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Land Resource Study

25 The land capability classification of Sabah Volume 1 The Tawau Residency

Land Resources Division, Ministry of Overseas Development

The land capability classification of Sabah

Volume 1

The Tawau Residency

Land Resources Division

The land capability classification of Sabah

Volume 1
The Tawau Residency

(with an Introduction and Summary for Volumes 1–4)

P Thomas, F K C Lo and A J Hepburn

Land Resource Study 25

Land Resources Division, Ministry of Overseas Development
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1976

THE LAND RESOURCES DIVISION

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

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

List of volumes

Title	The land capability classification of Sabah, P Thomas, F K Lo and A J Hepburn
Volume 1	The Tawau Residency (with an Introduction and Summary for Volumes 1-4)
Volume 2	The Sandakan Residency
Volume 3	The West Coast and Kudat Residencies
Volume 4	The Interior Residency and Labuan

Contents

	Page
LIST OF FIGURES	xi
LIST OF PLATES	xi
LIST OF MAPS	xii
ABSTRACTS AND KEYWORDS	xiii
GLOSSARIES	xv
PART 1. INTRODUCTION	1
Preface	1
History of the study	1
Procedures and team composition	2
Acknowledgements	2
PART 2. SUMMARY OF FINDINGS (VOLUMES 1-4)	5
Agriculture and forestry	5
Water	6
Grazing	6
Wildlife	6
Conservation	6
Mining	6
Further investigations	6

Page

PART 3. GEOGRAPHICAL BACKGROUND 7

Location 7

Topography and geology 7

Climate 10

Vegetation 12

Settlement and population 12

Communications 13

Economy 15
Timber 15
Agriculture 15
Fisheries 15
Industry 15

PART 4. SURVEY AND CLASSIFICATION OF RESOURCES 17

Survey and classification of specific resources 17
Geological surveys and mineral resource groups 17
Soil surveys and soil suitability (for agriculture)groups 18
Natural vegetation and timber resource groups 22
Hydrology and water resources 23
Topography and planimetry 24
Land tenure 24
Game and recreational resources 25
Present land use 25

The land capability classification 26
Land capability classes 26
Land exploitation units 26
Cartography, area measurement and data tabulation 28

PART 5. THE RESOURCES AND THEIR DISTRIBUTION 29

Mineral resources 29
Coal 29
Copper 30
Gold 31
Silver 31
Chromite 31
Manganese 31
Magnesite 31

Soil resources 32
Soil Suitability Group 2 One or more minor limitations 35
Soils developed on gently sloping hills 35
Derived from sedimentary rocks 35
Derived from basalt 35
Soils developed on terraces 35
Derived from alluvium 35
Derived from coral and alluvium 36
Soils developed on valley floors 36

	Page
Soil resources (continued)	
Soil Suitability Group 3 One serious limitation	36
Soils developed on strongly sloping hills	36
Derived from sedimentary rocks	37
Derived from volcanic ash	37
Derived from basic intrusive rocks	37
Soils developed on terraces	38
Derived from alluvium	38
Alluvium derived from volcanic ash	38
Soils developed on terraces and valley floors	38
Soils developed on riverine plains	39
Narrow valleys	39
Mature floodplains	39
Soils developed on coastal swamps	40
Soil Suitability Group 4 More than one serious limitation	40
Soils developed on terraces	40
Soils developed on tidal swamps	41
Soils developed on stranded beaches	41
Soil Suitability Group 5 Very serious limitation	41
Soils developed on mountains and steeplands	41
Forests and their timber resources	42
Introduction	42
Commercial forests: composition and distribution	44
Dipterocarps	47
Other commercial species	47
Timber resources of the forest reserves	47
Class I Protection forest reserves	47
Class II Commercial forest reserves	49
Undisturbed forests	49
Timber Resource Group 1	50
Timber Resource Group 2	52
Timber Resource Group 3	52
Disturbed forests	53
Regenerating forests	53
Non-commercial forests	53
Class III Domestic forest reserves	54
Class IV Amenity forest reserves	54
Class V Mangrove forest reserves	55
Virgin jungle reserves (V.J.R.)	55
Timber resources of the statelands	56
Commercial forests	56
Undisturbed forests	56
Disturbed forests	57
Non-commercial forests	57
Mangrove forests	58
Water resources	58
Surface water	58
Groundwater	59
Grazing resources	59
Present grazing land	61
Natural grassland	61
Game resources	61
Mammals	62
Reptiles	63
Birds	63

Page

Recreational land resources 63
Mountains and hills 64
Islands and beaches 64

PART 6. OPPORTUNITIES FOR RESOURCE DEVELOPMENT 67

History of land development 67

Alienation and gazettement and present land use 71

Population and manpower 75

Mining development opportunities 75
Possible mining areas 76

Agricultural development opportunities 76
Alienated land 77
Soil Suitability Group 2 79
Soil Suitability Group 3 79
Stateland 79
Soil Suitability Group 2 79
Soil Suitability Group 3 81
Forest reserves 83
Soil Suitability Group 2 83
Soil Suitability Group 3 85
Government reserves 85

Forestry development opportunities 85
Forest reserves 86
Stateland 86
Government reserves 89
Alienated land 89

Water resource development opportunities 90
Potable water 90
Water control 90

Conservation development opportunities 91
Conservation areas 91
Danum Valley 91
Tawau Hills Forest Reserve 91
Gunong Madai, Gunong Baturong, Segarong and Mensuli areas 93
Mount Silam 93
Gaya and Bohaydulong Islands 93
Sibuan, Adal and Sipadan Islands 93
Tinagat-Kalumpang foreshore 93
Beaches on the Dent Peninsula 93
Thermal springs 93

General opportunities 93
Conflicting resource potentials 94
Agriculture and forestry 94
Alienated land 94
Stateland 94
Forest reserves 98
Mining 98
Conservation and recreation 98
Forestry and fisheries 99

Page

Regional development opportunities 99
Kuamut Highlands 99
Kalabakan Valley 99
Cowie Deltas 102
Tawau Highlands 102
Semporna Lowlands 102
Segama Highlands 102
Segama Valley 102
Dent Hills 102

Recommendations for further studies 104

PART 7. REFERENCES AND RELEVANT WORKS 105

PUBLICATIONS OF THE LAND RESOURCES DIVISION 111

LIST OF FIGURES

1-1 Alienation and gazettement 72
1-2 Present land use 73
1-3 Soil suitability of the alienated land and its agricultural development 78
1-4 Suitability of the stateland for agriculture 80
1-5 Suitability of the forest reserves for agriculture 84

LIST OF PLATES

1-1 Oil palms and cocoa under *Gliricidia* shade, grown on basaltic soils of Soil Suitability Group 2. BAL Estate 20

1-2 Typical land use near BAL Estate. Tapioca, corn, peppers and bananas in foreground and wild coconuts, fruit trees and rubber behind, and forested steepland in distance 20

1-3 Commercial dipterocarp forest, Apas Road 45

1-4 Forested lands are being cleared for grazing. Improved pastures at the Veterinary Station, Apas Road 60

1-5 Mangrove cutting, Kuala Serudong 69

1-6 Mangrove chipping plant, Wallace Bay 69

1-7 Widespread recent oil palm cultivation in the Apas — Balung area 70

1-8 Neglected oil palm estate due to shortage of manpower in the Balung area 70

1-9 Flooding has restricted permanent crops on the Segama floodplain. Grazing has been attempted in recent years. Segama Estate 82

1-10 A typical limestone feature, Gunong Baturong 100

1-11 Many of the islands have good beaches and clear seas which could be developed for recreation purposes. Pulau Sibuan in Darvel Bay 100

Page

1-12 Scenic islands in Darvel Bay have a considerable recreational potential for the Semporna Lowlands. Pulau Mantabuan with coral reef in foreground, and the twin islands of Bod Gaya and Bohaydulong behind 101

1-13 The Dent Hills have a considerable agricultural and forestry potential. Logging road running west from the tip of the Dent Peninsula at Tegupi 103

LIST OF TEXT MAPS

1-1 Location of the Tawau Residency and its administrative districts 8
1-2 Physiography 9
1-3 Selected rainfall, climatological and hydrometric stations Mean monthly and annual rainfall, and period of recording 11
1-4 Communications 14
1-5 Geological surveys 21
1-6 Soil surveys 21
1-7 Forest surveys 21
1-8 Topographic and planimetric mapping 21
1-9 Alienation and gazettement mapping 21
1-10 Possible mining areas 30
1-11 Areas suitable for agriculture 33
1-12 Areas suitable for forestry 43
1-13 Forest reserves 43
1-14 Distribution of land categories 72
1-15 Cultivated areas including urban land 73
1-16 Areas worthy of future prospecting, including main likely mineral occurrences 75
1-17 Areas suitable for agriculture and the extent of their development 78
1-18 Suitability of stateland for agriculture 80
1-19 Suitability of forest reserves for agriculture 84
1-20 Suitability of forest reserves for commercial forestry 87
1-21 Suitability of stateland for commercial forestry 87
1-22 Suggested conservation areas 92
1-23 Main Segama catchment area showing the position of the Danum Valley 92
1-24 Areas of conflicting potential use between agriculture and forestry 95

SEPARATE MAPS (in separate folder)

Land capability classification, Tawau Residency. Scale 1:250 000 (4 sheets) 50-11, 50-12, 50-15, 50-16

Abstracts and keywords

Volumes 1-4

ABSTRACT

The study comprises quantified assessment of the land resources of the State of Sabah, Malaysia. There are four volumes, covering respectively the Tawau Residency, the Sandakan Residency, the West Coast and Kudat Residencies combined, and the Interior Residency with the island of Labuan. Each of the volumes is written in five parts:

Introduction/preface

Geographical background (a brief outline of the physical location, topography, geology, climate, vegetation, settlement, communications and economy of the area concerned.

Survey and classification of resources (information on the source of the material on which the reports are based, with details of the various surveys which have been carried out, and brief description of the principles of the land capability classification)

Resources and their distribution (description and location of the resources under the headings of mineral resources, soil resources, forest resources, water resources, grazing resources, game resources and recreational resources)

Opportunities for resource development (including a brief history of land development, description of development opportunities, outline of the same opportunities on a regional basis, and recommendations for further studies)

Volume 1 also carries a summary of recommendations for all four volumes.

30% of the State of Sabah is suitable for agriculture but only 10% of such land is cultivated; agricultural development possibilities vary considerably in the different residencies. The forest resources of the State are extensive and the need for conservation is emphasised. Attention is drawn to lack of information on water resources.

The study is accompanied by land capability classification maps at a scale of 1 : 250 000.

RÉSUMÉ

L'étude comprend une évaluation quantifiée des ressources terrestres de L'Etat de Sabah, en Malaysie. Elle comprend quatre volumes, sur la Résidence de Tawau, la Résidence de Sandakan, les Résidences combinées de la Côte Occidentale et de Kudat, et la Résidence Intérieure avec l'île de Labuan. Chacun de ces volumes est divisé en cinq parties: Introduction/preface; le miliéu géographiques (bref aperçu de l'emplacement physique, de la topographie, de la géologie, du climat, de la végétation, du peuplement, des communications et de l'économie de l'aire en question); analyse et classification des

ressources (détails concernant la source des informations sur lesquelles les rapports sont basés accompagnés de renseignements sur les études qui ont été accomplies, et description des principes de classification de la productivité potentielle des terres; resources et leur répartition (description et repartition des ressources sous les titres de ressources minérales, ressources terrestres, ressources sylvicoles, ressources hydrographiques, ressources en pâtures, ressources giboyeuses et ressources récréatives); possibilités d'exploitation des ressources. Le Volume 1 comporte un résumé des recommandations pour l'ensemble des quatre volumes.

30% de l'Etat de Sabah convient à l'agriculture, mais seulement 10% de ces terres sont cultivées; les possibilités d'exploitation agricole varient considérablement dans les différentes Résidences. Les ressources sylvicoles de l'Etat sont vastes et le besoin de conservation est mis en relief. L'attention est attirée sur le manque d'information au sujet des ressources hydrologiques.

L'étude est pourvue de cartes de la productivité potentielle des terres à l'échelle de 1 : 250.000.

DESCRIPTORS FOR COORDINATE 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

Volume 1

ABSTRACT

This volume contains a brief description of the physical and human environment of the Tawau Residency (Sabah, Malaysia) which covers an area of 13 963 km^2 (5 391 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. 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 indicates that approximately 35% of the land is suitable for agriculture and that 79% has a potential for commercial forestry.

RÉSUMÉ

Ce volume contient une description succincte de l'environnement physique et humain de la Résidence de Tawau (Sabah, Malaysie), qui s'étend sur une aire de 13.963 km^2 (5,391 mi^2). Les diverses études concernant les ressources effectuées dans la zone sont notées et un aperçu est donné de la méthodologie de la classification 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 prenant en considération le régime foncier, l'usage actuel des terres, la population et l'accessibilité. En conclusion, des recommendations sont formulées pour des études ultérieures susceptibles de faciliter la planification de la mise en valeur. Le rapport indique que 35% environ des terres conviennent à l'agriculture et 79% à l'exploitation des forêts.

Glossaries

1. TECHNICAL TERMS

Alienated land	Land for which a title, lease or provisional lease has been issued
Annual licence	A license 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*
Buffalo grass	*Paspalum conjugatum*
Carpet grass	*Axonopus compressus*
Centipede grass	*Ischaemium barbatum*
Centro	*Centrosema pubescens*
Coast grass	*Cynodon plectostachyus*
Guinea grass	*Panicum maximum*
Kazungulu	*Setaria sphacelata*
Lalang	*Imperata cylindrica*
Lotonosis	*Lotonosis bainesii*
Para grass	*Brachiaria mutica*
Paspalum	*Paspalum dilatatum*
Signal grass	*Brachiaria decumbens*
Siratro	*Phaseolus atropurpurens*
Stylo	*Stylosanthes gracilis*

Part 1

Introduction to Volumes 1-4

The attention of readers is also drawn to Part 2 'Summary of findings: Volumes 1-4', which gives a general picture of the report and its main conclusions

Part I

Introduction to Volumes I–V

Part 1
Introduction

PREFACE

This report is published with the permission of the Government of Sabah, Malaysia, to whom drafts of the study were submitted during 1974 and 1975. The study is an assessment of the land resources of Sabah and comprises four volumes, covering respectively:

Volume 1	The Tawau Residency
Volume 2	The Sandakan Residency
Volume 3	The West Coast and Kudat Residencies
Volume 4	The Interior Residency and Labuan

Each volume deals, for its particular area, with the geographical background, the survey, classification and distribution of resources, and opportunities for development.

A map showing the land capability classification of Sabah has been compiled at a scale of 1:250 000. It comprises ten sheets, the relevant sheets being included with each of the four volumes of this report. It should be noted that these maps were compiled from more detailed 1:50 000 land capability classification maps which together with other thematic maps were distributed to the various district and head-quarter offices.

The attention of readers who wish to gain a rapid impression of the main import of the study is directed to Part 2 of this volume, the 'Summary of findings'.

HISTORY OF THE STUDY

The present study derives from earlier initiatives, in May, 1966, when the Sabah State Development Committee appointed a Technical Sub-committee on Land Capability Classification charged with the task of classifying and mapping land capability for the whole of Sabah. Government agencies involved in natural resource surveys and planning were represented. In order to complete the work within an acceptable period it was considered that some outside help would be required, particularly in connection with surveys of the soil and forest resources and present land use. Requests were therefore made to the British and Canadian Governments for aid in carrying out soil surveys, forest inventory and land capability classification.

As a result, aid was given by Canada for the forest inventory and part of the soil survey, while technical assistance was provided by Britain for soil surveys and the land capability classification. In January 1971 the Land Resources Division formally assumed responsibility for these latter surveys. The soil surveys were completed in 1973 and following draft reports, a final report was published in 1975 as *Land*

Resource Study 20, The soils of Sabah (Acres *et al.* 1975). The land capability study was completed in 1975, and reported to the Government of Sabah in draft form; the present study is a revised version of this draft, accompanied by printed maps. A survey of current land use was undertaken by the Federal Division of Agriculture and the results are incorporated in the land capability classification.

PROCEDURES AND TEAM COMPOSITION

The methods employed in collating, interpreting and correlating the primary resource information are fully described in *Technical Monograph 1 Land Capability Classification* (Sabah, Malaysia, State Development Planning Committee, 1973).

It should be noted that all primary area measurements in this study were made in acres; the hectare equivalents have also been supplied in this report.

The team's main task was to coordinate the work of the various participating organisations, but it was also to collate, interpret and correlate the resource data, and produce the various maps and reports. The team comprised:

P Thomas	A member of the Land Resources Division and coordinator of the Land Capability Classification Project since its inception
F K C Lo	A member of the staff of the Department of Agriculture, Sabah. He joined the project in 1971
A J Hepburn	Formerly a member of the staff of the Forests Department, Sabah. He joined the project in 1973 with special responsibility for the forestry aspects

ACKNOWLEDGEMENTS

This report has drawn freely on information concerning closely related survey projects, such as the forest inventory and soil survey; and to note each individual reference would mean unnecessary repetition. The reader should therefore assume that much of the information is of a secondary nature and, unless positively stated, has in many cases been derived from the relevant articles given in the lists of references supplied in the last Part of each report.

To acknowledge every contribution and form of assistance which has made this study possible would be a monumental task. Almost every government department in Sabah, and some in West Malaysia, has been involved at one time or other; all have assisted willingly and generously. Without their unstinting help this work would not have been possible.

Special acknowledgement must be given to the help provided by the Director of Agriculture, Sabah, and his staff, who have over the years provided much of the incentive, encouragement and assistance to enable the work to be completed. This has been particularly evident in the form of generous provision of office facilities, local funding and support staff. The Project office support staff also merit special praise; without their willingness, industry and constant cheerfulness, this study would have been a far more difficult task. The Director of Lands and Surveys, Sabah, is also specially thanked for providing office accommodation during the period 1967-71. The Ministry of Finance, Sabah, under whose aegis much of the work was undertaken, is also specially thanked.

The main individuals and organisations involved in the study, in addition to the project team, are shown below:

Technical Sub-committee on Land Capability Classification

The following were members for whole or part of the time:

Agriculture Department	Datuk Dr Y T Shao (Chairman)
	P Thomas (Secretary)
	F K C Lo
	Dr V Lee
	R Smith (Chairman)
	A W Allen
	G Belton
	N L Tham
	E H Holland
	E M Scratton
	W H Williams
Ministry of Finance	W P Andu (Chairman)
	R McLean
	E Sinsua
	M Roberts
Forest Department	M P Fabia
	A J Hepburn
	M P Udarbe
	G S de Silva
	Dantalmura Yusop
	A J T Bayles
	D Nicol
Lands and Surveys Department	P M Sowdas
	G W Meggitt
	J A Fryer
	D M Brownhill
	L H Chin
	J Robertson
Geological Survey Department	D T C Lee
	K M Leong
	N Wong
	Dr G E Wilford
	Dr H J C Kirk
	J Newton-Smith
Drainage and Irrigation Department	A Manaf
	V Thiagarajah
	A R Goonting
	W E Rogers
Public Works Department	I Williams
	J Wong

Participating organisations

The organisations primarily concerned were:

Chief Minister's Department, Sabah
British High Commission, Malaysia
Canadian High Commission, Malaysia
Economic Planning Unit, Prime Minister's Department, Malaysia
Ministry of Agriculture and Fisheries, Sabah
Ministry of Finance, Sabah

Department of Agriculture, Sabah
Department of Forestry, Sabah
Department of Drainage and Irrigation, Sabah
Department of Geological Survey, Malaysia
Department of Public Works, Sabah
Department of Statistics, Malaysia
Division of Agriculture, Malaysia
Department of Meteorological Services, Malaysia
National Park Trustees, Sabah
Padi Board, Sabah
Land Development Board, Sabah and the
Department of Lands and Surveys, Sabah, particularly H Wong who compiled the land tenure maps

In conclusion, thanks must go to all local administrators and other government officers in the districts and headquarters, and many private individuals, whose courtesy, kindness and willingness to help contributed so much to the satisfactory conclusion of this study.

Part 2

Summary of findings

Volumes 1-4

Part 2

Summary of Findings

Volumes 1-4

Part 2
Summary of findings: Volumes 1-4

This summary is for the benefit of readers who wish to obtain a rapid impression of the main findings of the report as a whole.

The general classification of the land of Sabah is shown in the 1:250 000 land capability maps which accompany and support this report and in the larger-scale (1:50 000) maps held in headquarters and district offices in Sabah. The land capability classes can in turn be related to land exploitation units and to specific classes of mining areas, soils and forests: this relationship is shown in Table 5 on page 28 of this volume.

The text of the report describes the resources of Sabah and their distribution, and the opportunities which exist for different kinds of development.

There are extensive areas of land suited for both agriculture and forestry. There are also considerable opportunities for developing water, game and recreational resources. A number of areas are identified as being worthy of further mineral prospecting.

AGRICULTURE AND FORESTRY

The four volumes show that about 30% of the State is suited for agriculture and less than 10% of such land is being cultivated. This indicates a considerable opportunity for further agricultural development. The Sandakan Residency, described in Volume 2, offers the largest opportunity, closely followed by the Tawau Residency (Volume 1). The West Coast and Kudat Residencies (Volume 3) and the Interior Residency and Labuan (Volume 4) hold relatively little agricultural potential. In the Sandakan Residency, the greatest potential lies in the Kinabatangan Lowlands and the Segama Valley, but development is dependent on adequate flood mitigation in the Kinabatangan and Segama valleys and floodplains. Other regions of the Sandakan Residency with potential are the remote Milian Valley, the Dent Hills, Lokan Peneplain, Kaindangan Peneplain, Bengkoka Lowlands and the Sandakan Peninsula. Regions of future agricultural development in the Tawau Residency are the Kalabakan Valley, Semporna Lowlands, Segama Valley and the Dent Hills. Poor communications act as a constraint to early development in the Dent Hills and parts of the Kalabakan Valley, as does flooding in the Segama Valley. Development opportunities in the West Coast, Kudat and Interior Residencies are relatively meagre, the more important areas being the Bengkoka Peninsula and the Klias Hills.

The forest resources of the State are very extensive, almost 60% of the land containing undisturbed commercial forest. The Sandakan Residency holds the greatest potential for forestry, followed by the Tawau and Interior Residencies. The West Coast and Kudat Residencies hold relatively little potential for commercial forestry. Attention is drawn to the fact that considerable areas of undisturbed forest, particularly in the West Coast and Interior Residencies, occur on steep land where the forest serves an important function in protecting water catchments and reducing soil erosion. The conservation of these forests is important.

There is very considerable conflict between the interests of agriculture and forestry, and this is dealt with mainly in Volumes 1 and 2, because it occurs largely in the Tawau and Sandakan Residencies. This conflict is particularly discernable in a number of forest reserves which have extensive areas suited for agriculture. Even larger areas of stateland with commercial forests are shown to be unsuited for agriculture.

WATER

The study highlights the fact that there is little detailed information available on water resources and emphasises that comprehensive hydrological surveys are required. These are necessary to ascertain supplies of both potable and irrigable water and provide data for flood control purposes.

GRAZING

Extensive areas of natural grassland are shown to have soils suited for agriculture, and which could be developed for grazing,with proper management. The greatest opportunities are found in the West Coast and Kudat Residencies, and are described in Volume 3.

WILDLIFE

Attention is drawn to the scarcity of information on the game resources, and brings attention to the need for wildlife surveys. A brief account is given in each volume of the mammals, reptiles and birds. A suggestion for a game sanctuary covering the Danum Valley in the Segama Highlands is put forward in Volume 1.

CONSERVATION

Even though no proper surveys have been carried out on conservation and recreational land resources, 43 areas of outstanding merit are identified. The need is stressed for adequate conservation areas covering all types of vegetation to serve as gene pools (reserves of genetic resources) for the future.

MINING

The extent of the proven mining areas is very limited with only one mine actually in production. However, a number of areas are recommended for prospecting to determine the extent of the mineral deposits and their economic viability. These mainly occur in a broad area stretching from Darvel Bay in the south through the Segama and Labuk Highlands almost to the mouth of the Labuk River. These are dealt with in Volumes 1 and 2. Another major possible mining area is associated with the Kinabalu pluton, which is described in Volume 3. Copper ores appear to be the most widespread and offer the best prospects for mining, together with the Silimpopon and Tawau coalfields which are described in Volumes 1 and 4 respectively.

FURTHER INVESTIGATIONS

Finally, in each volume, recommendations are given for further studies. These include the need for more detailed and up-to-date information on many of the resources already surveyed, and on socioeconomic aspects not previously considered, so that land planning and development can be fully effective.

Parts 3-7

Tawau Residency

Part 3

Geographical background

LOCATION

The Tawau Residency is situated in the south-eastern part of the State of Sabah (Text Map 1-1) and is bounded by latitudes 4° 10'N and 5° 17'N and longitudes 116° 53'E and 119° 16'E. Included in the Tawau Residency is that part of Sebatik Island lying north of latitude 4° 10'N and also the offshore islands in the Darvel Bay and Semporna areas. The town of Tawau is the administrative centre of the residency and the other towns are Lahad Datu and Semporna, the administrative centres of the respective districts.

TOPOGRAPHY AND GEOLOGY

The topography of the Tawau Residency is varied with rugged mountainous country in much of the western and central part and generally flatter country in the south-east and east. It has been described by Collenette (1963) in his *Physiographic Classification of North Borneo*. Text Map 1-2 shows the various units of that classification which fall in the Tawau Residency.

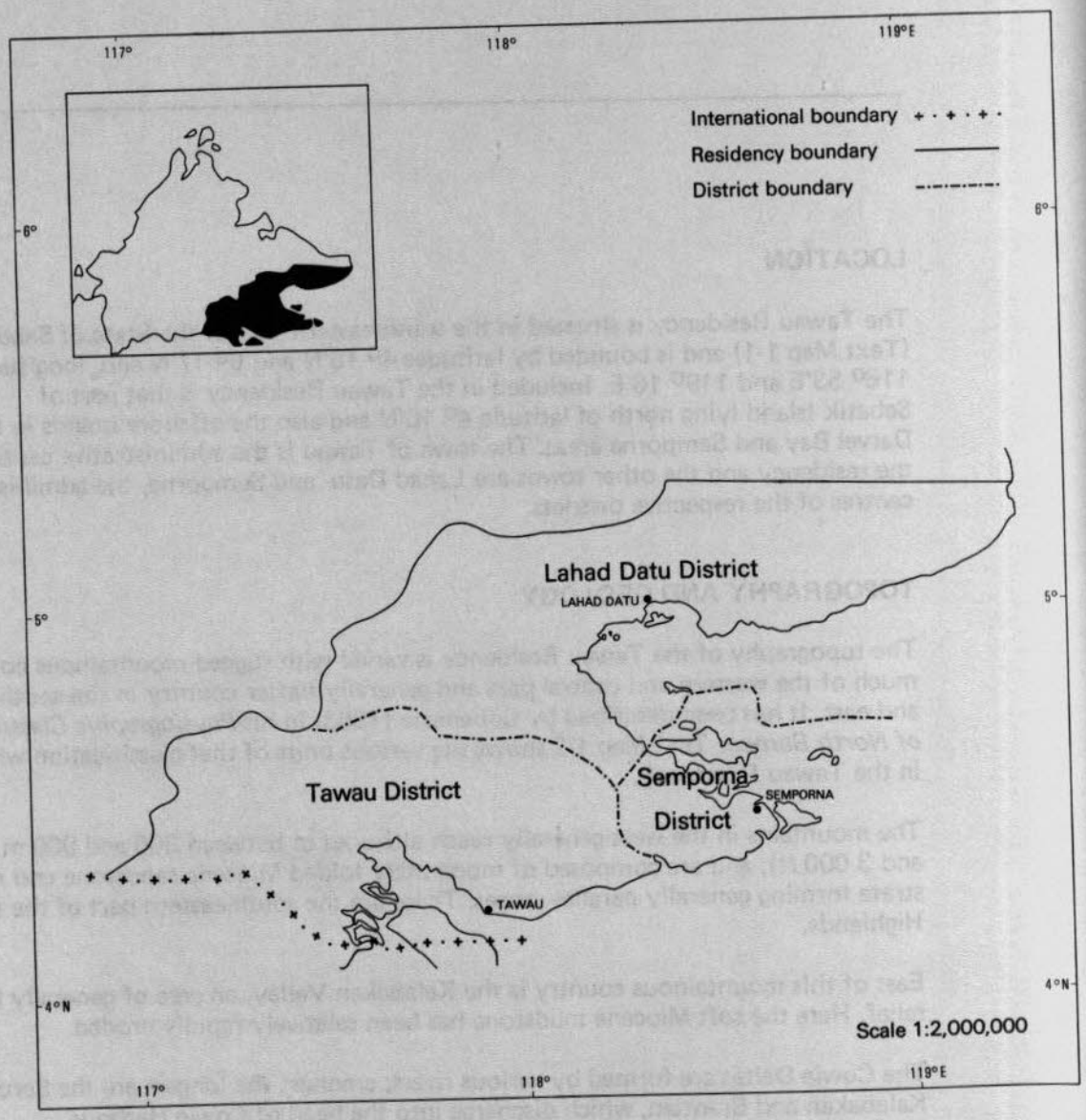
The mountains in the west generally reach altitudes of between 300 and 900 m (1 000 and 3 000 ft), and are composed of moderately folded Miocene sandstone and mudstone strata forming generally parallel ranges. These are the south-eastern part of the Kuamut Highlands.

East of this mountainous country is the Kalabakan Valley, an area of generally low relief. Here the soft Miocene mudstone has been relatively rapidly eroded.

The Cowie Deltas are formed by various rivers; amongst the longest are the Serudong, Kalabakan and Brantian, which discharge into the head of Cowie Harbour.

North and west of Tawau Town, inland from the coastal fringe, is an area of highland, the Tawau Highlands. Their dominant feature is the high rugged country round Mounts Magdalena 1 300 m (4 300 ft) and Wullersdorf 750 m (2 500 ft) which is developed on Pliocene and Quaternary volcanoes and associated lava flows. West of this volcanic area the country is generally lower with ridges of sedimentary rocks 300 to 600 m (1 000 to 2 000 ft) high, though some peaks are in the region of 900 m (3 000 ft).

The Semporna Lowlands, east of the Tawau Highlands, is an area of generally low land, although including isolated hills and blocks of high land; it stretches north to include the Tingkayu Valley and the offshore islands in Darvel Bay. The main features are: a low dissected peneplain, formed mainly by Miocene and Oligocene sandstone, shale and tuff in the north and by Quaternary volcanic ash in the south, drained by the Kalumpang, Balung and Sipit Rivers; hills formed by volcanic rocks of the Pliocene period in the Mount Pock area and lava fields of Quaternary age around Mostyn.



TEXT MAP 1-1 Location of the Tawau Residency and its three administrative districts

TEXT MAP 1-2 Physiography

Prepared by the Directorate of Overseas Surveys 1976

Cretaceous and Eocene rocks of the Chert-Spilite Formation occur to the south-east and north-west of Mostyn. Along the coast there is a complex pattern of alluvial plains and swamps. Bum Bum and Semporna islands at the eastern end of the Semporna Peninsula are largely raised coral reefs; while Bod Gaya and some of its neighbouring islands are relics of the rim of a large volcanic crater. Sebatik Island lying to the south-east of Tawau, which is considered part of the Semporna Lowlands, consists of a ridge of low hills built of Miocene to Oligocene sandstone-shale surrounded by alluvial terraces and swamps.

North of the Tawau Highlands and Semporna Lowlands is a rugged mountainous area, 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. There is also a great variety of Lower Triassic or older metamorphosed igneous rocks of uncertain age which form the Crystalline Basement. A notable feature of the area is the Orchid Plateau, which is bounded on three sides by steep scarps, with an area of about 36 km^2 (14 mi^2) and an elevation of approximately 600 m (2 000 ft). These highlands are drained mainly by the Segama River.

East of the Segama Highlands forming the hinterland of Lahad Datu is a generally low-lying area, the Segama Valley, where low hills and alluvial flats intermingle. The rocks in this area are mainly mudstone and tuff of Miocene age.

The north-eastern part of the residency is formed by the southern half of the Dent Peninsula, the Dent Hills, where again the country shows a general east-west trend. Much of the western half of the area is rugged and mountainous, with the Bagahak Range, built of Miocene volcanic rocks, rising to a height of 760 m (2 538 ft). Eastwards the topography is much more gentle with generally low-lying hills and ridges and alluvial flats. Apart from the volcanics of the Bagahak Range the rocks in the area are sedimentary, predominantly mudstone and sandstone, showing a west to east graduation from Upper Miocene to Quaternary. At the eastern extremity, there are raised coral platforms and alluvial deposits all along the southern and eastern shore line.

