of Group 7, all on Class IV land.

Alienated land

The area of non-cultivated alienated land with a commercial timber resource is relatively small and is summarised in Table 51. The major areas are listed in Table 52.

TABLE 51 Forest resource areas in alienated land

Land capability class	Timber resource group				Total	
	1, 2 and 3		7			
	ha	ac	ha	ac	ha	ac
IV	16 235	40 117	151	372	16 386	40 489
III	2 568	6 345	0	0	2 568	6 345
II	9	22	0	0	29	22
Total	18 812	46 484	151	372	18 963	46 856

TABLE 52 Major areas with a forest potential in alienated land

Region	Area	Forest potential	Land capability class	Approximate extent	
				ha	ac
Penawan Plain	Nabawan Settlement Scheme	Commercial forest	IV	9 900	24 500
Crocker Foothills	North-east of Beaufort			1 200	2 900

The remaining land with a commercial forest resource occurs as relatively small scattered patches and tracts.

The area in the Nabawan Settlement Scheme is known to be steep and quite unsuitable for agriculture and it is possible that the forest resources may be developed in connection with the Scheme. However, most other areas, having no committment to permanent forestry, are likely to be logged in the near future and the greater part eventually cleared for agricultural development.

WATER RESOURCE DEVELOPMENT OPPORTUNITIES

There is considerable demand and scope for developing the residency's water resources. It has been noted that serious drought conditions can occur on the interior plains, making irrigation an essential part of any form of agricultural development involving arable crops, particularly rice. In the wetter parts of the residency even though the overall rainfall is high its distribution may be irregular and unreliable, which also makes it important to irrigate rice-growing land.

With the high and frequent rainfall in the mountain ranges all the large valley basins are endowed with continuous supplies of water, and the volume and velocity of the Padas along its gorge has attracted considerable attention as a possible source of hydro-electric power. Labuan and the Klias Hills, however, are water-deficit areas because the catchments are generally too small to sustain streamflow during the longer periods of dry weather. It will have been seen in Part 4, when the water resources were discussed, that surface water is the main source of supply for all purposes, the use of groundwater being restricted to the two latter areas.

With the general lack of adequate hydrological information it is difficult to summarise the opportunities available for developing the water resources. The records are inadequate and incomplete, which underlines the importance of conducting a comprehensive survey in order to properly develop and utilise the water resources.

Potable water

With one notable exception, Labuan, the water resources are considered adequate to meet all foreseeable requirements. Even so, considerable attention will be required on the conservation and development of the resource in order to ensure sufficient supplies of potable water for an expanding urban and rural population. Prime consideration should be given to the catchments, where it is important not to destroy the natural vegetation. Fortunately, most of the main catchment areas are forested and are thereby afforded the maximum protection. Ideally the forest cover should be maintained and neither the vegetation nor soil disturbed. In cases where logging cannot be avoided it should be undertaken in such a way so as to minimise disturbance to the vegetation and and soil cover. Such operations would, therefore, have to be carefully controlled.

These are all long-term considerations; and what is required as a matter or urgency is that all sources of potable water supplies should be clearly identified. In this way steps can be taken without delay to protect their catchment areas by both conserving the vegetation and discouraging human settlement in order to avoid pollution

The irregular and discontinuous stream-flow on Labuan and the Klias Hills has already imposed serious problems as far as potable water supplies are concerned, particularly on Labuan. There, already, maximum draw-off of the island's known subterranean reserves is being made, and future increases in water consumption will largely depend on additional supplies being discovered. A drilling and survey programme is currently (1975) being undertaken with this in mind. The proven under-ground sources from which Kuala Penyu draws it supplies are quite adequate and are, in fact, some 40% in excess of current demands. The town's requirements for the foreseeable future seem assured. Full develeopment of the Klias Hills, however, will depend on considerably more supplies of water being available and, although the individual catchment areas are small, the topographic maps indicate that a number of small valleys exist which might be used for water storage. The potable water requirements of this Region might well largely rest on the construction of such small reservoirs. Similar topographic conditions occur on Labuan, and a small shallow reservoir, long disused, is located in the low northern hills. (See Plate 4-11). Additional sites suited for water storage might well be found there; if so, they might be used to supplement the potable requirements and also provide valuable water to irrigate the rice-fields to the south.

Water for irrigation

It is commonly agreed that wet-land rice cultivation requires at least 300 mm (12 inches) of rain a month during the growing season which takes four to five months. Because of the irregularity of the rainfall this requirement cannot even be met on the seaboard plains, which are so much wetter than those of the interior. Successful cultivation of wetland rice will depend on irrigation. This will be particularly essential where double-cropping is carried out.

A considerable expansion in the areas used for arable crops, particularly rice, can be expected. Further sources of irrigable water to meet the resultant demands will have to be discovered. This, once more, underlines the importance of obtaining adequate information on the hydrology in order to plan and develop the water supplies required.

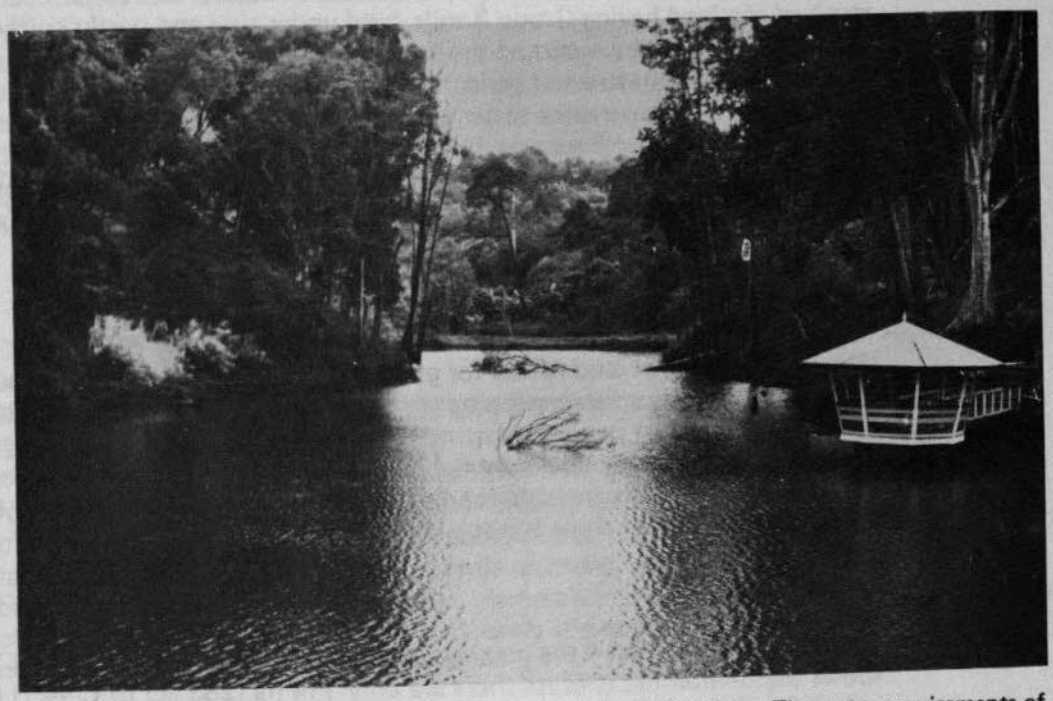
Water control and energy production

Flooding only assumes serious proportions at Beaufort. Elsewhere, even though almost all the rivers overflow their banks every few years or so, flooding has very little effect on settlement and development.

