Land Resource Study

25 The land capability classification of Sabah Volume 2 The Sandakan Residency

Land Resources Division, Ministry of Overseas Development

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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, Sandakan Residency. Scale 1 : 250 000 (7 sheets)

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Abstracts and keywords

ABSTRACT

This report contains a brief description of the physical and human environment of the Sandakan Residency (Sabah, Malaysia) which covers an area of 28 016 km^2 (10 817 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 shows that some 44% of the land is suited for agriculture and some 74% has a potential for commercial forestry.

RÉSUMÉ

Ce rapport contient une description succincte de l'environnement physique et humain de la Résidence de Sandakan (Sabah, Malaysia), qui couvre une aire de 28.016 km^2 (10.817 mi^2). Les diverses études relatives aux ressources effectuées dans la zone 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 façon 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 d'exploitation des terres sont discutées en tenant compte du régime foncier, de l'usage actuel des terres, de la population et de l'accessibilité. En conclusion, des recommandations sont formulées en vue d'études ultérieures susceptibles de faciliter la planification de la mise en valeur. Le rapport indique que 44% des terres conviennent à l'agriculture et 74% 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 of 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 smallholding 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.
Bakau	*Rhizophora mucronata*
Bangkita	*Rhizophora apiculata*
Belian	*Eusideroxylon zwageri*
Beus	*Bruguiera cylindrica*
Bintangor	*Calophyllum* spp.
Binuang	*Octomeles sumatrana*
Buta Buta	*Excoecaria agallocha*
Durian	*Durio* spp.
Gagil	*Hopea sangal*
Geriting	*Lumnitzera* spp.
Jelutong	*Dyera* spp.
Kapur	*Dryobalanops* spp.
Karai	*Meiogyne virgata* *Mezzetia leptopoda* *Sageraea lanceolata* also *Polyalthia* and other *Annonaceae*
Kayu malam	*Diospyros* spp.
Kedongdong	*Burseraceae* i.e. *Canarium* spp., *Dacryodes* spp., *Santiria* spp.
Kembang	*Heritiera simplicifolia* and other spp. of *Heritiera*
Keranji	*Dialium* spp.
Keruing	*Dipterocarpus* spp.
Laran	*Anthocephalus chinensis*
Layang layang	*Parishia insignis*
Limpaga	*Azadirachta excelsa* *Toona sureni* and other *Meliaceae*
Majau	*Shorea leptoclados*
Medang	*Lauraceae* spp. especially *Litsea*
Melapi	*Anthoshorea* section of *Shorea*
Mengaris	*Koompassia excelsa*
Merbau	*Intsia palembanica*
Nyatoh	*Sapotaceae* e.g. *Ganua, Madhuca, Palaquium, Payena* spp.
Obah suluk	*Shorea pauciflora*
Pengiran	*Anisoptera* spp.
Prepat	*Sonneratia alba*
Pulai	*Alstonia* spp.
Putat paya	*Planchonia valida*
Ranggu	*Koordersiodendron pinnatum*
Red seraya	*Rubroshorea* section of *Shorea*
Resak	*Vatica* or *Cotylelobium* spp.
Selangan batu	*Shorea* section of *Shorea*
Sengkuang	*Dracontomelon puberulum*
Sepetir	*Sindora* spp.
Serungan	*Cratoxylum* arborescens
Takalis	*Pentace* spp.
Tengar	*Ceriops tagal*
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 gracilis*
Kazungulu	*Setaria sphacelata*		

Parts 1-6

Part 1

Preface

This report is the second of a series of four describing the land capability classification of the residencies of Sabah, Malaysia. This volume deals with the Sandakan Residency. It is published with the permission of the Government of Sabah to whom a draft was submitted in 1974.

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.

Thanks are extended to the many persons and organisations who have helped in producing this volume; full acknowledgements are given in the introduction to Volume 1.

Part 2

Geographical background

LOCATION

The Sandakan Residency is situated in the north-eastern part of the State of Sabah (Text Map 2-1) and is bounded by latitudes 4° 30′ N and 6° 46′ N and longitudes 116° 30 E and 119° 20′ E. Included in the residency are various off-shore islands the largest of which is Jambongan at the northern-most point. The residency comprises the administrative districts of Sandakan, Kinabatangan, and Labuk and Sugut and has a total land area of approximately 2 801 767 ha (6 923 072 ac, 10 817 mi^2). Sandakan is the administrative centre and the only town in the residency. The administrative centres of the Kinabatangan and Labuk and Sugut Districts are respectively the settlements of Bukit Garam and Beluran.

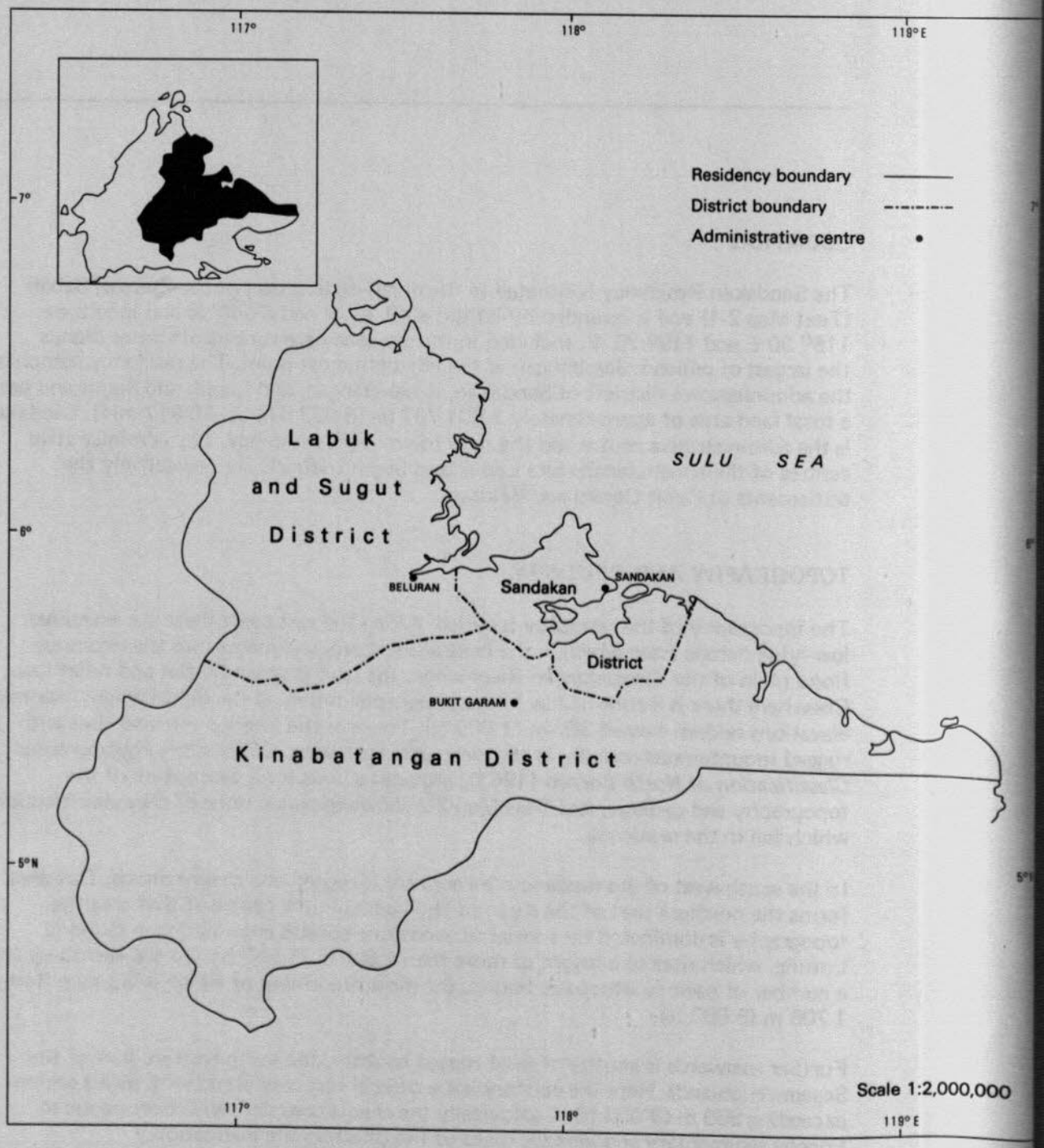
TOPOGRAPHY AND GEOLOGY

The topography of the residency is varied. Along the east coast there are extensive low-lying deltaic areas which in the central-southern part merge into the extensive flood plain of the Kinabatangan River where the land is generally flat and relief low. Elsewhere there is a zone of low hills and peneplains behind the deltas where maximum elevations seldom exceed 300 m (1 000 ft). Towards the interior the land rises with rugged mountainous country in the west and south-west. Collenette's *Physiographic Classification of North Borneo* (1963), provides a basis for a description of the topography and geology, and Text Map 2-2 shows the main units of that classification which fall in the residency.

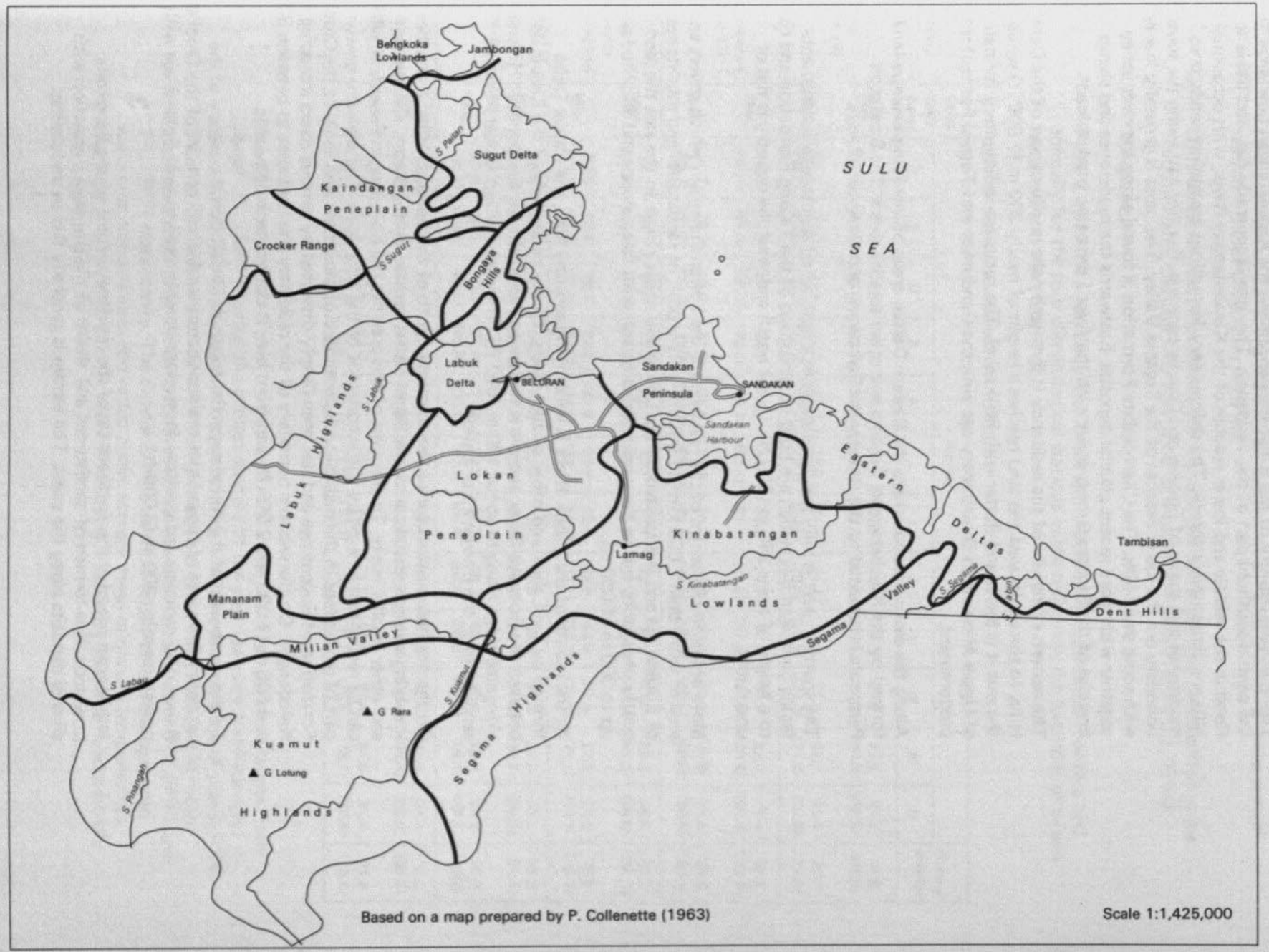
In the south-west of the residency the country is rugged and mountainous. This area forms the northern part of the Kuamut Highlands. In the centre of that area the topography is dominated by a series of sandstone cuestas culminating in Gunong Lotung, which rises to a height of more than 1 600 m (5 250 ft). To the east there are a number of basic to ultrabasic bodies, the most prominent of which is Gunong Rara, 1 706 m (5 600 ft).

Further eastwards is another area of rugged country, the north-western part of the Segama Highlands. Here the country has a general east-west trend with peaks seldom exceeding 900 m (3 000 ft). Geologically the area is complex, with Cretaceous to Eocene sedimentary and igneous rocks of the Chert-Spilite Formation.

Immediately to the north of the Kuamut Highlands are the upper reaches of the Kinabatangan River, the Milian Valley. This is a broad trough which separates the Kuamut and Labuk Highlands. At the western end it broadens out into the dissected Mananam Plain which overlies sandstones and shales of the Crocker Formation, while to the east of this it is narrowed by a ridge from the Labuk Highlands. The western part of the residency is in the main formed by the steep irregular hills of the eastern



TEXT MAP 2-1 Location of the Sandakan Residency and its administrative districts



TEXT MAP 2-2 Physiography

Prepared by the Directorate of Overseas Surveys 1976

part of the Labuk Highlands, with the highest peaks in excess of 1 300 m (4 300 ft). These hills are built of basic intrusive and extrusive and ultrabasic rocks of Eocene or Oligocene Age.

The low-lying country of the Kinabatangan Valley, the Kinabatangan Lowlands, form the central-southern part of the residency. The area is generally flat, and liable to flood in the middle and lower reaches of the Kinabatangan River, with occasional low hills and limestone outcrops. The sedimentary formations are mainly sandstones, mudstones and shales of Eocene and Quarternary age. Further east along the southern boundary are the lower reaches of the Segama Valley. The area is generally low-lying with some small hills. The Chert-Spilite Formation is found along the river valley together with more recent alluvial deposits. Eastwards the mudstones and slump breccias of the Segama Group occur with the Ayer Formation predominant.

The eastern extremity of the residency is formed by the northern part of the Dent Hills. In the south-west the land reaches a height of nearly 300 m (1 000 ft) while in the east it is lower and flatter with little relief. The rocks are sedimentary formations of Upper Miocene to Quarternary age with the Ganduman and Togopi Formations predominant.

Along the eastern seaboard are the Eastern Deltas, areas of low-lying swampy land formed by the Kinabatangan, Segama and other smaller rivers. The Sandakan Peninsula is bounded to the west by the Samawang and Garinono Rivers.

The southern part is hilly and terminates in a number of spectacular escarpments facing Sandakan Bay which are built of sandstone of the Tajong Formation and rise to a height of some 240 m (800 ft). In the north and west the country is flat or undulating.

More or less in the centre of the residency is the Lokan Peneplain which covers an area of more than 2 600 km^2 (1 000 mi^2). It is built of sandstones and mudstones of Eocene age and is dissected by the Lokan and other rivers. In the east the land is gently undulating but in the west relief is severe, with steep slopes and amplitudes up to 300 m (1 000 ft).

At the mouth of the Labuk River is a low lying swampy area, the Labuk Delta formed by the Labuk and other smaller rivers. To the north-west of the Labuk Delta between the Bongaya River and the Kaindangan Peneplain are the Bongaya Hills, an elongated ridge rising to about 180 m (600 ft). They are built of Upper Miocene sandstones of the Bongaya Formation.

On the northernmost sector of the coastline, north of the Bongaya Hills, is another low-lying swampy deltaic area, the Sugut Delta, formed by the Sugut, Kaindangan and other smaller rivers. To the west of this area lies the Kaindangan Peneplain, which can be recognised as such by the accordance of the ridge tops. The area, the greater part of which falls in the residency, is composed of sandstone and shale of the Crocker Formation of Eocene age and has been deeply dissected by various rivers including the Kaindangan. On the western boundary of the residency the land rises to between 300 and 600 m (1 000 and 2 000 ft) and from here it slopes south-eastwards.

To the south-west of the Kaindangan Peneplain on the western boundary of the residency is an area of rugged mountainous country which forms part of the Crocker Range. The rocks are sedimentary formations, mainly sandstone of Eocene age with peaks exceeding 900 m (3 000 ft).

Jambongan Island at the northern tip of the residency is part of the Bengkoka Lowlands. It is formed of sandstones and shales of the Bongaya Formation with alluvial deposits along the coast. The terrain is generally flat or undulating.

CLIMATE

The climate of the residency may be generally described as hot and wet. The mean daily maximum temperature is approximately 32°C (90°F) and the mean daily minimum about 22°C (72°F) with an average of 27°C (81°F). The mean annual rainfall is about 3 120 mm (123 in).

It is considered that the climate throughout the residency may be classified as the Tropical Rainy Climate (Af) according to Koppen's system (Trewartha, 1954).

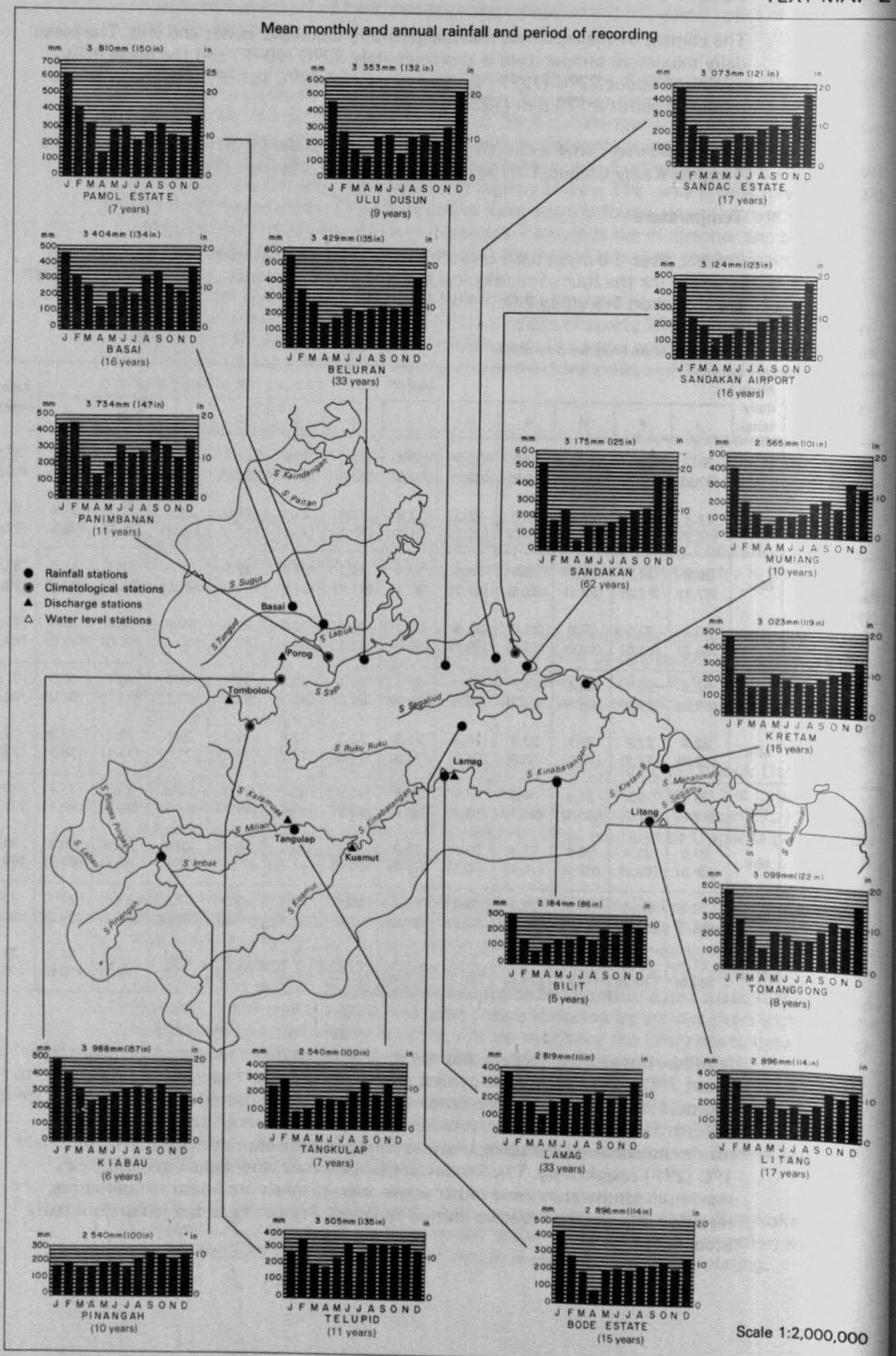
Temperature

Table 1 gives the mean daily maximum and minimum temperatures monthly and annually for the four climatological stations in the residency, the locations of which are shown on Text Map 2-3.

TABLE 1 Mean daily temperatures in °C (°F)

Station	Mean daily temp.	Month												Annual average
		J	F	M	A	M	J	J	A	S	O	N	D	
Kiabau (1964-68)	Max.	30.7 (87.2)	30.2 (86.4)	31.6 (88.8)	33.8 (92.8)	33.9 (93.1)	33.8 (92.8)	33.5 (92.3)	33.6 (92.5)	33.3 (92.0)	32.9 (91.2)	32.4 (90.3)	31.3 (88.3)	32.5 (90.5)
	Min.	21.1 (69.9)	21.0 (69.8)	21.8 (71.2)	22.2 (72.0)	22.3 (72.2)	21.8 (71.2)	21.4 (70.5)	21.4 (70.5)	21.6 (70.8)	21.3 (70.3)	21.7 (71.0)	21.4 (70.6)	21.7 (71.0)
Panimbanan (1964-73)	Max.	30.6 (87.1)	30.7 (87.3)	31.7 (89.1)	33.5 (92.3)	34.0 (93.2)	33.4 (92.1)	33.2 (91.7)	33.1 (91.5)	32.8 (91.0)	32.8 (91.0)	32.1 (89.8)	31.9 (88.4)	32.4 (90.4)
	Min.	20.2 (68.3)	20.3 (68.6)	20.6 (69.0)	21.2 (70.0)	21.4 (70.6)	21.1 (69.9)	20.8 (69.4)	20.6 (69.1)	20.9 (69.6)	20.9 (69.6)	20.8 (69.5)	20.6 (69.0)	20.8 (69.4)
Sandakan (1964-73) (incomplete)	Max.	29.3 (84.8)	29.7 (85.5)	30.4 (86.7)	31.5 (88.7)	32.4 (90.4)	32.1 (89.8)	32.1 (89.8)	32.2 (89.9)	32.1 (89.8)	31.5 (88.7)	30.7 (87.2)	30.0 (86.0)	31.2 (88.1)
	Min.	22.6 (72.7)	22.9 (73.2)	23.1 (73.5)	23.2 (73.8)	23.3 (74.0)	22.9 (73.3)	22.7 (72.8)	22.6 (72.7)	22.9 (73.2)	22.8 (73.1)	22.8 (73.1)	23.2 (73.7)	22.9 (73.3)
Telupid (1964-73)	Max.	30.9 (87.7)	30.9 (87.7)	32.4 (90.3)	34.3 (93.7)	34.3 (93.8)	33.8 (92.9)	33.6 (92.5)	33.6 (92.4)	33.3 (92.0)	32.9 (91.3)	32.3 (90.2)	31.7 (89.1)	32.8 (91.1)
	Min.	20.6 (69.0)	20.7 (69.3)	20.8 (69.5)	21.3 (70.4)	21.2 (70.1)	20.9 (69.7)	20.2 (68.4)	20.3 (68.6)	20.4 (68.8)	20.4 (68.8)	20.6 (69.1)	20.6 (69.1)	20.7 (69.2)
Mean for the 4 stations	Max.	30.4 (86.7)	30.4 (86.7)	31.5 (88.7)	33.3 (91.9)	33.7 (92.6)	33.3 (91.9)	33.1 (91.6)	33.1 (91.6)	32.9 (91.2)	32.6 (90.6)	31.9 (89.4)	31.1 (88.0)	32.3 (90.1)
	Min.	21.1 (69.9)	21.2 (70.2)	21.6 (70.8)	22.0 (71.6)	22.1 (71.7)	21.7 (71.0)	21.3 (70.3)	21.2 (70.2)	21.4 (70.6)	21.4 (70.5)	21.5 (70.7)	21.4 (70.6)	21.4 (70.6)

It will be noted from Table 1 that the diurnal variation in temperature ranges from about 7°C (12°F) during the coolest months of the year (January and February) to about 11°C (20°F) during the hottest months, with an overall average of about 10°C (18°F). The diurnal variation is much greater than the annual variation in mean maximum and minimum temperatures which average approximately 3°C (6°F) and 1°C (2°F) respectively. The Sandakan figures show rather below average mean maximum temperatures and rather above average mean minimum temperatures, resulting in a less than average diurnal variation. Proximity to the sea undoubtedly accounts for this.



TEXT MAP 2-3 Selected rainfall, climatological and hydrometric stations

Figures for extreme maximum temperatures show that temperatures in the region of 35°C (95°F) are not uncommon and occasionally will reach nearly 38°C (100°F). At the other end of the scale extreme minimum temperatures of about 18°C (65°F) are quite often recorded and very occasionally temperatures as low as 16°C (60°F).

Rainfall

The histograms of rainfall at the various recording stations depicted on Text Map 2-3 show that rainfall is not evenly distributed throughout the year. October to February, when the north-east monsoon is usually blowing, is the wettest period in the year, with the heaviest rainfall usually in January. On average and at nearly all stations, April is the driest month. The south-west monsoon which usually occurs from May to August does not normally bring especially wet weather.

While the average annual rainfall is about 3 120 mm (123 in), there is considerable variation between recording stations, from about 2 184 mm (86 in) at Bilit on the Kinabatangan to over 3 988 mm (157 in) at Kiabau on the Labuk River. It may be noted that all recording stations in the Labuk Valley show a higher rainfall than the average for the residency. It is thought that the reason for this may be that the valley acts as a sort of funnel into which rain and rain-clouds tend to be drawn. An important factor is that by its geographical position it receives the full force of the north-east monsoon which will blow more or less up the valley. On the other hand the stations in the Kinabatangan Valley and flood plain show a lower than average rainfall. The reason for this may well be that the area escapes the full force of the monsoon rains. It is of some interest to note that the most westerly recording station at Pinangah, in the centre of Sabah, shows a rather different rainfall pattern from the other stations in the residency. Here the wettest period of the year is August to December, with January one of the driest months.

VEGETATION

The natural climax vegetation is tropical rainforest and much of this is lowland dipterocarp forest. Within the lowland dipterocarp forest different forest types can be recognised and by far the most important of these in the Sandakan Residency is the *Parashorea tomentella/Eusideroxylon zwageri* type, (Fox, 1972). This, with minor variations covers the greater part of the residency, the main exceptions being the mountainous land in the south-west, in the Gunong Rara Forest Reserve, and the hills formed of igneous rocks in the Labuk Valley. In this type some 20% of the larger trees, (i.e. those with a girth of 6 ft or more), belong to the genus *Parashorea* with *P. tomentella* much the most common species. *Eusideroxylon zwageri* is present in the main storey though its abundance varies considerably. Principal associates are *Shorea leptoclados, Dryobalanops lanceolata* and *Dipterocarpus caudiferus.* These three species together with *Parashorea* generally account for 40% or more of the larger trees. Other species of *Rubroshorea* are present and the other three groups of *Shorea* are also represented. On the more hilly land *selangan batu* and species of the Richetia section of *Shorea* become more common while species of the Anthoshorea section are generally scarce. This type of forest is a very important component of the permanent forest estate. The *Parashorea malaanonan/Dryobalanops lanceolata* forest type (Fox, 1972) occurs in the foothills of the mountainous area in the south-west and on the hills formed by ultrabasic rocks in the Labuk Valley. The main associates of the two named species are various species of the Rubroshorea section of *Shorea.* On the steeper and higher land in these areas this type gives way to *selangan batu* forest in which *Parashorea malaanonan* and *Dryobalanops lanceolata* are scarce and species of *selangan batu* more common.

Apart from the lowland dipterocarp forest the other main forest types are tidal mangrove forests along the coast and freshwater swamp forest. In the mangrove forests the most important species are *Rhizophora mucronata* and *R. apiculata* while other species present include *Ceriops tagal, Sonneratia alba, Excoecaria agallocha* and various species of *Lumnitzera, Bruguiera* and *Avicennia.* The swamp forests are often characterised by the presence of *Myristicaceae* (Fox, 1972) while other species which locally form important constituents are, *Alstonia spathulata, Nauclea* spp., *Terminalia copelandii, Campnosperma coriacea* and *Lophopetalum multinervium.*

Secondary forest following shifting cultivation occurs mainly in the western and north-western parts of the residency while montane forest is found on some of the higher land in the west and south-west but is not extensive.

On sandstone hills and escarpments, particularly in the Sandakan area, heath or *kerangas* forest occurs. In this forest the canopy is generally low and the trees small to medium in size. Various species of *Eugenia* are common and some Dipterocarps are present. *Tristania clementis* occurs in pure stands as a low tree of small girth.

At present some 97% of the land area is still covered by forest, though of this some 12.6% has been disturbed by exploitation. The remaining land is mainly used for agriculture, with oil palm and rubber the most important crops.

SETTLEMENT AND POPULATION

The settlement and distribution of the population in the Sandakan Residency is reflected in the high proportion of the land area still covered by forest. With an average population density of 4.1 persons per km^2 (10.5 per mi^2) it is not surprising that there are very large areas without human habitation.

There is only one town in the whole residency and that is Sandakan. With a population of over 42 000 at the 1970 census (Sabah, Malaysia, Dept of Statistics, 1973) it is the largest town in the state. The town and the country immediately surrounding it has been the main centre of settlement for the non-indigenous population, in particular the large Chinese community. The town and district of Sandakan has also been a centre of settlement for a relatively large indigenous population. To date agricultural development and associated settlement has been concentrated in the Sandakan District and more especially in the Sandakan Peninsula as far as the forest reserve boundary at mile 39 on the Labuk Road.

Outside the Sandakan District the indigenous population is found mainly in relatively small villages scattered along the major rivers, in particular the Kinabatangan and its upper reaches, the Milian, and the Labuk and Sugut. Here the people practise shifting subsistence agriculture with the result that many of the settlements move periodically, though some of the larger ones are permanent and have schools, medical facilities, etc. The development of the timber industry in recent years has provided opportunities for more permanent employment for the inhabitants of these villages. Other small indigenous communities occur round the coast, particularly in the Labuk Bay area where the people obtain a livelihood from fishing.

Mixed communities have grown up round the larger timber camps most of which are situated on major rivers, especially the Kinabatangan. Such communities are not however permanent and as the timber is worked out so the camps and associated communities will move elsewhere.

Major agricultural development in the Lower Labuk area has given rise to considerable permanent settlement, likewise to a lesser extent on the Lower Segama.

The centres for Government administration outside Sandakan are Bukit Garam on the Kinabatangan River and Beluran at the mouth of the Labuk River. The population of both places is relatively small and there has been little associated settlement.

The population of the residency according to the 1970 census was 113 791. Table 2 gives a breakdown of this population by districts and major community groups.

It can be seen from Table 2 that though the total population is almost equally divided between indigenous and non-indigenous groups this does not apply within the individual districts. In the Sandakan District only 31.8% of the population is indigenous while 51.0% belongs to the Chinese community group and of that group 55% are Hakka. In the town of Sandakan the predominance of non-indigenous groups, in particular the Chinese, is even more pronounced; with the latter accounting for 64.5% of the population. In the Kinabatangan, and Labuk and Sugut Districts indigenous groups form respectively 85.3% and 77.8% of the population.

TABLE 2 Population by districts and community groups

Community group	Districts			Residency	
	Sandakan	Kinabatangan	Labuk & Sugut	Total	%
Kadazan	2 852	462	8 379	11 693	10.3
Bajau	2 900	55	1 448	4 403	3.9
Malay	3 159	12	1 194	4 365	3.8
Tambunuo	55	2	3 789	3 846	3.4
Suluk	4 933	297	593	5 823	5.1
Orang Sungei	3 567	8 324	2 385	14 276	12.5
Brunei	2 763	43	538	3 344	2.9
Tidong	1 091	7	1 511	2 609	2.3
Other indigenous	1 869	2 893	1 025	5 787	5.1
Total indigenous	23 189	12 095	20 862	56 146	49.3
Chinese	37 147	402	992	38 541	33.9
Indonesian	6 226	1 061	2 126	9 413	8.3
Filipino	4 060	255	1 040	5 355	4.7
Others	2 206	364	1 766	4 336	3.8
Total	72 828	14 177	26 786	113 791	100.0

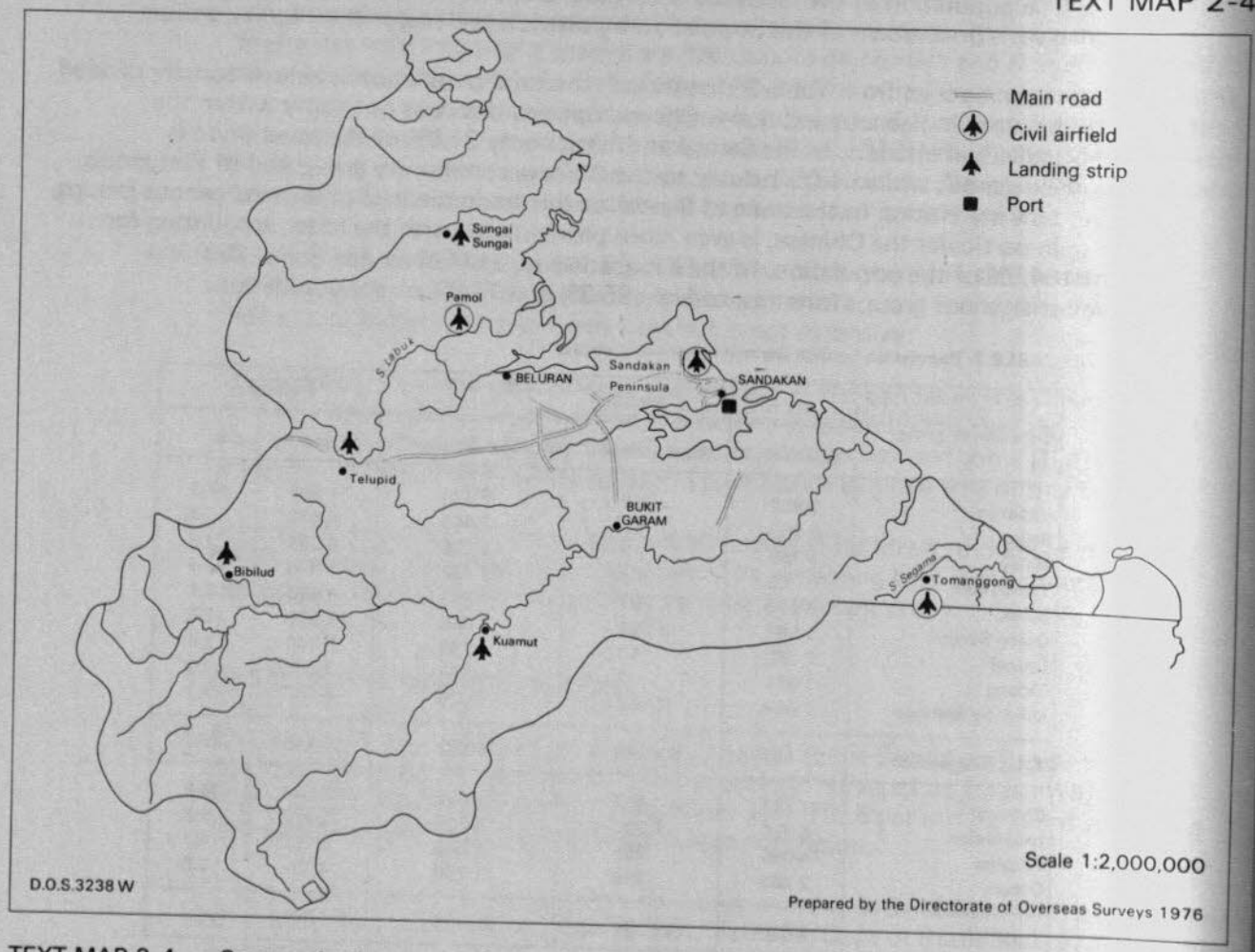
The Orang Sungei and Kadazan are the two most important indigenous community groups. The former account for 12.5% of the total population and 58.7% of the Kinabatangan District, while the latter make up 10.3% of total population and 31.3% in the Labuk and Sugut District. Of the non-indigenous groups other than Chinese the Indonesians are most numerous accounting for 8.3% of total population.

COMMUNICATIONS

The major features of the communications system are shown in Text Map 2-4. The road network is not extensive and internal communication depends very much on water transport. Air, sea and land transport provide external links.

Road

There are an estimated 365 km (228 mi) of all-weather trunk-roads maintained by the Public Works Department. These link Sandakan with the administrative centres of Bukit Garam and Beluran and with the Interior and West Coast Residencies via the East-West Highway. There are other publicly maintained roads which provide access to the agricultural development areas in the Sandakan Peninsula. There are also a number of road networks built and maintained by timber companies for the purpose of log extraction. However, most of these networks are isolated and do not link up with the public road system, and thus are of little use for the purpose of communication. Considerable stretches of the East-West Highway are sealed but all other roads except those in and around Sandakan Town are only gravelled.



TEXT MAP 2-4 Communications

Water

Because of the lack of a suitable road network the sea, inland waterways and rivers play an important part in internal communications. Water communications are vital to the timber industry as floating is the easiest and cheapest method of moving timber. All logs shipped from Sandakan reach the port by water.

Sandakan is the only deep water port with wharf facilities in the residency. These are at present somewhat limited but will be much improved when the new port, at present under construction, is completed. Sandakan Harbour, where logs are loaded onto ocean-going freighters, can provide a safe and secure anchorage for many ships.

There is a regular general shipping service from Sandakan to Singapore and Port Klang in Peninsula Malaysia. Timber carriers regularly sail to Japan, Korea, Taiwan and other places. Smaller boats transport goods round the coast and supply timber camps and estates. There are bulk fuel oil and palm oil terminals at Sandakan for the discharge and loading of oil.

Air

From Sandakan airport there are regular air services to other towns in the State, also to Tomanggong Estate on the Segama River and Pamol Estate on the Labuk River using small aircraft. Helicopters and small fixed wing aircraft are available on charter at

Sandakan. There is an airstrip at Telupid suitable for light aircraft. There are similar airstrips at Kuamut and Bibilud on the Kinabatangan (Folland and Acres, 1972), and Sungai-Sungai on the Sugut, but these were at the time of writing (1974) unserviceable.

ECONOMY

The economy is based on timber and agriculture in that order of importance with an expanding export trade in both. There is a healthy external trade surplus as shown by the 1973 import and export figures (Dept of Statistics, 1974) for Sandakan port given below:

Imports $M232.4 million
Exports $M380.6 million
Balance + $M148.2 million

Table 3 gives the volume and value of the main export commodities in 1973.

TABLE 3 Exports 1973, Sandakan Residency

Commodity	Weight or volume	Value $M million	Percentage of total export value	
Timber (logs and sawn)	2 300 000 tons	322.58	84.8	
Plywood	38 267 500 ft^2	6.02	1.6	87.1
Veneer	7 112 600 ft^2	2.79	0.7	
Palm oil	32 400 tons	17.65	4.6	
Palm kernels	5 600 tons	2.05	0.5	
Rubber	920 tons	1.42	0.4	5.7
Copra	580 tons	.40	0.1	
Cocoa beans	246 400 lb	.25	0.1	
Prawns	1 650 tons	14.34	3.8	7.2
Others	-	13.11	3.4	
Total	-	380.61	100.0	

Timber

The paramount importance of timber in the economy of the residency is emphasised by the figures given in Table 3. The log and sawn timber exports from Sandakan are about 40% of the total for the state while exports of plywood and veneer are 100% and 80% respectively. The main areas of timber exploitation are the Kinabatangan Lowlands and the Lokan Peneplain. The greater part of the timber exported is shipped from Sandakan, making it the most important timber-exporting port in the State.

Agriculture

The agricultural sector plays a relatively small but increasing part in the external trade economy. However, in the internal economy it has a more important role in providing employment and a means of livelihood for a large part of the population. As Table 3 shows, oil palm is by far the most important crop with rubber, coconuts and cocoa the only other significant crops. Oil palm is mainly grown on large private estates and Government settlement schemes, while rubber and coconuts are generally grown on small to medium sized holdings. Cocoa is a relatively new crop and cultivation is at present limited. In the western and north-western parts of the residency there is shifting cultivation based on rice, tapioca and maize. Although many people are involved this cultivation plays little or no part in the cash economy.

Fisheries

The prawn industry contributes quite considerably to the external trade economy, (Table 3). In addition the fishing industry as a whole plays a prominent role in the internal economy by supplying a major source of food.

Industry

The only industries which make any significant contribution to the external economy are those concerned with the processing of timber and agricultural produce. Industries in this sector are small at present but are fast expanding and becoming more important, and it is expected that they will play an increasing role in the economy in the future.