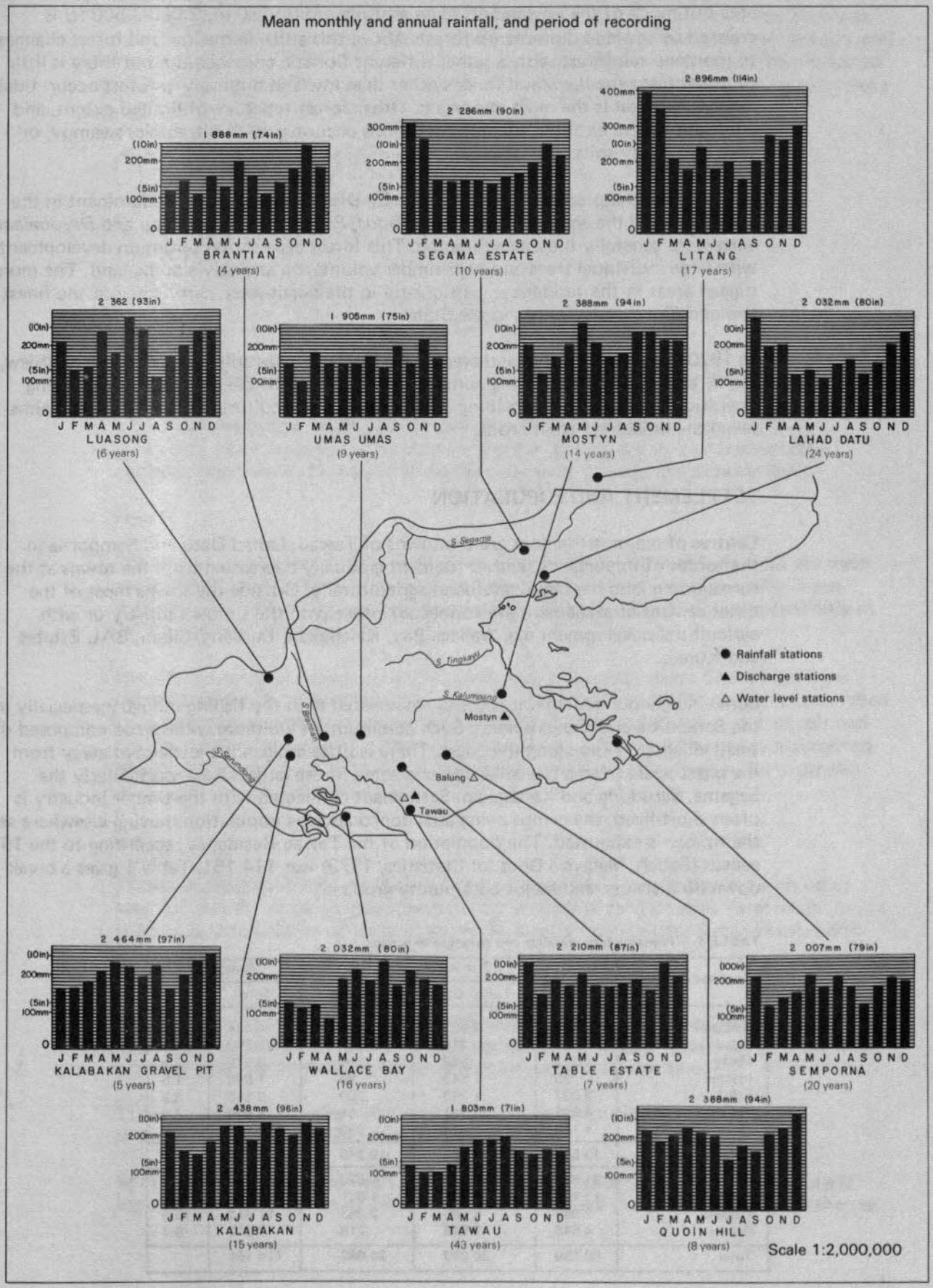
CLIMATE

Generally speaking the climate of the Tawau Residency is hot and wet. The average shade temperature is about 26°C (78°F), temperatures in the shade rising to around 29°C (84°F) at noon and falling to around 23°C (73°F) at night (Sabah, Malaysia, Department of Drainage and Irrigation, 1970). The mean annual rainfall varies from around 1 800 mm (71 in) in some localities to at least 2 500 mm (98 in) in others.

Rainfall is generally evenly distributed throughout the year though with a tendency for November, December and January to be the wettest months, and February and March the driest. However it must be pointed out that detailed climatic records for the residency are rather meagre particularly with regard to temperature (one station, Mostyn Estate). Rainfall figures (Sabah, Malaysia Department of Drainage and Irrigation, 1970) are based on records from the 14 stations shown in Text Map 1-3, but it should be noted that the majority of these are situated near the coast and there is no station further east on the Dent Peninsula than Lahad Datu.

The figures for Litang Estate, just north of the residency boundary, are shown, but have not been used in calculating the annual average. These may be more representative of the Dent Hills. This area probably receives more precipitation from the north-east monsoon than the others, which are to some extent protected from the full effect of the monsoon by the highlands in the north-west and north and the Dent Peninsula.

Despite the paucity of records it is nevertheless considered that the climate throughout the residency may be classified as the Tropical Rainy Climate (Af) according to Koppen's system (Trewartha, 1954).



TEXT MAP 1-3 Selected rainfall and hydrometric stations

VEGETATION

The natural vegetation is tropical rainforest. There are variations of forest type in the area but much of the lowland up to an altitude of 600-750 m (2 000-2 500 ft) is covered by lowland dipterocarp forest. Above this altitude the lowland forest changes to montane rainforest with a rather different floristic composition, but there is little of this forest type. Lowland forests other than lowland dipterocarp forest occur; tidal mangrove forest is the most important. Other forest types are of limited extent, and are found where extreme edaphic conditions occur e.g. with ultrabasic, swampy, or very acid sandy soils.

In the lowland dipterocarp forest the family Dipterocarpaceae is predominant in the tree flora with the species *Shorea leptoclados, Parashorea malaanonan* and *Dryobalanops lanceolata* generally the most common. This forest type shows optimum development, with large individual trees and high timber volume, on strongly sloping land. The more rugged areas in the residency, particularly in the north-west, carry some of the finest lowland dipterocarp forests in the State.

In 1970 about 93% of the land area of the residency was still covered by forest (Siew, 1973) though of this probably some 15-20% has by now been disturbed by logging operations. Most of the remaining land is used for agriculture, oil and coconut palms being the most important crops.

SETTLEMENT AND POPULATION

Centres of major settlement are the towns of Tawau, Lahad Datu and Semporna in that order of importance, with settlement gradually decreasing from the towns as the surrounding land has been developed agriculturally. Outside the towns most of the other centres of settlement are connected either with the timber industry or with agricultural development e.g. Wallace Bay, Kalabakan, Luasong, Silam, BAL Estates and Kunak.

Some indigenous settlement is closely associated with the fishing industry especially in the Semporna and Tungku areas. Such communities are more widespread composed of small villages mainly along the coast. There is little indigenous settlement away from the coast apart from a few villages along some of the larger rivers, particularly the Segama, Serudong and Kalabakan. Settlement connected with the timber industry is often short-lived, the camps being abandoned and the population moving elsewhere as the timber is exhausted. The population of the Tawau Residency, according to the 1970 census (Sabah, Malaysia Dept. of Statistics, 1973) was 114 161. Table 1 gives a break-down by districts and major community groups.

TABLE 1 Population by districts and community groups

Community group	Districts			Residency	
	Tawau	Lahad Datu	Semporna	Total	%
Kadazan	1 384	2 903	147	4 434	3.9
Bajau	1 260	3 216	18 307	22 783	20.0
Malay	2 312	848	215	3 375	2.9
Idahan	33	1 643	20	1 696	1.5
Suluk	2 037	1 298	280	3 615	3.2
Tidong	4 832	121	33	4 986	4.4
Other indigenous	1 740	874	238	2 852	2.5
Total indigenous	13 598	10 903	19 240	43 741	38.4
Chinese	21 628	5 924	1 620	29 172	25.5
Indonesian	17 429	4 069	1 021	22 519	19.7
Filipino	2 989	5 846	2 383	11 418	10.0
Others	4 545	2 548	218	7 311	6.4
Total	60 189	29 290	24 682	114 161	

It is apparent that only 38.4% of the population is indigenous and that over half of these belong to the Bajau community mainly living in the Semporna District. The largest community group is the Chinese with 25.5%, the majority living in the Tawau District, followed by the Bajau with 19.9% and the Indonesian with 19.7%. The large Indonesian and Filipino populations are closely associated with the timber industry and agricultural estate development. In Tawau the population is more urban than in Lahad Datu and Semporna as shown in Table 2. The relatively large Chinese community make up more than 50% of the urban population.

TABLE 2 Total and urban population, Tawau Residency

District	Total population	Urban population	
		Numbers	% of total
Tawau	60 189	24 247	40.2
Lahad Datu	29 290	5 169	17.6
Semporna	24 682	3 371	13.6
Residency	114 161	32 787	28.7

COMMUNICATIONS

The major features of the communications system are shown in Text Map 1-4. Internally, road transport is the most important, joining the three administrative centres. There are no railways. Air and sea transport provide the external links.

Road

There are an estimated 140 miles of all-weather trunk roads. Although most are maintained by the Public Works Department, the system in the Kalabakan valley is the responsibility of the timber interests working in the area. The roads are sealed only in the vicinity of the towns.

In addition, extensive areas are served by timber extraction roads. These have been constructed by the timber industry. Any account of such roads is soon outdated. When they cease to serve their purpose they are generally allowed to fall into disrepair and rapidly become impassable. In some cases, however, such roads have been maintained as infrastructure for subsequent agricultural development. This is seen, for example, in the Balung and Sipit areas.

Air

There are regular air services linking Tawau, Lahad Datu, and Semporna with other towns in Sabah. Tawau is also a terminal for scheduled services with Tarakan in Indonesia. The airstrips at Kalabakan and Mostyn are suitable for light aircraft only.

Water

Deep water ports, capable of accomodating ocean-going vessels, are located at Tawau and Lahad Datu. Facilities at Semporna are suited for coastal vessels only. There is an offshore palm oil terminal at Kunak which serves bulk oil-carriers.

Timber is regularly loaded onto large ships at a number of points in the more sheltered parts of Cowie Harbour and Darvel Bay.

Where there are no roads, rivers are frequently used to transport goods, particularly logs, as the lower courses of most of the main rivers are the sole easy link with the sea.

TEXT MAP 1-4 Communications

ECONOMY

Timber extraction and agriculture, in that order of importance, are the basis of the present day economy: both are geared to an expanding export trade.

It will be seen in Table 3 that Tawau has a considerable external, mainly overseas, trade surplus. The figures for the three districts reflect the importance of Lahad Datu and Tawau as producers of export commodities, mainly logs; the relatively low financial input being made to development in the Lahad Datu District as indicated by the import figure; and the low status of Semporna District in the residency's economy.

TABLE 3 Trade figures for 1972 (Dept. of Statistics, 1973)

District	$M million		
	Imports	Exports	Balance
Tawau	103.68	123.06	+ 19.38
Lahad Datu	22.01	147.43	+ 125.42
Semporna	1.83	21.21	+ 19.38

Timber

Timber production probably accounts for as much as 85% of earnings (Sabah, Malaysia, Dept. of Statistics, 1973). In 1972 the residency produced almost 2.3 million tons, valued at $M 212 million, which represents about 60% of the state's total exports. The greater part was derived from the hinterlands of Darvel Bay lying within the Lahad Datu District.

Agriculture

The agricultural sector plays a small, but increasingly important, part in the economy. It is largely based on plantation crops and geared to the export trade. The 1972 products were valued at $M 36 million (Sabah, Malaysia, Dept. of Statistics, 1973), comprising mainly palm oil, rubber, cocoa, and copra. These are mainly produced on a number of large privately owned estates and government settlement schemes. Smallholdings of coconut palms are found sporadically along the littoral of the mainland and on many of the islands, and serve as a cash crop which supplements the earnings from fishing for a number of communities. Shifting cultivation, based on rice, tapioca, and maize, is relatively rare, and has little or no effect on the cash economy.

Fisheries

Fisheries, although relatively unimportant as an export industry, play a prominent internal role in the economy as a major source of food. For example, the 1971 landings at Tawau Port alone were valued at almost $M6 million *(Sabah, Malaysia, Department of Agriculture, 1974).* The figure for the residency as a whole, would be considerably larger.

Industry

Industry is currently of little significance in the economy of the residency; what exists is largely based on wood processing. The production of sawn timber in 1972 amounted to approximately 40 000 m^3 (1.4 million ft^3), almost all of which was used to serve local needs. In the same year, 1.3 million m^2 (1.6 million yd^2) of wood veneer was manufactured, all of which was exported. In late 1971 a factory was opened on Sebatik Island for the production of wood chips from mangrove forest species for export to Japan (see Plate 1.6). Production has risen from approximately 100 000 t in 1972 to over 200 000 t in 1974.

The status of the palm oil industry is gaining in importance with four large oil-processing mills in production at BAL, Mostyn and Giram Estates and at Balung. Bulk storage facilities and shipping terminals have been established at Tawau and Kunak.

Part 4

Survey and classification of resources

Part 4 reviews the various investigations of specific land resources leading to the systematic surveys undertaken in the past two decades or so. 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

The earliest known resource investigations were undertaken in the 1880s. These were based on the work of mineral prospectors interested in gold deposits which were reputed to exist in large quantities in the Segama Highlands. Until the immediate post-war period, resource surveys were solely geological and essentially *ad hoc,* although they became increasingly systematic with the work of various oil exploration companies.

The 1950s saw a great impetus in land development, and a number of specific surveys were initiated which have now made it possible to compile the inventory of the main resources described in Part 5. Of these, minerals, soils and forest resources have been classified into groups according to their economic importance.

GEOLOGICAL SURVEYS AND MINERAL RESOURCE GROUPS

As early as 1885, a stretch of some 192 km (120 mi) of the Segama Valley lying 5 km (3 mi) on each side of the river was officially proclaimed a goldfield. The first recorded results of prospecting in the area, however, did not appear until 1886. The results were disappointing and by 1892 interest was transferred to the coastline and a number of small valleys between Silam and the Tingkayu Valley. Even though gold, silver and copper were discovered, the amounts were low (Fitch, 1955).

Coal was prospected between 1898 and 1903, and mined at Silimpopon between 1905 and 1932 (Collenette, 1954). In the meantime, in 1900, a final attempt to mine gold was made near the confluence of the Bole and Segama Rivers. This again failed (Fitch, 1955).

The first geological surveys were undertaken in the period 1912-14 and were associated with the search for oil in the Tawau area, the Serudong and Kalabakan Valleys, Sebatik Island and along the south coast of the Dent Peninsula (Collenette, 1954; Kirk, 1962; Haile, 1965).

The systematic geological survey of the eastern end of the Dent Peninsula was carried out between 1936 and 1959 as part of the search for oil in the area, and a geological map was produced for the extensive area lying south-east of the Segama River as far west as the Silabukan Valley (Haile and Wong, 1965).

In 1950 the first geological survey was made by the newly instituted Geological Survey Department of the then British Borneo Territories. This was the survey of the Silimpopon area. Text Map 1-5 gives an account of the areas covered by this and subsequent geological surveys undertaken by government, resulting in the complete geological mapping of the residency at a scale of 1:125 000. During these surveys special account was made of the mineral deposits encountered.

This information has provided the basis for determining the location, extent and value of the geological resources and their classification. In so doing, special emphasis has been made on the occurrence of metaliferous deposits such as copper, gold and silver, which are workable on an open-cast system of mining, i.e. those which may have an appreciable long-term effect on the use of land and thereby land capability. Four mineral resource groups are defined:

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, although occurring elsewhere in Sabah, has not been found in the Tawau 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

Even though there must have been some interest in land for agricultural purposes in the previous century and the first half of this century, relatively little development occurred and only scanty records were made.

The importance of identifying land for agricultural purposes was recognised by the Forest Department which 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.'

No systematic pedological work was undertaken before 1953 when a reconnaissance soil survey of the Semporna Peninsula was begun. This was followed by similar surveys of other parts of the residency, culminating in those of Acres and Folland, and Wright, and resulting in complete coverage by 1972. This is shown on Text Map 1-6, and reported in *Land Resource Study 20, The soils of Sabah* (Acres *et al.*, 1975) particularly in Volume 3 (Wright, 1975) and Volume 2 (Acres and Folland, 1975). It should be noted that all these surveys produced soil maps at the scale of 1:50 000, but these have not been published in *Land Resource Study 20* in which the soil maps are at the scale of 1:250 000.

The various soil 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 suitability for agricultural use. Suitability is assessed 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 are:

Soil Suitability Group 1 Soils with no limitations to agricultural development

These are generally deep, permeable and well aerated soils with good reserves of moisture; and they are either well supplied with plant nutrients or readily responsive to fertilisers. They are developed on level or almost level land where the upper slope limit is 5^{o}. Having no limitations to agricultural development, the soils are capable of growing a wide range of crops. It will be seen that soils of this group have not been recognised in the residency.

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^{o} range which would not require any expensive form of anti-erosion control, or shallow peat deposits never more than 50 cm (20 in) in depth. Although a wide range of crops can be grown on such soils the choice is generally more restricted and yields can be expected to be less than from Group 1 soils (See Plate 1-1).

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

This includes soils which are limited for agricultural development because they are on strongly sloping land in the 15 to 25^{o} 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. To thrive 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 pursuit would depend on careful selection of crops and good management.

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

This group would commonly include, for example, shallow soils developed on strongly sloping sites, or shallow soils with acute mineral deficiencies and strongly indurated subsurface horizons such as found in many podzols, very poorly drained and saline soils

* 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 Groups 1 and 2, Category 2 ('marginal land') to Group 3, and Category 3 ('unsuitable land') to Groups 4 and 5. The more detailed five-tier system employed on the 1:50 000 scale soil suitability maps is considered more appropriate for the purpose of this report. Inevitably, however, some differences in detail have resulted.

PLATE 1.1 Oil palms, and cocoa under *Gliricidia* shade, grown on basaltic soils of Soil Suitability Group 2, BAL Estate

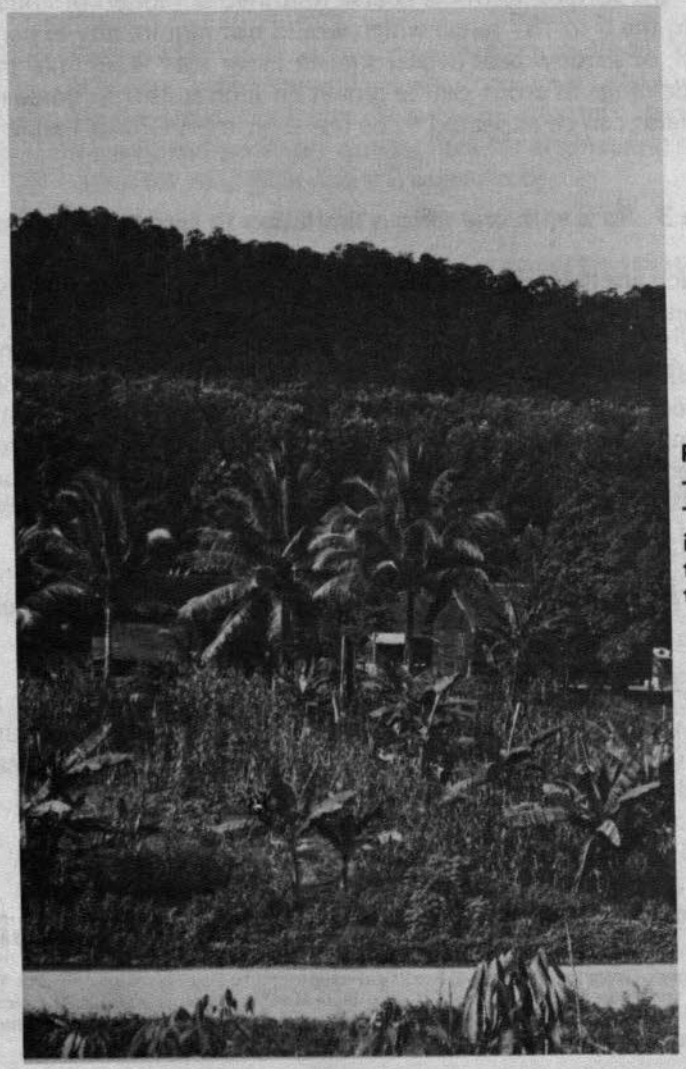
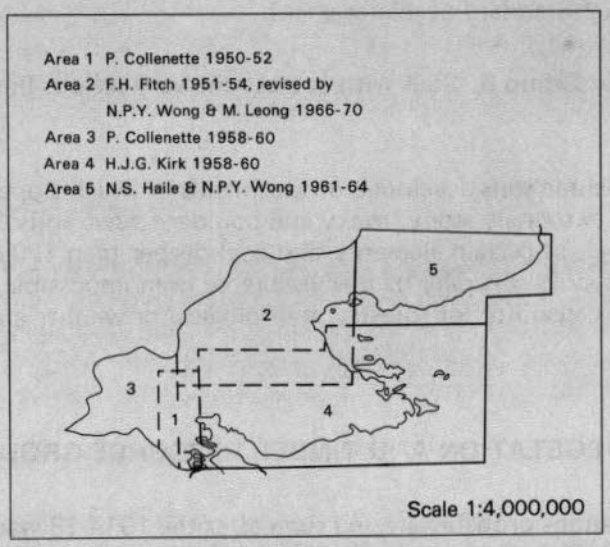
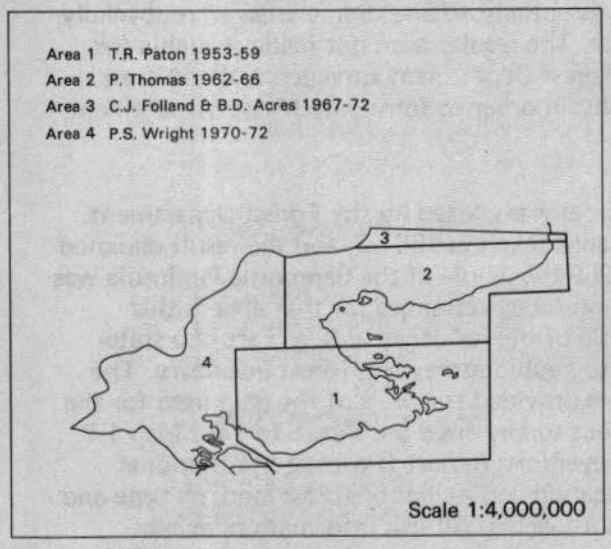


PLATE 1.2

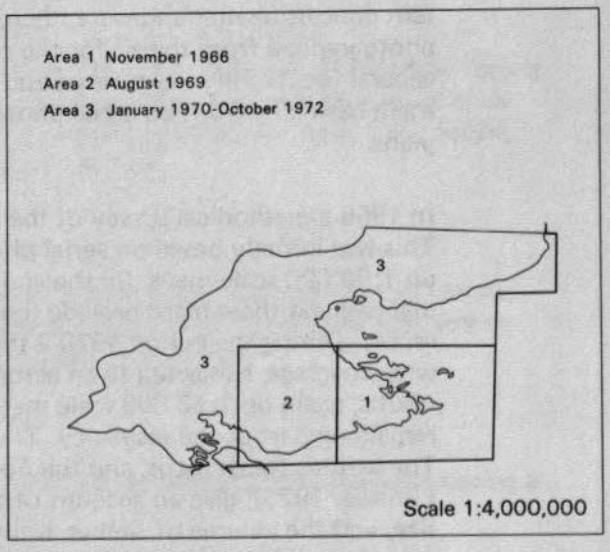
Typical land use near BAL Estate. Tapioca, corn, peppers and bananas in foreground with coconuts, fruit trees and rubber behind, and forested steepland in distance



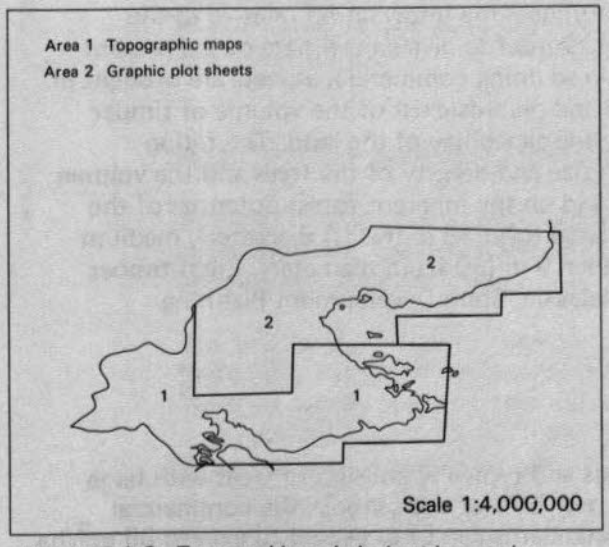
TEXT MAP 1-5 Geological Surveys



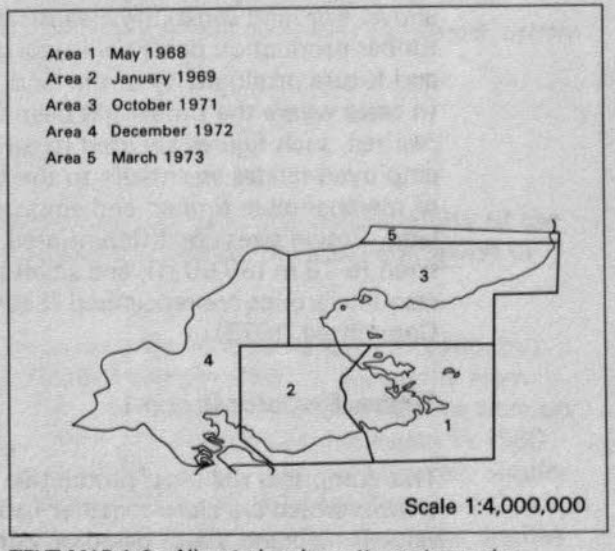
TEXT MAP 1-6 Soil Surveys



TEXT MAP 1-7 Forest Surveys



TEXT MAP 1-8 Topographic and planimetric mapping (1:50,000), 1974



TEXT MAP 1-9 Alienated and gazettement mapping

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

NATURAL VEGETATION AND TIMBER RESOURCE GROUPS

Logging operations probably started soon after the 1914-18 war, and even though timber exploitation played a relatively important position in the economy in the 1920-40 period it was not until after World War II that large-scale investigations were undertaken of the forest resources. These were initially done by a number of important concessionaires and were, therefore, essentially *ad hoc.* Some areas were specially photographed from the air for the purpose. The results were not made available for general use. During the same period the Forest Department surveyed selected areas, again basing its work on aerial photographs, in order to formulate forest management plans.

In 1966 a methodical survey of the resources was started by the Forest Department. This was initially based on aerial photographs taken in 1961-2, and the result depicted on 1:50 000 scale maps. By the end of 1969 the whole of the Semporna Peninsula was mapped and these maps provide the data on forest resources for that area in this report. During the period 1970-2 the whole of the residency was, as part of a state-wide coverage, subjected to an aerial photographic survey and forest inventory. 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 1-7. 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. Also shown are the terrain and water conditions of the land which are important in as far as timber extraction is concerned. The volume data are derived exclusively from the *Forest Inventory Report* mentioned above. For land capability classification purposes the information relative to the timber production potential is rearranged in order to give an estimate of the present and future productivity of the land, and in so doing commercial aspects are brought in. In cases where the timber has been felled and records exist of the volume of timber realised, such figures are used to estimate the capability of the land. The rating employed relates essentially to the crown size and density of the trees and the volume of merchantable timber, and emphasis is laid on the inherent forest potential of the land. Crown sizes are differentiated into large (over 18 m (60 ft) diameter), medium sized (9-18 m (30-60 ft), and small (less than 9 m (30 ft) in diameter). 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 30-60% of the canopy, if medium-sized over 90%. These are considered to be of average commercial value, and timber yields can be expected to be of the order of 62-89 m^3/ha (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 30-90%, and those with small crowns over 60%. By current standards such forests are considered to be marginally commercial, and may be expected to yield 35-62 m^3/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 form this group are non-commercial, consisting of montane forests and forests on hills with soils derived from ultrabasic rocks, which because of their species distribution and small size are of no present commercial value. They might, however, be used for timber production in the future.

Timber Resource Group 6

This group comprises other non-commercial forests, which includes coastal forests, freshwater swamp forests and areas of nipah *(Nipah 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

Relatively little is known about the source, extent, character and dependability of the water supplies. The records which exist are generally of short duration and sparse in geographical distribution.

The first rainfall stations were set up in Tawau and Lahad Datu as early as 1906, but there are a number of gaps in the records. Rainfall records exist for Semporna from 1936, but again these are not continuous. Ten other rainfall-recording stations were set up in the 1950s and 1960s. Investigation of the surface water supplies began in 1960 when systematic recordings of the water level of the Tawau River were started. Similar recordings of the Balung at Balung Estate began in 1963. In 1968 the Tawau station was adapted to record also the water discharge rates, and in the same year a similar station was established on the Kalumpang River near Mostyn Estate. The locations of the various hydrometric stations are shown in Text Map 1-3.

Water resources surveys have been undertaken in two specific areas (Binnie and Partners, 1967); (Ganendra, Ahmad and Associates, 1969). In 1967 an appraisal was made of the potable water supply for Semporna Town. This covered both the groundwater in the vicinity of the town and also surface supplies in the hills lying to the west. A study was undertaken in 1969 of some 2 000 ha (5 000 ac) of the Tawau River catchment in relation to the drainage of Tawau Town. Recently some attention has been given to the potable water supplies of the Lahad Datu area. Estimated discharge rates have been made for the Penchuran and Sapagaya Rivers near Lahad Datu, and the Segama River at Segama Estate.

Owing to the scarcity of hydrological information, and absence of any large-scale drainage and irrigation works, 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 5.

TOPOGRAPHY AND PLANIMETRY

The first systematic planimetric mapping was started in the immediate post-war years, and six planimetric plots of quarter degree sheets were published at the scale of 1:50 000 in 1950. The next maps were produced some 10 years later when compilation sheets were published, between 1961 and 1968, for sheets 4/117/10 and 11, and the remaining area lying east of meridian 117° 45". The first topographic maps were compiled in 1964-5 when seven sheets covering the Semporna Peninsula were published. In 1970 this coverage was extended over most of the western part of the Tawau District. Graphic plot sheets showing contour lines were made available for the remaining part of the residency during 1973. Text Map 1-8 shows the areas covered by the topographic maps and the graphic plots. These together with the preliminary and compilation plots 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

Even though the first titles to land were registered in the state as early as 1883 the earliest now extant for the residency date from 1910. During that time records of all land alienation, both leases and native titles, were maintained at the Land Registry Office in Tawau. This Office was the sole recorder of land titles for the residency. In 1913 a central land registry was set up for the whole state. Native titles, however, continued to be recorded only at the Tawau Land Registry Office.

The central land registry was responsible for gazetting land for specific government purposes, and the first reserve, a wireless station at Tawau, was established in 1919. Various other types of reserves were registered in the following two decades e.g. a native reserve at Apas in 1926, a forest reserve covering Pulau Timbun Mata in 1930, and in 1933, a bird sanctuary at Pulau Sipadan, a water supply reserve at Sembuduk, and a government residential reserve at Lahad Datu.

In the post-war years all plans of alienated and gazetted areas have been maintained at the Lands and Surveys Department headquarters. The task of systematically transferring the information portrayed on these plans onto standard 1:50 000 scale sheets started in 1968 and was completed in 1973. This is shown on Text Map 1-9. 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
State land	Land not allocated for government or private use
* Do not occur in Tawau Residency	

GAME AND RECREATIONAL RESOURCES

There has been very little study of the wildlife and recreational resources although two bird sanctuaries have been established and the hot springs near Tawau have been constituted as an amenity reserve.

The sole formal investigation of animal life was conducted in the Ulu Segama during 1969 (MacKinnon, 1970). This was largely related to the orang-utan, but the occurrence of other large animals is also reported. What little knowledge there is on the overall wildlife and recreational aspects, therefore, is restricted to Part 5 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 cultivation

Category 5 Permanent improved pasture

Category 6 Natural grassland

Category 7 Forest land

Category 8 Swamp, marshland and wetland forests

Category 9 Unused land

Plate 1-2 shows various forms of typical land use.

The land capability classification

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

Factual economic data concerning the profitability of 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 a moderately high level of management, 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 while land having the least number of uses is in Class V, 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 for economic reasons on the existence of adequate levels of minerals, or its agricultural crop potential or timber exploitation capacity, always in that order of importance, thus determining the form of land use which is likely to provide the maximum economic benefit. It should be noted that the Class I land in the residency possesses a mining potential only; agricultural and forestry prospects on such land are low. The 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 resources 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. Being 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 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**

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

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.

CARTOGRAPHY, AREA MEASUREMENT AND DATA TABULATION

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

In order to assist land development planning at the local administrative level, all the 1:50 000 scale thematic, topographic and land tenure maps are arranged to cover each district. Twelve loose bound volumes 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.

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 5

The resources and their distribution

It can be seen from the separate land capability classification map, and Tables 51a and 51b that there are large areas of land suitable for timber production and also extensive tracts of land possessing fertile soils, and therefore, suited for agriculture. The development prospects of the other land resources do not appear so great, but it will be seen in the following account that further mineral prospecting may identify significant deposits which could result in mining becoming an important industry, and areas can already be broadly identified for recreation and conservation purposes. Again, further appraisal work is required in order to ascertain more clearly these potentials.