The situation at Beaufort is critical where, as has been noted on page 58, the Padas overflows its banks many times a year and flooding is a well-known feature of the town and its neighbourhood. The ultimate solution to the problem might well rest with the plans to harness the water of the Padas above Beaufort as it runs through the Padas Gorge.

Nippon Koei Co. Ltd , in its report (1974) on the hydroelectric generating potential of the waters of the Gorge has estimated that a 'run-of-river' type of scheme would be economically feasible at Pangi (Plate 4-12). The plant would be capable of producing 466.5 million kilowatt-hours per annum, and would meet the requirements of Tenom and the towns on the seaboard from Beaufort to Kota Kinabalu. The report also suggests that a dam should be constructed across the Sook River near Keningau in order to help to control the flow of the Padas at the power-plant at Pangi. As part of the long-term hydroelectric development plans for the Padas the construction of an additional reservoir is recommended for Helogilat, some miles downstream along the gorge from Pangi.

If these engineering works are constructed they should play an important part in controlling the flow of the Padas particularly as it leaves the gorge at Beaufort. Only then will the town see any form of flood alleviation. Conversely, the situation on the Tenom Plain might well deteriorate. The Pangi Scheme, as proposed by Nippon Koei Co. Ltd , would involve a backing-up effect to some miles upstream from Tenom on both the Padas and Pegalan. Unless this effect can be overcome flooding might well become a far more serious proposition on the Plain.



Small disused reservoir in the northern hills of Labuan. The water requirements of both Labuan and the Klias Hills might be based on such a form of water storage

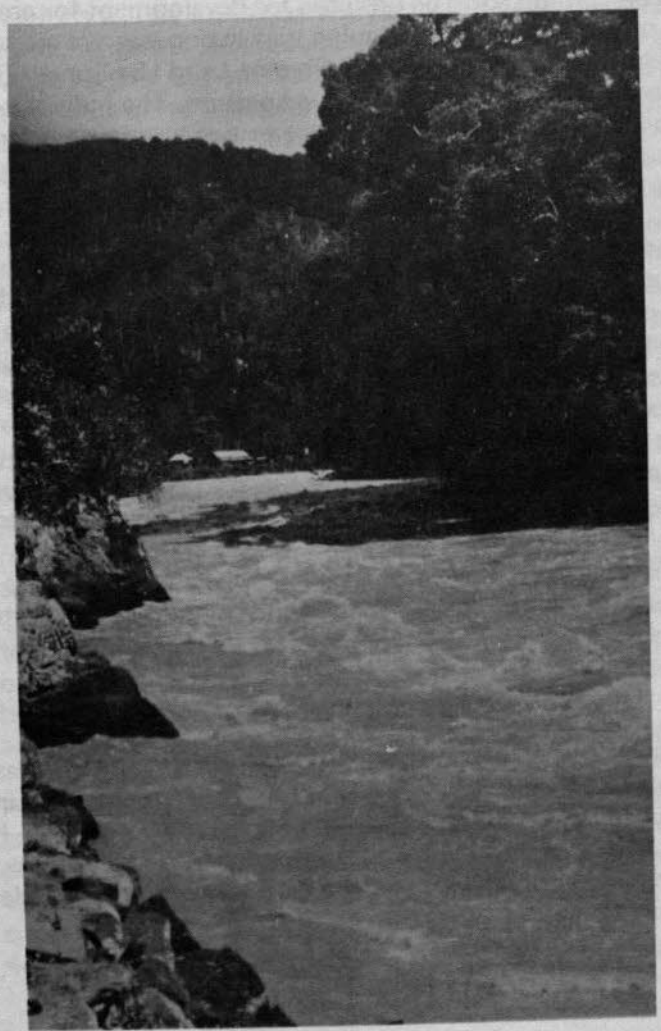


PLATE 4.12

Potential hydroelectric scheme site on the Padas Gorge

It will have been noted in Part 4, when the soil resources were discussed, that large areas of otherwise high quality alluvial land are severely limited for agriculture by drainage problems. With this in mind a start was made in the early 1960's to drain a part of the Klias area. There, about 3 250 ha (8 000 ac) have so far been drained, much of the land having Group 3 soils, held under title and partly cultivated. Attempts were also made to drain part of the deep peat swamp with Group 5 soils. These previously had not attracted agricultural interest, and remained largely uncommitted as stateland. The experience so far gained is that the drainage work on the former land has met with some success, but on the latter it has not. This underlines the importance of limiting any large-scale drainage works to the Group 3 soils occurring on the alluvial plains and freshwater swamps described in Part 4 of this report.

GRAZING RESOURCE DEVELOPMENT OPPORTUNITIES

Despite the fact that land suited for grazing is by no means extensive there are nevertheless opportunities for developing grazing resources both in the gazetted grazing reserves and in other natural grasslands, also possibly in other lands. In general, because of the need for relatively flat terrain, only Land Capability Class II land is considered to be really suitable for grazing purposes. However, Class III land may also be suitable where slope is not a limiting factor.

Grazing reserves

As can be seen for Part 4 the grazing reserves are not very extensive and Table 32 shows that within the reserves there are only 114 ha (283 ac) of Class II land of which only 17 ha (42 ac) are grassland and the balance mainly forested land. There are a further 754 ha (1 862 ac) of Class III land of which some 600 ha (1 500 ac) may be suitable for development for grazing in that slope is not a limiting factor. The remaining land in the grazing reserves 854 ha (2 111 ac) is Class IV and V, most of which is forested and considered to be unsuited for development for grazing. It is thus obvious that opportunities for developing the grazing reserves are somewhat limited and at the time of preparation of the Present Land Use Survey Report (Wong, 1973) there were only 18 ha (44 ac) of improved pasture. The individual grazing reserves are generally small being at the most one or two hundred hectares in extent.