In 1972 32 small to medium sized sawmills produced an estimated 1.7 million ft^3 of sawn timber (based on Dept of Statistics, 1973) most of which was used to meet local requirements. In 1973 there were two plywood mills and one veneer mill in operation and production amounted to about 38.3 million ft^2 of plywood and 7.2 million yd^2 of veneer (Dept of Statistics, 1974), most of which was exported.

In 1973 a factory was opened on Berhala Island for the production of wood chips from mangrove forest species for export to Japan. Production amounted to some 10 400 t in 1973 and 107 900 t in 1974.

At the time of wiring (1974) there were four large palm-oil processing mills in operation with another two under construction. Bulk storage facilities and a loading terminal have been established at Sandakan.

Part 3

Survey and classification of resources

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

Survey and classification of specific resources

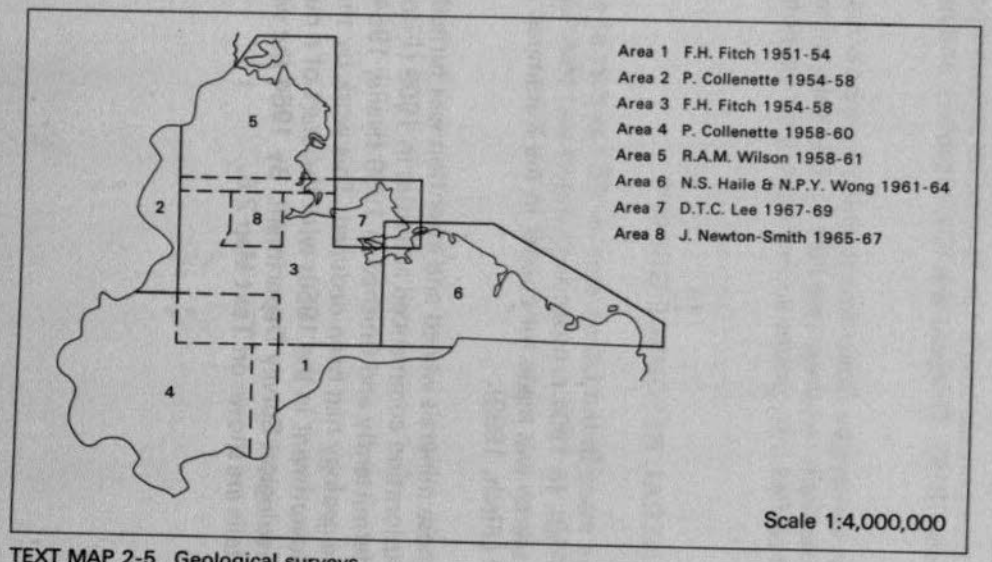
Even though there had been some exploration in the early part of the 19th century, the first known resource investigations did not commence until the 1880s. These were undertaken by mineral prospectors who worked over a number of areas (Fitch 1958, Collenette 1958, Wilson 1961, Haile 1964). The second decade of the 20th century saw the advent of oil exploration and the start of geological surveys. The government initiated a system of land classification at the same time, the ultimate aim of which was to produce a map for the State at 2 miles to 1 inch (1: 31 680) on which 'all areas of valuable forest are shown thereon as well as areas which can at once be thrown open for agriculture' (State of North Borneo, 1919). This goal was never reached, and no records have survived.

The 1950s saw the start of systematic surveys by Government which have now made it possible to compile an inventory of the main resources (see Part 4). Of these, minerals, soil and forest resources have been classified into groups according to their economic importance.

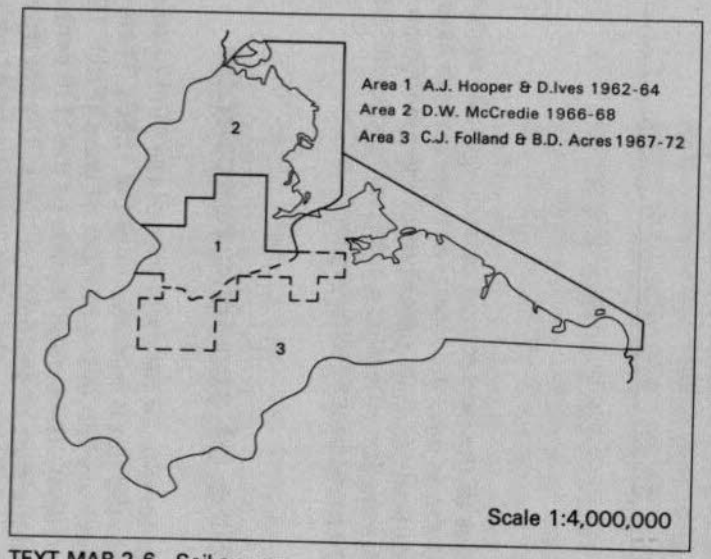
GEOLOGICAL SURVEYS AND MINERAL RESOURCE GROUPS

The first geological observations were made in the Labuk area in 1881 as part of a search for antimony (Tregonning, 1958). In 1904 prospecting interest was transferred to diamonds, again in the Labuk. A search was made for copper in the Karamuak Valley during the period 1908-1912 (Fitch, 1958).

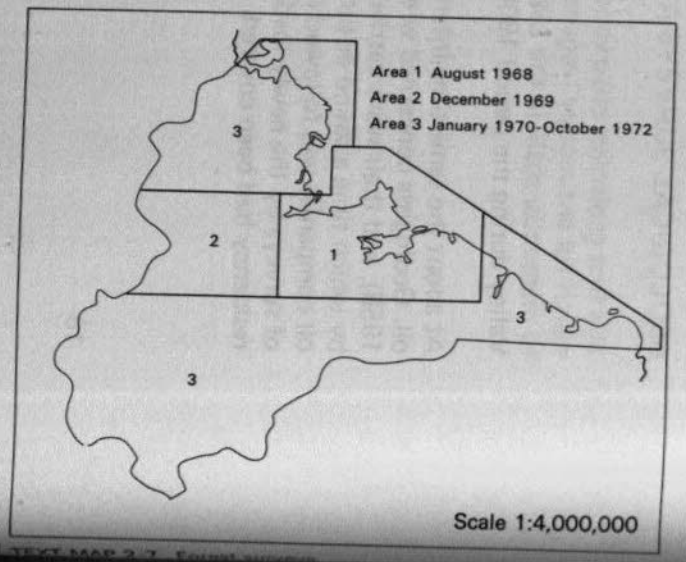
At about the same time interest in these minerals waned and attention was turned to oil. Geologists concerned with oil exploration commenced activities in 1909 (Fitch, 1958), and their work carried on intermittently and finished in 1959 (Haile, 1964), by which time a sound outline of the geology had been deduced. This work by the oil companies was followed up by Government in the 1950s with the start of a number of surveys by the newly instituted Geological Survey Department. By 1964 the whole residency had been covered. The details are shown on Text Map 2-5.

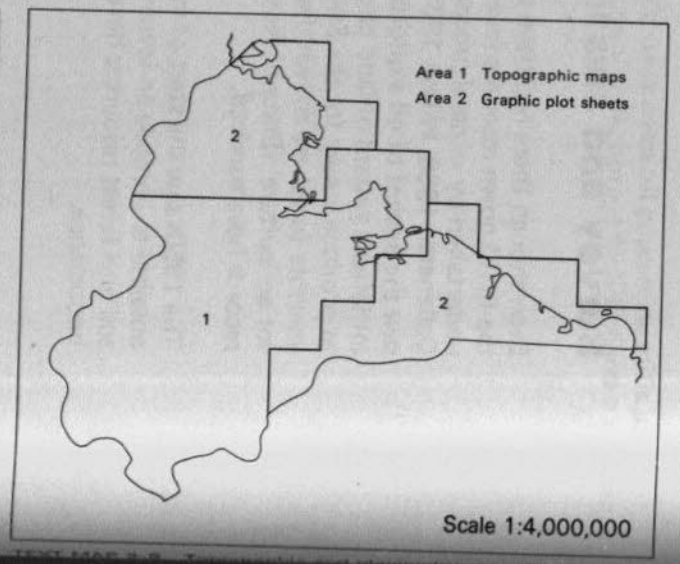


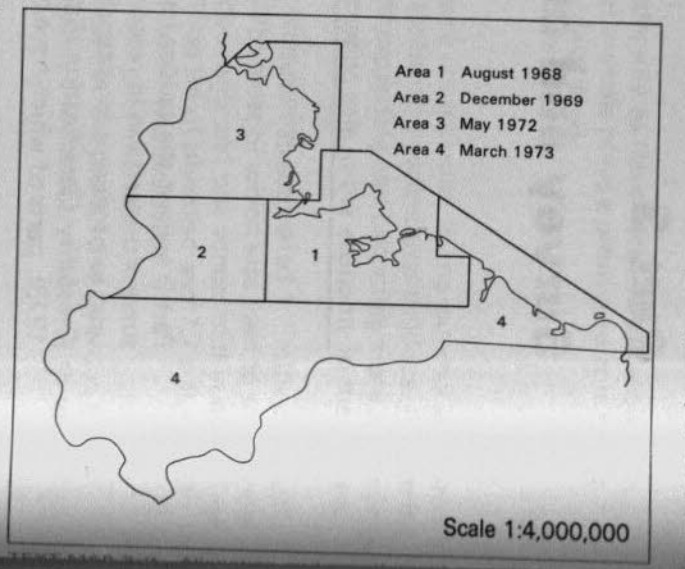
TEXT MAP 2-5 Geological surveys



TEXT MAP 2-6 Soil surveys







TEXT MAPS 2-5, 2-6, 2-7, 2-8 & 2-9

During these surveys special account was made of the mineral deposits, and this information has provided the basis for determining the location, extent and value of geological resources and their classification. Special emphasis in the classification has been given to the occurrence of metalliferous deposits which are workable on an open-cast system of mining, i.e. those which may have an appreciable long-term effect on land use and thereby its 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 might occur**

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

Group 1 land does not occur in the residency. The mineral resource groups are shown on 1:50 000 scale maps produced by the Sabah Geological Survey Department. These maps also give the location of current and potential quarry sites for engineering materials information which is of value for road planning and construction.

SOIL SURVEYS AND SOIL SUITABILITY (FOR AGRICULTURE) GROUPS

The importance of identifying land for agricultural purposes was recognised at a relatively early date. The Forst Department in its *Annual Report for 1917* (State of North Borneo, 1918) stated '..... for the examination of wild lands it is suggested that it might be desirable to extend our activities to include the preparation of reports on the agricultural value of lands examined. This would naturally lead to the collection of data sufficient to permit of the preparation of agricultural prospectuses which would be of use in attracting investment.' During the same year the Forest Department investigated the Dent Peninsula as part of the land classification and reported (State of North Borneo, 1918) '..... that there is close to 100 000 ac of land suited for coconuts and rice between the Sibat and Tambisan within 10 miles of the coast.' In the following years a number of other areas were investigated, but the records have not survived.

No systematic pedological work was undertaken before 1957 when the Department of Agriculture commenced the soil survey of the Sandakan Peninsula and the Labuk; the results of which were incorporated in the UN Labuk Valley Survey which started in 1962. Surveys were later extended over the remaining parts of the residency, culminating with the survey of the Sandakan and Kinabatangan Districts by Acres and Folland and resulting in complete coverage by 1972 (Text Map 2-6).

It should be noted that the final results of the survey of Acres and Folland are given in Volume 2 of the companion *Land Resource Study 20 The soils of Sabah.* (Acres and Folland, 1975). This survey, in common with the others, produced soil maps at the scale of 1: 50 000. These were not, however, published with the report; the scale of the soil maps in this case being 1: 250 000.

These surveys 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 employ five soil groups according to limitations to agricultural use associated with various soil characteristics as defined in *Land Capability Classification* (Sabah, Malaysia, State Development Planning Committee, 1973). 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.

The five soil suitability groups* recognised in this report are as follows:

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°. 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 for a significant proportion of the year within 120 cm (48 in) of the surface, 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 to 15° 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 Group 1 soils. (See Plate 2-1 and 2-2).

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° range, soils on deposits of peat varying in depth from 50 cm (20 in) to 120 cm (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. This group also includes alluvial soils subject to proven regular river floods, and unless the flooding is controlled they cannot be recommended for agricultural development.

To thrive generally on this group of soils, crops must be specifically adapted to the adverse soil conditions. The group is therefore unsuited to 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 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, also very poorly drained soils which because of their especially low-lying nature on main river flood plains receive the maximum effect of floods, 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 agricultural enterprise, even with a high standard of management.

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 rock, soils with toxic levels of certain elements, and peat soils deeper than 120 cm (48 in). Agriculture on such soils would generally be prohibitive, but they have a wide range of capability for forestry, hydrological or wildlife and conservation purposes.

*Note that 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 Group 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.

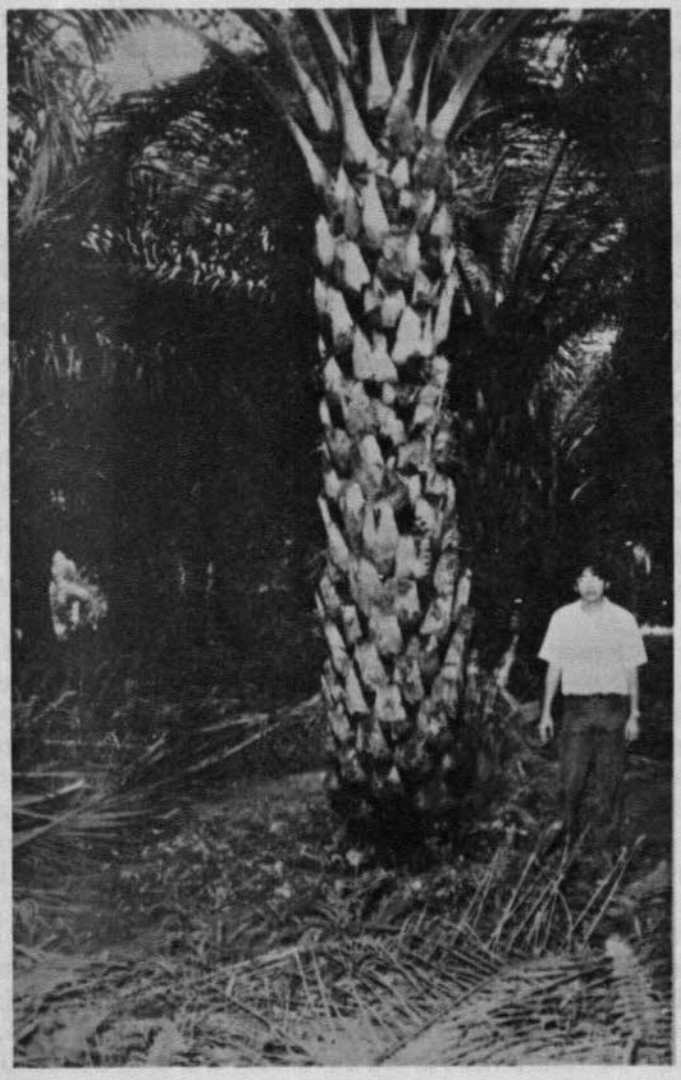


PLATE 2.1

Good oil palm growth on Group 2 soils. Oil Palm Research Station, Ulu Dusun

PLATE 2.2 Rubber grown successfully on Group 2 soils, Sandakan Peninsula

NATURAL VEGETATION AND TIMBER RESOURCE GROUPS

The earliest known forest surveys in the residency were undertaken in 1917, when 7 300 ha (18 000 ac)south of Beluran were covered (State of North Borneo, 1918), and also the Sapagaya Valley (State of North Borneo, 1919). By 1922 it was reported that 260 977 ha (645 025 ac) had been examined in various parts of the State in conjunction with the land classification (State of North Borneo, 1923). The Elopura Forest Reserve Working Plan was produced in 1940, and was the first of its kind (Colony of North Borneo, 1950).

Full records of these investigations are no longer available, but it would probably be safe to state that they were broad and cursory, and in 1949 their deficiency in sustaining an expanding timber industry was recognised in the Forest Department Annual Report (Colony of North Borneo, 1950) '..... the lack of topographical surveys and forest inventories have acted as a deterrent to most inquirers.' The first enumeration for forest inventory was undertaken in the Koyah area in 1951, and tests were made on timber volumes from aerial photographs (Colony of North Borneo, 1952). This marked the start of large-scale investigations of the forest resource. Much of this work was undertaken by a number of concessionaires and was therefore essentially *ad hoc*. Some areas were specially photographed from the air for the purpose. The results were not made available for general use. Meanwhile the Forest Department continued to survey in certain areas ear-marked for logging and, again, this work was essentially *ad hoc*.

1968 saw the start of a methodical survey of the resources by the Forest Department. These were based on aerial photographs taken largely in 1962, and the results depicted on 1:50 000 scale maps. By the end of 1969 the Sandakan and Labuk areas were mapped and these maps provide the data on forest resources for those areas in this report. During the period 1970-72 the whole of the residency was, as part of a state-wide coverage, subjected to an aerial photographic survey and forest inventory; and the results, again on 1:50 000 scale maps, have provided the basis of the data used for the remaining part of the residency. The various survey areas are shown in Text Map 2-7.

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 as are the terrain and drainage conditions of the land, factors important for timber extraction. 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, thus including commercial aspects. 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 (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/ha of timber (1 000 Hft^3/ac).

Timber Resource Group 2

These forests contain either fewer trees with large crowns or trees with medium-sized crowns which are close together. If composed of large crowns they form between 30 and 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 of the order of 62-89 m^3/ha of timber (700 - 1 000 Hft^3/ac).

Timber Resource Group 3

Forest areas included 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 between 30 and 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/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 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 fall into 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

Group 8 includes 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

Even though the first rainfall station, at Sandakan, was set up as early as 1879, it was not until the 1960s that hydrological investigations started in earnest (Sabah, Malaysia, Department of Drainage and Irrigation, 1970). By this time rainfall was being recorded at various points, mainly in the eastern half of the residency, and riverwater records at 7 stations. The location of the various hydrometric stations is shown in Text Map 2-3.

An investigation was made in 1967 into the development of the groundwater resources of the Sandakan Town area (Binnie and Partners, 1967), but no figure was arrived at regarding the reserves available. No overall hydrological study has been undertaken, and the present sum-knowledge of the water resources lies in the data from the various hydrometric stations. Thus, owing to the scarcity of the hydrological information it has not been possible to produce water resource maps for the residency. Information on the water resources is restricted to the account given in Part 4 of this report.

TOPOGRAPHY AND PLANIMETRY

The first systematic planimetric mapping was undertaken in the early 1960s, and compilation plots of quarter degree sheets, covering part of the Sandakan Peninsula, were published at the scale of 1:50 000, in 1962. In the following year preliminary plots were published covering the area to the south, i.e. the Dent, Segama and Lower Kinabatangan areas. The first topographic maps were published in 1964, and by 1965 the Sandakan Peninsula and the south-western part had been completed. The first planimetric maps for the remaining northern part were published as late as 1972-3 in the form of graphic plot sheets, and during the same period this map series was extended to include the areas covered by the 1963 preliminary plot sheets.

Text Map 2 -8 shows the areas covered by the topographic maps and the graphic plots. These together with the preliminary plot sheets have, depending on the date of survey, been used as the basis for the land capability and resource 1:50 000 scale mapping.

LAND TENURE

The first recorded title to land was made in 1883, for Dumondong Estate in Sandakan Bay, and a number of areas were alienated for agricultural purposes in the following years. The records were maintained at the Land Registry Office in Sandakan. This office was also responsible for gazetting land for specific government uses and the first reserve, a stone-quarry, was established in 1920. Various other types of reserves were registered during the 1920s e.g. a water supply protection reserve in 1929, and in 1930 the first forest reserve, on Berhala Island.

After the last war the records were transferred and maintained at the Lands and Surveys Department headquarters. The task of systematically transferring the information onto standard 1:50 000 scale maps started in 1968 and work continued intermittently until completion in 1973. This is shown in Text Map 2-9. The various forms of alienation and gazettement depicted on these maps are given in Table 4.

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; also game reserves and national parks*
Government reserve	Land allocated as state, airport, cemetery, educational, military*, police station, quarry, tamu-ground, agricultural, veterinary, bird sanctuary and water supply reserves
Stateland	Land not allocated for government or private use
*Do not occur in Sandakan Residency	

GAME AND RECREATIONAL RESOURCES

Even though the first collecting of animals was undertaken as early as 1881 (Davis, 1962), there has been no formal survey of the game resource of the residency.

The first important collection of mammals was made during 1927-8 west of Sandakan Town (Davis, 1962). Zoological expeditions were also made in 1929, in the same area, and in 1950 at Bukit Kretam and the vicinity of the Sapagaya River, and at Deramakot on the Kinabatabgan River in 1956 (Davis, 1962). The orang-utan (*Pongo pygmaeus)*

was studied at a number of places, particularly the Lokan, between 1963-9. In 1964 the newly constituted Game Branch of the Forest Department started research on the animal life. This has been largely centred on the turtles of Labuk Bay (de Silva, 1969) and the rehabilitation of captive orang-utan. Observations have also been made on the elephant *(Elephas maximus)* (de Silva, 1968).

Again, there has been no overall survey of the recreational resources. The information available is restricted to the account contained in the *Land Capability Classification Report* for the Sandakan District (Sabah, Malaysia, *Technical Sub-Committee on Land Capability Classification,* 1969). The relatively little knowledge available on the recreational land aspects for the residency is contained in Part 4 of 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 (Siew, 1973), and maps drawn to the scale of 1:25 000, 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 cultivations**

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, that of the *Land Capability Classification* (Sabah, Malaysia, State Development Planning Committee, 1973), is based on 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

PLATE 2.3 Oil palm and rubber cultivation on Class II land, Sandakan Peninsula

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 1 land in the residency possesses a mining potential only and that agricultural and forestry prospects on such land are low.

The land capability classes are defined thus:

Class I	**Land with a high potential for mineral development and therefore best suited for mining**
Class II	**Land with a high potential for agriculture with a wide range of crops and therefore best suited for a diversified form of agriculture.**
Class III	**Land possessing a moderate potential for agriculture with a restricted range of crops and therefore best suited for a limited variety of crops with a high level of tolerance to a range of soil conditions**
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 exploitation and generally best suited for conservation or recreational purposes**

LAND EXPLOITATION UNITS

Any one area of land may have one or more resource which may be economically exploitable. It follows, therefore, that on a 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 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 class connotation followed by a suffix indicating the assigned unit. The following land exploitation units are recognised:

Unit IA	**Land possessing a high potential for mineral development and therefore best suited for mining**
Unit IIA	**High potential for agriculture only**
Unit IIB	**High potential for agriculture and timber exploitation**

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 IIE	**High potential for both agriculture and timber exploitation and also a possible mining potential**
Unit IIF	**High potential for agriculture, a marginal potential for timber exploitation and also a possible mining potential**
Unit IIIA	**Moderate potential for agriculture only**
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 IIIE	**Moderate potential for agriculture, a high potential for timber exploitation, 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 IVD	**Marginal 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**

These units are recognised in order to provide a framework for development 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 which may occur in the economic or social structure.

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
	IIB	4	1-2	1-2
	IIC	4	1-2	3
	IID	3	1-2	4-6, 8
	IIE	3	1-2	1-2
	IIF	3	1-2	3
III	IIIA	4	3	4-6, 8
	IIIB	4	3	1-2
	IIIC	4	3	3
	IIID	3	3	4-6, 8
	IIIE	3	3	1-2
	IIIF	3	3	3
IV	IVA	4	4-5	1-2
	IVB	4	4-5	3
	IVC	3	4-5	1-2
	IVD	3	4-5	3
	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.

CARTOGRAPHY, AREA MEASUREMENT AND DATA TABULATION

Using the 1:50 000 scale topographic, graphic plots, or planimetric maps as a base, the information obtained from the surveys was 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 classification maps were 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 classification 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 have been 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 the purpose.

All area measurement was made in acres on the 1:50 000 scale maps by using dot-counting planimeters. Translucent copies of the present land use maps were superimposed on the land capability classification 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.

Part 4

The resources and their distribution

The residency has a very considerable potential for the development of its land resources. The separate land capability classification map and Tables 63a and 63b show that there are large areas suitable for timber production and extensive tracts of land suited for agriculture. Water resources hold a special position in the residency. All the information available to date points to the fact that the hydrological status of the main river systems is critical with an excess of runoff resulting in intensive floods severely limiting settlement on the plains, while away from the main valleys the water-catchments are too small to provide all-season supplies of water. It will also be seen from the following account that further mineral prospecting may identify significant mineral deposits which could result in mining becoming an important industry. A number of areas are broadly identified as having a potential for recreation and conservation purposes.

An account, in generalised terms, of the types, extent and location of the various resources is given below.

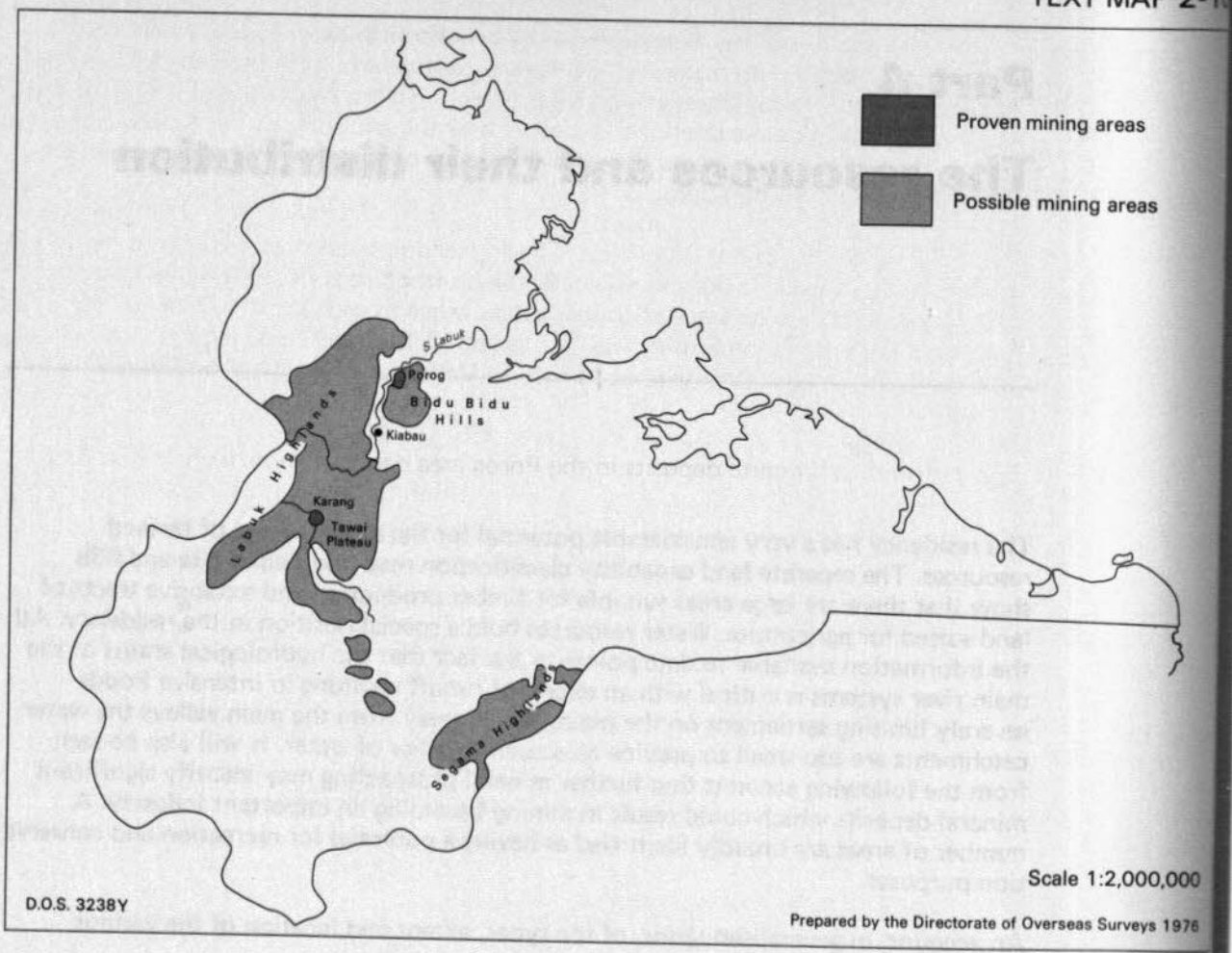
Mineral resources

Geological conditions favourable to the occurrence of a number of economic minerals are present intermittently over a widespread arc stretching from the Segama Highlands in the south through the Labuk Highlands to the mouth of the Labuk River. Mineralisation is associated with the igneous rocks, but the occurrences so far discovered are not considered worthy of mining at present. The reason for this is the number of limiting factors, of which small tonnage, market prices, low-grade, the need for costly processing, and remoteness, are the main ones. The areas where mineralisation has been proven and considered likely are shown in Text Map 2-10.

It may be seen in Tables 63a and 63b that land proven for mining (Land Capability Class I) occupies a relatively small area, but extensive areas, (234 866 ha, 580 364 ac, the sum of land exploitation units IID, E, F, IIID, E, F, IVC, D, and VB) are thought to have a possible mining potential (Mineral Resource Group 3). Further survey and prospecting work will be required over these areas, and the following synopsis gives an account of the information so far available for the more important minerals.

MINERAL RESOURCE GROUP 2 PROVEN MINING LAND

Group 2, land with proven reserves of minerals, occurs in the Karang and Porog areas over 194 ha (479 ac) and 416 ha (1 028 ac) respectively. Both have been prospected at various times since the early part of this century (Fitch 1958, Newton-Smith 1967).



TEXT MAP 2-10 Proven and possible mining areas

Copper

At least 80 000 tons of copper-rich deposits have been proven in the Karang Prospect located in the Karamuak valley south of Telupid (Fitch, 1958). It occurs as sulphides in shear zones in basalt associated with ultrabasic intrusions (Fitch, 1958). Assayed values range from 1.3% to 17% copper (Fitch, 1958).

Iron

Iron in the form of cupriferous limonite occurs in the Porog area some 3 km (2 mi) north of Kiabau on the Labuk River. It occurs as lateritic boulder deposits with about 60% iron content (Newton-Smith, 1967). Estimates of the reserves vary from 1½ million tons (British North Borneo (Chartered) Company records in Fitch, 1958) to 50 000 tons (Newton-Smith, 1967).

MINERAL RESOURCE GROUP 3 POSSIBLE MINING LAND

Survey and prospecting have revealed the occurrence of minerals in a number of places, of which the following are the most promising deposits:

Copper

Fitch (1958) has shown that the highest values for copper usually occur near suspected contacts between basalt and ultrabasic rocks. He demonstrated this during his survey

in the upper reaches of the Tungud River by geochemical prospecting, where high anomalous copper values occur in the alluvium particularly in the tributaries of the Perampangan, Kiboribi, Unsadan and Tinumbukan Rivers. Newton-Smith (1967) has also shown that the same relationship occurs near the tributary of the Kiabau River on the Labuk, where in two places the copper content of soil overlying spilite and ultrabasic rocks exceeds 3 000 ppm.

In the Sualog Valley of the Bidu Bidu Hills copper sulphides occur as disseminations in veins cutting ultrabsic rocks and also as bodies in fracture zones in sedimentary and basic igneous rocks. The assayed copper values range from 0.1% to 6.0% with an average of 0.7% (Newton-Smith, 1967). Between 0.1% and 17.59% copper has been assayed in similar rocks in the Bangau Bangau Valley, again in the Bidu Bidu Hills (Newton-Smith, 1967).

The cupriferous limonite deposits in the Porog area described above under Group 2 have yielded 2 000 – 3 000 ppm copper, in addition to their high iron content (Newton-Smith, 1967).

Iron

Considerable reserves of iron occur as nodular and bouldery laterite deposits formed by the weathering of ultrabasic rocks in the northern part of the Bidu Bidu Hills and on the Tawai Plateau. The deposits in the former cover an area of about 1.3 km^2 (1 mi^2), the total deposit is estimated at 172 million m^3 (225 million yd^3) and containing 42% iron (Newton-Smith, 1967) while on the Plateau it covers an area of about 13 km^2 (5 mi^2), consisting of some 223 million tonnes (225 million tons) with 40-49% iron (Wilford, 1968).

Nickel

Nickel occurs in the lateritic deposits in the Bidu Bidu Hills and on the Tawai Plateau. In the former the nickel values average about 0.37% (Newton-Smith, 1967), and in the latter 0.4-0.5% (Wilford, 1968).

Manganese

Newton-Smith (1967) showed during his survey that there is widespread occurrence of manganese limonitic nodules in the Bidu Bidu Hills, with the main occurrences in the Bangau Bangau, Sualog and Matapatau Valleys. The manganese content is about 5.9%, but the deposits, based on current standards, are not considered worthy of mining. He also described manganese occurring in fault breccia in the Paliu Valley, where the highest values obtained were 20%.

Chromite

Chromite commonly occurs in ultrabasic rocks, and is mined in the neighbouring Philippines in rocks closely related to the ultrabasics in the residency (Fitch, 1958). It has been discovered in the Porog Valley, but the proven reserves are insignificant (Newton-Smith, 1967).

Aluminium

The sole recorded occurrence of aluminium is over an area of 1.3 km^2 (½ mi^2) in the Malung Malung Valley of the Bidu Bidu Hills. The deposit consists of lateritic nodules and the recorded Al_2O_3 range is 30.31% to 51.30%. The total reserves are not known (Newton-Smith, 1967).

Zinc

Small quantities occur as sphalerite associated with copper mineralisation in the Bidu Bidu and Sualog Valleys. The assay of one sample revealed 4.63% zinc (Newton-Smith, 1967).

Gold and Silver

Minor amounts of gold and silver have been recorded associated with the copper sulphide deposits. In the Karang Prospect the highest gold assay was 1 dwt, silver 1 oz 1 dwt/t (Fitch, 1958); and the Bangau Bangau Valley gave a gold trace to 0.4 dwt/t, silver to 2.2 dwt/t. Silver values of 17.4 dwt/t have been recorded in the Sualog Valley (Newton-Smith, 1967).

Soil resources

Text Map 2-6 shows the various soil survey areas. It should be noted that the report on Area 3 shown on the map is incorporated in the companion *Land Resource Study 20, The soils of Sabah.*

The residency holds a very extensive agricultural soil resource. This is shown in Table 6, where 1 245 650 ha (3 078 053 ac) or 44.4% is indicated to be suited for various forms of agriculture (Soil Suitability Groups 2 and 3). All the soils have some form of limitation for agriculture and consequently *Group 1 soils do not occur.*

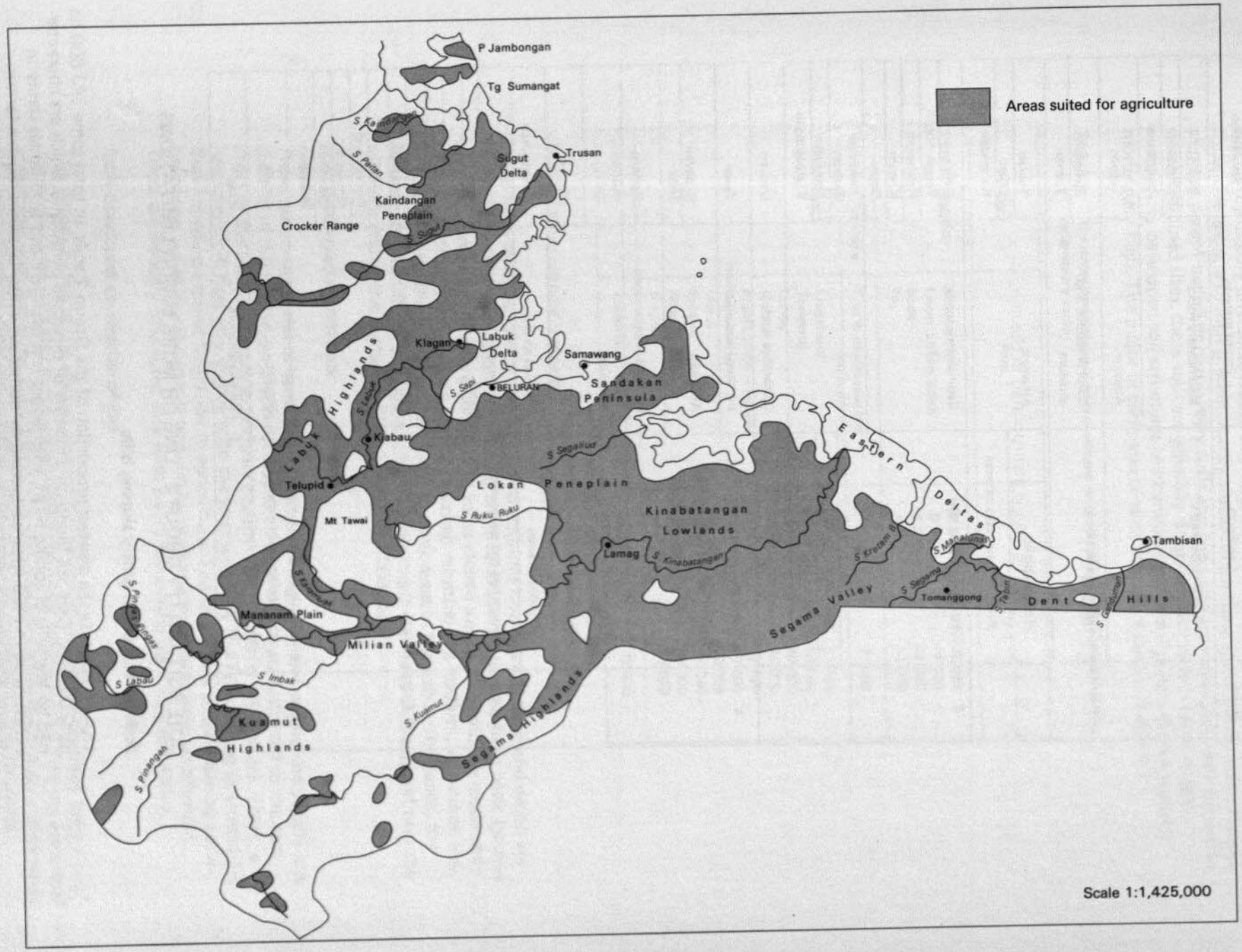
TABLE 6 Estimated areas of the soil suitability groups*

Soil suitability group	Degree of limitation for agriculture	ha	ac	%
2	Few minor limitations	382 313	944 707	13.6
3	One serious limitation	863 343	2 133 346	30.8
4	More than one serious limitation	377 205	932 085	13.5
5	Very serious limitation	1 179 331	2 914 159	42.1
Residency total		2 802 192	6 924 297	100.0

*Groups defined in *Land Capability Classification* (Sabah, Malaysia, State Development Planning Committee, 1973).

Text Map 2-11 shows that the soils considered suitable for agriculture occur mainly in the eastern half as a continuous belt in the lowlands, and sporadically in the western half generally associated with the main valley systems which intersect the highlands. This is shown in more detail on the land capability classification map.

Table 7 gives the main characteristics of the soil associations mapped in the residency and the soil suitability groups. The soil associations are described in Volume 1 of *Land Resource Study 20.*



TEXT MAP 2-11 Areas suited for agriculture (Soil Suitability Groups 2 and 3)

D.O.S. 3238 Z

Prepared by the Directorate of Overseas Surveys 1976

TEXT MAP 2-11

TABLE 7 Soil suitability classification and soil associations

Soil suitability group	Soils		Soil association
	Landform	Parent material	
2	Gently sloping hills	Sedimentary rocks	Rumidi
			Silabukan
			Lungmanis
		Alluvium	Tapang
	Terraces	Coral limestone and alluvium	Semporna
			Tungku
	Riverine plains	Alluvium	Tuaran
			Labau
	Riverine plains and terraces		Karamuak
3	Strongly sloping hills	Sedimentary rocks	Dalit
			Tengah Nipah
			Kalabakan
			Kretam
			Dagat
		Alluvium	Sinarun
	Terraces		Brantian
	Riverine plains		Kinabatangan
	Stranded beaches	Calcareous sand	Usukan
4	Terraces	Ironstone and alluvium	Tawai
		Alluvium	Kepayan
			Sook
		Peat and siliceous sand	Sipitang
	Freshwater swamps	Alluvium	Sapi
	Tidal swamps		Weston
	Stranded beaches	Siliceous sand	Tanjong Aru
5	Mountains and steeplands	Sedimentary and igneous rocks	Serudong
			Maliau
			Boititian
			Crocker
			Lokan
			Trus Madi
			Gumpal
			Gomantong
			Malubok
			Bidu-Bidu
			Mentapok
	Alluvial fans and terraces	Alluvium	Binalik
	Swamps	Peat and alluvium	Klias

SOIL SUITABILITY GROUP 2 ONE OR MORE MINOR LIMITATIONS

Soils developed on gently sloping hills

These constitute the greatest proportion of the Group 2 soils, in total some 343 600 ha (849 000 ac). They are found on a number of dissected peneplains which are characterised by low hills of rolling relief, with slopes less than 15° and amplitudes rarely in excess of 30 m (100 ft), interspersed by numerous valley bottoms. Such a terrain constitutes only a minor limitation to agricultural development. The other soil characteristics are generally favourable for most agricultural crops, and vary mainly according to their parent materials which can be conveniently described as follows:

Derived from sedimentary rocks

Parent materials consist mainly of sandstones, shales and mudstone, which are frequently closely intercalated and may vary in proportion from one area to another. Extensive areas, although predominantly derived from these rocks, have incorporations of other parent materials particularly tuffs and basic igneous rocks. Typically occurring on well drained sites, these soils are generally deep, medium to fine textures with moderately developed soil structures predominating, and the plant nutrient status is moderately high. The major occurrences of such soils are shown in Table 8.

