SOILS, VEGETATION, FAUNA AND NATURE CONSERVATION OF THE BERBAK GAME RESERVE, SUMATRA, INDONESIA

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Contents

Summary

The Berbak Game Reserve is located on the east coast of Sumatra, in the Jambi province in the Republic of Indonesia. The reserve was established in 1935 and is appr. 190 000 ha in acreage. It is at present the largest peat swamp reserve of the whole Pacific region. The fieldwork for the present study in this reserve was carried out from April to November 1983. Because of logistical problems, the survey had by and large to be limites to the eastern part of the reserve. The main findings were:

Soils: Berbak is part of the vast alluvial coastal plain of East Sumatra. The age of this alluvial plain has been assumed to be some 5000 years. The plain was formed under stable sea level conditions. Evidence has been found for a relative sea level drop of about two metres since 5000 BP. Sediments for the accreting coastal system are supplied by the Batang Hari river, with its catchment areas in the Barisan mountain chain. On the highly weathered sediments extensive peats were formed. The age of these peats (at least 10 meter in depth) is about 4500 years (C_{14}). Since 1965, large scale reclamation by spontaneous migrants from South Sulawesi is taking place along the coast. As a result of drainage with canals (parits) the shallow to moderate deep peat oxidized and at some places even disappeared entirely. In the mineral (marine) clayey soils under the peatlayer low to moderate amounts of pyrite were found. Severe acidification of the soil has been found, probably the result of too deep drainage. Such soils are acid sulphate soils and were classified as Sulfaquepts or sulfic Tropaquepts.

Vegetation: The main vegetation types of Berbak are freshwater-swamp forest (60 000 ha) and peat swamp forest (110 00 ha). The freshwater-swamp forest occurs along the rivers, on fluviatile deposits and is normally inundated for a large part of the year. The species richness is low varying from 25 to 40 species per sample plot of 0.2 ha. In this forest type, a distinct stratum could be observed, formed by Alstonia pneumatophora, a high growing species (upto 55 meter) contributing some 50% to the Basal area (B.A.) of 30-50 $m^2.ha^{-1}$.

The peat-swamp forest occurs on deep peat at a distance of at least 3 km from the rivers and coast. No evidence was found for the occurrence of a 'padang forest', as discribed by Anderson (1964) for the Riau province. The height of this forest type in Berbak on deep peat was somewhat less (upto 35 meter) than the freshwater-swamp forest. Clear floristic

differences between the two types were noticed and documented. Along the coast, patches of mangrove forest still remain after the reclamation-work. The present area of about 2000 ha is however only 10% of the former mangrove fringe of Berbak. This forest type consists of only a few species.

Fauna: Berbak, with its relatively unspoiled wetland habitats, is rich in wildlife, including species such as tiger (Panthera tigris), tapir (Tapirus indicus) and two crocodile species (Tomistoma schlegeli, Crocodilus porosus). It has a rich primates population, with species such as Hylobatis agilis and Symphalangus syndactylus. No evidence was observed of the presence of the Rhino species, mentioned for the area in the literature. However, no extensive mammal survey in the remote western part of the reserve has yet been carried out. The avifauna of Berbak is very rich with 224 species sofar recorded belonging to 49 families. All kingfisher species Alcedinidae, known for Sumatra, occur and from the Hornbills Bucerotidae, at least nine of Sumatra's ten species are present. During the migrating periods, many eastern palaeartic waders can be observed on the mudflats along the coast.

Nature conservation: Inspite of its status of Game reserve, six Buginese villages are located within the reserve, occupying 16 700 ha of the reserve's coastal area. The main landuse is the cultivation of rice and coconut. Reports on crops showed rather stable yields of about 3 ton hulled rice per year per hectare. However, due to several environmental constraints, more and more farmers tend to change from agriculture to off-shore fishery. Especially shrimps fishing is economically very rewarding. Nevertheless, it is highly questionable whether this fishing intensity can be maintained in the long term, without backsliding into overfishing.

Recommendations

In order to protect the ecological value of the Berbak reserve, it is recommended to set and legalise the reserve boundaries. The following aspects have to be regarded:

- forest concessions, located within the reserve boundaries have to be cancelled
- it is advisable to enlarge the reserve to the north and to the south-west

- for the boundary setting in the coastal area, three different options are discussed

The Berbak reserve should retain its status as game reserve (Suaka Margasatwa). The reserve has been selected as a MAB, man and biosphere reserve. It is recommended to implement this status.

As soon as Indmesia will join and ratify the Ramsar Convention (Convention on wetlands of International importance especially as waterfowl habitat) the Berbak reserve should be put on the World list of wetland reserves.

Preface

This study was carried out as part of the requirements for the Drs.-degree work in Biology at the University of Utrecht (The Netherlands) by the three authors.
For each student the research counts for a 12 month subject for the Nature Conservation Department of the Agricultural University at Wageningen (The Netherlands) and for a 6 month subject for the Department of Soil Science of the University of Utrecht. The work was partly supervised by personel of the Research Institute for Nature Management (RIN), in the field as well as in the office periods.

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The bodies who made it (financially) all possible:
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- The Netherlands Foundation for International Nature Conservation (Van Tienhoven Foundation)
- Utrecht University Fund
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Glossary

Explanatory list of Indonesian words

Indonesian	English
balai	- regional department
banteng	- acreage measure, 6 banteng = 1 ha
cagar alam	- nature reserve
camat	- chief of a district
depa	- Buginese linear measure, 1 depa = app. 1.6 m
desa	- village
dinas	- service, agency
gabah	- unhulled rice
gotong royong	- mutual assistance
kaleng	- rice bag
kanan	- right (direction)
kantor transmigrasi	- transmigration office
kabupaten	- residence (consists of several districts)
kecamatan	- district
kehutanan	- forestry
kepala desa	- chief of a village
kepala sub-balai	- head of a subregional department
kiri	- left
lembar	- acreage measure (Buginese), 1 lembar = 2.5 ha
marga	- chief of several villages
parang	- large chopping knife
parit	- drainage canal (Buginese)
pasar	- market place, village centre
pematang	- higher and drier grounds (levées and beachridges)
perkebunan	- horticulture
pertanian	- agriculture
PHPA (Perlindungan Hutan dan Pelestarian Alam)	- Directorate for forest protection and nature conservation
pikul	- weight measure (Buginese), 1 pikul = app. 3 kg
pompong	- fishing boat
pondok jaga	- sheltered watch post in a reserve
pos babinsa	- army station

pos polri - police station
puskesmas - health centre
semut - ant
sensus - survey
suaka margasatwa - game reserve
sungai (abbreviation: s.)- river

1 INTRODUCTION

1.1 Background and aim of the study

Nature conservation in Indonesia

In the third 5-year development plan (Repelita 3, 1979-1984), the Indonesian government emphasized the importance of extending the number of conservation areas in Indonesia. This extension is necessary in order to protect tropical ecosystems. Management and conservation of such ecosystems, particularly the tropical rainforest, are of great value, not only for the threatened plant and animal species, but also for man with respect to soil and water conservation (Sumardja 1981).

When new reserves are established, management plans for these areas are required. The body primarily in charge of the preparation of such plans is the Directorate General Perlindungan Hutan dan Pelastarian Alam (PHPA), Forest protection and Nature conservation. It is in this task assisted by projects carried out under FAO/UNDP and/or WWF/IUCN umbrella. Profound research on the nature and functioning of the reserves is needed for a better understanding of the problems in these areas.

In 1982, Ir. R. de Wulf, FAO associate expert, made a management plan for the Berbak reserve. This management plan was the starting point for the research reported hereafter.

The aims of the present study were:

1. to widen the knowledge on the natural environment of the reserve by studying soils, vegetation and fauna with special attention for the soil - vegetation relations.
2. to describe and analyse human activities inside the reserve (concentrated upon the coastal settlements) with special reference to the impact of these activities on the functioning of the reserve.

1.2 Execution of the study

The study was carried out in 1983, from February to November.
Before we started with the fieldwork we studied aerial photographs (scale 1:100 000) of the study area. The quality of the photos did not allow the preparation of a detailed photo interpretation map. Such map was to be used to compile the soil and vegetation map after the fieldwork. It was however difficult to distinguish vegetation types. We nevertheless, prepared and used a sketch map for orientation in the field and for selecting the sites for soil and vegetation research.

In the first period of fieldwork (April-June), we tried to carry out a preliminary reconnaissance survey of the soils and vegetation of Berbak. The easiest way to enter the reserve was by boat. We could reach the main river (S. Air Hitam Laut, Figure 1) up to Simpang Kubu, some 15 km linea recta inland from the coast. We also visited the southern part of the reserve by entering the S. Sungai Benu. Reaching the western part of the reserve was not possible, so we had to restrict our later studies to the eastern part of the reserve. In the first period we also collected data on nature conservation.

After the reconnaissance, we selected some transects for a more detailed soil and vegetation survey. This survey was carried out in a second period of fieldwork (September-November). We got assistance in the field by Ir. H. van Reuler (UNESCO, Jakarta) and Ir. W.H. Diemont (Research Institute for Nature Management, RIN, The Netherlands). Diemont studied the relationship between the physiography of the coast and the formation of pyrite (FeS_2) in the sediments. Five vegetation plots in the freshwater swamp and peat-swamp forest were studied in detail while in addition attention was given to the mangrove forests and collection concerning nature conservation and fauna. The research methods are described in more detail in the chapters concerned.

1.3 Scope and content of the report

This report is based on the field data, and literature research. After the introduction, a general description of the Berbak reserve is given (Chapter 2), including details on its accessibility and climate.

In Chapter 3 we discuss the geomorphology and soils. After discussing the genesis and morphology of the coastal plain of East Sumatra, the coastal system and the soils of Berbak are described. The latter part is largely based on own field data.

The Chapter on vegetation (4) mainly deals with the description of five vegetation plots in freshwater-swamp forest and peat-swamp forest, and a transect studied in the mangrove forest. Time did not allow a profound literature study for this part of the research.
Data on fauna (Chapter 5) are restricted to annotated species lists of mammals, birds, reptiles, amphibians, and insects. For some important animal species more detailed information is given.

A considerable part of the report is devoted to the human activities within the reserve (Chapter 6). We describe the different kinds of landuse in the coastal villages and the socialeconomic developments in the settlements.

The conservation values of the reserve are described in Chapter 7 together with the organization of the reserve management by PHPA.
In Chapter 8, some tentative management options are presented regarding the reclaimed coastal area. Furthermore we discuss the present legal status and boundaries of Berbak as a game reserve.

In the final Chapter, some recommendations are given on for future research work in relation to the reserves functioning as a reserve, at present and in the future.

2 GENERAL DESCRIPTION OF THE STUDY AREA

2.1 Location

The Berbak Game Reserve is situated on the eastcoast of Sumatra, in the Jambi province. In the south it borders the province of South Sumatra. The boundary is the Sungai Benu. In the east, it follows the coastline of the South China Sea. The northern and western boundaries are not formed by physical features, running partly along reclaimed agricultural land (in the north) and partly through still undisturbed forest (in the west) (Figure 1).

The whole reserve is part of the Kecamatan Nipah Panjang in the Tanjung Jabung Kabupaten. The Kebupaten administrative headquarters is located in Kuala Tungkal, at about 100 km distance (linia recta) of the reserve. The Berbak Reserve covers an area of 190,000 ha. It is the fourth largest conservation area in Sumatra (Appendix 1) (see note 1).

2.2 History of establishment

The initiative to establish a large reserve along the eastcoast of Sumatra, was taken by the "Nederlandsche-Indische Vereeniging voor Natuurbescherming" (Netherlands Indies Society for Nature Conservation). The first proposal of the Society was focussed on the active protection of the fauna and the typical flora of the swamp forests. Initially, the reserve was planned in the Lalang area in the Palembang residence, but later on the uninhabited Berbak area in the neighbouring residence of Jambi was selected (Endert 1936). On 29 October 1935 the Berbak area was given the status of "wildreservaat" (Game Reserve), by a decree of the Governor-General of the Netherlands-Indian government. The boundaries were slightly different from the present situation.

2.3 Physiography

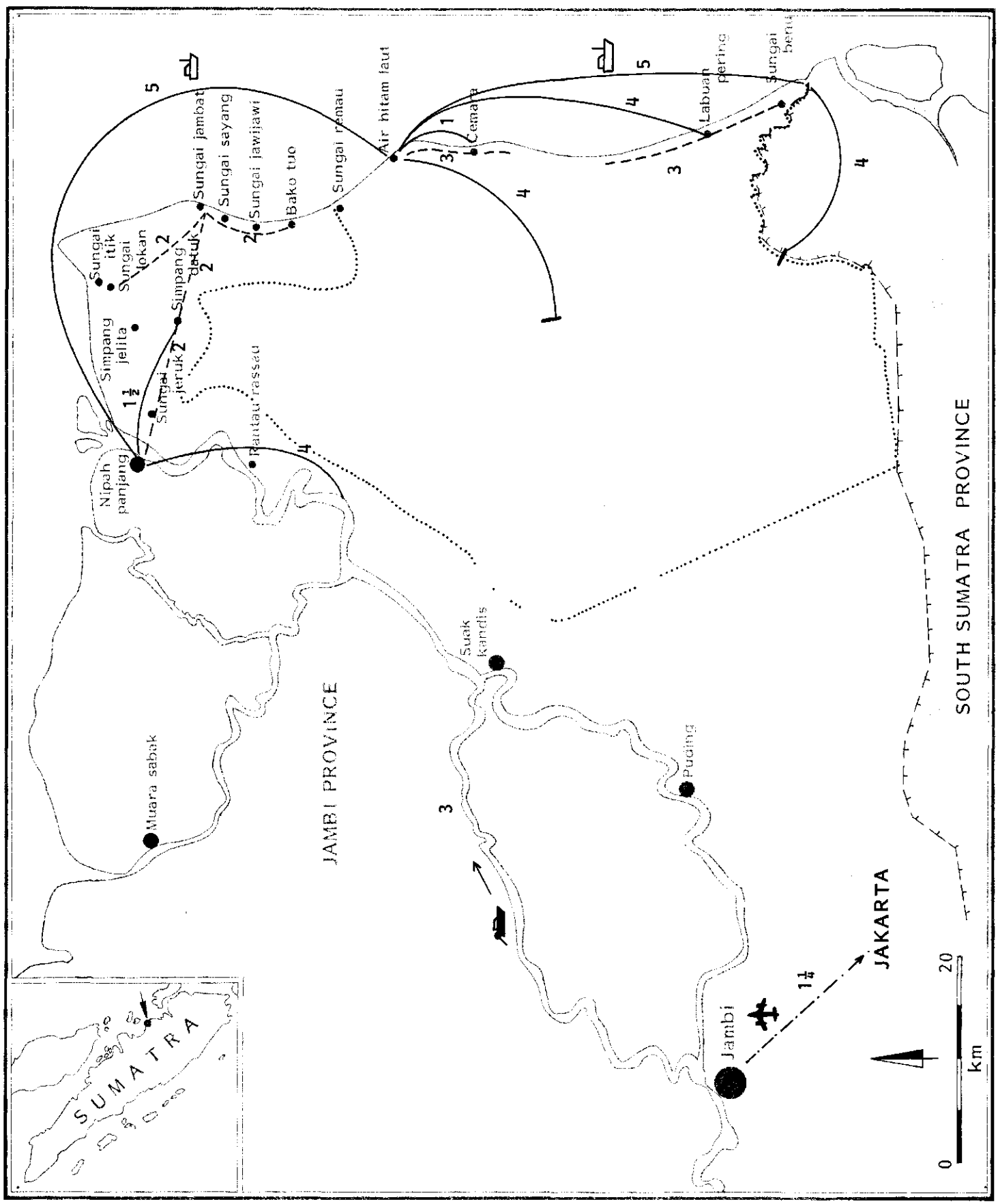
Berbak forms a part of the vast coastal plain of Sumatra. Once it consisted of a continuum of infinite mangrove forest, backed by extensive swamp forests at regular distance intersected by huge sluggish rivers (Appendix 2).

At present Berbak forms the only example of peat and freshwater-swamp forest, to this extent, sofar included in a reserve. Berbak's most important river is the Air Hitam Laut, which originate just outside the reserve.

Several little creeks wind in the mangrove forest where they flow

Figure 1. Accessibility and location of Berbak

—·— daily flights Jambi-Jakarta v.v.
---- roads
4 time in hours
maximum access
70 pk public speedboat between Jambi and Nipah panjang
Anggrek (common fishingboat)



through the sand and clay banks along the coast. The reserve is nearly entirely flat (Figure 5). Along the coast and the rivers, at some places levees (pematangs) occur, only a few metres higher than the surrounding grounds and hardly remarkable.

The Berbak Reserve is of high conservation value. It still is a relatively undisturbed swamp forest. Many of the Sumatran large mammals can be found such as tiger (Panthera tigris), tapir (Tapirus indicus) and some of the typical low-land forest reptiles: the estuarine crocodile (Crocodilus porosus) and false gavial (Tomistoma schlegeli). The rich avifauna includes many rare species like hornbills (Bucerotidae). Along the coast, the tidal mudflats and mangrove forest are important as a resting place and feeding ground for thousands of migrating eastern palaearctic waders.