Natural grasslands

There are a total of some 27 838 ha (68 786 ac) of natural grasslands outside the grazing reserves but only about 2 650 ha (6 547 ac) are Class II land with good suitability for improved pasture. Of this Class II land 60.0% is alienated, 22.6% is stateland and 17.4% is in government reserves. There are a further 11 555 ha (28 553 ac) of Class III land some of which may be suitable for development as improved pasture where slope is not a limiting factor. 50.2% of the Class III land is stateland, 32.7% is alienated and 15.6% is in forest reserves. In the remaining area of natural grassland some 13 633 ha (33 686 ac) is Class V land which is unsuited for agriculture and development for grazing purposes is not economically justified.

Table 53 indicates the main areas of Class III land in the stateland where slope is not a limiting factor. Class II land in the stateland is only found in small scattered tracts and patches.

Forested land

Table 54 shows that there are some 9 070 ha (22 410 ac) of forested Class II land i.e. Land Use Categories 7F, 7S and 8, which would be suited for grazing purposes. 54.1% of this land is alienated, 34.0% is stateland and 6.9% is in forest reserve. However it should be borne in mind that this land is also suited for other forms of cultivation and development for grazing purposes may conflict with other agricultural development.

TABLE 53 Main areas of natural grassland in the stateland where slope is not a limiting factor

Region	Area	Land Class	Approximate extent	
			ha	ac
Sook Plain	South of Kampong Sook	III	360	900
	West of Kampong Sook		160	390
	East of Kampong Sook		240	600
Keningau Plain	Kampong Kuangoh		680	1 690
	Kampong Dangulad		120	300
	Kampong Biah		60	160

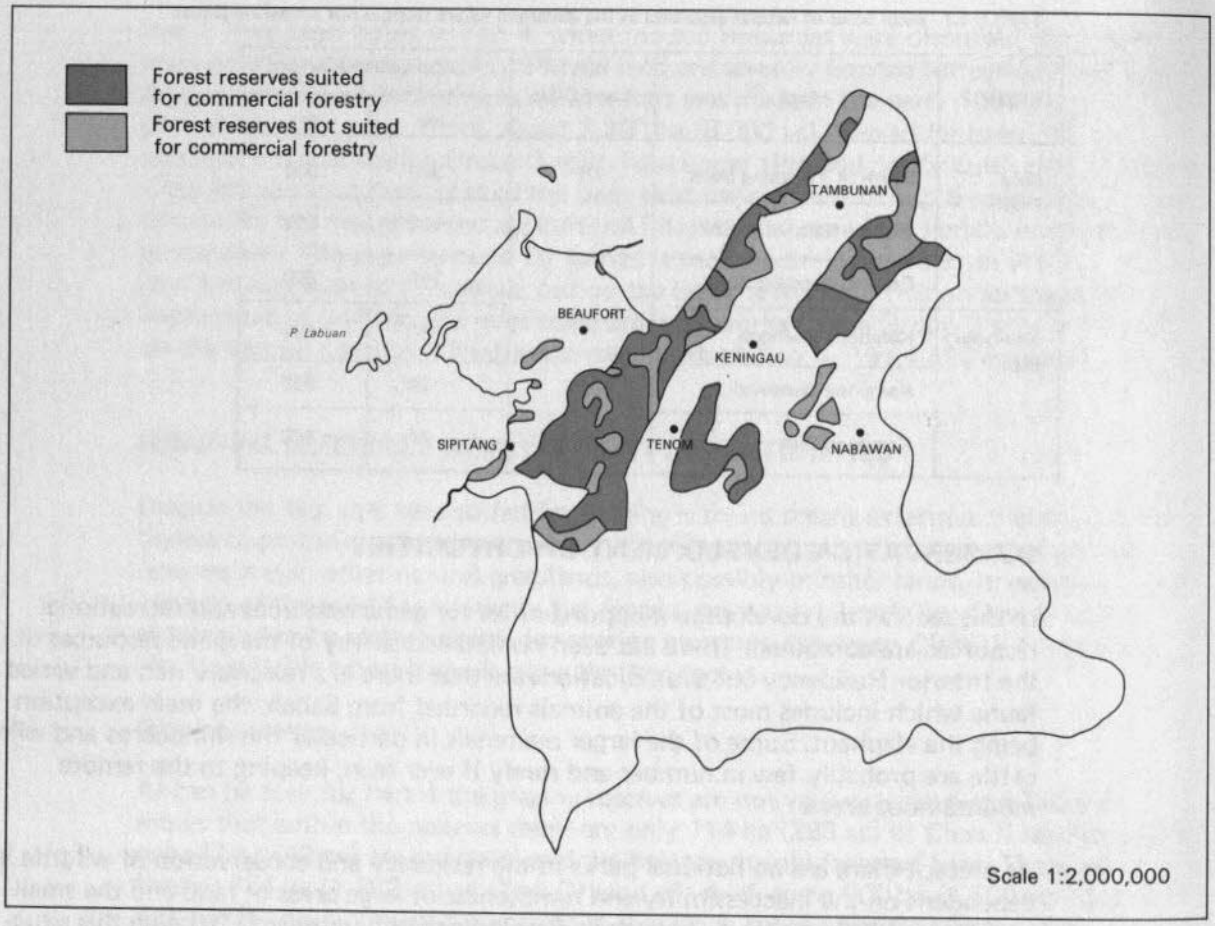
CONSERVATION DEVELOPMENT OPPORTUNITIES

In this section the development opportunities for game resources and recreational resources are combined. There has been no detailed survey of the game resources of the Interior Residency but the indications are that there is a relatively rich and varied fauna which includes most of the animals recorded from Sabah, the main exception being the elephant. Some of the larger mammals in particular the rhinoceros and wild cattle are probably few in number and rarely if ever seen, keeping to the remote mountainous areas.