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

Mineral resources

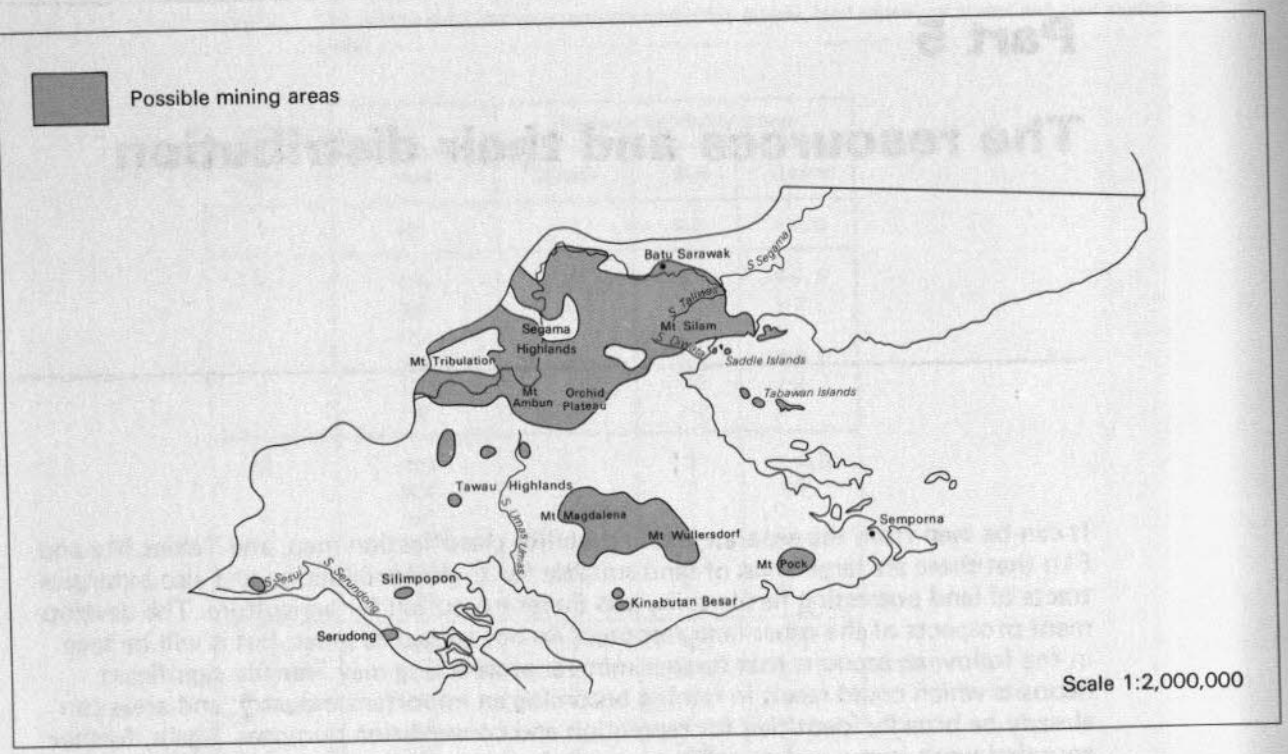
From Tables 51a and 51b it will be seen that land suitable for mining (Land Capability Class 1) occupies a relatively small area, 573 ha (1 416 ac); but extensive areas, totalling 261 245 ha (645 528 ac), are thought to have a possible mining potential (Mineral Resource Group 3). These areas are shown on Text Map 1-10. A high level of mineralisation is possibly present in some parts, but remains to be proven; exploration and prospecting have been severely limited by remoteness and poor communications.

Coal

Coal deposits constitute the only proven (Mineral Resource Group 2) mining resource, and this has been largely deduced from the mining operations carried out in the Silimpopon Coalfield during the early part of this century. Collenette (1954) has shown in his survey that the coal seams occur within gently dipping sedimentary rocks, mainly sandstone, shale and clay. So far only one bed, which is restricted to the Silimpopon area, is considered to be worthy of mining. This consists of what has been termed 'high rank sub-bituminous' coal. Previous mining operations were undertaken along inclines from the outcropping coal. These covered some 151 ha (374 ac).

It would appear therefore that over 401 ha (1 000 ac) remain to be exploited, in which it is estimated that, considering the main seam alone, there are about 10 614 000 long tons (lgt) (Collenette, 1954).

Possible coal mining areas (Group 3) have been identified in two other areas, in the Serudong and the Susui Valleys, but the quantities would not appear to be as extensive as those described for the Silimpopon Coalfield. The geology of these two areas has not been fully investigated and the information available suggests that the deposits are too thin to be mined economically, although a few thousand tons might be obtained by opencast methods in the Serudong (Collenette, 1954).



TEXT MAP 1-10 Possible mining areas

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Copper

Copper sulphide mineralisation has been identified as occurring in a number of places, but further work is required in order to ascertain whether economic levels of copper occur. A number of geochemically anomalous areas have been identified, where levels of more than 150 ppm total Cu have already been obtained.

The most promising of these would be in the Segama Highlands. Leong (1973) has shown during his survey that in the upper reaches of the Danum Valley extensive pyrite mineralisation occurs along a fault zone in sheared dolerite; while with geochemical prospecting in the upper reaches of the Taliwas and Diwata Valleys values greater than 200 ppm total Cu have been assayed.

Investigations in the Mount Pock area have indicated that copper occurs in quartz veins and also in intrusive and volcanic rocks. Even though the general range is of the order of 100-200 ppm total Cu, a few values greater than 300 ppm have been obtained (Geological Survey Malaysia, 1974).

Copper mineralisation has also been investigated in the mountainous zone north of Tawau where it appears to be associated with bodies of metasomatically silicified volcanic rock. The most promising areas would appear to be on the north slope of Mount Magdalena, and on the north-west flank of Mount Wullersdorf where analyses have revealed some levels greater than 300 ppm (Geological Survey Malaysia, 1974).

Gold

It will have been noted from Part 4 that there has been considerable interest in the search for gold. Both the early prospecting and modern geological surveys, however, have yet to show that economic levels occur.

The most promising results so far have been obtained from the Segama Highlands where the gold is thought to have its source in a number of mineralised zones composed of quartz and aplite veins associated with acid and intermediate intrusive rocks of the Crystalline Basement (Leong, 1973).

Assayed values range from 5 to 93 g/lgt (Fitch, 1955). In spite of extensive prospecting of the alluvium derived from these rocks only trace values have been obtained, even though up to 149 mg/yd^3 was recorded near Batu Sarawak. These and other results, however, indicated that the accumulations of alluvial gold were small and, based on market prices then operating, not of a scale worthy of mining. Gold has also been found in quartz veins and acid intrusive rocks in the headwaters of the Mantaritip Valley on Mount Pock, but the values determined so far have been low, 0.2-0.95 dwt*/ lgt (Kirk, 1962).

Kirk (1962) also obtained traces of gold as the result of panning operations on a number of alluvial deposits in the Semporna Peninsula. In the Mantaritip Valley the source of the gold is probably the intrusive rocks found on Mount Pock, and in the Umas Umas they may be secondary deposits from conglomeratic beds. The small amount of alluvial gold in the Mantri Valley is thought to have originated from silicified volcanic rocks occurring in the Tawau Highlands. Similar rocks occur on Mount Andrassy and its southerly neighbour, Kinabutan Hill, and these may also be gold bearing.

Silver

The most promising area for silver is in the Segama Highlands where Leong (1973) showed during his survey that mineralisation occurs in gneiss and associated quartz veins in the Mount Ambun area, and in the headwaters of the Subahan River it occurs with mylonitic rocks. Minor occurrences were found in the valley of the Diwata, the upper reaches of the Danum, and near Mount Tribulation in a range of intermediate to basic intrusive and metamorphic rocks. Silver has also been found, associated with the copper and gold mineralisation, on Mount Pock, where vein quartz material has yielded 192 dwt/lgt (Kirk, 1962).

Chromite

Chromite ore has been subject to prospecting on the northern slope of Mount Silam and the Saddle group of islands in Darvel Bay. Leong (1973) has shown that in both areas the deposits are associated with ultrabasic rocks. The results so far indicate that mining operations would not be economic, but further detailed investigations, particularly of the Silam Prospect, may prove profitable.

Manganese

Limonitic nodules in deeply weathered colluvium in the upper reaches of the Taliwas have yielded manganese (Leong, 1973). The reserves available are unknown, and further prospecting will be required in order to evaluate the deposit.

Magnesite

Leong (1973) has shown during his survey that evidence so far available points to the fact that even though magnesite occurs in many scattered areas in the Segama Highlands and Darvel Bay, the quantities are small. It has been found in veins cutting ultrabasic rocks south of the Orchid Plateau, the Sapagaya Valley, the coast near Silam, and on the Saddle and Tabawan Islands.

*1 pennyweight (dwt) = 1.555g

Soil resources

Text Map 1-6 in Part 4 shows the various soil survey areas. It should be noted that the reports on Areas 2 and 4 shown on the map are incorporated in *Land Resource Study 20, The soils of Sabah,* Volume 2 (Acres and Folland, 1975) and Volume 3 (Wright, 1975)

Table 6 shows that more than half of the residency is considered unsuitable for agriculture but extensive areas exist which are suited for various forms of agriculture (Soil Suitability Groups 2 and 3). Text Map 1-11 shows that the suitable areas are mainly situated on the seaboard, and on certain hinterland tracts, which are generally characterised by low relief interspersed with alluvial flats. This is shown in more detail on the separate land capability classification map.

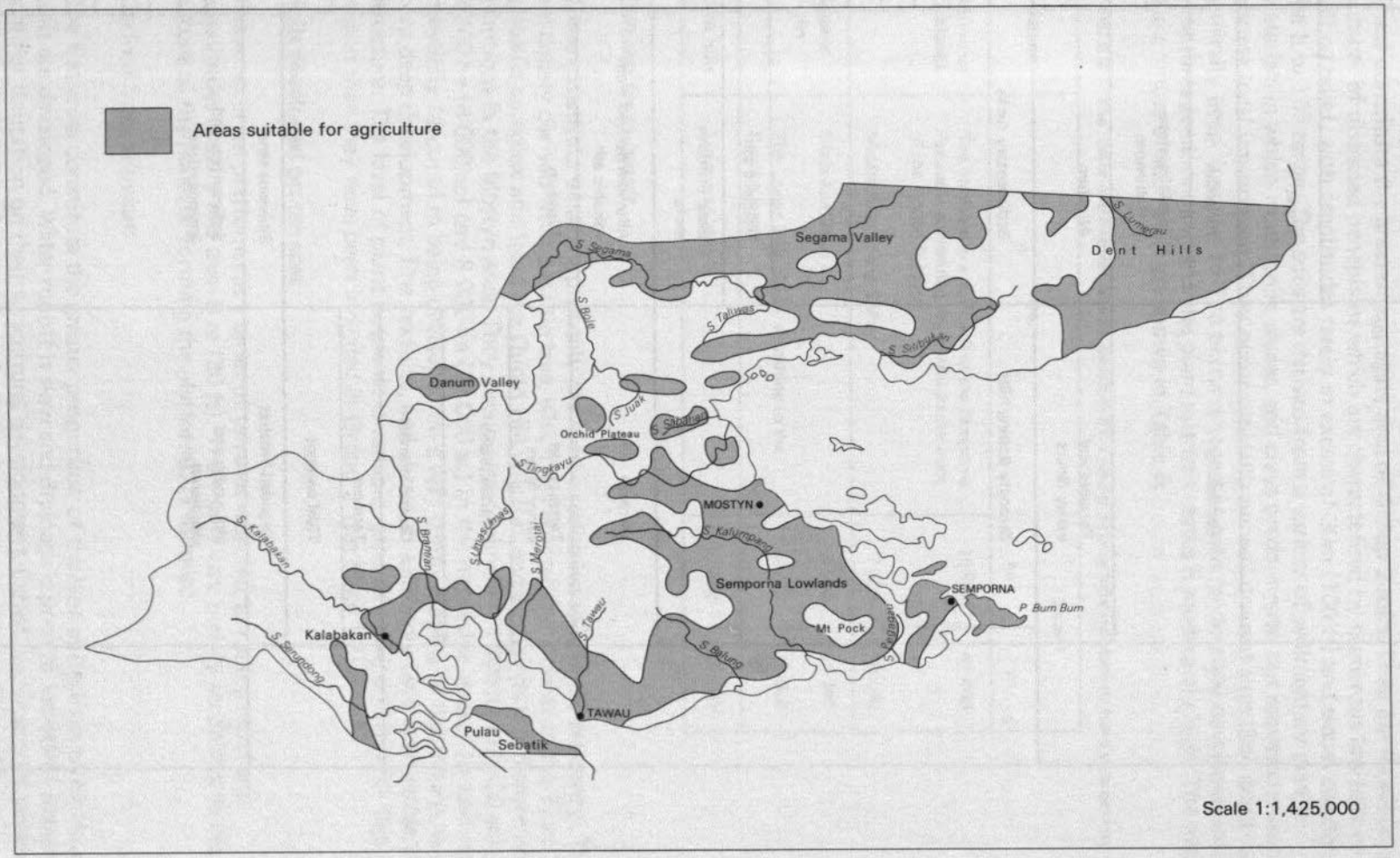
All the soils have some form of limitation for agriculture and consequently *Group 1 soils do not occur.*

TABLE 6 Estimated areas of the soil suitability groups*

Soil suitability group	Degree of limitation for agriculture	ha	ac	%
1	No limitation	0	0	0
2	Few minor limitations	147 380	364 170	10.5
3	One serious limitation	340 104	840 385	24.4
4	More than one serious limitation	83 773	207 000	6.0
5	Very serious limitation	825 339	2 039 140	59.1
Residency total		1 396 596	3 450 695	100.0

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

Table 7 gives the landforms and parent materials of the soil associations mapped in the residency and the soil suitability groups. The soil associations are described in Volume 1 of the companion *Land Resource Study 20 (The soils of Sabah*, Acres et al.) It will be seen that the Brantian Association occurs in Groups 2 and 3. This is because the classification is based on a reconnaissance survey and the range of soil variability which occurs within the association; some of its soils being dominant in one area and subordinate to others of differing suitability in other areas.



TEXT MAP 1-11 Areas suitable for agriculture (Soil Suitability Groups 2 and 3)

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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
		Basalt	Mostyn
			Table
	Terraces	Alluvium	Brantian
		Coral limestone and alluvium	Semporna
			Tungku
	Terraces and valley floors	Alluvium	Labau
			Karamuak
3	Strongly sloping hills	Sedimentary rocks	Dalit
			Tengah Nipah
			Kalabakan
			Mawing
			Kretam
			Dagat
			Bang
		Volcanic ash	Apas
		Basic intrusive rocks	Beruang
			Orchid Plateau
	Terraces	Alluvium derived from volcanic ash	Brantian
	Terraces and valley floors	Alluvium	
	Riverine plains		Kinabatangan
			Tuaran
	Coastal swamps		Sapi
4	Terraces		Kepayan
	Tidal swamps		Weston
	Stranded beaches	Siliceous sand	Tanjong Aru
5	Mountains and steeplands	Sedimentary and igneous rocks	Serudong
			Maliau
			Crocker
			Gumpal
			Mawing
			Lokan
			Gomantong
			Malubok
			Bidu Bidu
			Mentapok
			Kennedy Bay
			Tiger
			Wullersdorf

SOIL SUITABILITY GROUP 2 ONE OR MORE MINOR LIMITATIONS

Soils developed on gently sloping hills

Derived from sedimentary rocks

These constitute the greatest aggregate area of Group 2 soils. They are found on a number of dissected peneplains which are characterised by numerous low hills of rolling relief, with amplitudes rarely in excess of 30m (100 ft) and slopes usually in the 5 to 15° range. The soils are derived from a variety of sedimentary parent materials in which mudstones, shales, and clays predominate, but sandstones sometimes assume local importance. They occur typically on well drained sites. Soil depth is generally deep; medium to fine textures together with moderately developed soil structures predominate, 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
Semporna Lowlands	The north-eastern seaboard of the Semporna Peninsula continuing southward to the west of the Trusan Pegagau	16 600	41 000
	Middle Kalumpang Valley	7 300	18 000
Segama Valley	Silabukan Basin	9 300	23 000
	The Lower Bole Valley stretching to the Kuala Kawag	4 900	12 000
Dent Hills	Lumerau Valley	15 400	38 000

Derived from basalt

These constitute what are probably the most productive soils in the residency. They are largely derived from basaltic lava, which has erupted from cones in the Tiger-Table volcanic complex and from the Quoin Hill volcano, and as the result of fissure vent eruptions in the Mostyn area. They occupy approximately 4 900 ha (12 000 ac), 3 200 ha (8 000 ac) and 8 900 ha (22 000 ac) in the respective areas. The soils are especially favoured in being developed on a very gently sloping to flat terrain, with very deep development, fine textures, and above all a strongly developed stable crumb structure. The level of plant nutrients is variable, generally low; and it is for this reason that they have been included in Group 2 (see Plate 1-1).

Soils developed on terraces

These occur on platforms as a series of terraces with flat to rolling relief and amplitudes usually less than 9 m (30 ft). Their soils vary mainly according to the nature of the material forming the platforms, as follows:-

Derived from alluvium

The flat areas constitute the greater proportion of the land surface on which these soils are developed. Water runoff is slow and drainage is poor to imperfect imposing a minor limitation on their agricultural development. Otherwise these soils possess favourable characteristics such as deep development, medium to fine textures, moderately developed structures, and medium levels of plant nutrients. Such soils comprise about 34 800 ha (86 000 ac). They are best developed on the landward fringe of the Cowie Deltas, comprising a total area of approximately 13 400 ha (33 000 ac), as an almost continuous belt of land between the Merotai and Kalabakan

Rivers, and between the Silimpopon and Serudong. An outlier occurs on Pulau Simandalan. The remaining land occurs as relatively small localised terraces in a number of valleys found in the western part of the residency; mainly the Serudong, Kalabakan, Brantian, Umas Umas, Danum, and to the east of the Orchid Plateau. The alluvium forming these terraces is thought to be derived from the sandstones and shales of the adjacent country rocks.

Derived from coral and alluvium

Being composed mainly of limestone, which is relatively slowly weathered, the soils at such locations tend to be moderately shallow in depth, thus limiting development for most deep rooting agricultural crops. Conversely the coralline limestone affords a permeable substratum giving rise to good drainage conditions in the over-lying soil. Textures are clayey, and soil structure well developed. The soils possess a very favourable plant nutrient status. The major occurrences are shown in Table 9.

TABLE 9 The major occurrences of soils developed on coral terraces

Region	Area	Extent	
		ha	ac
Semporna Lowlands	Semporna Island	8 100	20 000
	Pulau Bum Bum	4 900	12 000
Dent Hills	Tegupi	3 200	8 000

It should be noted that a considerable acreage of these soils has been subject to a long history of mismanagement in the form of intense shifting cultivation, particularly on Pulau Bum Bum, where in many locations soil depth is now seriously limited. Such areas have been designated as Group 3.

Soils developed on valley floors

The upper reaches of a number of valleys in the western part of the residency have floodplains, with relatively good drainage, which are associated with low-lying terraces of moderate relief. The soils are developed on a wide range of alluvial material ranging from ultrabasic rocks to sandstones; they are, however, predominantly moderately fine to coarse textured, and frequently stony. 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.

These soils are considered to be suited for a wide range of agricultural crops. Their large scale development is limited by their small extent 5 300 ha (13 000 ac); and their distribution in scattered and relatively remote areas, in the Brantian, Umas Umas, Juak and Taliwas Valleys, and near Kalabakan Camp.

SOIL SUITABILITY GROUP 3 ONE SERIOUS LIMITATION

Soils developed on strongly sloping hills

The landscape is typically characterised by hills and ridges interspersed with narrow valleys, with an amplitude of relief rarely in excess of 75 m (250 ft) and slopes normally within the 15 to 20° range. Such a terrain constitutes a serious limitation to agricultural development and, more than any other feature, influences their grouping. The soil characteristics are dependant largely on the parent materials, which can be conveniently described as follows:

Derived from sedimentary rocks

These consist mainly of sandstones, shales, and mudstones, which are frequently closely intercalated and which may vary in proportion from one area to another. In spite of the steeper slopes, soil conditions are similar to those encountered on the easier terrain and developed on a similar range of parent materials described previously, under Group 2, Soils developed on gently sloping hills. Their distribution is given in Table 10.

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

Region	Area	Extent	
		ha	ac
Segama Valley	Uplands lying north of the Segama River and to the east including the Tamangong-Silabukan Valleys	101 200	252 000
Dent Hills	The main part of the southern watershed of the Dent Peninsula	89 400	221 000
Kalabakan Valley	Lower and middle reaches of the Kalabakan Valley	9 300	23 000
	Lower and middle reaches of the Umas Umas Valley	8 900	22 000
Semporna Lowlands	North of the Mount Pock Steeplands	8 100	20 000
	Upper Kalumpang Valley east of the Mantri River	4 900	12 000
Segama Highlands	Danum Valley	6 100	15 000
Kuamut Highlands	Lower Serudong Valley	2 400	6 000

Derived from volcanic ash

Dissected deposits of ash material occur as discontinuous peripheral zones lying south and east of the volcanic centres of the Tawau Highlands and west of the Mount Pock steeplands. These deposits are predominantly acid in mineral composition; but as the result of their high susceptibility to erosion their soils are little weathered and are endowed with a medium range of plant nutrients. Being formed on ash deposits the soils tend to be deeply developed and freely drained. Fine textures and moderately developed soil structures predominate. Some 8 900 ha (22 000 ac) occur in the Kalumpang Valley west of Mount Pock. A contiguous area of such land occurs adjacent to the middle reaches of the Tawau River where 4 900 ha (12 000 ac) have been delineated. Other areas are found forming an important part of the catchments of the Apas and Gading Rivers, comprising approximately 5 300 ha (13 000 ac).

Derived from basic intrusive rocks

Land occurring on such strongly sloping terrain and developed from basic intrusive rocks is best developed over some 5 700 ha (14 000 ac) in the Sapagaya Valley. There, the amplitude of relief tends to be in excess of the normal range, sometimes reaching 150 m (500 ft). The soils are marked by high plant nutrient levels, the presence of weathering basic rock, moderately fine to fine textures and a strongly developed soil structure.

The other area is restricted to the Orchid Plateau and occupies some 3 200 ha (8 000 ac). The relief consists of rolling and flat surfaces, rarely more than 90 m (300 ft) wide, dissected to depths of up to 30m (100 ft) with slopes generally in the

15 to 25° range. Again, such terrain conditions impose a serious limitation to agricultural development. The soils, however, are inherently fertile being derived from basic intrusive rocks. Weathering rock material is frequently found in the soils occurring on the slopes, but deep development marks the summit areas. Textures vary from medium to fine and soil structure tends to be strong.

Soils developed on terraces

These platforms are related to those described with Group 2 soils in the earlier section, and occur as a series of terraces in three main localities: on Sebatik Island, along a coastal belt of land in the Tawau area, and fringing the littoral of the Dent Peninsula.

The platform on Sebatik Island is formed by alluvial deposits similar to the coastal terraces fringing the Cowie Deltas on the adjacent mainland. It differs, however, in that it is more dissected, rising more steeply inland and becoming hilly with slopes of between 15 and 25°. Amplitudes range from 6 m (20 ft) near the sea to 30 m (100 ft) inland. Those found on the Dent Peninsula are less dissected with gentler slopes in the 5 to 15° range.

The coastal platform in the Tawau area is formed on alluvium derived from acidic volcanic ash material. It owes its origin to the levelling action of the sea resulting in an almost horizontal inclination, and subsequent erosion has given rise to rolling terrain, with slopes in the 5 to 15° range and amplitudes usually less than 30 m (100 ft). The characteristics of the soils are closely related to the types of materials which form the platforms, as follows:

Derived from alluvium

The soils are predominantly well drained, deeply developed, and medium textured. Soil structure is generally moderate. On Sebatik Island, where they occupy some 6 100 ha (15 000 ac), their potential for agriculture is seriously limited by the strongly sloping nature of the terrain on which they are developed.

On the Dent Peninsula, however, the soils of the terraces have been subject to strong leaching processes, resulting in small scattered areas of almost sterile bleached sands (mainly podzols) occurring on some summit areas. The plant nutrient status of these soils in general is considered to be low, seriously limiting agricultural development. They comprise about 4 000 ha (10 000 ac) in the area.

Alluvium derived from volcanic ash

The soils developed on alluvium derived from volcanic ash are generally characterised by deep development, medium to moderately fine textures, moderate structures, and a low plant nutrient status. The ash material is permeable resulting in well drained soil conditions. They constitute a very extensive feature occupying some 28 329 ha (70 000 ac) stretching from the Merotai River to the Kalumpang River. They have also been subject to a considerable degree of leaching, and this is particularly manifest on the southern fringe of the platform between the Apas and Kalumpang Rivers, and on a terrace located in the head waters of the Pang Burong River, where scattered areas of podzols occur. The low nutrient status gives rise to a serious limitation.

Soils developed on terraces and valley floors

Changes in the hydraulic regime in a number of valleys skirting the Tawau Highlands has resulted in the formation of a number of terraces composed of riverine alluvium. In some cases it is thought that the alluvial materials were originally laid down as lake-bed deposits. These terraces occur in the form of dissected plains, generally of rolling to flat relief, but they may be locally steeply dissected by stream and river courses. The soils are characteristically deeply developed, freely draining, fine-textured, and moderately structured but, according to the limited number of analyses available,

possess a relatively low nutrient status amounting to a serious limitation on agriculture. The chemical information on these soils is sparse but it is felt that, when more work has been done on this aspect, considerable areas will ultimately be up-graded to Group 2. Their major occurrences are shown in Table 11.

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

Region	Area	Extent	
		ha	ac
Tawau Highlands	Balung, Mantri, and Merotai Kechil Valleys	12 900	32 000
Semporna Lowlands	Tingkayu Valley	12 500	31 000
	Kalumpang Valley	5 700	14 000

Soils developed on riverine plains

These are marked by active accumulation of riverine deposits brought about by periodic flooding. Their nature can be conveniently considered according to their physiographic distribution as follows:

Narrow valleys

The plains in such valleys are rarely more than 1.5–3 km (1–2 mi) wide and are associated with low (6-9 m, 20-30 ft) dissected terraces with which they merge almost imperceptibly. Soil conditions are extremely variable, but inferior, usually very poor, drainage conditions predominate, imposing a serious limitation. Otherwise these soils are suited for a wide range of agricultural crops. The more extensive tracts of land are listed in Table 12.

TABLE 12 The major occurrences of Group 3 soils developed on narrow alluvial plains

Region	Area	Extent	
		ha	ac
Semporna Lowlands	The Mantaritip and a number of other valleys south of Mount Pock	5 300	13 000
	Sipit River system	3 200	8 000
	Pang Burong Valley	800	2 000
	Balung Valley	800	2 000
	Apas Valley	800	2 000
Dent Hills	A number of interdigiting valleys north and west of Tanjong Labian	3 200	8 000
Segama Highlands	Juak Valley	2 400	6 000
Tawau Highlands	Merotai Valley	1 200	3 000
	Tawau Valley	800	2 000

Mature floodplains

These are much wider and more extensive, and include as minor features levees, meander cutoffs and backswamps. Soil conditions are variable, following the normal

physiographic pattern developed on floodplains; with coarser textured and better drained soils occurring near the main stream channels and finer textures and poorer drainage predominating further away. Poorly drained to very poorly drained soils are the most common. In some of the larger floodplains the better drained soils may be extensive, and this is particularly evident along the middle reaches of the Segama and Sabahan Rivers. Even though their drainage is not considered to be a serious limitation, they have been included, for the purpose of this report, with the poorer drained Group 3 soils with which they are intimately associated.

Any plans for the large scale development of these plains will have to take into account a strong risk of floods. Although precise hydrological information is sparse, it is well known that these soils are subject most years to severe inundation by river waters. An account of their general distribution is given in Table 13.

TABLE 13 The major occurrences of soils developed on mature floodplains

Region	Area	Extent	
		ha	ac
Segama Valley	Middle Segama Valley north of Lahad Datu	8 500	21 000
	Lower Silabukan Valley	2 000	5 000
	Kuala Kawag	800	2 000
Semporna Lowlands	Lower Tingkayu Valley	2 400	6 000
	Upper Tingkayu Valley	1 600	4 000
Dent Hills	Middle Sabahan Valley	2 800	7 000
Kalabakan Valley	Lower Brantian Valley	800	2 000
	Lower Kalabakan Valley	800	2 000

Soils developed on coastal swamps

These are restricted to a transitional zone between the mangrove swamps and the coastal terrace of Sebatik Island, covering approximately 2 000 ha (5 000 ac). They are inundated by fresh water for most of the time, but occasional incursions of brackish water occur on the seaward fringe. It can be seen, therefore, that the very poor drainage of these soils seriously limit their potential for agriculture. Otherwise they would offer a satisfactory medium for a range of crops.

SOIL SUITABILITY GROUP 4 MORE THAN ONE SERIOUS LIMITATION

Soils developed on terraces

These have been mapped on the seaboard between the mouths of the Serudong and Silimpopon Rivers in the south-west, and the Sabahat River and Tanjong Labian in the north-east. The terraces are flat to gently rolling. These are essentially podzols, consisting of a layer of white, almost sterile, sand, which may reach a thickness of well over 3 m (10 ft) on the Dent Peninsula. The normal thickness is between 30 and 60 cm (1 – 2 ft) and overlies dark, frequently indurated, horizons. The underlying alluvium varies from clay to coarse sand. Soil drainage is variable, mainly poor, sometimes very poor.

The factors seriously limiting these soils with regard to agriculture are the low plant nutrient status and coarse texture. Shallowness, due to the presence of an indurated layer, and very poor drainage may be additional serious limitations in certain areas. They are inextensive, occupying some 400 ha (1 000 ac) in between the Serudong and the Silimpopon Rivers and about 1 200 ha (3 000 ac) between the Sabahat and Tanjong Labian.

Soils developed on tidal swamps

These form an almost continuous belt along the coastline of the residency but are most extensive in the estuaries of the larger rivers. 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 the very poor drainage, gives rise to two serious limitations. In addition, 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 drainage processes would lead to excessive acidity levels. Agricultural development, bearing in mind the present availability of land, is not recommended. The main areas are given in Table 14.

TABLE 14 The major occurrence of soils developed on tidal swamps

Area	Extent	
	ha	ac
Cowie Deltas, including the Sebatik coastline	43 300	107 000
Kalumpang Estuary	8 500	21 000
Silabukan Estuary	6 500	16 000
Narrow belt forming the coastline of Semporna Island	6 100	15 000
Tingkayu Estuary and the western coastline of Darval Bay	4 000	10 000
Sipit Estuary complex	2 900	7 000

Soils developed on stranded beaches

A series of slightly elevated sandy beaches are found sporadically along the shoreline. The soils are composed of beach sands, largely quartz; although localised deposits containing a relatively high proportion of calcareous material or ferromagnesian minerals are to be found. Being composed largely of quartz sand these soils offer a poor medium for the cultivation of agricultural plants, because of their low water retaining and poor nutrient retaining capacities. The extremely coarse textures and very low nutrient status constitute two very serious limitations.

The beaches are never very extensive in any one area, but are mainly concentrated along the coastline west of the Kalumpang Estuary 8 500 ha (21 000 ac), and along the south coast of the Dent Peninsula 4 000 ha (10 000 ac).

SOIL SUITABILITY GROUP 5 VERY SERIOUS LIMITATION

Soils developed on mountains and steeplands

These largely cover the areas of high elevation and relief, the Segama, Tawau, and Kuamut Highlands, and the Bagahak Range. They are not, however, restricted to these areas. Smaller zones occur generally as isolated hills and ridges throughout the lowland regions. They cover by far the greatest part of the residency, some 841 400 ha (2 079 000 ac), or 59%.

Topographic factors, more than any other, impose a very serious limitation to agricultural development. Slopes are generally in excess of 25°, the maximum normally considered permissible for agriculture. In addition to the physical difficulty of cultivating such slopes, accelerated soil erosion would likely be extreme on clearing the natural vegetative cover for agriculture. Further, these lands comprise the catchments of all the main rivers, and large-scale disturbance of the watersheds would further increase the effect of flooding on the plains.

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

Forests and their timber resources

INTRODUCTION

The main forest resource lies in the rich lowland dipterocarp forest, which still covers a large part of the land area. This forest usually extends up to an altitude of about 750 m (2 500 ft) when structure and species composition begin to change and the forest becomes montane. The lowland dipterocarp forest is generally fairly heterogeneous with dipterocarps accounting for between 70% and 90% of the stand. However, volume and species composition vary. Much of the forested area is on steep and hilly land and it is on this sort of terrain that lowland dipterocarp forest reaches its maximum development with very high volumes of commercial timber.

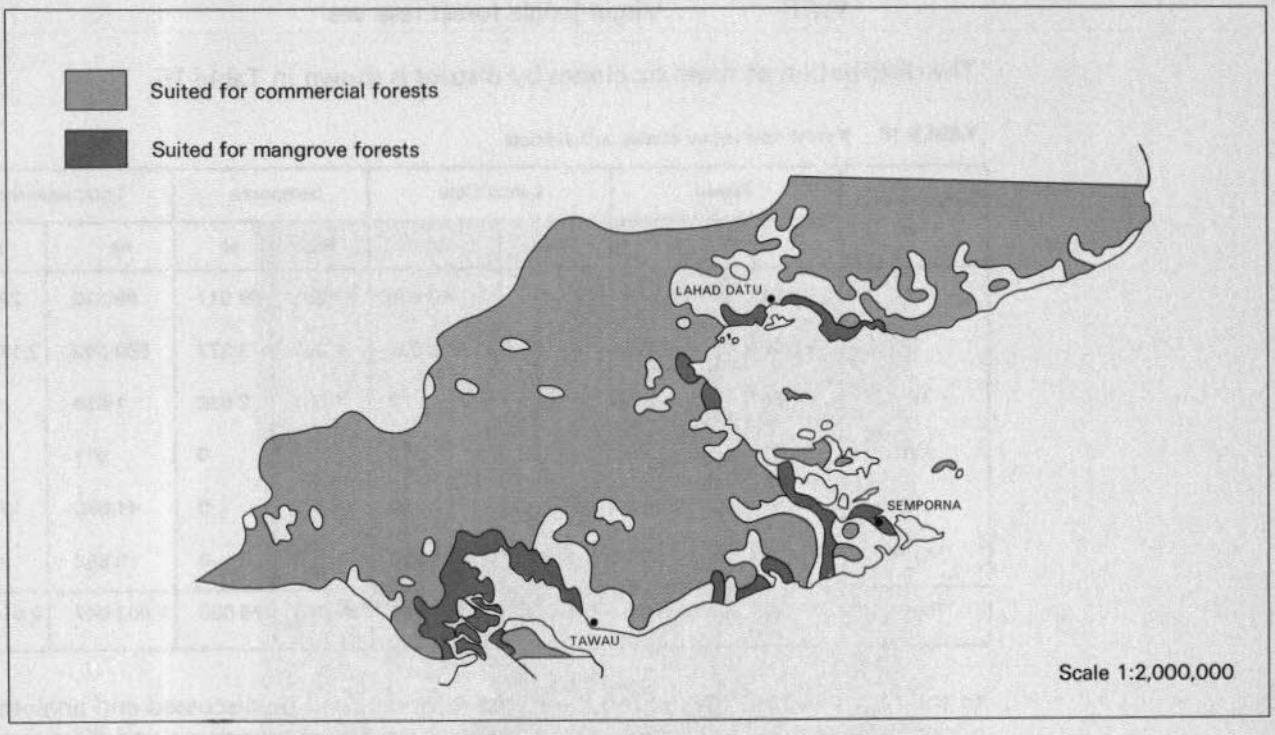
Approximately 1 103 800 ha (2 725 000 ac) of the lowland dipterocarp forest is considered commercial with an expected yield of the preferred dipterocarp species in excess of 35 m^3/ha (400 Hft^3/ac) (Timber Resource Groups 1, 2 and 3). The timber resource groups are defined in the section entitled 'Natural vegetation and timber resource groups' in Part 4. A further 60 700 ha (150 000 ac) is not considered commercial on account of the expected low yield (Timber Resource Group 4). Montane forest developed on land with an altitude of more than 750 m (2 500 ft) and yielding a low volume of commercial timber by present standards covers an area of some 12 700 ha (32 000 ac) (Group 5); it is classed as non-commercial. Other types of forest such as beach forest, transitional forest, freshwater swamp forest and areas of nipah palm (Group 6), which are non-commercial and have no potential value in the foreseeable future, total approximately 17 800 ha (44 000 ac). Commercial mangrove forest (Group 7) developed on estuarine flats contributes to the forest resource and covers an area of approximately 64 100 ha (158 500 ac). The distribution of the commercial forests and mangrove forests is shown in Text Map 1-12. Most of the commercial forest, whether in forest reserve or on stateland, is already under licence.