At present, a major part of the coastal area of the reserve has been reclaimed by Buginese people for the cultivation of rice and coconut. The population inside the reserve numbers about 6 000 people.

2.4 Accessibility

Access to the reserve is rather difficult and time-consuming. The poor infrastructure is a major problem along the whole coastal plain of southeast Sumatra (Hanson & Koesoebiono 1979).
The best way to go from the Reserve Head Quarters Nipah Panjang to desa Air Hitam Laut, which is the main entrance to the reserve, is by motor boat. This is a 5-hour trip, but during the strong December and January wind travel time may double (Figure 1).

roads

An overland connection for pedestrians and (motor)cycles along the shore is possible, between desa Air Hitam and desa Bako Tuo, but only during low tide. From desa Bako Tuo on, there is an unpaved raised clayey road to desa Sungai Lokan and desa Simpang Datuk. From these places to Nipah Panjang there are daily transports by ferries.
There are some well maintained footpaths between the coastal villages (Figure 1). A path through a virgin peat forest, in between desa Labuan Pering and desa Cemara, has been overgrown.

Navigable rivers

1. Sungai Air Hitam Laut

   The S. Air Hitam Laut is moderately deep, 15 m at its mouth, and can be entered by 30 ton boats, upto its tributary S. Kubu, after some 33 km (15 km linea recta from the coast). Further up the stream, the river is overgrown by the Batung weed (Susum anthelminthicum). The S. Simpang Malakka is for some 10 km the only navigable tributary by means of "perahus" (dug-outs). During the dry season, it may be already blocked at the place of conjunction with the S. Air Hitam Laut. Also during low tide, when the water level is some 1.5 m lower, boating is difficult, due to the remains of fallen trees, just underneath the water surface.

2. Sungai Benu

   The navigability of the S. Benu is about the same as the S. Air Hitam Laut, but the river is somewhat shallower (5-10 m). Mats of the Bakung weed (Susum anthelminthicum) block the river after some 25 km (15 km linea recta). The tributary S. Simpang Kanan can be navigated by means of dug-outs.

3. Sungai Air Hitam Dalam

   This small river is the best access for reaching the western inland boundary, and is at least navigable upto its tributary S. Simpang Batu Pahat (Figure 1).

   In general, in the wet season, accessibility on the river is better, even in parts more up the stream. Due to a considerable increased water level, the Bakung weed will detach.

   Only during high tide it is possible to travel by little boats from desa Air Hitam to desa Cemara and Labuan Pering.

2.5 Climate

The climate of Sumatra's east coast is largely affected by the Barisan mountain chain in the west, resulting in a somewhat dryer climate type. According to Oldeman (1979), the Berbak climate can be classified as the C_1-type, which means: 5-6 months with more than 200 mm rainfall per month and less than 2 months with 100 mm per month, which are considered as dry months. This C-type occurs in 15% of Sumatra (Oldeman 1978) (Figure 2).

Following the Köppen classification, Berbak lies in an Afa area, having a tropical rain forest climate, a temperature >18^{o}C in the coldest

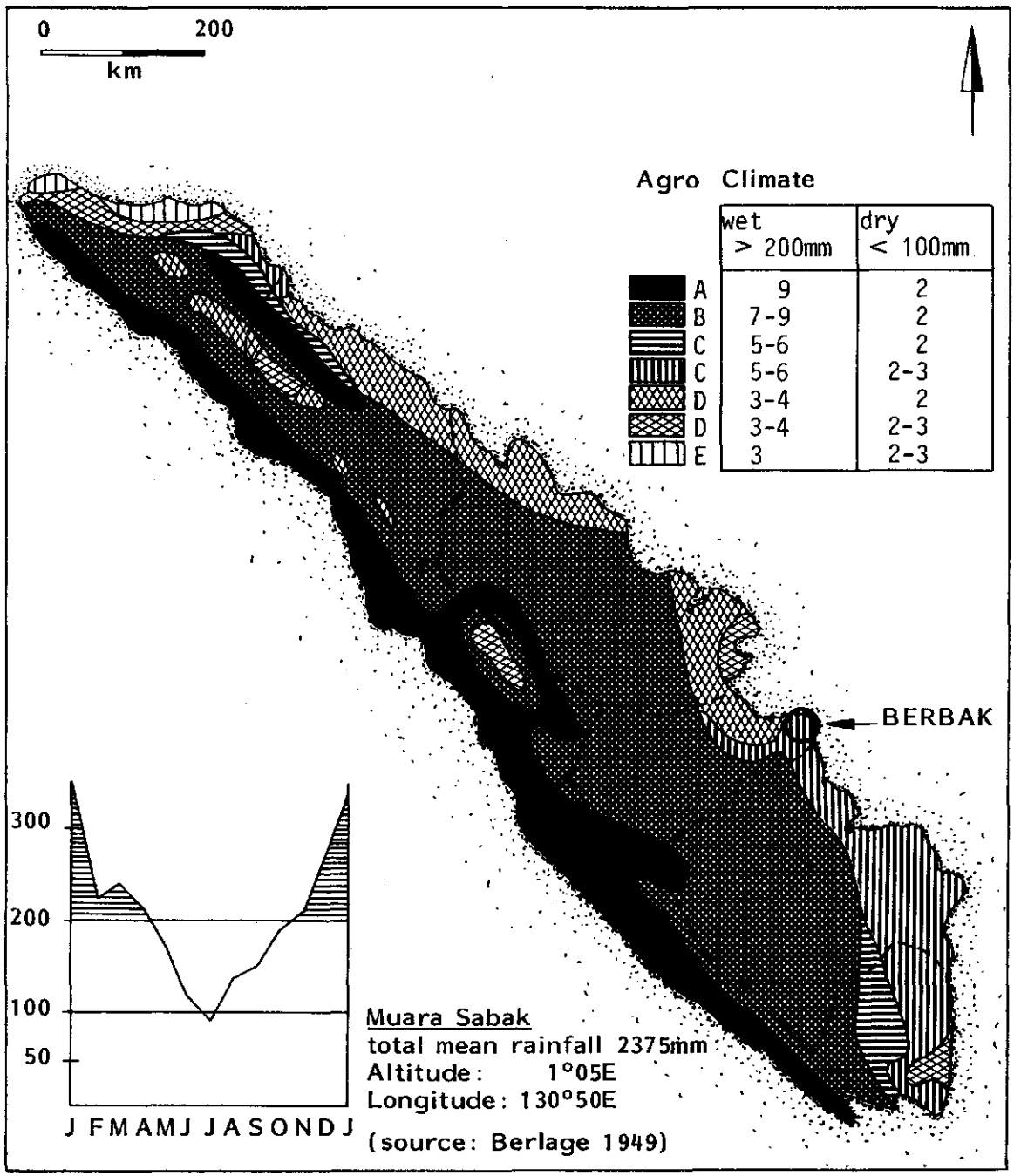


Figure 2 Agroclimatic map of Sumatra. Source: Oldeman (1978).

month, a precipitation of more than 60 mm in each month, and a temperature >22°C in the warmest month (Köppen 1931). Between November and February, northwestern currents bring humid air towards the east coast of Sumatra (Figure 3).

From April to October-November, the coast is under influence of a relatively dry south-easterly air stream originating in Australia (Figure 4) (Oldeman 1982).

rainfall

Data about the last 30 years from the meteorological station near Jambi, 90 km straight from Air Hitam, show an average annual rainfall of 2300 mm. This amount is rather low compared to Jambi's mountain area Kerinci, where rainfall figures of 4000 mm per year are recorded (Berlage 1949). Rainfall in the dry season is rather variable (Hanson & Koesoebiono 1979). Periods up to ninety days without rain have been observed. Extremely dry years occur once per 3-6 years (IUCN Press Services 1984). In 1981 and 1982, the Pacific region has suffered one of the severest droughts on record, as a result of the ocean current "El Nino" (Merle 1984). In cycles of about 80 years, and in a mild form every 3-6 years, this current repeatedly cast veils of unusually warm water, across the Pacific's surface, disrupting normal weather patterns (IUCN Press Service 1984). Rainfall figures in the Berbak reserve have been recorded since 1980. For 1981, 1982 and 1983 the annual rainfall is 2082; 1877 and 2313 mm respectively (Appendix 3). However, spatial variation in rainfall can be very substantial.

notes chapter 1

(1) large conservation areas in Sumatra (FAO 1981)

name	location	commissioned	acreage
1. N.P. Kerinci	W-Sumatra, Jambi Bengkulu, S-Sumatra	1984	1.600.000
2. N.P. Gunung Leuser	Aceh, N-Sumatra	1981	946.400
3. N.P. Sumatra Selatan	Lampung, Bengkulu	1981	356.800
4. S.M. Berbak	Jambi	1935	190.000
5. S.M. Way Kambas	Lampung	1937	123.500

N.P. = National Park

S.M. = Game Reserve (Suaka Margasatwa)

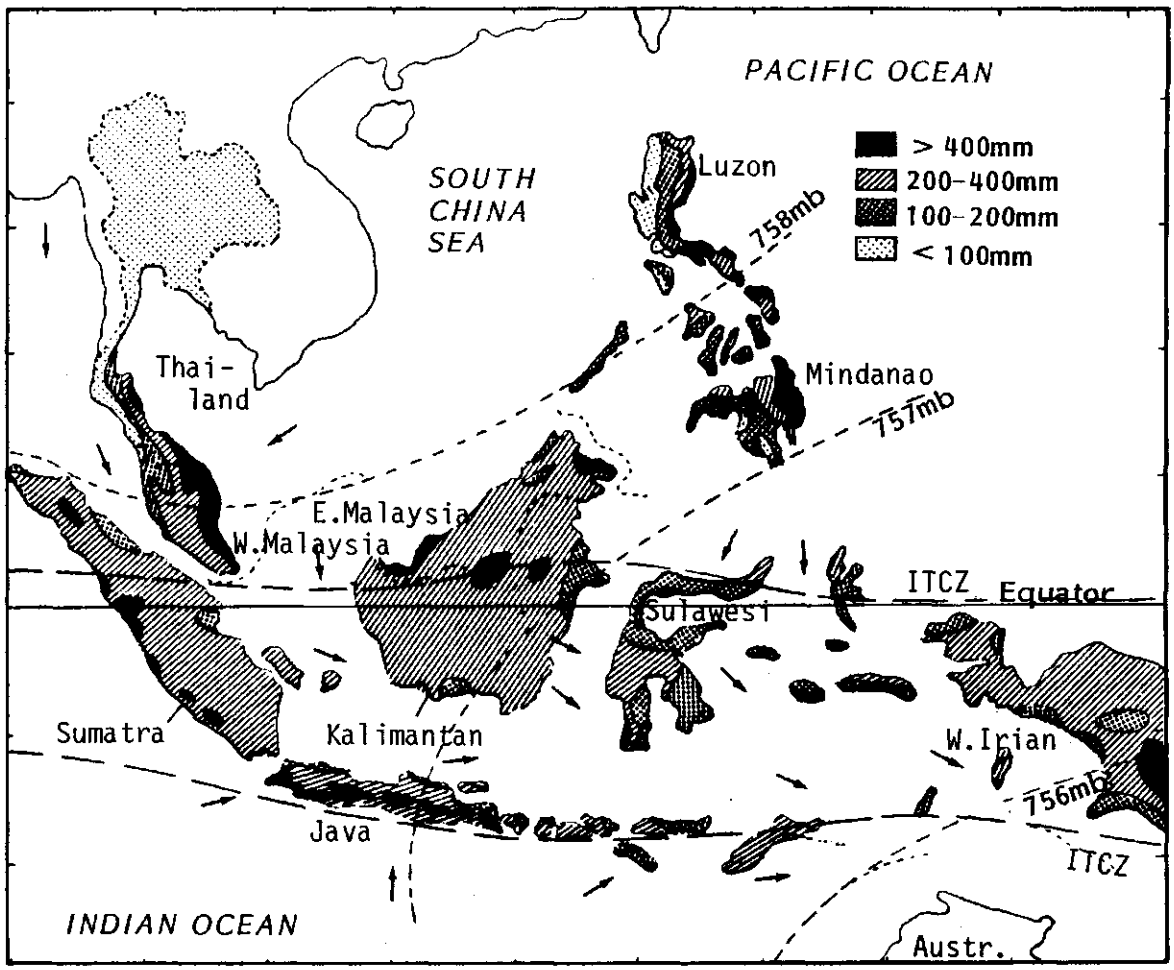


Figure 3 Rainfall pattern of December

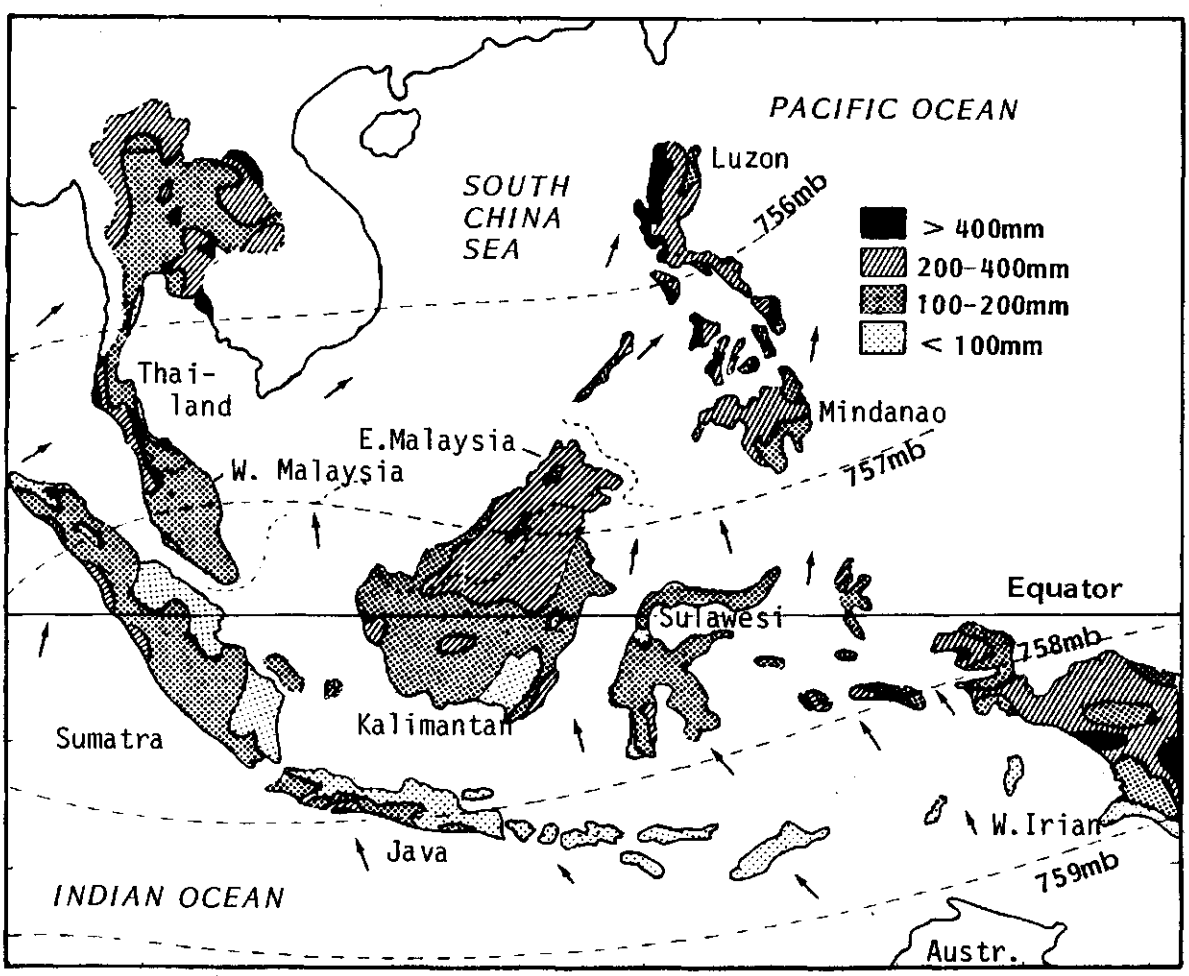


Figure 4 Rainfall pattern of June

3 GEOMORPHOLOGY AND SOILS

3.1 State of knowledge and objectives

Berbak is part of the vast alluvial coastal plain of East Sumatra. About 1/4 of Sumatra is occupied by this alluvial plain, mainly consisting of coastal swamp land.

The formation of the coastal plain is strongly influenced by relative sea level changes. In the Sunda region the sea level during Pleistocene times was about 75-100 m lower than the present level. After the last glacial, some 18,000 years ago, the sea level began to rise as a result of the melting land ice. The sea gradually rose and reached its highest level about 5000 BC. The sea level at that time was about 5 m higher than the present level (de Klerk 1983; van Tuyn 1932).

Several authors (Tjia 1970; van Heurn 1923; van Tuyn 1932; de Klerk 1983) presume a recent uplift of the land in the Sunda region.

After the stabilization of the sea level (5000 years BC), the lateral accretion of the coastal plain increased. It is presumed that from that time the alluvial plain of East Sumatra has been formed. According to Verstappen (1973) the age of the alluvial plain is 2000-5000 years.