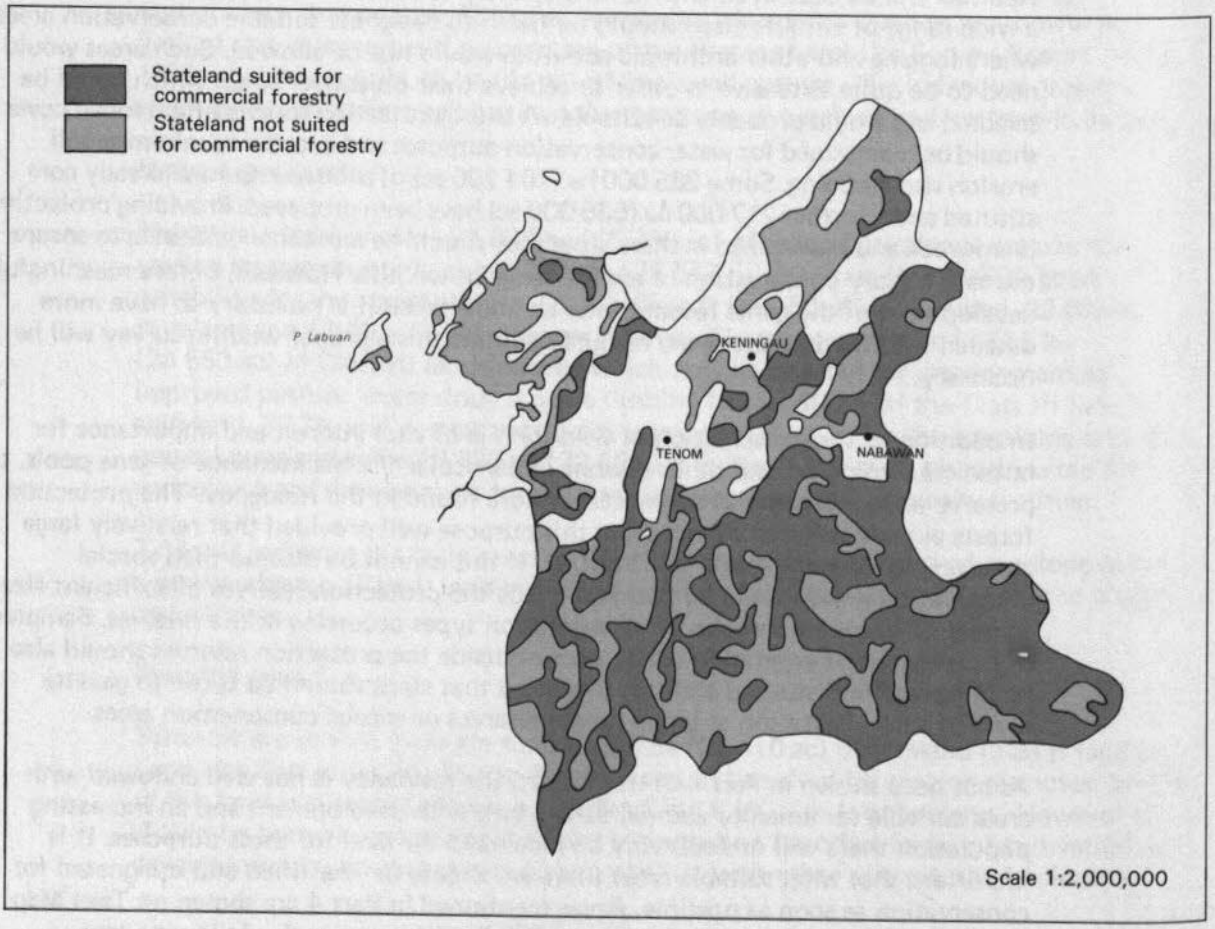
At present there are no national parks in the residency and conservation of wildlife is dependent on the inaccessibility and remoteness of large areas of land and the small population. With the likely large scale development of commercial logging this situation will change in the future and undoubtedly the fauna population will suffer. Habitats will be destroyed and hunting is likely to increase. To ensure the survival of a wide range of wildlife steps should be taken to designate suitable conservation areas where logging and other anthropic activities would not be allowed. Such areas would need to be quite extensive in order to achieve their objective. Areas which could be selected and would probably be suitable are those protection forests where forest cover should be maintained for water conservation purposes and in order to minimise soil erosion and flooding. Some 285 000 ha (704 200 ac) of such reserves are already constituted and a further 217 000 ha (536 000 ac) have been proposed. Providing protection is enforced and maintained in these areas they should be more than adequate to ensure the satisfactory conservation of a wide range of wildlife. However, before meaningful development of the game resource can be undertaken it is necessary to have more detailed information about the resource and for this a proper wildlife survey will be necessary.

In addition to the conservation of wildlife it is of vital interest and importance for botanical, ecological and other reasons in particular the maintenance of gene pools, to preserve adequate samples of the varied flora found in the residency. The protection forests already referred to will serve this purpose well provided that relatively large areas do remain completely undisturbed. If this cannot be assured then special conservation areas should be declared inside the protection reserves of sufficient size to include adequate samples of all vegetation types occurring in the reserves. Samples of other types of vegetation which occur outside the protection reserves should also be preserved undisturbed and it is suggested that steps should be taken to gazette areas of such vegetation as virgin jungle reserves or special conservation areas.

As has been shown in Part 4 of this report, the residency is not well endowed with areas suitable for amenity and recreation but, with development and an increasing population there will undoubtedly be a demand for land for these purposes. It is important that what suitable areas there are should be identified and designated for conservation as soon as possible. Areas mentioned in Part 4 are shown on Text Map 4-20 and the main features of each area briefly discussed in the following text.



TEXT MAP 4-18 Suitability of forest reserves for commercial forestry



TEXT MAP 4-19 Suitability of stateland for commercial forestry

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Prepared by the Directorate of Overseas Surveys 1976

Conservation areas

The approximate location of suggested conservation areas is shown on Text Map 4-20.

Crocker Range

There are some 19 500 ha (48 300 ac) of land in the Crocker Range above an altitude of 1 200 m (4 000 ft). Parts of this area may be developed in the future for recreation and amenity purposes on account of the markedly cooler climate and easy access in places. Undeveloped parts will serve as conservation areas for fauna and flora. It should be borne in mind that all this land lies within the Crocker Range Forest Reserve and any development should be planned so as to conform with the basic function of the Reserve i.e. watershed protection.

Trus Madi Range

There are some 33 600 ha (83 000 ac) of land in the Trus Madi Range above an altitude of 1 200 m (4 000 ft) all of which lies in the Trus Madi Forest Reserve. In view of the markedly cooler climate of this area it should have some potential for recreation and amenity purposes. However access to any part of the area is difficult and it can at present only be reached by walking. Prospects for any form of road access except possibly logging roads are remote and in view of this the possible potential of the area is unlikely to be realised for some time to come. It could perhaps be developed as a sort of wilderness area for trekking and camping but it is not thought that this will have much appeal to the general public.

Beaches along the west coast of the Klias Peninsula

These beaches are the only reasonable ones in the residency and will become important amenity and recreational areas for the growing population of the Beaufort and Kuala Penyu areas. The beaches and immediate foreshores should not be alienated but should remain as stateland with easy public access. At present only a few stretches are accessible by road and if they are all to serve as recreational and amenity areas for the general public road access will have to be improved.

Beaches on Labuan

The better beaches will become important amenity and recreational areas for the general public and for tourists if the island is developed as a resort. With this in mind foreshore development should be so planned that the amenity value of the beaches is maintained and they remain stateland with easy public access.