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

Region	Area	Extent	
		ha	ac
Lokan Peneplain	Beluran	49 400	122 000
	Lower Lokan Valley	5 700	14 000
	Bode	5 300	13 000
	Pin	4 900	12 000
Sandakan Peninsula	E to W continuous belt	31 200	77 000
Kinabatangan Lowlands	Lungmanis	27 100	67 000
	Tenegang	23 900	59 000
	Lamag	25 500	63 000
	Kretam	16 200	40 000
	Suan Lamba – Sukau	15 000	37 000
	Gomantong	11 000	27 000
	Malua	10 100	25 000
	Sekong	7 300	18 000
	Segaliud	6 900	17 000
	Koyah	6 900	17 000
Dent Hills	Lumerau	8 900	22 000

Derived from alluvial deposits

These form terraces, which have been dissected into low hills and flats, and which are fine textured and stoneless. The deposits are predominantly derived from basic igneous rocks, outcrops of which are confined to some incised slopes. The soils are moderately to strongly structured, and are strongly leached resulting in a medium, sometimes low, nutrient status. These soils are restricted to three areas in the Labuk Highlands, the Telupid area 19 000 ha (47 000 ac), the Kiabau area 2 400 ha (6 000 ac), and near the northern end of the Mananam Plain 1 600 ha (4 000 ac).

Soils developed on terraces

These occur on a series of terraces with flat to rolling relief and amplitudes usually less than 15 m (50 ft). Group 2 soils developed on such terrain are restricted to the east coast of the Dent Peninsula where they occupy some 7 700 ha (19 000 ac). There, a low level plain rises very gradually to the west with very low hills sloping at around 5°, thus imposing a minor limitation to agriculture. The whole area is underlain by coral-limestone but to the east this is overlain by predominantly fine textured alluvium. These are strongly-structured soils with a very favourable plant nutrient status.

Soils developed on riverine plains

The Group 2 soils of the alluvial plains occur as almost continuous meander belts along the larger rivers, and also in the upper reaches of many valleys, where they are associated sometimes with low-lying, almost level, terraces. The soils are developed on a wide range of alluvial material; they are, however, predominantly moderately fine to coarse textured and stoneless. Drainage conditions vary locally according to the topographic position on the valley floor, but they generally range from well drained to imperfectly

drained. The plant nutrient status ranges from medium to high and is periodically replenished as the result of detrital deposition from floodwaters. These soils are subject to flooding most years but because of their relatively high topographic position coupled with generally good internal drainage, the effects of flooding are not considered to constitute a serious hazard to their agricultural development. For the purpose of this report flooding is considered to be a minor limitation. Their main occurrences are given in Table 9a.

TABLE 9a The main occurrences of Group 2 soils developed on riverine plains

Region	Area	Extent	
		ha	ac
Kinabatangan Lowlands	Kinabatangan Valley	6 470	16 000
	Kretam	3 240	8 000
Labuk Highlands and Delta	Labuk Valley	4 050	10 000
Kaindangan Peneplain – Sugut Delta	Sugut Valley	4 050	10 000
	Kaindangan Valley	810	2 000
	Paitan Valley	810	2 000
Segama Valley	Tomanggong	3 240	8 000

Soils developed on riverine plains and associated terraces

These rarely occur along valleys more than 1.5 to 3 km (1 to 2 mi) wide. The floodplains are associated with low dissected terraces with which they merge almost imperceptibly. The plains and lower terraces are subject to short-term flooding. The soil parent materials are very variable, sometimes consisting of pebble beds. Consequently soil conditions are very variable; on the valley floors drainage is generally inferior and the soils tend to be shallow due to the high pebble content, whilst on the terraces the soils are generally well drained, and tend to be more deeply developed, having a medium to high nutrient status. Textures range from medium to fine. The lower-lying areas have minor limitations due to drainage and stony layers, but the upper terraces are well drained and the soils generally stone-free. The more extensive tracts of such land are listed in Table 9b.

TABLE 9b The main occurrences of Group 2 soils developed on riverine plains and associated terraces

Region	Area	Extent	
		ha	ac
Labuk Highlands	Lower Labuk Valley	4 050	10 000
	Karamuak Valley	2 430	6 000
	Tungud Valley	1 210	3 000
Milian Valley	Mananam	1 620	4 000
Kuamut Highlands	Upper Kuamut Valley	1 210	3 000
	Lower Kuamut Valley	810	2 000
	Pinangah Valley	810	2 000

SOIL SUITABILITY GROUP 3 ONE SERIOUS LIMITATION

Soils developed on strongly sloping hills

Derived from sedimentary rocks

Here the landscape typically consists of hills and ridges, interspersed by narrow valleys, with an amplitude of relief generally less than 75 m (250 ft) and slopes normally about 15-25°. Group 3 soils have been mapped in the Dent Hills on similar terrain except that the amplitude of relief tends to be greater, sometimes up to 150 m (500 ft).

These hills are formed from sedimentary rocks, of which mudstones and sandstones are by far the most common, although shales, tuffs and the wide range of rocks associated with the geological slump formations may assume local importance. The soil characteristics are similar to those described for soils developed from sedimentary rocks on gently sloping hills, under Soil Suitability Group 2; but here the more strongly sloping terrain, more than any other feature, constitutes a serious limitation to agricultural development, and hence their classification into Group 3. Their main occurrences are given in Table 10.

TABLE 10 The major occurrences of Group 3 soils developed on strongly sloping hills and derived from sedimentary rocks

Region	Area	Extent	
		ha	ac
Kinabatangan Lowlands	Kinabatangan – Segama watershed	127 500	315 000
	Suan Lamba	10 500	26 000
	Gomantong	7 300	18 000
	Lamag	6 900	17 000
Kaindangan Peneplain	Paitan – Sugut	46 100	114 000
	Tungud Valley	10 100	25 000
	Murud Kurud	6 500	16 000
	Kaindangan	3 200	8 000
Lokan Peneplain	Beluran	29 100	72 000
	Lokan Valley	8 100	20 000
Milian Valley	Mananam	23 500	58 000
Dent Hills	Ganduman	22 300	55 000
	Tabin	8 100	20 000
Kuamut Highlands	Upper Kuamut Valley	22 300	55 000
	Imbak	14 600	36 000
	Kuamut	4 500	11 000
Labuk Highlands	Karamuak Valley	11 700	29 000
Sandakan Peninsula	Samawang	2 400	6 000

Derived from alluvial deposits

Strongly sloping hills formed by alluvial deposits are restricted to the upper reaches of the Kinabatangan, where they constitute strongly dissected terrace remnants. The hills have a relief amplitude of about 30-45 m (100-150 ft), convex crests and slopes in the 15-25° range. The deposits overlie mudstones and sandstones which sometimes outcrop on the lower slopes.

The soils are deeply developed, textures range from moderately coarse to moderately fine, and structure tends to be strongly developed. Plant nutrient status is low, but the soils will 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 11.

TABLE 11 The major occurrences of Group 3 soils developed on strongly sloping hills and derived from alluvial deposits

Region	Area	Extent	
		ha	ac
Labuk Highlands	Labau Valley	18 200	45 000
	Pingas Pingas Valley	6 100	15 000
Kuamut Highlands	Upper Pinangah Valley	1 600	4 000

Soils developed on terraces

These occur on river terraces or terrace remnants composed of mainly medium textured, sometimes pebbly, old alluvium. They have been slightly dissected giving rise to flat to undulating summits with short flanking slopes generally less than 15°, and an amplitude of relief less than 30 m (100 ft).

The soils are predominantly well drained, deeply developed, and medium textured. Soil structure is generally moderately developed. They have been subject to strong leaching processes, and this is particularly marked in some small scattered areas with the development of almost sterile bleached sands (podzols). Accordingly, the plant nutrient status of these soils is in general low, imposing a serious limitation to agricultural development.

They occur discontinuously throughout the length of the main valley systems but only occasionally along the coastal tracts. Their main occurrences are given in Table 12.

TABLE 12 The main occurrences of Group 3 soils developed on terraces

Region	Area	Extent	
		ha	ac
Labuk Delta	Klagan	7 300	18 000
Milian Valley	Mananam	3 200	8 000
Labuk Highlands	Telupid	2 800	7 000
Kinabatangan Lowlands	Lamag	2 800	7 000
	Gomantong	2 400	6 000
	Upper Pinangah Valley	2 400	6 000
	Lokan	2 000	5 000
Kuamut Highlands	Imbak	2 000	5 000
	Kuamut	2 000	5 000

Soils developed on riverine plains

These are marked by active accumulation of riverine deposits brought about by periodic flooding.

These plains are wide and extensive, and the Group 3 soils occur in the zone between the meander-belts and the backswamps. In general they are at a slightly lower level than the former and higher than the latter. They occur in the lower reaches of all the main valleys, sometimes in the middle, and may be as wide as 5 km (3 mi) in parts. Extensive areas merge with the coastal swamps.

Soil conditions are dominated by the effects of periodic flooding. The alluvium varies considerably in texture, but is generally medium to fine except in zones adjoining the meander belts and sandstone hills where more sandy conditions occur. The deposits are generally stone-less and deep. Poor to very poor drainage conditions prevail (a serious limitation to agriculture). These soils are inherently very fertile with the mineral nutrients being regularly replenished as the result of detrital deposition.

Any plans for the large scale agricultural development of these soils will have to take into account the strong flood risk. Although precise hydrological data are sparse, it is well known that these soils are subject to severe river flooding in most years. An account of their general distribution is given in Table 13.

TABLE 13 The main occurrences of Group 3 soils on riverine plains

Region	Area	Extent	
		ha	ac
Kinabatangan Lowlands	Kinabatangan Valley	72 400	179 000
	Kretam Valley	5 700	14 000
Segama Valley	Tomanggong	25 900	64 000
Eastern Deltas	Ganduman	9 700	24 000
	Lumerau	7 700	19 000
Sugut Delta	Sugut Valley	4 000	10 000
	Paitan Valley	1 200	3 000
Labuk Delta	Klagan	2 400	6 000
Lokan Peneplain	Samawang	1 600	4 000
	Segaliud	800	2 000

Soils developed on stranded beaches

These consist of coral debris and occur on a number of very small islands lying to the north-east of the Sandakan Peninsula, and from Tambisan to Tegupi fringing the tip of the Dent Peninsula where they occupy almost 1 200 ha (3 000 ac). The beaches lie parallel to the coastline at about 3 m (10 ft above sea level (a.s.l.)), and may show typical strand and swale development. Although generally composed of coral-sand, some swale sites are formed by accumulations of medium to fine textured calcareous alluvium. These sites are marked by very poor drainage conditions, while in the higher levels excessively well drained conditions may prevail.

The main limiting factors for agricultural development are their extreme coarseness of texture (serious limitation) together with the inferior drainage found in places. Otherwise these soils afford a favourable medium for agricultural crops, being developed on a very equable terrain and endowed with high levels of plant nutrients.

SOIL SUITABILITY GROUP 4 MORE THAN ONE SERIOUS LIMITATION

Soils developed on terraces

Derived from ironstone and alluvium

These are restricted to the Tawai Plateau in a broad shallow basin 330-420 m (1 100–1 400 ft) a.s.l., and occupy some 1 200 ha (3 000 ac). The surface of the plateau is uneven and gullied and swamp conditions generally prevail. The soils are developed on the nodular and bouldery laterite deposits, which have been described earlier in connection with the mineral resources and frequently consist of concretionary and bouldery material in a medium to fine textured matrix, overlain sometimes by moderately thick to shallow peat deposits. The nutrient status of the mineral soil is low.

It can be seen, therefore, that these soils are subject to a number of serious limitations, i.e. shallow depth, low nutrient status and very poor drainage, and are not recommended for agricultural development.

Derived from alluvium

These occur on low-lying terraces formed on old alluvium interspersed sometimes by floodplains comprised of coarse textured deposits. The alluvium of the terraces is fine to medium textured, sometimes pebbly, and the flatter areas have surface deposits of white sand marking the presence of podzols. The floodplains are marked by poor to very poorly drained soils, sometimes with shallow peat development. The soils of the terraces

have been subject to intense leaching processes, and those on the floodplains contain very little weatherable mineral. These factors together contribute to the generally low nutrient status. This, together with very poor drainage and coarse textures, imposes a number of serious limitations to agricultural development. The main areas are given in Table 14.

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

Region	Area	Extent	
		ha	ac
Sugut Delta	Sugut	9 700	24 000
	Paitan	3 600	9 000
	Kaindangan	1 200	3 000
Lokan Peneplain	Ruku Ruku	4 900	12 000
	Sapi	3 600	9 000
Kuamut Highlands	Kuamut	2 400	6 000
	Imbak	1 600	4 000
Bengkoka Lowlands	Jambongan Island	1 600	4 000
Labuk Highlands	Telupid	1 600	4 000
	Upper Labau Valley	1 200	3 000

Derived from peat and siliceous sand

These soils occur in depressions on marine terraces and are restricted to the Sugut Delta where they occupy an aggregate total of 9 400 ha (23 250 ac). They are very poorly drained and the centres of the depressions are marked by permanent swamps with deep peat accumulation. The slightly drier peripheral areas are marked by bleached, almost sterile sands and the development of podzols. The peat depth coupled with very poor drainage, coarse textures and low nutrient status give rise to a number of serious limitations to agriculture.

Soils developed in freshwater swamps

These are best developed in the lower reaches of the main rivers adjoining the coastal swamps, although extensive areas also occur both along the coast and inland on the floodplains and tributary valleys. Being topographically very low, the watertables in these swamps are above or near the surface throughout the year, and on the floodplains bear the maximum impact of the frequent floods.

Although in general these are inherently fertile soils with medium to high levels of plant nutrients, they cannot at present be recommended for agricultural development, and hold a special position in the soil suitability classification as far as the residency is concerned. As noted earlier, the valleys of the larger rivers are subject to periodic severe flooding, the worst in the state. Control of this flooding can only be brought about by establishing a system of engineering works to regulate the flow from the main catchments, and an elaborate drainage system on the plains. This can only be done on a regional basis, and will take a very long time. Draining the swamps will pose additional problems because of their low-lying nature and frequently their distance from the main natural drainage. Together they pose serious limitations and until they are overcome these soils cannot be recommended for agricultural development. The main areas are given in Table 15.

TABLE 15 The main occurrences of Group 4 soils developed in freshwater swamps

Region	Area	Extent	
		ha	ac
Kinabatangan Lowlands	Abai	14 200	35 000
	Gomantong	4 000	10 000
	Lokan	1 600	4 000
	Dewhurst Bay	1 200	3 000
Labuk Delta	Sapi	12 500	31 000
	Klagan	5 700	14 000
	Beluran	1 200	3 000
	Bongaya	800	2 000
Sugut Delta	Paitan	4 500	11 000
	Trusan	3 200	8 000
	Kaindangan	800	2 000
Sandakan Peninsula	Samawang	2 800	7 000
Segama Valley	Tomanggong	2 800	7 000
Dent Hills	Ganduman to Tegupi coastal strip	2 400	6 000

Soils developed in tidal swamps

These form an almost continuous belt along the coastline of the residency but are most extensive in the deltaic regions. Being close to sea level they are very poorly drained, and periodically flooded by tidal waters which frequently give rise to saline soil conditions. The salinity, with very poor drainage, results in two serious limitations. Also, extensive areas of these soils may contain high levels of sulphur; and it is likely that in many cases attempts at reclaiming such land for agriculture by draining will lead to excessive acidity levels. Bearing in mind the present availability of land, agricultural development is not recommended. The main areas are given in Table 16.

TABLE 16 The main occurences of Group 4 soils developed in tidal swamps

Region	Area	Extent	
		ha	ac
Eastern Deltas	Trusan Duyong to Dewhurst Bay	45 700	113 000
	Dewhurst Bay to Tambisan	33 600	83 000
	Sandakan Harbour	24 700	61 000
Sugut Delta	Trusan to Bongaya	37 600	93 000
	Kaindangan and Paitan Estuaries	13 000	32 000
	Tanjong Sumangat	6 100	15 000
Labuk Delta	Klagan to Sapi	28 300	70 000
Lokan Peneplain	Beluran to Samawang	9 300	23 000
Sandakan Peninsula	Tanjong Pisau to Sandakan (coastline)	8 100	20 000
	Gum Gum	3 200	8 000
Bengkoka Lowlands	Jambongan Island	6 500	16 000

Soils developed on stranded beaches

Fairly extensive areas of stranded beaches composed of highly siliceous quartz-sand occur both along the coastline and sometimes inland surrounded by tidal swamps.

They are similar to those described earlier except for their highly siliceous nature. Being largely composed of quartz the nutrient status is very low, which together with the extreme coarseness imposes two serious limitations for agriculture. Their main distribution is given in Table 17.

TABLE 17 The main occurrences of Group 4 soils developed on stranded beaches

Region	Area	Extent	
		ha	ac
Eastern Deltas	Tanjong Aru to Dewhurst Bay Tangusu Bay	10 100 1 200	25 000 3 000
Sugut Delta	Tanjong Sumangat to Tanjong Sugut	3 600	9 000
Sandakan Peninsula	Samawang	800	2 000

SOIL SUITABILITY GROUP 5 VERY SERIOUS LIMITATION

Soils developed in peat swamps

Extensive areas of swamp occur both on the floodplains and deltaic regions, where drainage is so poor that the watertable remains continuously above the surface. This has resulted in the formation of peat, which may be over 6 m (20 ft) in depth, which is considered to be a very serious limitation to agriculture. In general the peat is formed from woody material. Strongly acidic, with a low nutrient status and with its waterlogged nature, it affords a very poor medium for the growth of crops. The peat swamps are also subject to the severe flooding in common with the other freshwater swamps described earlier and are therefore not recommended for agricultural development. The main peat swamp areas are given in Table 18.

TABLE 18 The main peat swamp areas

Region	Area	Extent	
		ha	ac
Kinabatangan Lowlands	Gomantong Lamag Sukau	10 500 1 600 1 600	26 000 4 000 4 000
Eastern Deltas	Manalunan	10 100	25 000
Sugut Delta	Lower Sugut	6 900	17 000
Labuk Delta	Klagan to Sapi	1 600	4 000

Soils developed on alluvial fans and terraces

These are associated with streams draining the mountains formed by ultrabasic and basic igneous rocks. The fans frequently coalesce as low level to gently undulating terraces. They are formed by dominantly fine textured, rarely stony, alluvium.

The soils are deeply developed, generally well structured, medium to fine textured and freely draining except in localised depressions. However, they are in the main very low in plant nutrients, and have a trace element toxicity problem which constitutes a very serious limitation to agricultural development.

Individual occurrences are usually small in extent, and the main areas are listed in Table 19.

TABLE 19 The main occurrences of Group 5 soils developed on alluvial fans and terraces

Region	Area	Extent	
		ha	ac
Labuk Highlands	Lower Labuk Valley	4 000	10 000
	Telupid	1 200	3 000
	Karamuak Valley	1 200	3 000
	Upper Tungud Valley	800	2 000

Soils developed on mountains and steeplands

These largely cover the areas of high elevation and relief in the Crocker Range, Labuk Highlands, Kuamut Highlands, Segama Highlands, the Lokan Peneplain, and the cuestas of the Sandakan Peninsula. They are very extensive in the residency, occupying some 1 179 000 ha (2 914 000 ac), or 42% of the total area.

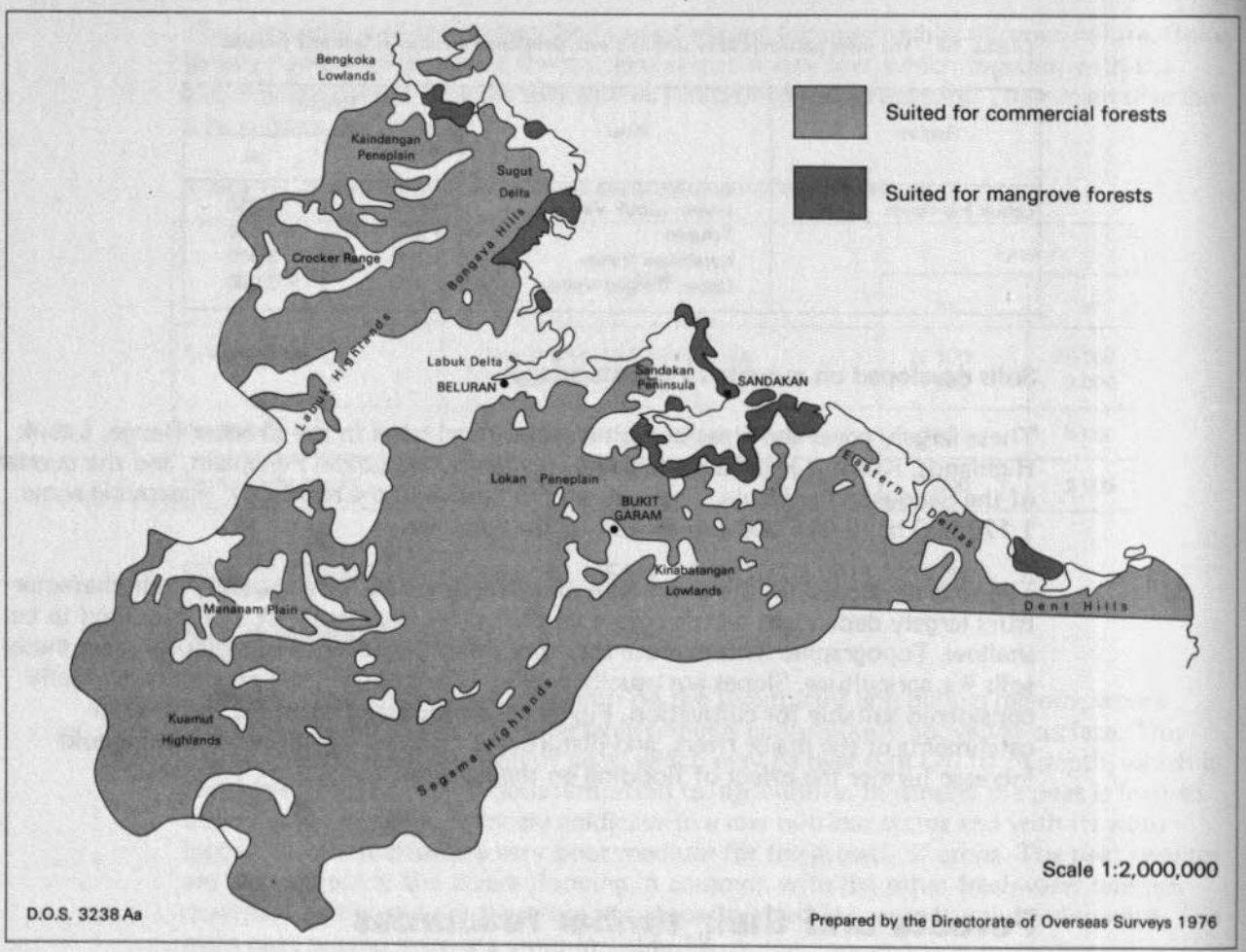
The soils developed on the mountains and steeplands are very variable, their characteristics largely dependant on the nature of the parent rock material, but they tend to be shallow. Topographic factors more than any other, however, very seriously limit these soils for agriculture. Slopes are usually well in excess of 25°, the maximum normally considered suitable for cultivation. Further the mountains form the main water-catchments of the major rivers, and disturbance of their vegetation and soil would increase further the effect of flooding on their plains.

Forests and their timber resources

INTRODUCTION

Some 97% of the land is still covered by forest and of this approximately 70% is lowland dipterocarp forest, which forms the most valuable part of the forest resource. The lowland dipterocarp forest usually extends up to an altitude of about 750 m (2 500 ft) when structure and species composition begin to change, the commercial volume decreases markedly and the forest becomes montane. In general the lowland dipterocarp forest is fairly heterogeneous but with dipterocarps approximately accounting for 70%-90% of the stand by volume. Total volume and species composition vary particularly between forest on the lowlands and on steep hilly land, the latter having a generally higher volume and higher proportion of dipterocarps.

Approximately 2 104 800 ha (5 200 960 ac) of stateland, forest reserve and alienated land carry lowland dipterocarp forest which is considered commercial, with an expected yield of the preferred dipterocarp species in excess of 35 m^3/ha (400 Hft^3/ac). Of this area some 885 400 ha (2 187 800 ac) carry Timber Resource Group 1 forest with an expected yield of more than 89 m^3/ha (1 000 Hft^3/ac), a further 217 000 ha (536 200 ac) carry Timber Resource Group 2 forest with an expected yield of more than 62 m^3/ha (700 Hft^3/ac), while 233 700 ha (577 500 ac) carry Group 3 forest with an expected yield of more than 35 m^3/ha (400 Hft^3/ac). The balance of the area is commercial forest, which cannot be grouped because yield information is not available. 150 000 ha (370 800 ac) of stateland and forest reserve carry forest which is at present considered non-commercial on account of the expected low yield i.e., less than 35 m^3/ha (400 Hft^3/ac). 54 550 ha (134 800 ac) of land above 750 m (2 500 ft) carry montane forest which is regarded as non-commercial on account of the low volume and species composition. Other types of forest such as beach forest, transitional forest, freshwater swamp forest and areas of nipah palm, which are at present noncommercial and have no value in the foreseeable future, total approximately 239 800 ha (592 500 ac). Commercial mangrove forest, which contributes to the productive forest resource, covers an area of approximately 104 000 ha (257 000 ac). It should be noted that most of the commercial forest, whether in forest reserve or on stateland is already



TEXT MAP 2-12 Areas suited for forestry

under licence. The areas suited for commercial forests and mangrove forests are shown on Text Map 2-12.

The volume figures given in the various tables in this section are average cubic metres per hectare (m^3/ha) together with the equivalent hoppus cubic feet per acre (Hft^3/ac). Volumes include all timber with a basal diameter in excess of 51 cm (20.1 in) (1.6 m(5 ft 3 in) girth) over bark measured to a top diameter of 46 cm (18 in) (1.4 m (4 ft 8 in) girth) over bark or point of branching, whichever is 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 exploitation that has occurred since that period has not been taken account of.

The yield parameters used in defining Timber Resource Groups 1, 2 and 3 only refer to the main species and timber groups of the Dipterocarpacae 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.

About 63% of the land area of the residency is constituted as forest reserve of various classes and forms part of the permanent forest estate. The approximate location of these forest reserves is shown on Text Map 2-13. 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

The distribution of these six classes by district is shown in Table 20.

TABLE 20 Forest reserves by classes and districts

Forest reserve class	Sandakan		Labuk & Sugut		Kinabatangan		Total residency	
	ha	ac	ha	ac	ha	ac	ha	ac
I	5 845	14 442	145 776	360 218	49 554	122 450	201 175	497 110
II	13 927	34 413	221 331	546 916	1 283 886	3 172 516	1 519 144	3 753 845
III	117	290	1 674	4 136	0	0	1 791	4 426
IV	4 364	10 783	689	1 703	0	0	5 053	12 486
V	33 189	82 012	0	0	0	0	33 189	82 012
V.J.R.	121	300	1 812	4 475	5 459	13 490	7 392	18 265
Total	57 563	142 240	371 282	917 448	1 338 899	3 308 456	1 767 144	4 368 144

In the remainder of this section the forest resources will be discussed and analysed under three major headings: (a) commercial forest (its composition and distribution): (b) the timber resources of each class of reserve (90% of commercial forest occurs in forest reserves); and (c) the timber resources of the state lands.

COMMERCIAL FORESTS: COMPOSITION AND DISTRIBUTION

The most important part of the forest resource is the huge area of commercial lowland dipterocarp forest falling into Timber Resource Groups 1, 2 and 3. Table 21 shows the distribution of these groups in forest reserves and stateland. Group 1 accounts for 55% of the total, Group 2 14.5%, Group 3 17.6% and unclassified commercial forest 12.9%. Commercial forests also occur on alienated land but they have not taken into account as they are not extensive and the land being alienated is committed for development.

Table 22 gives the volume composition of undisturbed Timber Resource Groups 1, 2 and 3 by main timber species. Apart from Dipterocarpaceae other timbers with established merchantibility and good potential are included under other commercial species.

Dipterocarps

It will be noted from Table 22 that the percentage of Dipterocarpaceae in the total volume decreases from 89.4% in Timber Resource Group 1 to 79.3% in Group 3; with an average for all commercial forest of 87.8%. Red seraya, (Rubroshorea group of *Shorea*) which includes *majau,* (*Shorea leptoclados*) and *obah suluk,* (*Shorea pauciflora*), is the most common timber group accounting for 30.2% of the volume in Group 1 and 25.8% in both Group 2 and 3. *Majau* is generally the most common species of red seraya and one of the most common of all species, forming on average 6.5% of the total volume in Group 1, 4.0% in Group 2, and 4.6% in Group 3. After red seraya, *urat mata* is the most common timber in Group 1 and *Parashorea malaanonan* and *P. tomentella,* the two species which for practical purposes constitute the *urat mata* group, are on average the most common of all species in all groups. In sampling units 1, 2 and 3 *P. tomentella*

TABLE 21 Commercial forest in forest reserves and stateland

Timber resource group	Forest reserves		Stateland including government reserves		Total	
	ha	ac	ha	ac	ha	ac
Group 1						
Undisturbed forest*	880 166	2 174 913	258 530	638 835	1 138 696	2 813 748
Disturbed forest**	381	942	81	200	462	1 142
Total	880 547	2 175 855	258 611	639 035	1 139 158	2 814 890
Group 2						
Undisturbed forest	216 865	535 880	82 129	202 943	298 994	738 823
Disturbed	845	2 087	380	940	1 225	3 027
Total	217 710	537 967	82 509	203 883	300 219	741 850
Group 3						
Undisturbed forest	218 299	539 422	126 820	313 376	345 119	852 798
Disturbed forest	15 674	38 732	3 165	7 822	18 839	46 554
Total	233 973	578 154	129 986	321 198	363 958	899 352
Group 1, 2 & 3						
Undisturbed forest	1 315 330	3 250 215	467 479	1 155 154	1 782 809	4 405 369
Disturbed forest (a)+	16 900	41 761	3 627	8 962	20 527	50 723
Disturbed forest (b)	33 108	81 812	28 771	71 094	61 879	152 906
Regenerating forest++	170 339	420 912	36 473	90 125	206 812	511 037
Total	1 535 677	3 794 700	536 359	1 325 335	2 072 027	5 120 035

*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. The result is 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

+Disturbed forest (a) is the sum total of that in the separate resource groups. (b) is disturbed forest which while not at present carrying sufficient volume for inclusion in resource Group 1, 2 or 3 undoubtedly has the potential to be classed as commercial 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

is considerably more common than *P. malaanonan* while in sampling unit 5 the situation is reversed. An insignificant amount of *urat mata* comes from *P. smythiesii* and *P. parvifolia.* In Group 2 and 3 forest the *keruing* group is second in importance. In Timber Resource Group 1 *urat mata* is followed by *keruing,* while in Groups 2 and 3 *kapur* is the third most important timber group. It will be noted that in Groups 2 and 3 *urat mata* is respectively sixth and fourth equal in importance, while in all forests *melapi* is the least important of the named timber groups. Included in the other species of Dipterocarpaceae are *gagil* and *selangan* (*Hopea* spp), *penigiran* (*Anisoptera* spp), *pengiran* (*Anisoptera* spp) and *resak* (*Vatica* and *Cotylelobium* spp).

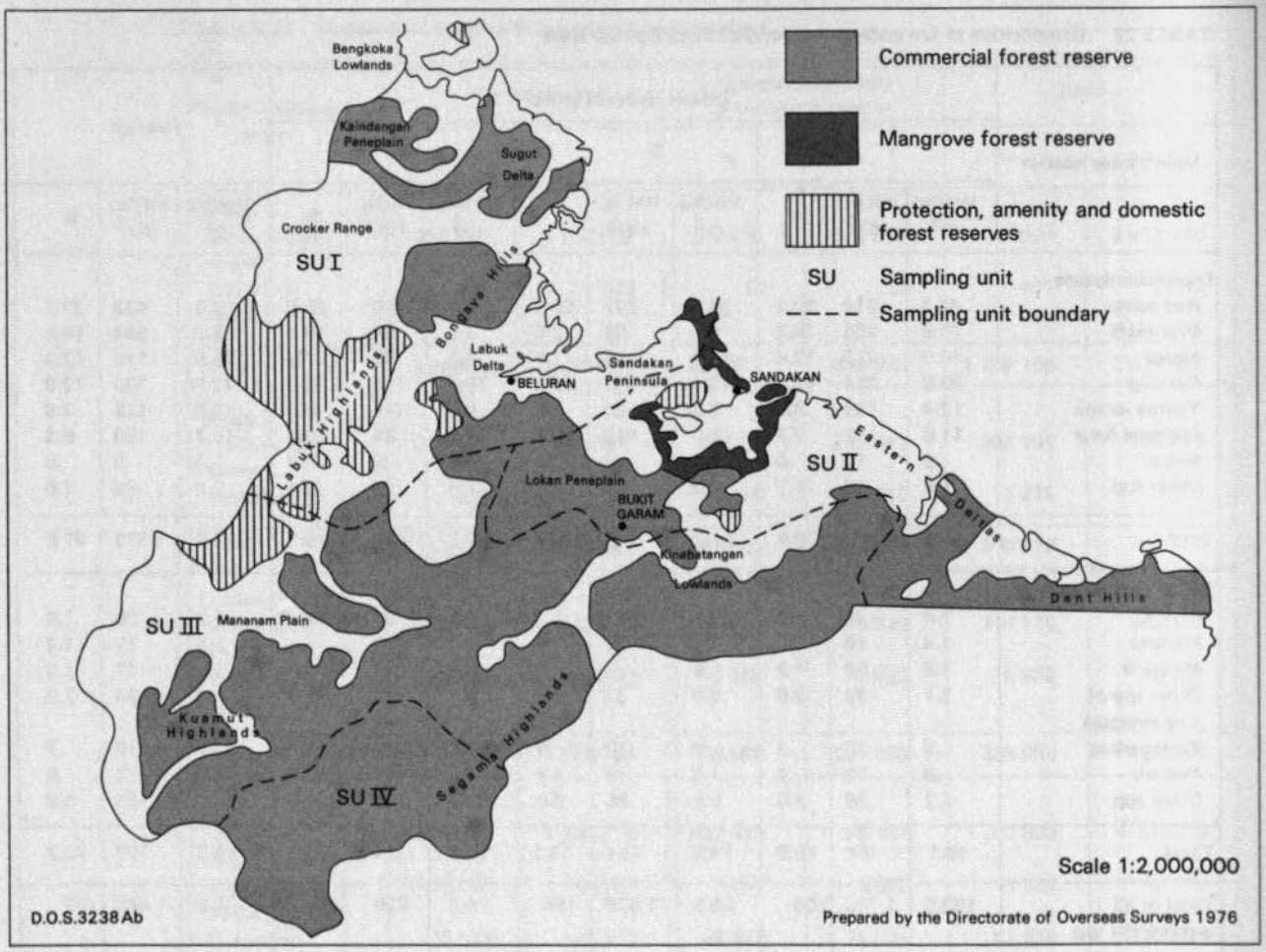
TABLE 22 Composition of the undisturbed forests of commercial value

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	46.1	518	30.2	24.7	277	25.8	19.3	216	25.8	37.7	423	29.2
Urat mata	23.6	266	15.5	8.3	93	8.6	7.5	84	10.0	18.2	204	14.1
Kapur	19.0	213	12.4	11.8	133	12.3	8.3	94	11.2	15.9	178	12.3
Keruing	20.8	234	13.7	13.1	147	13.7	10.4	117	13.9	17.7	199	13.8
Yellow seraya	12.4	139	8.1	8.9	100	9.3	4.0	44	5.3	10.2	115	7.9
Selangan batu	11.8	132	7.7	10.0	112	10.4	7.5	84	10.0	10.7	120	8.3
Melapi	.9	10	.6	1.1	12	1.1	.6	6	.7	.8	9	.6
Other spp	1.8	20	1.2	1.2	38	3.6	1.6	20	2.4	2.0	23	1.6
Total	136.4	1 532	89.4	81.2	912	84.8	59.2	665	79.3	113.2	1 271	87.8
Other commercial spp												
Belian	2.8	32	1.9	1.1	13	1.2	1.8	20	2.4	2.3	26	1.8
Medang	1.4	16	.9	1.8	20	1.9	1.6	18	2.1	1.5	17	1.2
Mengaris	1.8	20	1.2	.6	7	.6	1.3	14	1.7	1.5	17	1.2
Other spp of Leguminosae	3.1	35	2.0	3.0	33	3.2	2.8	32	3.8	3.0	34	2.3
Kedongdong	.9	10	.6	.9	10	.9	.9	10	1.2	.9	10	.7
Nyatoh	.9	10	.6	1.3	15	1.4	1.5	16	2.0	1.0	12	.8
Other spp	5.2	58	3.4	5.9	66	6.0	5.6	64	7.5	5.5	61	4.2
Total	16.1	181	10.6	14.6	164	15.2	15.5	174	20.7	15.7	177	12.2
Total of all commercial spp	152.5	1 713	100	95.8	1 076	100	74.7	839	100	128.9	1 448	100

Other commercial species

Species other than Dipterocarpaceae which are considered to be of commercial importance account for only 10.6% of the total commercial volume in Group 1, 15.2% in Group 2 and 20.7% in Group 3. However the total volume of these other commercial species is very similar in all forests varying by no more than 9.4%. The only species or named timber group which accounts for more than 2% of the total volume is *belian* (*Eusideroxylon zwageri*) and that only in Group 1. The more important species included in the group 'other species of Leguminosae' are *sepetir* (*Sindora* spp), *merbau* (*Intsia* spp) and *keranji* (*Dialium* spp). The group 'other species' includes *binuang* (*Octomeles sumatrana*), *karai* (Annonaceae spp), *kembang* (*Heritiera* spp), species of Sterculiaceae other than *Heritiera*, *laran* (*Anthocephalus chinensis*), *kaya 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).

Although all the other commercial species are considered to have established merchantibility and good potential it must be acknowledged that at present few are regularly extracted. The low unit area volumes are an important factor in their poor merchantibility. In some cases, in particular with *medang* (Lauraceae spp other than *belian*), and *kayu malam* (*Diospyros* spp), most of the trees belong to the understory and many do not reach the minimum girth size for consideration as commercial timber. If however lower basal girth and top diameter limits were taken then the volume of timber available might be expected to be considerably larger.



TEXT MAP 2-13 Forest reserves and forest inventory sampling units

TIMBER RESOURCES OF THE FOREST RESERVES

A very large part of the commercial forest is found in forest reserves which have been classified in Table 20 according to their main functions. The resources of the different classes of forest reserve are now analysed.

Class I Protection forest reserves

The distribution of Class I, Protection forest, reserves is shown on Text Map 2-13 where they have been incorporated with the relatively minor areas occupied by Class III and IV reserves, Domestic forest and Amenity forest. As indicated in Table 20 their total area amounts to 201 175 ha (497 110 ac). The main purpose of maintaining forest cover in these areas is the protection of water catchments and the prevention of soil erosion on steep land. In some reserves there are other more specific reasons. As might be expected, the greater part of these forests are located on hilly and moutainous terrain. The major reserves together with the main reasons for their establishment are listed below:

1. UluTungud — To protect the headwaters and catchment areas of the Tungud and other rivers and minimise erosion of unstable soils

2. Tawai — To protect the headwaters and catchment areas of the Tangkulup and other rivers rising in the Tawai Hills, and minimise erosion of unstable soils

3.	Ulu Telupid	To protect the headwaters and catchments of streams rising in the area and to minimise erosion of unstable soils
4.	Lipaso	As for Ulu Telupid
5.	Trus Madi Extension	To protect the catchment areas of rivers and streams rising on the eastern flank of the Trus Madi Range, in particular those of the Karamuak and Kegibongan Rivers, and minimise erosion of unstable soils
6.	Bidu Bidu	To protect the catchment area of the Bidu Bidu and other rivers rising in the Bidu Bidu Hills and minimise erosion of unstable soils
7.	Gomantong	To provide an area of permanent forest cover round the Gomantong birds-nest caves in order to maintain the environment considered necessary for the swiftlets producing the birds nests

Considerable areas of protection forest carry commercial timber stands and these have been classified accordingly. Details are given in Table 23.

TABLE 23 Distribution of Timber Resource Groups 1, 2 and 3 in Class I, Protection forest reserves

Timber resource group	Undisturbed		Disturbed		Total	
	ha	ac	ha	ac	ha	ac
1	65 295	161 346	0	0	65 295	161 346
2	40 959	101 210	77	190	41 036	101 400
3	36 574	90 376	154	380	36 728	90 756
Total	142 828	352 932	231	570	143 059	353 502

While an area of 142 828 ha (352 932 ac) carries commercial stands of timber it cannot really be considered as commercial forest since logging is not generally allowed in protection forest, though in some areas restricted and carefully controlled exploitation may be permitted. In addition to this area there is a further 1 060 ha (2 621 ac) of regrowth following logging. While lack of information on the yield prevents classification into Groups 1, 2 or 3 it is felt that this may be regarded as potential commercial forest. Forest with an expected yield of less than 35 m^3/ha (400 Hft^3/ac) covers 45 855 ha (113 310 ac), much of this is small crown forest occurring on ultrabasic soils. There are 9 146 ha (225 599 ac) of non-commercial montane forest on land with an altitude of more than 750 m (2 500 ft). Non-commercial freshwater swamp forest covers 263 ha (650 ac) while regrowth after shifting cultivation, non-forested and non-productive land account for the balance of 1 792 ha (4 428 ac). The average composition of the undisturbed forest in Groups 1, 2 and 3 is shown in Table 24.