In Jambi province, the Batang Hari is and was the main river which supplies the sediments. These sediments originate as weathering products from the hinterland, the Barisan mountain chain, stretching in northwest-southeast direction, at the western part of Sumatra. The rapid weathering causes a high silt content of the river water and the accretion of the alluvial plain. However, most of the material is weathered so intensely that mainly clayey particles remain (Verstappen 1973).

Lateral accretion can be very rapid. Data based on old maps give a long-turn average of 100 $m.year^{-1}$ for the area near Palembang. More recent measurements, comparing the coastline of 1969 with 1975, show an average accretion of 20 $m.year^{-1}$, with 30 m/year as a maximum (Obdeyn 1941).

The two main rivers in the reserve are the S. Air Hitam Laut and the Sungai Benu (Figure 5). They catch their water from the extensive peats of East Jambi. Both rivers have their origin just outside the reserve, at an elevation of about 20 m above sea level. Between these two rivers a few small rivers flow into the South China sea. They are tidal creeks (e.g. S. Cemara) and are restricted to the mangrove area. At some places

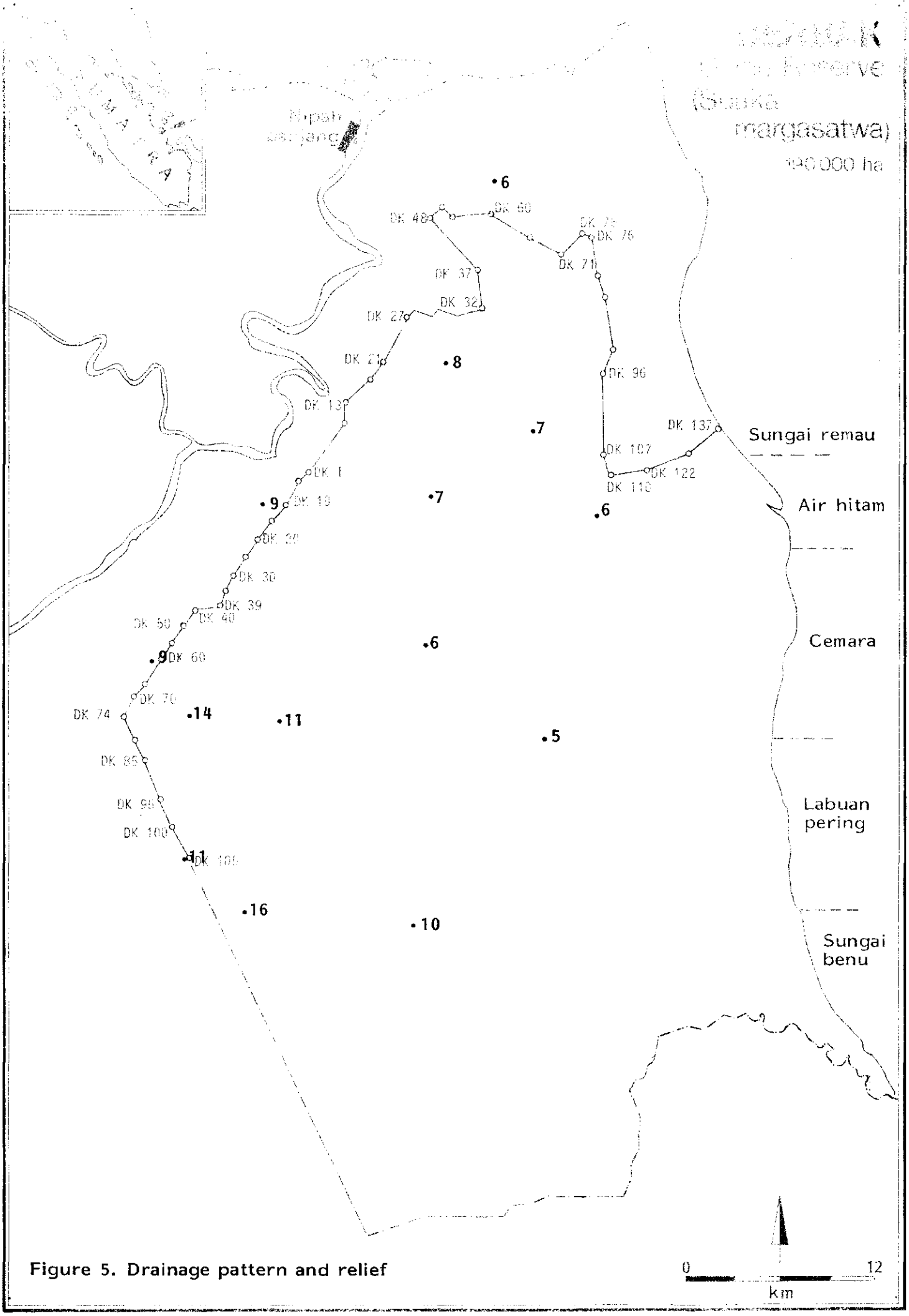


Figure 5. Drainage pattern and relief

the coastal area is also drained by "parits", drainage canals made by the Buginese people. The reserve consists of lowland with a highest elevation of 15 m, in the southwestern part of the reserve.

The area is subject to tidal influences. The spring tidal range along the southeast coast of Sumatra is about 3 m. Tides along the east coast are diurnal during spring tides and mixed during neap tide (U.N. 1978). Tides have been recorded in the last 3 years near Berbak in Nipah Panjang. The spring tidal range is 3.5 m. Incidental records available from PHPA officers in desa Air Hitam Laut indicate a same range near the mouth of S. Air Hitam Laut. At a distance of about 10 km (linea recta) from the coast the maximum tidal range is about 1 m.

The objective of this chapter is to present and discuss the collected data on sedimentation, peat development and soils of Berbak. A more detailed report, including information on swamps in West Malaysia will be published by Diemont & Van Reuler (in press).

Methods

As boring equipment we used three types of augers, depending on the soil types. For the ripe clays and sands we used the "Edelman" auger, for clays the gauge auger, and for soft muds and peats the special peat auger, produced by Eykelkamp BV, Lathum, The Netherlands.

During the first period of fieldwork, the area was reconnoitred at random. At each boring site the following observations were made according to the FAO guidelines for soil profile descriptions:

- soil description (of each horizon);
- depth of the peat;
- measurements of pH of soil water and chloride determinations;

Along the transects the same information was gathered. One transect was made in the undisturbed forest, from the riverside of S. Air Hitam Laut to about 8 km from the river, where peat of about 10 m occurs. This transect begins near S. Simpang Gadja (Appendix 6, no 40-47) and goes southward. Near desa Cemara, the soils were also studied more in detail. A transect was made along parit 1. The level of the soil surface is measured along this parit. Along both transects soil samples were taken. The following chemical and physical properties were measured:

- pH (H_2O_2, H_2O)
- C (organic) and N (organic)
- phosphate

- exchangeable cations (Na^{+}, K^{+}, Ca^{2+} + Mg^{2+}, Al^{3+}, H^{+})
- pyrite (FeS_2)
- texture
- moisture content

For methods of soil analysis see Appendix 7.

Some samples are carbon dated (C-14) in Groningen.

3.2 **Sedimentation and peat development**

In Berbak we found evidence for a recent relative drop of the sea level:

1) Buried soils occur at a distance of 3 km from the present coastline (Figure 6, transect Cemara). From this figure it can be seen that the sediments underneath the peat are deposited about 1 - 2 m above the present highest high water level (H.H.W.).
2) Borings in the levee of the S. Air Hitam Laut (near soil site 40) reveal that vegetation started to grow at 2 m depth. The height of the levee is estimated ± 5 m above the present sea level. This means that the sea level has at earlier times been ± 3 m above the present level.
3) A relict sandy beach ridge (soil sites no. 56, 57, 58) occurs at a distance of about 8 km inland from the present coastline. The base of this beach ridge is several meters elevated above the present sea level.

The peat above the buried soils near Cemara (Figure 6) dates from 4500 years ago. So, the sea level dropped about 2 m since that time. The age of the peat (2½ km from the present coastline) also reveals that lateral accretion has been very slow in the last 4500 years. Or, more probably, periods of accretion were followed by periods of coastal erosion.

At present, erosion takes place at some places along the coast, i.e. between Labuan Pering and Cemara. Here, the peat forest almost reaches the coast. Comparison of the topographical map of 1935 with the aerial photographs of 1976 reveals erosion. A farmer of Labuan Pering stated that, some 50 years ago, the coastline near S. Sungai Kapas (parit 8 "kanan", see Figure 22) was about 1 km seaward from the present one. Mangrove forest has been eroded. He also mentioned that 200 m of land was eroded since 1972.

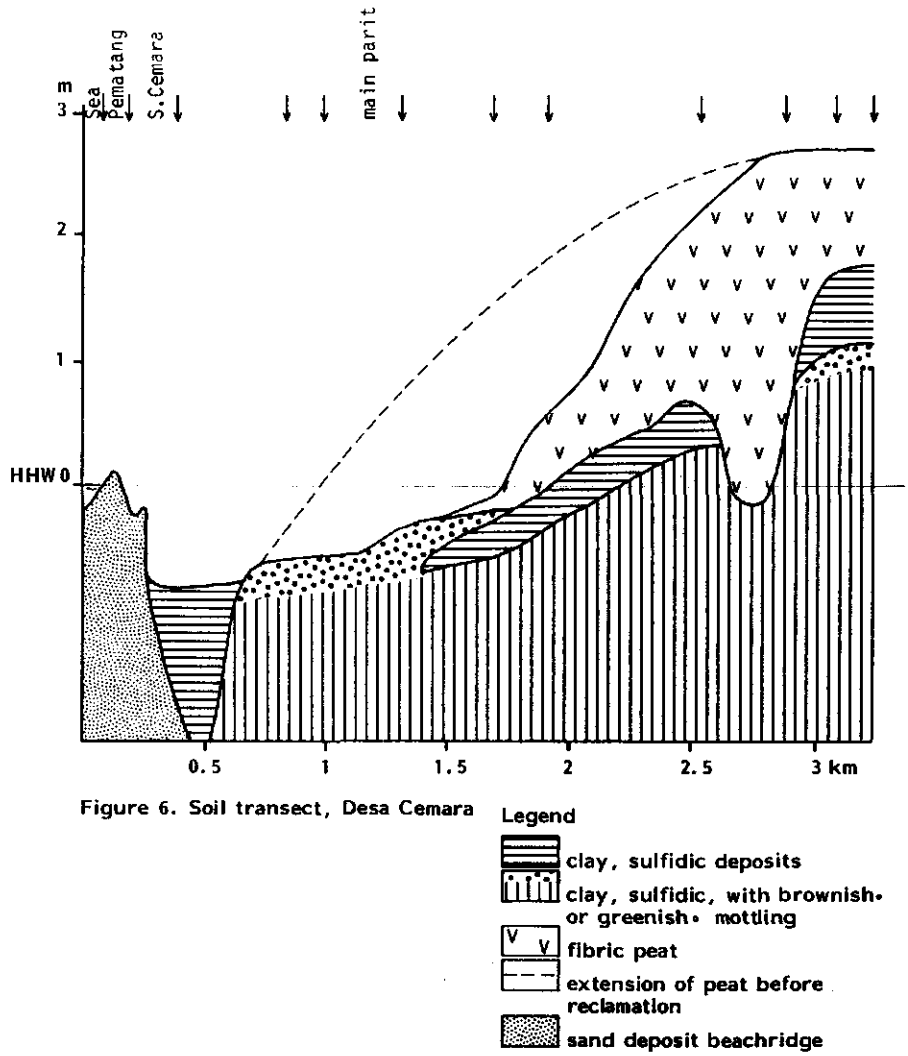


Figure 6. Soil transect, Desa Cemara

Figure 6 Soil transect in desa Cemara.

At other places (e.g. just south of S. Cemara) lateral accretion takes place. The mangrove tree species Avicennia intermedia colonizes bare mudflats. A zone of about 50 m fringing the bare mud is colonized by Avicennia intermedia of about 1-3 years old, indicating a lateral accretion of about 15 m/year. A sharp transition occurs towards a 200 m zone of Avicennia alba and Avicennia intermedia of about 10 m in height and an estimated age of about 8-10 year. This indicates a lateral accretion of about 20 m/year. Also the vertical silting up is fast. Stems of trees in the 10 years old Avicennia zone are buried by 40-60 cm fresh sediment, suggesting a vertical accumulation of 4-6 cm/year.

The coastline of Berbak is rather straight: sandy beach ridges alternate with mudflats. Behind the sandy beach ridges, more clayey backswamps occur, covered with mangrove vegetation. Southward from the mouth of the S. Air Hitam Laut a sandbank of some 10 km in length is stretched at a distance of about 200 m from the coast. Between S. Air Hitam Laut and S.

Benu are some tidal creeks, with a length of a few km, more or less perpendicular to the coastline. Some of these creeks have been filled up with peat or disappeared as a result of coastal erosion.

The coastal system of Berbak can be classified as an accreting coast system according to the classification of Diemont & van Wijngaarden (1974).

A large part of the study area consists of peat. It is generaly accepted that tropical peat can be formed in alluvial plains, during periods of a slowly rising sea level or a stable one. For the Sunda region it is presumed that the lowland peats started to grow about 4000-5000 years ago, when the rising of the sea level slowed down.

Some peat samples of Berbak have been dated (Table 1). These findings agree with C-14 datings in the literature.

Table 1 C-14 determinations of peats in Berbak

soil site	profile nr.	distance to the sea km	depth of the peat m	sample depth m	age years BP
82	2	± 3 km	3	3	4575±90
44	7	± 12 km	3	3	4780±55
48	8	± 12 km	±10	7	3015±50

Remarkable is the old age of the peat 3 km from the coast. This could be an indication that the peat started to grow at about the same period over a large area.

According to Driessen & Sudjadi (1981), the peat started to grow as topogenous peat. Organic matter accumulated under conditions of stagnant fresh water supplied by riverfloods. The acid nature of the sediments also hindered decomposing of organic matter. Vertical peat growth led to gradually drier conditions and less frequent flooding. The peats became rain dependent, ombrogenous peats.

In Berbak deep peats, up to 10 m thick, occur at a distance of 7 km from S. Air Hitam Laut and 10 km from the coast. Measurements near boring 44 show that the pH in these peats is about 5.0 in the topsoil, decreasing to about 2.8 in the subsoil. These data confirm that the peats

are entirely rainwater fed, ombrogenous peats. Another proof is the low amounts of Cl^- in the peats.

Polak (1933) was one of the first authors to describe the vast lowland peats of East Sumatra. She described the doom shape of the ombrogenous peats. For the peats in Berbak we also assume a doom shape.

Figure 7 shows a possible cross section of the Berbak peat.

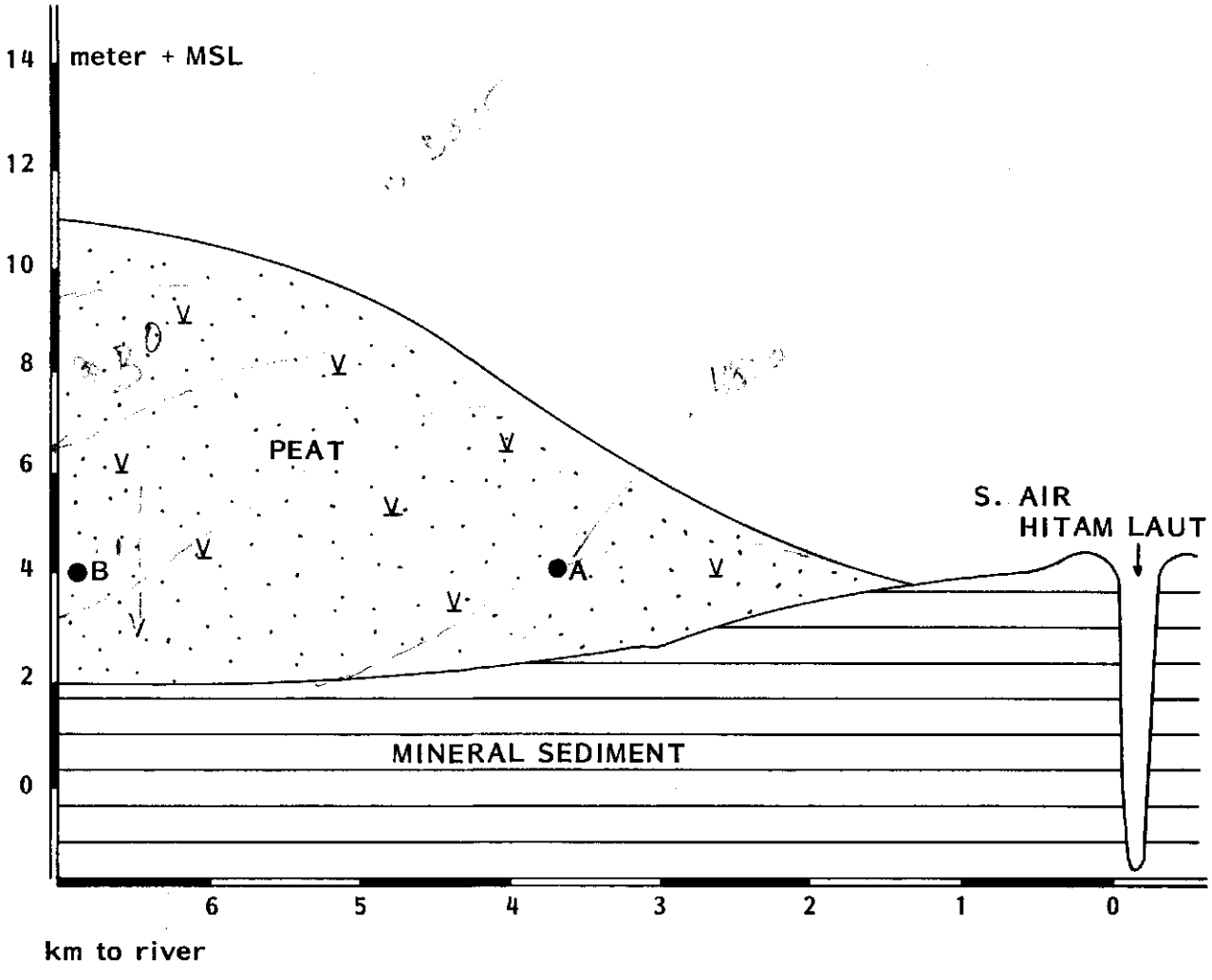


Figure 7 Tentative cross section of the Berbak peat about 12 km inland

In this figure we plotted the depth of the two samples from which C-14 data are available. No. A has an age of 4780 ± 55 years and no. B only 3015 ± 50 years. It appears that no. A in spite of less accumulation of peat, is of an older age. These findings indicate that the peat has developed from the edge of the peat dome (with older peat) towards the centre of the dome. This is in contradiction with other theories (Driessen & Sudjadi 1981; Andriesse 1974) about formation of these peat

domes, which suppose a development from the centre to the edge of the dome.