The volume figures given in the various tables in this section are average cubic metres per hectare (m^3/ha) with the equivalent hoppus feet per acre (Hft^3/ac) figures also shown. 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 no account has been taken of subsequent changes in forest cover resulting from exploitation or other activity.

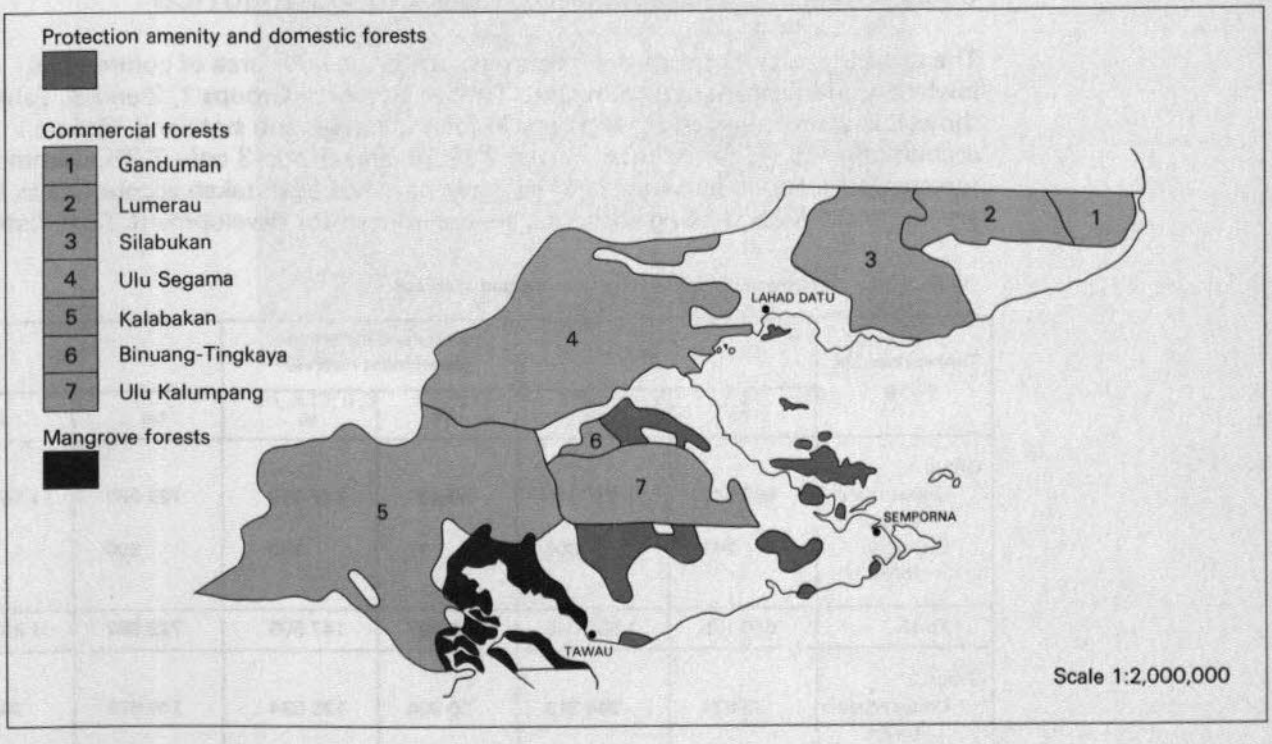
The yield parameters used in defining Timber Resource Groups 1, 2 and 3 only refer to the main species and timber groups of the Dipterocarpaceae i.e. red seraya, urat mata, kapur, keruing, yellow seraya, melapi and selangan batu. The scientific and vernacular names of the main trees are given in the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

About 80% of the forest area and 90% of commercial forest 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 1-13. The forest reserves are classified as follows:

Class I	Protection forest reserves
Class II	Commercial forest reserves



TEXT MAP 1-12 Areas suited for forestry



TEXT MAP 1-13 Forest reserves

Prepared by the Directorate of Overseas Surveys 1976

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 15.

TABLE 15 Forest reserves by classes and districts

Forest reserve class	Tawau		Lahad Datu		Semporna		Total residency	
	ha	ac	ha	ac	ha	ac	ha	ac
I	42 512	105 046	18 875	46 639	27 931	69 017	89 318	220 702
II	366 990	906 820	491 035	1 213 332	1 367	3 377	859 392	2 123 529
III	607	1 500	0	0	1 067	2 636	1 674	4 136
IV	113	279	798	1 973	0	0	911	2 252
V	41 670	102 966	0	0	0	0	41 670	102 966
V.J.R.	5 232	12 928	5 350	13 220	0	0	10 582	26 148
Total	457 124	1 129 539	516 058	1 275 164	30 365	75 030	1 003 547	2 479 733

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 16 shows the distribution of these groups in forest reserves and stateland. Group 1 accounts for 75.6% of the total, Group 2 17.2% and Group 3 only 7.2%. Commercial forests also occur on alienated land but they have not been taken account of as they are not extensive and being alienated, are committed for development. (See Plate 1-3).

TABLE 16 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 *	669 942	1 655 446	59 620	147 319	729 562	1 802 765
Disturbed forest **	243	600	77	190	320	790
Total	670 185	1 656 046	59 697	147 509	729 882	1 803 555
Group 2						
Undisturbed forest	98 871	244 313	50 804	125 534	149 675	369 847
Disturbed forest	3 524	8 708	16 722	41 319	20 246	50 027
Total	102 395	253 021	67 526	166 853	169 921	419 874

*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 partly logged, probably selectively for certain species. The result is that while the stand may still carry 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

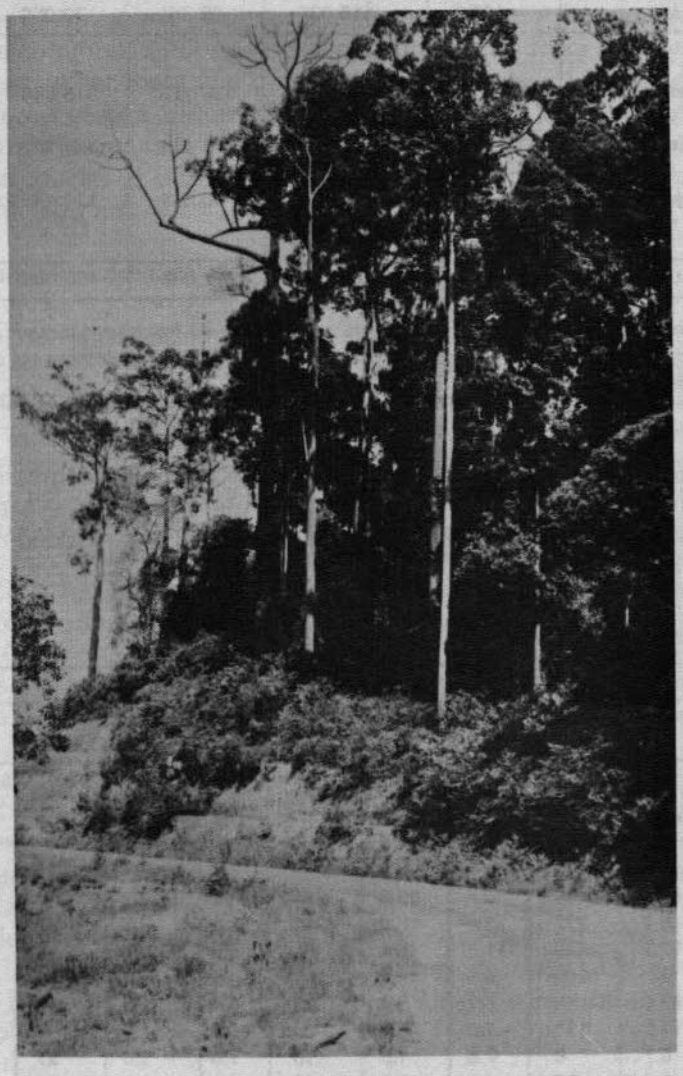


PLATE 1.3 Commercial dipterocarp forest, Apas Road

Timber resource group	Forest reserves		Stateland including government reserves		Total	
	ha	ac	ha	ac	ha	ac
Group 3						
Undisturbed forest	38 989	96 344	17 739	43 833	56 728	140 177
Disturbed forest	7 564	18 690	10 612	26 223	18 176	44 913
Total	46 553	115 034	28 351	70 056	74 904	185 090
Group 1, 2 & 3						
Undisturbed forest	807 802	1 996 103	128 163	316 686	935 965	2 312 789
Disturbed forest	11 331	27 998	27 411	67 732	38 742	95 730
Regenerating forest+	81 763	202 038	46 314	114 441	128 077	316 479
Total	900 896	2 226 139	201 888	498 856	1 102 784	2 724 998

+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

Table 17 gives the volume composition of Timber Resource Groups 1, 2 and 3, by main timber species, for the residency. Apart from Dipterocarpaceae, other timbers of established merchantibility and good potential are included under other commercial species.

TABLE 17 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	44.1	495	29.4	28.0	314	28.2	13.7	154	21.0	40.9	459	29.3
Urat mata	35.4	397	23.6	18.9	212	19.0	8.5	95	12.9	32.2	362	23.0
Kapur	17.7	199	11.8	5.4	61	5.5	6.7	75	10.2	15.7	176	11.2
Keruing	9.7	109	6.5	11.8	132	11.9	8.4	94	12.8	9.9	111	7.1
Yellow seraya	13.0	146	8.7	8.4	95	8.5	1.5	17	2.3	11.9	134	8.5
Selangan batu	11.7	131	7.8	5.9	66	5.9	3.1	35	4.8	10.6	119	7.6
Melapi	0.7	8	0.5	1.6	18	1.6	2.4	27	3.7	0.9	10	0.6
Other spp.	2.0	23	1.4	3.2	36	3.2	2.0	23	3.1	2.2	25	1.6
Total	134.3	1 508	89.7	83.2	934	33.8	46.3	520	70.8	124.3	1 396	88.9
Other commercial spp.												
Belian	1.5	17	1.0	1.9	22	2.0	1.7	19	2.7	1.6	18	1.1
Medang	1.4	16	1.0	1.6	18	1.6	1.8	20	2.8	1.4	16	1.0
Mengaris	2.1	24	1.4	1.8	20	1.8	1.7	19	2.7	2.0	23	1.5
Other spp. of Leguminosae	3.6	40	2.4	4.3	48	4.3	3.7	41	5.5	3.7	41	2.6
Kedongdong	1.1	12	0.7	0.7	8	0.7	1.2	13	1.7	1.1	12	0.8
Nyatoh	0.9	10	0.6	0.9	10	0.9	0.5	6	0.8	0.9	10	0.6
Other spp.	4.8	54	3.2	4.9	35	3.1	8.5	96	13.2	4.9	55	3.5
Total	15.4	173	10.3	16.1	181	16.2	19.1	214	29.2	15.6	175	11.1
Total all commercial spp	149.7	1 681	100	99.3	1 115	100	65.4	734	100	139.9	1 571	100

Dipterocarps

It will be noted from Table 17 that the percentage of Dipterocarpaceae in the total volume decreases from 89.7% in Group 1 forest to 70.8% in Group 3. Red seraya (*Rubroshorea* group of *Shorea*), which includes *majau* (*Shorea leptoclados*) and *obah suluk* (*Shorea pauciflora*), is the most common, accounting for 29.4% of the volume in Group 1, 28.2% in Group 2 and 21.0% in Group 3. *Majau* is generally the most common single species within the group and forms on average 11% of the total stand in Group 1, 5% in Group 2 and 2.7% in Group 3. After red seraya the most common timber in all groups is *urat mata* (*Parashorea* spp). The bulk of this timber comes from two species of *Parashorea*, namely *P. malaanonan* and *P. tomentella* with the former being more common. An insignificant amount comes from *P. parvifolia* and *P. smythiesii.* After these two timber groups the order of abundance varies with the different forest groups and there is generally a greater percentage range between the groups. This is particularly so with yellow seraya (*Richetia* group of *Shorea*). Included in the other species of Dipterocarpaceae are *gagil* and *selangan* (*Hopea* spp.), *pengiran* (*Anisoptera* spp.) and *resak* (*Vatica* spp.).

Other commercial species

Among the non-dipterocarp species of commercial importance, *belian* (*Eusideroxylon zwageri*), *mengaris* (*Koompassia excelsa*) and *medang* (*Lauraceae* spp.) are the most common, though in no forest group does any one account for more than 2.7% of total volume. The trees included in the other species of Leguminosae are mainly *sepetir* (*Sindora* spp.), *merbau* (*Intsia* spp.) and *keranji* (*Dialium* spp.) while those included in 'other species' are *binuang* (*Octomeles sumatrana*), *karai* (*Annonaceae* spp.), *kembang* (*Heritiera* spp.),species of Sterculiaceae other than *Heritiera, laran* (*Anthocephalus chinensis*), *kayu malam* (*Diospyros* spp.), *limpaga* (*Meliaceae* spp.), *jelutong* (*Dyera* spp.), *durian* (*Durio* spp.), *ranggu* (*Koordersiodendron pinnatum*), *pulai* (*Alstonia* spp.), *putat paya* (*Planchonia valida*), *bintangor* (*Calophylium* spp.), *serungan* (*Cratoxylum arborescens*), *takalis* (*Pentace* spp.),*sengkuang*and *layang layang* (*Anacardiaceae* spp. other than *rengas* and *ranggu*). While their percentage shows a wide range between the forest groups the actual volumes do not vary greatly.

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 of these species and timber groups are an important factor in their poor merchantibility. In some cases, in particular with *medang* (*Lauraceae* spp.) and *kayu malam* (*Diospyros* spp.), most of the species belong to the understorey and many of the trees do not reach the minimum girth size for consideration as commercial timber. If, however, a lower basal girth and top diameter limit were accepted, the volume of timber available might be expected to be considerably larger.

TIMBER RESOURCES OF THE FOREST RESERVES

The forest reserves provide by far the greatest source of commercial timber and it is appropriate to analyse their resources. To summarise the importance of the reserves, it will be noticed that 82% of the total forest reserves are of Timber Resource Groups 1, 2 and 3, and 90% of the commercial forest is found in forest reserves (Tables 15 and 16).

Class 1 Protection forest reserves

The distribution of Class I reserves, Protection forest, is shown on Text Map 1-13 where they have been incorporated with the relatively minor areas occupied by the domestic and amenity forests. As indicated in Table 15 their total area amounts to 89 318 ha (220 702 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 with unstable soils. As might be expected, the greater part of these forests are located on hilly and mountainous terrain. The major reserves together with the main reasons for their establishment are listed below:

1.	Tawau Hills	To protect the headwaters and catchment areas of the Merotai, Tawau and Balung Rivers, minimise erosion of the unstable soils and conserve an area of natural scenic beauty
2.	Madai Baturong	To protect the edible birds nest caves in the Madai and Baturong limestone outcrops
3.	Timbun Mata	To conserve the flora and fauna on the island and to minimise erosion on the steep hills
4.	Mt. Pock	To protect the headwaters and catchment areas of streams rising in the highlands formed by Mount Pock, Gunong Siagil and Gunong Sigalong which provide Semporna's water supply
5.	Mt. Wullersdorf	To minimise soil erosion and conserve a scenic area of botanical interest
6.	Mt. Andrassy	To protect the headwaters of a number of small rivers and minimise soil erosion

Considerable areas of protection forest carry good timber stands and these have been classified accordingly. Details are given in Table 18. The disturbed forest is forest that has been selectively logged and it is classified according to the expected yield.

TABLE 18 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	44 912	110 976	0	0	44 912	110 976
2	2 423	5 988	2 792	6 899	5 215	12 887
3	9 737	24 059	335	829	10 072	24 888
Total	57 072	141 023	3 127	7 728	60 199	148 751

While this area of forest carries commercial stands of timber it cannot really be considered as commercial forest since, in general, logging is not allowed in protection forest, though in certain areas restricted and carefully controlled felling may be permitted.

Forest regenerating after logging covers 17 063 ha (42 163 ac) and it is probable that much of this would fall into Groups 1, 2 or 3 if the actual yields were known. Disturbed and undisturbed lowland dipterocarp forest with an expected average yield of less than 35 m^3/ha (400 Hft^3/ac) covers 3 934 ha (9 720 ac). Non-commercial montane forest covers 1 141 ha (2 820 ac). There are 24 ha (60 ac) of other non-commercial transitional forest and 1 998 ha (4 938 ac) of mangrove forest. Regrowth following shifting cultivation and land which is non-forested or non-productive amounts to 4 962 ha (12 260 ac). The composition of the undisturbed forest in Groups 1, 2 and 3 is shown in Table 19.

In all groups red seraya is the most abundant timber group followed in Groups 1 and 3 by *urat mata* and in Group 2 by *keruing*. An interesting point is the relatively high volume of *melapi*, (Anthoshorea group of *Shorea*), particularly in Group 1. None of the other commercial species contribute a significant volume.

TABLE 19 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	40.8	458	29.1	25.8	290	26.8	16.6	187	26.0	36.2	406	29.5
Urat mata	34.1	383	25.0	13.4	151	13.9	6.2	70	9.7	28.7	322	23.3
Kapur	8.6	97	6.3	4.1	46	4.2	2.4	27	3.7	7.4	83	6.0
Keruing	7.0	79	5.2	17.5	196	18.1	4.6	52	7.3	7.1	80	5.8
Yellow seraya	14.9	167	10.9	6.8	76	7.0	4.2	47	6.5	12.7	143	10.4
Selangan batu	1.2	14	.9	1.8	20	1.8	2.0	22	3.0	1.4	16	1.1
Melapi	10.9	122	8.0	4.7	53	4.9	4.5	50	6.9	9.5	107	7.8
Other spp.	2.1	24	1.6	1.8	20	1.8	6.4	72	10.0	2.8	32	2.3
Total	119.6	1 344	87.8	75.9	852	78.5	46.9	527	73.3	105.8	1 189	86.2
Other commercial spp.												
Belian	1.5	17	1.1	2.7	30	2.8	1.3	15	2.1	1.5	17	1.2
Medang	1.3	15	1.0	1.3	15	1.4	2.2	25	3.5	1.5	17	1.2
Mengaris	3.1	35	2.3	1.5	17	1.6	1.3	15	2.1	2.8	31	2.3
Other spp. of Leguminosae	3.1	35	2.3	4.7	53	4.9	4.7	53	7.3	3.5	39	2.8
Kedongdong	1.2	13	.8	1.4	16	1.5	1.1	12	1.6	1.2	13	.9
Nyatoh	1.1	12	.8	1.5	17	1.6	1.6	18	2.4	1.2	13	.9
Other spp.	5.3	60	3.9	7.6	85	7.7	4.8	54	7.7	5.3	60	4.5
Total	16.6	187	12.2	20.7	233	21.5	17.0	192	26.7	17.0	190	13.8
Total of all commercial spp.	136.2	1 531	100	96.6	1 085	100	63.9	719	100	122.8	1 379	100

Class II Commercial forest reserves

The object of the Class II, Commercial forest,reserves is the supply of timber and other produce to meet the general demands of trade. As shown in Table 15 there are 859 392 ha (2 123 529 ac) of this class of reserve in the residency. For ease of reference and because of variation in composition, the reserves are divided into five main areas, namely:

1. That part of the Kalabakan Forest Reserve falling in the residency.
2. The Ulu Kalumpang and the smaller and adjacent Binuang Tingkayu forest reserves.
3. That part of the Ulu Segama Forest Reserve in the residency.
4. That part of the Silabukan Forest Reserve in the residency.
5. That part of the Lumerau and Ganduman Forest Reserves in the residency.

The position of these reserves is shown on Text Map 1-13. Additional small areas of the Koyah, Tenegang and Kretam reserves lie in the residency but cannot be shown on the map, although they are shown on the separate land capability classification map.

Undisturbed forest in Class II reserves

As the name implies these are forests, which, as far as is known, are virgin and have not been exploited for timber. The area of undisturbed forest in Timber Resource Groups 1, 2 and 3 in the different reserve areas is given in Table 20.

TABLE 20 Undisturbed forest in Class II, Commercial forest, reserves

Forest reserve area	Timber resource group						Total	
	Group 1		Group 2		Group 3			
	ha	ac	ha	ac	ha	ac	ha	ac
Kalabakan	218 702	540 404	37 088	91 643	4 200	10 379	259 990	642 426
Ulu Kalumpang and Binuang-Tingkayu	68 882	170 206	11 957	29 545	1 930	4 769	82 769	204 520
Ulu Segama	202 159	499 528	19 662	48 584	4 034	9 968	225 855	558 040
Silabukan	58 564	144 709	21 170	52 311	8 118	20 060	87 852	216 080
Lumerau and Ganduman	62 855	155 313	1 759	4 328	9 632	23 799	74 246	176 664
Koyah, Tenegang and Kretam	4 033	9 966	3 871	9 564	1 105	2 731	9 009	22 261
Total	615 195	1 520 126	95 507	235 995	29 019	71 206	739 721	1 827 827

The composition of undisturbed Group 1, Group 2 and Group 3 forest in the Class II, Commercial forest, reserves is discussed below and summarised in Tables 21 to 23 respectively.

Timber Resource Group I Table 21 shows that the Kalabakan area carries the highest average volume of Dipterocarpaceae and the highest average total volume. It is closely followed by the Lumerau/Ganduman area with the other three lagging behind, at best only carrying 90% of the Kalabakan volume. The ratio between dipterocarp and non-dipterocarp timbers is very similar in all areas, with dipterocarps accounting for between 87.7% and 90.5% of the total volume of commercial species. In all areas the red seraya (Rubroshorea section of *Shorea*) timber group is the most abundant accounting for between 24.4% and 31.9% of the commercial volume. In all but the Lumerau-Ganduman area *urat mata* (*Parashorea* spp.) is the second most abundant timber group and in that area its place is taken by the *keruing* (*Dipterocarpus* spp.) timber group. After red seraya and *urat mata* the order of abundance of the various timber groups in the Dipterocarpaceae varies from area to area and with considerable variation in the volume and percentage of the different groups. It may be noted that yellow seraya, (Richetia section of *Shorea*) and *selangan batu* (Shorea section of *Shorea*) are considerably more abundant in the Kalabakan than in the other areas. Red seraya, *urat mata, kapur, keruing* and yellow seraya, in general the five most abundant timber groups in the Dipterocarpaceae and certainly the most preferred commercially, account for between 77.3% and 85.5% of the total commercial volume. Among the other non-dipterocarp commercial species *belian* (*Eusideroxylon zwageri*) and *mengaris* (*Koompassia excelsa*) are the most abundant, though in no area does either account for more than 3% of the total stand. In the Lumerau–Ganduman area there is approximately twice as much *belian* as in any other area. This may be attributed to the generally flatter topography of the area with more low-lying ground.

TABLE 21 Composition of Timber Resource Group 1 in Class II, Commercial forest reserves

Main timber species	Kalabakan			Kalumpang			Ulu Segama			Silabukan			Lumerau-Ganduman		
	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	51.1	574	31.9	44.5	500	31.8	39.5	443	27.5	41.7	468	29.6	38.5	433	24.4
Urat mata	35.9	402	22.4	36.2	407	25.9	38.1	428	26.5	36.2	407	25.7	22.7	255	14.4
Kapur	10.0	112	6.2	9.5	107	6.8	23.3	262	16.2	24.4	274	17.3	29.3	329	18.6
Keruing	9.4	105	5.9	5.0	56	3.6	7.2	81	5.0	5.6	63	4.0	30.4	341	19.3
Yellow seraya	18.8	211	11.7	12.7	143	9.1	8.3	93	5.8	7.7	86	5.4	14.0	157	8.8
Selangan batu	16.5	185	10.3	11.5	129	8.2	11.1	127	7.7	7.7	86	5.4	2.3	25	1.4
Melapi	0.7	8	0.5	1.2	14	0.9	0.4	4	0.3	0.4	4	0.3	1.7	19	1.1
Other spp.	2.6	29	1.6	2.0	22	1.4	1.7	19	1.2	2.0	23	1.5	0.6	7	0.4
Total	145.0	1 628	90.5	122.6	1 377	87.7	129.6	1 455	90.2	125.7	1 411	89.2	139.5	1 567	88.4
Other commercial spp.															
Belian	1.7	19	1.1	1.8	20	1.3	1.8	20	1.3	2.3	26	1.7	4.8	54	3.0
Medang	1.3	15	0.8	1.7	19	1.2	1.6	18	1.1	1.2	14	0.9	1.6	18	1.0
Mengaris	1.8	20	1.1	2.9	33	2.1	2.0	23	1.4	2.2	25	1.6	2.4	27	1.5
Other spp. of Leguminosae	4.8	54	3.4	3.4	38	2.4	2.0	23	1.4	3.1	35	2.2	2.3	25	1.4
Kedongdong	0.9	10	0.6	0.9	10	0.6	1.2	13	0.8	1.2	13	0.8	1.0	11	0.6
Nyatoh	1.0	11	0.6	1.0	11	0.7	0.7	8	0.5	0.8	9	0.6	0.8	9	0.5
Other spp.	3.7	42	2.3	5.5	62	4.0	4.7	53	3.3	4.3	48	3.0	5.4	61	3.6
Total	15.2	171	9.5	17.2	193	12.3	14.0	158	9.8	15.1	170	10.8	18.3	205	11.6
Total of all commercial spp.	160.2	1 799	100	139.8	1 570	100	143.6	1 613	100	140.8	1 581	100	157.8	1 772	100

TABLE 22 Composition of Timber Resource Group 2 in Class II, Commercial forest reserves

Main timber species	Kalabakan			Kalumpang			Ulu Segama			Silabukan			Lumerau-Ganduman		
	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	31.7	356	32.9	25.2	283	25.9	28.2	317	26.2	29.8	334	27.4	24.7	277	24.0
Urat mata	15.6	175	16.2	15.8	177	16.2	26.0	292	24.1	22.3	250	20.5	24.5	275	23.8
Kapur	0.6	7	0.6	4.1	46	4.2	8.2	92	7.6	9.6	108	8.9	11.2	126	10.9
Keruing	7.9	88	8.1	16.1	181	16.6	10.8	121	10.0	12.6	141	11.5	11.5	130	11.2
Yellow seraya	8.5	95	8.9	7.8	88	8.1	9.6	108	8.9	9.5	107	8.8	9.2	103	8.9
Selangan batu	9.5	107	9.9	4.9	55	5.0	4.1	46	3.8	4.2	47	3.9	3.8	43	3.7
Melapi	0.8	9	0.8	1.9	21	1.9	1.9	21	1.7	1.6	18	1.5	0.8	9	0.8
Other spp.	4.5	51	4.7	1.8	20	1.8	3.1	35	2.9	2.8	32	2.6	2.3	25	2.1
Total	79.1	888	82.1	77.6	872	79.9	91.9	1 033	85.3	92.4	1 038	85.0	88.0	987	85.4
Other commercial spp.															
Belian	1.3	15	1.4	2.9	32	2.9	1.9	21	1.7	2.1	23	1.9	0.4	5	0.4
Medang	2.1	23	2.1	1.3	15	1.4	1.4	16	1.3	1.1	12	1.0	1.4	16	1.4
Mengaris	1.2	13	1.2	1.3	15	1.4	1.9	21	1.7	2.3	26	2.1	2.0	23	2.0
Other spp. of Leguminosae	5.6	63	5.9	4.9	55	5.0	3.0	34	2.9	3.1	35	2.9	3.8	43	3.7
Kedongdong	0.8	9	0.8	1.3	15	1.4	0.4	4	0.3	0.4	4	0.3	1.0	11	1.0
Nyatoh	1.4	16	1.5	1.3	15	1.4	0.4	4	0.3	0.3	3	0.2	0.4	4	0.3
Other spp.	4.8	54	5.0	6.5	73	6.6	6.9	78	6.5	7.2	81	6.6	6.0	67	5.8
Total	17.2	193	17.9	19.5	220	20.1	15.9	178	14.7	16.4	184	15.0	15.0	169	14.6
Total of all commercial spp.	96.3	1 081	100	97.1	1 092	100	107.8	1 211	100	108.8	1 222	100	103.0	1 156	100

TABLE 23 Composition of Timber Resource Group 3 in Class II reserves

Main timber species	Kalabakan			Kalumpang			Ulu Segama			Silabukan			Lumerau-Ganduman		
	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	14.3	160	26.0	21.2	238	31.2	12.6	142	17.7	11.2	126	17.1	15.9	179	23.0
Urat mata	6.1	69	11.1	9.9	111	14.6	14.4	162	20.2	8.7	98	13.3	8.6	97	12.4
Kapur	2.4	27	4.4	2.8	32	4.2	10.7	120	15.0	8.5	95	12.8	8.5	96	12.3
Keruing	4.5	51	8.2	3.3	37	4.9	8.2	92	11.3	10.2	115	15.5	8.2	92	11.8
Yellow seraya	0.5	6	0.9	2.5	28	3.7	2.3	26	3.2	1.7	19	2.6	1.7	19	2.4
Selangan batu	7.5	84	13.7	5.3	59	7.8	1.8	20	2.5	1.5	17	2.3	0.9	10	1.3
Melapi	0.2	2	0.2	1.0	11	1.4	3.1	35	4.4	4.5	50	6.8	3.6	40	5.2
Other spp.	1.5	17	2.7	4.3	48	6.3	2.4	27	3.4	2.0	22	2.9	1.2	14	1.9
Total	37.0	416	67.2	50.3	565	74.1	55.5	624	77.9	48.3	542	73.3	48.6	547	70.3
Other commercial spp.															
Belian	1.2	13	2.1	2.0	22	2.9	1.0	11	1.4	1.4	16	2.2	1.7	19	2.5
Medang	2.5	28	4.6	3.1	35	4.6	1.6	18	2.3	1.0	11	1.5	2.3	25	3.2
Mengaris	1.6	18	2.9	1.9	21	2.8	1.2	13	1.6	0.3	3	0.4	3.2	36	4.6
Other spp. of Leguminosae	6.0	67	10.8	3.8	43	5.6	3.4	38	4.8	2.7	31	4.2	3.5	39	5.0
Kedongdong	1.3	15	2.4	1.1	12	1.6	1.2	14	1.7	1.2	13	1.7	0.8	9	1.2
Nyotah	0.6	7	1.1	0.6	7	0.9	0.3	3	0.3	0.4	5	0.7	0.7	8	1.0
Other spp.	4.9	55	8.9	5.1	57	7.5	7.1	80	10.0	10.5	118	16.0	8.5	95	12.2
Total	18.1	203	32.8	17.6	197	25.9	15.8	177	22.1	17.5	197	26.7	20.7	231	29.7
Total of all commercial spp.	55.1	619	100	67.9	762	100	71.3	801	100	65.8	739	100	69.3	778	100

Timber Resource Group 2 Table 22 shows that the Silabukan area carries the highest average volume of Dipterocarpaceae and is very closely followed by the Ulu Segama area with the Lumerau-Ganduman area not far behind. The Kalabakan and Ulu Kalumpang areas carry a very similar volume but it is only some 85% of that in the Silabukan area. This is in contrast to the Group 1 forests where the Kalabakan area carries a considerably higher volume of Dipterocarpaceae than the Silabukan area. Red seraya is the most abundant timber group accounting for between 23.9% and 32.9% of the stand and in all but the Kalumpang area *urat mata* is the next most abundant timber group; in that area its place is taken by the *keruing* group. The average volume of *kapur* varies very much with a very low volume at Kalabakan. The average volume of *keruing* shows considerably variation while that of yellow seraya shows remarkably little. As in Group 1 forests the Kalabakan area carries a bigger volume of *selangan batu* than any other area. The five main timber groups in the Dipterocarpaceae account for between 66.7% and 78.8% of the total commercial volume. Although the non-dipterocarp commercial species comprise a larger proportion of the stand than in Group 1 forests the volume of individual species and groups is still too small to be of any significance. The average volume of *belian* in the Lumerau-Ganduman area is very much less than in Group 1 forests and no one species or timber group is the most abundant in all areas.

Timber Resource Group 3 Table 23 shows that the Ulu Segama area carries the highest average volume of Dipterocarpaceae, 77.9% of total volume, and the highest average total volume, while the Kalabakan area carries the lowest total volume and the lowest proportion of Dipterocarpaceae, only 67.2% of the total volume. This is in marked contrast to the position in the Group 1 forests, where the Kalabakan area carries the highest volume and the highest proportion of Dipterocarpaceae. Red seraya is the most abundant timber group in four of the areas but in the Ulu Segama its place is taken by *urat mata.* At Kalumpang *urat mata* is the second most abundant group and marginally so at Lumerau-Ganduman where the volume of *urat mata, kapur* and *keruing* is very similar. At Ulu Segama red seraya is the second most abundant group while at Silabukan it is *keruing* and at Kalabakan *selangan batu.* The variation in the volumes and percentages of the different timber groups is considerable and much more marked than in Group 1 or Group 2 forests. In general there is a slight increase in the volume of other non-dipterocarp commercial species compared to Groups 1 and 2 but the available volumes of individual species and groups remains low and of little importance. No one species or group is the most abundant in all areas though *medang* (Lauraceae spp.) shows a general increase in abundance.