Padas Gorge

There are places in the Padas Gorge with easy access and good views of the river which could possibly be developed for recreational and amenity purposes. The almost complete dependence on the railway for access is an important consideration in any such development. The situation would be improved by the presence of a road; but whether this would be economically justifiable together with the present railway is not clear. Another important consideration is the possible construction of engineering works for generating hydroelectricity. Every effort should be made to ensure that these are compatible with the natural beauty of the Gorge.

Tambunan Valley

The Valley has potential for recreation and amenity purposes and with improved roads and facilities is likely to attract visitors. The site of Mat Salleh's fort might be developed as an historic monument. Any development planning for other purposes should take account of the possible value of the area for recreation and amenity.

Labau Valley

This valley may have some value for recreation and amenity purposes in particular for people interested in hiking and camping. However at present access is difficult and depends on the long road journey from Keningau and along bridle trails which wind northwards to the head of the valley. Facilities for visitors are almost totally lacking. It is therefore likely to be some time before the potential of the area can be developed.

Batu Punggul

The limestone outcrops in this area with their caves may prove an attraction for residents, visitors and tourists interested in seeing the more remote parts of the country. At present access is very difficult, and until this is improved there can be no hope of developing the possible potential of the area.

GENERAL OPPORTUNITIES

The various land resources have been discussed in Part 4, and the preceding sections have dealt with the opportunities for development which exist for each particular resource. Hence, attention has so far been focused on the individual resources. Any piece of land may, however, contain one or more resource worthy of use and, for any overall planning to be effective, all the various development options must be clearly defined in order that the best decision can be arrived at on the permanent form of land use. These, as has been described in Part 3, are expressed by the land exploitation units.

Another important consideration is land tenure. It will have been seen from the preceding pages that considerable anomalies exist between land tenure and present land use, that is, much land is not being used for the purpose to which it has been legally committed under the Land Ordinance. Hence, this aspect should also be weighed with the conflicting resource development potentials in order to arrive at a sound decision on the permanent use of land. This is of paramount importance for overall planning, particularly that involving the public sector; which then lends itself to an appraisal, on a regional basis, of the various development opportunities which exist.

Conflicting resource development potentials

The overall picture is expressed by the data on the land exploitation units given in Table 54. Land exploitation units IIC, IIIB and C express both agricultural and forestry capabilities and it can therefore be seen that the conflict between agriculture and forestry extends over a total of some 48 329 ha (119 422 ac). The data also indicates some conflict between mining and agricultural interests as expressed by land exploitation units IID and IIID, E and F; but it should be noted that as such possible mining land is categorised. Until the mineral resources have been proven mining interests on such land should, for planning purposes, be subordinate to that of agriculture. Hence it can be seen that, in practical terms, the main conflict is restricted to agriculture and forestry. The main areas involved are shown on Text Map 4-21, and the extent of the conflict between agriculture and forestry in terms of the land categories on Table 55.

By far the greatest conflict occurs as stateland where some 43 918 ha (108 522 ac) are involved. The main areas are shown on Text Map 4-21. The two northern areas, in the Labau Valley and Penawan Plain, are both reasonably accessible and already partly populated. They are not likely, however, to be fully settled and farmed for some considerable time, and it might well be possible in some places to obtain more than one harvest of logs before the full requirements of agriculture are satisfied. Agricultural development in the southern areas will be inhibited by remoteness and lack of population. There are considerably more attractive areas available for settlement elsewhere in the State, and until they have been taken up no agricultural demands can be expected in the areas. This is likely to take a very long time. In the meantime the land would best be used for forestry.

TABLE 54 Present land use and land capability in ha (ac)

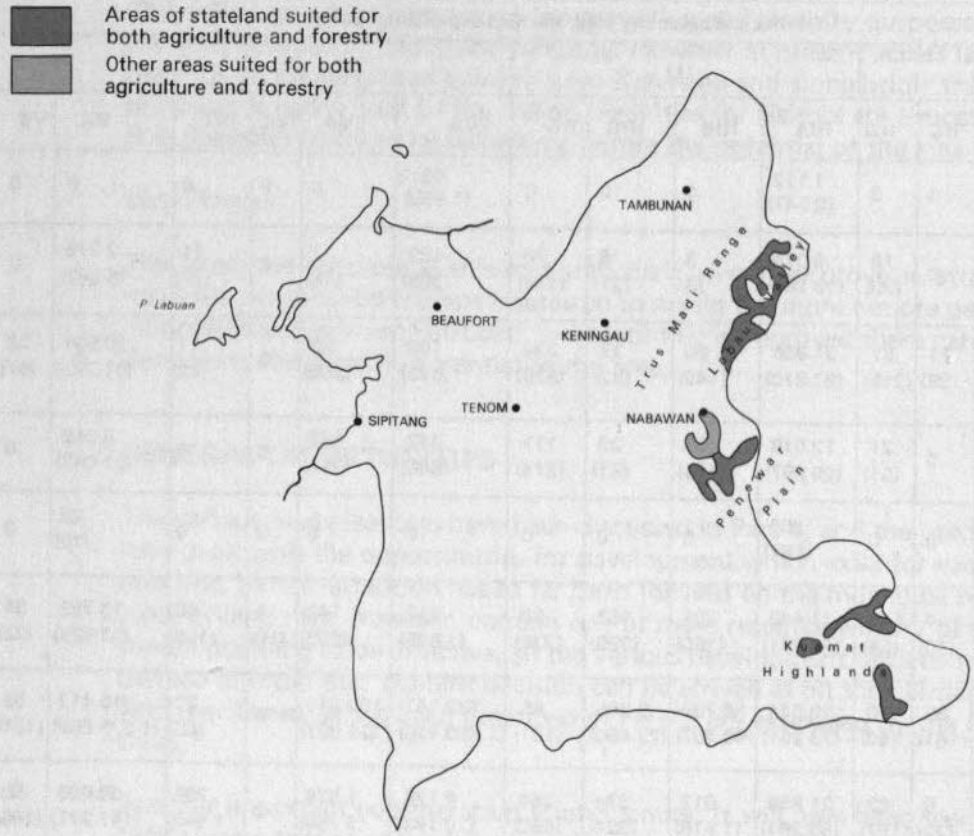
Present land use category*	Land capability class and land exploitation units													
	I	II			III				IV				V	
	IA	IIA	IIC	IID	IIIA	IIIB	IIIC	IIID	IVA	IVB	IVC	IVE	VA	VB
1	0	153 (378)	0	0	1 112 (2 747)	0	0	0	631 (1 559)	0	0	0	0	0
2	3 (7)	1 181 (2 918)	0	15 (38)	5 374 (13 280)	3 (8)	8 (21)	70 (174)	123 (305)	7 (18)	0	11 (27)	2 779 (6 867)	0
3	34 (84)	9 416 (23 267)	11 (28)	87 (215)	21 805 (53 879)	60 (149)	33 (82)	334 (826)	190 (470)	83 (205)	0	17 (42)	20 931 (51 722)	23 (57)
4	0	1 137 (2 809)	0	21 (51)	12 018 (29 697)	55 (135)	33 (81)	111 (274)	342 (846)	142 (351)	0	0	8 516 (21 043)	0
5	0	0	0	0	68 (167)	0	0	0	0	0	0	0	29 (72)	0
6	41 (101)	2 642 (6 527)	4 (10)	23 (56)	11 449 (28 291)	105 (260)	161 (399)	96 (238)	617 (1 525)	142 (352)	4 (10)	40 (100)	13 729 (33 925)	31 (78)
7F	36 (90)	3 819 (9 436)	65 (161)	16 (40)	29 644 (73 251)	36 709 (90 707)	9 508 (23 495)	65 (161)	732 147 (1 809 136)	168 311 (415 897)	0	27 (68)	515 412 (1 273 585)	53 (131)
7S	70 (174)	4 529 (11 192)	9 (22)	63 (157)	21 556 (53 264)	613 (1 516)	374 (924)	264 (652)	4 125 (10 193)	1 518 (3 750)	0	785 (1 940)	59 600 (147 271)	99 (246)
8	0	562 (1 388)	0	6 (15)	5 732 (14 163)	253 (625)	195 (481)	33 (82)	12 770 (31 555)	3 412 (8 432)	0	11 852 (29 287)	63 418 (156 707)	34 (84)
9	0	220 (545)	0	0	1 297 (3 205)	90 (222)	39 (96)	8 (19)	437 (1 079)	894 (2 208)	0	38 (94)	1 921 (4 747)	0
Unit total	184 (456)	23 658 (58 460)	89 (221)	231 (572)	110 054 (271 944)	37 888 (93 622)	10 352 (25 579)	981 (2 426)	751 383 (1 856 668)	174 509 (431 213)	4 (10)	12 771 (31 558)	686 336 (1 695 939)	241 (596)
Class total	184 (456)	23 979 (59 253)			159 276 (393 571)				938 668 (2 319 449)				686 578 (1 696 535)	