3.3 Distribution and classification of soil types

The soils of Berbak can be divided in mineral soil material (clays, sands) and organic materials (peats). The soil map (Appendix 4) shows the distribution of the different soil types. On this map, the soils are not defined according to the classification system of Soil Taxonomy (USDA 1975). We used a rough type of classification, based on general features (riverine clays, marine clays, shallow and deep peats, sands). In the following we discuss the classification of the soils according to Soil Taxonomy.

Mineral soils

The mineral soils occur along the coast and along the rivers. These soils are predominantly clays, from marine origin. There are some sandy soils, which occur along the coast as a beach ridge.

According to the classification system of Soil Taxonomy, all mineral soils are Entisols or Inceptisols. Entisols are soils which show hardly any pedogenic horizon development. Young alluvial deposits belong to this order. The wet Entisoils form the suborder of the Aquents. In 2.3.2 we discussed the genesis of potentially acid sulphate soils and acid sulphate soils. Central to the classification of these soils are the sulfuric horizon and sulfidic materials. A sulfuric horizon is composed of mineral or organic soil material with a pH <3.5 and yellow jarosite mottles. Sulfidic materials are waterlogged mineral or organic soil materials with 0.75 percent or more sulfur, mostly in the form of sulfides (often pyrite: FeS_2). A drawback of the definition of the sulfuric horizon is that yellow jarosite mottles are absent in some acid sulphate soils (van Breemen 1982). Van Breemen states that therefore another characteristic, pointing to sulfuric acid as the acidifying agent, should be used in combination with pH to define the sulfuric horizon. Data available indicate that the presence of at least 0.05% of water soluble SO_4 is a better criterion than the presence of jarosite. He proposes the following definition:

"A sulfuric horizon is composed of mineral, organic or mixed soil material, generally containing yellow jarosite mottles with hue 2.5Y or yellower and chroma 6 or more, that has a pH <3.5 and contains at least

0.05% water soluble sulfate."

In practice, the pH criterion alone will be sufficient because very few soils with a pH (in water) below 3.5 were not affected by sulfuric acid.

Potential acid sulphate soils must be classified as Sulfaquents, if sulfidic material occurs within 50 cm of the mineral soil surface. All marine clays in Berbak, still under tidal influence, are probably Sulfaquents. They occur near Cemara and at some other places, under mangrove vegetation (near Labuan Pering). Also the riverine clays along the S. Air Hitam Laut formed under Nypa fructicans vegetation contain a high amount of pyrite (>0.75%), so they are Sulfaquents. If sulfidic material is present between 50 and 100 cm depth, the soil is classified as a Sulfic Tropaquent. Soil profile 75 is an example of a Sulfaquent. At a depth of 30 cm, the soil contains 1.13% pyrite. This soil is located in the mangrove near Cemara and is flooded by high tides. The vegetation consists mainly of Avicennia alba.

Characteristic for most of the marine clays is the layering: a dark brown (10YR 4/3) clay, with rather much organic matter, upon a grey/blue (5GY 4/1) clay, often with green glauconite mottling.

Acid sulphate soils are classified as Sulfaquepts, if a sulfuric horizon has its upper boundary within 50 cm of the soil surface. Less extreme acid soils are Sulfic Tropaquepts, these are Tropaquepts with jarosite mottles and a pH 3.5-4 somewhere within the 50 cm depth, or jarosite mottles and a pH <4 in some part between 50-150 cm depth. Both groups belong to the order of the Inceptisols, which are a next stage in soil development compared with the Entisols. The Inceptisols are somewhat riper and the upper horizon shows mottling. Most marine clays in Berbak are reclaimed and cultivated for agriculture. As a result of draining and excluding from tidal influence, the Sulfaquents developed into Sulfaquepts or an intermediate form. The acidification of most marine clays is not very severe, the pH is often between 3.5 and 4. Locally, serious acidification occurred (pH <3.5), i.e. the soils near desa Air Hitam Laut. These soils are real Sulfaquepts. At other places jarosite mottling along the parits can be observed (Cemara and Labuan Pering), also indicating Sulfaquepts. The soils on drier fluviatile clays can also be classified as Sulfaquepts or Sulfic Tropaquepts.

A problem is the exact mapping of the soil types, because they have a scattered distribution depending on varying local conditions.

Furthermore, the identification in the field is difficult and the number of soil analyses that could be carried out had to be limited. Therefore, only preliminary conclusions could be drawn.
The sandy soils can be classified as Psamments, a suborder of the Entisols.

Organic soils (Peats)

On the soil map, shallow peat (0,5-1,5 m peat) and deep peat (>1.5 m peat) are distinguished. According to Soil Taxonomy these organic soils are classified as Histosols. A soil is a Histosol if half or more of the upper 80 cm consists of organic soil material.
Organic soil material contains:

- more than 18% organic carbon, if the mineral fraction has 60% or more clay,
- more than 12% organic carbon, if the mineral fraction has no clay,
- an intermediate proportional content of organic carbon if part but less than 60% of the mineral fraction is clay.

The hardly decomposed peats are the Tropofibrists, also characterized by a low bulk density (containing much water). Probably, all deep peats in Berbak can be classified as Tropofibrists. Soil profiles 43-50 belong to this group.

The shallow peats, in general, contain better decomposed organic matter and have a higher bulk density. These peats are Tropohemists. If sulfidic materials are present in the upper 100 cm, these peats are Sulfihemists. Peats with a sulfuric horizon in the upper 50 cm are Sulfohemists. We found low amounts of pyrite in the peats (0.10-0.20%), too low to classify the peats as Sulfohemists or Sulfihemists. The shallow peats are located between the mineral soils and the deep peats. Not only geographically they form a transition, but also with respect to chemical and physical properties.

3.4 Pyrite formation

The sediments which are deposited along the coast and along the rivers, are not supplied by the S. Air Hitam Laut and the Sungai Benu. Both rivers contain only acid water (pH 3.5), derived from the extensive peats. The river water contains only organic matter, causing the black colour of the water and no sedimentation load is present (Air Hitam means black water). The sediments probably originate from the S. Batang Hari.

They are transported southward and deposited along the coast, influenced by a northeastern current in the South China sea. The sediments have a strongly weathered, acid character.

Apart from some sandy deposits (Appendix 5) the sediments in Berbak are clays. They are deposited under saline to brackish conditions. Under mangrove and Nypah vegetation secundary pyrite (FeS_2) is formed, according to the overall reaction:

$$Fe_2O_3 + 4\ SO_4^{2-} + 8\ CH_2O + \tfrac{1}{2}O_2 \longrightarrow 2\ FeS_2 + 8\ HCO_3^- + 4\ H_2O.$$

The essential ingredients for the formation and the accumulation of pyrite are (Pons & van Breemen 1982):

1) sulfate, continuously supplied over an appreciable period (e.g. with sea water),
2) iron containing minerals, present in the sediment,
3) metabolizable organic matter (CH_2O) (supplied by mangrove vegetation),
4) sulphate reducing bacteria, which are practically always present,
5) an anaerobic environment,
6) limited aeration for oxidation of all sulfide to disulfide.

The pyrite containing soils are potential acid sulphate soils. They are unripe to ripe and pyrite has accumulated under tidal influence. In areas with a rapid accreting coast, no serious accumulation of pyrite is to be expected. The vertical silting up of the sediment prohibits formation of pyrite. Amounts of pyrite are less than 0.5% pyrite sulfur, compared with 1-2.5% pyrite sulfur in estuarine systems (Diemont & van Wijngaarden 1974; Pons & van Buuren 1982). According to Diemont & van Wijngaarden (1974), rather high pyrite amounts can be expected under a Rhizophora vegetation. So, in the accreting coastal system of Berbak high amounts of pyrite are not to be expected. In table 2 the amount of pyrites of some soil profiles in the coastal area of Berbak are given:

Table 2 Amounts of pyrites (% Fe) the solum and in the underlying parent material in an accreted coastal system

soil site	profile nr[1)]	solum depth cm	solum pyrite-Fe %	solum C %	parent material depth cm	parent material pyrite-Fe %	parent material C %
81	1	115	0.19*	1.1	190	0.73	2.8
82	2	305	0.93	3.8	355	0.63	1.9
80	3	95	0.63	6.7	145	0.98	2.8
77	4	105	0.76	2.6	145	0.80	2.3
75	5	30	1.13	2.0			
79	12	105	0.09*	1.2	325	0.80	1.8
78	14	110	1.70	7.3	245	1.36	0.8
76	16	135	1.06	3.6			

* oxidized; green mottling

1) Depth of ombrogenous peat: profile nr. 1, 2, 3, 4, 12 resp. 90, 280, 80, 20, ± 40 cm peat.
Landuse: ananas (nr. 1, 2), paddy/coconut (nr. 3, 4, 14), burned forest (nr. 1, 12).
Mangrove: mainly Avicennia alba (nr. 5), coconut (nr. 16).
methods: appendix 7

Only profile 5 is still under tidal influence, it is flooded by high tides. The results show an amount of pyrite of about 1% (0.6-1.7%), much higher than amounts found by Diemont & van Wijngaarden (1974) in the solums of an accreting coast in West Malaysia (about 0.5% pyrite).

The mineral soils along S. Air Hitam Laut contain higher amounts of pyrite, although these soils (Table 3, profile 7, 6, 10) are now under freshwater conditions. We sampled (at a distance of about 12 km linea recta from the coast) in a transect the mineral subsoil of a peat 3 m in depth about 3 km from the river, a backswamp about 200 m from the river and a levee. Besides, a soil profile under a Nypa vegetation, near the mouth of the river was sampled. This soil is regularly flooded with brackish-salt water.

Table 3 Amounts of pyrite (FeS_2) in the solum and parent material of soils along the S. Air Hitam Laut

soil site	profile nr[1)]	depth cm	pyrite-Fe %	C %	depth cm	pyrite-Fe %	C %
44	7	370	0.62	20.6	445	2.29	6.0
38	6	300	2.23	6.7	425	2.02	1.8
40	10	130	2.38	10.1	265	1.64	0.3
		190	0.81	3.0			
62	11	65	0.62*	5.1	345	2.51	3.2
		165	1.13	3.3			
		215	2.68	5.8			

* partly oxidized

1) Depth of ombrogenous peat: 320 cm (nr. 7).
Landuse: primary forest, backswamp 500 m from the river (nr. 6); primary forest ± 3 km from the river (nr. 7); levee, mottling reddish-brown till 60 cm depth, primary forest (nr. 10); mouth of the river near desa Air Hitam, Nypa fructicans vegetation, with lobster hills (nr. 11).
methods: Appendix 7.

These amounts of pyrite indicate a marine origine of the sediments along the S. Air Hitam Laut. Probably pyrite has been formed under a Nypa-vegetation, which shifted more seaward following the accreting coast. Pandanus tectorius, also a palm species replaced Nypa fructicans when conditions changed from brackish to fresh water.

A large part of the coastal area has been brought into culture. The topsoil became aerated and oxidized as a result of drainage (by parits). Pyrite oxidized and sulfuric acid appeared, causing a considerable drop in pH, from 6 to 4 or 3. An other oxidation product is jarosite, an iron (III) sulfate compound, causing the pale yellow mottling, characteristic for these soils. These acid, oxidized soils are acid sulphate soils. Most soils show a pH of 3.5-4.

3.5 Physical and chemical properties of the soils

Physical properties

Texture: Most mineral soils in Berbak belong to a clayey family, which means that the mineral soil fraction contains more than 40% clay (particles <2 mu). The clays have not a very fine texture, only a few soils have more than 60% clay. Other textural classes which are present: clay loam and sandy clay loam.

Structure and ripeness: The recently deposited clays in the mangrove have not yet any structure. The soft sediments contain much water. The ripeness of a soil is determined by its amount of water.The ripeness is expressed by the n-value according to Pons & Zonneveld (1965), and varies from <0.7 for ripe soils to >2.0 for unripe soils. The soils in the mangrove are half ripe to unripe. An example is soil profile 75; at a depth of 30 cm the n-value is 2.11, unripe.

The clays along the coast, which are reclaimed for agriculture came under drier conditions. The irreversible process of physical and chemical ripening started. The most striking phenomenon for physical ripening is the withdrawal of water from the soil. The topsoil of these riper clays has more structure development and is half ripe to ripe. During dry periods cracks can be observed in the topsoil of arable land, especially around desa Air Hitam Laut. These cracks are caused by a drying out of the soil. The subsoil of the marine clays consists of half ripe to unripe sediments.

The riverine clays of the levees along the S. Air Hitam Laut have a half ripe to ripe topsoil in the outer bends and a half ripe topsoil in the inner bends. The subsoil consists of half ripe to unripe sediments. Peats: the water content of the peats is very high. The bulk density is a measure for the dry matter per volume. The peats are characterized by low bulk densities (Table 4). Deep peats contain more water, have a lower bulk density than shallow peats. Draining causes a considerable subsidence of the peats and this process is irreversible.

Chemical properties

Pyrite (FeS_2): One of the most determining features of the soils in Berbak is the occurrence of pyrite. In 3.4 we discussed the formation of pyrite. The highest amounts of pyrite are found in clays under a mangrove-vegetation, and in the sediments along the river S. Air Hitam Laut (3.4 Table 2 and 3).

pH: Related to the occurrence of pyrite is the potential and actual acidity of the soils. The soils in the tidal area, regularly flooded with brackish to salt water, have a $pH_{(H2O)}$ of about 6-7.

Mineral soils excluded from tidal influence have a lower pH, ranging from 2.5-4 in the topsoil to 4-5 in the subsoil. The peats are also rather acid (Table 4).

Organic C and C/N ratio: The mineral soils contain 2-5% of organic carbon throughout the whole soil profile. The conditions are not favourable for a fast mineralization of organic matter (low pH). The C/N ratio of the clays ranges from 10 to 50. The peats consist nearly entirely of organic matter (percentage of organic C x 1.724 = percentage organic matter). The deep ombrogenous peats contain 40-50% organic C. The C/N ratio of the peats is rather high, 60-70 (Table 4), which indicates an oligotrophic environment.

Some properties of the soils in the vegetation transects

In table 4 the most important properties are listed. The soils of plots BI and BII are clays. BII has a histic top horizon with a lower bulk density than the subsoil. BIII and BIV are deep peats with low bulk densities, a somewhat higher C/N ratio, low amounts of phosphate and nitrogen, and low pHs. The soil of the freshwater-swamp forest (plot BII) has the highest amounts of phosphate and nitrogen in the topsoil. It has the highest soil fertility, which is reflected in the structure of the vegetation (4.3).

Table 4 Chemical and physical properties of the soils of the vegetation plots

Plot	profile nr.	distance to river	depth of peat	vegetation	depth	bulk density (kg/dm^2)	pH (H_2O)	C:N ratio	Phosphate (kg/ha 0.2m)	Nitrogen (N) (ton/ha 0.2 m)
BI	35	50 m	0 cm	Riveredge forest	0-25 cm	0.54	3.5	26	6	4.4
					25-50 cm	0.44	2.9	33	4.4	3.8
BII	38	500 m	20 cm	Fresh water swamp forest	0-25 cm	0.28	3.3	26	61	6.8
					25-50 cm	0.82	3.7	72	14	1.2
BIII	43	4.5 km	2.5 m	Peat swamp forest	0-25 cm	0.11	3.0	67	-	1.0
					25-50 cm	0.17	3.0	32	10.7	5.6
BIV	46	7 km	9 m	Peat swamp forest	0-25 cm	0.16	3.0	61	19	2.4
					25-50 cm	0.08	3.1	79	5.6	0.8

3.6 Conclusions

1) In Berbak, we found evidence for a relative drop of the sea level of about 2 m since ± 5000 years ago.
2) The coastal system of Berbak can be described as an accreting system; at some places, however, erosion takes place.
3) The mineral soils of Berbak are mainly clays. They occur along the coast and along the rivers. The coastal sediments contain rather low amounts of pyrite (FeS_2), about 1%, which is in accordance with findings in literature for comparable accreted coasts. In the freshwater soils along the river we found much higher amounts of pyrite (>2%). The pyrite containing soils are potential acid sulphate soils or Sulfaquents.
4) At some places, i.e. near the mouth of S. Air Hitam Laut, actual acid sulphate soils or Sulfaquepts are formed as a result of reclamations. The pH dropped to 2 - 3, which limits agriculture.
5) Most of the soils in Berbak are organic soils, divided in shallow peat (0.5-1.5 m peat) and deep peat (>1.5 m peat). The peat started to grow about 5000 years ago under conditions of a slowly sinking sea level. Deep, ombrogenous peat of about 10 m is found at distance of 7 km from the S. Air Hitam Laut and 12 km from the coast.
6) C-14 datings suggest a growth of the peat from the edge towards the centre of the dome, which is in contradiction with other theories.