Disturbed forests in Class II reserves

Relatively small areas of disturbed forest which can nevertheless be classified into Groups 1, 2 and 3 occur in these reserves and their distribution is given in Table 24.

TABLE 24 Disturbed forest in Class II reserves

Forest reserve area	Timber resource group						Total	
	1		2		3			
	ha	ac	ha	ac	ha	ac	ha	ac
Kalabakan	0	0	542	1 339	1 420	3 509	1 962	4 848
Ulu Kalumpang & Binuang-Tingkayu	0	0	190	470	320	790	510	1 260
Ulu Segama	243	600	0	0	1 484	3 667	1 727	4 267
Silabukan	0	0	0	0	4 004	9 895	4 004	9 895
Total	243	600	732	1 809	7 228	17 861	8 203	20 270

Regenerating forest in Class II reserves

There are some 64 400 ha (159 100 ac) of regenerating forest which have been classified as Group 1, 2 and 3 forest on the basis of the yield. 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

Disturbed and undisturbed lowland dipterocarp forest with an expected yield of less than 35 m^3/ha (400 Hft^3/ac) totals approximately 17 400 ha (43 000 ac). Non-commercial montane forest the average composition of which is given in Table 25 covers some 13 150 ha (32 500 ac). In this forest the Dipterocarpaceae account for 67.8% of the volume with *selangan batu* the most abundant timber group. *Kapur* (*Dryobalanops* spp.) is absent while *resak* (*Vatica* spp.) is considerably more abundant than in lowland dipterocarp forest.

TABLE 25 Composition of montane forest in the Class II reserves

Main timber species	Vol/ha m^3	Vol/ac Hft^3	%
Dipterocarpaceae			
Red seraya	5.6	63	13.8
Urat mata	2.7	30	6.6
Kapur	0.0	0	
Keruing	0.6	7	1.5
Yellow seraya	6.1	69	15.1
Melapi	0.1	1	0.2
Selangan batu	7.5	84	18.4
Resak	4.1	46	10.0
Other spp.	0.9	10	2.2
Total	27.6	310	67.8
Other commercial spp.			
Nyatoh	5.6	63	13.8
Medang	3.0	33	7.2
Leguminosae (all spp.)	1.5	17	3.7
Kedongdong	0.4	5	1.1
Others	2.6	29	6.4
Total	13.1	147	32.2
Total all commercial spp.	40.7	457	100.0

Other non-commercial forest such as coastal forest and fresh water swamp forest account for some 1 200 ha (3 000 ac). There are approximately 11 500 ha (28 500 ac) of logged forest which are now regenerating but for which no information is available on yield. This forest has therefore been classified as Group 8 though in fact most of it should probably be Group 1, 2 or 3. The balance of the total area amounting to approximately 3 800 ha (9 400 ac) either carries regrowth following shifting cultivation or is non-forested or otherwise non-productive.

Class III Domestic forest reserves

The object of Class III, Domestic forest, reserves is to supply timber and other produce for local requirements. There are only two small domestic forests in the residency the details of which are given in Table 26.

TABLE 26 Timber resource groups in Class III, Domestic forest reserves

Forest reserve	Timber resource group								Total	
	1		2		7		8			
	ha	ac	ha	ac	na	ac	ha	ac	ha	ac
Tajong	563	1 390	44	110	0	0	0	0	607	1 500
Tanjong Nagas	570	1 407	73	180	4	10	420	1 039	1 067	2 636
Total	1 132	2 797	117	290	4	10	420	1 039	1 674	4 136

The forest of Timber Resource Groups 1 and 2 carries an average volume of commercial timber of 124 m^3/ha (1 395 Hft^3/ac). Of this some 107 m^3 (1 200 Hft^3) (86%) comprises species of Dipterocarpaceae with red seraya 29.5 m^3 (332 Hft^3) and *urat mata* 29.3 m^3 (330 Hft^3) the most abundant timber groups. Of the Group 8 forest 101 ha (250 ac) are regenerating while the balance is mainly regrowth following shifting cultivation.

Class IV Amenity forest reserves

These are constituted to provide areas for local amenity and for research work. There are four small amenity forests in the residency, details of which are given in Table 27.

TABLE 27 Timber resource groups in Class IV, Amenity forest reserves

	Timber resource group								Total	
	1		3		4		8			
	ha	ac	ha	ac	ha	ac	ha	ac	ha	ac
Pulau Sakar	355	877	28	70	411	1 016	0	0	799	1 973
Membalua	64	159	0	0	0	0	0	0	64	159
Baradaya	0	0	0	0	24	60	0	0	24	60
Babanga	0	0	4	10	0	0	20	50	24	60
Total	419	1 036	32	80	435	1 076	20	50	911	2 251

The commercial forest of Groups 1 and 3 carries an average volume of commercial timber of 113.4 m^3/ha (1 274 Hft^3/ac). Of this 95.2 m^3 (1 070 Hft^3) comprises species of Dipterocarpaceae with *urat mata* 29.6 m^3/ha (333 Hft^3/ac) and red seraya 18.4 m^3 (207 Hft^3) the most abundant timber groups. The Group 4 forest in the Pulau Sakar Reserve is small-crowned and associated with ultrabasic rock formations, carrying a low volume of timber; while that in the Baradaya Reserve is disturbed forest, the result of selective exploitation.

Class V Mangrove forest reserves

There are a total of 41 670 ha (102 966 ac) of Class V, Mangrove forest, reserves of which 36 634 ha (90 522 ac) are productive mangrove and classified as resource Group 7 (see Table 15). The location of these mangrove forests, restricted to the Cowie Harbour area, is shown in Text Map 1-13 and their composition is given in Table 28.

TABLE 28 Composition of the mangrove forest in forest reserves

Species	Volume		%
	m^3/ha	Hft^3/ac	
Bakau (*Rhizophora mucronata*)	20.5	230	22.4
Bangkita (*R. apiculata*)	22.8	256	24.9
Beus (*Bruguiera* spp.)	14.1	159	15.5
Tengar (*Ceriops tagal*)	6.8	76	7.4
Geriting (*Lumnitzera* spp.)	11.6	130	12.7
Other species*	15.5	174	17.1
Total	93.3	1 025	100.0

*These include *api api* (*Avicennia* spp.) *prepat* (*Sonneratia alba*) and *buta buta* (*Excoecaria agallocha*)

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 0.7 m (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 longer. 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 forests) 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 structure, composition and regeneration of the virgin jungle. Their total area in the residency is 10 580 ha (26 148 ac). Details of the resource groups are given in Table 29.

TABLE 29 Timber resource groups in virgin jungle reserves in ha (ac)

Timber resource group						Total
1	2	3	4	7	8	
8 301 (20 511)	826 (2 040)	404 (999)	684 (1 689)	161 (399)	206 (510)	10 582 (26 148)

The forest in Timber Resource Groups 1, 2 and 3 carries an average volume of commercial timber of 145.8 m^3/ha (1 637 Hft^3/ac). Of this, 130.3 m^3 (1 463 Hft^3) (89.4%) is composed of species of Dipterocarpaceae with red seraya 46.5 m^3 (522 Hft^3) (31.9%) and *urat mata* 34.6 m^3 (389 Hft^3) (23.8%) the two most abundant timber groups. The Group 4 forest is undisturbed lowland dipterocarp forest carrying a low volume of timber. The Group 8 forest is mainly regenerating forest which was inadvertently logged.

TIMBER RESOURCES OF THE STATELANDS

Considerable areas of stateland remain forested mainly by lowland dipterocarp forest though there is as well a substantial area of mangrove forest.

Commercial forests in the statelands

As shown in Table 16 the area of commercial forest in Timber Resource Groups 1, 2 and 3 on stateland amounts to 201 888 ha (498 856 ac). In general this forest is developed on land with more gentle and less rugged topography than the forests in the forest reserves. Table 16 shows that there is a much larger proportion of forest of Groups 2 and 3 than in forest reserves, which indicates that in general the stateland forests are not so rich and the land is not as suited for forestry purposes.

Undisturbed forests

Some 128 170 ha (316 700 ac) of the total area of commercial forest is undisturbed and the composition of this forest is given in Table 30.

TABLE 30 Composition of undisturbed commercial forest on stateland

Main timber species	Timber resource group									Total		
	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	39.0	438	28.5	24.8	279	25.0	12.7	143	20.6	29.7	334	26.7
Urat mata	33.8	379	24.6	17.4	196	17.6	6.8	76	11.0	23.5	264	21.1
Kapur	19.1	214	13.9	6.2	70	6.3	5.0	56	8.0	12.0	135	10.8
Keruing	6.9	78	5.1	14.0	158	14.2	9.0	101	14.6	10.1	113	9.0
Yellow seraya	10.2	115	7.5	7.7	86	7.7	1.0	11	1.6	7.9	89	7.1
Selangan batu	8.4	94	6.1	4.8	54	4.8	3.0	34	4.9	6.1	68	5.4
Melapi	0.7	8	0.5	2.3	25	2.3	2.1	24	3.5	1.6	18	1.5
Other spp.	1.9	21	1.4	2.7	30	2.6	2.1	24	3.5	2.3	25	2.0
Total	120.0	1 347	87.6	79.9	897	80.5	41.7	468	67.5	93.2	1 047	83.6
Other commercial spp.												
Belian	2.6	29	1.9	2.3	26	2.3	2.1	24	3.5	2.4	27	2.2
Medang	1.2	14	0.9	1.6	18	1.6	1.7	19	2.8	1.4	16	1.3
Mengaris	2.7	30	2.0	2.2	24	2.2	1.4	16	2.4	2.3	26	2.1
Other spp. of Leguminosae	3.4	39	2.5	3.9	44	3.9	3.7	41	5.8	3.6	41	3.2
Kedongdong	1.2	13	0.9	0.8	9	0.8	1.2	14	2.0	1.1	12	0.9
Nyatoh	0.8	9	0.6	0.8	9	0.8	0.5	6	0.8	0.8	9	0.7
Other spp.	5.0	56	3.6	7.8	88	7.9	9.4	105	15.2	6.7	75	6.0
Total	16.9	190	12.4	19.4	218	19.5	20.0	225	32.5	18.3	206	16.4
Total of all commercial spp.	136.9	1 537	100	99.3	1 115	100	61.7	693	100	111.5	1 253	100

If this table is compared with Table 21 it will be noted that the Group 1 forests on statelands do not on average carry as heavy a stand of commercial timber as any of the commercial forest reserve areas. The volume of Dipterocarpaceae is lower than in any of the forest reserve areas while the volume of other commercial species is higher than in three of the areas and only marginally lower than the other two. The stateland forest carries lower volumes of red seraya and *urat mata* except when compared with the Lumerau-Ganduman area. The average volumes of the other timber groups in the Dipterocarpaceae in stateland forests fall within the range of volumes of these groups in the forest reserve areas.

Comparing the other commercial species the difference between stateland forests and the forest reserve areas is neither regular nor large and in general the volumes and percentages of the different timber groups are similar.

Comparison with Table 22 in respect of Group 2 forests in the commercial forest reserve areas shows that the difference in volumes both of the Dipterocarpaceae and of all commercial species is rather less than in Group 1 forest and in fact the stateland forest falls within the range of the variation of the forest reserve areas.

The stateland forest carries rather less red seraya than the forest reserve areas with the exception of the Lumerau-Ganduman area, which has a marginally lower volume. As far as *urat mata, kapur, selangan batu* and other species of Dipterocarpaceae are concerned the volumes in stateland forest occupy a mid-way position between the upper and lower limits in forest reserve areas. With the exception of the Kalumpang area the stateland forests carry a higher volume of *keruing.* They carry less yellow seraya than any of the forest reserve areas but more *melapi*.

As far as the other commercial species are concerned there is no significant difference between the stateland and commercial forest reserve areas. The total average volume of these species in the forest reserve areas varies from 15.0 to 19.6 m^3/ha (169 to 220 Hft^3/ac) while the average for the stateland forest is 19.4 m^3/ha (218 Hft^3/ac). The volumes of the various species and timber groups in stateland forest fall well within the range of variation in the different reserve areas.

Comparison with Table 23 in respect of Group 3 forests in the commercial forest reserve areas shows that with the exception of the Kalabakan area the volume of Dipterocarpaceae and the total volume of commercial species is lower in the stateland forests. However the average volumes of all the timber groups in the Dipterocarpaceae fall within the range of variation in the forest reserve areas. If however the Kalabakan area, which has a considerably lower volume of Dipterocarpaceae than the other areas is excluded then the volume of *urat mata* and yellow seraya in stateland forest is on the low side compared to the reserve areas.

With the exception of the Lumerau-Ganduman area the average volume of other commercial species is higher in the stateland forest. However, apart from *belian* of which there is a slightly higher volume in stateland forest than in any reserve areas the volumes of the various timber groups fall well within the range of variation in the reserve areas.

Comparison of the commercial forests in stateland with those in commercial forest reserve areas indicates that in general the latter carry higher average volumes of Dipterocarpaceae while the difference in volume of the non-dipterocarp commercial timbers is very marginal.

Disturbed forests

Logging of stateland forest under annual and special licences has been extensive and widespread with the result that there are now large areas of forest which have been either partially or fully exploited. Some 27 400 ha (67 700 ac) has been disturbed by selective logging but can still be classified as commercial forest on the basis of the expected yield. A further area of approximately 46 300 ha (114 400 ac) has been more completely logged and is now regenerating; it is classified as commercial forest on the basis of its known potential. Unlike the regenerating forest in forest reserves it will not have received any silvicultural treatment.

Non-commercial forests in the statelands

There are some 24 300 ha (60 000 ac) of undisturbed and 20 200 ha (50 000 ac)of disturbed lowland dipterocarp forest with an expected yield of less than 35 m^3/ha (400 Hft^3/ac). Freshwater swamp forest covers approximately 5 400 ha (13 400 ac) and non-commercial mangrove forest, mainly nipah palm, another 4 400 ha (10 800 ac).

Some 2 500 ha (6 200 ac) carry regrowth following shifting cultivation. There is no non-commercial montane forest on stateland; all land with an altitude in excess of 760 m (2 500 ft) falls in forest reserve.

Mangrove forests in the statelands

Commercial mangrove forests (Timber Resource Group 7) cover an area of approximately 26 100 ha (64 500 ac). The most important and abundant species are *bakau* (*Rhizophora mucronata*) and *bangkita* (*Rhizophora apiculata*), while *beus* (*Bruguiera* spp.), *tengar* (*Ceriops tagal*), and *geriting* (*Lumnitzera* spp.) are common and locally abundant. The average composition of these forests is given in Table 31, volumes are calculated in the same way as for Class V, Mangrove forest, reserves.

TABLE 31 Composition of the mangrove forests on stateland

Species	Volume		%
	m^3/ha	Hft^3/ac	
Bakau	29.5	331	30.5
Bangkita	35.2	396	36.4
Beus	9.7	109	10.0
Tengar	4.2	47	4.3
Geriting	8.0	70	8.3
Other species*	10.2	114	10.5
Total	96.8	1 087	100.0

*Other species include *api api, perepat* and *buta buta*

If comparison is made with the mangrove forest in Class V, Mangrove forest, reserves, see Table 28, it will be noted that the total volume in mangrove forest on stateland is slightly higher and the volume and percentage of *bakau* and *bangkita* considerably larger, i.e. 64.7 m^3 (727 Hft^3), 66.9% compared with 43.3 m^3 (486 Hft^3) 47.3%.

Water resources

It will have been seen in the section on the climate of the residency and from Text Map 1-3 that the rainfall is of the order of 1 800 mm (71 in) to 2 500 mm (98 in) per annum, depending on the locality, and is fairly evenly distributed throughout the year.

A detailed and comprehensive range of meteorological data is available for one location only, the Tawau water works on the Tawau River. The mean annual precipitation is 1 786 mm/a (70.3 in/a). Pan evaporation is relatively high, of the order of 1 400 mm/a (55 in/a). Humidity is also high, an average figure for relative humidity of 70% being recorded (Sabah, Malaysia Department of Drainage and Irrigation, 1970).

SURFACE WATER

The hydrology of two river catchments, the Tawau and Kalumpang, have been subject to study based on recordings made at the two hydrometric stations established in 1968.

The Tawau catchment has an area of 104 km^2 (40 m^2) and has a channel length of less than 32 km (20 mi). Its upper reaches are in the steeplands of the Tawau Hills Forest Reserve, after which it meanders mainly through a tract of low cultivated hills. Because the records were only started as recently as 1968 it is not possible to evaluate accurately its water resource potential, but the data available point to mean annual runoff of over 760 mm (30 in) (Manaf, 1974).

Again, because of the short duration of the records for the Kalumpang station, starting from 1968, it is difficult to give with any precision an account of the water resources of the Kalumpang catchment. The information available up to the present date indicates that, with an estimated area of 544 km^2 (210 mi^2) and a channel length of about 48 km (30 mi) through mainly steep and forested land, flood conditions occur but are of short duration, and mean annual runoff approximates to over 630 mm (25 in) (Manaf, 1974).

Cursory investigations have been made of the stream and river resources available in relation to the supply of potable water to Semporna and Lahad Datu towns. At present Semporna's supply is obtained from a number of streams flowing south and east from the Mount Pock steeplands, some 24 km (15 mi) west of the town. The courses of these streams are, however, short and steep, and yields have failed during long dry periods.

The Public Works Department has studied various aspects of water supplies (Chong, 1974) to Lahad Datu township which at present obtains its water from the Sungei Penchuran which normally produces some 1 362 000 l/d (300 000 gal/d). This figure is gradually decreasing, probably as the result of increasing flood runoff due to the logging operations in its catchment, putting a considerable strain on the town's water supplies. Two other rivers in the Lahad Datu area have accordingly been investigated. The Sapagaya to the west is thought to be able to yield 2 270 000 l/d (500 000 gal/d), and the Segama to the north 227 300 000 l/d (50 000 000 gal/d).

In addition to the Segama, there are a number of large rivers lacking hydrological information. The most important of these are the Kalabakan, Tingkayu, Silabukan, Tungku and Sabahan. These will in future play an important developmental role in providing both water and possibly hydro-electric power. Two reaches of the Segama River may be particularly suited for hydro-electric generating purposes, at the Tempadong Gorge and further upstream at the Dismal Gorge.

GROUNDWATER

Groundwater investigations have been restricted to the immediate vicinity of Semporna Town, which until fairly recently obtained its supplies by pumping from shallow wells in coral limestone. Yields were of the order of 363 000 l/d (80 000 gal/d), but the water varied from sweet to brackish depending on the water level, and related sea-water pollution from the adjoining tidal areas. Accordingly, the reliable yield of sweet water from the aquifer is considered to be negligible.

Grazing resources

In recent years there has been increasing interest in developing forested land and agricultural holdings into pasture for beef production (Plate 1-4) and, with this in mind, the Agriculture Department has been evaluating the agronomic performance of various introduced pasture species together with a number of economic factors involved in the production of beef.

Flat to gently sloping land may, theoretically, be suitable for pastures, but a number of factors would normally militate against the use of land for grazing. Soil erosion and degradation during pasture establishment and the heavy initial capital expenditure may restrict a large scale development of the industry. It is likely, however, that grazing may ultimately emerge from its present very subordinate role to become a valuable component of agriculture in the residency.

PLATE 1.4 Forested lands are being cleared for grazing. Improved pastures at the Veterinary Station, Apas Road

PRESENT GRAZING LAND

A survey of the cattle industry in 1968 revealed that some 2 747 ha (6 790 ac) were used for grazing purposes (Fagg, 1969). There probably has been a small increase in the total acreage since then. The total cattle population in 1970 was 3 889 (Census, 1970, unpublished data).

Most of the grazing is done on unimproved pastures composed of native grasses under coconut palms. The most common of these grasses are carpet grass (*Axonopus compressus*), buffalo grass (*Paspalum conjugatum*) and *lalang* (*Imperata cylindrica*). These afford, in general, rough grazing of low nutritional value.

Attempts to improve these pastures are as yet at an early stage. Probably about 81 ha (200 ac) have so far been established for both research and commercial purposes. They are composed mainly of guinea grass (*Panicum maximum*), paragrass (*Brachiaria mutica*), stylo (*Stylosanthes gracilis*), centro (*Centrosema pubescens*) and various other species of *Paspalum*.

NATURAL GRASSLAND

Approximately 14 127 ha (34 909 ac) of natural grassland occurs in the residency. Although usually occurring in the vicinity of the main agricultural areas, they are not used for grazing purposes. They are largely infested with *lalang* (*Imperata cylindrica*), which is of very low value for grazing. It can be seen (Table 32) that a large proportion of these grasslands is likely to be suited for establishing improved pastures and, as it is mainly alienated and stateland, most of this land is readily available.

TABLE 32 Suitability of natural grassland for pasture improvement

Suitability for improved pastures*	Extent									
	Alienated land		Forest reserve		Government reserve		Stateland		Total	
	ha	ac	ha	ac	ha	ac	ha	ac	ha	ac
Good	2 180	5 388	337	832	10	24	1 945	4 806	4 472	11 050
Medium	2 552	6 307	430	1 063	161	397	1 945	4 805	5 088	12 572
Poor	1 051	2 598	2 183	5 394	56	138	1 278	3 157	4 568	11 287
Total	5 783	14 293	2 950	7 289	227	559	5 168	12 768	14 128	34 909

*This is based on the rating for agricultural development:
Good = diversified agriculture (Land Capability Class II);
Medium = restricted agriculture (Land Capability Class III);
Poor = not suitable for agriculture (Land Capability Class IV and V).

Game resources

Even though there has not been a comprehensive survey of the game resources, it can be said that the residency contains a rich and varied fauna. This is largely restricted to the forests, and with the continued spread of logging and agricultural settlement, the animal population is increasingly being restricted to the remoter mountainous parts. All evidence points to the fact that the game resources are decreasing.

Herds of elephant are a prominent feature, and have been reported in the past almost everywhere. They probably migrate over the residency along certain trails, avoiding the steeper land and the main settled areas. It is highly likely that their main centres of population occur in the Ulu Segama and within the Silabukan Forest Reserve. It is difficult to estimate the numbers in the residency, but it would be safe to say that of the total number of 2 000 which is estimated to exist in the State (Keith, 1949), a significant proportion is found here.

Similarly no reliable figure is available of the population of the sumatran rhinoceros. MacKinnon (1970) estimates that the total figure for Sabah is as low as 100 individuals and, based on sightings of the animal, it is probable that a relatively large proportion live in the Tawau Residency, mainly in the steeplands of the Ulu Segama and the Silabukan Forest Reserve.

The orang-utan, whose decreasing number, like that of the sumatran rhinoceros, is of considerable concern to world wildlife conservationists, has been studied in parts of the Ulu Segama Forest Reserve. It is estimated that of a total world population of 5 000, 1 000 live within the Reserve (MacKinnon, 1971), probably restricted to the less hilly areas.

Wild cattle occur both as small herds and individuals. They are uncommon, and at present no estimate can be made of their numbers. They seem to occur mainly in the Ulu Segama, the Segama Valley and Kalumpang Forest Reserve.

A great variety of the smaller mammals are ubiquitous in the forested areas. Of these, and probably of most interest, is the Malaysian bear. There is a great variety of cats, the most important being the clouded leopard which is the largest and relatively rare, and the civets, which are represented by a number of species. Gibbon apes are relatively plentiful, and a number of monkey species are to be found (for details see Table 33), and frequently encountered in relatively large tribes. Large numbers of wild deer and pig are common in both primary and logged forest areas, and the latter in particular frequently encroach on the cultivated areas in search of food. Both forests and plantations are populated by a number of species of primitive primates, squirrels and shrews. The more important of these include the slow loris, the tarsier, the red giant flying squirrel and the flying lemur. The important and common mammals are listed in Table 33.

TABLE 33 The important and more common mammals

Elephant	*Elephas maximus*
Sumatran rhinoceros	*Didermocerus sumatrensis*
Orang-utan	*Pongo pygmaeus*
Wild cattle	*Bos javanicus lowi*
Malaysian bear	*Helarctos malayanus euryspilus*
Clouded leopard	*Neofelis nebulosa*
Civets	*Viverride* spp.
Gibbon ape	*Hylobates mulleri*
Maroon leaf monkey	*Presbytis rubicunda*
Grey leaf monkey	*Presbytis aygula hosei*
Proboscis monkey	*Nasalis larvatus*
Pig-tailed macaques	*Macaca nemestrinus nemestrinus*
Long-tailed macaques	*Macaca fascicularis*
Wild pig	*Sus barbatus barbatus*
Sambar deer	*Cervus unicolor brookei*
Barking deer	*Muntiacus muntjak pleiharicus*
Mouse deer	*Tragulus napu* and *Tragulus javanicus*
Slow loris	*Nycticebus coucang borneanus*
Tarsier	*Tarsius bancanus*
Flying lemur	*Cynocephalus variegatus*
Red giant flying squirrel	*Petaurista petaurista*
Flying fox	*Pteropus* spp.

REPTILES

Of the reptiles, the crocodile *(Crocodilus porosus)* is the most spectacular; and those which remain are probably restricted to the remotest riverine areas, being reported in recent years only in the upper reaches of the Segama River. Monitor lizards *(Varanus salvator)* are to be found in small numbers along most of the main rivers.

A large number and great variety of snakes occur, but are rarely seen. Most are small and harmless; the python *(Python* sp*)* appears to be common, and the King Cobra *(Naga hannah)* has been identified a number of times.

Green and hawksbill turtles *(Chelonia mydas, Eretmochelys imbricata)* are known to seasonally frequent the waters of Darvel Bay and nest on a number of its islands. Their numbers are probably declining as the result of hunting and the intensive harvesting of their eggs.

BIRDS

Economically, the most important birds are the swiftlets which inhabit the limestone caves at Baturong, Madai, Tepadong, Segarong and elsewhere; the nests of which are edible and of some commercial value.

The game birds reported include various pheasant in the Segama and Kuamut Highlands and the Kalabakan Valley, migratory garganey teals in the Kalabakan Valley, and pigeons which are particularly common on Sebatik Island.

The bird life of the coast and islands is particularly varied, the most important of which is the megapode. The reserves established on Sipadan and Bohaydulong Islands are meant to afford sanctuary to this and other sea birds. The Nicobar pigeon nests on Sipadan Island.

TABLE 34 The birds of interest

Swiftlet	*Collochalia fuciphaga* and *c.brevirostris*
Great argus pheasant	*Argusianus argus*
Bulwers pheasant	*Lophura bulweri*
Crested fireback pheasant	*Lophura ignita*
Pigeon	*Columbidae* spp.
Parrot	*Psittacidae* spp.
Wrinkled hornbill	*Aceros leucocephalus corrugatus*
Rhinoceros hornbill	*Buceros rhinoceros*
Wreathed hornbill	*Aceros undulatus undulatus*
Helmeted hornbill	*Rhinoplax vigil*
White crested hornbill	*Berenicornis commatus*
Ferruginous wood partridge	*Caloperdix oculea*
Chestnut breasted partridge	*Arborophila charltoni*
Egrets	*Egretta* spp.
Garganey teal	*Anas querquedula*
American golden plover	*Pluvialis dominica*
Long-billed curlew	*Numenius madascariensis*
Common sandpiper	*Tringa hypolcuros*
Osprey	*Pandian haliactus*
Megapode	*Megapodius freycinet*
Nicobar pigeon	*Caloenas nicobarica*

Recreational land resources

With few exceptions good quality recreation land is restricted to the mountains and volcanic peaks and to some of the islands of Darvel Bay. The potential for recreation of the lowlands is severely restricted by the hot and humid climate coupled with a rather uninteresting topography and natural forest vegetation much of which has been largely

modified by the effects of logging operations, agricultural settlement and cultivation. So far, the use of land for recreation has been negligible, but is likely to increase considerably with further settlement and development, and awareness by the population of the amenity value of the land.

Water-based recreation activities are limited in many parts by the discolouration of both the sea and inland waters, and by most of the coastline being fringed by mangrove swamps. All the main rivers carry a heavy load of suspended material, and their waters together with those of their estuarine zones are generally strongly discoloured. This is particularly the case with Cowie Harbour into which a number of rivers discharge.

MOUNTAINS AND HILLS

The most significant areas of mountains and hills with a potential for recreation lie within two main foci, the Tawau Highlands, and the Segama Highlands, but there are a number of limestone hills elsewhere which are worthy of conservation.

Part of the Tawau Highlands rise to over 1 200 m (4 000 ft) within 24 km (15 mi) of Tawau Town. At such an altitude the maximum day temperatures could be expected to be close to 23°C (75°F) and night temperatures around 18°C (65°F), giving rise to a welcome change from the oppressive heat of the lowlands. In addition the country is extremely rugged with a number of spectacular volcanic peaks and ridges, and abounds in a number of fast flowing clear streams. The natural vegetation is varied and remains untouched by logging operations.

Thermal springs are known to occur in three places, all located in the Tawau Highlands. Their recreation potential mainly lies in their therapeutic value. The springs located about 5 km (3 mi) north of Tawau Town have already been constituted as an amenity reserve, and together with the second series of springs located about 4 km (2½ mi) north of Table Estate are charged with hydrogen sulphide. The third spring, which occurs some 7 km (4½ mi) south-west of Quoin Hill is said to be slightly saline (Kirk, 1962).

The mountainous areas of the Segama Highlands are of larger extent but are generally far more remote from the centres of population than the Tawau Highlands, although Mount Silam which is 880 m (2 890 ft) a.m.s.l. is within 16 km (10 mi) of Lahad Datu Town and is already connected to the Lahad Datu road network. The topography of the Highlands is very varied with a number of peaks over 900 m (3 000 ft) in elevation interspersed by steep ridges, valley basins and dissected plateau features. Many stretches of the Segama River and its main tributaries such as the Danum and Bole are picturesque: fast-flowing, with waterfalls and rapids cutting through high gorges. The natural history of the Segama Highlands is of wide variety; the forests have been largely untouched but are being increasingly encroached upon by logging operations; and it will be noted in the previous section that the area contains a large game resource, in particular affording a sanctuary for such rare animals as the sumatran rhinoceros and the orang-utan.

The limestone hills at Baturong, Madai, Sagarong and Mensuli are of considerable attraction. They are frequently sheer and spectacular, and permeated by caves which sometimes attain large dimensions. The large flocks of swiftlets and bats which inhabit these caves add to the recreation potential of these areas.

ISLANDS AND BEACHES

Many of the islands of Darvel Bay are of considerable scenic value, with good sandy beaches and coral reefs surrounded by clear seas. The most attractive of these are probably Sibuan, Adal and Sipadan Islands. Some of the islands are steep and precipitous. The twin islands of Gaya and Bohaydulong which rise to almost 460 m (1 500 ft) from the sea are a prominent feature of the seascape of the Bay, and are worthy of special attention. Bohaydulong was constituted a bird-sanctuary as early as

1933, but it is highly unlikely that game birds survive in appreciable numbers. Gaya is a protection forest reserve, and its flora is of special interest, orchids being particularly common. An added attraction to these, and many of the other islands, is the surrounding coral reefs and deep clear water with turtles and game fish.

On the mainland the main stretches of attractive beaches occur to the east of Tawau, between Batu Tinagat and the Kalumpang estuary, and intermittently between Tanjong Membatu and the eastern extremity of the Dent Peninsula.

Part 6

Opportunities for resource development

Before discussing the opportunities available for using and developing the land resources of Tawau Residency, and thereby outlining its likely future course of development, it is instructive to consider the course of events which has given rise to the present land use pattern.

HISTORY OF LAND DEVELOPMENT

Tregonning (1958) in *Under Chartered Company Rule* records the history of the State of Sabah. Very little is known of the history prior to the late nineteenth century; the seas and coastline were scourged by marauding pirate bands for which slave-raiding was an important occupation. All evidence indicates that the population was extremely sparse, a situation no doubt largely determined by the periodic slaving raids, and restricted to scattered communities in the safer coastal backwaters and along the large rivers. Apart from a little shifting cultivation the main use made of the land was in the form of collecting forest produce such as rattan, damar, wax, camphor and honey. These, together with some edible birds nests, a little gold and cultivated sago, were exported from three small ports located at Tungku, near Pulau Sakar south of Lahad Datu, and on Sebatik Island (Whelan, 1970).

In the 1870s a concerted attempt was made to solve the pirate problem, and this was largely resolved by 1879 with the fall of the last pirate stronghold at Tungku (Whelan, 1970). The ensuing peace and stability afforded a suitable climate for the establishment of government control, exploration and development.

The first government station was established at Silam in about 1880 largely in response to the gold mining interests in the Segama Highlands, and an abortive attempt was made to construct a road inland from the coast to serve these interests.

In 1881 a government experimental garden was established at the station, the first in the State. Almost all tropical crops were tested.

A little later, the first estates were developed with a new crop, tobacco. These were located on the middle course of the Segama River and near the government outposts which were set up at Lahad Datu and Tawau. As a result of the sparse local population the first (of what was to become an almost continuous stream) immigrant labour was introduced, in this first instance to serve the needs of the tobacco growers. At about the same time the establishment of coconut palm groves was encouraged by the administration in the Tawau area marking the start of the copra industry, and similar undertakings spread to Lahad Datu and the newly established town of Semporna. Also in the 1880s a revival of interest occurred in edible birds nests as an export commodity, and a number of caves were discovered, or rediscovered, in the Darvel Bay area. Many of the tobacco estates were abandoned in 1891 as the result of a fall in the world price for the commodity. The government obtained undisputed possession of the Cowie Harbour area and as a result Tawau was formally constituted as a town in 1898.

Rubber cultivation on a commercial scale did not start until the early part of the present century, when estates were set up at Tawau and Lahad Datu, some on earlier tobacco holdings. During the same period a start was made on issuing titles, in the form of leases and native titles, on all land alienated for agriculture. Towards the end of the following decade the first government reserves were constituted.