*1 Urban land; 2 Horticulture; 3 Tree, palm and permanent crops; 4 Shifting agriculture; 5 Improved pasture; 6 Grassland; 7F Forest; 7S Scrub forest; 8 Swamp, marshland and wetland forest; 9 Unused and cleared land; 10 Unclassified land

TABLE 55 The extent of the conflict between agriculture and forestry in the various land categories

Land category	Extent	
	ha	ac
Stateland	43 918	108 522
Alienated land	2 679	6 622
Forest reserve	1 731	4 278

Note: no such conflict occurs within the grazing and government reserves



Scale 1:2,000,000

TEXT MAP 4-21 Areas of conflicting potential use between agriculture and forestry

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Prepared by the Directorate of Overseas Surveys 1976

It will have been noted from Table 55 that the areas of alienated land and forest reserve involved are not extensive. The largest and only conspicuous area of alienated land with both an agricultural and forestry potential occurs on the part of the Penawan Plain allocated for the Nabawan Settlement Scheme. Early agricultural development can be expected on such land. The areas within the forest reserves are small and individually inconspicuous, and with their small size together with the general availability of land suited for agriculture elsewhere there is hardly likely to be a significant demand for their excision from the reserves for agricultural development purposes.

REGIONAL DEVELOPMENT OPPORTUNITIES

This report has so far described the land resources and the various opportunities available as far as their development is concerned. It has also outlined the various options which exist and strategies which may be employed in land development matters. The information has been presented so as to assist fairly detailed planning. Broad-scale planning, however, may best be undertaken on a regional basis, and the following account gives an outline of the main development opportunities which exist in the physiographic regions defined in Part 2.

Crocker Range

The overall prime function of the region is that of water conservation as it is on the main part of the Crocker Range, which lies to the north in the West Coast Residency. It is of paramount importance that the whole of the Range is protected in order to ensure the water supplies. Fortunately, this has already been largely assured by the Crocker Range Forest Reserve which has been primarily established for this purpose and which does, in fact, cover all the main watershed areas. The reserve is virtually all forested and it is of utmost importance that the tree cover remains intact. Logging in the reserve should, therefore, be strictly prohibited.

The problem arising from the effects of shifting cultivation is not as great as in the northern parts of the Range, but it does exist. Fortunately the main areas used at present are located on the lower steeplands where the effect on the water regime is not so serious. The activities of these shifting cultivators cannot, however, be condoned, and every form of encouragement should continue to be given to those involved to migrate from the mountains to a sedentary form of agriculture in the lowlands. Only when this has been fully accomplished will the whole of the Range be clad with a continuous tree-cover,

In the very long term, when the lowlands of the seaboard and interior have been fully settled and support a large population, the cool and scenic higher parts of the Range will be fully valued for recreation purposes. Any form of planning involved, however, should be compatible with the overall function of the Range, which is watershed protection.

Meligan Range

This, like the Crocker Range, is an important water catchment region, constituting in particular the headwaters of the Padas River. Its future also lies in protection forestry, and in this connection the overall interest would be best served by the establishment of a forest reserve. There would be a few agricultural enclaves in the reserve, notably at Long Pa Sia and Meligan where there is considerable scope for improvement in the present standard of farming. This is probably the only way in which the shifting cultivator will be induced to leave the high slopes and lead a more sedentary existence in the lowlands.

Trus Madi Range

The part which falls within the residency boundary forms important watersheds for three main rivers: the Pegalan, Sook and Labau (Kinabatangan). Thus, even though the south-west ridges and slopes are covered by commercial forests the over-riding use of the the land should be water conservation. This is also largely assured by the protective function of the Trus Madi Forest Reserve which covers most of the higher and more critical catchment areas. In the long-term this conservational use might well be joined by that of recreation and, in order to ensure their compatibility careful planning will be required.

In the lower ridges and hills of the south-west part of the Range the watersheds are not so critically important and, with proper operational planning, logging might well become an important industry. This zone should be included in the permanent forest estate for this purpose.

Witti Range

It is difficult to predict any form of real development for this region. Although mountainous and extremely remote it is populated, albeit very sparsely. The inhabitants depend on subsistence farming and are mainly shifting cultivators; but the prospects for agriculture are very limited, largely restricted to a more intensive use of a number of narrow valley bottoms. It is difficult to foresee any significant increase in the general

population and, with improving prospects for other better agricultural regions, both in the Residency and the State, considerable emigration might well occur.