4 VEGETATION

4.1 State of knowledge and objectives

The knowledge of the vegetation of Berbak is very limited. The only report on its vegetation is by Franken & Roos (1981) who studied a vegetation plot in the freshwater-swamp forest containing about 100 tree species (including species of the undergrowth). Features of the vegetation structure are described. Floristic surveys have been done by Mr. Soetrisno, former PHPA-subbalai of the Jambi province. Jacobs (National Herbarium at Leyden, The Netherlands) made some collections of plants in 1981. However, on these surveys no reports have been published and we could not find preliminary results or research notes.

In the province of Riau, Anderson (1976) studied the peat swamp forest of three areas: Telok Kiambang, Muara Tolam and Sungai Siak Kecil. Until now, only a preliminary report with basic data has been published.

The first objective of our study was to obtain a general overall knowledge of the different vegetation types, floristic diversity, and forest structure. Secondly, to study in detail some vegetation transects, thereby covering the main vegetation types of the reserve. Unfortunately the aerial photographs available are of too small a scale (1:100 000) and not clear enough to be used for a photo interpretation map of the Berbak vegetation. Therefore, the ultimate goal to make a vegetation map of the Berbak reserve had to be abandoned.

Methods

During the reconnaissance period (April-June 1983) the area surveyed was limited to a distance of 5 km from the riversides of the S. Air Hitam Laut and S. Sungai Benu. The location of the vegetation plots was chosen on account of physiognomic and floristic criteria and soil features. Each plot covered approximately 0,3 ha. In these plots 80-100 trees were chosen at random and identified by their local names with the help of PHPA-guides. Characteristics of the leaves, outerbark, innerbark, wood, latex, buttresses, pneumatophores, height and flowering were described.

In the second field period (September-November) we managed to survey more remote areas up to 10 km from the S. Air Hitam Laut. Two transects were recorded and studied in detail. A transect near S. Simpang Gadja is

8 km in length and contains five vegetation plots (map: Appendix 5), each in an other vegetationt type. These types are classified on geomorphological and pedological criteria. Two plots located on the river levees cover 50x20 m. Three plots in the freshwater-swamp forest and peat-swamp forest cover 50x40 m. Reason for the differences in size was the density of the vegetation and uniformity. Much attention was paid to the representativity of each plot for the type of vegetation, on account of knowledge gathered in the reconnaissance period on structure and floristic composition.

The following features were described:

- Physiognomy,
- Floristic composition (trees >5 m and undergrowth <5 m),
- Height (Ht) of the trees,
- Height of the first branch (Hf),
- Basal area: stemcover (at breast height),
- Occurrence of palms, rattans and lianas,
- Occurrence of pneumatophores and butresses,
- Characteristics of innerbark, outerbark, wood, latex, smell of slash and flowering.

From almost every species a herbarium specimen was collected. Most of the specimens consist of sterile material only because very few trees were flowering. The material has been identified in the National Herbarium at Leyden (The Netherlands).

A second transect, in the mangrove, is located near the desa Cemara. It is 10 m wide and 600 m long, and crosses a small mangrove creek (S. Cemara). It includes dry beach forest and mangrove. Except for the basal area, the same features as described above are surveyed.

On two other spots (2 km and 6 km south of desa Cemara) the mangrove was studied superficially.

4.2 General description

The vegetation can tentatively be divided in seven types on basis of geomorphological and pedological criteria (Table 5).

Table 5 Classification of the vegetation, using geomorphological and pedological criteria.

Type	Geomorphology	soil
Freshwater swamp forest	Mineral riverine deposits	reduced clay
Peat swamp forest	Ombrotrophic peats	reduced acid peat
Riverine forest	Levee, pematang	oxidized clay (0-30 cm)
	Levee, pematang	reduced clay
Riverbank vegetation	River	-
Mangrove forest	Salt water and brackish deposits	reduced clay
Dry beach forest	Sandy marine deposits	oxidized sand (0-60 cm)

The main vegetation types, covering the largest areas in the reserve, are the freshwater-swamp forest (60 000 ha) and two types of peat-swamp forest (in total 110 000 ha). The two types of riverine forest (located on a reduced-clay levee respectively oxidized-clay levee) cover only a small zone along the river, not more than 100-200 m wide. Apart from the mangrove and dry beach forest, these vegetation types are floristically characterized by the presence of a few species only, or difference in abundance of certain species. Furthermore, there are some differences in forest structure. The tree species in the swamp vegetation of Berbak number nearly 160, of which we found 100 (Appendix 8: species list).

The freshwater-swamp forest occurs mainly near the rivers in a zone of 2-5 km width and along the coast behind the mangrove and reclamations. It is normally inundated between December and March. The peat-swamp forest normally starts about at 3-5 km distance from the river and about 8 km from the coast. On some locations, however, the peat swamp forest is found within 500 m from the river. Between desa Cemara and desa Labuan Pering it also is fringing the eroded coast (par. 2.2.3). In contrast to the freshwater-swamp forest, where large thick trees are common (Photo 8), on the very deep peats the trees generally have a smaller diameter (Photo 10). The riverine forest occurs on the levees which are normally wet in the inner bends of the river and drier (often with an oxidized

topsoil) in the outer bends. Especially in the wetter parts there is a large influence of the kneeshaped slender pneumatophores of the Mammea sp. on the microrelief.
Within the swamp forest vegetation we noticed a large spatial variability of species. In the freshwater swamp forest we observed some places with a very open vegetation. There were only a few trees growing alone or in groups. Large areas were covered only by a thicket of Korthalsia sp. (Rotan semut) with a height of 1-4 m. This vegetation is impenetrable, not in the least because of the overwhelming amount of 2.5 cm large ants (semut) occupying the branches.
In the riverine forest and freshwater-swamp forest some locations have an abundant undergrowth of rattans (Photo 8) and palms (mainly Licuala valida) (Photo 11). In the peat swamp forest the vegetation is more open. The undergrowth contains mainly herbs (Photo 10).

The forest is rich in epiphytes, mostly ferns and climbers (Photo 4). Many trees have buttresses or stilt-roots (Photo 7 and 12). Thick and thin trees are mixed at random but can also occur in scattered groups. Special mentioning deserve some small pematangs (relatively high levees) near the mouths of small tributaries. On these permatangs sometimes Bambusa sp. (bamboo) is abundant.

The riverbank vegetation consists mainly of palms. All along the riverbank up to 8 or 10 km linea recta from the coast, Nypa fructicans (Photo 1) is the dominant and nearly only species. More up the stream the species is quite abruptly replaced by Pandanus tectorius (Photo 2). Both species do not occur together, except where in the Nypa zone tributaries flow into the main river (not too near to the coast). Here Pandanus can occur in small groups but almost never mixed with Nypa. The sharp discontinuity of species indicates a critical drop of the salinity of the riverwater under tidal influence.

Normally, the riverbank vegetation is not wider than 20 m. Only near the coast the Nypa zone can be wider. Here the riverbank is for a large surface under direct tidal influence. The daily inundation reaches further inland so the biotope has a more mangrove-like character (Photo 6). Further upstream (where Pandanus fringes the river) the herb Susum anthelminticum (Photo 3) occurs, a floating riverplant which covers large areas with thick mats, until near Sungai Kubu (in the S. Air Hitam Laut) and near S. Simpang Kanan (in the S. Sungai Benu) it entirely blocks the river.

Along the coast, mangrove forests occur (Photo 13). In vast areas this vegetation has disappeared, due to human impact but also because of natural erosion. It is a rather low vegetation (up to 35 m high), often open and consists of very few species. Due to differences in inundation, the abundance of certain species alters. Pneumatophores occur in large quantities, most of them are stilt-like (Photo 16). The enormous flying buttresses of Rhizophora mucronata (Photo 15) are very impressive. Trees are often flowering, but remarkably flowering takes place especially near the borders of the vegetation.

Near desa Cemara, between the mangrove and the coast, dry beach forest occurs on the sandy ridges. It is a rather open forest of mainly Casuarina equisetifolia (Photo 17). The undergrowth consists of grasses (Ischaemum spec.) and composites. Between the dry beach forest and the mangrove, a zone of bushes dominated by Clerodendrum spec. occurs.

4.3 Vegetation of riverine forest, freshwater swamp forest and peat swamp forest

Differences between the five vegetation plots are clearly discernable. Since the plots were carefully chosen after a reconnaissance period of three months in order to get a representative sample of the vegetation types in the transect, the observed patterns can be interpreted as being characteristic for these vegetation types. In the following comparison, only commonly and abundantly occurring species are mentioned in the characterization of the vegetation types. It cannot be ruled out that rare species are typical for certain vegetation types, but information on this matter is lacking and the aspect cannot be included in this comparison.

Some general data are given in Table 6. A comprehensive description of the five vegetation plots is given in Appendix 9.

Table 6 Five vegetation types based on the the five vegetation plots BI-BV

Plot nr.	VEGETATION TYPES / DATA	Distance from the river of the vegetation plot	Number of trees/ha	Basal Area m2/ha	Basal Area of trees with ø > 30 cm	Palms	Rattans	Height of the vegetation	Distinct layers	Pneumatophores	Number of species
BV	Riverine forest on oxidized clay	25 m	1200	21,71	58,2	+	+	45	-	very few	± 25/1000 m2
BI	Riverine forest on reduced clay	20 m	1830	36,99	30,3	+	+	50	-	very many	± 32/1000 m2
BII	Freshwater swampforest	500 m	1405	51,29	73,6	+	+	60	2	many	± 45/2000 m2
BIII	Peatswampforest 3½ m deep peat	4,5 km	1285	32,70	58,8	-	+	50	-	few many	30-40/2000 m2
BIV	Peatswampforest > 8 m peat	8 km	1505	47,75	64,2	-	-	55	-	few	±55/2000 m2

Species richness:

The number of species per plot varies between + 25.ha^{-1} in the riveredge forest on the recluded levee and ± 55 in the peat forest on very deep (<8 m) peat (Table 7).

This number is comparable with the species richness of swamp forests in Riau (Sumatra), Kalimantan (Anderson 1976) and Johore (Malaysia) (Corner 1978) (Table 7).

Table 7 Comparison of the mean species richness between several swamp forests in South East Asia (between brackets: lowest - highest amount of species within an area).

LOCATION / VEGETATION TYPE	Berbak game reserve Jambi province, Sumatra Silvius, Simons, Verheugt	Berbak game reserve Roos & Franken 1981	Telok kiambang Riau province Sumatra Anderson 1976	Muara tolam Riau province Sumatra Anderson 1976	Sungai stuk kecil Riau province Sumatra Anderson 1976	Sungai durian/rasau Kalimantan barat Anderson 1976	Sungai sebangau Kalimantan tengah Anderson 1976	Jurung Road Singapore, Malaysia Corner 1978
Freshwater swamp forest (including riverine forest)	34 (25-45)	75						32 (31-33)
Peat swamp forest	45 (35-55)		34 (24-49)	46 (44-49)	31 (29-32)	39 (23-55)	49 (39-62)	

Floristic differences:

Main differences between the floristic composition of the vegetations are given in Table 8.

Table 8 Characteristic and differentiating species of five swamp forests in Berbak

x : characterizing species

- : remarkable absence

	Riverine forest on reduced levee BV	Riverine forest in oxidized levee BI	Freshwater swamp forest BII	Peat swamp forest 2½ m deep peat BIII	Peat swamp forest > 8 m deep peat BIV
1. Oncosperma tigillarium	X				
2. Callophyllum sp.	X				
3. Mammea sp.	X	X			
4. Theysmanniodendron sp.		X			
5. Antidesma montanum			X		
6. Alstonia pneumatophora			X		
7. Baccaurea bracteata			X		
8. Blumeodendron tokbrai			X		
9. 'Bengkal' (Lauraceae)				X	
10. Tetramerista glabra				X	X
11. Gluta sp.				X	X
12. Magnoliaceae (undet.)					X
13. Polyalthya sp.	X	X	X	X	-
14. Dyospyros bantamensis			X	X	X
15. Stemonurus secundiflorus		X	X	X	X
16. Eugenia sp.	X	X	X	X	X

The riverine forest is characterized by Mammea Sp.. which is dominant on the reduced clay-levee and abundant on the oxidized one. In all other vegetation types it is rare or absent. The abundance of its pneumatophores is an important physiognomic feature on the reduced levee. Furthermore, the vegetation of the oxidized levee is characterized by the occurrence of Allophyllus cobbe in the under and middle storey and Callophylum sp. in the upper storey.

The freshwater-swamp forest is characterized by Alstonia pneumatophora in the upper storey, although it can occur in the riveredge forest on reduced clay as well. But there it is rare and plays a minor role in the forest structure. Franken & Roos (1981) studied a vegetation plot in the freshwater-swamp forest of Berbak too. It was one of the wettest places in the forest, the largest part being inundated up to knee height. Like in plot BII Alstonia pneumatophora was the dominant species in the upper storey. Anderson (1976) found this species in the peat swamp forest of Telok Kiambang (Riau province Sumatra). The trees had an average basal area of 0.077 m^2. In plot BII the trees have an average basal area of 0.85 m^2. This can be an indication that Alstonia pneumatophora does not have its optimum conditions on peat. This is supported by the fact that we never encountered it on deep peat.

Apart from the huge Alstonia in the upper storey, Antidesma montanum, which is abundant in the under storey, is indicative for the freshwater--swamp forest. It is rare or absent in the other vegetation types. However, in the plot of Franken & Roos (1981) it played a minor role. Two other important species are Baccaurea bracteata and Blumeodendron tokbrai. They are not uncommon in the other types, but the abundancy in plot BII certainly is a distinguishing feature.

The freshwater-swamp forest and riverine forest are distinguished from the peat swamp forests by the occurrence of the palm Licuala valida. Large areas in the subgrowth and under storey can be covered by this species. Furthermore, rattans are common to abundant as well. On shallow to moderately deep peat, rattans are common too but on deep peats they are rare.

A typical species of the moderately deep peat forest is 'Bengkal' (Lauraceae). Typical for the deep peat forest is the species of the Magnoliaceae, which is abundant in the under and middle storey. Some characteristic middle- and upper-storey species of the peat swamp forest are Tetramerista glabra and Gluta sp.

Remarkable is the absence of Polyalthia sp. in the deep peat forest which is abundant or common in the other vegetation types. With its conspicuous white outerbark it is an important feature to distinguish both peat swamp forest types.

Some species which are common in both freshwater swamp forest and the peat swamp forest are: Kompassia malaccensis in the upper storey and Dyospyros bantamensis and Stemonurus secundiflorus in middle and understorey.

On the deep peat 2 km further from the river than plot BIV, the herb Nepenthes ampullaria was dominant in the subgrowth. As this plant is able to derive its nitrogen from small insects which it catches in beakers at the end of the leaves, its occurrence might be an indication for a low nitrogen level in the peat soil.

Differences in forest structure:

Some important physiognomic features are:
- the abundance of the pneumatophores of Mammea sp. in the riverine forest;
- the abundance of the pneumatophores of Alstonia pneumatophora in the freshwater swamp forest;
- the occurrence of large areas dominated by the palm Licuala valida in freshwater swamp forest and both riverine forests, resulting in a dense understorey;
- the absence of rattans in the peat swamp forest on deep peat, resulting in a more open understorey.

Furthermore, there are differences in forest structure concerning height of the vegetation, basal area, tree density and layering (Table 6). The basal area varies between 21,7 $m^2.ha^{-1}$ in the riverine forest on the oxidized levee to 51,29 $m^2.ha^{-1}$ in the freshwater-swamp forest. Although in most plots the trees with a diameter smaller than 30 cm cover more than 90% of the total number of trees, the basal area is covered for 60-70% by trees with a diameter larger than 30 cm. Only in plot BV on the oxidized levee, in the riverine forest, this ratio is the other way round, due to the very small number of trees with a diameter larger than 30 cm. The peat-swamp forest on deep peat (plot BIV) has a very high basal Area, compared to findings of Anderson (1976) in Telok Kiambang. He generally found basal areas of 30 $m^2.ha^{-1}$. A plot surveyed near the

peatdome had a basal area of 22,5 $m^2.ha^{-1}$, so less than half of the basal area of plot BIV. Anderson described some forests of the peatdomes as 'Padang forests', a forest mainly composed of small trees with a polelike aspect, small dense crowns and generally an even canopy.