Coal mining operations started at Silimpopon in 1904, and ceased in 1932 (Collenette, 1954). The coal was transported to a depot on Sebatik Island for shipment on ocean going vessels.

1919 marked the first export of manila hemp from Tawau. This crop had been newly introduced into the state and grown on part of the land presently occupied by BAL Estate. This crop was to hold an important position in the economy and by 1930, when there was a temporary collapse of the rubber industry, the holdings had spread to Mostyn and the Brantian and Balung Rivers, and in 1940 some 2 400 ha (6 000 ac) were being cultivated.

The growth of the timber industry appears to have been gradual, and by 1937 just over 56 600 m^3 (2 million ft^3) was exported from the residency, from Semporna and Tawau (State of North Borneo, 1938). Starting from 1930 and coinciding with the growth of the industry a number of forest reserves were established, and by 1938 a total of some 69 900 ha (172 000 ac) were formally gazetted.

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 mangorve forest and large scale felling for the production of chips for export. (See Plates 1-5 and 1-6).

By far the greatest impact on land development has occurred during the past two decades and is largely related to the enormous growth of the timber industry during the period. In the mid 1950s timber concessions were granted over a number of large areas consisting of both forest reserves and stateland. These concessions covered most of the Kalabakan Valley, the Semporna Lowlands, and the Segama Valley, together with some of the adjacent hill and mountain regions. Much of these areas have now been logged, licences have been issued on virtually all the remaining commercial forests, and felling keeps abreast of the granting of forest rights. The forest reserves have continued to increase in numbers and extent to the present total of 1 003 534 ha (2 479 733 ac) (see Table 35). 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).

Many of the roads built by the timber industry during the course of timber extraction have been retained and form the basis for the main road system joining the 3 towns and Bakapit in the north-east and Kalabakan in the south-west. These roads have also formed the basis for agricultural development in the past two decades resulting in large areas being settled and planted in the Apas Balung area and near Pegagau.

The introduction of oil palms and cocoa as new crops coincided with the opening up of the large areas for timber exploitation and agriculture. The first large scale commercial plantings were made in the 1950s, and after only a decade or so a number of large oil palm estates and settlement schemes had been established in the Tawau and Kunak areas (Plates 1-7 and 1-8), and cocoa was being cultivated near Quoin Hill, on part of BAL Estate, and a small area on Sebatik Island.

The success of oil palms and cocoa coincided with the decline of the tobacco and manila hemp industries. The last remaining tobacco estate, which was situated on the

PLATE 1.5
Mangrove cutting, Kuala Serudong

PLATE 1.6 Mangrove chipping plant, Wallace Bay

PLATE 1.7 Widespread recent oil palm cultivation in the Apas – Balung area

PLATE 1.8 Neglected oil palm estate due to shortage of manpower in the Balung area

Segama floodplain near Lahad Datu, closed in 1962; and production ceased on the last manila hemp holding, on BAL Estate, before the end of the decade. An attempt was made to establish a large banana plantation in the Sabahan area in the late 1960s, but this has subsequently failed. The early part of this decade saw the setting up of a mangrove chip industry. A large area of the Tawau Forest Reserve in the Cowie Deltas has been allocated for this purpose.

The growth of the timber industry and the increase of agriculture has continued without any major changes since 1960. An important feature of this latest phase of development is that many areas which were planted with permanent crops have subsequently been abandoned, remaining neglected and non-productive. In many cases this can be attributed to a shortage of manpower. This is discussed in the later section devoted to population and manpower.

ALIENATION, GAZETTEMENT AND PRESENT LAND USE

It will be seen from the foregoing account that extensive areas have been allocated for specific purposes, being gazetted as forest reserves, titles granted for land alienated for agricultural purposes, and land reserved for specific government uses. However, large areas remain unallocated as stateland.

Table 35 and Figure 1-1 show that by far the greatest proportion of land (1 003 534 ha (2 479 933 ac) or 71.9%) has been reserved for forestry purposes. The distribution of the forest reserves is shown on Text Map 1-13. The table and figure also show that a large area remains as stateland (294 126 ha (726 786 ac) or 21.0%), that the land alienated for agriculture is relatively small in extent (96 078 ha (237 410 ac) or 6.9%), and that the government reserves occupy a very small area (2 738 ha (6 766 ac or 0.2%) of the residency. Text Map 1-14 shows the distribution of these land categories.

TABLE 35 Alienation and gazettement by districts in ha (ac)

District	Land category				Total
	Alienated land	Forest reserves	Government reserves	Stateland	
Tawau	44 591 (110 185)	457 118 (1 129 539)	565 (1 397)	62 233 (161 190)	567 507 (1 402 311)
Semporna	22 223 (54 913)	28 929 (71 484)	311 (768)	52 840 (130 568)	104 303 (257 733)
Lahad Datu	29 264 (72 312)	577 487 (1 278 710)	1 862 (4 601)	176 053 (435 028)	724 666 (1 790 651)
Total	96 078 (237 410)	1 003 534 (2 479 733)	2 738 (6 766)	294 126 (726 786)	1 396 476 (3 450 695)

Even though the forests have been exploited and agriculture has been developed over a long period, considerable areas remain forested (1 318 300 ha (3 263 119 ac) or 94.6%) and a relatively small proportion (46 893 ha (116 072 ac) or 3.4%) is being used for agricultural purposes. These points are shown in Table 36 and illustrated by Figure 1-2.

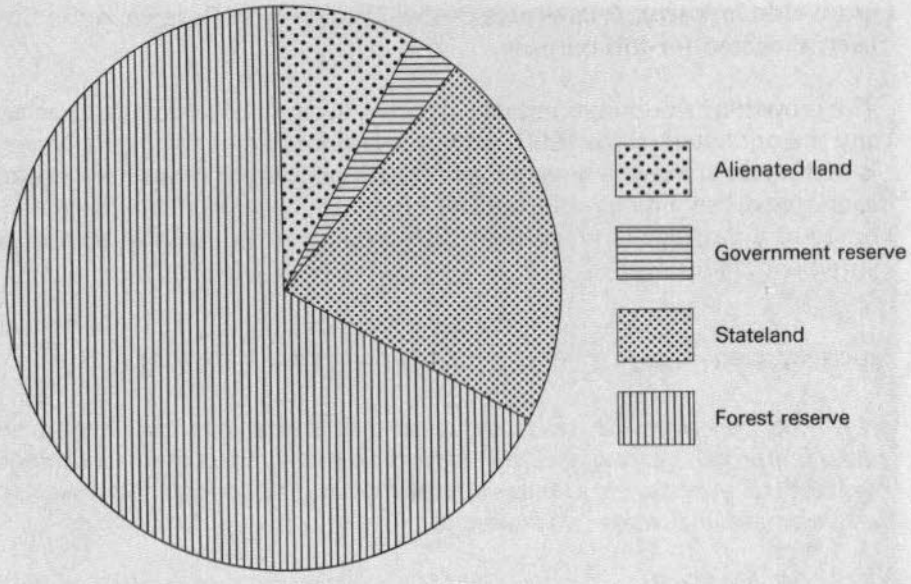
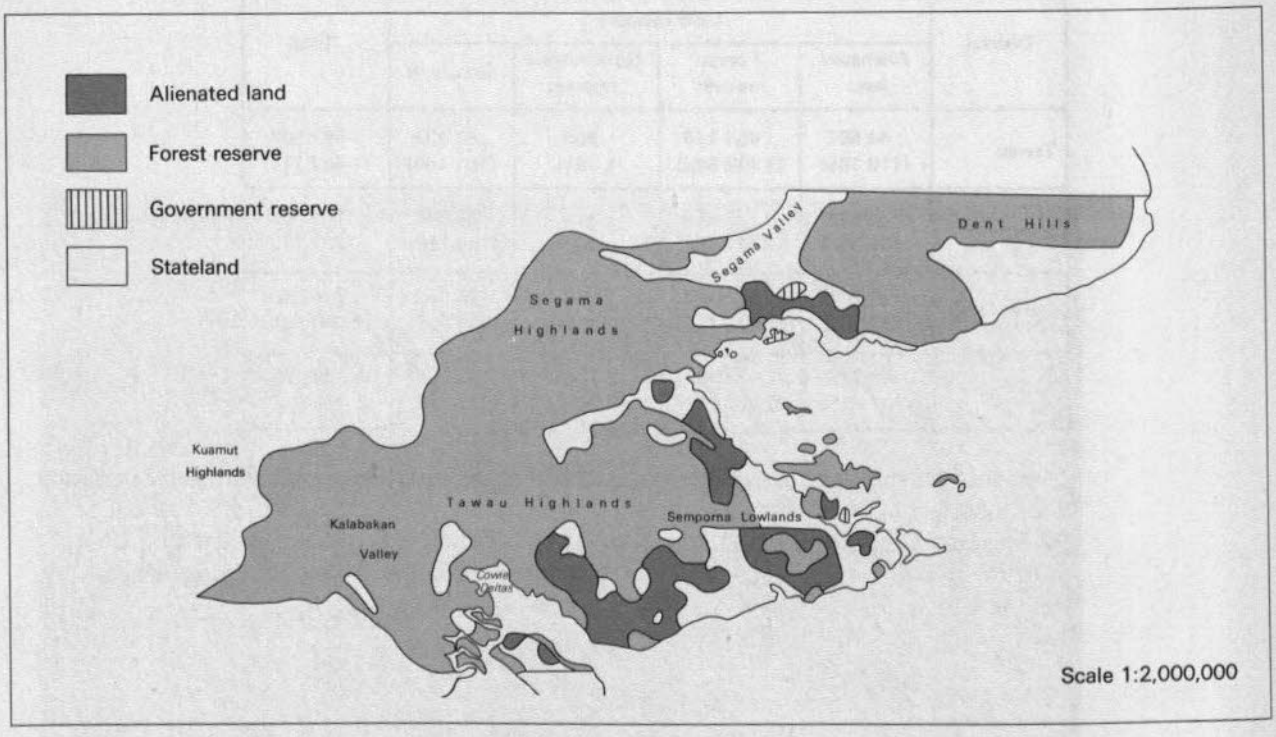


FIGURE 1-1 Alienation and gazettement



TEXT MAP 1-14 Distribution of the land categories

Prepared by the Directorate of Overseas Surveys 1976

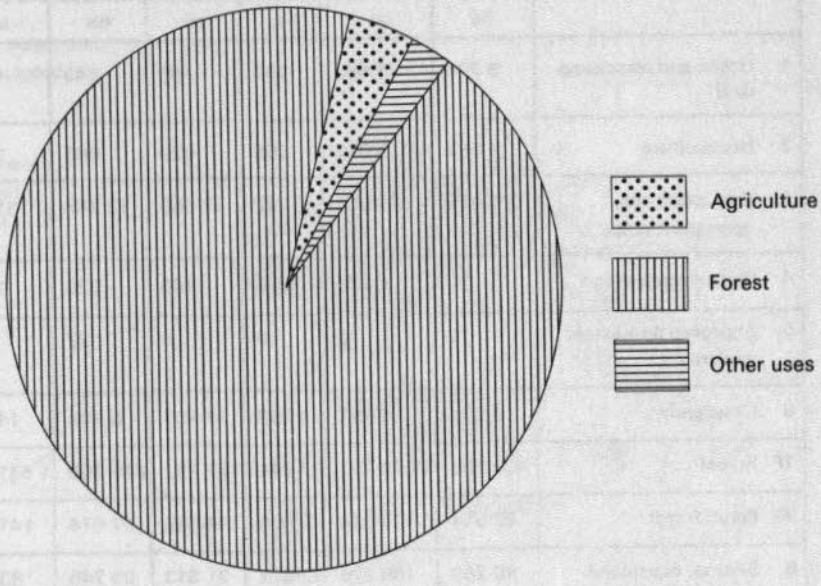
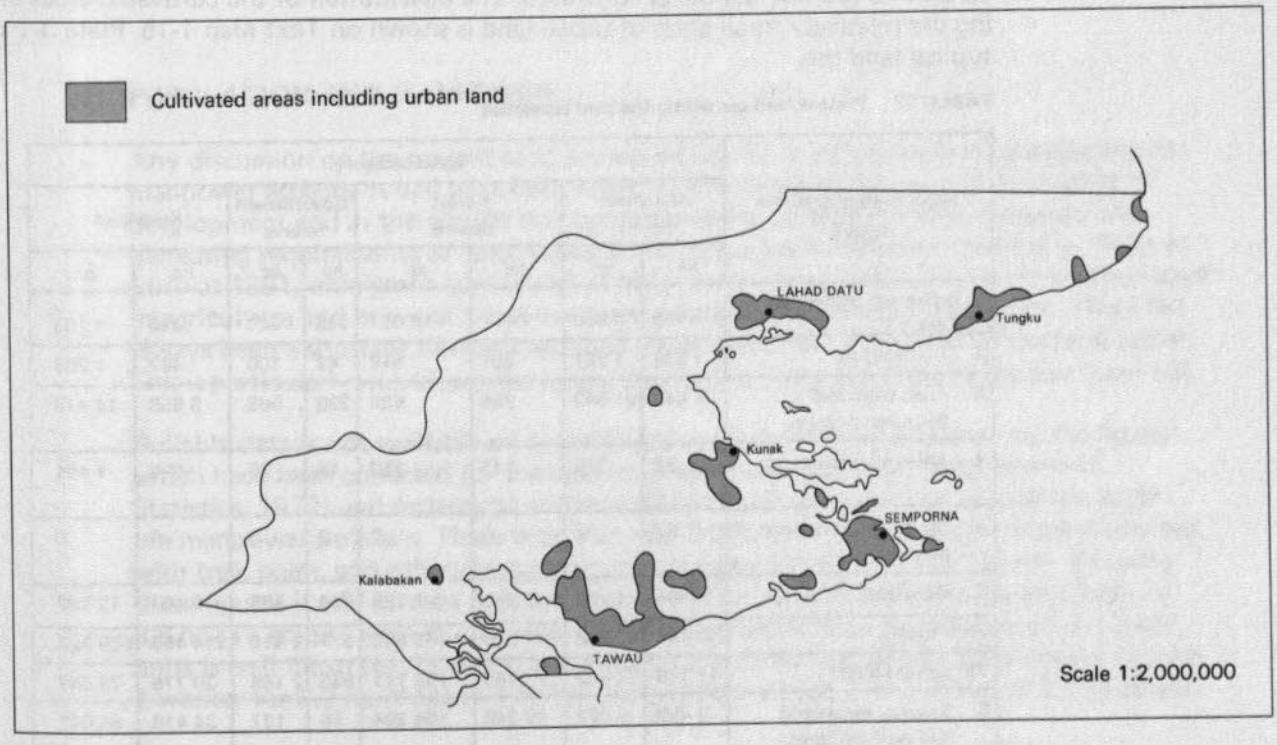


FIGURE 1-2 Present land use



TEXT MAP 1-15 Cultivated areas including urban land

Prepared by the Directorate of Overseas Surveys 1976

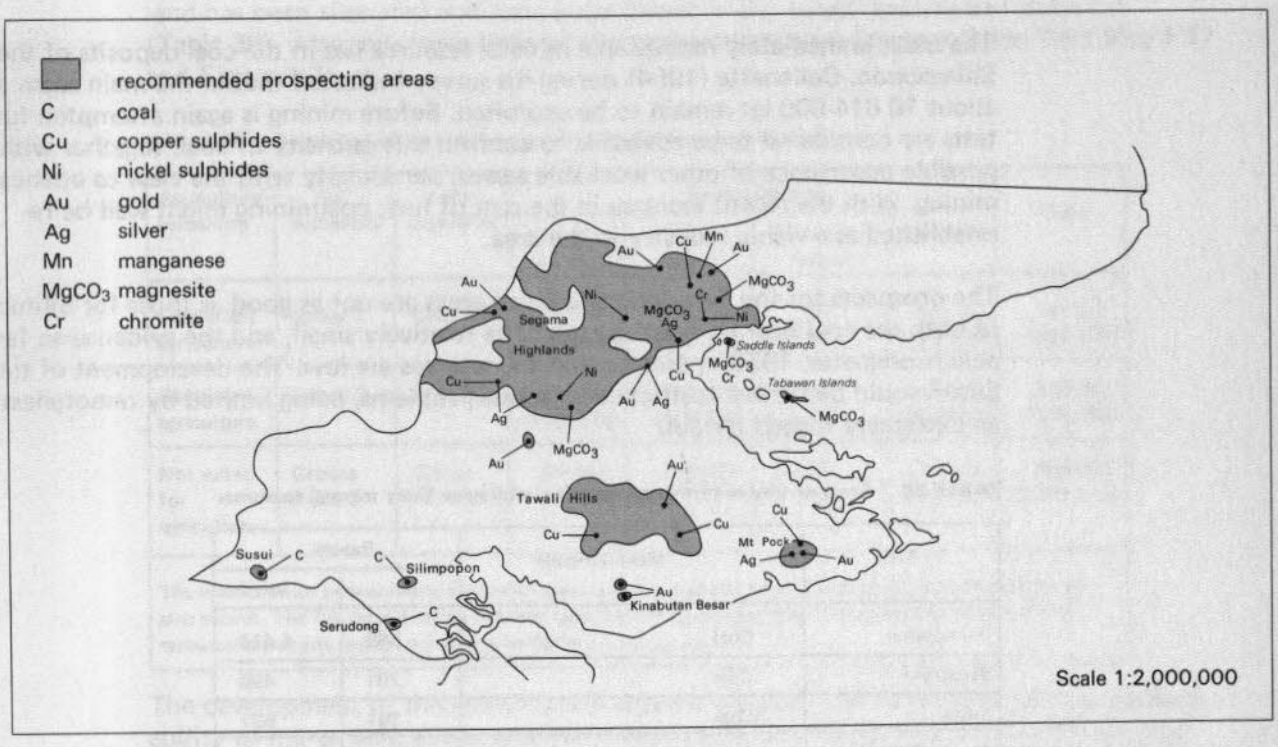
TABLE 36 Present land use by districts (1973)

Major present land use category	District						Total	
	Tawau		Semporna		Lahad Datu			
	ha	ac	ha	ac	ha	ac	ha	ac
1 Urban and associated land	8 774	21 682	190	469	643	1 590	9 607	23 741
2 Horticulture	1 587	3 922	255	629	866	2 141	2 666	6 602
3 Tree, palm and permanent crops	23 415	57 859	7 230	17 866	12 748	31 500	43 391	107 225
4 Shifting cultivation	79	196	227	560	529	1 307	835	2 063
5 Improved permanent pasture	0	0	0	0	37	92	37	92
6 Grassland	3 598	8 891	4 790	11 837	5 739	14 181	14 127	34 909
7F Forest	433 198	1 070 432	67 941	167 883	619 669	1 531 203	1 120 577	2 769 518
7S Scrub forest	53 514	132 234	9 990	24 685	57 074	141 029	120 578	297 948
8 Swamp, marshland and wetland forest	40 763	100 725	12 672	31 313	25 745	63 617	79 180	195 655
9 Unused and cleared land	2 578	6 370	1 008	2 491	1 615	3 991	5 201	12 852

Over 75% of the forested land occurs within the forest reserves, as shown in Table 37. The table also indicates that over 21% of the forested land in the residency is contained in the stateland, and that some 95% of the stateland remains forested. Similarly, almost half of the land alienated for agriculture remains under a forest cover with only 39 041 ha (96 637 ac) being cultivated. The distribution of the cultivated areas including the relatively small areas of urban land is shown on Text Map 1-15. Plate 3-1 shows typical land use.

TABLE 37 Present land use within the land categories

Major 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	1 558	3 850	7 457	18 427	146	361	446	1 103
2 Horticulture	1 936	4 781	201	518	42	100	487	1 203
3 Tree, palm and permanent crops	37 049	91 549	256	635	228	565	5 858	14 476
4 Shifting cultivation	87	215	145	359	10	25	592	1 464
5 Improved permanent pasture	37	92	0	0	0	0	0	0
6 Grassland	5 784	14 293	2 950	7 289	226	559	5 167	12 768
7F Forest	33 704	83 282	871 668	2 153 892	977	2 415	214 459	529 929
7S Scrub forest	11 170	27 602	77 746	192 111	885	2 188	30 776	76 047
8 Swamp, marshland and wetland forest	2 459	6 077	42 248	104 394	55	137	34 418	85 047
9 Unused and cleared land	2 294	5 669	853	2 108	132	326	1 922	4 749



TEXT MAP 1-16 Areas worthy of further prospecting, with main likely mineral occurrences

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POPULATION AND MANPOWER

Any discussion on the present land use would not be complete without considering its manpower aspects. It will have been noted in the foregoing account of the history of development and in the section on population in Part 3 that, in order to satisfy the increasing requirements of land development, it has been necessary to bring in, from as early as 1881, immigrant labour and, at the present stage, most of the workers employed in agriculture and many of those involved in forestry are of expatriate stock. There has always been a shortage of manpower and it has been most felt in the agricultural sector. This is particularly well illustrated by the deserted cultivations of the 1960s (see Plate 1-8).

Reliable data is not available on the population involved in agriculture, but the figures which have been collected for the workers employed on estates (Department of Statistics, 1972) and settlement schemes (Sabah Land Development Board) illustrate the manpower problem. These total just over 6 200 individuals, and the acreage planted with tree, palm, and other permanent crops is some 43 391 ha (107 225 ac). By using these figures it will be seen that the ratio of cultivated land to workers is very high i.e. 6.8 ha (17 ac) per worker. The inability of such a work-force to effectively farm such units is well illustrated in that it is normally considered that oil palm and rubber require 1 worker for 3.2 ha (8 ac) to 4 ha (10 ac) and cocoa 1 for 2.4 ha (6 ac) to 3.2 ha (8 ac).

MINING DEVELOPMENT OPPORTUNITIES

The mineral resources are described in Part 5. It will have been noted that some 261 818 ha (646 944 ac) are considered to be mineralised to such an extent so as to be worthy of further prospecting. The main areas, with the likely mineral occurrences are shown in Text Map 1-16 and Table 38.

Mineral Resource Group 3 Possible mining areas

The most immediately recoverable mineral resource lies in the coal deposits of the Silimpopon. Collenette (1954) during his survey indicated that in the main seam alone about 10 614 000 lgt remain to be exploited. Before mining is again attempted further tests are considered to be advisable to confirm this quantity of coal, together with the possible occurrence of other workable seams, particularly with the view to opencast mining. With the recent increase in the cost of fuel, coalmining might well be re-established as a viable industry in the area.

The prospects for the Serudong and Susui areas are not as good as those for Silimpopon. In both the coal bearing areas appear to be relatively small, and the evidence so far available (Collenette, 1958) indicates that the reserves are low. The development of the Susui would be further restricted by access problems, being limited by remoteness over an extremely rugged terrain.

TABLE 38 Areas worthy of further prospecting, with main likely mineral resources

Area	Main minerals	Extent	
		ha	ac
Silimpopon	Coal	568	1 416
Serudong	Coal	201	498
Susui	Coal	281	697
Segama Highlands	Copper, nickel, gold, silver, chromite, manganese, magnesite	207 467	513 534
Saddle Islands	Chromite, magnesite	80	200
Pulau Tabawan	Magnesite	643	1 594
Umas Umas Valley	Gold	202	500
Tawau Hills	Copper, gold	40 889	101 212
Mount Andrassy	Gold	281	697
Kinabutan Hill	Gold	362	897
Mount Pock	Copper, gold, silver	5 153	12 754

By far the largest and most important mineralised zone falls in the Segama Highlands, where sulphides of copper and nickel, together with gold, silver, chromium, manganese and magnesite are known to occur (Part 4). Most of the zone is mountainous and remote, but access is likely to improve with the building of logging roads. Due consideration should therefore be given to undertaking a prospecting programme in conjunction with the road building.

The mining prospects for the deposits of chromite and magnesite on the Saddle and Tabawan Islands appear to be low. At present these areas do not appear to warrant further investigation. The prospects of mining gold in the Umas Umas Valley are better. The increasing road access into the area being made by timber interests is likely to aid the detailed investigations of the deposits which are required. Further investigations are also required in order to assess whether economic deposits of copper and gold exist in the Tawau Hills area,and possibly gold on Mount Andrassy and Kinabutan Hill.

Fairly detailed investigations have already been undertaken in recent years in the Mount Pock area (Geological Survey Malaysia, 1971). The results have been disappointing and it is considered that low priority should be given to this area for any further prospecting.

AGRICULTURAL DEVELOPMENT OPPORTUNITIES

It will have been noted from Part 5 that the residency holds a considerable agricultural land resource, a total of 147 377 ha (364 170 ac) being classified as soils of Soil

Suitability Group 2, and 340 099 ha (840 385 ac) as Group 3. Relatively little of this land has been alienated and most is contained in the forest reserves and stateland (Table 39). Also, relatively little of this resource has been developed (see Text Map 1-17 and Figure 1-3).

TABLE 39 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	27 510 (67 976)	63 630 (157 230)	74 (184)	56 163 (138 780)	147 377 (364 170)
Restricted agriculture	Group 3	Class III	47 106 (116 400)	173 497 (428 710)	638 (1 576)	118 858 (293 699)	340 099 (840 385)
Not suited for agriculture	Groups 4 and 5	Classes IV, V and I	21 463 (53 034)	766 407 (1 893 793)	2 026 (5 006)	119 104 (294 307)	909 000 (2 246 140)

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 page 28.

The development of this resource will depend on a number of factors, such as the availability of manpower, access and communications, but the order in which this development is undertaken should primarily rest on considerations concerning the legal status of the land, i.e., in the following order: alienated land before stateland, and both before forest and government reserves. Ideally such considerations should be made in conjunction with the suitability of the land, i.e., Soil Suitability Group 2 land being developed before Group 3 land.

Alienated land

The selection of land for agriculture has, in the past, been reasonable; almost 78% of the land alienated for agriculture is suited for the purpose. This comprises a total of 74 616 ha (184 376 ac) consisting of 27 510 ha (67 976 ac) of Soil Suitability Group 2 and 47 106 ha (116 400 ac) of Group 3 soils (Table 39).

The progress being made in cultivating this land, however, has been slow; some 59% only being farmed. This is shown in Table 40, and illustrated by Figure 1-3. Such areas are eminently suited for agricultural development, being already alienated for that purpose, and access is generally good.

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

Agricultural suitability	Present land use category*												
	Cultivated				Sub total	Non-cultivated						Sub total	Total
	2	3	4	5		1	6	7F	7S	8	9		
Diversified agriculture	576 (1 423)	12 518 (30 931)	27 (67)	0	13 121 (32 421)	817 (2 020)	2 180 (5 388)	8 359 (20 654)	2 389 (5 903)	112 (278)	531 (1 312)	14 389 (35 555)	27 510 (67 976)
Restricted agriculture	1 242 (3 068)	18 996 (46 939)	57 (140)	37 (92)	20 331 (50 239)	570 (1 409)	2 552 (6 307)	15 986 (39 502)	5 832 (14 411)	338 (834)	1 497 (3 698)	26 775 (66 161)	47 106) (116 400)
Not suited for agriculture	117 (290)	5 536 (13 679)	3 8	0	5 656 (13 977)	170 (421)	1 051 (2 598)	9 359 (23 126)	2 949 (7 288)	2 009 (4 965)	267 (659)	15 806 (39 057)	21 462 (53 034)
Total					39 108 (96 637)							56 970 (140 773)	96 078 (237 410)

*See Table 37

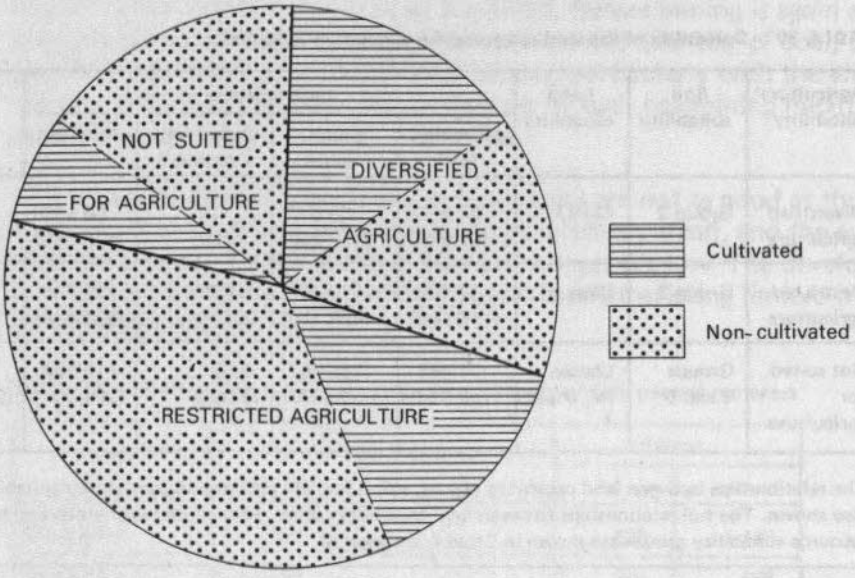
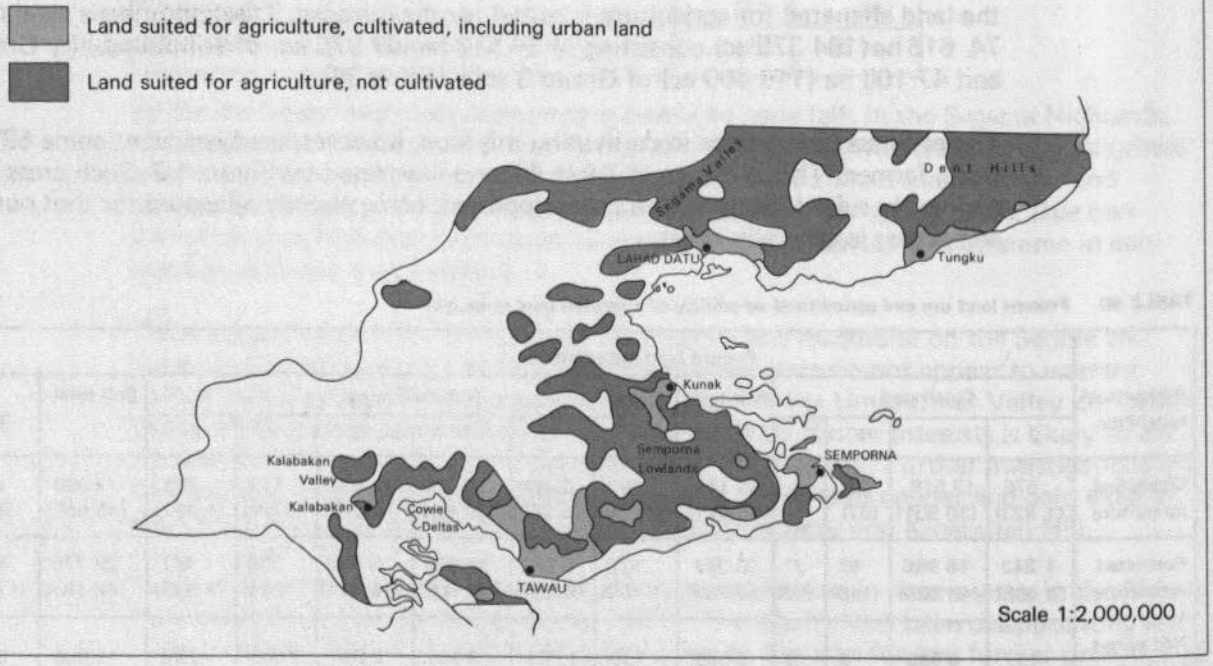


FIGURE 1-3 Soil suitability of the alienated land and its agricultural development



TEXT MAP 1-17 Areas suitable for agriculture and the extent of their development

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Soil Suitability Group 2

Some 14 389 ha (35 555 ac) of alienated but uncultivated land have been classified as Group 2 soils (Table 40). The largest contiguous tract occurs to the west of the Pegagau in the Semporna Lowlands. This is developed on gently sloping hills and derived from mudstones, shales and sandstones. The others consist of relatively small scattered areas, and are shown on the land capability classification map.

Soil Suitability Group 3

Table 40 also shows that 26 775 ha (66 161 ac) of Group 3 soils have been alienated but not cultivated. The largest area is found in the Semporna Lowlands where some 9 000 ha (22 000 ac) occur on the strongly sloping hills adjacent to the Mount Pock steeplands, and with soils derived from mudstones, shales and sandstones to the north, and volcanic ash to the south. Extensive areas also occur in the Apas–Balung area, totalling some 7 000 ha (17 000 ac), consisting of volcanic ash and alluvial soils which are found developed on both the strongly sloping land and on the terraces. Approximately 4 000 ha (10 000 ac) of similar land also occurs in the Merotai Valley.

Stateland

The stateland holds a large agricultural soil resource and considerable opportunities for agricultural development. Being uncommitted, such land is readily available for acquisition and cultivation. By reference to Table 39 it will be seen that a total of 175 021 ha (432 479 ac), or 59% of the stateland, is considered suitable. This is illustrated by Figure 1-4, and the distribution shown on Text Map 1-18.

Soil Suitability Group 2

The Group 2 soils of the stateland would normally be first considered for development. There are 56 163 ha (138 780 ac) (Table 39). The main areas are given in Table 41, and the general distribution on the separate land capability classification map.

The development prospects for the Sipit area are particularly favourable, with a relatively good road link to the port at Kunak and the main trunk road system, and already a reasonably good logging/road infrastructure has been developed through most of the area. Even so, the construction of a permanent road from near the Pegagau Bridge on the Semporna road to Kunak would greatly facilitate agricultural development in the area.