Although considerable areas of commercial forests exist away from the main valleys, the prospects for logging are not good. This is mainly because of the difficulties caused by the generally mountainous terrain and by the long haulage distances involved and, again, watershed protection considerations are important in some places. Even so, the best overall prospects for the region would appear to be involved with forestry, and there is considerable scope for establishing forest reserves over extensive areas.

Kuamut Highlands

Here again, and in common with the other parts of the region in the adjacent Tawau and Sandakan Residencies, the main development will be based on forestry. Much of the land is steep and rugged and logging in many areas will be extremely difficult. Any development plans should take into account the importance of the main watersheds, and the general interests of forestry would best be served by extending the forest reserve coverage over most of the region; leaving as stateland the presently remote and uninhabited valleys which have been identified as suited for agriculture.

Klias Hills

Endowed with good soils, a farming population and a rapidly improving road system, development here will almost exclusively be based on agriculture. Most of the land has already been taken-up under land titles but considerable areas remain unused. The major problem foreseen as far as development is concerned is inducing the land-owners to utilise their holdings fully.

Crocker Foothills

Again, even though considerable areas are held under title, there is considerable scope for increasing the amount of cultivation in the alienated land. Considerable areas of stateland also remain which can be developed for agriculture. Communications are good and there is a readily available population to serve further development.

There is also some prospect for forestry in the belt of stateland which separates the agricultural land on the seaboard and the Crocker Range Forest Reserve inland. Considerable areas are forested ahd have commercial stands of timber and the interests of the State would best be served by affording the protection of a forest reserve to this land. The prime use should be watershed protection, but the possibility of allowing strictly controlled logging on some lower slopes should be kept in mind.

Talankai Valley

The future prospects for the Talankai Valley are closely inter-linked with those of the adjoining Witti Range. The problems are largely the same; with the economy mainly involved with shifting cultivation on mountain slopes, but with commercial forests still remaining away from the inhabited valleys. The main opportunity appears to lie with forestry, largely protective and large areas should be gazetted as forest reserves.

In addition to the more intensive use of the narrow valley bottoms for agriculture there is some scope in developing the Labang Basin for permanent agriculture.

Western Islands

Any significant changes will be restricted to Labuan where, although there is considerable scope for intensifying cultivation on the farming lands and thereby considerably increasing the agricultural productivity, development in the foreseeable future will be largely involved with the requirements of the bourgeoning off-shore oil industry. The possibility of the coal mining industry being re-established on the island should not be overlooked.

Klias Plain

There do not appear to be any real prospects for development in the rather inhospitable peat and mangrove swamps which cover most of this region. Forestry will be very limited, and the prime function of the deltaic swamps will be as feeding and spawning grounds sustaining the important fishing industry of Brunei Bay.

The alluvial stretches, however, have a considerable potential for further agricultural development particularly with the intensification of agriculture, and when the control of the Padas flooding has been achieved, they will become very important agricultural areas.

Crocker Plains

The remaining seaboard plains are relatively small, mainly riverine, relatively highly populated, almost completely alienated but under-cultivated. Once more their future development rests with agriculture by employing more intensive farming systems.

Tenom, Keningau and Tambunan Plains

Almost all of the Tenom and Tambunan Plains and a great proportion of the Keningau Plain has been alienated and, although they are already very important farming areas, prospects for considerably more agricultural development are outstanding on the Tenom and, to a lesser extent, the Keningau Plain. This will depend on the ability of the land-owners to fully farm their holdings, or alternatively some degree of agrarian reform.

Sook-Dalit Plain

Being largely uncommitted except for some forest reserve areas, with a small but gradually increasing population, and with greatly improving road access this region offers a considerable challenge to development planning. Although soil conditions are not in general particularly good there are considerable opportunities for agricultural development on the better soils. The extensive grass-covered parts of the Plain, which are covered by sheet lalang, the result of soil degradation due to an earlier history of intense shifting cultivation, have attracted the attention of both grazing and forestry interests. Undoubtedly both cattle farming and plantation forestry can be carried out on such land, but whether they can be considered economic propositions has to be proven.

Penawan Plain

Falling within the boundary of the Nabawan Settlement Scheme most of the northern part of this region is already earmarked for agricultural development. The Scheme has been designed to accommodate traditional shifting cultivators from the Talankai Valley to the south and to offer them a sedentary form of agriculture. It is foreseen that agriculture will expand over the years but, because of the limited area of suitable land it will never become a particularly significant farming region.

RECOMMENDATIONS FOR FURTHER STUDIES

This report provides a general basis for development planning. It should by no means be construed to be the final statement for the purpose. There remain considerable gaps in our knowledge of the resources; much of the work now requires updating; no account has been made of socioeconomic and demographic aspects. For land planning and development to be fully effective the following recommendations are made; they are not in any particular order of importance:

1. Conducting prospecting work on the Labuan Coalfield with the view to reviving the coal industry on the island.

2. Carrying out more detailed soil surveys over the areas recommended for agricultural development. These should be made in conjunction with agronomic studies into the relationships between crops and the soils, together with fertilizer and other management requirements.

3. Constituting forest reserves on land unsuited and not used for agriculture, updating the forest inventory, obtaining more detailed information on the forest resource and formulating a forest management plan compatible with overall planning and development.

4. Undertaking a systematic hydrological survey of the residency with a view to conserving and controlling the water resources in a way consistent with the use of the other resources.

5. Conducting an overall survey of the game resource in order to identify areas which can be used for wildlife conservation.

6. Making a complete appraisal of the areas identified as having a capability for conservation and recreation.

7. Undertaking specific studies on population and manpower, particularly in relation to migration, in order to satisfy the demands of agricultural development in the State as a whole.

8. Being alienated but not cultivated, a considerable part of the agricultural soil resource is not being used. This problem requires further study with the view to introducing measures which would ensure that the landowners make maximum use of their holdings.

9. Carrying out a full study on the practice of shifting cultivation with the view to curtailing its spread and ultimately resettling the people involved to a sedentary form of agriculture.

10. Conducting detailed studies on the establishment of feeder roads necessary for servicing the agricultural development areas.

11. And, largely in conjunction with the foregoing studies, formulating an overall development plan compatible with the interests of the State and Nation and based on the projected requirements of mining, agriculture, forestry, conservation and recreation, with the view to the phased development of the land resources.