The percentage of dipterocarps in the total volume of commercial timber varies from 88.8% in Timber Resource Group 1 to 80.6% in Group 3, though the volume of dipterocarps in Group 3 is little more than 50% of that in Group 1. In all groups red seraya is the most abundant timber group followed in Groups 1 and 3 by *keruing*. In Group 2 *urat mata* and *keruing* are equal in abundance after red seraya. As might be expected in this type of forest *selangan batu* is relatively common and is the third most abundant timber in Groups 1 and 3 and fourth in Group 2. The percentage of other commercial species in the total volume of commercial timber varies from 11.2% in Group 1 to 19.4% in Group 3 while the actual volume varies by 19.2%, which is considerably less than the variation in the volume of dipterocarps between groups. Except for *medang* (Lauraceae spp other than *belian*), no species or named timber group of the other commercial species accounts for more than 2% of the total volume in Timber Resource Group 2.

TABLE 24 Composition of undisturbed Group 1, 2 and 3 forest 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	42.2	474	30.0	33.0	370	35.0	19.9	223	25.3	33.9	380	30.2
Urat mata	12.4	139	8.8	11.5	129	12.2	4.3	48	5.5	10.1	113	9.0
Kapur	13.1	147	9.3	7.3	82	7.7	5.2	58	6.6	9.4	106	8.5
Keruing	21.4	240	15.2	11.5	129	12.2	17.3	194	22.0	17.5	197	15.7
Yellow seraya	13.1	147	9.3	6.1	68	6.5	5.0	57	6.4	9.0	101	8.1
Selangan batu	17.6	198	12.6	8.5	95	9.0	8.9	100	11.4	12.8	144	11.5
Melapi	1.6	18	1.1	1.5	16	1.6	1.0	12	1.3	1.4	16	1.3
Other spp	3.4	38	2.5	1.9	24	2.2	1.6	17	2.1	2.6	29	2.3
Total	124.8	1 401	88.8	81.3	913	86.4	63.2	709	80.6	96.7	1 086	86.8
Other commercial spp												
Belian	.8	9	.6	1.8	20	1.9	1.6	17	2.0	1.3	14	1.2
Medang	1.6	18	1.2	2.0	23	2.2	.9	10	1.1	1.6	18	1.4
Mengaris	.7	8	.5	.3	3	.3	1.2	13	1.5	.7	8	.6
Other spp of Leguminosae	4.3	49	3.1	3.6	40	3.8	4.4	50	5.7	3.5	39	3.1
Kedongdong	1.1	12	.8	.6	7	.7	.9	10	1.1	1.8	20	1.6
Nyatoh	.6	7	.4	.8	9	.9	1.4	16	1.8	.9	10	.8
Other spp	6.6	74	5.1	3.7	41	4.1	4.8	55	7.7	4.9	56	4.5
Total	15.7	177	11.2	12.8	143	13.6	15.2	171	19.4	14.7	165	13.2
Total all commercial spp	140.5	1 578	100	94.1	1 056	100	78.4	880	100	111.4	1 251	100

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. As shown in Table 20 there are 1 519 144 ha (3 753 845 ac) of this class of reserve in the residency. For reference purposes and because of variation in composition the reserves are grouped according to the forest inventory (Forestal International Limited, 1973) sampling units into which they fall. The boundaries of these four sampling units i.e. SU I, SU 2, SU 3 and SU 5 (part) are shown on Text Map 2-13.

There is a gradual broad change in the dipterocarp composition of the Class II reserves from north to south-west in the residency. This is demonstrated in Table 25 which gives the proportion by volume of the four most abundant dipterocarp timber groups in the four sampling units for Timber Resource Groups 1, 2 and 3.

Table 25 shows that in Sampling Unit I the commercial forest consists of red seraya *keruing,* and *kapur,* with yellow seraya and *selangan batu* as relatively important components. In Sampling Unit 2 the forest is again basically red seraya, *keruing,* and *kapur* but with *urat mata.* In Unit 3 no three groups are so predominant and the forest is a mixture of red seraya with *urat mata, keruing, kapur, selangan batu* and yellow seraya. While red seraya remains by far the most abundant timber group the importance of *keruing* and *kapur* has declined. In Sampling Unit 5 the forest has become very definitely red seraya and *urat mata,* with *selangan batu* and yellow seraya forming important components.

It may be noted that in Timber Resource Group 1 the highest volume of dipterocarps occurs where the four most important timber groups form the highest proportion of total volume i.e. Sampling Unit 5 followed by 2.

TABLE 25 Proportion of the four most abundant dipterocarp timber groups in Timber Resource Groups 1, 2 and 3 in the Class II reserves

Sampling unit	Timber resource group					
	1		2		3	
	Timber group	%	Timber group	%	Timber group	%
1	Red seraya	29.2	*Kapur*	22.7	*Keruing*	24.2
	Keruing	19.3	Red seraya	19.4	Red seraya	23.9
	Kapur	15.0	*Keruing*	19.0	*Selangan batu*	10.8
	Selangan batu	10.2	Yellow seraya	7.5	*Kapur*	7.1
	Total	73.7		68.6		66.0
2	Red seraya	25.1	*Keruing*	21.5	Red seraya	22.3
	Keruing	18.7	Red seraya	21.3	*Kapur*	13.0
	Kapur	18.5	*Kapur*	16.6	*Urat mata*	12.5
	Urat mata	15.0	*Urat mata*	9.4	*Keruing*	11.1
	Total	77.3		68.8		58.9
3	Red seraya	31.2	Red seraya	23.3	Red seraya	26.8
	Urat mata	14.8	*Selangan batu*	17.9	*Kapur*	13.7
	Keruing	13.7	*Keruing*	12.6	*Urat mata*	13.3
	Kapur	12.6	Yellow seraya	11.3	*Selangan batu*	10.0
	Total	72.3		65.1		63.8
5	Red seraya	32.3	Red seraya	34.8	Red seraya	28.7
	Urat mata	23.7	*Urat mata*	13.5	*Urat mata*	20.9
	Yellow seraya	12.6	*Selangan batu*	13.2	*Selangan batu*	11.9
	Selangan batu	8.8	Yellow seraya	12.5	*Keruing*	7.1
	Total	77.4		74.0		68.6

Tables 27, 28 and 29 show that while the volume of Dipterocarpaceae varies considerably between sampling units and timber resource groups, from a maximum of 153.3 m^3/ha (1 723 Hft^3/ac) in Timber Resource Group 1 in Sampling Unit 5 to a minimum of 48.5 m^3/ha (544 Hft^3/ac) in Group 3 in Unit 2, the volume of other commercial species varies far less. In this case the maximum is 21.2 m^3/ha (238 Hft^3/ac) in Group 3 in Unit 2 and the minimum is 12.3 m^3/ha (137 Hft^3/ac) in Group 2 in Unit 3. The overall average volumes for the four sampling units show little variation between timber resource groups for other commercial species, but, as expected, very considerable variation for Dipterocarpaceae (Table 26).

TABLE 26 Average volumes of Dipterocarpaceae and other commercial species in Timber Resource Groups 1, 2 and 3 in Class II reserves

Timber group	Timber resource group								
	1			2			3		
	m^3/ha	Hft^3/ac	%	m^3/ha	Hft^3/ac	%	m^3/ha	Hft^3/ac	%
Diptero-carpaceae	138.0	1 550	89.5	79.2	890	84.4	58.2	654	78.8
Other commercial spp	16.1	181	10.5	14.6	164	15.6	15.7	176	21.2

Whereas the volume of Dipterocarpaceae shows a large variation depending on the terrain, soil and other factors, the volume of other commercial timbers on average remains more or less constant.

Undisturbed forest in Class II reserves

As the name implies these are forests which, as far as is known, have not been commercially exploited for timber. The area of undisturbed forest in Timber Resource Groups 1, 2 and 3 in the four sampling units is given in Table 27.

TABLE 27 Undisturbed forest in Class II reserves

Sampling unit	Timber resource group							
	1		2		3		Total	
	ha	ac	ha	ac	ha	ac	ha	ac
1	82 133	202 952	39 205	96 877	36 315	89 735	157 653	389 564
2	156 590	386 937	26 111	64 522	20 636	50 993	203 337	502 452
3	368 685	911 031	66 349	163 951	120 047	296 640	555 081	1 371 622
5	201 354	497 552	42 205	104 289	2 395	5 918	245 954	607 759
Total	808 762	1 998 472	173 870	429 639	179 393	443 286	1 244 155	3 074 340

The composition of undisturbed Group 1, 2 and 3 timber in the four sampling units is given in Tables 28, 29 and 30 respectively.

Timber Resource Group 1 Table 28 shows that the part of Sampling Unit 5 which falls in the residency, the rugged mountainous country in the south west the Gunong Rara Forest Reserve, carries the highest average total volume and the highest average volume of Dipterocarpaceae. The forest in this sampling unit is rich in red seraya, *urat mata* and yellow seraya, these three timber groups accounting for 68.6% of the total volume. The three timber groups, together with *selangan batu,* are more abundant than in the other sampling units. The lowest average total volume and the lowest average volume of Dipterocarpaceae is found in Sampling Unit 1, the northern part of the residency. In this unit red seraya is the most abundant timber group followed by *keruing* and *kapur.* The volume of *urat mata* is relatively low amounting to only 6.2% of the total while yellow seraya accounts for 9%. The forest in Unit 2, the area around Sandakan Bay and the south-east part of the residency, carries the second highest total volume and volume of Dipterocarpaceae. Red seraya is again the most abundant timber group but accounts for a smaller proportion of the total volume than in the other units; *keruing* is the second most abundant group followed very closely by *kapur*. These two groups together account for a greater proportion of the total volume than in any other unit particularly Sampling Unit 5. *Urat mata* is the fourth most abundant timber group followed by yellow seraya. *Selangan batu* is much less abundant in this unit than any of the others. In Sampling Unit 3, the Kinabatangan area, Dipterocarpaceae form 88.3% of the total volume. Red seraya is the most common timber group accounting for 31.2% of total volume, more than twice that of *urat mata* which is the next most common, followed by *keruing* and *kapur.* In this unit yellow seraya accounts for only 5.6% of total volume. The other commercial species account for no more than 11.7% of total volume in any sampling unit and this is reflected in the insignificant volumes of the species and timber groups. The only one which makes up more than 2% of the total volume is *belian* and that only in Sampling Units 2 and 3. In Unit 1 it is almost non-existent.

Timber Resource Group 2 Table 29 shows that the average total volume of commercial timber varies between 112.3 m^3/ha (1 261 Hft^3/ac) and 90.5 m^3/ha (1 016 Hft^3/ac), with Dipterocarpaceae making up between 81.4% and 87.0% of the total. As indicated, the forest in Sampling Unit 2 carries the highest average total commercial volume and volume of Dipterocarpaceae. The total commercial volume in Units 3 and 5 is similar, while that in Unit 1 is rather less. In Units 3 and 5 red seraya is the most abundant timber group, while in Unit 1 *kapur* is, and in Unit 2 the volume of *keruing* just exceeds that of red seraya. In Sampling Unit 5 *urat mata* is the second most abundant species, while in Units 1 and 2 red seraya is, and in Unit 3 *selangan batu.* It is of interest to note

TABLE 28 Composition of Timber Resource Group 1 in Class II reserves, by sampling units

Main timber species	Sampling unit												Average		
	1			2			3			5					
	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	%	Vol/ha m^3	Vol/ac Hft^3	%
Dipterocarpaceae															
Red seraya	40.0	449	29.2	41.2	463	25.1	45.7	514	31.2	54.2	609	32.3	46.4	521	30.1
Urat mata	8.5	95	6.2	24.5	275	15.0	21.7	243	14.8	39.7	446	23.7	25.4	285	16.5
Kapur	20.6	231	15.0	30.2	339	18.5	18.5	207	12.6	10.7	120	6.4	19.0	213	12.3
Keruing	26.4	296	19.3	30.6	343	18.7	20.0	225	13.7	9.5	107	5.7	20.1	226	13.0
Yellow seraya	12.3	138	9.0	14.7	165	9.0	8.2	92	5.6	21.1	237	12.6	13.1	147	8.5
Selangan batu	14.0	157	10.2	2.0	23	1.2	13.1	147	9.0	14.7	165	8.8	11.5	129	7.5
Melapi	1.7	19	1.2	1.9	21	1.1	0.3	4	0.2	0.6	7	0.4	0.8	9	0.5
Other spp	1.0	13	0.9	0.6	7	0.4	1.9	21	1.2	2.8	31	1.6	1.7	20	1.1
Total	124.5	1 398	91.0	145.7	1 636	89.0	129.4	1 453	88.3	153.3	1 722	91.5	138.0	1 550	89.5
Other commercial spp															
Belian	0.2	3	0.2	4.9	55	3.0	3.4	38	2.3	1.9	21	1.1	2.9	33	1.9
Medang	1.0	11	0.7	1.6	17	1.0	1.5	17	1.0	1.4	15	0.8	1.4	16	.9
Mengaris	0.3	4	0.2	2.7	30	1.6	2.2	25	1.5	1.4	16	0.8	1.9	21	1.2
Other spp of Leguminosae	3.0	33	2.2	2.0	23	1.3	2.9	33	2.0	4.2	47	2.5	3.1	35	2.0
Kedongdong	1.3	14	0.9	0.9	10	0.5	0.7	7	0.5	1.0	11	0.6	0.9	10	0.6
Nyatoh	0.6	6	0.4	0.6	7	0.4	1.1	12	0.8	1.0	11	0.6	0.9	10	0.6
Other spp	5.9	67	4.4	5.3	60	3.2	5.3	60	3.6	3.5	40	2.1	5.0	56	3.3
Total	12.3	138	9.0	18.0	202	11.0	17.1	192	11.7	14.4	161	8.5	16.1	181	10.5
Total all commercial spp	136.8	1 536	100	163.7	1 838	100	146.5	1 645	100	167.7	1 882	100	154.1	1 731	100

that in Sampling Units 1 and 3 *urat mata* is of little importance, while in Unit 5 *kapur* is almost non-existent and there is only a small amount of *keruing*. There is a considerable variation between sampling units in the volume of other commercial species with Unit 2 having the highest as in Timber Resource Group 1, and Unit 3 the lowest. In general the proportion of total volume of individual species and timber groups is insignificant though *belian* does account for 3.6% of total volume in Unit 2 and *medang* 3.4% in Unit 5.

Timber Resource Group 3 Table 30 shows that the average total volume of commercial timber varies between 78.5 m^3/ha (881 Hft^3/ac) and 69.7 m^3/ha (782 Hft^3/ac), with Dipterocarpaceae making up between 69.5% and 80.0% of the total. As indicated, the forest in Sampling Unit 1 carries the highest average total commercial volume and volume of Dipterocarpaceae. This is in marked contrast to Timber Resource Group 1 and Group 2 where it carried the lowest. Units 3 and 5 carry a very similar total and Dipterocarpaceae volume, while Unit 2 carries the lowest total volume and a much lower than average Dipterocarpaceae volume. In Sampling Units 2, 3 and 5 red seraya is easily the most abundant timber group, but in Unit 1 it is marginally exceeded by *keruing*. In Unit 5 *urat mata* is the second most abundant timber group while in Units 2 and 3 *kapur* is second in abundance though closely followed by *urat mata*. *Selangan batu* is the third most abundant timber group in Units 1 and 5. The proportion of other commercial species in the total commercial volume varies from 20.0% to 30.5%. In view of the increased proportion of other commercial species a number of individual species and timber groups do account for more of the total. *Belian* accounts for 2% or more of the total in Sampling Units 1, 2 and 3 though it is completely absent in Unit 5. *Mengaris (Koompassia excelsa)* accounts for 2% in Unit 1 and 5% in Unit 2. *Medang* forms 3.9% of the total in Unit 5. *Nyatoh* makes up 2.1% of the total in Sampling Unit 3.

TABLE 29 Composition of Timber Resource Group 2 in Class II reserves, by sampling units

Main timber species	Sampling unit												Average		
	1			2			3			5					
	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	%	Vol/ha m^3	Vol/ac Hft^3	%
Dipterocarpaceae															
Red seraya	17.6	197	19.4	23.9	269	21.3	22.1	249	23.3	33.4	375	34.8	24.1	271	24.9
Urat mata	4.1	46	4.6	10.6	119	9.4	5.5	61	5.8	12.9	145	13.5	7.8	87	8.0
Kapur	20.5	230	22.7	18.6	209	16.6	9.6	108	10.2	0.4	4	0.4	11.2	126	11.6
Keruing	17.2	193	19.0	24.1	271	21.5	12.0	135	12.6	2.2	25	2.3	12.6	141	13.0
Yellow seraya	6.8	77	7.5	9.2	103	8.2	10.7	120	11.3	12.0	135	12.5	9.9	111	1.1
Selangan batu	5.3	59	5.8	4.3	48	3.8	16.9	190	17.9	12.6	142	13.2	11.4	128	11.8
Melapi	0.6	7	0.7	0.9	10	0.8	1.8	20	1.9	0.6	6	0.6	1.1	12	1.1
Other spp	1.6	19	1.7	1.5	17	1.3	3.8	43	4.0	8.4	95	8.7	4.0	46	4.2
Total	73.7	828	81.4	93.1	1 046	82.9	82.4	926	87.0	82.5	927	84.9	82.1	922	84.4
Other commercial spp															
Belian	0.6	7	0.7	4.1	46	3.6	1.1	13	1.2	0.4	4	0.4	1.3	14	1.3
Medang	1.2	14	1.4	1.8	20	1.6	1.5	17	1.6	3.3	37	3.4	1.9	21	2.0
Mengaris	0.9	10	1.0	1.6	17	1.4	0.3	4	0.3	0.2	3	0.2	0.6	7	1.6
Other spp of Leguminosae	3.5	39	3.8	3.2	37	2.8	2.8	31	3.0	2.0	22	2.1	2.8	31	2.9
Kedongdong	1.0	11	1.1	1.4	16	1.3	0.3	3	0.3	1.4	15	1.4	0.9	10	0.9
Nyatoh	1.9	21	2.1	1.4	16	1.3	1.0	11	1.0	1.4	16	1.5	1.4	15	1.4
Other spp	7.7	86	8.5	5.7	63	5.1	5.3	58	5.6	4.7	53	5.0	5.7	66	6.0
Total	16.8	188	18.6	19.2	215	17.1	12.3	137	13.0	13.4	150	14.0	14.6	164	15.6
Total all commercial spp	90.5	1 016	100	112.3	1 261	100	94.7	1 063	100	95.9	1 077	100	96.7	1 086	100

TABLE 30 Composition of Timber Resource Group 3 in Class II reserves, by sampling units

Main timber species	Sampling unit												Average		
	1			2			3			5					
	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	%	Vol/ha m^3	Vol/ac Hft^3	%
Dipterocarpaceae															
Red seraya	18.7	210	23.9	15.6	175	22.3	19.7	221	26.8	21.1	237	28.7	19.0	213	25.7
Urat mata	3.0	34	3.8	8.7	97	12.5	9.7	109	13.3	15.4	173	20.9	8.3	93	11.3
Kapur	5.6	63	7.1	9.1	102	13.0	10.1	113	13.7	4.4	49	5.9	8.9	101	12.1
Keruing	19.0	213	24.2	7.8	87	11.1	6.4	72	8.7	5.2	58	7.1	9.0	102	12.3
Yellow seraya	5.0	56	6.3	1.6	18	2.4	3.7	41	5.0	1.7	19	2.4	3.7	41	4.9
Selangan batu	8.5	95	10.8	3.7	41	5.3	7.3	82	10.0	8.8	98	11.9	7.2	80	9.7
Melapi	1.2	14	1.6	0.9	10	1.2	0.1	2	0.2	0.3	4	0.4	0.5	5	0.6
Other spp	1.3	15	1.7	1.1	14	1.7	1.6	19	2.3	1.6	19	2.2	1.6	19	2.2
Total	62.3	700	79.4	48.5	544	69.5	58.6	659	80.0	58.5	657	79.5	58.2	654	78.8
Other commercial spp															
Belian	1.6	17	2.0	1.6	18	2.4	1.9	21	2.6	0.0	0	0.0	1.8	20	2.4
Medang	0.8	9	1.0	2.3	26	3.3	1.9	21	2.6	2.9	32	3.9	1.7	19	2.3
Mengaris	1.6	17	2.0	3.5	39	5.0	1.0	11	1.3	1.3	14	1.7	1.4	15	1.9
Other spp of Leguminosae	3.5	40	4.5	3.5	39	5.0	2.5	28	3.5	4.6	52	6.3	2.8	33	3.8
Kedongdong	0.8	9	1.0	0.9	10	1.2	0.9	10	1.2	0.7	8	0.9	0.9	10	1.2
Nyatoh	1.3	15	1.7	0.7	8	1.0	1.6	17	2.1	0.1	2	0.2	1.4	16	1.9
Other spp	6.6	74	8.4	8.7	98	12.6	4.9	56	6.7	5.5	62	7.5	5.7	63	7.7
Total	16.2	181	20.6	21.2	238	30.5	14.7	164	20.0	15.1	170	20.5	15.7	176	21.2
Total all commercial spp	78.5	881	100	69.7	782	100	73.3	823	100	73.6	827	100	73.9	830	100

Disturbed forest in Class II reserves

Relatively small areas of disturbed forest which can still be classified into Timber Resource Groups 1, 2 and 3 occur in these reserves and their distribution is given in Table 31. Considerably larger areas of disturbed forest also occur which cannot be classified into Groups 1, 2 and 3 because of lack of information on the yield. However, as they have been exploited in the past when the tendency was only to work the better forests it is considered that they can justifiably be regarded as having a commercial potential.

TABLE 31 Disturbed forest in Class II reserves, by sampling units

Sampling unit	Timber resource group						Unclassified		Total	
	1		2		3					
	ha	ac	ha	ac	ha	ac	ha	ac	ha	ac
1	0	0	65	160	2 607	6 441	8 769	21 669	11 441	28 270
2	381	942	703	1 737	5 536	13 680	13 678	33 799	20 298	50 158
3	0	0	0	0	7 378	18 231	10 661	26 344	18 039	44 575
5	0	0	0	0	0	0	0	0	0	0
Total	381	942	768	1 897	15 521	38 352	33 108	81 812	49 778	123 003

Regenerating forest in Class II reserves

There are some 168 500 ha (416 150 ac) of regenerating forest in Class II, which because of lack of information on the yield cannot be classified into Timber Resource Groups 1, 2 or 3. However, as it has been exploited it is considered that such forest can also be classified as commercial. Much of this forest will have been given silvicultural treatment, which it is hoped will increase the yield over the next rotation.

Non-commercial forests in Class II reserves

The commercial forest reserves also include approximately 79 000 ha (195 209 ac) of undisturbed lowland dipterocarp forest (Timber Resource Group 4) with an expected yield of less than 35.6 m^3/ha (400 Hft^3/ac).

Also included is non-commercial montane forest (Timber Resource Group 5) which covers some 36 000 ha (88 956 ac). In this forest the average volume of commercial species is only 23.5 m^3/ha (264 Hft^3/ac) of which the Dipterocarpaceae account for 67.3% with yellow seraya and red seraya the most important timber groups. Among the other commercial species *medang* and *nyatoh* are the most important. The average composition of this forest is given in Table 32 where it is grouped with the montane forest in the protection forest reserves.

Other non-commercial forest such as freshwater swamp forest, coastal forest and non-commercial mangrove forest (Group 6) total approximately 55 450 ha (137 000 ac). Areas of regrowth after shifting cultivation, non-forest land and non-productive land (Group 8) account for some 26 900 ha (66 470 ac).

Class III Domestic forest reserves

The object of Class III, Domestic forest, reserves is to supply timber and other forest produce for local requirements. There are only two small domestic forests in the residency the details of which are given in Table 33.

TABLE 32 Composition of montane forest in Class II, Commercial, and Class I, Protection forest, reserves

Main timber species	Vol/ha m^3	Vol/ac Hft^3	%
Dipterocarpaceae			
Red seraya	3.7	42	15.7
Urat mata	1.4	16	6.0
Kapur	0	0	0
Keruing	2.0	22	8.4
Yellow seraya	3.9	44	16.7
Selangan batu	2.3	26	9.9
Melapi	.4	4	1.5
Resak	1.5	17	6.6
Other species	.6	7	2.5
Total	15.8	178	67.3
Other commercial species			
Nyatoh	2.1	24	8.9
Medang	2.3	26	9.8
Leguminosae (all species)	.8	9	3.4
Kedongdong	.2	2	.9
Others	2.3	25	9.7
Total	7.7	86	32.7
Total all commercial species	23.5	264	100

TABLE 33 Timber resource groups in Class III, Domestic forest reserves

Forest reserve	Timber resource group												Total	
	1		2		3		4		6		8			
	ha	ac	ha	ac	ha	ac	ha	ac	ha	ac	ha	ac	ha	ac
Labuk Road	0	0	0	0	81	200	0	0	0	0	36	90	117	290
Jambongan	610	1 508	45	110	534	1 319	465	1 149	20	50	0	0	1 674	4 139
Total	610	1 508	45	110	615	1 519	465	1 149	20	50	36	90	1 791	4 426

The forest in Groups 1, 2 and 3 carries an average volume of commercial timber of 111.8 m^3/ha (1 255 Hft^3/ac). Of this 86.8% comprises species of Dipterocarpaceae with red seraya (27.2%) *keruing* (24.6%) and *kapur* (9.0%) the most abundant timber groups.

Class IV Amenity forest reserves

These reserves are constituted to provide areas for local amenity and for forest research work. There are four amenity forests in the residency including the Kabili-Sepilok Forest Reserve which is of international importance from the point of view of forest research work. The Gum Gum and Sibuga Reserves, which are both very small, are used for trial plantations. Sapa Paya Forest Reserve is an area of botanical and ecological interest. Details of the timber resource groups in these reserves are given in Table 34.

The commercial forest of Groups 1, 2 and 3 carries an average volume of commercial timber of 131.9 m^3/ha (1 481 Hft^3/ac). Of this 87.9% comprises species of Dipterocarpaceae with red seraya (23.1%) *keruing* (20.2%) and *kapur* (17.5%) the most abundant timber groups. Group 4 in the Kabili-Sepilok Reserve is small-crowned forest on sandstone hills while the Group 8 is disturbed forest and regrowth after logging. Group 8 in Gum Gum and Sibuga Reserves is plantation.

TABLE 34 Timber resource groups in Class IV, Amenity forest reserves

Forest reserve	Timber resource group												Total	
	1		2		3		4		6		8			
	ha	ac	ha	ac	ha	ac	ha	ac	ha	ac	ha	ac	ha	ac
Gum Gum	0	0	0	0	0	0	0	0	0	0	48	120	48	120
Kabili-Sepilok	1 846	4 562	550	1 360	510	1 260	474	1 171	12	30	870	2 150	4 262	10 533
Sibuga	0	0	0	0	0	0	0	0	0	0	53	130	53	130
Sapa Paya	308	761	8	20	373	922	0	0	0	0	0	0	689	1 703
Total	2 154	5 323	558	1 380	883	2 182	474	1 171	12	30	971	2 400	5 052	12 486

Class V Mangrove forest reserves

There are only two Class V, Mangrove forest, reserves in the residency, namely, the Elopura Reserve, which includes all the mangrove forest around Sandakan Harbour, and the Sibyte Reserve which covers the mangrove forest on the eastern shoreline of the Sandakan Peninsula; these are indicated on Text Map 2-12. These cover an area of 33 189 ha (82 012 ac), of which 29 800 ha (73 637 ac) is productive mangrove, 3 260 ha (8 055 ac) non-commercial mangrove, 45 ha (110 ac) logged-over mangrove and the balance other forest. The composition of the productive mangrove forest is given in Table 35 (see Plate 2-4).

TABLE 35 Composition of productive mangrove forest in forest reserves*

Species	Vol/ha m^3	Vol/ac Hft^3	%
Bakau (Rhizophora mucronata)	26.2	294	39.2
Bangkita (Rhizophora apiculata)	22.4	252	33.6
Beus (Bruguiera spp)	1.4	15	2.0
Tengar (Ceriops tagal)	5.4	61	8.1
Api-Api (Avicennia spp)	1.1	12	1.6
Prepat (Sonneratia alba)	0.2	2	0.2
Buta-Buta (Excoecaria agallocha)	1.2	13	1.7
Geriting (Lumnitzera spp)	1.6	18	2.4
Other species	7.4	84	11.2
Total	66.9	751	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 and over (diameter measured at 70 cm (2.3 ft) above stump height), to a top diameter of 5 cm (2 in) inside bark. Stem volume includes any merchantable pieces of branchwood of 1.2 m (4 ft) or larger. An allowance of 11.3% has been made for defect.

Virgin jungle reserves (V.J.R.)

Virgin jungle reserves are areas inside other forest reserves (mainly Class II, Commercial forest), which are set aside to remain permanently undisturbed. Their purpose is to serve as samples of the original virgin jungle and as gene-pools for the future when the rest of the primary forest has been disturbed and altered by exploitation. They are used for some aspects of research work particularly that concerned with the composition, structure and growth of the virgin jungle. Their total area in the residency is 7 392 ha (18 265 ac). Details of the timber resource groups are given in Table 36.

TABLE 36 Timber resource groups in virgin jungle reserves in ha (ac)

Timber resource group							Total
1	2	3	4	6	7	8	
3 344 (8 264)	1 433 (3 541)	833 (2 059)	353 (871)	117 (290)	1 206 (2 980)	105 (260)	7 391 (18 265)

TIMBER RESOURCES OF THE STATELANDS

Considerable areas of stateland carry forest, much of which is lowland dipterocarp forest, though there is a substantial area of mangrove forest. Both of these are discussed below. The lowland dipterocarp forests include commercial and non-commercial representatives.

Commercial forest in the statelands

As shown in Table 21 the area of commercial forest on stateland amounts to 536 359 ha (1 325 335 ac) and the distribution by sampling units and timber resource groups is given in Table 37.

TABLE 37 Distribution of commercial forest on stateland by sampling units

Timber resource group	Sampling unit					
	1		2		3	
	ha	ac	ha	ac	ha	ac
1	82 373	203 546	9 553	23 606	166 604	411 683
2	59 234	146 368	3 057	7 555	19 838	49 020
3	58 389	144 281	3 376	8 343	65 055	160 752
Unclassified*	12 969	32 046	13 622	33 659	5 808	14 351
Total	212 965	526 241	29 608	73 163	257 305	635 806

*Disturbed forest which cannot be classified into resource Group 1, 2 or 3 but is nevertheless considered to have a commercial potential

N.B. There is no stateland in that part of Sampling Unit 5 which falls in the Sandakan Residency.

Undisturbed forest

There are approximately 467 500 ha (1 155 200 ac) of undisturbed commercial forest, the average composition of which is given in Tables 38 and 39. It will be seen from the following text that there is considerable variation in the composition of the undisturbed commercial forest of the stateland, although for the purpose of this report sampling units 2 and 3 are treated together.

Sampling Unit 1 Table 38 shows that in Timber Resource Groups 1 and 2 red seraya is the most abundant timber followed by *keruing* and *kapur*. In Group 3 *keruing* is marginally more abundant than red seraya with *selangan batu* third. The forest can be described as red seraya, *keruing, kapur* forest with *selangan batu* an important constituent. The volume of other commercial species does not vary greatly between timber resource groups and the volumes of individual species are generally insignificant, no one exceeding 2% of the total volume. It is of interest to note that in all three resource groups the forest on stateland carries a slightly higher total volume and volume of dipterocarps than the forest in the commercial forest reserves.

TABLE 38 Composition of undisturbed commercial forest on stateland in Sampling Unit 1

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	40.6	456	29.2	27.6	310	29.9	19.1	215	24.1	30.5	342	28.3
Urat mata	8.7	97	6.2	10.2	115	11.1	3.0	33	3.7	7.4	84	6.9
Kapur	16.6	186	11.9	13.9	155	15.0	5.3	59	6.6	12.4	140	11.5
Keruing	28.4	320	20.4	14.2	160	15.4	19.5	219	24.6	21.7	243	20.1
Yellow seraya	12.6	141	9.0	5.2	58	5.6	5.0	57	6.4	8.2	92	7.6
Selangan batu	14.4	162	10.3	4.0	45	4.3	8.8	99	11.1	9.7	109	9.0
Melapi	2.2	25	1.6	.9	10	1.0	1.3	14	1.6	1.5	17	1.4
Other spp	2.1	23	1.5	1.2	14	1.3	1.5	17	1.9	1.7	19	1.5
Total	125.6	1 410	90.1	77.2	867	83.6	63.5	713	80.0	93.1	1 046	86.3
Other commercial spp												
Belian	0.3	4	0.2	0.6	7	0.6	1.6	18	2.0	0.9	9	0.7
Medang	1.5	17	1.1	1.6	18	1.7	.9	10	1.2	1.4	15	1.3
Mengaris	0.3	3	0.2	0.7	8	0.8	1.4	16	1.8	0.7	8	0.7
Other spp of Leguminosae	2.9	33	2.1	3.5	39	3.7	3.6	40	4.4	3.3	37	3.0
Kedongdong	1.3	14	0.9	0.9	10	1.0	0.8	9	1.0	1.0	11	0.9
Nyatoh	0.5	6	0.4	1.3	15	1.4	1.3	15	1.7	1.0	11	0.9
Other spp	6.9	77	5.0	6.6	74	7.2	6.3	71	7.9	6.6	75	6.1
Total	13.7	154	9.9	15.2	171	16.4	15.9	179	20.0	14.8	166	13.7
Total all commercial spp	139.3	1 564	100	92.4	1 038	100	79.4	892	100	107.9	1 212	100

TABLE 39 Composition of undisturbed commercial forest on stateland in Sampling Units 2 and 3

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	47.8	537	31.6	21.9	246	22.4	20.1	226	27.6	38.5	433	30.4
Urat mata	22.7	255	15.0	6.9	77	7.0	9.3	104	12.7	17.9	201	14.1
Kapur	19.8	223	13.1	11.4	129	11.7	9.4	105	12.9	16.5	185	13.0
Keruing	20.8	233	13.7	13.8	154	14.1	6.0	68	8.3	16.4	184	13.0
Yellow seraya	8.8	99	5.8	10.2	115	10.5	3.9	44	5.4	7.7	86	6.1
Selangan batu	11.8	133	7.8	15.3	171	15.6	7.4	83	10.1	11.0	123	8.7
Melapi	0.4	4	0.3	1.6	18	1.7	0.2	2	0.3	0.4	5	0.3
Other spp	2.1	23	1.4	3.4	38	3.5	2.0	22	2.7	2.1	24	1.7
Total	134.2	1 507	88.7	84.5	948	86.4	58.3	654	80.0	110.5	1 241	87.3
Other commercial spp												
Belian	3.4	38	2.2	1.5	17	1.6	1.9	21	2.6	2.8	32	2.2
Medang	1.4	15	0.9	1.5	16	1.5	2.0	22	2.7	1.5	17	1.2
Mengaris	2.2	25	1.5	0.5	5	0.5	0.8	9	1.1	1.7	19	1.4
Other spp of Leguminosae	2.9	33	1.9	2.9	33	3.0	2.1	24	2.9	2.7	31	2.2
Kedongdong	0.7	8	0.5	0.4	5	0.4	1.0	11	1.3	0.8	9	0.6
Nyatoh	1.1	12	0.7	1.0	11	1.0	1.7	19	2.4	1.2	14	1.0
Other spp	5.4	61	3.6	5.4	62	5.6	5.0	57	7.0	5.4	59	4.1
Total	17.1	192	11.3	13.2	149	13.6	14.5	163	20.0	16.1	181	12.7
Total all commercial spp	151.3	1 699	100	97.7	1 097	100	72.8	817	100	126.6	1 422	100

Sampling Units 2 and 3 These two units have been amalgamated as the area in Unit 2 is relatively small and the composition of the forest in the two units is not dissimilar. It can be seen from Table 39 that in all three timber resource groups red seraya is the most abundant timber group followed closely by *keruing* and *kapur*, and the four together make up 73.4% of the total volume. In Group 2 *selangan batu* is the second most abundant timber followed by *keruing* and then *kapur;* in this case the first four make up only 63.8% of the total volume. In Group 3 *kapur* and *urat mata* are more or less equal second in abundance with *selangan batu* third. The first four make up 63.3% of the total volume. The forest in these two units can be described as red seraya, *urat mata, kapur, keruing* forest with *selangan batu* an important component.

Among the other commercial species *belian* contributes more than 2% of the total volume in Groups 1 and 3 and in the latter *medang* and *nyatoh* also. The individual volumes of the other timber species is insignificant.

Comparing tables 38 and 39 it may be noted that in Sampling Units 2 and 3 Group 1 carries a rather higher total commercial volume and Group 3 a rather lower one than in Unit I. The volume of the other commercial species shows greater variation in Units 2 and 3 than in Unit I.

Disturbed forests

Logging of stateland forest under annual and special licences has been very extensive and widespread with the result that there are now large areas of forest which have been either partially or fully exploited. Some 3 627 ha (8 962 ac) have been disturbed by selective logging but can still be classified as commercial forest on the basis of the expected yield. A further area of 28 771 ha (71 094 ac) of disturbed forest cannot be classified on the basis of expected yield, but is nevertheless regarded as having a commercial potential by reason of the fact that it has been exploited. It is unlikely that this would have happened had the original forest carried a stand likely to yield less than 35.6 m^3/ha (400 Hft^3/ac). In addition some 36 500 ha (90 200 ac) have been fully exploited and are now regenerating. Although no information is available about the actual yield it is considered as having a commercial potential for the same reason as given above. Unlike the regenerating forest it will not have received any silvicultural treatment.

Non-commercial forests in the statelands

There are approximately 32 900 ha (81 300 ac) of undisturbed lowland dipterocarp forest (Group 4) in the stateland with an expected yield of less than 35.6 m^3/ha (400 Hft^3/ac) and some 12 400 ha (30 600 ac) of non-commercial montane forest (Group 5). Transitional and beach forest cover approximately 69 000 ha (170 500 ac), freshwater swamp forest approximately 50 800 ha (125 500 ac) and non-commercial mangrove forest mainly nipah palm approximately 60 400 ha (149 250 ac). These together comprise the Timber Resource Group 6. Approximately 83 500 ha (206 300 ac) carries secondary forest following shifting cultivation (Group 8).

Mangrove forests in the statelands

Commercial mangrove forests (Timber Resource Group 7) cover an area of approximately 62 250 ha (153 800 ac) the average composition of which is given in Table 40.

Volumes are calculated in the same way as for mangrove forest in mangrove forest reserves. If comparison is made with Table 35, it will be seen that though the total volume is higher in the forest on stateland, the volume of *bakau* and *bangkita*, the two most important species, is higher in the forest reserves.

TABLE 40 Composition of the productive mangrove forest on stateland (all sampling units)

Species	Vol/ha m^3	Vol/ac Hft^3	%
Bakau (Rhizophora mucronata)	20.8	234	25.4
Bangkita (Rhizophora apiculata)	22.9	258	27.9
Beus (Bruguiera spp*)*	3.3	37	4.0
Tengar (Ceriops tagal)	5.9	66	7.2
Api Api (Avicennia spp*)*	5.6	63	6.8
Prepat (Sonneratia alba)	5.6	63	6.8
Buta Buta (Excoecaria agallocha)	2.8	31	3.4
Geriting (Lumnitzera spp*)*	6.2	69	7.5
Other spp	9.1	102	11.0
Total	82.2	923	100

Water resources

It will have been noted during the discussion on the climate in Part 2 that rainfall is high with an annual average of about 3 120 mm (123 in), which is generally unevenly distributed with a peak in January, and the Labuk Valley having overall the most rain. Loss of surface water by evaporation is high and is probably greatest in the Sandakan area where the pan evaporation for 1968 was 2 029 mm (78.9 in) (Sabah, Malaysia, Drainage and Irrigation Department, 1970). Inland loss appears to be less. Manaf (1974) states that the annual pan evaporation at Telupid on the Labuk River has been measured at 1 585 mm (62.4 in) and at Kuamut on the Kinabatangan River at 1 563 mm (61.5 in). These figures indicate that there is about 60% loss near the coast and around 50% inland.

Even though there has been no systematic water resource survey of the residency, all available information points to the fact that there is a high runoff in the larger valley systems, which have their main catchments in the highlands, while in the lowlands the water catchments are frequently too small to yield permanent supplies of water. The latter effect is well illustrated on the Sandakan Peninsula where the potable supplies for Sandakan Town are obtained from subterranean sources.

The following account has been largely obtained from the hydrological reports on the Labuk Valley and the Kinabatangan Basin produced by the Sabah Drainage and Irrigation Department (Manaf, 1974), the report on the development of the groundwater resources of the Sandakan Town area (Binnie and Partners, 1967), and the geological report on the Sandakan Peninsula (Lee, 1970).

SURFACE WATER

The residency is drained by four of the largest rivers in Sabah which together probably account for well over half of the state's runoff. These are, in order of size, the Kinabatangan, Labuk, Segama and Sugut. While hydrological data are not available for the Segama and Sugut, the information on the Kinabatangan and the Labuk Rivers is likely to be representative for all the main river systems in the residency. The catchments are largely forested, but extensive areas, particularly in the lower reaches, are being logged.

The Kinabatangan Basin covers approximately 12 200 km^2 (4 700 mi^2) with a main river length of about 400 km (250 mi). Except for the upper reaches of the Labau River, a tributary, the basin falls within the residency boundary. The main tributary is the Kuamut with a catchment area of about 3 060 km^2 (1 180 mi^2) and a main channel length of about 160 km (100 mi). The main catchments are found in the Kuamut, Labuk

and Segama Highlands where hydraulic gradients are steep and runoff, estimated at 114-127 cm (45-50 in) per annum, is rapid. To the east of Kuamut the valley opens into a generally broad floodplain which extends to the sea with an estimated average gradient of 1:10 000 (Plate 2-5). Tidal influence extends as far inland as Pintasan when particularly high tides can cause a backing-up effect on the river water, particularly during floods. Acres and Folland (1975) have shown during their soil survey that the main flooding occurs usually between December and March but may occur in November and April; the periodicity of the severest floods appears to be irregular, roughly every 3 to 8 years. Below Pintasan the severest floods may last 2-3 weeks and up to one week above. History has shown that these floods have resulted in the floodplain being untenable for permanent agriculture.