On the deepest peat we found in Berbak, the peat swamp forest was about 10-15 m lower than the forest of plot BIV, resulting in a height of 35-40 m (Figure 8). The diameter of the trees also was smaller, and the forest was denser. Still this forest is not comparable with the 'padang forest'-type.

An important structural aspect of the freshwater-swamp forest is the layering of the vegetation. Alstonia pneumatophora forms (together with some other species) a distinct toplayer (Figure 8). The layering of this vegetation might be the origin of the large number of trees with Ht/d <<100 in the middlestorey and understorey (nearly 44%) (Appendix 10). The Ht/d ratio is important considering the hypothesis that a nearly fullgrown tree has a good competitive position and therefore is able to invest in the expansion of its trunk. Normally the line Ht/d=100 is taken as a standard (Hallé 1978).

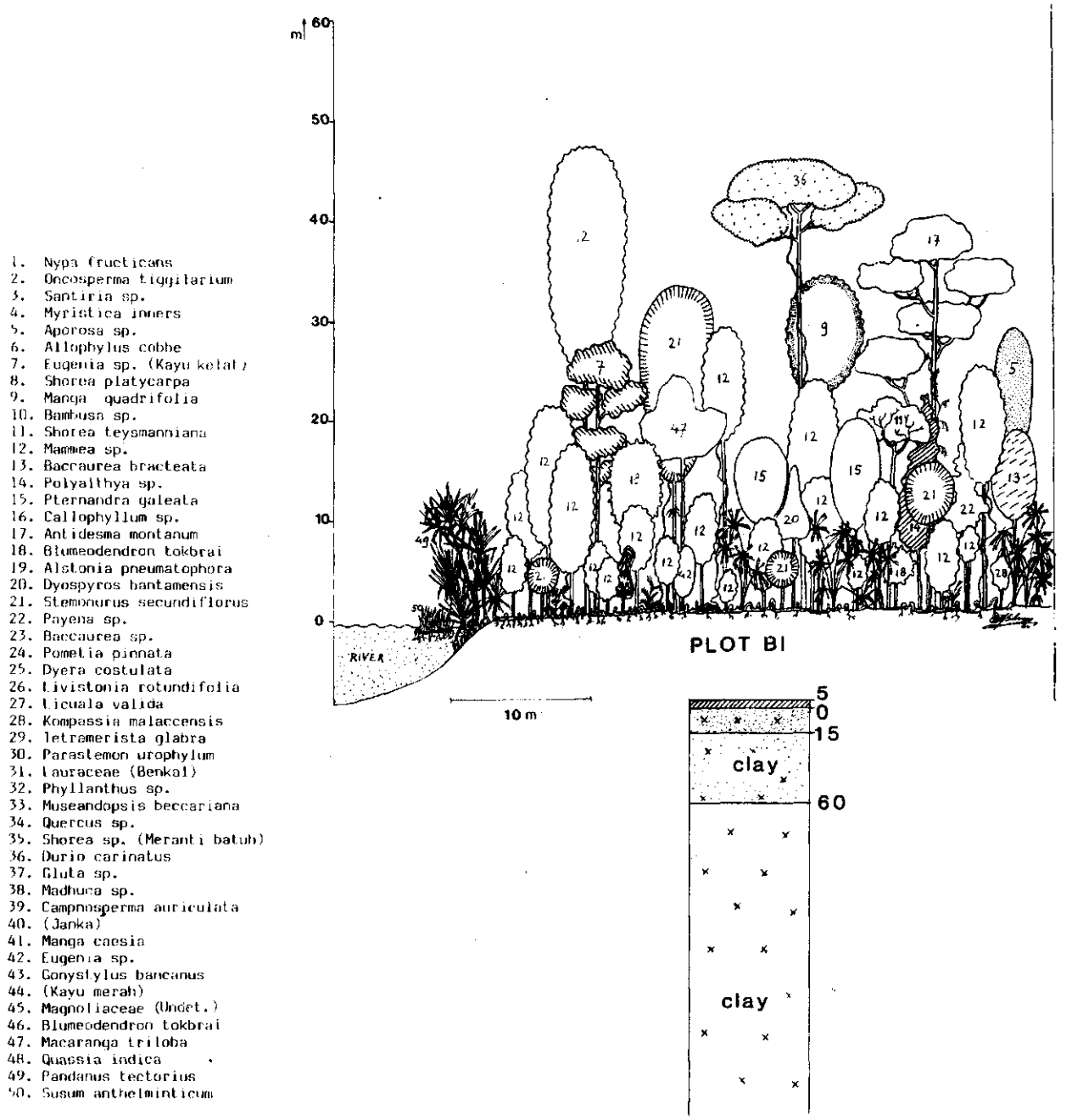
In the Ht/d figures (Appendix 9) the differences in Ht/d ratios and their change from understorey to upperstorey are clear.
Remarkable is the number of trees with Ht/d <<100 in the riverine forest. In the peat-swamp forest there is a continuous change of many trees with Ht/d >100 in the upper storey to many trees with Ht/d >100 in the lower stories.

Explanation of the profile diagram

Figure 8 Transect through the riverbank vegetation, riverine forest, freshwater-swamp forest and peat-swamp forest

- The profile diagram of each vegetation plot represents a total surface of 400 m^2 (40x10 m). The scale of plot BV is slightly different from the other plots.
- The total number of trees of each species in the diagram is comparably with the number of trees in the vegetation plot.
- Height of trees and the height of the first branch (treebole base) are comparable with the measured heights in the field.

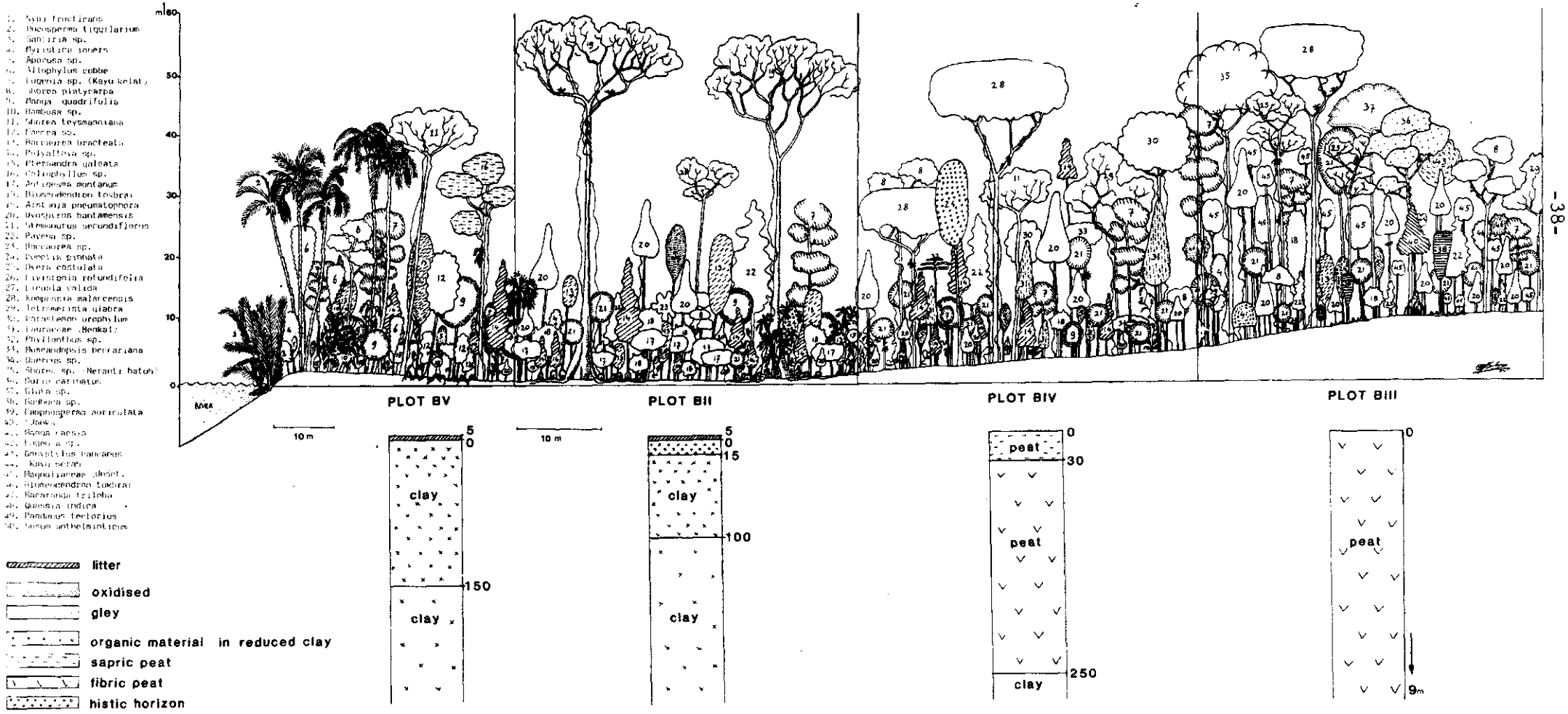
- The trees are placed at random in the diagram of each plot, except Oncosperma tiggilarium in plot BV.
- The coverage of each crown is estimated.
- The number of rattans, epiphytes, lianas and pneumatophores is not commarable with the number in the field.
- At the farthest end of the diagram of plot BIV, the decrease of forest height on very deep peat is indicated.



1. Nypa fruticans
2. Oncosperma tiggilarium
3. Santiria sp.
4. Myristica inners
5. Aporosa sp.
6. Allophylus cobbe
7. Eugenia sp. (Kayu kelat)
8. Shorea platycarpa
9. Manga quadrifolia
10. Bambusa sp.
11. Shorea teysmanniana
12. Mammea sp.
13. Baccaurea bracteata
14. Polyalthya sp.
15. Pternandra galeata
16. Callophyllum sp.
17. Antidesma montanum
18. Blumeodendron tokbrai
19. Alstonia pneumatophora
20. Dyospyros bantamensis
21. Stemonurus secundiflorus
22. Payena sp.
23. Baccaurea sp.
24. Pometia pinnata
25. Dyera costulata
26. Livistonia rotundifolia
27. Licuala valida
28. Kompassia malaccensis
29. Tetramerista glabra
30. Parastemon urophylum
31. Lauraceae (Benkal)
32. Phyllanthus sp.
33. Museandopsis beccariana
34. Quercus sp.
35. Shorea sp. (Meranti batuh)
36. Durio carinatus
37. Gluta sp.
38. Madhuca sp.
39. Campnosperma auriculata
40. (Janka)
41. Manga caesia
42. Eugenia sp.
43. Gonystylus bancanus
44. (Kayu merah)
45. Magnoliaceae (Undet.)
46. Blumeodendron tokbrai
47. Macaranga triloba
48. Quassia indica
49. Pandanus tectorius
50. Susum anthelminticum

Figure 8b. Profile diagram of a riveredge forest on a reduced clay-levee and freshwater-riverside vegetation

Figure 8a. Profile diagram of the transect through brackish water - riverside vegetation on an oxidized clay-levee, freshwater swamp forest and peat swamp forest



4.4 Mangroves

Mangroves near desa Cemara

The transect is located about 300 m south of parit 1 of desa Cemara. It starts at the sandy beach and is directed east-west (inland). It crosses a small mangrove creek (S. Cemara), that flows from north to south in the transect. About 1 km southward this creek bends to the east and mouths into the South China Sea (Photo 15).

Between the beach and the river, the transect crosses ten different vegetation zones (Figure 9).
The main zones are:
1: Beach vegetation with Convulvulaceae
2: Dry beach forest, dominated by Casuarina equisetifolia
3: Small zone with Juncus and grasses
4 and 5: Young Avicennia intermedia followed by a mangrove forest with three species (see Figure 9).
6: A second zone of dry beach forest, with older Casuarina trees.
7 and 8: Transitional zone between the dry beach forest and the mangrove forest, consisting of Excoecaria agallocho and Clerodendrum sp.
9 and 10: Wet mangrove forest, containing six species; nearer the river five species (see Figure 9).
An extensive description is given in Appendix 9.

At the westside of the Sungai Cemara, the vegetation consists mainly of four species: Avicennia alba, Avicennia intermedia/officinalis, Bruguiera parviflora, Rhizophora mucronata. Figure 10 shows the differences in height. Avicennia intermedia/officinalis dominates the vegetation in the lower storey. Avicennia alba is dominant above 15 m height. Remarkable is that both Avicennia increase in height after 200 meters distance from the river.

In the back of this mangrove zone two species of Acanthus occur: A. ebracteatus and A. ilicifolius. At some places they are abundant. Occasionally Cereops candolleana occurs. 350 m from the river the mangrove forest has been cut. Here both Acanthus species cover large areas.