Part 6

References and relevant works

ACRES B D BOWER R P BURROUGH P A FOLLAND C J KALSI M S THOMAS P and WRIGHT	1975	The soils of Sabah. *Land Resour. Stud* no. 20, Vols 1-5.
ACRES B D	1972	The ascent of Trusmadi. *Sabah Soc. J.* **5**, 365-370.
ALLEN A W FORSTER P H	1956	A survey of the soils and agriculture of the Keningau Plain. *Unpubd Rep. Dep. Agric. N. Borneo.*
BACON A J	1975	Personal communication (Dep. of Agriculture, Sabah, Malaysia).
BOWER R P BURROUGH P A KALSI M S and THOMAS P	1972	The soils of the southwest area of Sabah Malaysia. Preliminary draft land resource study. *Rep. Dep. Agric. Sabah, Malaysia.*
BOWER R P BURROUGH P A KALSI M S and THOMAS P	1975	The soils of Sabah. Vol 4, South-western districts. *Land Resour. Stud.* no. 20.
BRYANT P W	1956	The Cambridge Expedition to British North Borneo 1956. Cambridge, England: Cambridge University Exploration Club.
COLLENETTE P	1958	The geology and mineral resources of the Jesselton-Kinabalu area, North Borneo. *Mem. geol. Surv. Dep. Br. Terr. Borneo* no. 6.
COLLENETTE P	1963	A physiographic classification of North Borneo. *J. trop. Geogr.* **17**, 28-33.
COLLENETTE P	1965	The geology and mineral resources of the Pensiangan and Upper Kinabatangan Area, Sabah, Malaysia. *Mem. geol. Surv. Borneo Reg. Malay.* no. 12.

COLONY OF NORTH BORNEO	1963	An ordinance to consolidate and amend the law for the protection and conservation of certain species of wild animals and birds; and for purposes connected therewith and incidental thereto. *Ordinance, Govt Colony N. Borneo* no. 11.
COLONY OF NORTH BORNEO FOREST DEPARTMENT	1953	*A. Rep. Forest Dep. N. Borneo 1952.*
COLONY OF NORTH BORNEO FOREST DEPARTMENT	1954	*A. Rep. Forest Dep. 1953.*
DAVIS D D	1962	Mammals of the lowland rain-forest of North Borneo. *Bull. Singapore natn. Mus.* no. 31.
DEPARTMENT OF AGRICULTURE		See under Sabah.
DEPARTMENT OF STATISTICS		See under Malaysia.
FORESTAL INTERNATIONAL LIMITED	1973	Sabah forest inventory 1969-72. Vancouver, Canada: Forestal International Limited.
FOX J E D	1972	The natural vegetation of Sabah and natural regeneration of the dipterocarp forests. Bangor: University College of North Wales, (Ph.D. thesis).
MALAYSIA DEPARTMENT OF STATISTICS	1973	*A. Bull. Statists Sabah 1972.*
MALAYSIA DEPARTMENT OF STATISTICS	1974	*Mon. Statists Sabah Jan. 1974.*
MARTYN H S Chmn.	1973	Minutes of the meeting on forest reservation proposals for the Interior held at the Bilik Gerakan Lembaga Bandaran Kota Kinabalu on 19 November 1973.
McCARTHY M	1974	Beaufort urban drainage spate level/frequency analysis. *Rep. Public Works Dep. Sabah, Malaysia.*
MEDWAY, LORD	1965	Mammals of Borneo. Field keys and an annotated checklist. Kuching, Sarawak: Malaysian Branch of the Royal Asiatic Society.
MOTLEY J	1852	Report on the geological phenomenon on the island of Labuan and neighbourhood. *Journal of the Indian ARchipelago and Eastern Asia 1852.*
NIPPON KOEI CO LTD	1974	A feasibility report of the Padas River hydro-electric power development. Sabah Power Development Project. Asian Development bank. Tokyo, Japan: Nippon Koei Co. Ltd. Consulting Engineers.

PANTON W P	1966	Land capability classification in the States of Malaya, Malaysia. *Proc. 2nd Malay. Soil Conf. Kuala Lumpur 1966* 128-133.
REINHARD M and WENK E	1951	Geology of the Colony of North Borneo. *Bull. geol. Surv. Dep. Br. Terr. Borneo* no. 1.
SABAH MALAYSIA DEPARTMENT OF	1971	In annexes to the report on the development of a beef industry in the State of Sabah, Malaysia, prepared by Asian New Zealand Development Consultants Ltd. (1973).
SABAH MALAYSIA DEPARTMENT OF AGRICULTURE	1974	Pasture research in Sabah. *Internal Rep. Dep. Agric. Sabah, Malaysia.*
SABAH MALAYSIA DRAINAGE AND IRRIGATION DEPARTMENT	1970	Hydrological records of Sabah to 1968. Kota Kinabalu: Drainage and Irrigation Department, Hydrology Division.
SABAH STATE DEVELOPMENT PLANNING COMMITTEE	1973	Land capability classification. A general inventory of land resources. *Tech. Monogr. St. Dev. Plann. Comm.* no. 1.
ST. JOHN S	1862	Life in the forests of the Far East. London: Smith Elder.
STATE OF NORTH BORNEO	1919	*A. Rep. Forest Dep. N. Borneo 1918.*
STATE OF NORTH BORNEO	1921	*A. Rep. Forest Dep. N. Borneo 1919.*
STATE OF NORTH BORNEO	1922	*A. Rep. Forest Dep. N. Borneo 1921.*
STATE OF NORTH BORNEO	1923	*A. Rep. Forest Dep. N. Borneo 1921.*
STATE OF NORTH BORNEO	1931	*A. Rep. Forest Dep. N. Borneo 1930.*
SYMINGTON C F	1943	Foresters manual of Dipterocarps. *Malay. Forest Rec.* no. 16.
THOMAS P LO F	1971	Land capability and present land use of the Labuan District. Unpublished report filed under Agriculture Department, Sabah, LCC. 5/67/17/9.
TREGONNING K G	1958	Under chartered company rule (North Borneo 1881-1946). Singapore: University of Malaya Press.
TREGONNING K G	1960	North Borneo. London: HMSO.
TREWARTHA G T	1968	An introduction to climate. New York: McGraw-Hill.

UDARBE M P	1974	Letter. Filed under F.D. *703/5.* Sabah Forest Department.
WALLS J J	1975	Personal communication. (Marine Department, Sabah, Malaysia).
WHELAN F G	1970	A history of Sabah. Singapore: Macmillan and Co. (S) Private Ltd.
WILSON R A M	1964	The geology and mineral resources of the Labuan and Padas Valley area, Sabah, Malaysia. *Mem. geol. Surv. Borneo Reg. Malay.* no. 17.
WILDE D	1975	Personal communication. (Hydraulics Division, Public Works Department, Sabah).
WONG I F T	1973a	The present land use of Sabah, 1970. Sabah Present Land Use Report, Ministry of Agriculture and Fisheries, W. Malaysia. no. 5.
WONG I F T	1973b	The present land use of the Interior Residency Sabah, 1970. Sabah Present Land Use Report, Ministry of Agriculture and Fisheries, W. Malaysia. no. 1.

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