The hydrology of the Labuk follows a similar pattern. The catchment covers an area of approximately 5 750 km^2 (2 220 mi^2) with a main river length of 260 km (160 mi), the source being the southern flanks of Mount Kinabalu. It enters the residency east of Tampias where after passing through a succession of steep, generally narrow, valleys it meanders through a floodplain which continues to the delta. The mean annual rainfall for the catchment is estimated at over 2 500 mm (100 in) with annual runoff varying from about 1 400 mm (56 in) up-river from Telupid to 195 cm (77 in) on the Tungud River.

Details of the runoff of the Labuk and Tungud Rivers as measured at three gauging stations together with the approximate areas of the basins above the gauging stations are given in Table 41.

TABLE 41 Annual runoff for the Labuk and Tungud Rivers

River	Gauging station	Runoff		Approximate area of river basin			
				Above station		Total	
		mm	in	km^2	mi^2	km^2	mi^2
Labuk	Tomboloi	1 424	56.05	2 758	1 065	4 895	1 890
	Porog	1 563	61.62	3 629	1 401		
Tungud	Basai	1 953	76.89	686	265	850	328

Similar to the Kinabatangan, the Labuk has an unenviable history of flooding, episodes of which are described in Manaf's (1974) hydrological report as follows: 'In January 1963 a historical flood occurred and flooded almost a tenth of the total basin with some areas under 15 ft of water. Another flood of higher magnitude occurred in February 1974 and brought disaster to the whole basin, destroying thousands of acres of crops, countless domestic animals, and a family of four ..... The depth of flood water at Pamol Estate was approximately 20 ft or so. Estimated peak instantaneous flood discharge at Porog (down-river from Telupid) was in the region of 300 000 to 400 000 cusecs. Fortunately, the duration of the flood was less than 3 days'. (See Plate 2-6).

In the lowlands most of the catchments are small and not capable of sustained yields, stream flow being intermittent. This has already posed water supply problems in the developing areas, particularly on the Sandakan Peninsula where some agricultural communities located away from the larger streams and rivers rely on roof collection methods. Another method of ensuring permanent water supplies has been the construction of small earth dams. A large earth dam is planned for the Garinono Valley, some 29 km (18 mi) west of Sandakan Town. The estimated minimum daily yield is about 45 500 000 l/d (10 000 000 gal/d) (Sabah, Malaysia, Technical Sub-Committee on Land Capability Classification, 1969). An area of about 1 730 ha (4 270 ac) within the catchment has been gazetted as a reserve in order to ensure a water supply.

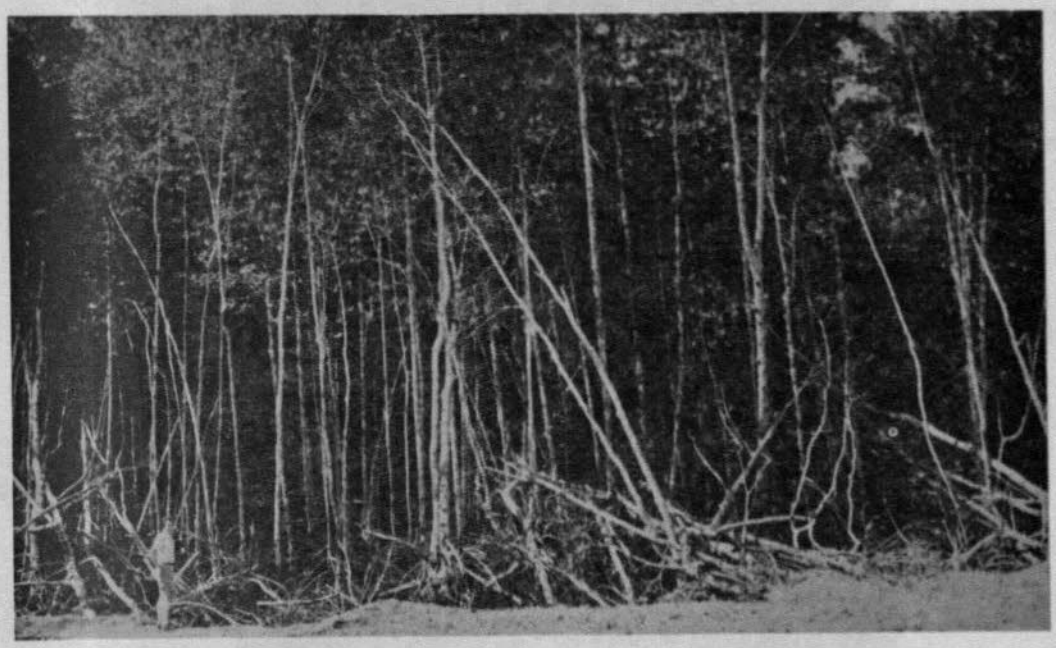


PLATE 2.4 Mangrove forest (*Rhizophora* sp. predominant) near Sandakan

PLATE 2.5 Kinabatangan floodplain

PLATE 2.6
Orang utan in the Sepilok Forest Reserve

PLATE 2.7 Damage to cocoa caused by the flooding of the Sungei Labuk. Rumidi Estate

GROUNDWATER

Generally the country rocks of the residency have a low porosity and permeability and the prospects of developing the groundwater resources are therefore poor. A notable exception, however, is found in the massive sandstone beds which mark the cuesta features on the Sandakan Peninsula, Kuamut Highlands, Bongaya Hills and Jambongan Island. These are likely to store considerable reserves of water. This is well illustrated in the vicinity of Sandakan Town where extensive aquifers have been discovered and which are estimated to be capable of yielding around 18 000 000 l/d (4 000 000 gal/d) (Fu, 1974). Almost all the potable water supplies for Sandakan Town are derived from these sources, and are pumped from a series of wells scattered over an area of about 3 240 ha (8 000 ac). Approximately 2 830 ha (7 000 ac) of the main escarpment has been constituted as a water protection reserve in order to ensure the maximum rate of subterranean percolation of rain water to recharge the aquifers.

In addition to the massive sandstone beds the prospects of important aquifers occurring in the limestone deposits, particularly those marking the Gomantong area, are good.

Grazing resources

There has been increasing interest in recent years in converting forested land and some old plantations into pasture for beef production, but very little use has been made of the land for grazing purposes.

PRESENT GRAZING LAND

Rajah (1973) in his report on animal husbandry in the residency has shown that the total cattle population might be as low as 1 600, with some hundreds of goats and buffaloes. No estimate is given of the extent of the land being grazed, but it is likely to be small and generally restricted to small scattered unimproved pastures adjoining forested land and plantations. The pastures are low quality, composed of native grasses such as carpet grass (*Axonopus compressus*), para grass (*Brachiaria mutica*) and lalang (*Imperata cylindrica*).

POTENTIAL GRAZING LAND

Theoretically, all flat to gently sloping land can be developed as pastures, but a number of factors would normally militate against the use of much of such land in the residency for grazing. The large initial capital expenditure required to prepare logged-over areas of such land might well be prohibitive, and it would appear that initially, at least, the best prospects would be for natural grassland.

The natural grassland covers approximately 22 063 ha (34 514 ac). It will be seen from Table 42 that a substantial proportion of these natural grasslands (8 563 ha, 21 157 ac) are inherently suited for grazing. Much of them occur on land which has already been alienated for agriculture or remains uncommitted as stateland; they are, therefore, readily available for development for grazing purposes. Lalang (*Imperata cylindrica*) is dominant, but as it is a grass of very low nutritional value, it would be imperative to introduce good quality fodder crops as pastures.

In addition to the natural grasslands, a considerable potential for developing improved pastures occurs in the forested land. This would be largely restricted to Land Capability Class II, and by reference to Tables 63a and 63b it can be seen that some 353 266 ha (872 929 ac) may be considered for the purpose.

TABLE 42 Suitability of natural grassland for pasture improvement

Suitability for improved pastures*	Alienated land		Forest reserve		Government reserve		Stateland		Total	
	ha	ac	ha	ac	ha	ac	ha	ac	ha	ac
Good	4 702	11 619	1 092	2 698	91	226	2 678	6 614	8 563	21 157
Medium	1 281	3 165	4 946	12 222	202	500	2 093	5 174	8 522	21 061
Poor	1 053	2 601	1 840	4 548	90	222	1 995	4 925	4 978	12 296

*This is based on a rating for agricultural development:
Good = diversified agriculture (Land Capability Class II0
Medium = restricted agriculture (Land Capability Class III)
Poor = not suited for agriculture (Land Capability Class IV and V)

Game resources

Davis (1962) in his account the 'Mammals of the Lowland Rain-Forest of North Borneo' has described the Bornean forest as 'perhaps the most favourable environment on earth for both plant and animal life. Among the mammals, some of the most generalised of living forms flourish side by side with some of the most specialised'. This is well illustrated by the rich and varied fauna found throughout the residency, where some 130 species of mammals alone have been described, 58 of these being bats (Davis, 1962).

With the continuously increasing spread of logging operations and agricultural development and the disturbance of the natural forest ecosystem, the animal population is continuously changing. Some species are being forced to remoter largely undisturbed areas, others face extinction through hunting, while some species have increased considerably in numbers. All evidence, however, points to the fact that the overall game resources are decreasing.

MAMMALS

The asiatic elephant generally captures the most interest. It has been found almost everywhere in the residency except for the mountainous zone marking the western boundary, which appears to deter further inland penetration (de Silva, 1968). Little is known of its migratory routes, but it probably moves from one area to another on certain trails, avoiding as far as possible the main settled areas and the steeper land. Although relatively abundant, its numbers are probably decreasing. Davis (1962) quotes an account by Pryer (1881) as follows: 'To the south of the Bay of Sandakan vast herds roam the forest'. In 1915 elephants were found 3 km (2 mi) from Sandakan Town while as recently as 1946 a herd of 100 was seen near the 14th milepost on the Labuk Road (de Silva, 1968). Today herds of 20 to 40 are not uncommon particularly in the eastern lowlands, where they have caused considerable damage to oil palm plantations.

The sumatran rhinoceros is rarely encountered but holds a special position in the game population. The declining world population is of considerable concern to wildlife conservationists and the species faces possible extinction. Probably once widely but thinly distributed throughout the residency, its numbers have now declined as the result of hunting, to a situation where reported sitings have been restricted in recent years to the Segama Valley and Dent Hills.

The residency, in common with some other regions of Borneo, probably has one of the richest primate faunas in the world, a total of 12 species having been described within its boundary (Davis, 1962) (for details see Table 43). The largest of these is the orang-utan (see Plate 2-7) which, although still fairly common here, is considered to be an endangered species on a worldwide basis. The greatest known population of these

animals is to be found in and around the Kabilil Sepilok Forest Reserve where a station has been set up for the purpose of releasing captive apes. The gibbon ape is relatively plentiful, and a number of monkey species are found, frequently encountered in large tribes. Of these the crab-eating macaque is probably one of the most common mammals in Borneo (Davis, 1962), which together with the proboscis monkey and the pig-tailed macaque are frequently found in the estuarine swamps. The other primate representatives found include a number of species of primitive primates and shrews, many of which are nocturnal and arboreal, and therefore rarely seen (for further details see Table 43).

Pigs and deer constitute the most popular game animals and provide a significant proportion of the diet of the rural communities. The bearded pig is common in both forested and logged areas, and its numbers appear to be increasing, particularly near cultivated areas in which it causes considerable crop damage. Deer are fairly common in the forests, and being essentially browsing animals also appear to thrive in logged areas, but are more rarely seen in plantations. The four species are given in Table 43.

Wild cattle occur individually or in small herds but as the result of over-hunting their numbers are now greatly depleted and they are rarely encountered, although there are encouraging signs that their population is increasing in the larger logged-over areas, particularly in the Lower Segama Valley.

Three species of cat have been described in the residency (Davis, 1962). The details are given in Table 43. Much the largest of these is the clouded leopard. The related civets and mongooses in the residency provide one of the richest viverrid faunas in the world (Davis, 1962).

Of the carnivores, the Malaysian bear and the hairy-nosed otter are probably of most interest, although rarely seen.

Squirrels are the most common mammals and they are predominantly arboreal. Ten species have been described in the residency (Davis, 1962), three of which are flying squirrels.

There are a great number of bats, of which the world's largest, the flying fox, is the most conspicuous, sometimes as flights of hundreds in loose formation.

Of the large aquatic mammals Fox (1973) reports that the dolphin occurs in Sandakan Harbour and sometimes the lower reaches of its rivers, and the sea-cow is sometimes caught in fish traps.

TABLE 43 The important and more common mammals

Asiatic elephant	*Elephas maximus*
Sumatran rhinoceros	*Didermocerus sumatrensis*
Orang-utan	*Pongo pygmaeus*
Gibbon ape	*Hylobates mulleri*
Crab-eating macaque	*Macaca fascicularis*
Pig-tailed macaque	*Macaca nemestrinus*
Proboscis monkey	*Nasalis larvatus*
Leaf monkeys	*Presbytis* spp. (4 species)
Tree shrew	*Tupaia* sp.
Slow loris	*Nycticebus coucang borneanus*
Tarsier	*Tarsius bancanus*
Bearded pig	*Sus barbatus barbatus*
Sambar deer	*Cervus unicolor*
Barking deer	*Muntiacus muntjak pleiharicus*
Mouse deer	*Tragulus napu* and *T. javanicus*
Wild cattle	*Bos javanicus lowi*
Clouded leopard	*Neofelis nebulosa*
Marbled cat	*Felis marmorata-marmorata*
Leopard cat	*Felis bengalensis borneoensis*
Malay cat	*Viverra tangalunga tangalunga*
Musang	*Paradoxurus hermaphoroditis philippinensis*
Short-tailed mongoose	*Herpestes brachyarus rajah*
Collared mongoose	*Herpestes semitorquatus semitorquatus*
Malaysian bear	*Helarctos malayanus euryspilus*
Hairy nosed otter	*Lutra sumatrana*
Giant squirrel	*Ratufa affinis sandakanensis*
Giant flying squirrel	*Petaurista petaurista rajah*
Flying fox	*Pteropus hypomelanus tomesi*
Dugong (sea-cow)	*Dugong dugon*
Dolphin	*Sousa* sp.

REPTILES

The most important reptiles are the turtles which nest on the group of islands Selingan, Bakkungaan Kechil and Gulisaan, collectively known as the Turtle Islands. Two species are known to nest, the green turtle (*Chelinia mydas*) and the hawksbill turtle (*Eretmochelys imbricata*), while the loggerhead turtle is known to visit the waters (de Silva, 1968). The population is declining as the result of hunting, and the intensive harvesting of the eggs during the past thirty years or so (Sabah, Malaysia, Technical Subcommittee on Land Capability Classification, 1969). A hatchery has been established on Selingan, and there are signs that the numbers of hawksbill turtles are increasing.

The number of crocodiles (*Crocodilus porosus*) is also declining as a result of overhunting. They are now rarely encountered, and are probably restricted to the remoter riverine areas, particularly in the backswamps of the main floodplains. In recent years a number of crocodile farms have been established on the Sandakan Peninsula. The monitor lizard (*Varanus salvator*) is found along most rivers.

Although rarely seen, a large number and variety of snakes are known to occur. Most are small and harmless, although the python (*Python* sp.) and the King Cobra (*Naga hannah*) have been identified a number of times.

BIRDS

There is a rich and varied bird population, but it has not been studied to any great extent. Probably the most comprehensive account available is that given by Fox (1973) for the Kabili-Sepilok Forest Reserve, the bird-life of which is likely to be fairly representative of the residency as a whole. The following account is largely based on Fox's report.

The game-birds are fairly common, the largest being the argus pheasant which is quite plentiful in the forest. Also present is the crested fireback pheasant. Other ground-game include the partridges (see Table 44). Many species of pigeon are found, sometimes in large flocks feeding on fruiting trees, the largest being the green imperial pigeon. Others include the green pigeons. A number of snipe are found, usually in cleared low-lying areas and estuarine flats.

The most spectacular birds of the forest are probably the hornbills, the commonest being *Buceros rhinoceros.*

Economically the most important are the swiftlets which sustain the edible birds-nest industry centred on the Gomantong caves.

The large birds of the coastline include the nomadic Brahminy kite, the white-bellied sea eagle whose numbers are declining (Smythies, 1960), and various gulls and terns. Smythies (1960) states that the megapode breeds in coastal forest in the Sandakan area, but being prized as game it is doubtful whether it exists in any numbers.

TABLE 44 The birds of interest

Great Argus pheasant	*Argusianus argus*
Crested fireback pheasant	*Lophura ignita*
Chestnut-brested tree partridge	*Arborophila charltoni*
Black wood partridge	*Melanoperdix nigra*
Crimson-headed wood partridge	*Haematortyx sanguiniceps*
Green imperial pigeon	*Ducula aenea*
Green pigeons	*Treron capellei* and *T. vernans*
Snipe	*Capella* spp.
Rhinoceros hornbill	*Buceros rhinoceros*
Swiftlets	*Collochalia fuciphaga* and *C. brevirostris*
Brahminy kite	*Haliastur indus*
White-bellied sea eagle	*Haliaetus leucogaster*
White-winged black tern	*Childonias leucoptera*
Megapode	*Megapodius freycinet*

Recreational land resources

At present very little use is made of land for recreation purposes, being confined to the urban sector of Sandakan Town as small-scale developments such as sports fields and a golf course, and some beaches for water-based activities.

With few exceptions, land with a good recreational potential is restricted to the off-shore islands. The coastal waters are usually discoloured and much of the coastline is fringed by mangrove swamp.

In the lowlands recreational pursuits are limited by the hot and oppressive climate and the discolouration of the rivers. The dense vegetative cover restricts movement and viewing. Some of the mountainous regions are spectacular and high enough to provide a significantly cooler climate than the lowlands, but their development potential is severely limited by access problems.

ISLANDS AND BEACHES

Even though it has a very long coastline, much of the residency is fringed by dense mangrove swamp, and beaches when developed frequently merge into mud-flats at or below the tidal zone. This is due to the number of large rivers which discharge along the coast, and result in the waters being discoloured. Some exceptions are to be found, particularly along the Dent coastline running south from Tambisan, where the shelving beaches are clean and sandy and the water generally clear. The sea off the north-west tip of Jambongan Island is also generally clear and there is a small high-quality beach associated with red sandstone cliffs over 30 m (100 ft) high at Tanjong Buli Gantungan. There is a similar beach on the southern shore of Pulau Berhala near Sandakan Town (see Plate 2-8); the red sandstone cliffs are even higher, rising precipitously some 150 m (500 ft), but the water is often discoloured.

The highest quality recreational land occurs in the Turtle group of islands (Plate 2-9). They are of considerable scenic attraction, with clean sandy beaches, fringed by coconut palms and washed by clear seas. There are a number of coral reefs associated with the islands, and the presence of turtles also adds to their attraction. Water-based activities are further enhanced by the presence of game-fish.

MOUNTAINS AND HILLS

There are a number of areas in the Kuamut and Labuk Highlands which are mountainous and spectacular, with altitudes above 1 200 m (4 000 ft), sometimes over 1 500 m (5 000 ft). At such altitudes the temperature is usually below 23°C (75°F), providing a better climate than the lowlands. The most scenic of these are the Maliau Basin, the eastern side of Trus Madi, and the mountains formed by igneous rocks in the Labuk Highlands particularly at Tawai and the Meliau Range. These mountainous zones are intersected by many rivers and streams, stretches of which are of some attraction, particularly along the upper reaches of the Kuamut, Labau, Labuk and Tungud Rivers. These are fast flowing with seasonally clear water, and some waterfalls. The most notable of these falls is at Wasai Mayo on the Kuamut River. Approximately 6m (20 ft) high and 60 m (200 ft) wide, this is the largest in the state (Collenette, 1965). Being largely untouched by human influence the natural history of these mountainous areas is of wide variety and is likely to remain generally unspoilt because they are remote and access is difficult. These constraints, however, will also operate against their development for recreation purposes.

There are also a number of picturesque steepland features in the lowlands. These are more accessible, and will become increasingly so with rural development.

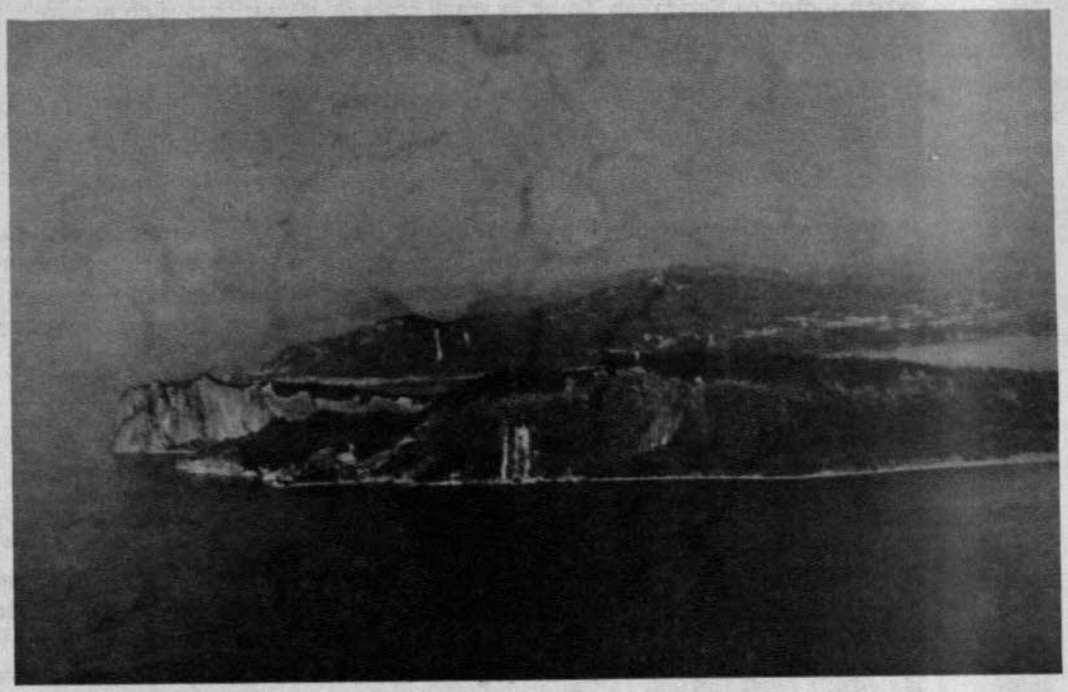


PLATE 2.8 Scenic cliffs and beaches. Pulau Berhala near Sandakan Town

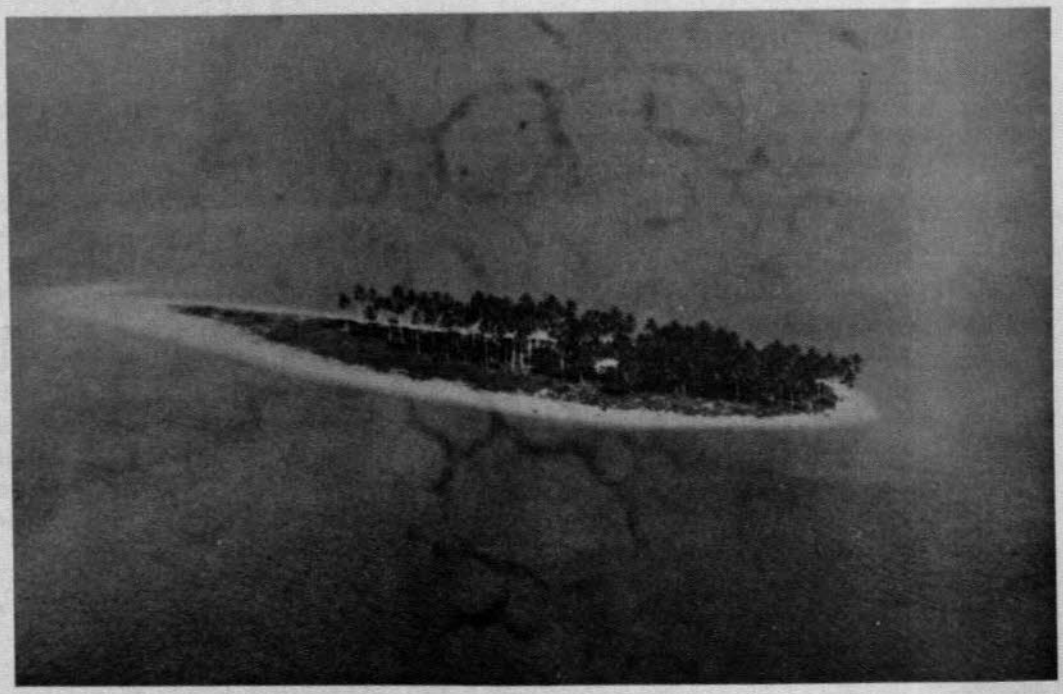


PLATE 2.9 One of the Turtle Islands, which have a considerable recreational potential

The most notable of these are the escarpments near Sandakan Town and close-lying Pulau Berhala. Characterised by long sandstone cliffs which, with the sparsely wooded slopes rising to over 240 m (800 ft), these lead to attractive views over the valleys and ridges of the hinterland and provide good viewing points over the sea and Sandakan Harbour.

The limestone hills and ridges at Gomantong also hold considerable attraction. Some rise sheer to over 210 m (700 ft) above the surrounding land. They are permeated by a number of caves, some of huge dimensions, which are inhabited by vast flocks of swiftlets and bats.

Part 5

Opportunities for resource development

Any discussion on land capability and by inference the future likely course of land development would not be complete without considering the course of events which has given rise to the present land use pattern. Relatively little use was made of the land resources in the past but this picture has been rapidly changing in recent years with development especially timber exploitation, reaching more and more into the remote areas. Considerable resource development opportunities remain, however.

HISTORY OF LAND DEVELOPMENT

Very little is known of the history of Sandakan Residency prior to the nineteenth century. The population distribution was probably similar to that of today, with small scattered villages along the coastal belt and the main rivers, engaged in fishing and some trade, and smaller groups inland sustained by shifting agriculture and the collection of jungle produce. An account by Hunt (Whelan, 1970) in 1812 describes communities on the lower reaches of the Paitan, Sugut, Labuk and Kinabatangan Rivers, together with six villages around Sandakan Harbour and one at Tambisan, which were engaged with trade based on the jungle produce. Probably the main product was the edible birds-nest; together with other commodities such as camphor, wax, rattan, clove-bark, sago, ivory and tree trunks for ships spars.

In the ensuing years, however, piracy took its toll, severely curtailing trade and transporting much of the population into slavery. In the 1870s the situation had reached its head. By 1876 the costal areas were almost uninhabited and the first villages on the main rivers were as far as 96 km (60 mi) from the sea (Haile, 1964), some of the rivers had been deserted, and in 1877 alone 600 natives were sold as slaves to Sulu (Tregonning, 1958). By 1878 all trade had come to a virtual halt, slavery was rampant, and of the communities which once flourised around Sandakan Harbour, only one remained (Tregonning, 1958), in the relative safety of the north-west corner of Sandakan Harbour. In 1879, however, the pirate hold of the east coast was broken (Whelan, 1970) and the ensuing peace and stability formed the basis for the subsequent government control, exploration, development and trade.

The first government station was established in the same year on the present site of Sandakan Town (Folland and Acres, 1972) and rapidly became the main port for the revitalised trade in jungle produce. Government influence rapidly spread along the coast and main rivers, and by 1882 covered remote areas such as Pinangah on the Kinabatangan River, where an administrative station had been established (Folland) and Acres, 1972). During the same period a number of explorers traversed the residency, from Marudu Bay to the Labuk River, between the Kinabatangan River via the Lokan area to Sandakan, and from the Kinabatangan to the Lower Segama River (Haile, 1964).

By 1885 the revival of the export trade was fully established, and jungle produce such as edible birds-nests, rattan, gutta-percha, damar, kapok, illipe nuts, lakka-wood, ivory and crocodile skins were being brought down the rivers and shipped from the new port of Sandakan (Tregonning, 1958). In the meantime a number of attempts were made at cultivating various crops near Sandakan Town. These included sugarcane, tapioca, opium, soyabean, pineapple and manila hemp, all of which failed for a variety of reasons (Tregonning, 1958).

The first successful agricultural enterprise, tobacco, was started in 1883 and by 1890 a number of estates had been established as the result of liberal grants of land, around Sandakan Harbour and along the main rivers (Tregonning, 1958). On the Kinabatangan alone a number of estates were cultivating tobacco on the long stretch between Melapi and Pintasan (Acres and Folland, 1975).

The first export of logs in 1885 (Tregonning, 1958) marked the start of the timber industry and the beginning of the large-scale felling of the forests which has gone on ever since. This was diversified in 1892 when a start was made on felling extensive areas of mangrove forest around Sandakan Harbour in order to sustain a newly established cutch industry.

The first interest in tree crops occurred in the last decade of the century, with rubber, coffee and coconuts. Even though rubber was planted as a trial at 'Bongaya on the River Labuk' (Tregonning, 1958) as early as 1892, the first estates were not established until 1907 when planting was started at the Bode and Sekong Estates south of Sandakan Harbour, along the Kinabatangan at Melapi, Bilit, Lamag and Tangkulap, and on the Sandakan Peninsula (Acres and Folland, 1975). Shortly after rubber planting started at Litang on the Lower Segama. An attempt was made to grow coffee near Sandakan in 1894, but despite government encouragement over the next 40 years it never became an important crop (Tregonning, 1958). In 1900 coconut palms were planted over extensive areas along the coast and some islands, particularly near Sandakan and in Sandakan Harbour (Acres and Folland, 1975).

These burgeoning developments required labour which, as the result of the greatly depleted native population brought about by the effects of slaving, was not available locally. Recourse had to be made to immigrant labour and the first batch arrived in Sandakan as early as 1882. By 1907 over half of the estate labour was non-native (Tregonning, 1958), and this situation has continued ever since in both the agricultural and forestry sector; the shortage of labour had come to stay.

The story of agriculture during the first half of the century is one of stabilisation and then general decline. During the first decade a depression occurred in the once flourishing tobacco industry and in 1913 the last of the estates on the Labuk and Sugut Rivers were abandoned, and by 1929 production ceased on the one remaining tobacco estate, at Batu Puteh on the Kinabatangan (Tregonning, 1958). The vicissitudes of rubber in the remoter areas were similar and production virtually ceased on the estates along the Kinabatangan by about 1921. Small-scale development, however, continued in the hinterland of Sandakan, mainly in the form of smallholdings which today remain largely neglected. Coconuts, never being a large estate crop, survived better; but there has been very little replanting for decades and most of the palms are now approaching senility. Even though some 320 ha (800 ac) of coffee were being grown near Sandakan in 1935 (Tregonning, 1958), the crop today has virtually ceased to have any commercial importance.

Meanwhile, from its start in 1885 the logging industry gradually increased in importance. In 1918 timber licences and leases had been issued for areas in the Labuk and Sugut, the Kinabatangan at Sukau, Kretam, around Sandakan Harbour and also on the Sandakan Peninsula (State of N. Borneo, 1919). Production gradually increased but almost came to a halt during the last war. By 1948, however, the log production was over 190 000 m^3 (5.3 million ft^3) (Colony of N. Borneo, 1949), with the main logging operations being undertaken on the Kinabatangan Lowlands and the Sandakan Peninsula. During the 1950s and 60s these spread considerably, and today timber is being extracted from the broad zone marking the eastern half of the residency from

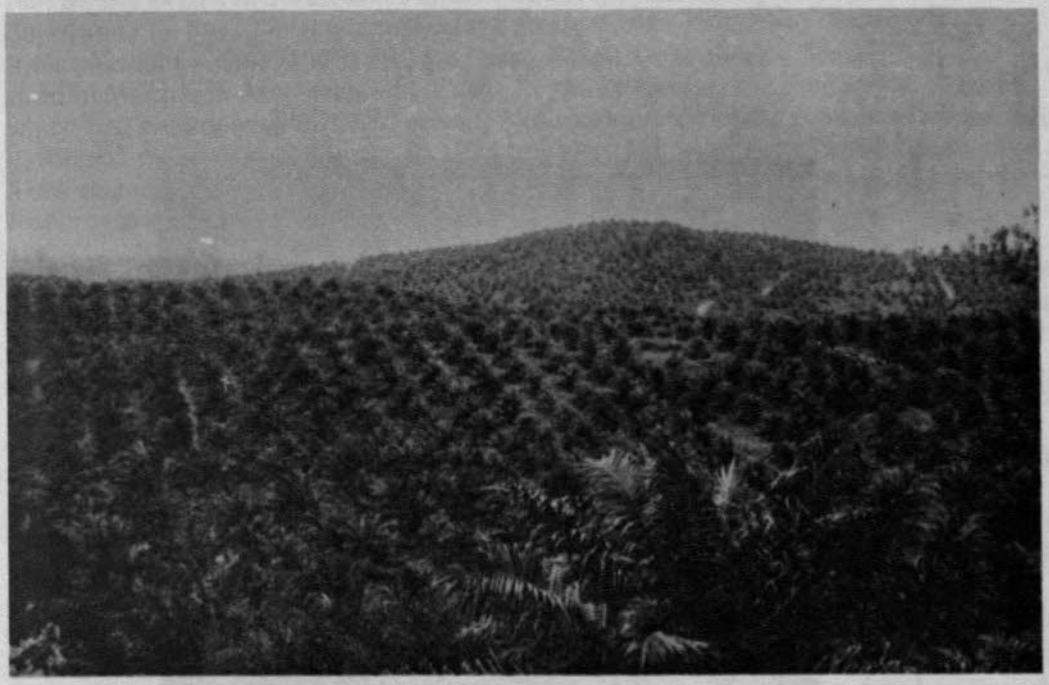


PLATE 2.10 Recent widespread oil palm cultivation on Sandakan Peninsula

PLATE 2.11 An attempt at agricultural development on the Kinabatangan floodplain. Wet padi pilot scheme, Bukit Garam

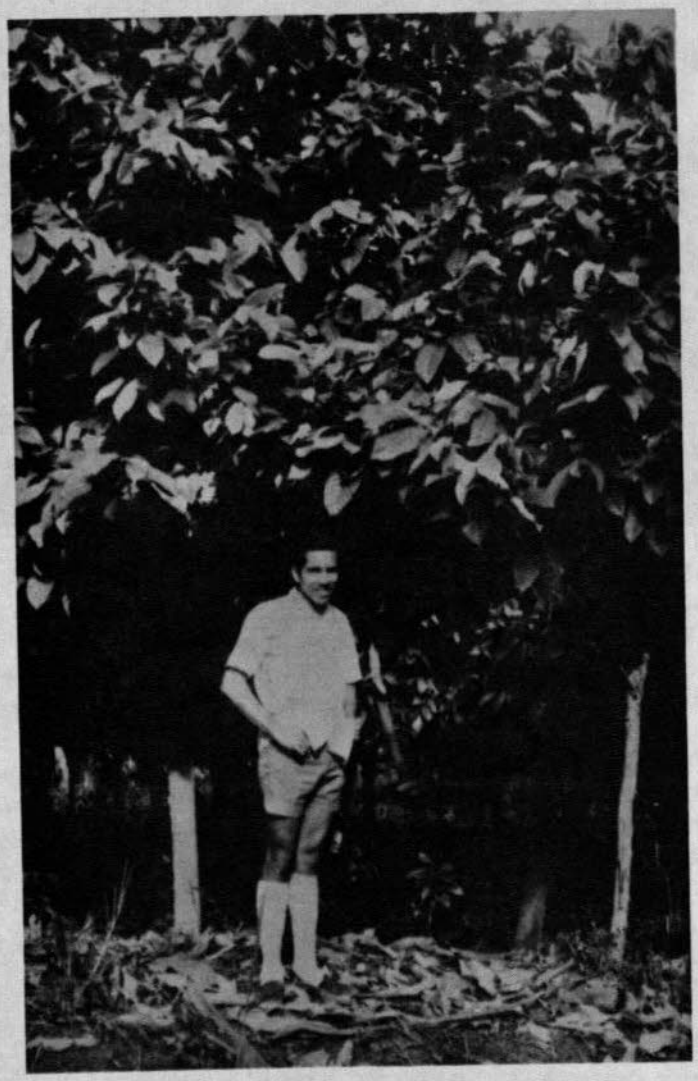


PLATE 2.12 Good cocoa growth, Rumidi Estate, Lower Labuk

Jambongan Island in the north to the Dent Hills in the south. Meanwhile the volume of timber cut has increased enormously, well over 4.5 million m^3 (126 million ft^3) being produced in 1973 (Sabahm Malaysia, Forest Department, 1974). More detailed information on the extent of forest areas under licence, the rate of exploitation and forest policy may be found in the report on the *Sabah Forest Inventory,* (Forestal International Limited, 1973) and the *Sabah Forest Development Study Phase 3,* (Hedlin Menzies & Associates Ltd 1972). In 1962 however, the production of cutch, which had commenced in 1892, ceased, thus marking for a time the end of widespread cutting of the mangrove forests. In 1974 however, following a demand for mangrove as a raw material for wood pulp, extensive areas have been licenced for logging and the mangroves are again being cut for industrial purposes.

Except for the Sandakan Peninsula, logging operations have had very little permanent effect on land development, largely relying on temporary tracks and railways, the rivers and sea for access and transportation. On the peninsula, however, the exploitation of timber has resulted in a fairly good system of roads which are served by the main East-West Highway, and has formed the basis for the agricultural development seen in that area since 1960. This has been largely based on the oil palm, and though the first estate was only established on the Lower Labuk River in 1960 (N. Borneo Department of Agriculture, 1960), a number of plantations were started on the Sandakan Peninsula shortly after, together with one at Suan Lamba, and one at Tomanggong on the Lower Segama River. Today, the oil palm is the most important crop. (Plate 2–10).

Cocoa is also a post-war crop. The first large scale planting started in 1959 at Malabuk on the middle reaches of the Kinabatangan River. Some 240 ha (600 ac) were planted, but these were subsequently abandoned due to flood damage (Folland and Acres, 1975). A second estate was established at Rumidi on the Lower Labuk in 1963, and is now the sole producer of cocoa in the residency. (Plate 2–11).

Throughout these decades of trials with various crops and the ensuing agricultural diversification, the cultivation of the staple food, rice, continued. Based on the practice of shifting cultivation it remains fairly common, occurring sporadically along most of the valley tracts. In an attempt to establish rice growing as a permanent form of agriculture, and with the view of cultivating rice extensively on the alluvial plains, a rice pilot scheme was started in 1968 on the Kinabatangan floodplain at Bukit Garam near Lamag (Plate 2–12). The results are so far inconclusive.

Table 45 gives an account of the present land use. A very high proportion (97.4%) still remains under some form of forest cover, and even with the relatively long history of agricultural enterprise only 1.4% is cultivated. The three main crops are oil palm, rubber and coconuts which represent 37.3%m 18.5% and 8.8% respectively of agricultural land (Siew, 1973).

ALIENATION, GAZETTEMENT AND PRESENT LAND USE

It will have been noted under 'History of land development' that forestry has been by far the most important industry, and that this is related to the extensive areas which have been constituted as forest reserves. This is shown in Table 46 and Figure 2–1, where by far the greatest proportion has been gazetted as forest reserves, 75% of which in the Kinabatangan District. They also indicate that a large area (31.1%) remains uncommitted as stateland, very little (8%) of which occurs in the Sandakan District. Also they show that the land alienated for agriculture is relatively small (5.5%), of which the greatest proportion (56.6%) occurs in the Sandakan District; and the total area reserved for specific government purposes is relatively very small (0.3%) and the greatest proportion again occurs in the Sandakan District, mainly as water protection reserves. The distribution of these various land categories is shown on Text Map 2–14.

TABLE 45 Present land use by districts (1973)

Major present land use categories	District						Residency total	
	Sandakan		Kinabatangan		Labuk & Sugut			
	ha	ac	ha	ac	ha	ac	ha	ac
1 Urban and associated land	1 078	2 664	369	911	432	1 067	1 879	4 642
2 Horticulture	2 689	6 646	935	2 310	1 604	3 963	5 228	12 919
3 Tree, palm and permanent crops	14 497	35 823	3 533	8 731	7 755	19 163	25 786	63 717
4 Annual or rotational crops (shifting cultivation)	385	951	2 357	5 824	5 027	12 423	7 769	19 198
5 Improved permanent pasture	0	0	0	0	0	0	0	0
6 Grassland	6 059	14 972	6 038	14 921	9 968	24 632	22 065	54 525
7F Forest	113 794	281 184	1 329 942	3 286 288	524 178	1 295 243	1 967 914	4 862 715
7S Scrub forest	16 850	41 637	193 569	478 308	134 139	331 458	344 558	851 403
8 Swamp, marshland and wetland forest	59 250	146 407	208 735	515 783	150 179	371 093	418 164	1 033 283
9 Unused and cleared land	3 731	9 220	1 756	4 340	3 368	8 323	8 856	21 883
10 Unclassified land	0	0	0	0	5	12	5	12

TABLE 46 Alienation and gazettement by districts in ha (ac)

District	Land category				Total
	Alienated land	Forest reserves	Government reserves	Stateland	
Sandakan	87 846 (217 068)	55 470 (137 066)	4 693 (11 597)	70 325 (173 773)	218 334 (539 504)
Kinabatangan	24 056 (59 443)	1 327 131 (3 279 341)	3 402 (8 407)	392 645 (970 225)	1 747 234 (4 317 416)
Labuk & Sugut	43 216 (106 786)	385 163 (951 737)	429 (1 061)	407 848 (1 007 793)	836 656 (2 067 377)
Total	155 118 (383 297)	1 767 764 (4 368 144)	8 524 (21 065)	870 818 (2 151 791)	2 802 224 (6 924 297)

By far the greatest areas of forest are contained in the forest reserves, although the stateland holds a very significant proportion of the forests. This is shown in Table 47, the forest reserves and stateland holding 64.3% and 31.2% respectively of the total forested land. The table also shows that of the total of 155 118 ha (383 297 ac) which has been alienated for agricultural purposes, some 116 374 ha (287 565 ac) or 74.8% have not been developed, remaining uncultivated and under forest. Only 26 528 ha (65 551 ac) or 17.1% are cultivated, and their distribution is shown on Text Map 2–15.