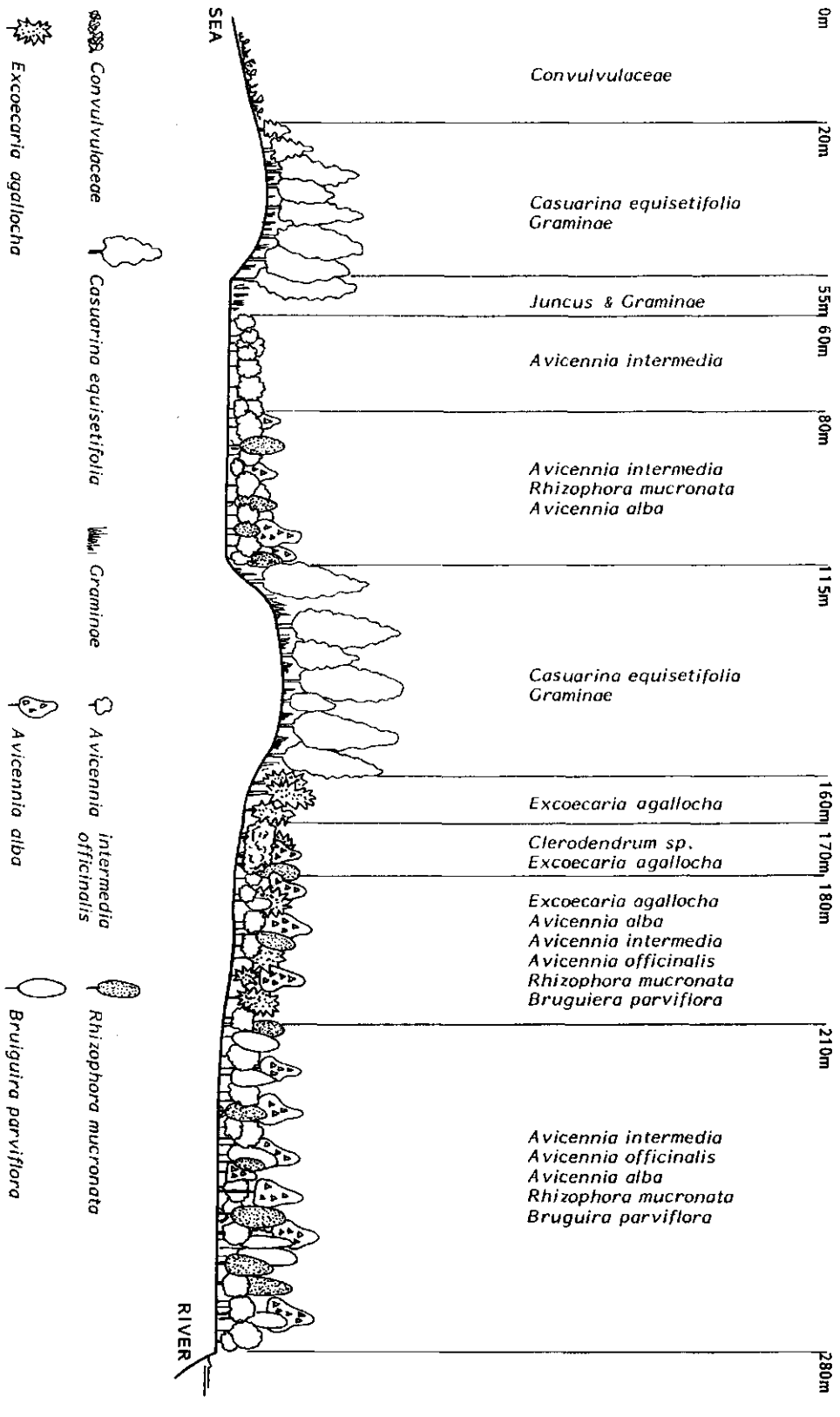


Figure 9 Mangrove transect, simplified profile diagram near desa Cemara

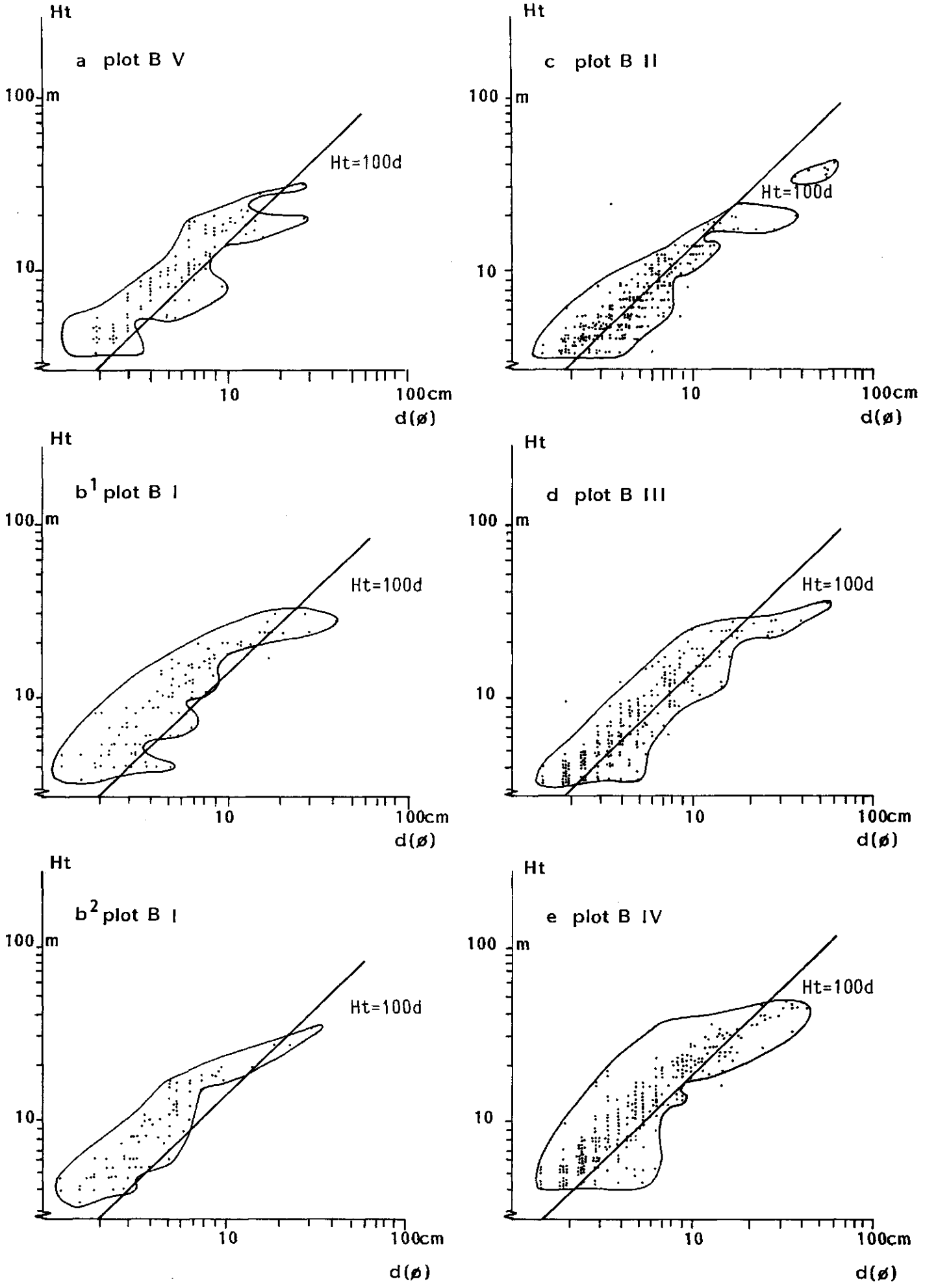


Figure 10 Average height of the four main tree species of the mangrove forest on the west side of Sungai Cemara.

Mangroves south of the Sungai Cemara

South of the river mouth of the S. Cemara a muddy mangrove occurs. Avicennia intermedia and A. officinalis are dominant, also as colonizing species (Figure 11, (Photo 13).

Rhizophora mucronata, Avicennia alba and Bruguiera parviflora occur mainly in the back swamp. The muddy (very unripe) clay is characterized by a fast colonizing zone. Every year a new mangrove forest zone is established, up to 30 m in length. 5 or 6 years old trees have buried roots at a depth of 50-60 cm.

In the zone 120-170 m inland, saplings of Avicennia intermedia and A. officinalis are abundant (Photo 16). The back swamp (with somewhat riper clay) has been disturbed almost everywhere. On places where it is not yet brought into agriculture, young shoots of Excoecaria agallocha grow out the remainders of the chopped old trees. Acanthus ebracteatus and A. ilicifolius cover large parts of the acreage.

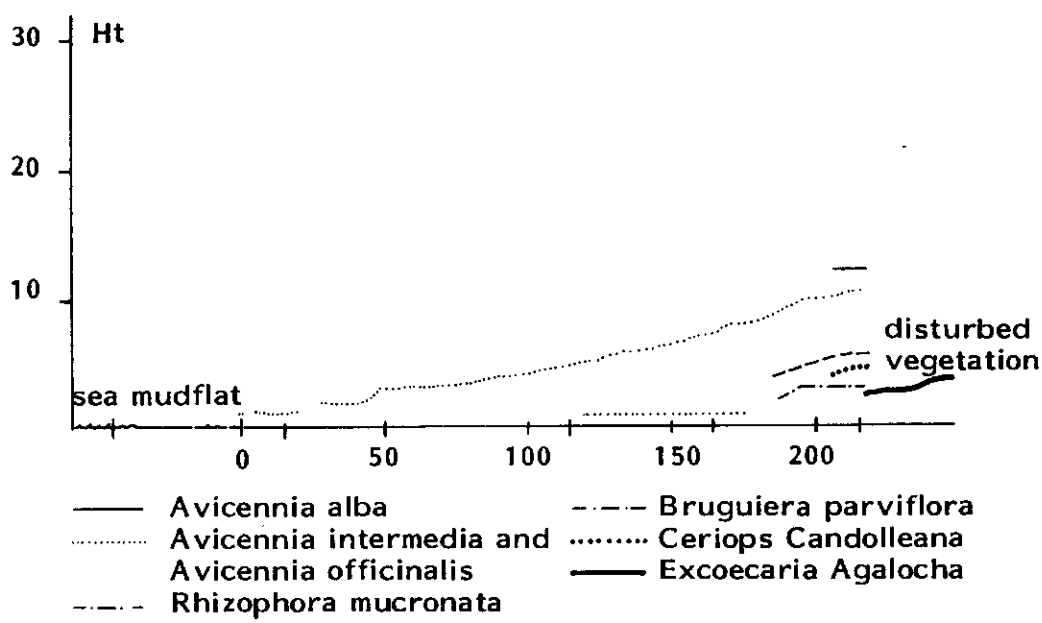


Figure 11 Transect through muddy mangrove south of desa Cemara, showing the height of the occurring tree species.

4.5 Conclusions

1) The main vegetation types of Berbak are peat-swamp forest and freshwater-swamp forest covering nearly 90% of the total area.
2) The freshwater-swamp forest occurs on mineral riverine deposits (reduced clay). The peat-swamp forest occurs on ombrotrophic peats (reduced acid peat).
3) The vegetation on the levees and pematangs can be subdivided from the freshwater-swamp forest on criteria of geomorphology, pedology, flora and vegetation structure.
   The main floristic criterium is the abundance of Mammea sp. Important structural criteria are the occurrence of many pneumatophores and the absence of tall trees.
4) Alstonia pneumatophora is an important species of the freshwater-swamp forest. It dominates the highest stratum and determines the basal area for nearly 50%.
5) The basal areas, found in the freshwater-swamp forest, are comparable to the findings of Anderson (1976) in the Riau province (30-50 $m^2.ha^{-1}$). High basal area values are found in the peat-swamp forest (47,7 $m^2.ha^{-1}$).
6) Remarkable is the height of the peat swamp forest on very deap peat. Instead of a 'padang forest', a quite normal peat-swamp forest is found, with a height of at least 35 m and a normal number of species (55/2000 m^2).
7) Ratans occur mainly in the freshwater-swamp forest and the riverine forest. In the freshwater-swamp forest places occur where rotan semut (Korthalsia sp.) is dominant.
8) Floristic differences between the freshwater-swamp and the peat-swamp forest are apparent. In peat-swamp forest Polyalthya sp. (Putih putih) and Alstonia pneumatophora are lacking. Others are more abundant: Tetramerista glabra, Gluta sp., Dyera costulata and Payena sp. Some species are restricted to peat: one species of the Magnoliaceae ((yet)unidentified nr 4), Blumeodendron kurzii and Myristica sp.
9) Distinct strata occur only in the freshwater-swamp forest, due to Alstonia pneumatophora.
10) The Ht/d ratio is very low in the freshwater-swamp forest, due to a high amount of thick trees.

11) The riverbank vegetation consists of:
    - in sometimes brackish water: Nypa fructicans
    - in always fresh water: Pandanus tectorius and
      Susum anthelminticum
12) The mangrove forest is largely disturbed. It consists of very few species, mainly Avicennia alba, Avicennia intermedia. Avicennia officinalis, Rhizophora mucronata, Bruguiera parviflora, and Excoecaria agallocha.
13) The dry beach forest is dominated by Casuarina equisetifolia.
14) The species richness of swamp forests of Berbak is comparable with the species richness of freshwater and peat-swamp forests in Riau (Sumatra), Kalimantan and Johore (Malaysia).

5 FAUNA

5.1 State of knowledge and objectives

Little is known about the fauna of the Berbak game reserve. Only a few zoologists did some (brief) surveys: Endert (1936), Wind (1976), De Wulf (1982), Blouch (1983). Blouch did a survey on large mammals' occurrence in South East Sumatra with special reference to Rhinos and Elephants, but he found no evidence for their presence in Berbak.

The objective of our studies was to collect data on the occurrence of large mammals, birds and large reptiles. Some insect collections were made as well.

Methods

We mainly used visual methods, i.e. direct observations of living animals, tracks and incidentally dead animals. In the forest, observation of living animals is very difficult because of the vegetation density. The sight range seldom exceeds 20-30 m. Conditions are very hard. After several bad experiences one is more inclined to watch for pneumatophores and the sharp rattans in order not to stumble down and to get hurt. During the cleaning of the path with 'parangs' (large chopping knife), a lot of noise is made. Identification in the field has mainly been done with 'Guide to the mammals of the Southeast Asian Archipelago and New Guinea' (van Strien 1981/1982). For determination of the tracks photographs were made. They were also identified in the field with 'A guide to the tracks of mammals of western Indonesia' (van Strien 1983).

The avifauna study had a thorough character. Many observations have been done in all kinds of habitats. A lot of forest species, like hornbills were frequently seen above the rivers crossing from one side to the other at treetop height. Others were regularly encountered near the borders of small tributaries (S. Simpang Malaka). Notes were made about number, habitat, and date of observation. The identification was mainly done with 'A Field Guide to the birds of South-East Asia' (King 1975) and 'Sumatran birds' (van Strien 1977). Since an extensive account on birds does not fit within the framework of this report, a special report on birds of Berbak will be published elsewhere. Reptiles were occasionally met. Identifications of turtles and snakes were done at Leyden (The Netherlands) in the Museum of Natural History, on account of photographs, descriptions and some collected specimens.

5.2 **Mammals**

A species list of large mammals is given in Table 9. A comprehensive description about occurrence and observation is given in Appendix 10. On Figure 12 the location of the observation sites is mapped.

Table 9. Preliminary species list of large mammals of the Berbak game reserve.

		Number of observations	Riverine forest	Freshwater swamp forest	Peat swamp forest	Mangrove (including Nypa-zone near coast)	Dry beach forest	Cultivated area	Literature species not observed in the last years
Cynocephalus variegatus	Flying lemur	1		X					
Macaca fascicularis	Crab-eating Macaque	Many	X	X	X	X	X		
Macaca nemestrina	Pig-tailed Macaque	1	X						
Presbytis cristata	Silvery leaf Monkey	+ 40	X	X	X	X	X		
Symphalangus syndactylus	Siamang	8		X	X				
Hylobates agilis	Dark-handed Gibbon	1		X					
Manis javanicus	Scaly Ant-eater	X							FAO 1982a
Sundasciurus tenuis	Slender Squirrel	2		X					
Callosciurus prevostii	Prevost's Squirrel	10		X	X				
Lariscus insignis	Three-striped ground-Squirrel	1	X						
Petaurista petaurista	Red Giant flying-Squirrel	1		X					
Hystix brachyura	Common Porcupine	X							FAO 1982a
Helarctos malayanus	Sun Bear	1		X				X	
Martes flaviguia	Yellow-throated Marten	3		X					
Lutra lutra	Common Otter	+ 4	X			X			
Arctitis binturong	Binturong	1	X						
Felis bengalensis	Leopard Cat	1				X			
Panthera tigris	Tiger	7	X	X		X		X	
Tapirus indicus	Malay Tapir	6	X	X	X				
Rhinoceros sondaicus	Javanese Rhinoceros	-							FAO 1976b
Dicerorhinus sumatrensis	Sumatran Rhinoceros								FAO 1982 a
Sus scrofa	Common wild Pig	Many	X	X		X		X	
Sus barbatus	Bearded Pig	4?	X	X				X	
Tragulus javanicus	Lesser Mousedeer	3	X	X					
Tragulus napu	Larger Mousedeer	3	X	X					
Cervus unicolor	Sambar	2		X					
Bubalus bubalus	Waterbuffalo								Endert 1936
Pteropus vampirus	Kalong	2							

Remarks to Table 9:

The peat-swamp forest being less thoroughly surveyed than the other areas, the number of species recorded in this biotope might give an underestimation of the actual species richness. Tracks of animals are difficult to find in this forest because of the rough litter on the topsoil.

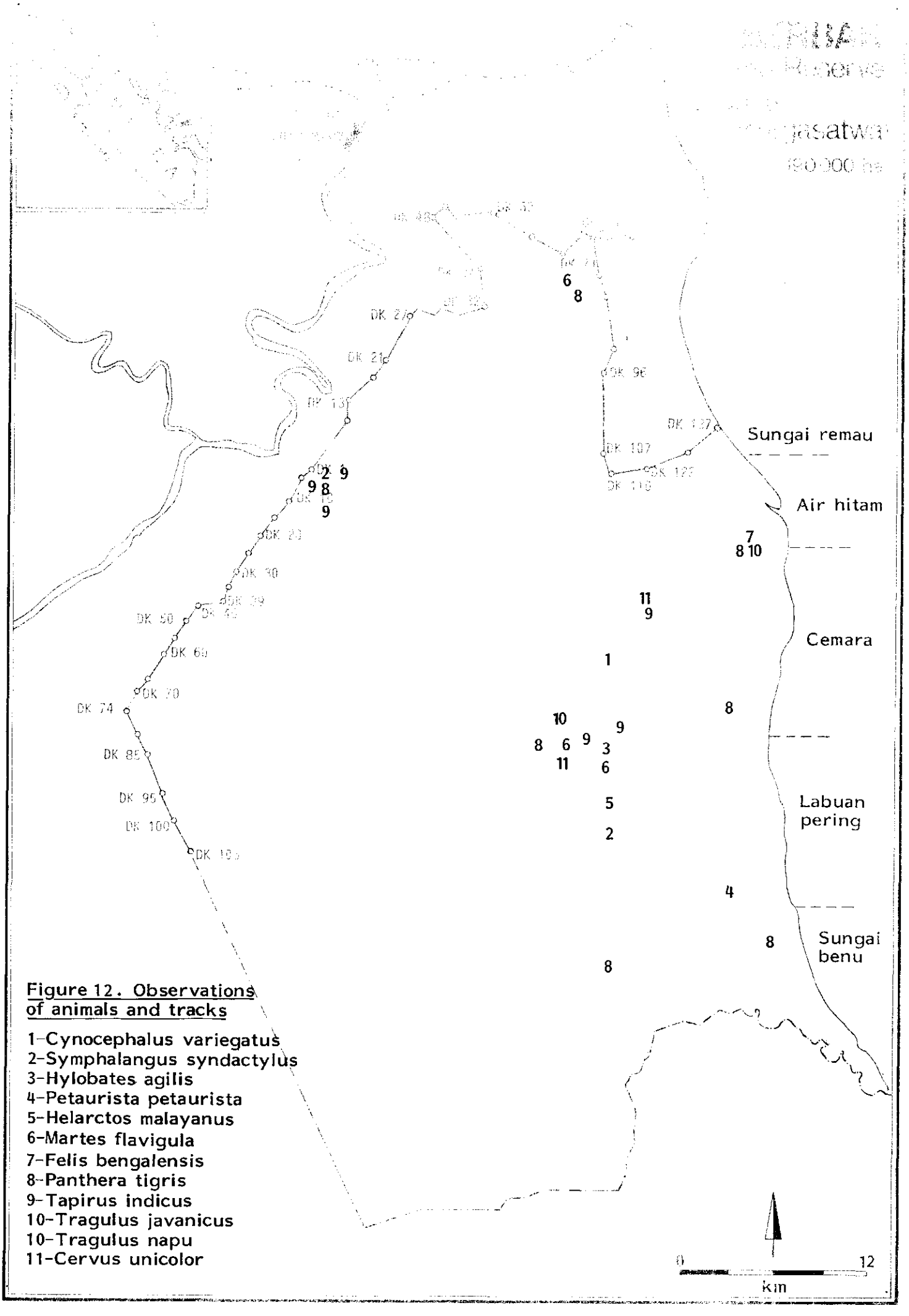


Figure 12. Observations of animals and tracks

1-Cynocephalus variegatus
2-Symphalangus syndactylus
3-Hylobates agilis
4-Petaurista petaurista
5-Helarctos malayanus
6-Martes flavigula
7-Felis bengalensis
8-Panthera tigris
9-Tapirus indicus
10-Tragulus javanicus
10-Tragulus napu
11-Cervus unicolor

5.3 **Birds**

The species list of birds is given in Appendix 11. This list is not yet complete. To the very last days of the fieldwork period new species were recorded. Some more species should occur. Especially in the freshwater swamp forest and peat swamp forest, where the observation of birds is very difficult due to the dense vegetation, new species for Berbak might be found.