TABLE 41 Main areas of Group 2 soils occurring in stateland

Region	Area	Soils		Extent	
		Landform	Parent material	ha	ac
Semporna Lowlands	Sipit	Gently sloping hills	Sedimentary rocks	10 100	25 000
	Middle Kalumpang Valley			2 400	6 000
	Semporna Island	Terraces	Coral reefs	4 400	11 000
	Pulau Bum Bum			4 800	12 000
Dent Hills	Tegupi			1 600	4 000
Kalabakan Valley	Kalabakan to Brantian coastal belt		Alluvium	6 900	17 000
Segama Highlands	Upper Taliwas Valley	Terraces and valley floors		2 000	5 000

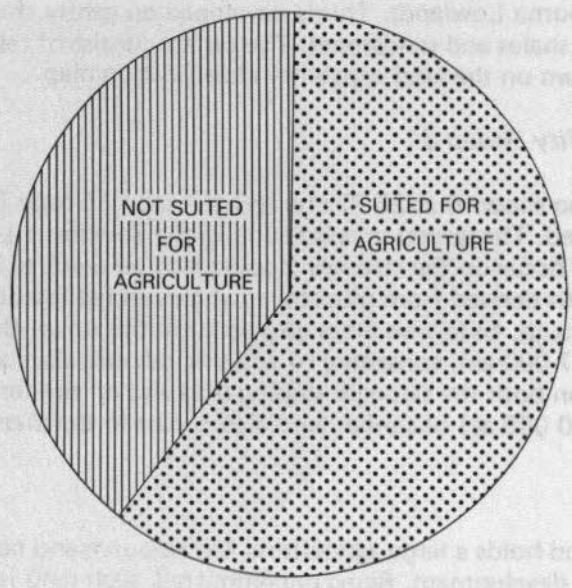
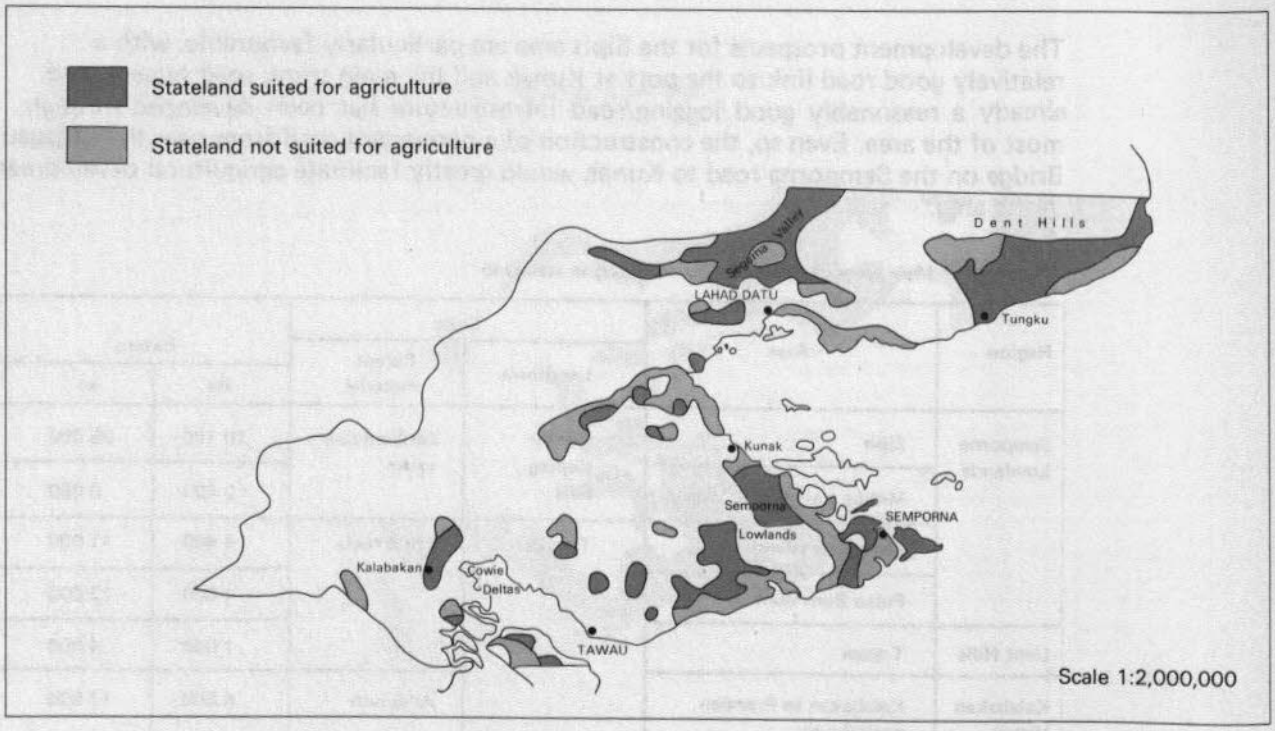


FIGURE 1-4 Suitability of stateland for agriculture



TEXT MAP 1-18 Suitability of stateland for agriculture

Prepared by the Directorate of Overseas Surveys 1976

Similarly, the Middle Kalumpang Valley, the Kalabakan – Brantian coastal belt and the Upper Taliwas Valley, although not offering individually such large areas as the Sipit, appear to be well suited for development because of their proximity to permanent roads. The same applies generally to Semporna Island, but any large-scale agricultural development there will be severely limited by the scattered nature of such land, with individual areas rarely exceeding a hundred hectares.

Access to the two remaining areas, at Tegupi and on Pulau Bum Bum, is poor, and is dependant on sea communications with the ports of Lahad Datu and Semporna respectively. While it will be relatively easy to develop port facilities and a road system on Pulau Bum Bum, considerable difficulties will be encountered with the Dent Hills. 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 (see later).

Soil Suitability Group 3

The Group 3 soils occurring in the stateland occupy 118 858 ha (293 699 ac). The main areas are given in Table 42.

TABLE 42 Main areas of Group 3 soils occurring in stateland

Region	Area	Soils		Extent	
		Landform	Parent material	ha	ac
Dent Hills	South of the Lumerau and Ganduman forest reserves	Strongly sloping hills and alluvial flats	Sedimentary rocks and alluvium	42 800	106 000
Segama Valley	Middle Segama Plain and adjacent uplands			41 200	102 000
Semporna Lowlands	Sipit area north of the Mount Pock steeplands			3 200	8 000
	Balung to Kalumpang area	Terraces	Volcanic ash	15 400	38 000
	Apas to Balung area			6 000	15 000
Tawau Hills	Scattered areas lying south of the Tawau Hills Forest Reserve	Strongly sloping hills		4 400	11 000
Segama Highlands	Sapagaya Valley		Basic intrusive rocks	4 400	11 000
Cowie Deltas	Sebatik Island	Terraces	Alluvium	3 200	8 000

It would appear that the areas most suited for early development, having easy access to road communications, are found in the Semporna Lowlands, the Tawau Hills, and the Sapagaya Valley.

There is already a jeep track system over most of the area on Sebatik Island, and the development of port facilities which would improve communications with Tawau would be a relatively easy task.

The problems of developing the areas in the Segama Valley and the Dent Hills are, however, far greater. With the former the solution would appear to rest with the main trunk road which is being built to join Lahad Datu and Sandakan, and which will traverse the area, and bridge the Segama River. Spur-roads to the east and west would be required to facilitate development of the whole area. The question of the considerable flood hazard which occurs over parts of the area poses further problems, and the solution would depend on either controlling the flooding or, what appears to be the more

PLATE 1.9 Flooding has restricted permanent crops on the Segama floodplain. Grazing has been attempted in recent years. Segama Estate

practical solution for the immediate future, the choice of an agricultural system which is compatible with the pattern of flooding (Plate 1-9). The development of the Dent Hills area would be dependant on the construction of the road-link with the Lahad Datu system discussed for the Tegupi area above.

Forest reserves

The forest reserves, even though the greater proportion is not considered suited for agriculture (Figure 1-5), hold in total a very large agricultural resource potential, some 49% of the residency. Out of a total of 486 640 ha (1 204 555 ac) suited for agriculture in the residency (Table 6), some 237 127 ha (585 940 ac) (Table 39) occur in the forest reserves. The distribution is shown on Text Map 1-19.

Relatively low priority, however, should be given to the development of agriculture on such land, because it constitutes a significant part of the country's permanent forest estate and is an important component sustaining a permanent timber industry. This is particularly important in the light of the earlier discussion on the availability of land already alienated and the extent of potential agricultural land in the stateland.

Soil Suitability Group 2

When it may be found necessary to extend agricultural development into the forest reserves, first consideration should ideally be given to the Group 2 soils which comprise 63 630 ha (157 230 ac) (Table 39). The main areas are given in Table 43, and their general distribution on the separate land capability classification map.

TABLE 43 Main areas of Group 2 soils occurring in forst reserves

Region	Area	Soils		Extent	
		Landform	Parent material	ha	ac
Dent Hills	Lumerau Valley	Gently sloping hills	Sedimentary rocks	10 500	26 000
Semporna Lowlands	Middle Kalumpang Valley			4 800	12 000
Segama Valley	Silabukan Valley			9 300	23 000
	Kuala Sungei Bole			4 800	12 000
Tawau Highlands	Merotai to Brantian coastal belt	Platform	Alluvium	10 000	25 000
Kuamut Highlands	Serudong to Silimpopon Valleys			7 300	18 000
Dent Hills	Tegupi		Coral reefs	1 600	4 000
Segama Highlands	Juak Valley	Valley floor	Alluvium	2 000	5 000
	Upper Taliwas Valley			1 200	3 000

It will have been seen from the foregoing account that the agricultural development of the Dent Hills will largely depend on a road link being constructed to the west, and that the Middle Kalumpang Valley is already well suited as far as road access is concerned. The Juak Valley and Upper Taliwas Valley areas are already served by logging roads and very little road construction would be required to facilitate the development of the Merotai-Brantian and Silabukan Valley areas. It is highly likely that the development of the Serudong and Silimpopon areas would depend on the construction of a road-link with the Kalabakan Valley road system. Similarly, development in the Kuala Sungei Bole area will depend on a link with the Lahad Datu-Sandakan trunk road.

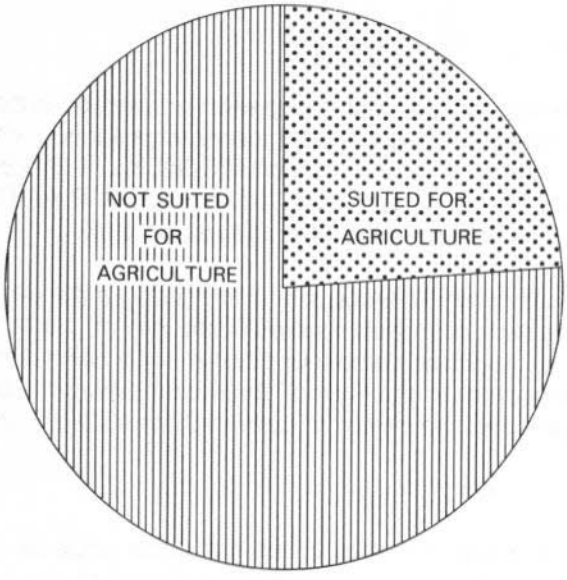
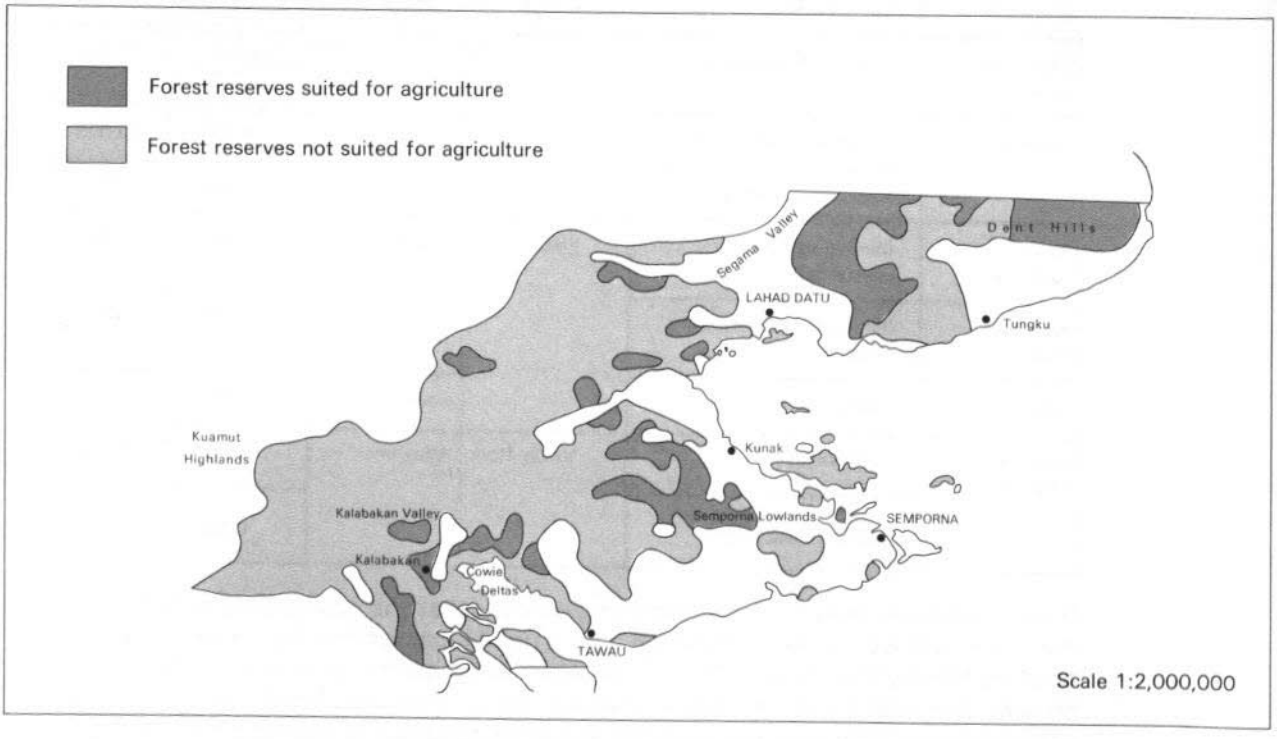


FIGURE 1-5 Suitability of forest reserves for agriculture



TEXT MAP 1-19 Suitability of forest reserves for agriculture

Prepared by the Directorate of Overseas Surveys 1976

Soil Suitability Group 3

Low agricultural development priority would normally be given to areas of Group 3 soils in the forest reserves. They comprise a total of 173 497 ha (428 710 ac). Their most extensive areas are given in Table 44, and their general distribution on the separate land capability classification map.

TABLE 44 Main areas of Group 3 soils occurring in forest reserves

Region	Area	Soils		Extent	
		Landform	Parent material	ha	ac
Dent Hills	Ganduman-Lumerau forest reserves	Strongly sloping hills	Sedimentary rocks	45 200	112 000
Kalabakan Valley	Kalabakan Valley			2 800	7 000
Segama Highlands	Danum Valley			6 100	15 000
Tawau Highlands	Umas Umas Valley	Strongly sloping hills and alluvial flats	Sedimentary rocks and alluvium	8 900	22 000
	Mantri Valley			4 800	12 000
Segama Valley	Middle Segama Plain and adjacent uplands			70 300	174 000
	Silabukan Valley			10 500	26 000
Semporna Lowlands	Tingkayu Valley*	Terraces and valley floors	Alluvium	10 900	27 000
	Kalumpang Valley*			5 700	14 000
Segama Highlands	Juak Valley	Alluvial plains		2 400	6 000

*Considerable areas may ultimately be upgraded to Group 2, see page 39

The constraint imposed by poor access has already been discussed for the Dent Hills and the Middle Segama Valley, together with the flood problems apertaining to the latter area. The opportunities for agricultural development in relationship to a relatively good road access in the Kalumpang, Silabukan and Juak Valleys have also been mentioned.

The areas in the Kalabakan Valley are similarly well sited, being close to the main road system, and the Umas Umas, Mantri and Tingkayu Valley areas are all, at present (1974), easily accessible by logging roads. The Danum Valley, however, remains relatively remote.

Government reserves

The government reserves occupy a relatively insignificant proportion of the residency (Figure 1-1), some 0.2%, or 2 733 ha (6 766 ac). It will also have been seen (Table 39) that only 712ha (1 760 ac) are considered suited for agriculture. The government reserves will, therefore, play little or no part in the future development of agriculture in the residency.

FORESTRY DEVELOPMENT OPPORTUNITIES

The forest resources of the residency are very considerable and they will continue to play an important role in its development and economic life. As has been noted in Part 5, logging licences have been issued covering virtually all the commercial forests and it is therefore very likely that in the normal course of events a large part of these forests will be logged in the forseeable future. However some 3 100 km^2 (1 200 mi^2) of the forest in forest reserves are in the Sabah Foundation Licence agreement area

and this forest will be worked on a sustained yield basis. Priority for the development of this resource should be dependent on two important factors, namely the legal status of the land and its suitability for agriculture. As far as the former is concerned the order of priority should be forest reserves, statelands, government reserves and alienated land. In the case of the latter, priority should 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 II (see Table 5).

As can be seen from Tables 45, 46, 48 and 49 there are a total of some 63 577 ha (157 097 ac) of commercial mangrove forests. These are an important forest resource which can be developed but development must take full account of the important role these forests play in providing nursery and feeding grounds for prawns and fish. Exploitation of these forests must be controlled and care must be taken to ensure that they are satisfactorily regenerated as soon as possible after felling. For the purpose of this section of the report, Timber Resource Groups 1, 2 and 3 are taken together and are not dealt with separately (see also 'Natural vegetation and timber resource groups' in Part 4 and 'Forests and their timber resources' in Part 5). The reason for this is that the three groups often occur as an intimate mixture in the forest; they all carry commercial stands and it would be quite impractical to consider separate exploitation and development. As Groups 4 to 6 and Group 8 are considered non-commercial, areas classified as such are not given consideration for development. However, there are areas of forest which have been logged and do not at present carry commercial stands of timber; because of lack of information on past yields these have been classified as Group 8. The fact that the areas have been logged would in general indicate a commercial stand of timber and thus a true classification into Group 1, 2, 3 or 7.

Forest reserves

Forest resource development areas in forest reserves are summarised in Table 45 and shown on Text Map 1-20.

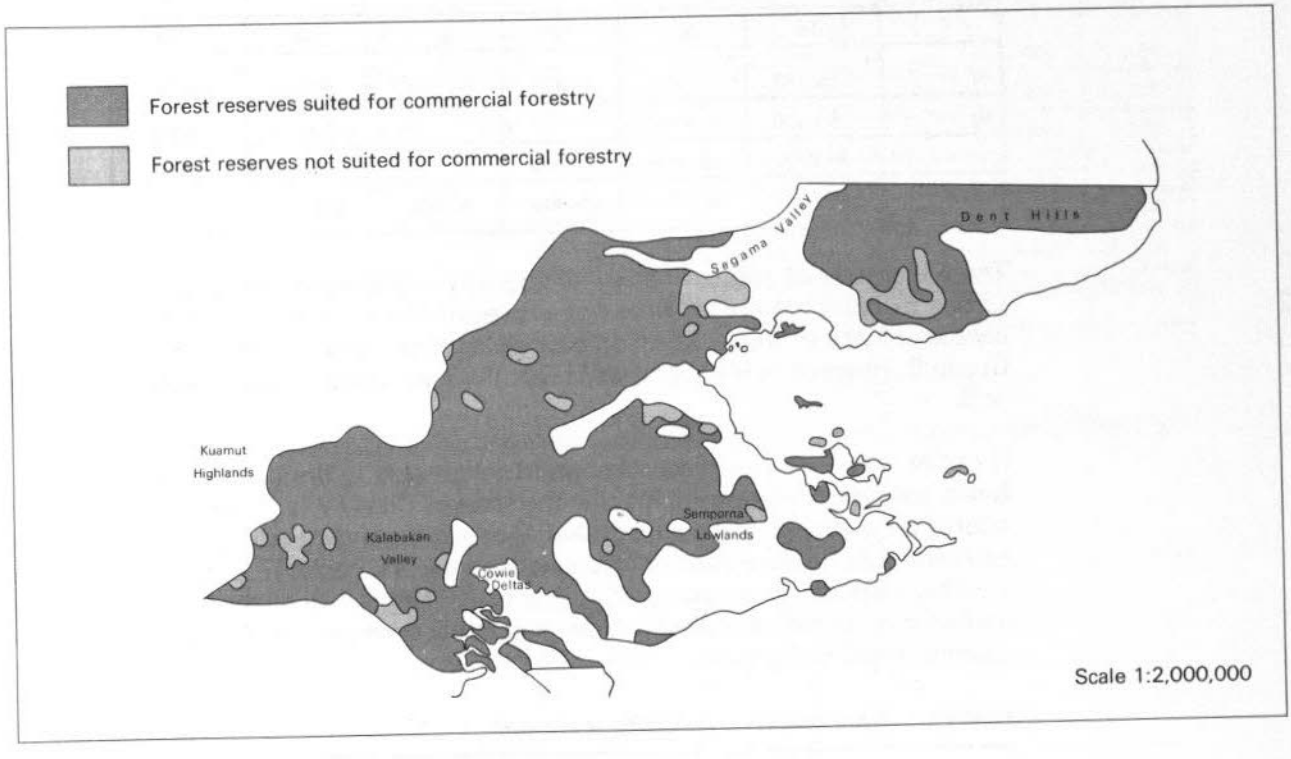
TABLE 45 Timber resource development areas in forest reserves

Land capability class	Timber resource group				Total	
	1, 2 and 3		7			
	ha	ac	ha	ac	ha	ac
IV	667 228	1 648 698	36 634	90 522	703 862	1 739 220
III	158 182	390 863	0	0	158 182	390 863
II	58 340	144 155	0	0	58 340	144 155
Total	883 750	2 183 716	36 634	90 522	920 384	2 274 238

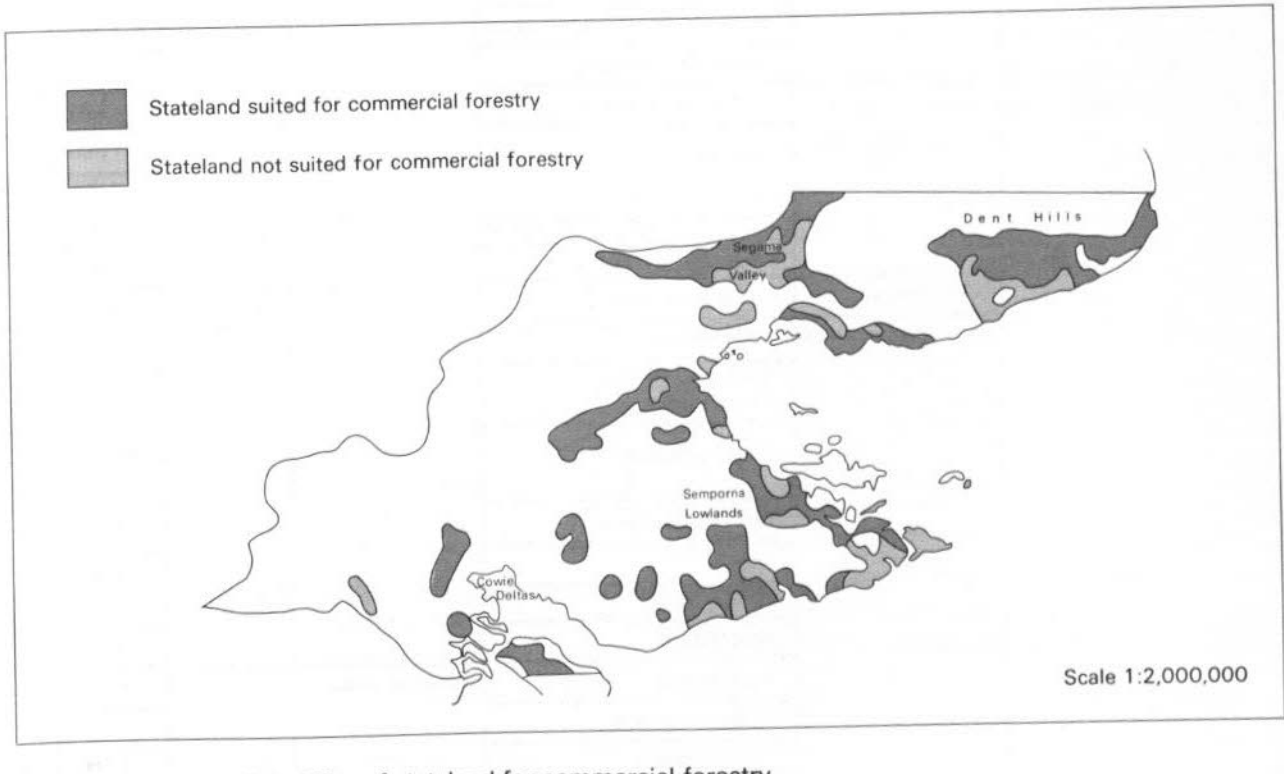
Some 17 402 ha (43 000 ac) which have been exploited and now carry immature stands fall into Land Capability Class V since the land has no agricultural potential and there is no information on the past yield on which to base a forest resource group rating. However in view of the fact that the areas were logged it is likely that, if yield figures were available, they would merit a timber resource group rating of 1, 2 or 3 and should therefore be in Class IV. The main area of such land amounting to approximately 9 700 ha (24 000 ac) occurs in the Silabukan Forest Reserve in the vicinity of the Bagahak Range.

Stateland

Areas of stateland where forest resource development opportunities occur are summarised in Table 46 and shown on Text Map 1-21.



TEXT MAP 1-20 Suitability of forest reserves for commercial forestry



TEXT MAP 1-21 Suitability of stateland for commercial forestry

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TABLE 46 Timber resource areas in stateland

Land capability class	Timber resource group				Total	
	1, 2 & 3		7			
	ha	ac	ha	ac	ha	ac
IV	69 155	170 879	25 896	63 988	95 051	234 867
III	93 076	229 987	0	0	93 076	229 987
II	35 972	88 885	0	0	35 972	88 885
Total	198 203	489 751	25 896	63 988	224 099	533 739

There is an area of approximately 20 235 ha (50 000 ac) of forest which has been disturbed by exploitation and does not at present carry commercial stands of timber; because of lack of information on past yields it can only be classified as Timber Resource Group 8. However it is likely that in fact this land warrants classification in Group 1, 2 or 3.

It can be seen that a considerable opportunity exists in the stateland to extend the forest reserves. These would include the areas of Class IV land, which are either considered large enough to be constituted as new independent reserves, or by boundary extension can be incorporated into existing reserves. Table 47 lists the major areas with a timber resource group rating of 1, 2, 3 or 7. The balance of the land with a forestry potential is in small scattered patches and tracts as shown on the separate land capacity classification map.

TABLE 47 Major areas suited for forestry in stateland

Region	Area	Forest potential	Land capability class	Approximate extent	
				ha	ac
Tawau Highlands	Merotai	Commercial forest	IV	3 200	8 000
	Upper Apas and Gading valleys			1 400	3 500
	Upper Merotai valley			1 000	2 500
	East of Mt Wullersdorf			600	1 500
	Brantian			1 800	4 500
			II & III	7 700	19 000
	Upper Apas and Gading valleys		III	1 800	4 500
	Upper Mantri valley			600	1 500
Cowie Deltas	Simandalan Island		II	1 000	2 500
Semporna Lowlands	Sebatik Island		IV	6 500	16 000
	East of Mostyn and Giram Estates			2 400	6 000
	Tingkayu/Sabahan			22 300	55 000
			II & III	2 400	6 000
	Balung/Kalumpang			18 200	45 000
	Sipit			8 500	21 000
	Sebatik Island		III	1 200	3 000
	Apas/Balung			5 300	13 000
	Kuala Balung	Mangrove forest	IV	1 200	3 000
	Kuala Kalumpang			3 000	7 500
	Trusan Pegagau			3 600	9 000
	Trusan Segarong			2 400	6 000
	Kuala Tingkayu			3 000	7 500

TABLE 47 (continued)

Region	Area	Forest potential	Land capability class	Approximate extent	
				ha	ac
Segama Valley	North of Segama River	Commercial forest	IV	1 000	2 500
			II & III	21 900	54 000
	South of Segama River		III	1 000	2 500
	Lahad Datu	Mangrove forest	IV	800	2 000
	Lahad Datu to Kennedy Bay			5 900	14 500
Dent Hills	Dent Peninsula	Commercial forest	IV	15 800	39 000
			II & III	25 700	63 500

Government reserves

Forest resource development opportunities in the government reserves are of little or no consequence and are summarised in Table 48.

TABLE 48 Timber resource areas in government reserves

Land capability class	Timber resource group				Total	
	1, 2 & 3		7			
	ha	ac	ha	ac	ha	ac
IV	922	2 277	3	8	925	2 285
III	66	164	0	0	66	164
II	11	27	0	0	11	27
Total	999	2 468	3	8	1 002	2 476

Alienated land

Forest resource areas in undeveloped alienated land are summarised in Table 49. 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 49 Timber resource areas in alienated land

Land capability class	Timber resource group				Total	
	1, 2 & 3		7			
	ha	ac	ha	ac	ha	ac
IV	6 947	17 165	1 044	2 579	7 991	19 744
III	17 101	42 256	0	0	17 101	42 256
II	6 639	16 404	0	0	6 639	16 404
Total	30 687	75 825	1 044	2 579	31 731	78 404

The major areas of land with a forest resource group rating of 1, 2 and 3 and 7 are listed in Table 50. The balance of land with a forest potential is mainly in small scattered patches and tracts as shown on the land capability classification map.

TABLE 50 Major areas suited for forestry in alienated land

Region	Area	Forest potential	Land capability class	Approximate extent	
				ha	ac
Tawau Highlands	Mt. Andrassy	Commercial forest	IV	600	1 500
Semporna Lowlands	Tanjong Nagos		IV	800	2 000
	Sabahan			1 000	2 500
	Mt. Pock			3 000	7 500
			II & III	6 700	16 500
	Balung-Kalumpang			2 200	5 500
	Lormalong			200	500
	Tingkayu			2 200	5 500
	Kuala Tingkayu	Mangrove forest	IV	1 000	2 500
Segama Valley	Silabukan	Commercial forest	II & III	800	2 000

WATER RESOURCE DEVELOPMENT OPPORTUNITIES

It is not easy to identify the opportunities for developing the water resources of the area. This is mainly due to the lack of pertinent hydrological data, and also the uncertainty about the pattern of future development and the resulting demand for water.

With a relatively high and uniform rainfall the greater part of the area is endowed with reasonably good water resources in the form of rivers, which normally maintain a good flow throughout the year except during unusually prolonged periods of dry weather. However this does not apply to the eastern end of the Semporna and Dent Peninsulas where streams are small and tend to fail quickly during dry periods.

Potable water

Water resource development will be necessary to ensure an adequate supply of potable water for the main towns.

Tawau draws its supplies from the Tawau River and figures given in Part 5 indicate that this will provide an adequate supply for the foreseeable future providing the catchment area is protected.

The present source of supply for Lahad Datu is already proving inadequate and unreliable. Preliminary data given in Part 5 indicate that the Segama River could easily supply the town's requirements both now and for the foreseeable future.

Semporna has an unsatisfactory and inadequate water supply particularly during prolonged dry periods. The nearest large river, which it appears could provide the town's requirements whatever the season, is the Kalumpang. Development of this resource will however be dependent on increased demand and expansion of the town. The development of water resources in rural areas will depend on the pattern of future agricultural development and settlement.

Water control

Considerable areas of good land are rendered unsuitable for agricultural development because of the flood hazard. The main areas of such land are listed in Table 13. If flood control is to be effective it seems likely that permanent structures will be necessary on

some rivers. Once flooding has been controlled consideration can be given to the alternatives of irrigation or drainage, which will be dependent on the crops to be grown. Padi cultivation will mean irrigation while most tree crops will require drainage. If dams are constructed to control flooding there may be possibilities of using these for the production of hydroelectric power. Other possible sources of such power are some of the waterfalls in particular those on the Beruang and Ayer Terjun Rivers where they plunge off the Orchid Plateau.

An important aspect of water control is catchment protection. With the wide-spread logging which is taking place at present high priority must be given to this. Protection of all steepland catchment areas is necessary but more especially those of the rivers providing potable water supplies for major population centres and agricultural settlement areas.

CONSERVATION DEVELOPMENT OPPORTUNITIES

Despite the lack of detailed studies it is known that there is abundant and varied wildlife in the residency. However the rapid exploitation of the virgin forest with the resulting disturbance of the ecosystem will endanger some species in particular the orang-utan *(Pongo pygmaeus)* and the exceedingly rare sumatran rhinoceros *(Didermocerus sumatrensis)*. If these and other species of wildlife are to survive in reasonable numbers then measures should be taken to designate conservation areas where both the wildlife and the habitat will be protected.

While the natural vegetation of much of the residency is lowland dipterocarp forest nevertheless within the area there is a considerable variety of flora. There is a need to conserve adequate samples of as many different types of vegetation as possible for botanical, ecological and plant breeding purposes, so conserving for perpetuity examples of the original natural vegetation.

With the development of the country and an increasing population, particularly in urban areas, there will be a demand in the future for areas for amenity and recreation purposes. Areas suited for these purposes should be designated with a view to conservation.