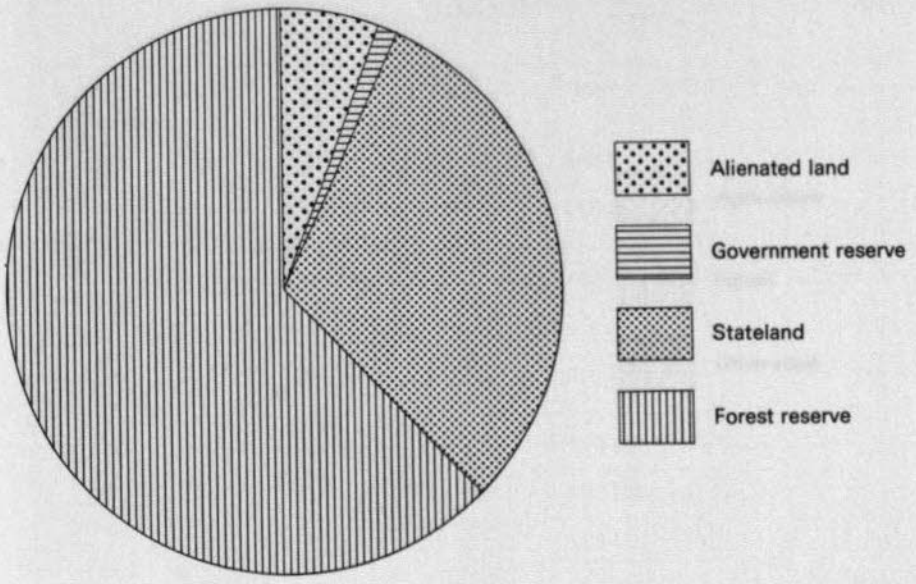
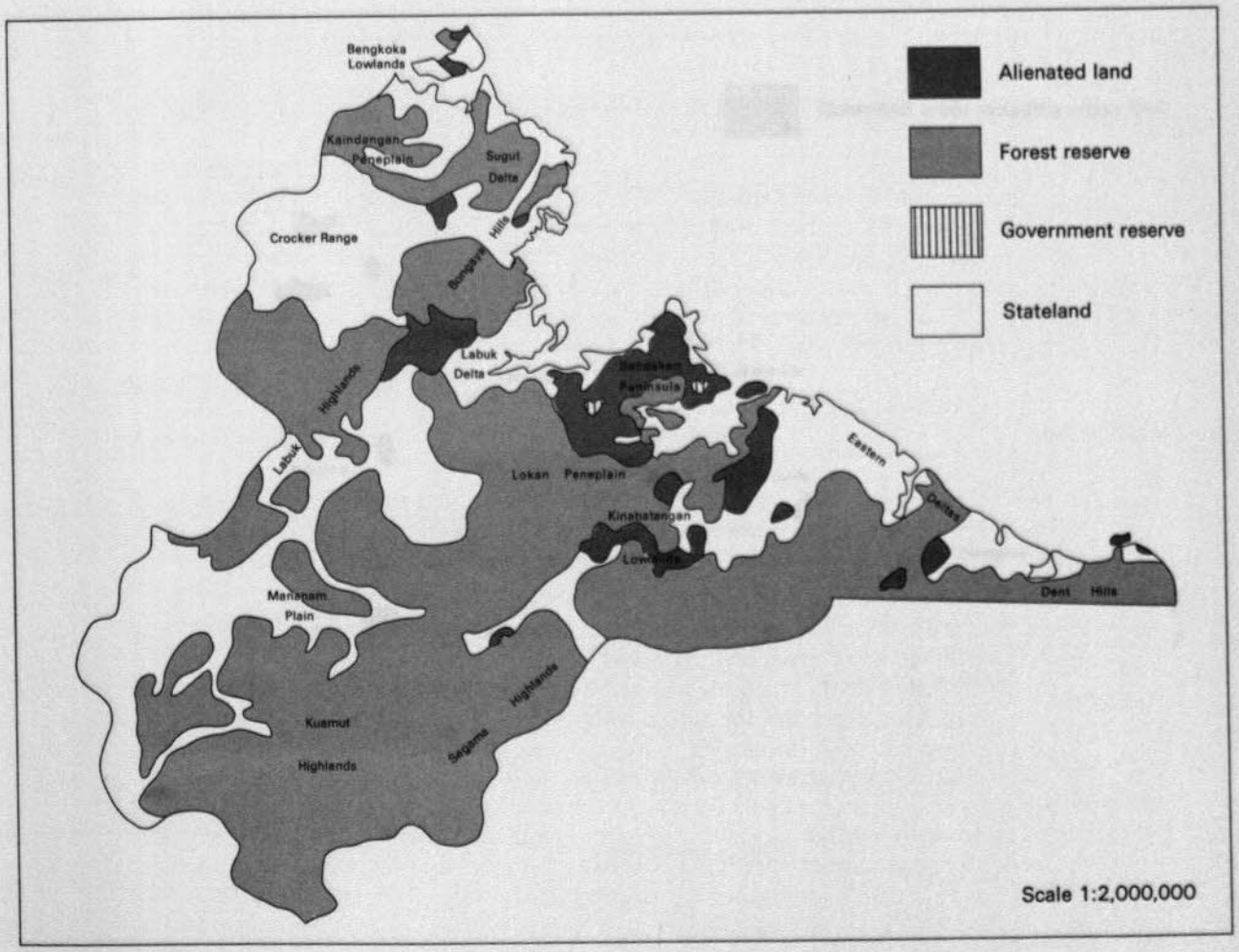


FIGURE 2-1 Alienation and gazettement



TEXT MAP 2-14 Alienation and gazettement

Prepared by the Directorate of Overseas Surveys 1976

TABLE 47 Present land use categories within the land categories

Present land use category	Land category							
	Alienated land		Forest reserve		Government reserve		Stateland	
	ha	ac	ha	ac	ha	ac	ha	ac
1 Urban and associated land	1 040	2 569	258	638	296	732	284	703
2 Horticulture	2 611	6 451	273	690	545	1 347	1 793	4 431
3 Tree, palm and permanent crops	23 189	57 301	1 046	2 584	96	237	1 455	3 595
4 Shifting cultivation	728	1 798	438	1 084	166	411	6 437	15 905
5 Improved permanent pasture	0	0	0	0	0	0	0	0
6 Grassland	7 036	17 385	7 878	19 468	387	956	6 765	16 716
7F Forest	75 437	186 405	1 377 046	3 402 729	3 077	7 603	512 334	1 265 978
7S Scrub forest	19 359	47 836	245 179	605 837	1 813	4 481	78 207	193 249
8 Swamp, marshland and wetland forest	21 572	53 304	133 781	330 573	1 995	4 930	260 816	644 475
9 Unused and cleared land	4 142	10 236	1 838	4 541	149	368	2 727	6 738
10 Unclassified land	5	12	0	0	0	0	0	0

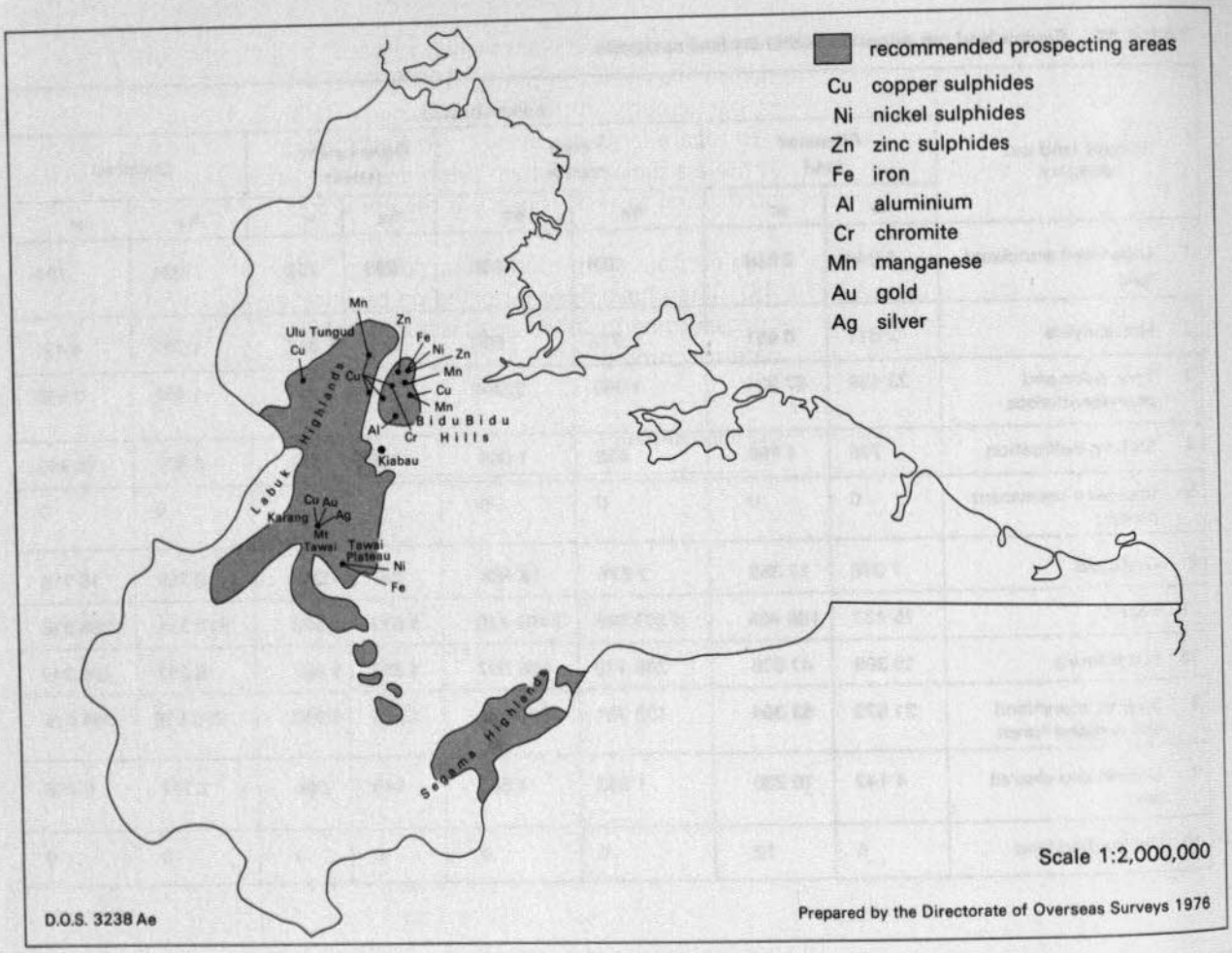
MINING DEVELOPMENT OPPORTUNITIES

The mineral resources have been described in Part 4, and it will have been noted that even though the occurrence of a number of metallic minerals has been proven, their mining is, for a variety of reasons, not considered at present to be economic. It will also have been noted that extensive areas, covering some 235 524 ha (581 871 ac) are considered to be mineralised and worthy of further prospecting. These areas, together with the main known mineral occurrences, are shown in Text Map 2–16. Much of this land has not been prospected, and significant new mineral deposits are likely to be discovered with further investigations.

Possible mining areas

The two most promising areas are the Karang and Porog Prospects, which have been classified as Mineral Resource Group 2, Proven mining land. Even though favourable assay values for copper and iron respectively, have been obtained from these deposits the main constraint to mining is their small size. The prospects for mining in those areas would therefore depend on large ore-bodies being found nearby. An additional factor will be the presence of ancillary minerals which would increase the value of the ore-bodies, particularly gold and silver with the Karang Prospect and copper and possibly chromite with the Porog Prospect.

The Tawai Plateau has the largest known mineral reserves in the residency, but the evidence available indicates that the proportion of iron and nickel is too low for mining. There is also evidence (Wilford, 1968) that the deposits have not been fully investigated, and the prospecting records are incomplete. If economic mineral levels are discovered, severe terrain problems would have to be overcome before mining is fully established on a sound basis. These problems include access, due to the generally precipituous sides of the plateau and water control, due to the swampy nature of the land surface.



TEXT MAP 2-16 Areas worthy of future prospecting, with known main mineral occurences

The lateritic deposits found on the northern part of the Bidu Bidu Hills would appear to have a lower potential for mining. While the iron and nickel contents are of the same order as those on the Tawai Plateau, the reserves are considerably smaller. Access for mining operations however, would not pose such a serious problem and water control would probably be minimal.

The high anomalous copper values described in the alluvium in the Ulu Tungud area (Fitch, 1958) indicate that copper mineralisation exists in the catchment of the upper reaches of the Tungud River. This area has not been prospected, and a comprehensive survey might be rewarding.

Nodules containing manganese are widespread on the Bidu Bidu Hills, and are particularly common in the Bangau Bangau, Sualog and Matapatau Valleys but deposits large enough to sustain mining operations have yet to be discovered. The prospects for the manganese deposits which occur in the fault zone in the Paliu Valley seem better. The best assay values obtained indicate that the mineralised zone might be particularly rich in manganese, but there is no estimate of the extent of the reserves. Further prospecting is clearly necessary in this area.

In view of the high concentration of copper in the soil near Kuala Kiabau, Newton Smith, (1967) has indicated during his survey that further geophysical investigations may be warranted in the area, to ascertain the source of the copper, which is thought to be from underlying sulphide veins. He has shown that these veins might also underly the nearby Porog Prospect with its iron-rich surface deposits. Therefore any prospecting in the Porog area should also take into account the possibility of copper-rich mineralisation in the underlying bed-rock.

Even though copper mineralisation has been shown to occur in a number of other localities in the Bidu Bidu Hills (Newton-Smith, 1967) (in some cases localised deposits are very rich in copper, particularly in the Bangau Bangau Valley), widespread drilling operations have failed to locate large ore-bodies. An electromagnetic survey in the Sualog Valley has nevertheless shown that high sulphide mineralisation is likely to occur in two fracture zones, and drilling to test its grade is recommended (Newton-Smith, 1967).

The other deposits which contain aluminium, zinc, gold and silver all occur in the Bidu Bidu Hills (see Table 48). They have been reported on by Newton-Smith (1967), who considers that further prospecting in those areas is not considered warrantable, the reserves being inadequate for mining.

TABLE 48 Areas with proven mineralisation

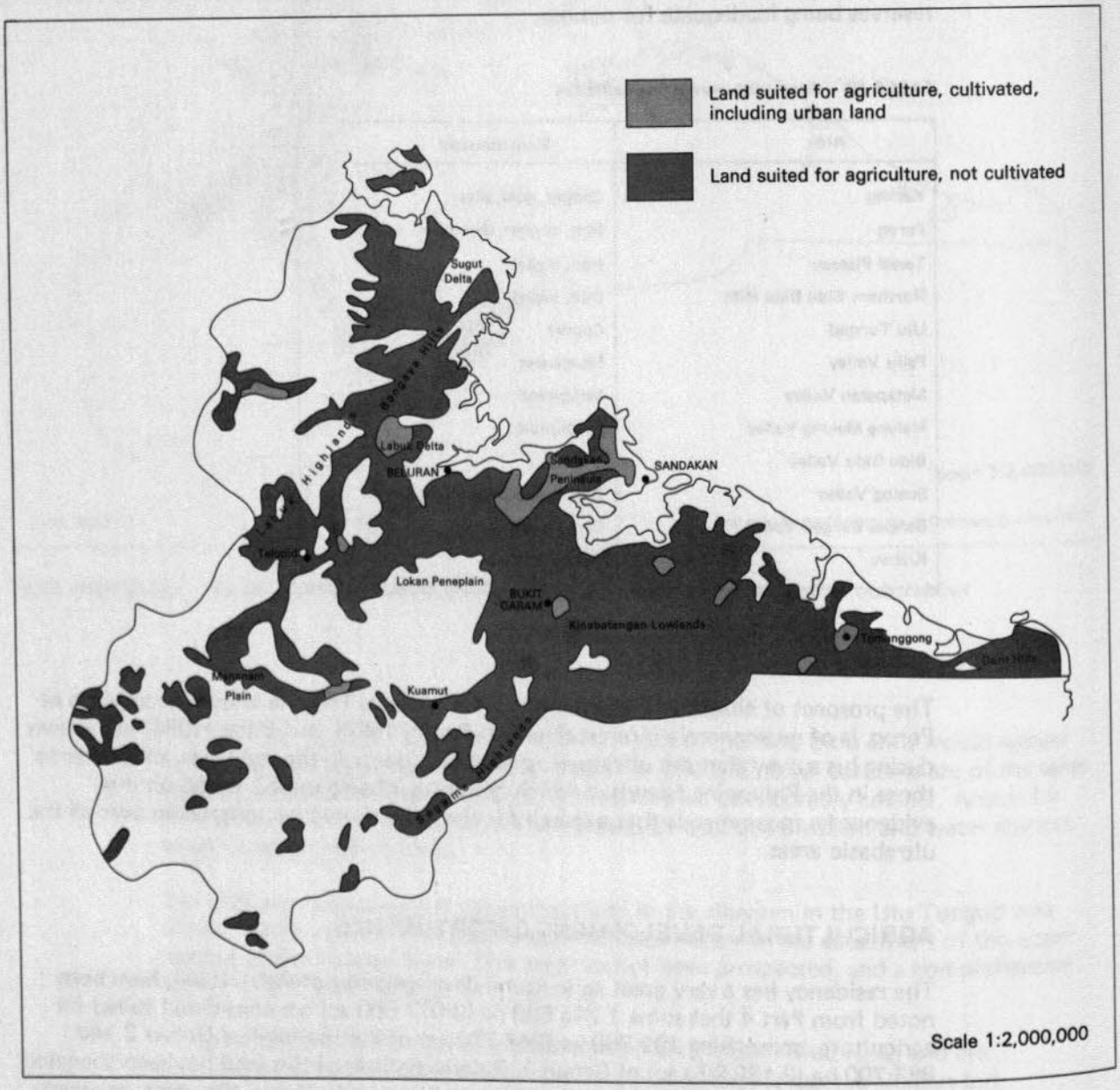
Area	Main minerals
Karang	Copper, gold, silver
Porog	Iron, copper, chromite
Tawai Plateau	Iron, nickel
Northern Bidu Bidu Hills	Iron, nickel
Ulu Tungud	Copper
Paliu Valley	Manganese
Matapatau Valley	Manganese
Malung Malung Valley	Aluminium
Bidu Bidu Valley	Zinc
Sualog Valley	Copper, manganese, zinc, silver
Bangau Bangau Valley	Copper, manganese, gold, silver
Kiabau	Copper

The prospect of chromite being mined is very remote. The one known occurrence at Porog, is of no economic interest (Newton-Smith, 1967), but Fitch (1958) has shown during his survey that the ultrabasic rocks which occur in the residency are similar to those in the Philippine Islands in which chromite is being mined. Based on this evidence he recommends that a search for chromite should be undertaken over all the ultrabasic areas.

AGRICULTURAL DEVELOPMENT OPPORTUNITIES

The residency has a very great agricultural development potential. It will have been noted from Part 4 that some 1 245 500 ha (3 077 600 ac) are considered suited for agriculture, comprising 382 300 ha (944 700 ac) of Soil Suitability Group 2 and 863 200 ha (2 132 900 ac) of Group 3. Relatively little of this land has been alienated and most is contained in the forest reserves and stateland (Table 49). Also, relatively little of the soil resource has been developed and cultivated. This is shown on Text Map 2–17 and illustrated by Figure 2–3.

The agricultural development of the soil resource will depend on a number of factors, such as the availability of manpower, access and communications, but the order in which it is undertaken should primarily be related to the legal status of the land in the following order: alienated land before stateland, and both before forest and government reserves. The question of the quality of the land should also be considered in conjunction with the legal status; hence, ideally the better soils (Soil Suitability Group 2) should be developed before Group 3 land.



TEXT MAP 2-17 Areas suitable for agriculture and the extent of their development

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TABLE 49 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	Stateland	
Diversified agriculture	Group 2	Class II	79 054 (195 343)	190 918 (471 759)	2 016 (4 982)	110 144 (272 166)	382 132 (944 250)
Restricted agriculture	Group 3	Class III	56 762 (140 260)	584 251 (1 443 685)	5 182 (12 806)	216 963 (536 116)	863 158 (2 132 867)
Not suited for agriculture	Groups 4 and 5	Classes IV, V and I	19 301 (47 694)	992 594 (2 452 700)	1 326 (3 277)	543 711 (1 343 509)	1 556 932 (3 847 180)

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. 27.

Alienated land

Over 81% of the land alienated for agriculture is suited for the purpose. This comprises a total of some 125 800 ha (335 600 ac), consisting of approximately 79 050 ha (195 350 ac) of Soil Suitability Group 2 and 56 760 ha (140 260 ac) of Group 3 (Table 50).

TABLE 50 Present land use and agricultural suitability of alienated land in ha (ac)

Agricultural suitability	Present land use categories*												
	Cultivated				Sub-total	Non-cultivated							Sub-total	Total
	2	3	4	5		1	6	7F	7S	8	9	10		
Diversified agriculture	1 363 (3 367)	14 413 (35 616)	142 (351)	0	15 918 (39 334)	455 (1 125)	4 702 (11 619)	39 434 (97 441)	10 857 (26 827)	4 678 (11 559)	3 010 (7 438)	0	63 136 (156 009)	79 054 (195 343)
Restricted agriculture	494 (1 221)	6 745 (16 669)	431 (1 065)	0	7 671 (18 955)	207 (511)	1 281 (3 165)	28 666 (70 833)	5 883 (14 537)	12 244 (30 256)	810 (2 003)	0	49 091 (121 305)	56 762 (140 260)
Not suitable for agriculture	754 (1 863)	2 030 (5 016)	155 (382)	0	2 939 (7 261)	738 (933)	1 053 (2 601)	7 337 (18 131)	2 619 (6 472)	4 650 (11 489)	322 (795)	5 (12)	16 363 (40 433)	19 302 (47 694)
Total	2 611 (6 451)	23 189 (57 301)	728 (1 798)	0	26 528 (65 550)	1 040 (2 569)	7 036 (17 385)	75 437 (186 405)	19 359 (47 836)	21 572 (53 304)	4 142 (10 236)	5 (12)	128 590 (317 747)	155 118 (383 297)

*See Table 47

The rate of agricultural development has, however, fallen far behind that of alienation. By reference to Table 50 it can be seen that only 15 918 ha (39 334 ac) of the Group 2 and 7 671 ha (18 955 ac) of the Group 3 soils are cultivated. Thus it can also be seen that only 17.4% of the land suited for agriculture and alienated for the purpose is being farmed, and that a considerable soil resource remains unused in the alienated land.

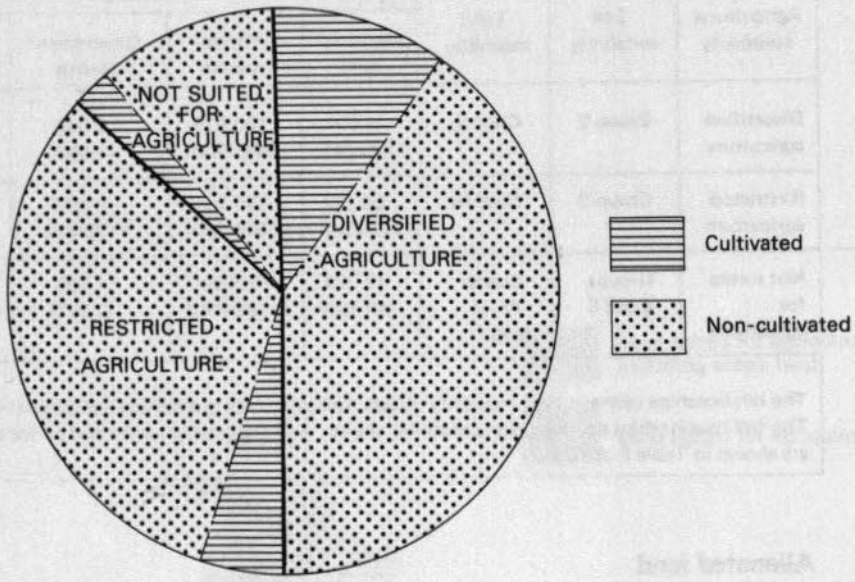
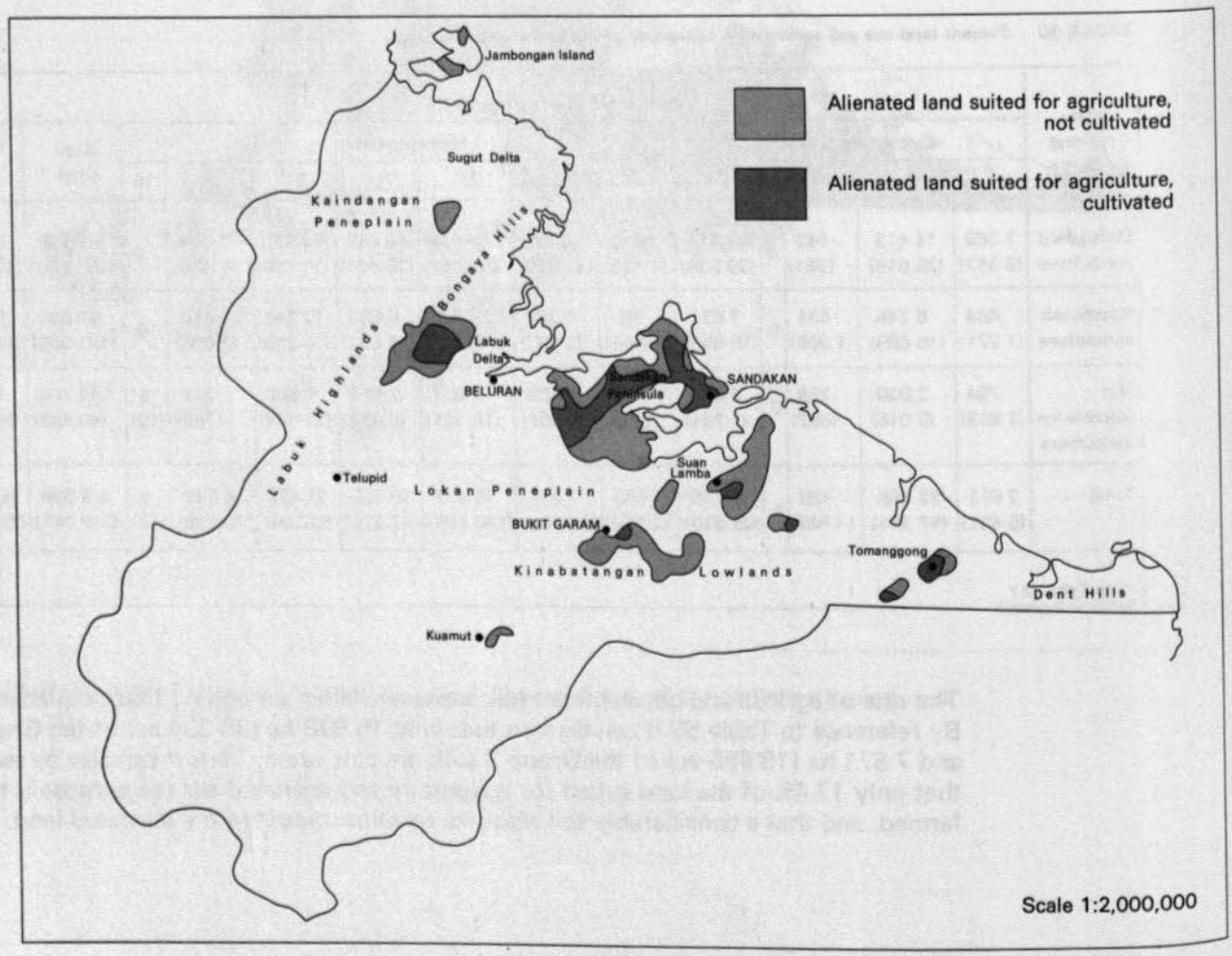


FIGURE 2-3 Soil suitability of the alienated land and its agricultural development



TEXT MAP 2-18 Suitability of alienated land for agriculture

Prepared by the Directorate of Overseas Surveys 1976

Table 51 gives an account of the main alienated areas with a remaining agricultural development potential.

TABLE 51 The main alienated areas with a remaining agricultural development potential

Agricultural suitability	Region	Area	Soil		Extent	
			Landform	Parent material	ha	ac
Diversified agriculture	Sandakan Peninsula	E to W continuous belt	Gently sloping hills	Sedimentary rocks	21 900	54 000
	Kinabatangan Lowlands	Suan Lamba			8 100	20 000
		Bode			5 300	13 000
	Sugut Delta	Jambongan Island			2 000	5 000
	Lokan Peneplain	Beluran			1 600	4 000
Restricted agriculture	Kaindangan Peneplain	Sungei Sungei	Strongly sloping hills		2 800	7 000
	Sandakan Peninsula	Samawang			2 00	5 000
	Kinabatangan Lowlands	Suan Lamba			8 100	20 000
		Bode			5 700	14 000
		Kinabatangan Valley	Riverine plains	Alluvium	6 900	17 000

The agricultural development of many of these areas is difficult because of poor access, which is largely dependant on sea and river communications.

This constraint, however does not appertain to the Sandakan Peninsula in which the greatest single potential of this category exists. The Peninsula is well served by the East-West Highway which runs along its spine, and it is of easy access to the port and other services of Sandakan Town. Apart from the Kabili-Sepilok and other small forest reserves almost all the Peninsula has been alienated. It will be seen from Table 52 that only a small proportion, 25.7%, of the land has been developed. It would seem, therefore, that priority should be given to agricultural development in that area.

TABLE 52 Cultivation of land suited and alienated for agriculture on the Sandakan Peninsula

Agricultural suitability	Cultivated		Non-cultivated		Total		% cultivated
	ha	ac	ha	ac	ha	ac	
Diversified agriculture	8 072	19 947	22 224	54 917	30 297	74.864	26.6
Restricted agriculture	1 085	2 682	4 196	10 396	5 293	13 078	20.5
Total	9 158	22 629	26 432	65 313	35 589	87 942	25.7

The same applies to the adjacent Bode and Beluran areas, where even less development has taken place.

Stateland

The stateland holds a considerable agricultural soil resource. Approximately 26.3% of all the land suited for agriculture occurs in the stateland. By reference to Table 49 it can be seen that 327 107 ha (808 282 ac), or 37.6% of the stateland is suited for agricultural development. This is illustrated by Figure 2–4, and the distribution shown on Text Map 2–19.

Soil Suitability Group 2 in stateland

The Group 2 soils of the stateland would normally be the first considered for development. There are 100 144 ha (272 166 ac) available as shown in Table 49. The main areas are listed in Table 53 and the general distribution is shown in the land capability classification map.

The prospects for early agricultural development of the soil resources of the Telupid, Segaliud and Beluran areas are particularly favourable. All are within fairly easy reach of the East-West Highway. Recently, there has been considerable agricultural interest in them, and it is likely that most of the land will be formally alienated in the near future.

The immediate development prospects for the Lower Lokan valley are not as good. The areas with Group 2 soils occur within 13 km (8 mi) of Bukit Garam, which has recently been connected with the East-West Highway and the Sandakan road-system, but individual areas are generally small, rarely more than 800 ha (2 000 ac), and unless the possibility of acquiring for agricultural purposes neighbouring land in forest reserves is contemplated, their road connection to Bukit Garam would seem to warrant relatively low priority.

A similar road construction would be required to facilitate development in the Kiabau area. This might be done by establishing a road link along the Labuk Valley to connect Pamol and Telupid, or initially by extending the road system from the estates on the Lower Labuk.

TABLE 53 The main areas of Group 2 soils occurring in the stateland

Region	Area	Soil		Extent	
		Landform	Parent material	ha	ac
Labuk Highlands	Telupid	Gently sloping hills	Alluvium	16 200	40 000
	Kiabau			2 000	5 000
Kinabatangan Lowlands	Suan Lamba – Sukau		Sedimentary rocks	10 100	25 000
	Malua			4 000	10 000
	Tenegang			3 700	9 000
	Segaliud			3 200	8 000
Kaindangan Peneplain – Sugut Delta	Kaindangan			7 700	19 000
	Jambongan Island			5 300	13 000
	Paitan			4 900	12 000
	Sugut Valley	Riverine plains	Alluvium	3 600	9 000
Crocker Range	Kaingaran	Gently sloping hills	Sedimentary rocks	6 500	16 000
Lokan Peneplain	Beluran			3 200	8 000
	Lower Lokan Valley			1 200	3 000
Dent Hills	S of Tambisan			2 000	5 000

The prospect of connecting the Suan Lamba-Sukau area with the trunk road system seems at present remote. It will ultimately depend on the construction of an easterly spur-road from the projected Sandakan to Lahad Datu road, a distance of about 40 km (25 mi). Until this is done development will have to depend on the somewhat tenuous seaklink from Suan Lamba to Sandakan, and also a feeder road-system emanating from Suan Lamba;

The periphery of the Kaingaran area is already connected with the Ranau roadsystem and the East-West Highway. Even though designated as stateland, much of the area is inhabited and subject to shifting cultivation. The establishment of largescale agriculture,

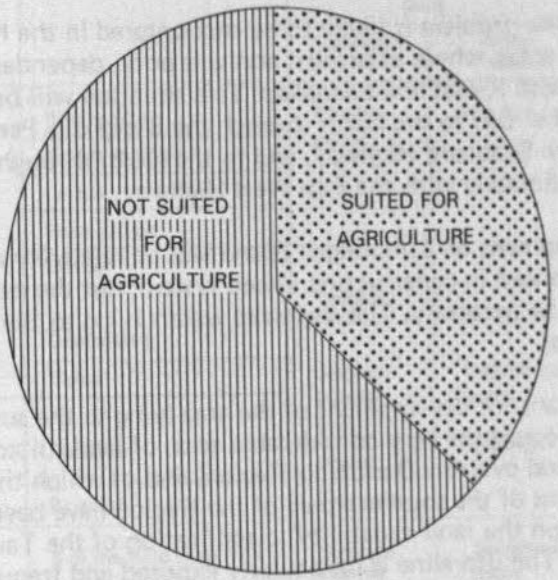
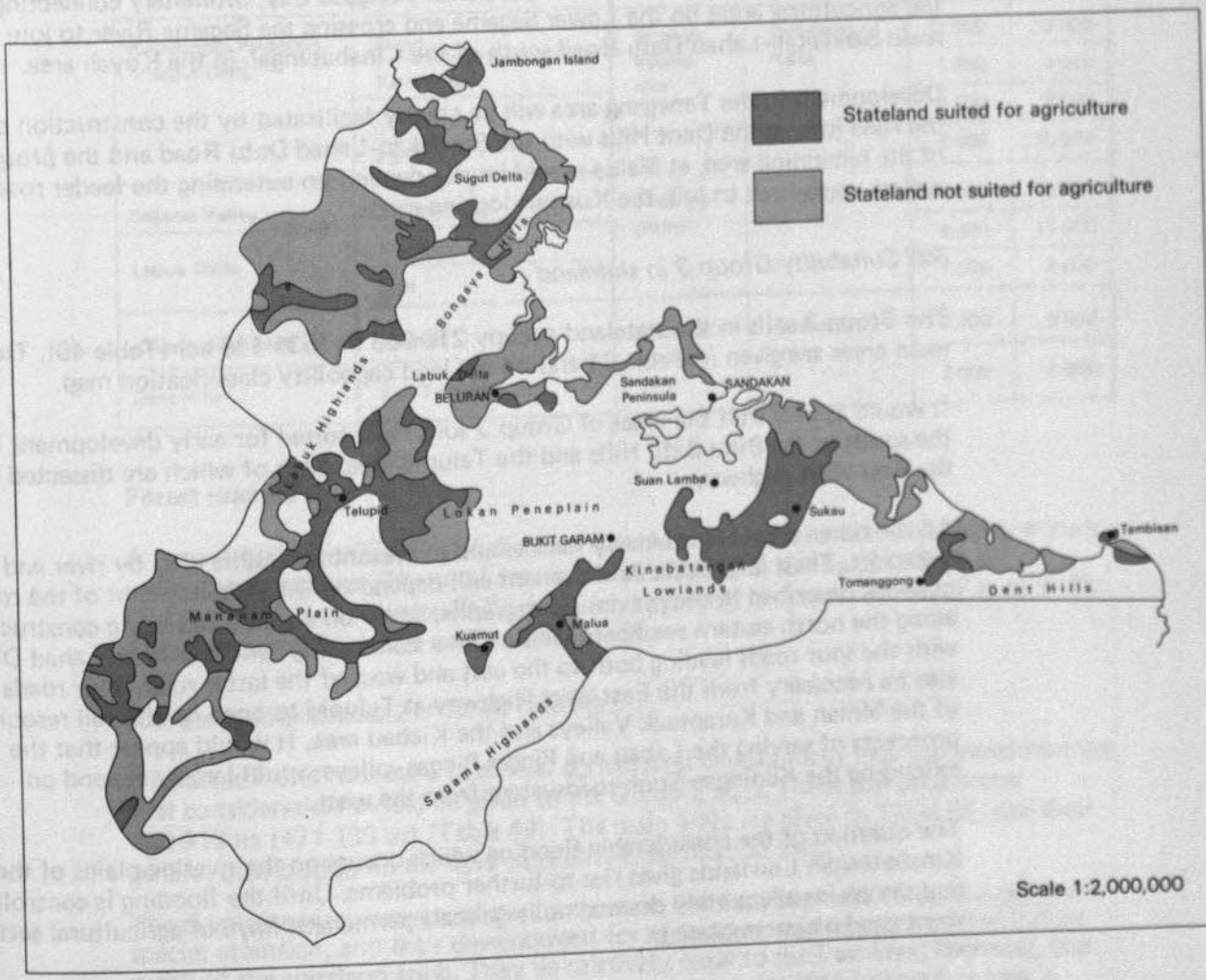


FIGURE 2-4 Suitability of stateland for agriculture



TEXT MAP 2-19 Suitability of stateland for agriculture

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particularly on a plantation basis, will therefore have to take into account the customary rights to the land of the local people.

A similar problem is likely to be encountered in the Kaindangan, Paitan and Sugut valley areas, where at present access is poor, dependant largely on water communications with Kudat and Sandakan. This situation will be greatly alleviated by the contruction of a road to the north through the Bengkoka Peninsula connecting with the Western-Seaboard Highway, and to the south through the estates on the Lower Labuk and ultimately with the East-West Highway.

Development on Jambongan Island will be relatively easy; no undue difficulty would be experienced in constructing a road system, but the establishment of shipping facilities would be necessary. The sheltered waters lying to the south of the Island may serve the purpose.

Any plans for development of the area lying to the south of Tambisan will have to take into account the very considerable areas of land suited for agriculture which are found in general over the Dent Hills Region, and of which this area forms a part. The access problems of the southern part of the Region have been discussed in the companion report on the land capability classification of the Tawau Residency in which it is stated 'The shoreline is particularly exposed and frequently storm-bound, and the development of adequate port facilities may well be found impossible. The development of this area may largely depend on constructing some 58 km (36 mi) of main road to link with the Lahad Datu road system and its port. In so doing, settlement of the extensive areas of other land suited for agriculture in the Dent Hills would be facilitated.' In order for the Region to be fully developed an additional road link will be found necessary running to the west, south of Tungusu Bay, ultimately connecting with the agricultural areas on the Lower Segama and crossing the Segama River to join the main Sandakan-Lahad Datu Road south of the Kinabatangan in the Koyah area.

Development in the Tenegang area will be greatly facilitated by the construction of the road joining the Dent Hills with the Sandakan-Lahad Datu Road and the prospects of the remaining area, at Malua would largely depend on extending the feeder road system westwards to join the Kuamut logging-roads.

Soil Suitability Group 3 in stateland

The Group 3 soils in the stateland occupy 216 963 ha (536 116 ac) (Table 49). The main areas are given in Table 54 and on the land capability classification map.

It would appear that the areas of Group 3 soils most suited for early development lie to the south of the Bidu Bidu Hills and the Telupid area, both of which are dissected by the East-West Highway.

All the other areas are relatively remote and at present accessible only by river and sea transport. Their large-scale development will depend on the establishment of the road-network described in the previous paragraphs; based on a trunkroad being constructed along the north-eastern sea-board, and another connecting Sandakan with Lahad Datu, with the spur roads leading both to the east and west of the latter road. Spur roads will also be necessary from the East-West Highway at Telupid to open-up the soil resources of the Milian and Karamuak Valleys and the Kiabau area. It would appear that the prospects of serving the Labau and Pingas Pingas valleys would largely depend on extending the Keningau-Sook roadsystem from the west.

The question of the considerable flooding which occurs on the riverine plains of the Kinabatangan Lowlands gives rise to further problems. Until the flooding is controlled and the plains adequately drained no large-scale permanent form of agricultural settlement can be contemplated.

TABLE 54 Main areas of Group 3 soils occurring in the statelands

Region	Area	Soils		Extent	
		Landform	Parent material	ha	ac
Kinabatangan Lowlands	Bilit to Abai	Riverine plains	Alluvium	29 500	73 000
	Koyah to Bilit			28 300	70 000
	Lamag			4 500	11 000
	Suan Lamba			2 400	6 000
	Lamag	Terraces		1 600	4 000
	Gomantong			1 600	4 000
	Malua	Strongly sloping hills	Sedimentary rocks	6 000	15 000
Milian Valley	Mananam			3 600	9 000
				23 000	57 000
		Plains	Alluvium	1 600	4 000
	Pinangah	Terraces		3 200	8 000
Lokan Peneplain	S of the Bidu Bidu Hills	Strongly sloping hills	Sedimentary rocks	21 000	52 000
Labuk Highlands	Labau Valley		Alluvium	18 200	45 000
	Pingas Pingas Valley			2 400	6 000
	Telupid	Terraces		2 400	6 000
	Karamuak Valley			2 000	5 000
Kaindangan Peneplain – Sugut Delta	Sugut	Strongly sloping hills	Sedimentary rocks	12 900	32 000
	Kaindangan			1 600	4 000
	Paitan			3 200	8 000
Segama Valley	Tomanggong	Riverine plains	Alluvium	4 000	10 000
Labuk Delta	Klagan			4 900	12 000
	Sapi			4 500	11 000
Kuamut Highlands	Kuamut	Strongly sloping hills	Sedimentary rocks	1 600	4 000
Dent Hills	S of Tambisan			3 200	8 000
				2 000	5 000

Forest reserves

A large proportion (62.2%), of the land suited for agriculture in the residency occurs in the forest reserves. The total area is estimated as 775 169 ha (1 915 44 ac) (Table 49). This represents 43.8% of all land gazetted as forest reserves (Figure 2–5). The distribution is shown on Text Map 2–20.

Soil Suitability Group 2 in forest reserves

When it is found necessary to extend agricultural development into the forest reserves first consideration should be given to the Group 2 soils. These comprise some 190 918 ha (471 159 ac) (Table 49). The main areas are given in Table 55, and their general distribution on the land capability classification map.

The development prospects of the Lungmanis, Beluran, Sapi and Telupid areas merit special attention, and their development for agriculture might be considered before many of the stateland areas. They lie relatively close to the East-West Highway, and already a logging-road infrastructure exists in many parts. The Lungmanis area is particularly well served, with the recently completed road to Bukit Garam skirting its eastern boundary. They are also favourably located to facilitate the logical expansion of agricultural settlement which is occurring on the adjacent Sandakan Peninsula.

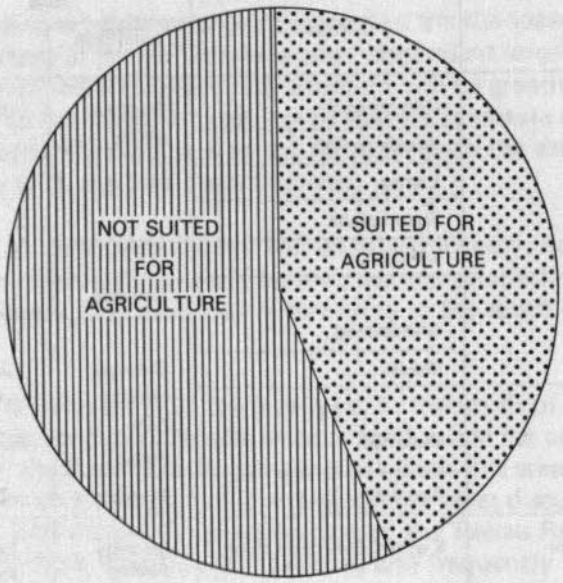
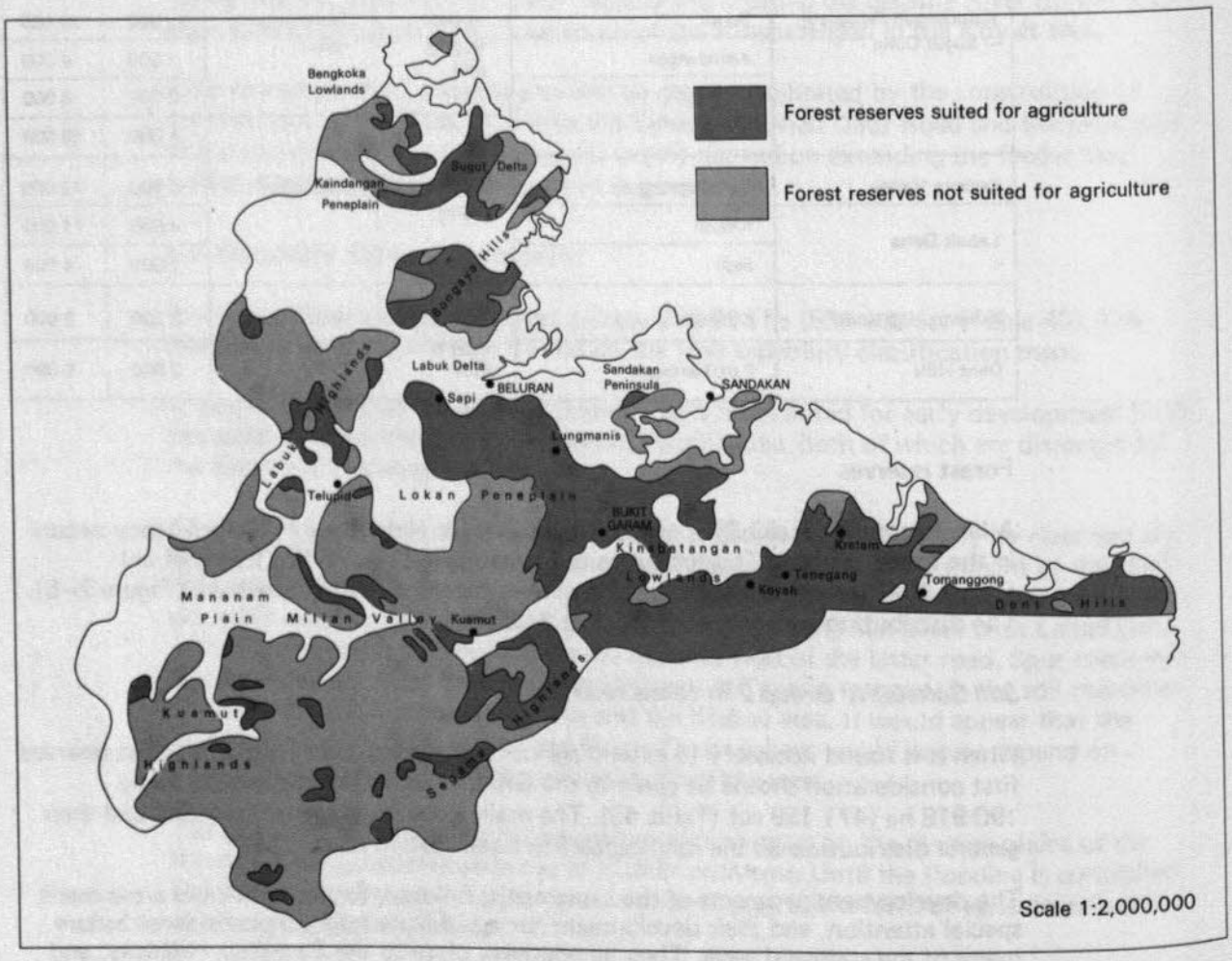


FIGURE 2-5 Suitability of forest reserves for agriculture



TEXT MAP 2-20 Suitability of forest reserves for agriculture

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TABLE 55 Main areas of Group 2 soils occurring in the forest reserves

Region	Area	Soils		Extent	
		Landform	Parent material	ha	ac
Lokan Peneplain	Lungmanis	Gently sloping hills	Sedimentary rocks	36 900	91 000
	Beluran			10 500	26 000
	Sapi			9 700	24 000
	Lower Lokan Valley			5 700	14 000
Kinabatangan Lowlands	Tenegang			20 200	50 000
	Kretam			16 200	40 000
	Gomantong			10 900	27 000
	Lamag			10 500	26 000
	Sekong			7 300	18 000
	Malua			6 000	15 000
	Koyah			6 000	15 000
Dent Hills	Lumerau			8 900	22 000
	Tambisan – Tegupi coastal strip		Coral limestone and alluvium	5 700	14 000
Labuk Highlands	Telupid		Alluvium	2 800	7 000
Sandakan Peninsula	Sepilok		Sedimentary rocks	2 000	5 000

The Sepilok area is likewise favourably located, lying south of the East-West Highway, but it is of utmost importance to maintain this area as a forest reserve in order to preserve its very considerable scientific and conservation value.

Reasonable access to the Koyah and Tenegang areas will be afforded by the completion of the Sandakan-Lahad Datu trunk road, and their status as forest reserves might well be relatively short-lived. Already there are plans to acquire 2 000 ha (5 000 ac) of the Koyah area for agricultural research purposes.

The prospects for large-scale agricultural development in the Kretam area are remote and will largely depend on the extension of a number of spur roads from the Sandakan-Lahad Datu Road which has been outlined above during the discussion on the development of the statelands. When these have been completed, and a good road network established, consideration would then be given to acquiring for agricultural purposes the areas at Sekong, Gomantong, Lamag, Malua, the Lower Lokan Valley and the Dent Hills.

Soil Suitability Group 3 in forest reserves

Low priority would normally be given for agriculture on the Group 3 soils in the forest reserves. They comprise some 584 251 ha (1 443 685 ac) (Table 49). The main areas are given in Table 56 and their general distribution on the land capability classification map.

Falling astride the East-West Highway, the Group 3 soils in the Beluran area are easily accessible.

The constraint imposed by poor access has already been discussed for the Dent Hills, Segama Valley, Kinabatangan Lowlands, the Karamuak and Lokan valleys, and the Kaindangan Peneplain and Sugut Delta, together with the flood problem of the Kinabatangan Valley.

TABLE 56 Main areas of Group 3 soils occurring in forest reserves

Region	Area	Soils		Extent	
		Landform	Parent material	ha	ac
Kinabatangan Lowlands	Kinabatangan-Segama water-shed	Strongly sloping hills	Sedimentary rocks	127 500	315 000
	Lamag			6 900	17 000
	Gomantong			1 200	3 000
	Kinabatangan Valley	Riverine plains	Alluvium	32 800	81 000
	Kretam Valley			5 700	14 000
Lokan Peneplain	Beluran	Strongly sloping hills	Sedimentary rocks	28 300	70 000
	Lokan Valley			8 100	20 000
		Terraces	Alluvium	2 000	5 000
Kaindangan Peneplain	Paitan – Sugut	Strongly sloping hills	Sedimentary rocks	27 100	67 000
	Tungud Valley			10 100	25 000
	Kaindangan			1 600	4 000
Kuamut Highlands	Upper Kuamut Valley			22 300	55 000
	Imbak			14 500	36 000
		Terraces	Alluvium	2 000	5 000
Dent Hills	Ganduman	Strongly sloping hills	Sedimentary rocks	20 200	50 000
	Tabin			8 100	20 000
Segama Valley	Tomanggong	Riverine plains	Alluvium	20 200	50 000
Labuk Highlands	Karamuak Valley	Strongly sloping hills	Sedimentary rocks	11 700	29 000
Sugut Delta	Trusan	Riverine plains	Alluvium	2 800	7 000

Flooding is also as severe in the Segama Valley, and this has been discussed in the companion report on the land capability classification of the Tawau Residency. The prospects for the floodplain of the Kretam river are better. Its catchment area is relatively small, and even though hydrological information is lacking, it is not reputed to be subject to severe flooding. The area is, however, particularly remote, and it is unlikely to be linked to a main road system for some considerable time.

Government reserves

It will have been noted from Table 46 and Figure 2–1 that the Government reserves occupy a relatively insignificant proportion of the Residency, some 0.3% or 8 524 ha (21 065 ac). By reference to Table 49 it can be seen that 7 198 ha (17 788 ac), or 84% of the reserves are considered suited for agriculture. Much of this land, however, is held for agricultural research and demonstration purposes, and large areas are used for water and river-bank conservation. Their general distribution is shown on the land capability classification map.

FORESTRY DEVELOPMENT OPPORTUNITIES

The forest resources of the residency are very considerable and will always play an important role in the economy. While there are large areas of forested land which, having a good agricultural potential as well as a forestry potential, will almost certainly in time be lost to forestry, there are nevertheless extensive areas with little or no

agricultural potential. These provide considerable forestry development opportunities. As has been noted in Part 4 logging licences have been issued covering most of the commercial forests and it is expected that the greater part of these forests will be logged within the next ten to twenty years. However, some 4 650 km^2 (1 800 mi^2) of the commercial forest reserves are in the Sabah Foundation licence agreement area and this forest is being worked on a sustained yield basis.

Priority for the development of these forest resources is dependant on two important factors: the legal status of the land and its suitability for agriculture. As far as the former is concerned the order of priority will be forest reserves, statelands, government reserves and alienated land. In the case of the latter 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 III and then II (see Table 5). Class V land with no potential for either agriculture or forestry is not considered for development.

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 (Commercial mangrove forest) is treated separately. The reason for this is that Groups 1, 2 and 3 often occur as an intimate mixture in the forest, they all carry commercial stands of timber and in most cases it would be quite impractical to consider separate exploitation and development. On the land capability classification map these groups are not shown separately. As Groups 4, 5, 6 and 8 are considered to have no commercial potential in the foreseeable future, areas classified as such are not considered as having any development opportunities.

Forest reserves

Forest resource development areas in forest reserves are shown on Text Map 2–21 and summarised in Table 57.

It can be seen from Table 57 that if all the Class II and III land in forest reserves is developed for agriculture then the area of commercial forest will be reduced by some 47%. Development and improvement of the forest resource should in general be concentrated on the commercial forest on Class IV land.

Stateland

Areas of stateland where commercial forest resource development opportunities occur are shown on Text Map 2–22 and summarised in Table 58.

It can be seen from Table 58 that a considerable area of stateland has a commercial forest potential and that a large proportion of this, 59% is Class IV land, which is not suitable for agricultural development. There is thus ample opportunity to extend the permanent forest estate either by incorporating this Class IV land into existing forest reserves or, where large enough areas exist, creating new reserves. At the same time the large area of Class IV land classified as Timber Resource Group 7 provides an opportunity to extend the area of mangrove forest reserves. Table 59 lists the major areas of stateland suited for forestry.

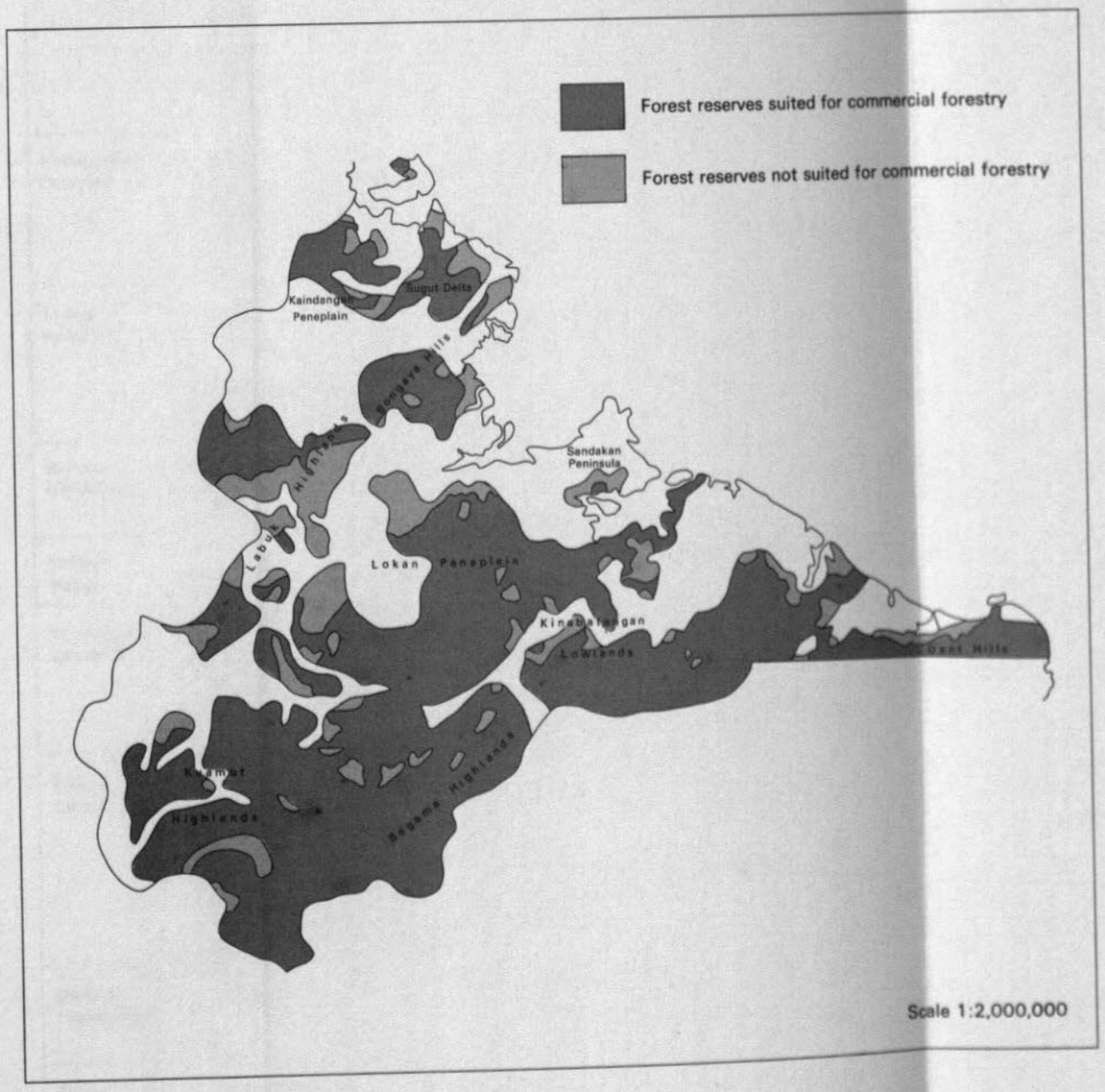
The balance of the land with a forestry potential is in relatively small scattered patches and tracts. Class IV land is shown on the Land Capability Map but Class III and II land with a forestry potential is not delineated.

TABLE 57 Timber resource development areas in forest reserves

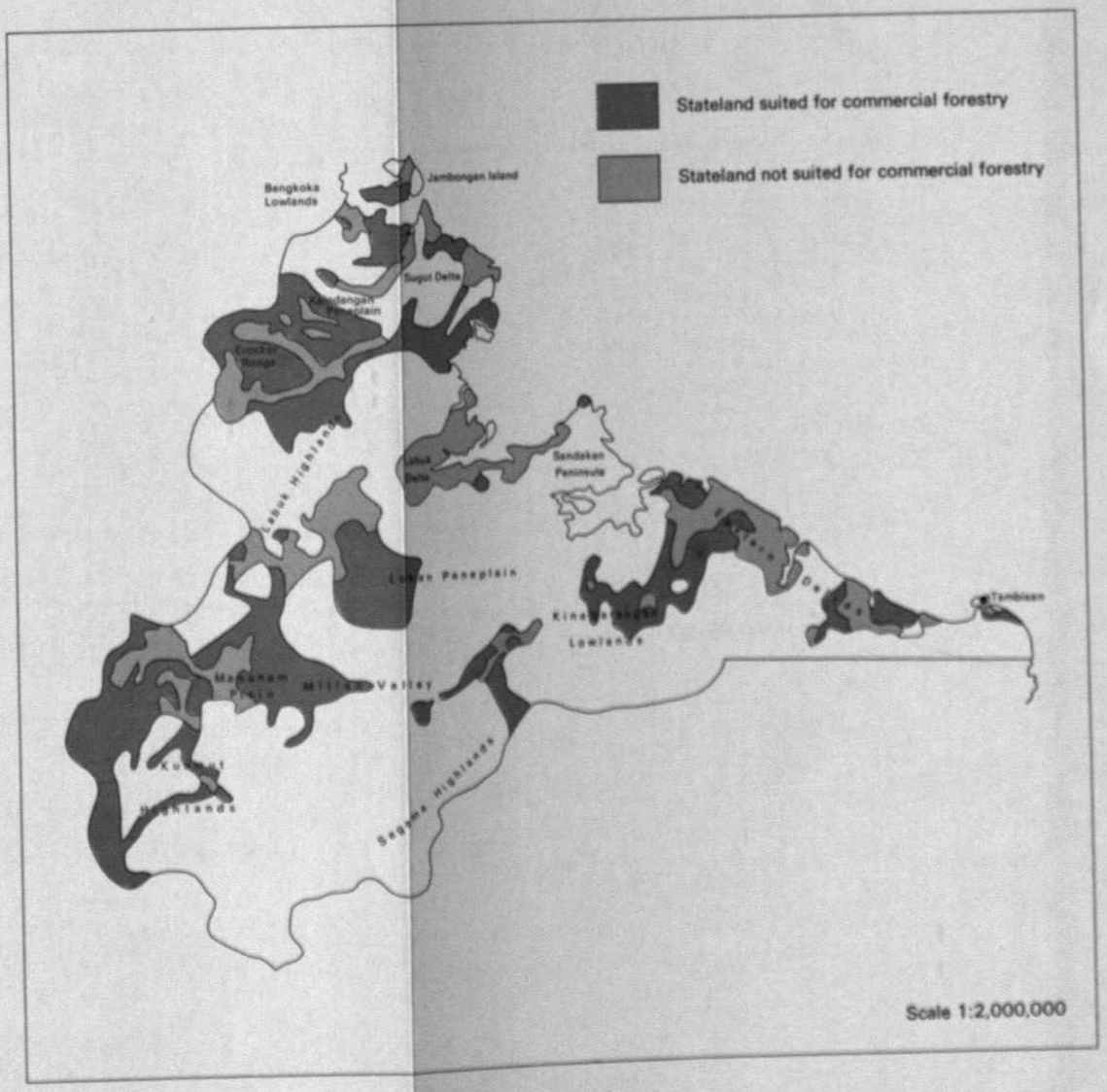
Land capability class	Timber resource group				Total	
	1, 2 & 3		7			
	ha	ac	ha	ac	ha	ac
IV	806 064	1 991 787	30 006	74 146	836 070	2 065 933
III	541 950	1 339 160	0	0	541 950	1 339 160
II	168 081	415 330	0	0	168 081	415 330
Total	1 516 095	3 746 277	30 006	74 146	1 546 101	3 820 423

TABLE 58 Timber resource development areas in stateland

Land capability class	Timber resource group				Total	
	1, 2 & 3		7			
	ha	ac	ha	ac	ha	ac
IV	311 430	769 546	63 432	156 742	374 862	926 288
III	150 626	372 197	0	0	150 626	372 197
II	64 094	158 378	0	0	64 094	158 378
Total	526 150	1 300 121	63 432	156 742	589 582	1 456 863



TEXT MAP 2-21 Suitability of forest reserves for commercial forestry



TEXT MAP 2-22 Suitability of stateland for commercial forestry

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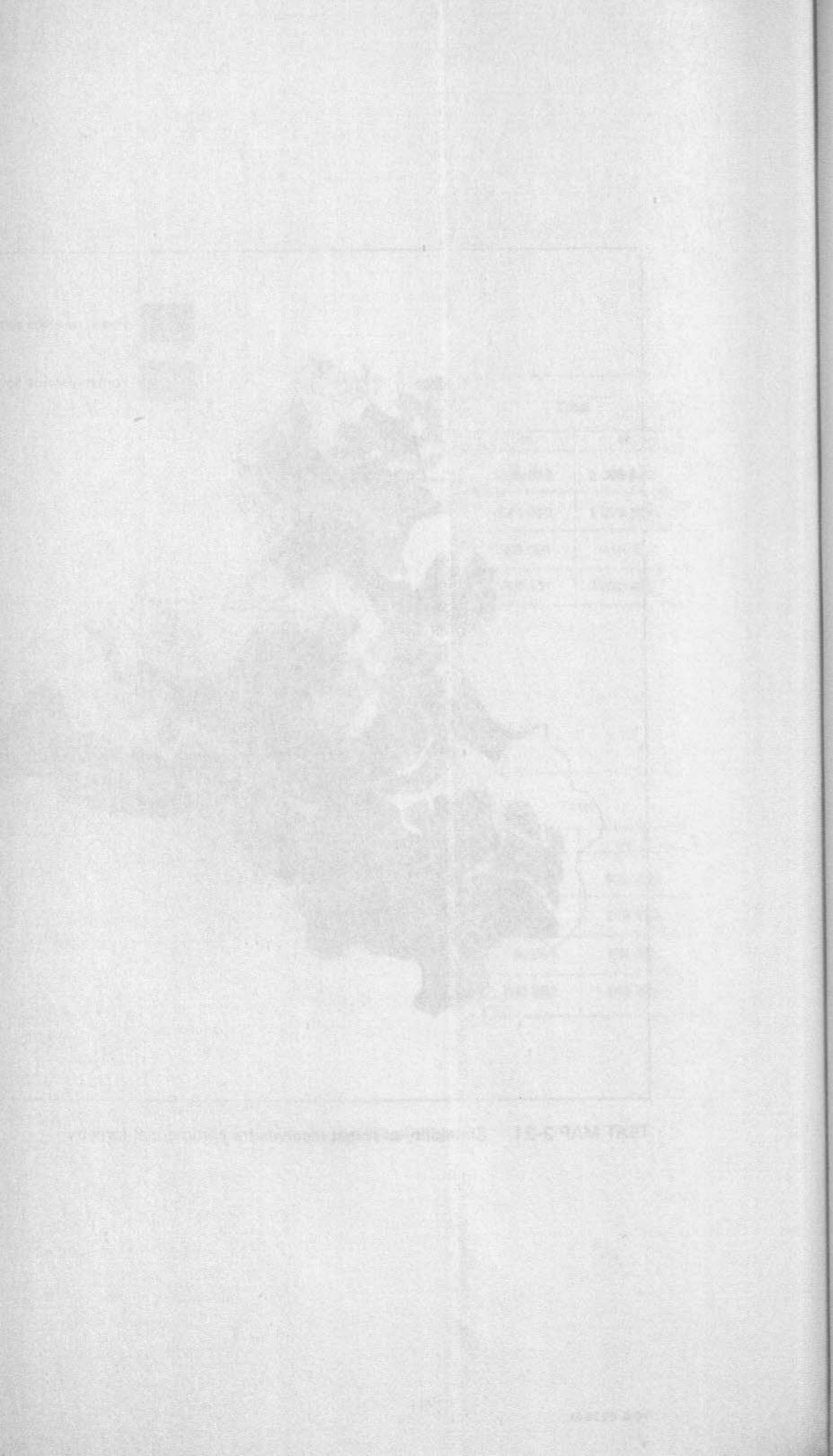


TABLE 59 Major areas suited for forestry in stateland

Region	Area	Forest potential	Land capability class	Extent	
				ha	ac
Labuk Highlands	Upper reaches of Milian river	Commercial forest	IV	61 100	151 000
	Watershed between Tungud and Sugut rivers			26 100	64 500
	Headwaters Kawiyan river			3 680	9 100
	East of Bukit Taviu			3 920	9 700
	Upper reaches of Sapa Paya river			8 340	20 600
			III	4 450	11 000
	Upper reaches of Milian river			20 150	49 800
	Upper reaches of Tungud river			5 420	13 400
	Telupid		II	4 200	10 400
Kaindangan Peneplain	Headwaters of Sungei Sungei river		IV	38 450	95 000
	Right bank of Sugut river			16 190	40 000
	Headwaters of Paitan river			2 020	5 000
	Middle reaches of Sugut		III	12 300	30 400
			II	5 220	12 900
Lokan Peneplain	Headwaters of Lokan river		IV	22 820	56 400
			III	22 050	54 500
			II	1 540	3 800
	Headwaters of Sapa Paya river			2 220	5 500
	Kolapis river			3 240	8 000
Kuamut Highlands	Pinangah		IV	2 750	6 800
	Headwaters of Pinangah and Melikop rivers			24 280	60 000
			III	3 480	8 600
Milian Valley	Tongod and Tongod river		IV	8 090	20 000
	Kampong Tonkabira		III	3 480	8 600
Kinabatangan Lowlands	Left bank of Kinabatangan river from Batu Puteh to Bilit		IV	9 300	23 000
			III	3 680	9 100
	Between Pintasan and Lamag			2 100	5 200
	Between Bilit and Bukit Bulud Napa			10 200	25 200
			II	3 680	9 100
Eastern Deltas	Bukit Bulud Napa to Abai		IV	4 490	11 100
	Trusan Kinabatangan			2 950	7 300
	Lower reaches of Segama river			2 550	6 300
			III	3 760	9 300
	Bungon and Mumiang rivers	Mangrove forest	IV	8 340	20 600
	Trusan Kinabatangan			5 540	13 700
	Manalunan river to Tangusu Bay			7 690	19 000
Segama Highlands	Latangan river	Commercial forest	IV	3 480	8 600
			III	4 450	11 000
			II	3 680	9 100
Sugut Delta	Paitan River left bank		IV	2 020	5 000
	The lower reaches of the Paitan and Kaindangan rivers		III	2 180	5 400
				5 620	13 900
	Arbar River		II	3 320	8 200
	Schomburgk Bay	Mangrove forest	IV	9 910	24 500
	Tanjong Sumangat to Trusan			7 650	18 900
Bengkoka Lowlands	Jambongan Island	Commercial forest	IV	2 060	5 100
			II	4 090	10 100
		Mangrove forest	IV	4 330	10 700
Dent Hills	Tambisan	Commercial forest	III	1 820	4 500
			II	1 740	4 300
Sandakan Peninsula	Northern tip of Sandakan Peninsula	Mangrove	IV	2 670	6 600

Government reserves

Forest resource development opportunities in the government reserves are negligible, they are summarised in Table 60.

TABLE 60 Timber resource areas in government reserves

Land capability class	Timber resource group				Total	
	1, 2 & 3		7			
	ha	ac	ha	ac	ha	ac
IV	51	124	119	295	170	419
III	3 185	7 869	0	0	3 185	7 869
II	1 200	2 966	0	0	1 200	2 966
Total	4 436	10 959	119	295	4 555	11 254

Alienated land

Forest resource areas in non-cultivated alienated land are summarised in Table 61. Such areas, having no commitment to permanent forestry, are highly likely to be logged in the near future and the greater part cleared for agricultural development.

TABLE 61 Timber resource areas in alienated land

Land capability class	Timber resource group				Total	
	1, 2 & 3		7			
	ha	ac	ha	ac	ha	ac
IV	7 287	18 005	718	1 771	8 005	19 776
III	25 568	63 180	0	0	25 568	63 180
II	31 678	78 276	0	0	31 678	78 276
Total	64 533	159 461	718	1 771	65 251	161 232

The major areas of non-cultivated alienated land suited for forestry are listed in Table 62.

TABLE 62 Major areas suited for forestry in alienated land

Region	Area	Forest potential	Land capability class	Extent	
				ha	ac
Sandakan Peninsula	Mile 15 to 30 Labuk Road	Commerical forest	II	10 930	27 000
Kinabatangan Lowlands	Bode Estate		IV	1 620	4 000
			III	2 470	6 100
			II	890	2 200
	Sekong Estate		III	1 740	4 300
			II	1 500	3 700
	Between Sandakan Harbour and the lower Kinabatangan river		III	2 670	6 600
			II	2 190	5 400
	Between Batu Puteh and Bilit		IV	2 100	5 200
			III	2 550	6 300
			II	2 510	6 200
Lokan Peneplain	Between Samawang and Moynod rivers		II	4 650	11 500
Kaindangan Peneplain	Left bank of Sugut river near Tegupeh		III	3 400	8 400

The balance of land with a forest potential is in small scattered patches and tracts. The Class IV land is shown on the land capability classification map but areas of Class II and III land with a forest potential are not delineated.

WATER RESOURCE DEVELOPMENT OPPORTUNITIES

Compared with mining, agriculture and forestry, it is considerably more difficult to summarise the opportunities available for developing the water resources. This is mainly due to insufficient hydrological data, and also the difficulty of predicting with any precision the future pattern of settlement and development and the resultant demand for water and its control. From the information available, however, certain guidelines can be evolved.

With the high rainfall well distributed throughout the year most of the large valley basins are endowed with continuous supplies of water and the overall problem is a periodic excess of water resulting in flooding. Away from the main valley systems all evidence points to the fact that the catchments are generally too small to sustain streamflow during the longer periods of dry weather. This is particularly the case in many parts of the Sandakan Peninsula and the tip of the Dent Peninsula.

Potable water

The development of the water resources will be necessary to ensure adequate supplies of potable water for the towns and agricultural communities which will be established.

Already this necessity is clearly seen in the Sandakan Peninsula where, because surface water is inadequate, most of the urban supplies are obtained from subterranean sources, and a large part of the rural population is sustained by roof collection methods. The importance of the groundwater sources will continue for Sandakan Town and, in order to ensure sustained yields, it is essential that the main escarpments should be used primarily for water conservation purposes. Further urban spread should be prohibited in these areas in order to facilitate the maximum rate of water percolation into the underlying aquifers. This would probably be best done by extending the water-protection reserves to cover all the escarpment areas. In the long-term, however, the demand from an expanding urban and rural population on the Peninsula can only be met from surface sources. The topographic maps show that there are some catchment areas which could be used for water-supply purposes by dam construction; and it will have been noted in Part 4 of this report where the surface water resources are discussed that permanent supplies are already being assured from some small reservoirs and that the construction of a relatively larger dam is planned for the Garinono valley, thereby capable of yielding some 45 400 000 litres/day (10 000 000 gal/day) for both the needs of Sandakan Town and some of the rural areas (see Plate 2–13).

A similar situation is likely to be found with the development of the Dent Hills, particularly along the eastern sea-board, small catchments but with the possibility of subterranean aquifers, in this case occurring in coral-limestone bedrock. There the solution to the water-supply problem might rest in the construction of small dams or the sinking of wells, or both. The porous sandstone beds on Jambongan Island are also likely to yield water suited for the potable supplies of an expanding community since, in common with the extremity of the Dent Peninsula and many seaboard areas, adequate all-season surface supplies are unlikely. The hydrology of these areas, including those served by smaller rivers and streams running into Sandakan Harbour, particularly the Segaliud, Bode, Sekong and Sapagaya, and the Mumiang and Kretam to the east, should be investigated in order to ascertain the water supplies available to sustain the communities which will be eventually established.

Even though these investigations would form part of a long range-plan for the residency the development opportunities for any such surface water resources should be clearly identified as soon as possible since the maximum utilisation of the potential water catchments must be assured by employing the most stringent conservation methods. Ideally the catchments should be sterilised by prohibiting settlement, and it is essential that the forest cover should be retained.

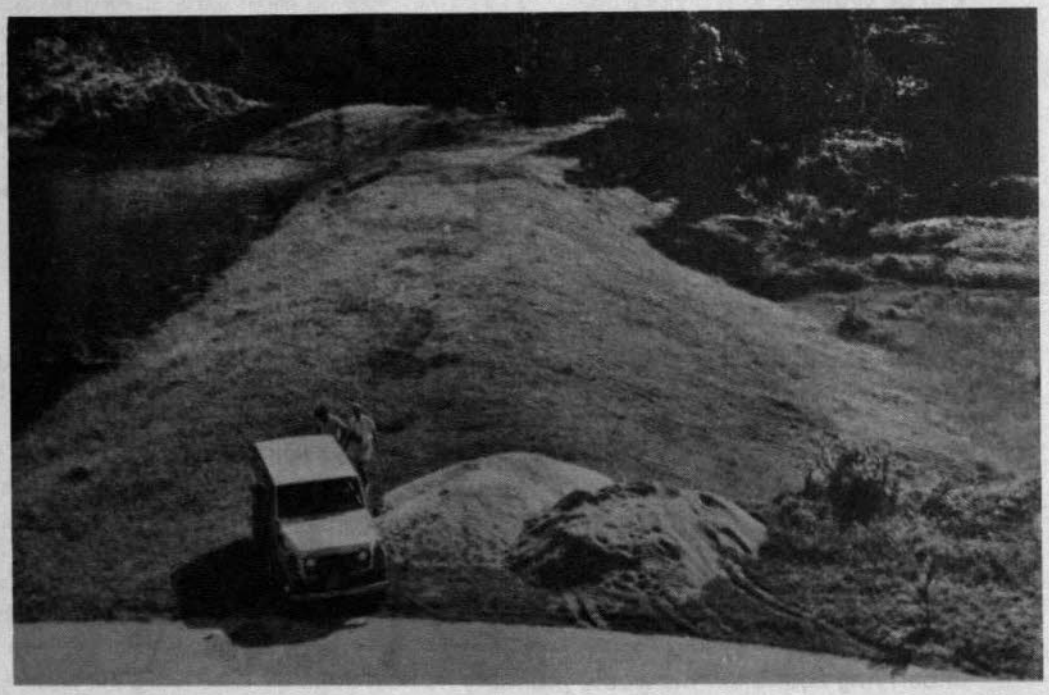


PLATE 2.13 Small dam and reservoir constructed for the potable water supply of the forest training school and research centre, Sepilok, Sandakan Peninsula

It will have been noted during the description of the soil resources in Part 4 of this report, and the foregoing discussion on the agricultural development opportunities, that considerable areas of otherwise good quality land are rendered unsuitable for permanent settlement and cultivation due to flooding. This land occurs on the main riverine plains, and the main areas are listed in Tables 4–13 and 4–15.

The extent of the flooding is not known with any degree of precision, but the territorial soil map which is contained in Volume 2 of the companion *Land Resource Study 20, The soils of Sabah* indicates, for example, that in the Kinabatangan valley alone some 1 970 km^2 (760 mi^2) are subject to severe floods. Early priority should therefore be given to initiating a series of studies on the main river basins and when their hydrology is clearly understood proper development plans can be formulated. These are likely to lead to the construction of a number of barrages across the upper reaches of the rivers.

When flooding has been controlled consideration should then be given to whether the land should be irrigated or drained. This will be largely dependent on the choice of crops.

The rainfall data indicate that irrigation will be necessary for rice cultivation. No undue problems are likely to be encountered in obtaining adequate supplies of water in the main river basins and larger valleys, but considerable difficulties are likely to be encountered in obtaining adequate quantities of irrigation water for some of the deltaic and coastal plains, particularly in the Trusan Sapi and Samawang areas.

Drainage would be generally necessary for tree crops grown on much of the flood-controlled land and would also be required for the more low lying and swampy areas in both the riverine and coastal tracts which might be chosen for rice cultivation. It would appear, therefore, that drainage schemes designed to improve the conditions of such waterlogged areas are likely to prove to be economically feasible in view of their otherwise suitability for agricultural development.

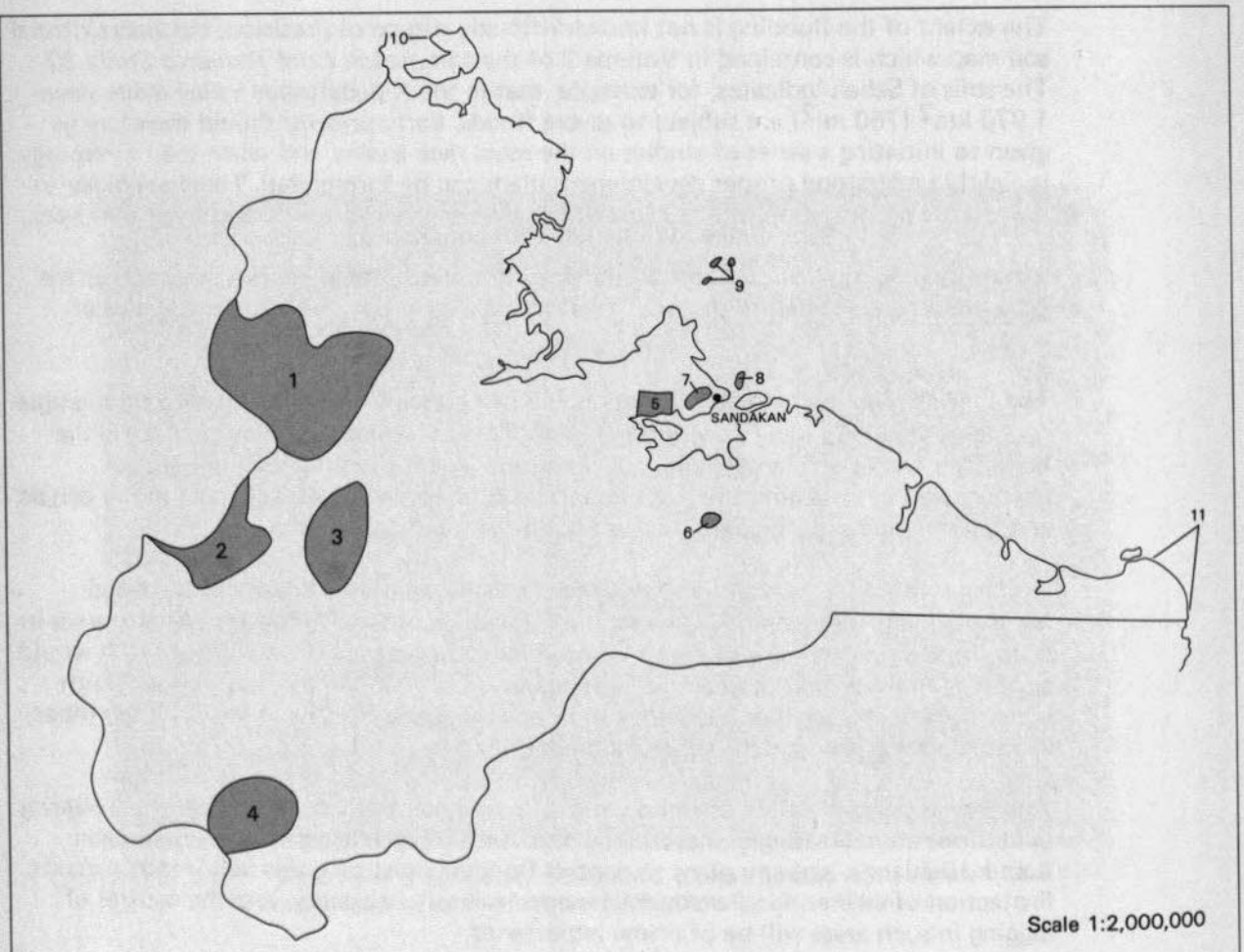
Another important aspect of flood-control is catchment protection. Widespread logging operations are increasingly encroaching on the main watersheds in the Kuamut and Labuk Highlands, and any plans to control flooding must take this factor into account. Protection of all steepland water catchments is clearly necessary, and the control of logging in such areas will be of prime importance.