Conservation areas

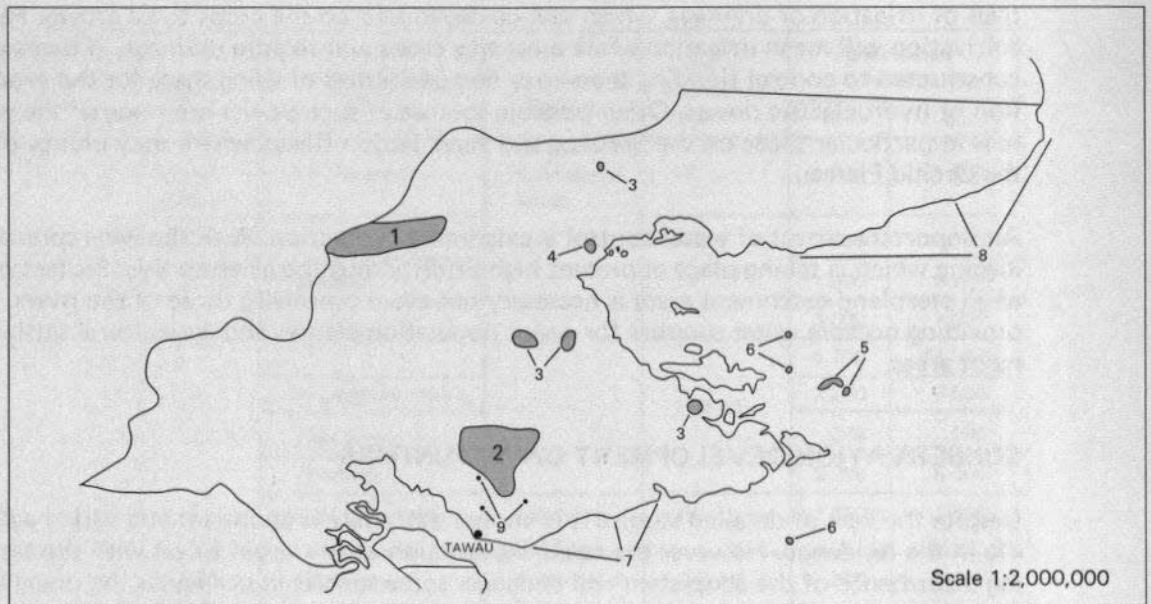
The approximate location of suggested conservation areas is shown on Text Map 1-22.

Danum Valley

This is suggested as a conservation area (game sanctuary). It is known to have a rich fauna from personal observation (Wright, 1972). The area is shown in more detail on Text Map 1-23. It is in the heart of the Ulu Segama Forest Reserve and is more or less surrounded by land which is unsuitable for agriculture and is therefore likely to remain permanently under forest. It comprises the whole catchment area of the Danum River and is enclosed by high land. It is approximately 29 000 ha (72 000 ac) in extent and this is considered the minimum size required to fulfill the purpose. Extension of the area south to the Segama River and west to the watershed to include all the catchment area north of the main river would provide a much larger area which would serve the purpose that much better. All of the suggested area has been licensed for logging but it is hoped that logging rights over part will be surrendered.

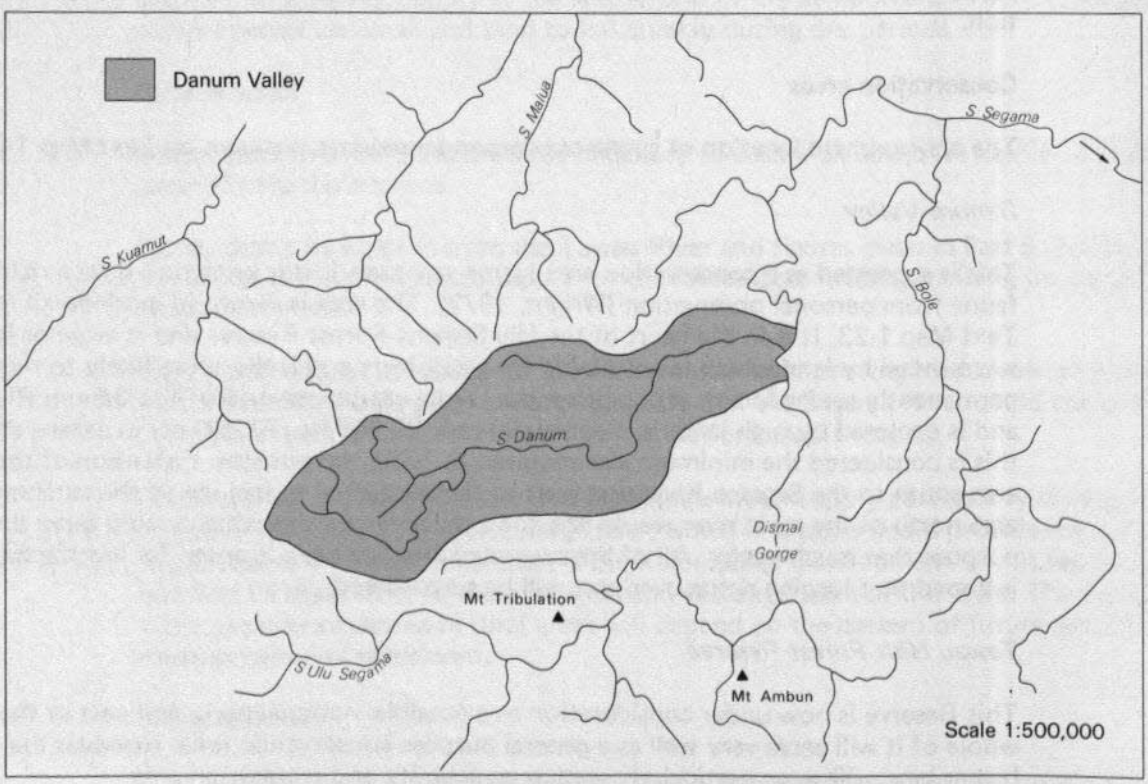
Tawau Hills Forest Reserve

This Reserve is now under consideration as a possible national park, and part or the whole of it will serve very well as a general purpose conservation area. However the higher land will serve particularly well as an amenity and recreastion area.



Area	Main purpose of conservation
1 Danum Valley	Wildlife, flora
2 Tawau Hills Forest Reserve	Recreation, amenity, flora, wildlife
3 Gunong Madai, Gunong Baturong, Segarong and Mensuli areas	Flora, amenity
4 Mount Silam	Recreation, amenity, flora
5 Gaya and Bohaydulong islands	Amenity, flora, wildlife
6 Sibuan, Adal and Sipadan islands	Recreation, amenity, wildlife
7 Foreshore Tinagat-Kalumpang	Recreation, amenity
8 Beaches on Dent Peninsula	Recreation, amenity
9 Thermal springs near Tawau Town, Table Estate and Quoin Hill	Amenity, recreation, flora

TEXT MAP 1-22 Suggested Conservation areas



TEXT MAP 1-23 The main Segama River catchment area showing the position of the Danum Valley

Prepared by the Directorate of Overseas Surveys 1976

Gunong Madai, Gunong Baturong, Segarong and Mensuli areas

These are isolated limestone hills containing bird's-nest caves and an interesting and specialised limestone flora (see Plate 1.10 in the section on Regional development opportunites).They are interesting from a zoological, botanical and ecological point of view and have some attraction as amenity and recreation areas. The bird's-nest caves may have some tourist potential in the future.

Mount Silam

This ultrabasic mountain should have considerable value in the future as an amenity and recreation area for the population of nearby Lahad Datu, particularly on account of the change in climate experienced in the upper part of the mountain and the fine views obtainable from the summit. Good road access to a point some two thirds of the way to the summit already exists. The mountain is very interesting ecologically and botanically because of the marked Massenerhebung or isolated mountain effect, which it exhibits, resulting in a lowering of the altitudinal zoning of vegetation.

Gaya and Bohaydulong Islands

These islands are scenically very attractive though their use for amenity and recreation purposes is somewhat limited by the lack of beaches. However there is attractive coral in the vicinity. Bohaydulong is a bird sanctuary and Gaya carries a rich orchid flora.

Sibuan, Adal and Sipadan Islands

These are very scenic typically tropical islands with sandy beaches and offshore coral. They have an excellent potential for recreation and amenity both for local people and for tourists.

Tinagat-Kalumpang foreshore

The beaches, which occur along this stretch of foreshore could become an important recreation and amenity area for the population of Tawau Town and the surrounding areas.

Beaches on the Dent Peninsula

There are scattered beaches all along the coastline from Tanjong Membatu to the eastern end of the Peninsula. As the Dent Peninsula is developed and settled and population increases so these beaches will become important recreational and amenity areas. Any plans for the development of the Dent Peninsula should ensure that these beaches should remain accessible for these purposes.

Thermal springs near Tawau Town, Table Estate and Quoin Hill

The springs near Tawau have already been developed for amenity and recreational purposes. At present the others are relatively inaccessible and development is unlikely in the near future. However they could serve as recreational and amenity areas sometime in the future. The flora associated with these springs is of some interest.

GENERAL OPPORTUNITIES

Part 5 of this report has given an account of the land resources which occur in the residency, and the foregoing section of Part 6 the development opportunities which exist for each individual resource relative to the present land use and alienation and gazettement pattern. This information is important to the potential entrepreneur with the development of one particular resource in mind, e.g. mining, agriculture or forestry. For overall planning, however, it is important to consider the various development opportunities both in context with the purpose for which the land has already

been allocated and with the conflicts which may occur between the utilisation of these resources, and then to identify on a regional basis the various development opportunities which exist for the resources.

Conflicting resource development potentials

The overall picture is represented by Tables 51a and 51b. It will be seen that the main conflict occurs between agriculture and forestry (land exploitation units IIB, C, E, F and111B,C, E and F). The possible conflict with mining is also indicated (land exploitation units IID, E, F, IIID, E, F, IVC and D), while conservation and recreation will pose some problems, together with the role of the mangroves in relationship to logging and fisheries. (See p. 27 for classification of land exploitation units).

Agriculture and forestry

These areas are shown on Text Map 1-26. Some 496 250 ha (1 226 216 ac) are suited for both purposes, but it is anticipated that in time most will be used for agriculture. However this conflict between agriculture and forestry will only be ultimately resolved when the manpower and access constraints on agricultural development, discussed earlier under agriculture development opportunities, have been resolved. This is likely to take considerable time, and the main limiting factor will be the lack of a population large enough to settle and cultivate these areas. It will have been noted, from the earlier section devoted to population and manpower, that the present work-force is unable to maintain effectively the present agricultural holdings. With this in mind any plans to develop such land should take into account such factors. In this way considerable areas could be used for further timber production, from natural regeneration or from plantations, with at least one more harvest of logs being attained before permanent agricultural settlement occurs.

Broadly, the development of agriculture on such land should follow the same priorities outlined when the agricultural development opportunities were discussed.

First consideration should normally be given to such land already alienated for agriculture, followed by that included in stateland, and then the forest reserves. Only 208 ha (413 ac) of the government reserves hold a conflict between agriculture and forestry, and because of this relatively small figure, the question of the government reserves is not discussed further.

Alienated land It can be seen from Tables 52a and 52b that of the alienated land which still remains forested some 23 740 ha (58 660 ac) are suited for both purposes. With normal development such land will, in the foreseeable future, be cultivated and its timber production potential thereby largely lost.

Stateland The distribution of stateland with an agricultural and forestry capability is shown on Text Map 1-24, and it will be seen from Tables 53a and 53b that such land covers some 131 747 ha (325 543 ac). The development of agriculture in the extensive areas occurring in the Segama Valley and particularly the Dent Hills is likely to be inopportune in the foreseeable future because of the access problems which have been discussed earlier. The possibility of maintaining these areas for timber production on a temporary basis should therefore be borne in mind.

TEXT MAP 1-24 Areas of conflicting potential use between agriculture and forestry

D.O.S. 3238S

Prepared by the Directorate of Overseas Surveys 1976

TABLE 51a Present land use and land capability (ha)

Present land use category	Land capability class and land exploitation unit																			
	Class	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	29	880	130	15	0	4	0	523	230	104	1	108	0	780	3	5 883	0	12	352	554
2	11	696	102	48	5	3	0	1 072	372	15	0	1	0	80	14	118	0	5	171	0
3	55	10 112	4 355	1 322	3	0	0	14 505	6 068	22	4	12	0	2 114	357	9	0	505	3 919	27
4	0	282	19	5	0	0	0	274	100	0	0	0	0	45	24	5	0	1	75	4
5	0	0	0	0	0	0	0	37	0	0	0	0	0	0	0	0	0	0	0	0
6	21	3 093	637	583	40	120	0	2,869	2 018	50	64	87	0	1 239	202	512	0	96	2 022	477
7F	451	11 573	68 683	20 270	1 064	6 346	0	16 624	211 726	16 654	5 944	14 373	102	440 314	58 501	187 914	616	6 758	36 674	15 822
7S	5	7 535	3 051	1 249	1 030	241	6	12 061	17 006	1 626	2 501	1 375	0	42 219	1 762	1 256	0	401	13 586	12 263
8	1	1 900	797	198	0	60	0	3 910	4 060	1 205	26	0	0	1 034	278	4	8	56 374	9 370	13
9	0	377	359	183	0	0	0	1 015	1 537	13	0	3	0	829	8	227	0	56	532	4
Unit total	573	36 448	78 133	23 874	2142	6 774	6	52 880	243 119	19 487	8 541	15 959	102	488 654	61 148	197 928	624	64 208	66 701	29 164
Class total	573	147 377						340 098						812 554					96 865	

TABLE 51b Present land use and land capability (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	HC	IID	IIE	IIF	IIIA	IIIB	IIIC	IIID	IIIE	IIIF	IVA	IVB	IVC	IVD	IVE	VA	VB
1	72	2 174	322	38	0	10	0	1 292	569	256	3	267	0	1 927	8	14 536	0	29	870	1 368
2	27	1 720	253	119	12	8	0	2 649	919	36	0	4	0	197	29	292	0	12	423	0
3	137	24 987	10 762	3 266	8	0	0	35 841	14 994	54	10	30	0	5 224	883	23	0	1 247	9 683	68
4	0	697	46	13	0	0	0	677	248	0	0	0	0	111	59	12	0	3	186	11
5	0	0	0	0	0	0	0	92	0	0	0	0	0	0	0	0	0	0	0	0
6	52	7 642	1 573	1 441	98	296	0	7 090	4 987	123	158	214	0	3 061	499	1 264	0	237	4 996	1 178
7F	1 115	28 598	169 716	50 088	2 631	15 682	0	41 077	523 176	41 151	14 689	35 516	252	1 088 017	144 557	464 336	1 522	16 698	90 621	39 096
7S	12	18 618	7 540	3 087	2 544	595	15	29 802	42 023	3 524	6 181	3 397	0	104 324	4 354	8 046	0	992	33 572	30 302
8	1	4 696	1 969	490	0	148	0	9 662	10 032	2 977	65	0	0	2 555	688	10	20	139 301	23 153	32
9	0	931	886	451	0	0	0	2 509	3 799	32	0	8	0	2 049	19	561	0	139	1 314	10
Unit total	1 416	90 063	193 067	58 993	5 293	16 739	15	130 691	600 747	48 153	21 106	39 436	252	1 207 465	151 096	489 080	1 542	158 658	164 818	72 065
Class total	1 416	364 170						840 385						2 007 841					236 883	

TABLE 52a Present land use and land capability in 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	IIF	IIIA	IIIB	IIIC	IIID	IIIE	IIIF	IVA	IVB	IVC	IVD	IVE	VA	VB
1	0	755	62	1	0	0	0	298	192	80	0	0	0	31	3	0	0	0	135	0
2	0	498	43	35	0	38	0	927	313	0	0	2	0	21	9	0	0	1	89	0
3	0	7 217	4 099	1 195	3	0	0	13 509	5 457	13	4	12	0	1 896	261	0	0	446	2 933	0
4	0	23	0	3	0	0	0	29	27	0	0	0	0	0	0	0	0	0	3	0
5	0	0	0	0	0	0	0	37	0	0	0	0	0	0	0	0	0	0	0	0
6	0	1 131	575	396	4	74	0	1 134	1 391	6	16	5	0	463	105	34	0	6	443	0
7F	0	2 845	2 805	2 123	55	530	0	3 146	11 804	796	0	176	65	3 309	1 225	296	12	69	4 448	0
7S	0	1 233	829	325	0	0	2	1 755	3 753	285	0	39	0	1 753	127	162	0	28	879	0
8	0	89	24	0	0	48	0	153	88	96	0	0	0	24	38	0	0	947	1 000	0
9	0	243	110	130	0	49	0	525	960	11	0	0	0	223	0	0	0	0	44	0
Unit total	0	14 034	8 547	4 207	62	656	2	21 516	23 985	1 287	20	233	65	7 721	1 768	492	12	1 497	9 972	0
Class total	0	27 509						47 106						11 490					9 972	

TABLE 52b Present land use and land capability in alienated land (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	1 866	152	2	0	0	0	737	475	197	0	0	0	78	8	0	0	0	335	0
2	0	1 231	106	86	0	8	0	2 290	774	0	0	4	0	52	23	0	0	2	213	0
3	0	17 834	10 129	2 952	8	0	0	33 382	13 485	32	10	30	0	4 684	645	0	0	1 103	7 247	0
4	0	58	1	8	0	0	0	73	67	0	0	0	0	0	0	0	0	0	8	0
5	0	0	0	0	0	0	0	92	0	0	0	0	0	0	0	0	0	0	0	0
6	0	2 794	1 422	978	10	184	0	2 803	3 437	15	40	12	0	1 143	260	83	0	16	1 096	0
7F	0	7 031	6 932	5 246	135	1 310	0	7 775	29 167	1 966	0	434	160	8 176	3 027	732	30	170	10 991	0
7S	0	3 046	2 048	804	0	0	5	4 338	9 273	704	0	96	0	4 332	313	401	0	70	2 172	0
8	0	219	59	0	0	120	0	378	218	238	0	0	0	60	94	0	0	2 339	2 472	0
9	0	600	272	320	0	0	0	1 298	2 372	28	0	0	0	551	0	0	0	0	108	0
Unit total	0	34 679	21 121	10 396	153	1 622	5	53 166	59 268	3 180	50	576	160	19 076	4 370	1 216	30	3 700	24 642	0
Class total	0	67 976						116 400						28 392					24 642	

1 Urban land; 2 Horticulture; 3 Tree, palm and permanent crops; 4 Shifting cultivation; 5 Improved pasture; 6 Grassland; 7F Forest; 7S Scrub forest; 8 Swamp, marshland and wetland forest; 9 Unused and cleared land. For Definitions, see Part 4.

TABLE 53a Present land use and land capability in state land (ha)

Present land use category	Land capability class and land exploitation unit																		
	Class I	Class II						Class III						Class IV					Class V	
		IIA	IIB	IIC	IID	IIE	IIF	IIIA	IIIB	IIIC	IIID	IIIE	IIIF	IVA	IVB	IVC	IVD	IVE	VA	VB
1	0	83	24	15	0	4	0	94	36	24	0	0	0	8	0	3	0	12	144	0
2	0	185	57	5	5	0	0	96	40	11	0	0	0	8	2	0	0	4	72	0
3	0	2 821	233	120	0	0	0	804	584	5	0	0	0	213	96	2	0	53	899	28
4	0	236	10	2	0	0	0	236	24	0	0	0	0	20	1	0	0	1	59	3
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	1 669	44	187	13	32	0	1 458	440	17	9	21	0	166	32	23	0	75	936	45
7F	0	6 235	20 345	12 266	407	1 340	0	9 455	73 997	7 348	846	3 078	37	49 571	6 729	5 483	180	5 660	10 854	632
7S	0	4 931	1 041	431	884	217	4	6 058	4 863	242	1 677	832	0	5 427	312	520	0	138	2 901	298
8	0	1 635	200	128	0	0	0	2 935	2 093	585	2	0	0	718	203	4	8	20 098	5 797	13
9	0	57	244	53	0	0	0	446	467	4	0	0	0	388	4	19	0	33	210	0
Unit total	0	17 852	22 199	13 207	1 309	1 593	4	21 582	82 544	8 234	2 534	3 931	37	56 519	7 379	6 054	188	26 074	21 873	1 019
Class total	0	56 164						118 862						96 214					22 892	

TABLE 53b Present land use and land capability in state land (ac)

Present land use category	Land capability class and land exploitation unit																		
	Class I	Class II						Class III						Class IV					Class V	
		IIA	IIB	IIC	IID	IIE	IIF	IIIA	IIIB	IIIC	IIID	IIIE	IIIF	IVA	IVB	IVC	IVD	IVE	VA	VB
1	0	206	59	36	0	10	0	232	90	59	0	0	0	19	0	7	0	29	356	0
2	0	456	141	13	12	0	0	238	100	28	0	0	0	21	6	0	0	10	178	0
3	0	6 971	577	297	0	0	0	1 987	1 443	12	0	0	0	527	237	5	0	131	2 221	68
4	0	584	25	5	0	0	0	582	59	0	0	0	0	50	2	0	0	3	146	8
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	4 124	109	461	32	80	0	3 603	1 086	42	22	52	0	410	78	58	0	185	2 315	111
7F	0	15 406	50 272	30 308	1 005	3 312	0	23 363	182 843	18 157	2 090	7 605	92	122 489	16 626	13 549	446	13 985	26 820	1 561
7S	0	12 185	2 573	1 064	2 185	535	10	14 968	12 017	599	4 144	2 056	0	13 409	771	1 284	0	342	7 168	737
8	0	4 041	495	316	0	0	0	7 252	5 172	1 446	4	0	0	1 774	501	10	20	49 661	14 323	32
9	0	142	602	131	0	0	0	1 102	1 154	4	0	0	0	959	11	47	0	82	519	0
Unit total	0	44 115	54 853	32 631	3 234	3 937	10	53 327	203 964	20 343	6 260	9 713	92	139 658	18 232	14 960	466	64 428	54 046	2 517
Class total	0	138 780						293 699						237 744					56 563	

TABLE 54a Present land use and land capability in forest reserves (ha)

Present land use category	Land capability class and land exploitation unit																		
	Class I	Class II						Class III						Class IV					Class V	
		IIA	IIB	IIC	IID	IIE	IIF	IIIA	IIIB	IIIC	IIID	IIIE	IIIF	IVA	IVB	IVC	IVD	IVE	VA	VB
1	0	27	45	0	0	0	0	39	2	0	1	108	0	740	0	5 880	0	0	64	551
2	0	6	2	0	0	0	0	6	15	0	0	0	0	50	0	118	0	0	12	0
3	0	66	23	0	0	0	0	46	27	2	0	0	0	5	0	7	0	5	75	0
4	0	21	0	0	0	0	0	9	49	0	0	0	0	25	23	5	0	0	13	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	283	17	1	23	13	0	216	94	21	39	61	0	609	65	454	0	14	620	419
7F	457	2 493	45 533	5 877	603	4 476	0	4 022	125 900	8 503	5 099	11 120	0	386 712	50 534	182 019	369	1 029	21 355	15 176
7S	0	1 370	1 181	487	145	24	0	4 207	8 362	895	805	504	0	35 034	1 320	2 569	0	235	9 039	11 965
8	0	176	573	70	0	0	0	805	1 878	525	22	0	0	292	38	0	0	35 327	2 541	0
9	0	76	5	0	0	11	0	2	110	0	0	3	0	218	3	129	0	23	268	4
Unit total	457	4 520	47 379	6 435	771	4 524	0	9 352	136 437	9 947	5 966	11 796	0	423 685	51 983	191 181	369	36 634	33 988	28 115
Class total	457	63 630						173 497						703 852					62 103	

TABLE 54b Present land use and land capability in forest reserves (ac)

Present land use category	Land capability class and land exploitation unit																		
	Class I	Class II						Class III						Class IV					Class V	
		IIA	IIB	IIC	IID	IIE	IIF	IIIA	IIIB	IIIC	IIID	IIIE	IIIF	IVA	IVB	IVC	IVD	IVE	VA	VB
1	0	66	111	0	0	0	0	96	4	0	3	267	0	1 830	0	14 529	0	0	159	1 362
2	0	15	6	0	0	0	0	14	38	0	0	0	0	124	0	292	0	0	29	0
3	0	164	56	0	0	0	0	113	66	6	0	0	0	13	0	18	0	13	186	0
4	0	53	0	0	0	0	0	22	122	0	0	0	0	61	57	12	0	0	32	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	700	42	2	56	32	0	533	232	52	96	150	0	1 505	161	1 123	0	36	1 533	1 036
7F	1 115	6 161	112 512	14 522	1 491	11 060	0	9 939	311 098	21 012	12 599	27 477	0	955 565	124 870	449 768	911	2 543	52 769	37 500
7S	0	3 385	2 919	1 204	359	60	0	10 395	20 662	2 212	1 989	1 245	0	186 569	3 262	6 349	0	580	22 336	29 565
8	0	436	1 415	174	0	0	0	1 990	4 642	1 297	54	0	0	721	93	0	0	87 293	6 279	0
9	0	189	12	0	0	28	0	4	273	0	0	8	0	539	8	318	0	57	662	10
Unit total	1 115	11 169	117 073	15 902	1 906	11 180	0	23 106	337 137	24 579	14 741	29 147	0	1 046 927	128 451	472 409	911	90 522	83 985	69 473
Class total	1 115	157 230						428 710						1 739 220					153 458	

Forest reserves The greatest conflict occurs in the forest reserves, with some 216 522 ha (535 018 ac) at issue (Tables 54a and 54b). The distribution is shown on Text Map 1-24.

These areas, falling in forest reserves, should ideally only be scheduled for agricultural development after all the other areas suited for cultivation have been developed; but owing to varying access it might be found necessary to open up some areas of the forest reserves before the statelands. For example, the stateland areas on the Dent Peninsula are likely to remain relatively remote for a long period in the future, and some of the areas in the Binuang-Tingkayu, Ula Kalumpang and Kalabakan forest reserves are already easily accessible.

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 forseeable 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 III land will be required for agricultural development and that forest development will be restricted mainly to Class IV land.

Mining

From Tables 51a and 51b it is seen that 232 076 ha (573 463 ac) (the sum of land exploitation units IID, E, and F, IIID, E, and F and IVC and D), are classified as having a possible mining potential together with an agricultural or forestry capability alone or in combination. This represents almost 87% of the possible mining land. It is likely, however, that even if prospecting ultimately results in mining being undertaken in the residency, the land so used will be relatively small in extent, and, therefore, will not have a significant effect on the other uses.

Conservation and recreation

Fortunately, many of the areas which have been identified as being suited for conservation and recreation purposes are located in high rugged country, or are sandy beaches or islands where the agricultural potential is low, and little or no conflict with other uses is likely. Some of the mountainous areas, however, may also have a commercial forestry potential. The over-riding factor in such cases will be watershed conservation. If logging is likely to disrupt the water regime of a catchment, the best choice would be conservation.

This policy also should be extended to the main water-catchments with commercial forests which may not have a recreational use. Logging in such areas, if allowed at all should be undertaken under the most stringent conditions so as to ensure minimum disturbance to the hydrology.

Some conflict is likely to occur between the possible use of the Danum Valley for game conservation with the alternative uses for forestry or agriculture. Most of the area has a forest capability and it will have been noted that some 6 000 ha (15 000 ac) are suited for agriculture. It is shown however that the Valley contains a game population worthy of conservation and it is felt that such a use should be overriding.

The question of virgin jungle reserves with commercial stands of timber will continue to be a point of conflict between conservation and logging interest. Every effort, however, should be made to ensure their inviolability.

Following the start of logging operations in the mangroves, 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.

REGIONAL DEVELOPMENT OPPORTUNITIES

A fundamental consideration for development planning will be the land resource information which has been discussed in this report. Such planning may best be undertaken on a regional basis, and the following account gives a broad outline of the main development opportunities which exist in the physiographic regions discussed in Part 3. It is important that this account should be read in conjunction with the separate land capability classification map which gives in more detail the recommended long-term use of the land resources.

Kuamut Highlands

Here, the main development opportunity will be based on forestry, although much of the land is steep and rugged, and logging may in some parts prove to be difficult. The lower reaches of the Serudong and Silimpopon Valleys are generally suited for agriculture, and coal mining may be possible in two areas. The likelihood of developing the coal resources of the Susui Valley near the western boundary is remote.

Kalabakan Valley

Here again, forestry is likely to play a major long-term role, and logging is likely to be easier because of the less rugged terrain. Agriculture will also be an important industry in the eastern part, particularly along the coastal belt.

Cowie Deltas

Future development will be largely based on the extensive mangrove forests. Agriculture will be restricted to a small area of Simandalan Island.

Tawau Highlands

Much of the land suited for agriculture has been alienated and largely developed. However a considerable potential for agriculture still exists in the lower reaches of the Brantian, Umas Umas and Merotai Valleys. Nevertheless by far the greatest proportion is only suited for forestry, and there are opportunities for extending the forest reserve boundaries so as to include certain areas of stateland which are only suited for that purpose. The development of a number of recreational areas will be required, and there is a possibility that mining may become an important industry.

Semporna Lowlands

This region is identified as being generally the most favoured for early settlement and development. This will be based on the extensive areas of agricultural land which remain to be exploited and its relatively good road-system. Some readjustment of the forest reserve boundaries will be necessary to accommodate the expansion of the agricultural land. Land development for recreation and conservation purposes will be largely centred on certain off-shore islands, and the two limestone features on the mainland (see Plates 1 - 11 and 1 - 12).

Segama Highlands

Forestry is likely to play the most prominent long-term part in the economy of this region, although mining may be developed in time in certain areas. The prospects for agriculture are limited, and restricted to a number of scattered, frequently remote valleys. The opportunity exists to extend the forest reserve boundaries to include areas of stateland suited for forestry only. Opportunities also exist for recreation and conservation, of which the game resource may be an important aspect.

Segama Valley

This region is largely suited for agriculture, but future settlement and cultivation over its greatest part will be limited by the access and flooding problems. Any development plan will have to take these factors into account, together with the extensive land resources which occur in the adjacent part of the Sandakan Residency, and which will be discussed in Volume 2 of this Study.

Dent Hills

Future development will be based almost equally on the commercial forest resource and the land suited for agriculture. The western, and most accessible, half is in the main suited for forestry only, while the eastern half has a very considerable agricultural land resource. The development of this resource will depend on overcoming the access problem, and this will have to be undertaken in conjunction with the development planning of the extensive area of land suited for agriculture which occurs contiguously to the north in the Sandakan Residency (See Plate 1 -13).

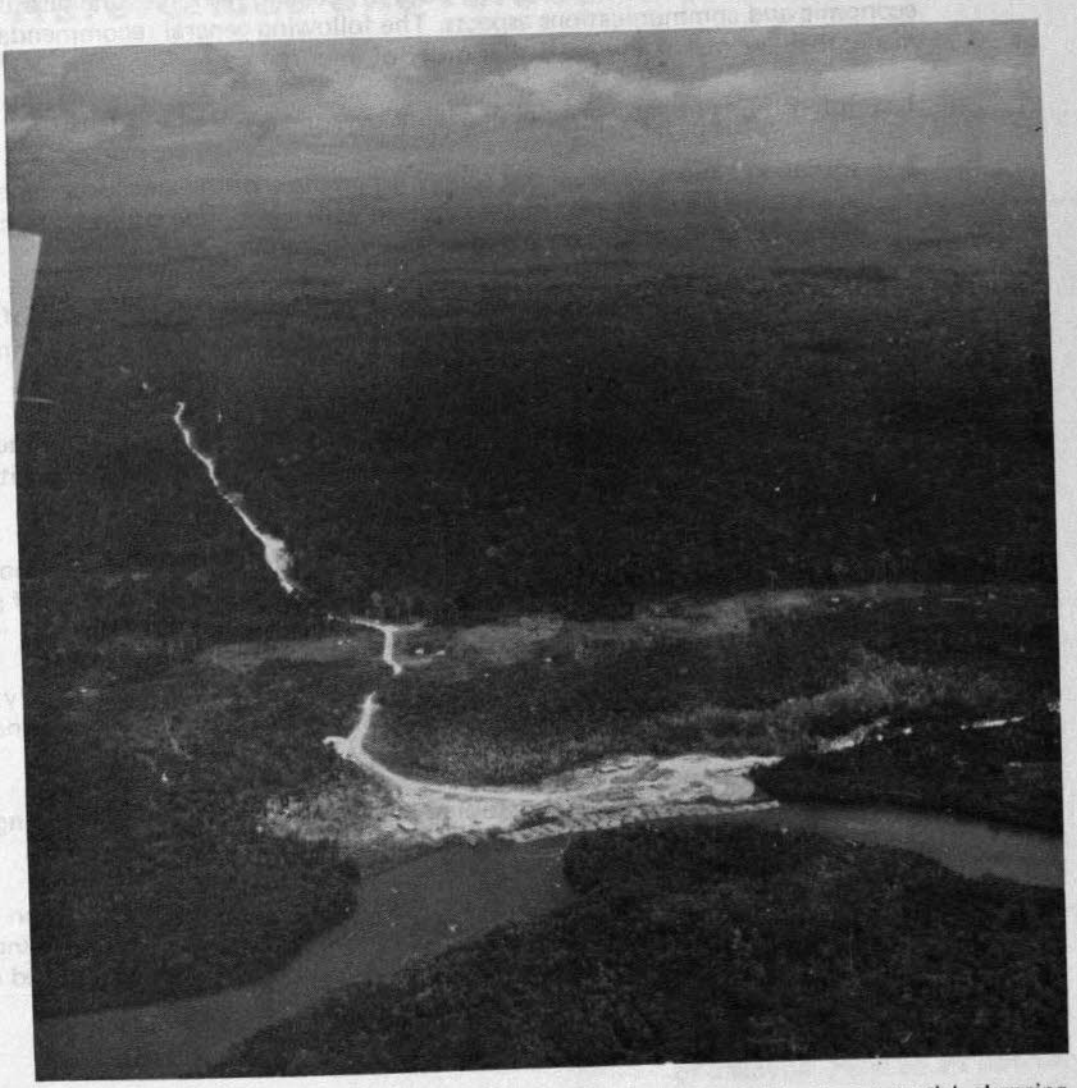


PLATE 1.13 The Dent Hills have a considerable agricultural and forestry potential. Logging road running west from the tip of the Dent Peninsula at Tegupi

RECOMMENDATIONS FOR FURTHER STUDIES

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

1. Intensifying mineral prospecting work over the areas selected

2. Initiating a more detailed soil survey programme of the areas recommended for agricultural development in conjunction with agronomic studies into crop/soil relations, crop suitability, fertiliser and management needs

3. Updating the forest inventory, obtaining more detailed information of the forest resource and the furmulation of a forest management plan compatible with overall planning and development

4. Undertaking a systematic hydrological survey of the residency with the view to conserving and controlling the water resources in a way compatible with general development planning

5. Undertaking systematic wildlife and recreation surveys, and thereby positively identifying in any overall development plan areas which are worthy of permanent use for such purposes

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

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

8. And, largely in conjunction with the foregoing studies, the formulation of 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 7

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