The possibility of ultimately producing hydroelectric power from the flood-controlling barrages should also be kept in mind. This would largely depend on the future demand for electricity and would primarily rest in the foreseeable future on the requirements of industry, particularly if ore-processing plants are established in the mineral belt. Other possible sources of such power are some of the waterfalls, particularly those which plunge off the Tawai Plateau.

CONSERVATION DEVELOPMENT OPPORTUNITIES

No detailed survey of the game resources of the residency has been carried out, but observations and reports indicate that wildlife is still generally quite abundant. However, the destruction of natural habitats, the result of exploitation of the forests and expanding land development is bound to take its toll and lead to a general decrease in the wildlife resources. This will be particularly so with some species. The most threatened species are probably the sumatran rhinoceros, the elephant, the orang-utan, the wild cattle and the clouded leopard.

If these and other species of wildlife are to be preserved in reasonable numbers for the interest and benefit of future generations, means will have to be taken to designate suitable conservation areas where the wildlife and the habitat will be protected. Within the residency there are considerable areas of protection forest reserve and some of these should be developed for this purpose.



	Area	Main purpose of conservation
1	Meliau Range	Fauna, flora, recreation.
2	Trus Madi (eastern slopes)	Fauna, flora, recreation.
3	Mount Tawai	Recreation, flora, fauna.
4	Maliau Basin	Fauna, flora, recreation.
5	Kabili-Sepilok Forest Reserve	Flora, fauna, amenity.
6	Gomantong	Recreation, amenity, fauna.
7	Mount Walker Forest Reserve and near by sandstone escarpments	Amenity, recreation.
8	Berhala Island	Amenity, recreation.
9	Turtle Islands	Amenity, recreation, fauna.
10	Tanjong Buli Gantungan	Recreation, amenity.
11	Dent Peninsula, south from Tambisan	Recreation, amenity.

TEXT MAP 2-23 Suggested conservation areas

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In addition to the animal life it is of vital interest and importance for botanical, ecological and other purposes, particularly the maintenance of gene-pools, to conserve adequate samples of the different types of vegetation found in the residency. While much of the natural vegetation is lowland dipterocarp forest there are variations within this broad type as well as a considerable variety of flora associated with particular edaphic conditions. A start has been made in conservation with the establishment by the Forest Department of a number of Virgin Jungle Reserves the object of which is to preserve examples of different undisturbed forest types. Unfortunately experience has shown that these reserves are not inviolate as originally intended and some have been logged thus defeating their fundamental purpose. More conservation areas for wildlife, both floral and faunal should be established with stringent legal safeguards.

With development and an increasing population particularly in urban areas suitable areas for recreation and amenity purposes will be required. It is important that such areas should be identified and designated for conservation as soon as possible, particularly in view of the fact that land suited for this purpose is rather limited.

Systematic surveys of the recreation and game resources are, therefore, clearly required. This is likely to take some considerable time, and in the meantime the areas outlined as being suited for such purposes in Part 4 of this report should be given special attention.

Conservation areas

The approximate location of suggested conservation areas is shown on Text Map 2–23.

Meliau Range

A range of mountainous steepland with considerable scenic attraction with stunted vegetation and rising to a height of 1 335 m (4 385 ft). It is the catchment area of the headwaters of the Tungud River. A suitable conservation area for wildlife, both floral and faunal, with a possible long term potential for recreation when access is improved.

Trus Madi (eastern slopes)

Scenically attractive rugged mountainous country extending up to the summit of Trus Madi (2 653 m (8 699 ft)), a suitable conservation area for wildlife in general and some potential for recreation.

Mount Tawai

An igneous massif rising to 1 340 m (4 400 ft) with a high level plateau and considerable scenic attraction, a potential recreation area when access improves and of particular interest botanically and ecologically.

Maliau Basin

A rugged mountainous area, much of which lies above 900 m (3 000 ft), formed by a series of long sandstone cuestas which rise to over 1 500 m (5 000 ft) with Gunong Lotung the dominant peak. The scenery is striking, but the area is very inaccessible. A very suitable conservation area for wildlife, both faunal and floral, with long term possibilities for recreation.

Kabili-Sepilok Forest Reserve

An area of approximately 4 000 ha (10 000 ac) close to Sandakan providing prime examples of various types of forest much of it undisturbed. A known habitat of orang-utan and other fauna. The area is internationally known on account of the botanical

and ecological research work carried out there. This area must be conserved and a variety of reasons not the least of which is its amenity value. The presence of orang-utan is a considerable tourist attraction.

Gomantong

The striking limestone hill with its birds-nest caves full of swiftlets and bats has general interest and could be developed for local recreational and amenity purposes and as a tourist attraction. The fauna of the area has considerable zoological interest.

Mount Walker Forest Reserve and nearby sandstone escarpments

The proximity of this area to Sandakan and its relatively easy access gives it considerable value for local amenity and recreational purposes. The sandstone escarpments are scenically attractive and provide good viewing points.

Berhala Island

The high red sandstone cliffs are a prominent landmark at the entrance to Sandakan Harbour while the beach at their foot is one of the few attractive beaches available to the population of Sandakan. This area is very suited for conservation for local recreational and amenity purposes.

Turtle Islands

The combination of sandy beaches, clear seas and the opportunity to see turtles make these islands a very important local recreational and amenity area as well as a major tourist attraction. The turtle conservation work centred on this area is also of considerable value and importance.

Tanjong Buli Gantungan

The beach, cliffs and clear seas make this a potential recreation and amenity area for the local population.

Dent Peninsula, south from Tambisan

The beaches and clear seas along the foreshore in this area give it some potential for local recreation and amenity purposes. As the hinterland is developed and settled, however, their usefulness will increase and it is important that the pattern of alienation should be designed so as to ensure their access to the general public.

GENERAL OPPORTUNITIES

Up to this stage the discussion has been restricted to the description of the individual resources (Part 4), and the development opportunities which exist for each separate resource relative to the present land use and alienation and gazettement pattern (in the foregoing sections of Part 5). This information is important to the potential *entrepreneur*, whose interest would normally lie in the development of one particular resource, e.g. mining, agriculture or forestry. For overall planning, particularly with that which should be undertaken by the public sector, however, all options available on the use of land must be considered. In order to do this the prime necessity is to identify the various uses which may be made of the land by a clear understanding of the conflicting resource development potentials and these should be considered in the context in which the land has already been allocated. This would then lead on to a regional appraisal of the various development opportunities which exist for the resources.

TABLE 63a Present land use and land capability (ha)— total

Present land use category*	Land capability and land exploitation unit																		
	Class I	Class II						Class III						Class IV					Class V	
	IA	IIA	IIB	IIC	IID	IIE	IIF	IIIA	IIIB	IIIC	IIID	IIIE	IIIF	IVA	IVB	IVC	IVD	IVE	VA	VB
1	0	463	67	50	0	2	0	384	156	32	13	0	0	53	2	0	2	18	619	64
2	0	2 087	249	171	213	3	10	1 215	120	57	16	0	0	38	5	0	0	41	1 010	0
3	0	8 407	5 323	1 244	0	0	0	6 829	640	356	0	0	0	203	76	0	0	172	2 535	0
4	0	1 876	144	81	105	0	4	2 346	375	74	24	11	0	304	114	0	0	120	2 166	0
5	0	0	0	0	0	0	0	5	8	5	0	0	0	4	0	0	0	0	0	0
6	0	3 515	3 687	1 116	237	0	7	3 482	3 882	953	64	140	2	1 180	187	172	34	128	2 917	360
7F	185	44 610	141 458	41 556	7 729	3 295	3 538	46 730	497 962	45 708	9 900	16 165	6 245	898 539	35 530	61 441	7 442	1 825	68 135	29 919
7S	0	13 641	46 992	8 651	2 621	486	215	28 596	80 652	9 644	1 134	197	164	43 116	6 658	6 774	1 096	406	38 239	50 276
8	0	15 982	11 611	5 535	209	450	76	36 373	35 554	24 178	155	43	0	44 368	13 554	81	62	114 422	114 422	23 571
9	371	1 756	2 096	680	72	2	3	1 392	837	309	39	2	0	197	36	3	0	158	896	7
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	0
Unit total	556	92 337	211 627	59 084	11 186	4 238	3 853	127 352	620 186	81 316	11 345	16 558	6 411	998 002	56 162	68 471	8 636	117 292	230 942	104 197
Class total	556	382 325						863 168						1 243 563					335 139	

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

For definitions see Part 3

TABLE 63b Present land use and land capability (ac) — total

Present land use category	Land capability class and land exploitation unit																		
	Class I	Class II						Class III						Class IV					Class V	
	IA	IIA	IIB	IIC	IID	IIE	IIF	IIIA	IIIB	IIIC	IIID	IIIE	IIIF	IVA	IVB	IVC	IVD	IVE	VA	VB
1	0	1 144	166	123	0	6	0	915	385	78	32	0	0	102	4	0	5	44	1 531	107
2	0	5 162	616	422	503	8	24	3 003	296	140	40	0	0	95	13	0	0	102	2 496	0
3	0	20 774	13 154	3 075	0	0	0	16 875	1 582	879	0	0	0	501	187	0	0	425	6 265	0
4	0	4 635	355	200	260	0	10	5 817	948	194	59	28	0	763	281	0	0	296	5 352	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	8 685	9 111	2 759	586	0	18	8 605	9 593	2 354	158	347	4	2 917	462	426	83	317	7 208	891
7F	457	110 228	349 543	102 685	19 099	8 142	8 743	115 470	1 230 465	112 944	24 943	39 943	15 432	2 220 291	87 795	151 820	18 390	4 511	168 362	73 931
7S	0	33 709	116 117	21 376	6 476	1 201	531	70 660	199 292	23 830	2 803	487	405	118 894	16 452	16 740	2 709	1 003	94 488	124 231
8	0	39 492	28 690	13 677	517	1 111	188	89 877	87 853	59 744	384	107	0	109 633	33 491	200	154	227 186	282 736	58 243
9	916	4 337	5 180	1 680	178	4	7	3 441	2 068	763	97	6	0	486	90	8	0	391	2 213	18
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	7	0
Unit total	1 373	228 166	522 932	145 997	27 619	10 472	9 521	314 663	1 532 482	200 926	28 037	40 918	15 841	2 453 682	138 775	169 194	21 341	234 280	570 657	257 421
Class total	1 373	944 707						2 132 867						3 017 272					828 078	

Conflicting resource development potentials

Tables 63a and 63b give an overall picture of the extent of the conflict which arises between the choices available for the development of the mining, agricultural and forest resources. It can be seen that the main conflict occurs between agriculture and forestry (land exploitation units IIB, C, E, F, IIIB, C, E and F). A possible conflict between mining with agriculture is also indicated (land exploitation units IID, E, F, IIID, E and F), with forestry (land exploitation units IVC, D and E), and all these combined (land exploitation units IIE, F, IIIE and F). Very little of such land is, however, likely to be used for mining, and in such cases mineral interests should be subordinate to those of agriculture and forestry, until any mining potential has been proven.

While not identified on Tables 63a and 63b, some conflict is also likely to occur between conservation and recreation interests and the other development opportunities, and this is likely to be particularly important in respect to logging.

A conflict may also arise between forestry and fisheries in respect to the mangroves. As can be seen from Tables 57, 58, 60 and 61 there are a total of some 94 275 ha (232 954 ac) of commercial mangrove forests (Group 7). In the past there was quite extensive felling of mangrove to supply bark for the manufacture of cutch, a tanning material. However when the cutch industry finally closed down in 1963 the demand for mangrove was restricted to relatively small amounts of timber for firewood, charcoal, building poles, piling, fishing stakes and other minor local uses. Recently the situation changed and there is now a demand for mangrove timber as a raw material for the pulp industry. This has resulted in the licensing of extensive areas of mangrove forest and large scale felling for the production of chips for export.

Following the start of these operations concern has been expressed about the effect of such widespread felling of mangrove forest on the productivity of the prawn and fishing industries. There is considerable evidence to indicate that mangrove forest plays an important part in providing nursery and feeding grounds for prawns and fish and it is as yet uncertain what effect the present large scale felling may have on its ability to fulfill this role.

Thus while the mangrove forest is a valuable resource care must be taken to ensure that in exploiting it, its ability to fulfill its important biological role is not destroyed or seriously impaired.

It is at present uncertain whether associated nipah palm forest provides the same quality of nursery and feeding grounds as mangrove forest.

Agriculture and forestry

The main areas suited for both agriculture and forestry are outlined in Text Map 2–24. Some 1 003 273 ha (2 479 127 ac) (Tables 63a and 63b) are considered suited for both agriculture and forestry. It is anticipated that, in the long-term, most will be used for agriculture. (See Plate 2.15). At present, however, this conflict must be seen in light of the constraints imposed on agricultural development by poor communications and the small population. Thus, even with the availability of such an extensive area only 38 775 ha (95 813 ac) (Siew, 1973) are cultivated, and the full development of the land suited for both agriculture and forestry alone would mean an almost 26–times increase in the area under agricultural crops. This is obviously going to take a very considerable period of time. With this in mind, any plans to develop such land should take into account such a time aspect, i.e. when individual areas are likely to be required for agricultural purposes. In this way considerable areas could be used for further timber production, by regenerated natural forests or plantations (see Plate 2.14), with at least one more harvest of logs being obtained before permanent agricultural settlement occurs.

The development of agriculture on such land should follow the same priorities outlined when the agricultural opportunities were discussed in the early section. First consideration should normally be given to such land which has already been alienated for agriculture, followed by that included in stateland, then the forest reserves and finally the government reserves.

Alienated land

It can be seen from Tables 64a and 64b that of the alienated land which remains forested (present land use categories 7F, 7S and 8), some 57 288 ha (141 413 ac) are suited for both purposes. With the course of normal development, however, such land will in the foreseeable future be cultivated and its natural timber production capability thereby largely lost

Stateland

The distribution of stateland with a combined agricultural and forestry capability is shown on Text Map 2–24, and it can be seen from Tables 65a and 65b (land exploitation units IIB, C, F, IIIB, C, E and F) that such land comprises some 111 285 ha (274 990 ac).

Based on present communications criteria, the only area of such land with early prospects for large-scale agricultural development is near Telupid and the nearby easterly tract lying south of the Bidu Bidu Hills. This area is well served by the East-West Highway and already large-scale logging is in operation.

The development of agriculture on a wide-spread basis in all the other areas is likely to be inopportune in the foreseeable future because of the access problems, which have been discussed in the earlier section devoted to the agricultural development opportunities. The possibility of maintaining these areas for timber production on a temporary basis should always be kept in mind.

Forest reserves

By far the greatest conflict occurs in the forest reserves, with some 713 629 ha (1 763 405 ac) at issue (Tables 66a and 66b). This represents 40% of the total area occupied by the reserves. The distribution of such land is shown on Text Map 2–24.

Ideally, falling in forest reserves, these areas should be scheduled for agricultural development only after all the alienated land and stateland suited for cultivation have been developed, but because of the variable access factor it will be necessary to open-up areas of the forest reserves before some of the stateland or even parts of the alienated land. While it is accepted that the Class II and III land in forest reserves has a potential for agricultural development, its use for this purpose will depend upon demand, which in turn will be determined by availability of capital and labour, markets for the produce and other factors. Where there is little prospect of this Class II and III land being developed for agriculture in the foreseeable future then there is no reason why it should not be used for forest development as an interim measure. Such development, which would follow exploitation of the primary forest might either be relatively short term such as plantations of fast growing species for pulp or in some areas, longer term in the form of natural regeneration for the production of veneer and saw logs. At the same time it must be recognised that ultimately most Class II and II land will be required for agricultural development and that forest development will be restricted mainly to Class IV land.

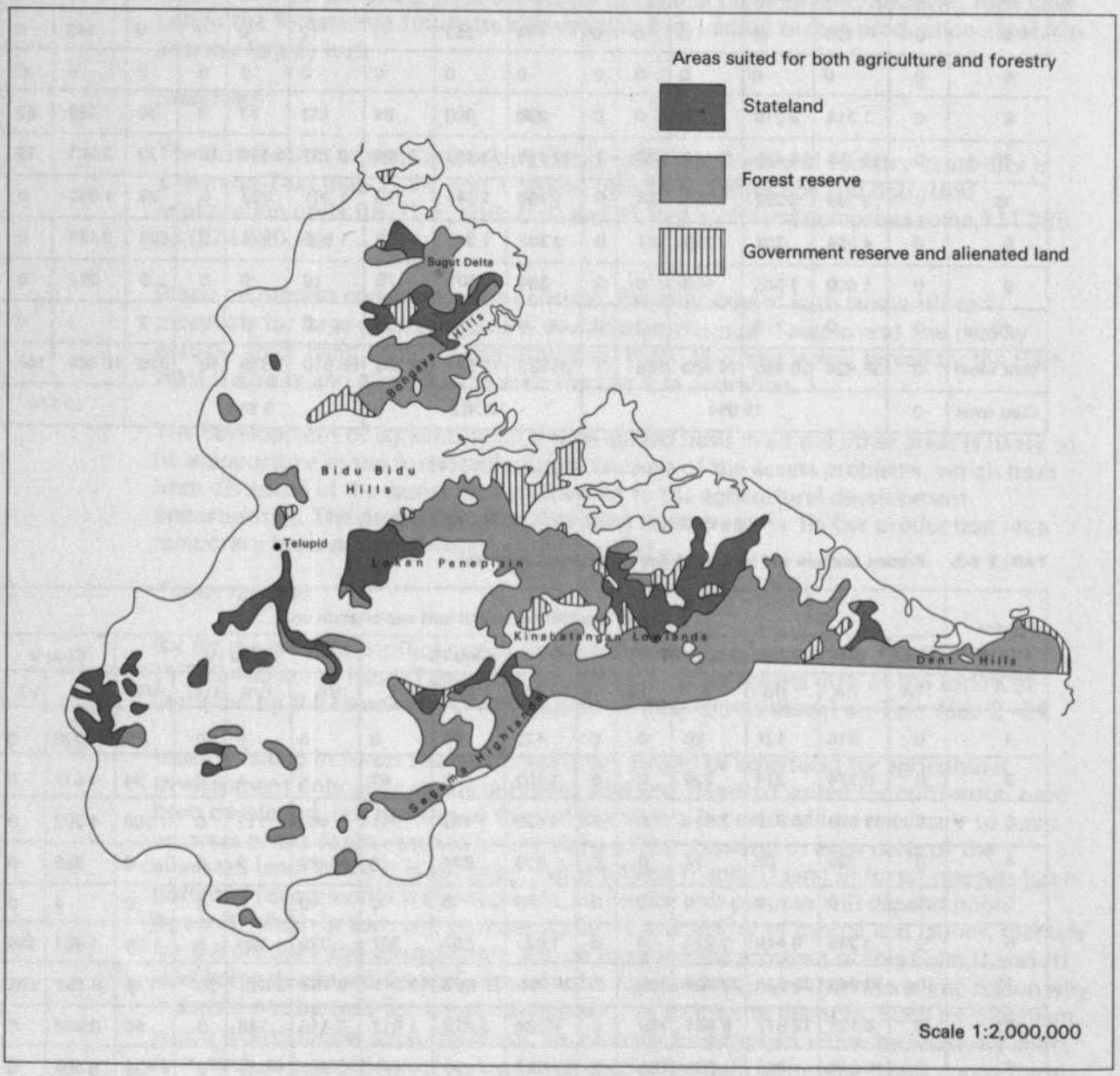
It will be seen on Text Map 2–24 that the most susceptible zone falls in the Sungei Sapi and Lokan-Segaliud Forest Reserves which are already served by trunk roads, and with the southern extension of the main road to Lahad Datu the Koyah Forest Reserve will become readily accessible. With the construction of the road from the north the areas falling within the Paitan, Sugut and Bongaya forest reserves will become more attractive for agricultural development than at present, but this is much less imminent. Plans are already afoot to excise part of the Ganduman Forest Reserves for agricultural purposes, but large-scale development in the Dent Hills Region is only envisaged when ready road access to the main trunk road system has been attained.

TABLE 64a **Present land use and land capability of alienated land (ha)**

Present land use category	Land capability class and land exploitation unit														
	Class I	Class II					Class III			Class IV				Class V	
	IA	IIA	IIB	IIC	IID	IIE	IIIA	IIIB	IIIC	IVA	IVB	IVC	IVE	VA	VB
1	0	370	50	36	0	0	170	37	0	2	0	0	0	375	0
2	0	1 123	127	113	0	0	445	33	15	3	2	0	14	735	0
3	0	7 984	5 211	1 218	0	0	5 838	600	308	183	45	0	76	1 725	0
4	0	121	13	8	0	0	174	257	1	12	0	0	0	143	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	1 314	2 610	779	0	0	298	399	84	133	73	0	10	769	67
7F	0	15 759	14 421	9 190	63	1	10 115	11 168	7 382	2 737	1 138	10	72	3 301	79
7S	0	3 289	5 252	2 251	64	0	1 766	3 341	776	1 261	303	0	23	1 033	0
8	0	4 054	264	299	61	0	9 343	1 335	1 566	1 560	278	0	623	2 189	0
9	0	1 000	1 503	506	0	0	234	501	76	19	0	0	8	294	0
10	0	0	0	0	0	0	0	0	0	0	0	0	2	3	0
Unit total	0	35 824	29 450	14 400	188	1	28 883	17 671	10 208	55 910	1 839	10	828	10 568	146
Class total	0	79 054					56 762			8 588				10 714	

TABLE 64b **Present land use and land capability of alienated land (ac)**

Present land use category	Land capability class and land exploitation unit														
	Class I	Class II					Class III			Class IV				Class V	
	1A	IIA	IIB	IIC	IID	IIE	IIIA	IIIB	IIIC	IVA	IVB	IVC	IVE	VA	VB
1	0	915	121	89	0	0	420	91	0	5	0	0	0	928	0
2	0	2 774	314	279	0	0	1 101	83	37	8	4	0	34	1 817	0
3	0	19 729	12 876	3 011	0	0	14 425	1 483	761	453	112	0	189	4 262	0
4	0	299	33	19	0	0	429	634	2	29	0	0	0	353	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	3 246	6 449	1 924	0	0	1 971	987	207	329	180	0	26	1 901	165
7F	0	38 940	35 635	22 708	155	3	24 995	27 597	18 241	6 763	2 813	24	178	8 158	186
7S	0	8 128	12 977	5 563	159	0	4 364	8 256	1 917	3 115	749	0	56	2 552	0
8	0	10 018	652	738	151	0	23 087	3 298	3 871	3 855	686	0	1 539	5 409	0
9	0	2 472	3 715	1 251	0	0	578	1 237	188	48	0	0	20	727	0
10	0	0	0	0	0	0	0	0	0	0	0	0	5	7	0
Unit total	0	86 521	72 772	35 582	465	3	71 370	43 666	25 224	14 605	4 544	24	2 047	26 114	351
Class total	0	195 343					140 260			21 220				26 465	



TEXT MAP 2-24 Areas of conflicting potential use between agriculture and forestry

D.O.S. 3238Am

Prepared by the Directorate of Overseas Surveys 1976

TABLE 65a Present land use and land capability of stateland (ha)

Present land use category	Land capability class and land exploitation unit																		
	Class I	Class II						Class III						Class IV					Class V	
	IA	IIA	IIB	IIC	IID	IIE	IIF	IIIA	IIIB	IIIC	IIID	IIIE	IIIF	IVA	IVB	IVC	IVD	IVE	VA	VB
1	0	58	6	9	0	2	0	68	21	9	13	0	0	3	0	0	2	8	41	43
2	0	697	37	53	204	3	10	438	22	20	16	0	0	32	4	0	0	13	242	0
3	0	258	84	17	0	0	0	462	32	39	0	0	0	17	18	0	0	76	450	0
4	0	1 537	117	48	105	0	4	1 965	76	43	24	11	0	281	114	0	0	117	1 994	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	1 784	476	174	237	0	7	1 610	254	127	57	45	0	182	81	2	34	98	1 567	31
7F	166	16 633	29 335	13 825	4 685	1 982	2 766	23 630	92 475	16 787	2 365	1 717	1 925	256 175	19 158	2 575	659	662	22 766	2 049
7S	0	7 505	6 402	3 317	2 166	73	177	18 841	9 583	2 998	667	92	60	7 204	4 244	152	19	312	13 893	501
8	0	7 935	3 277	2 572	117	292	76	14 490	15 064	9 925	140	0	0	14 061	7 121	0	62	62 460	99 653	23 571
9	0	478	419	104	72	2	3	682	73	54	39	2	0	150	36	0	0	112	500	0
Unit total	166	36 888	40 153	20 119	7 587	2 355	3 042	62 186	117 600	30 003	3 321	1 868	1 985	278 105	30 776	2 729	776	63 858	141 106	26 195
Class total	166	110 144						216 963						376 244					167 300	

TABLE 65b Present land use and land capability of stateland (ac)

Present land use category	Land capability class and land exploitation unit																		
	Class I	Class II						Class III						Class IV					Class V	
	IA	IIA	IIB	IIC	IID	IIE	IIF	IIIA	IIIB	IIIC	IIID	IIIE	IIIF	IVA	IVB	IVC	IVD	IVE	VA	VB
1	0	144	15	23	0	6	0	167	53	22	32	0	0	8	0	0	5	20	101	107
2	0	1 729	92	131	503	8	24	1 083	54	50	40	0	0	79	9	0	0	31	598	0
3	0	637	208	42	0	0	0	1 143	79	97	0	0	0	42	45	0	0	189	1 113	0
4	0	3 799	289	118	260	0	10	4 855	189	107	59	28	0	695	281	0	0	289	4 926	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	4 409	1 175	429	586	0	18	3 979	627	315	142	111	0	449	200	4	83	242	3 871	76
7F	32	41 099	72 486	34 163	11 577	4 899	6 834	58 390	228 505	41 480	5 843	4 243	4 757	633 008	47 339	6 362	1 629	1 636	56 254	5 064
7S	0	18 545	15 820	8 197	5 353	181	437	46 556	23 680	7 407	1 647	227	149	17 802	10 488	376	47	770	34 330	1 237
8	0	19 608	8 097	6 355	290	721	188	35 805	37 233	24 526	346	0	0	34 744	17 597	0	154	154 336	246 243	58 243
9	0	1 180	1 036	256	178	4	7	1 684	180	133	97	6	0	372	90	0	0	279	1 236	0
Unit total	32	91 150	99 218	49 714	18 747	5 819	7 518	153 662	290 590	74 137	8 206	4 615	4 906	687 199	76 049	6 742	1 918	157 792	348 672	64 727
Class total	32	272 166						536 116						929 700					413 399	

TABLE 66a Present land use and land capability of forest reserves (ha)

Present land use category	Land capability class and land exploitation unit																		
	Class I	Class II						Class III						Class IV					Class V	
	IA	IIA	IIB	IIC	IID	IIE	IIF	IIIA	IIIB	IIIC	IIID	IIIE	IIIF	IVA	IVB	IVC	IVD	IVE	VA	VB
1	0	31	12	4	0	0	0	47	77	17	0	0	0	36	2	0	0	0	32	0
2	0	131	10	0	0	0	0	78	36	1	0	0	0	3	0	0	0	15	4	0
3	0	129	14	6	0	0	0	496	8	6	0	0	0	2	12	0	0	16	356	0
4	0	217	13	25	0	0	0	103	15	18	0	0	0	15	0	0	0	3	28	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	371	573	148	0	0	0	1 003	3 173	666	6	96	2	866	33	171	0	16	491	263
7F	19	11 566	96 884	18 420	298	1 311	772	12 373	394 143	21 008	7 536	14 448	4 320	639 604	15 232	58 856	6 783	1 091	41 926	27 791
7S	0	2 814	35 304	3 066	390	413	38	7 708	67 089	5 459	468	105	103	39 629	2 110	6 623	1 077	70	22 938	49 775
8	0	3 906	8 070	2 617	31	158	0	12 017	18 485	12 275	15	43	0	28 745	6 155	81	0	28 761	12 421	0
9	371	270	169	51	0	0	0	450	252	103	0	0	0	26	0	3	0	34	101	7
Unit total	390	19 434	141 050	24 339	3 402	1 882	810	34 275	483 278	39 553	8 025	14 692	4 425	708 926	23 544	65 734	7 860	30 006	78 297	77 836
Class total	390	190 918						584 249						836 070					156 193	

TABLE 66b Present land use and land capability of forest reserves (ac)

Present land use category	Land capability class and land exploitation unit																		
	Class I	Class II						Class III						Class IV					Class V	
	IA	IIA	IIB	IIC	IID	IIE	IIF	IIIA	IIIB	IIIC	IIID	IIIE	IIIF	IVA	IVB	IVC	IVD	IVE	VA	VB
1	0	77	30	11	0	0	0	116	190	42	0	0	0	89	4	0	0	0	79	0
2	0	323	26	0	0	0	0	193	90	3	0	0	0	8	0	0	0	37	10	0
3	0	318	34	16	0	0	0	1 226	20	16	0	0	0	6	30	0	0	39	879	0
4	0	537	33	63	0	0	0	254	38	44	0	0	0	39	0	0	0	7	69	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	917	1 415	366	0	0	0	2 479	7 841	1 646	16	236	4	2 139	82	422	0	41	1 214	650
7F	47	28 579	239 400	45 516	7 367	3 240	1 909	30 573	973 928	51 912	18 621	37 700	10 675	1 580 461	37 639	145 434	16 761	2 697	103 598	68 672
7S	0	6 953	87 237	7 576	964	1 020	94	19 046	165 777	13 488	1 156	260	256	97 923	5 215	16 364	2 662	173	56 679	22 994
8	0	9 651	19 941	6 469	76	390	0	29 695	45 677	30 332	38	107	0	71 029	15 208	200	0	71 068	30 692	0
9	916	667	419	125	0	0	0	1 112	623	255	0	0	0	64	0	8	0	84	250	18
Unit total	963	48 022	348 535	60 142	8 407	4 650	2 003	84 694	1 194 184	97 738	19 831	36 303	10 935	1 751 758	58 178	162 428	19 423	74 146	193 470	192 334
Class total	963	471 759						1 443 685						2 065 933					385 804	

Most of the other areas are likely to remain remote in the foreseeable future and, as suggested during the discussion on similar land occurring in the stateland, they could be used for forestry purposes, including timber plantations, on a medium-term basis.

Government reserves

Tables 67a and 67b give the data on the extent of the government reserves which are suited for both agriculture and forestry. Some 4 385 ha (10 835 ac) are involved which represents about 51.4% of the total area of the reserves.

TABLE 67a Present land use and land capability of government reserves (ha)

Present land use category	Land capability class and land exploitation unit†										
	Class I	Class II			Class III			Class IV			Class V
	IA	IIA	IIB	IIC	IIIA	IIIB	IIIC	IVA	IVB	IVE	VA
1	0	3	0	0	86	21	6	0	0	10	171
2	0	136	74	5	253	28	20	0	0	0	28
3	0	36	15	2	33	0	2	0	0	3	4
4	0	0	0	0	113	35	16	0	0	0	2
5	0	0	0	0	0	0	0	0	0	0	0
6	0	46	29	16	71	56	75	0	0	3	90
7F	0	652	818	120	612	176	350	24	2	0	144
7S	0	33	34	16	281	639	412	22	0	2	375
8	0	87	0	46	522	670	411	2	0	98	159
9	0	8	4	19	27	11	76	1	0	3	0
Unit total	0	1 001	974	226	1 998	1 636	1 549	49	2	119	972
Class total	0	2 201			5 183			170			972

† Land exploitation units IA, IID, IIE, IIF, IIID, IIIE, IIIF, IVC, IVD and VB do not occur in the government reserves.

TABLE 67b Present land use and land capability of government reserves (ac)

Present land use category	Land capability class and land exploitation unit											
	Class I	Class II			Class III			Class IV			Class V	
	IA	IIA	IIB	IIC	IIIA	IIIB	IIIC	IVA	IVB	IVE	VA	VB
1	0	8	0	0	212	51	14	0	0	24	423	0
2	0	336	184	12	626	69	50	0	0	0	70	0
3	0	90	36	6	81	0	5	0	0	8	11	0
4	0	0	0	0	279	87	41	0	0	0	4	0
5	0	0	0	0	0	0	0	0	0	0	0	0
6	0	114	72	40	176	138	186	0	0	0	222	0
7F	0	1 610	2 022	298	1 512	435	1 311	59	4	0	352	0
7S	0	82	83	40	694	1 579	1 018	54	0	4	927	0
8	0	215	0	115	1 290	1 655	1 015	5	0	243	392	0
9	0	18	10	48	67	28	187	2	0	8	0	0
Unit total	0	2 473	2 407	559	4 937	4 042	3 827	120	4	295	2 401	0
Class total	0	5 439			12 806			419			2 401	

PLATE 2.14

Forest plantation with good growth of *Pinus caribaea* in Sibuga Forest Reserve

PLATE 2.15 Extensive areas are suited for both agriculture and forestry. Logging on such land in the Segaliud area

The land involved occurs generally as small, scattered and sometimes narrow tracts and are generally not large enough for estate-type holdings. Most of this land is held for water and river-bank conservation purposes and, inspite of the agricultural and timber producing capabilities, it is of utmost importance that such land is retained for these protective purposes. The remaining areas largely occur on government agricultural stations, and as such will ultimately become fully planted with agricultural crops.

Mining

From Tables 63a and 63b it can be seen that 53 583 ha (132 411 ac), are classified as having a possible mining potential and are suited for agriculture. It is likely, however, that even if prospecting results in mining being undertaken, the land so used will be relatively small in extent and, therefore, will not have any significant effect on the over-all agricultural pattern. The tables also show that almost 96% of the land with a possible mining potential is also capable of sustaining economic yields of timber, but here again, because relatively little of such land is likely to be used for mining, no serious conflict is likely to arise.

Conservation and recreation

It will have been seen during the earlier account on the development opportunities which exist for conservation and recreation that most of the land suited for such purposes is located either in high rugged country or along sandy beaches or on islands. Such places have little or no agricultural potential, but the mountainous areas frequently have commercial stands of timber. Limited and selective logging will in some areas be compatible with recreational uses in that it would improve access and, if undertaken wisely, should not unduly lower scenic values. The over-riding factor in such cases, however, will be water-shed conservation. If logging is likely to disrupt the water-regime of a catchment, the best choice would be conservation.

In the lowlands the Virgin Forest Reserves and particularly the Kabili-Sepilok Forest Reserve which have commercial stands of timber are a serious point of conflict between conservation and logging interests and, in certain parts, with agriculture. Every effort, however, should be made to ensure their inviolability.

A conflict is also likely to arise between recreational interests and urban development on the escarpments near Sandakan Town. Their use for amenity and recreation purposes is compatible with their water conservation function, and together, underline the importance of preventing further urban expansion into these lands.

The question of the irreversible effect on the game population of logging and particularly agricultural settlement must also be accepted. Ultimately most of the game will be contained in the forest reserves and other areas which might be allocated for pure conservation purposes; by which time the conflict between game and land development will be largely resolved. The increase in certain animal populations after logging, particularly those of pig and deer, and the slow rate of agricultural development after logging hold a possible key to an interim multiple-use of such land; and management methods might be evolved whereby herds of game could be reared on a semi-restricted free-range basis over logged land prior to cultivation. Such land would then be of recreational value and, in addition to offering good hunting, would provide an important source of animal protein.

Another point of conflict between game and land development interest is likely to occur in the Gomantong Forest Reserve which affords protection to the large flocks of swiftlets which feed around its limestone caves. The caves lie close to commercial forests and land highly suited for agriculture. Although the feeding habits of the swiftlets are imprecisely known it is possible that land development might have a harmful effect on their population, and ultimately the edible birds-nest industry which it sustains.

REGIONAL DEVELOPMENT OPPORTUNITIES

The land resource information contained in this report is of fundamental use for the planning of development in the Sandakan Residency. Broad-scale planning 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 of this report. It is important that this account is read in conjunction with the land capability classification map which gives in more detail the recommended long-term use of the land resources.

Kuamut Highlands

Here, the main development will be based on forestry. Much of the land is steep and rugged, and logging in many areas will prove to be difficult. In addition the Highlands provide the main water-catchment for the Kinabatangan River, and it will be essential to develop the timber industry in such a way so as to minimise the rate of stream and river runoff. This will entail retaining large areas of forested land, which will be compatible with the development of its conservation and recreation potential. The prospects for agriculture are very limited and restricted to a number of scattered, frequently remote, valleys.

Segama Highlands

Forestry is also likely to play a prominent long-term part in the economy of this region, although mining may be developed in certain parts. The northern zone contiguous with the Kinabatangan Lowlands has an agricultural capability, but access is likely to impose a considerable constraint to development.

Labuk Highlands

Here again, forestry is likely to play a major long-term role, and it will be necessary for logging to be operated in such a way so as to minimise flooding by the Kinabatangan and Labuk Rivers. Forestry would also have to be undertaken in a form compatible with the conservation and recreation potential which exist for certain parts. There is also ample scope for agricultural development particularly along the valleys centred on Telupid. The main part of the mineral belt runs through the region and a mining industry might in time be developed.

Crocker Range

A small part only of this region falls within the residency boundary and its development will be co-ordinated with the main area of the Crocker Range lying to the west and north. The prospects are, however, limited and largely restricted to a more intensive agricultural use of the riverine tracts; most of which are inhabited and at present subject to a shifting-form of cultivation.

Milian Valley

Development prospects are generally restricted to agriculture, but again the scope is limited. The most formidable barrier is its inaccessibility, since the region is populated and largely used for shifting cultivation. Any development plan should therefore be based on road construction and the establishment of a permanent form of agriculture. An intensive extension programme of crop selection, education and other agricultural services would be required.

Kinabatangan Lowlands and Segama Valley

These contiguous regions hold the greatest single opportunity for agricultural development in the residency and possibly the whole State, but future settlement and cultivation over their greater part will be limited by access and flooding problems. Until these have been resolved there will be considerable scope for continuing forestry in these regions.

Dent Hills

Future development in the part which falls in the Sandakan Residency will, when access has been improved, be based on agriculture. Any planning should take into account the extensive area suited for agriculture in the south, which has been discussed in the companion volume on the Tawau Residency.

Sandakan Peninsula

Almost all of this region is eminently suited for agriculture, access is good, most of the forest has been logged, and the greater part alienated. The spread of cultivation has, however, been slow, and there is considerable scope for increasing the rate of agricultural development.

Lokan Peneplain

Agriculture and forestry will play almost equally important roles here. The north-eastern part will be used for agriculture and this is conceivable in the near future because it is a natural extension to the Sandakan Peninsula and therefore its future development. The remaining part will continue to be an important forestry area.

Bongaya Hills

Poor access and a lack of population will severely restrict agricultural development in this region. The choice of agriculture would generally be restricted to a limited range of crops. Forestry is, therefore, likely to remain the main industry in the foreseeable future.

Kaindangan Peneplain and Bengkoka Lowlands

The greatest potential for these contiguous regions will rest on forestry, although there are considerable areas which will be developed for agriculture when they become accessible by road. There is also a limited scope for agriculture on Jambongan Island. Agricultural development in both regions will be helped by the settlement which already exists, and which could form the nuclei for future expansion.

Sugut, Labuk and Eastern Deltas

Future development will be largely based on the extensive mangrove forests. Agriculture will be restricted to relatively small floodplain areas where they extend into the estuarine zones.

RECOMMENDATIONS FOR FURTHER STUDIES

The regional development potential for general planning purposes has been outlined in the previous section. For planning and development to be fully effective, however, further studies are necessary on both the land resources and also the socio-economic and communications aspects. The following general recommendations for further studies are made; they are not in any particular order of importance:

1. Intensifying mineral prospecting work over the areas selected.
2. Undertaking more detailed soil surveys of the areas recommended for agriculture together with agronomic studies into crop/soil relations, crop suitability, and management and fertiliser requirements.
3. Updating land use surveys and the alienation detail with the view to intensifying cultivation in the main agricultural areas.
4. Updating the forest inventory, obtaining more detailed information on the forest resource, and the formulation of a forest management plan compatible with overall planning and development.

5. Undertaking a systematic hydrological survey of the residency with the view to conserving and controlling the water resources in a way consistent with all other forms of land-use.

6. Undertaking systematic wildlife and recreation surveys in order to positively identify in any overall development plan areas which are worthy of permanent use for such purposes.

7. Investigating the possibility of establishing game-farming on logged-over land with the view both to recreation and providing a source of animal protein.

8. Investigating the ecological requirements of the swiftlets, with the view to ascertaining the nature and extent of the vegetation which is required to sustain their numbers and, therefore, the edible birds-nest industry.

9. Undertaking specific studies of population and manpower, particularly in relation to the large agricultural development potential and future economic and marketing trends.

10. Undertaking communication studies, largely with the object of servicing the present and, particularly, the future agricultural areas.

11. And, largely in conjunction with the foregoing studies, formulating an overall development plan 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

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