Some remarks on rare birds and some special families:

Egretta eulophotes - Chinese Egret

This vulnerable species (IUCN Red data book) was observed once on the beach near desa Cemara (two specimens).

Ibis cinereus - Milky Stork

This species was seen quite often along the coast. Occasionally up to 16 specimens were seen together.

Ciconia episcopus stormi - Storm's Stork

From this species two specimens were seen between S. Simpang Kubu and S. Simpang Gaja, on the borders of the river S. Air Hitam.

Aviceda leuphotes - Black Baza

According to King (1975) and Brown & Amadon (1968) this species is not known from Sumatra. In winter, however, its range includes the Malayan peninsula. Because of the geographical position (beneath the end of the Malayan peninsula), Berbak is one of the most probable places on Sumatra for this species to appear. It is generally known that especially in winter small groups of these birds cross the South China Sea in the direction of Sumatra. On 3-11-1983, four specimens were seen near S. Simpang Gadja.

Argusianus argus - Great Argus

We did not observe this species ourselves. But according to the PHPA-guides this bird is occasionally seen and heard in the freshwater-swamp forest.

Fam. Scolopacidae

On the mudflats along the coast, in the migrating period and from November to March many waders are observed (Photo 46). Especially Limosa limosa was seen in large flocks (up to 2000 specimens). Species occurring in fairly large flocks (100-500) are: Charadrius mongolus, Pluvialis squatarola, Limosa lapponica, Tringa totanus, Xenus cinereus and Calidris ferruginea. For some species King (1975) does not mention the occurrence on Sumatra: Tringa stagnatilis and Calidris tenuirostris. The first

species was seen in small numbers (10-15). The C. tenuirostris occurs in flocks of 40-70 birds.

Fam. Alcedinidae

All known kingfishers from Sumatra occur in Berbak (11 species). Some of them are confined to the rivers: Alcedo meninting, Alcedo atthis, Ceyx erithacus, Halcyon coromanda and Halcyon concreta. Others occur along the rivers and in the mangrove forests as well: Pelargopsis capensis, Halcyon pileata and Halcyon chloris. The last one also occurs in the cultivated areas behind the mangroves. There it is sharply separated from the Halcyon smyrnensis which occurs just a little bit further landinward. Sometimes this spatial division in habitat is not more than a few hundred meters. Near desa Cemara a small overlap in their distribution was noticed. Sofar it had been assumed that these species occupied strictly separated habitats.

Ceyx rufidorsus seen only in the mangrove. Some species are also observed along the parits in the cultivated areas (Alcedo atthis and Alcedo meninting). Most common are: Alcedo meninting, Halcyon chloris and Pelargopsis capensis. Common are: Halcyon smyrnensis and Alcedo atthis (only in winter). Other species are rarely seen (one to five specimens in total).

Fam. Bucerotidae

From this family nine species are observed. The rarest one is the Rhinoplax vigil ('undeterminate'-listed in the IUCN Red data book). This species was regularly heard and seen. Noteworthy is also Buceros bicornis.

Aegithina lafresnayei - Great Iora. This species was not yet known from Sumatra. It was seen two times in the dry beach forest near desa Cemara.

5.4 **Reptiles and Amphibians**

A species list is given in table 10:

Table 10. Preliminary species list of reptiles and amphibians.

		Rivers	Swamp forest	Nypa vegetation	Mangrove	Cultivated land	Dry beach forest
Turtles	: Orlitia borneensis	X					
	Cyclemys dentata		X				
Snakes	: Python reticulatus		X			X	
	Bungarius fasciatus			X			
	Boiga dendrophila melanota			X			
	Cerberus rhynchops				X		
	Dendrophis pictus					X	
Lizards	: *Draco sp.*		X				
	Varanus salvator	X		X	X		
	Tachydromus sexlineatus (Daudin)						X
	Mabuia rudis (Boulenger)		X				
Crocodiles:	Tomistoma schlegeli	X					
	Crocodilus porosus	X					
Toads	: Bufo subasper	X					

A comprehensive description of the observations is given in Appendix 12. The species list is incomplete, especially as to snakes, lizards and amphibians. PHPA guides told us that also some other turtle species occur in the rivers. One of these species might well be the Batagur baska.

5.5 Insects

During the fieldwork some insect collections were made. The preliminary results of pitfall transects and hand/lamp catchings are given in Appendix 13.

5.6 Conclusions

1) Berbak has a rich fauna including species such as Symphalangus syndactylus, Hylobatis agilis, Helarctos malayanus, Lutra lutra, Arctitis binturong, Panthera tigris and Tapirus indicus.
2) The large mammals mainly occur on the higher grounds in the fresh-water swamp forest and on the levees and pematangs along the river. Pigs are common also in the disturbed vegetation along the coast. This is probably the reason why also the tiger frequently visits the reclamed area.
3) The avifauna of Berbak is very rich, containing 224 species of 49 families. It includes some species not yet known from Sumatra: Aviceda leuphotes and Aegithina lafresnayei. All kingfisher species (Alcedinidae) known from Sumatra (11) occur. From the hornbill species (Bucerotidae, Sumatra 10 species) nine species have been observed in Berbak, including Rhinoplax vigil and Buceros bicornis.
4) During the migrating period and the winter, many waders (Scolopacidae and Charadridae) visit the mudflats of Berbak, totally 22 species.
5) Until now 13 species of reptiles are known from Berbak, including the Tomistoma schlegeli, Crocodilus porosus and Orlitia borneensis. It is likely that Berbak has far more reptiles, especially more snakes, turtles, agamas and skinks.

6 HUMAN ACTIVITIES

6.1 State of knowledge and objectives

For analysing the various impacts of landuse upon the ecosystem of the reserve and possible impacts of future development, the following subjects have been investigated:

- which parts of the reserve have been cleared for agricultural purposes;
- which settlements have been established inside the reserve;
- the social geographical developments in these settlements from the time of reclamation until now;
- impact of reclamation on the surrounding forest (i.e. burning zone);
- the development of fishery production offshore along Berbaks coast;
- poaching activities inside the reserve;
- small scale sawmill activities near the reserve.

Methods

Data were gathered by means of fieldwork and interviews; besides, some literature was studied. However, there is little literature available on coastal swampland development in the Jambi province. For the Berbak reserve, de Wulf & Kauf (1982) carried out a preliminary research on the impact of reclamation inside the reserve upon the ecosystem. Nevertheless, data on agricultural and fishery production in these villages are completely lacking.

- The description of the socio-economic development of the Bugineze villages within the reserve, is based on two main sources:
  - statistics on the population survey of 1980; Sensus Pendudukan 1980 (Biro Pusat Statistik Jambi 1980a) and
  - the national agriculture survey; Sensus Pertanian 1983 (Biro Pusat Statistik Jambi 1984).

    Data of this survey were acquired directly from the several municipalities.

  Interviews were made with the village leaders (Kepala desa), to confirm our findings. This information was checked again with findings from the statistic offices of the Camat and on provincial level in Jambi. Farmers and fishermen were frequently interviewed. This was occasionally possible with the help of the PPA guards, who translated the Bugineze language into the Indonesian language.
- Information on agricultural production, including agro-climate figures,

could be obtained at the Agricultural Service of the Jambi province in Jambi and Nipah Panjang. Literature on agriculture in coastal swampland has been studied, among others Collier (1979a, 1980), Driessen & Sudewo (1977), Hanson & Koesoebiono (1970). Additional climatic data could be derived from the Meteorological Station of Jambi.

- Information on woodlogging activities within the reserve was gained by interviewing PHPA officials in Jambi and Bogor. Also reports made by survey teams of PHPA concerning these forestry activities were studied.

6.2 Regional landuse and population pressure

With an acreage of 4.5 million ha and 1.4 million inhabitants (3.1 inhabitants/km^2), Jambi is one of the smallest Sumatran provinces. The settlements are mainly situated along the Batang Hari river and its tributaries. The coastal swamp area is nearly unoccupied. Main agricultural products are rice and coconut. Rubber is extensively planted along the main river. Important industrial activities are: rubber processing, wood logging, timber processing, and oil exploitation (Indonesian Statistics Year Book 1982).

Adjacent to the reserve's western boundary, in the Kecamatan Kumpeh, there are no settlements, apart from some villages on the banks of the Sungai Kumpeh (Biro Pusat Statistik Jambi 1980b). Virtually, the whole area is under two forest concessions, which both border the reserve boundary (6.4) (Figure 14).

Kubu tribe

In these swamplands the Kubu tribe, the original inhabitants of the Sumatran-Malayan lowlands still roam through the forest in small family groups. These people live in a primitive nomadic or semi-nomadic form of a hunting and gathering economy (Loeb 1972). They hunt and collect nearly everything: tubers and roots, insects, snails, lizards, crocodiles, riverfish, turtles, monkeys etc. Often they follow a fixed route, determined by the maturing of edible fruits or the migrating pattern of wild pigs (Sus scrofa and S. barbatus) (van Rooyen 1927).

Under Dutch-Indies government, their occurrence in Sumatra was already restricted to the triangle formed by the coastal plain, between the Batang Hari river in the north, the Musi river in the south and the Barisan mountain chain in the west (Hagen 1908).

At present, the population figure is not known. Recent data from the Indonesian authorities show that there are about 14 000 Kubus left (Withington 1967). But the figures are rough estimates and not very reliable. Increasing reclamation in the lowlands of Jambi and South Sumatra by governmental or spontaneous settlers and large scale capital intensive economic activities, such as oil exploitation and wood logging, more and more occupy their last residence. Their ultimate choice will be, either to assimilate with the new settlers or to migrate to more inconvenient places like the coastal swamp (Withington 1967) and protected areas like Berbak.

For Berbak, it is estimated that there are still 150 Kubus living (PHPA guards, pers.inf.). However, also for Berbak precise data are lacking. In 1970 there was a little Kubu village near Sungai Kubu, where this river discharges into the S. Air Hitam Laut (PHPA guards, pers.inf.). Sometimes the Kubus were seen when village people were gathering forest produce or at remote parits (canals) along the river. In desa Air Hitam one Kubu woman now is living. She was found by farmers after she had been left alone by her relatives because of illness.

In the last years, the number of encounters is decreasing. It is assumed by the guards that the Kubus have retreated to more undisturbed sites of the reserve. We found evidence of Kubu activities near soil site nr. 4, some 5 km from the S. Air Hitam Laut (bare foot tracks) and near soil site 44 (broken twigs, used for their orientation) (Figure 13).

Transmigrants projects

Transmigrants projects, to relieve Java from its population pressure and for the economical development of Sumatran's lowland resources, started in Jambi in 1937 (Metz & Klomp 1940).

During Repelita I (1969-1974) and Repelita II (1974-1979), 100 000 ha were planned to be reclaimed in Jambi, but only 18 340 ha came under construction (Collier 1979b). Within the PT Satya Jaya Raya logging area (Figure 14) 24 000 ha swamp forest were cleared during Repelita III (1979-1984) (Kantor Transmigrasi Jambi 1983). In the end of the Seventies, a reconnaissance survey was carried out by P_4S (Directorate for opening tidal swamp land for rice cultivation), near the reserve

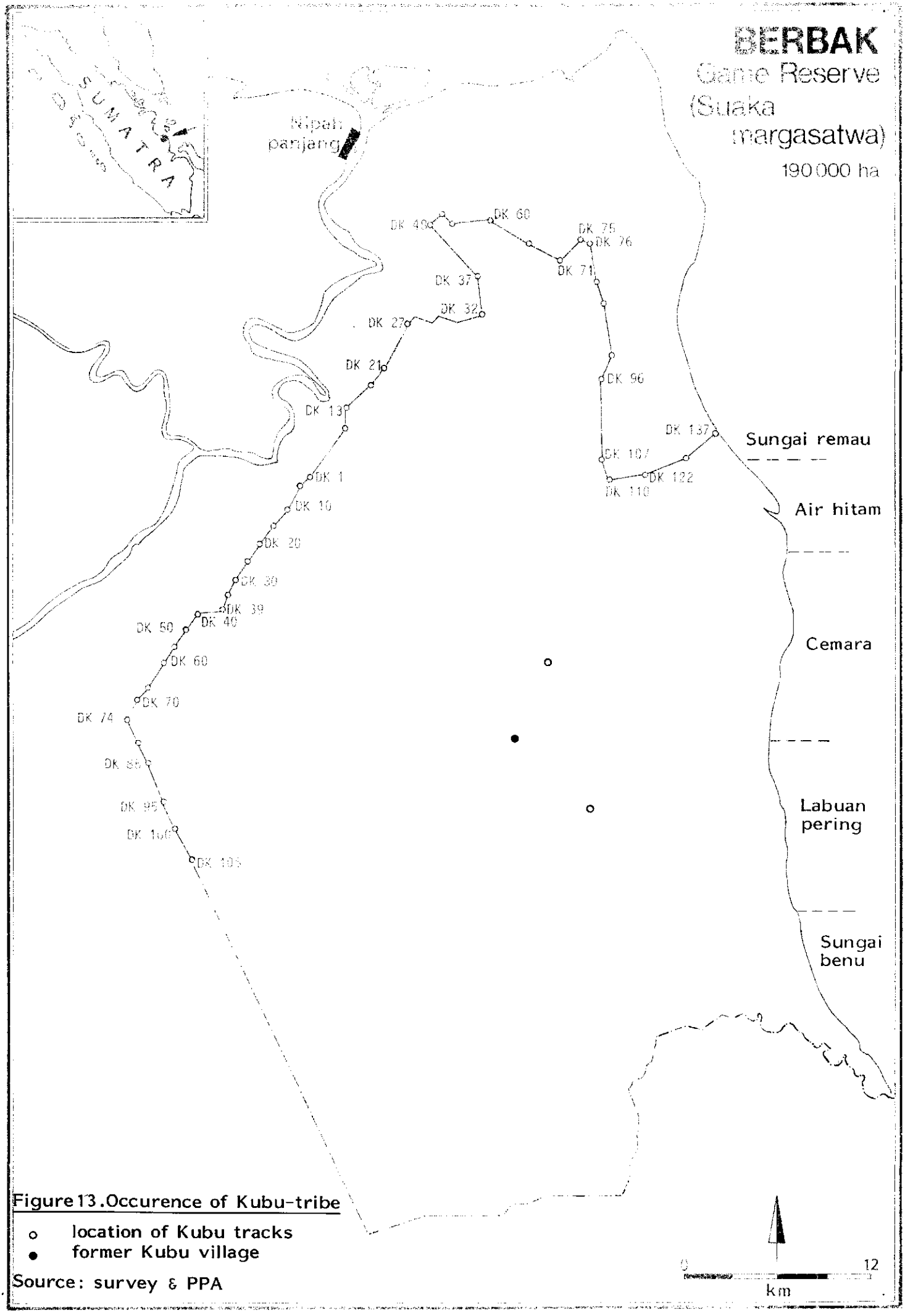


Figure 13. Occurence of Kubu-tribe

- ○ location of Kubu tracks
- ● former Kubu village

Source: survey & PPA

boundary in the North West. The area proved to be unsuitable for transmigrant settlements, no second stage development was scheduled near the reserve boundaries (v.d. Eelaart, senior consultant Euroconsult, pers.inf. 1983).

Besides the governmental supported reclamations, large numbers of spontaneous migrants from South Sulawesi, Java and Madura have opened up the tidal-influenced swamp land in Jambi for rice and coconut cultivation (Collier 1979a).

6.3 Reclamation within the reserve

6.3.1 History of the encroachment

Soon after the establishment of the Berbak reserve, some reclamations took place inside the reserve between 1936 and 1939. About 205 ha land were cleared in the northern part; 108 ha by farmers for food crop production and 25 ha forest were converted into rubber plantations (Mol 1941).

Large scale reclamations (some 40 000 ha) were carried out from the early Fifties on, in the Tanjung Jabung area in the northern part of Berbak. At that time, the boundaries of the reserve were not marked. In 1965/1966, a first group of Buginese settlers came to Berbak. They cleared land along the mouth of the S. Air Hitam Laut and near Sungai Remau. These farmers, spontaneous migrants from South Sulawesi (Kabupaten Wajo and Bone), left their place of birth at the period of the Kahar Muzakar Revolution (MAB 1983). This migration wave reached its peak in 1955, when more than 10 000 Bugis came to Jambi. Most of these immigrants started to work several years on already opened land from relatives, before moving to the coastal swamp area of the provinces of Riau, South Sumatra and Jambi, to open land for themselves (Collier 1979b). In the Berbak reserve, near Air Hitam Laut, 800 ha land were cleared, between 1965 and 1970 (Figure 15) (1). A second wave of migrants came in the early Seventies with the opening of three other villages (desa Sungai Benu, desa Labuan Pering, desa Cemara).

Figure 14. Forest concessions

A concession area of HPH Baru wood company: 100.000ha

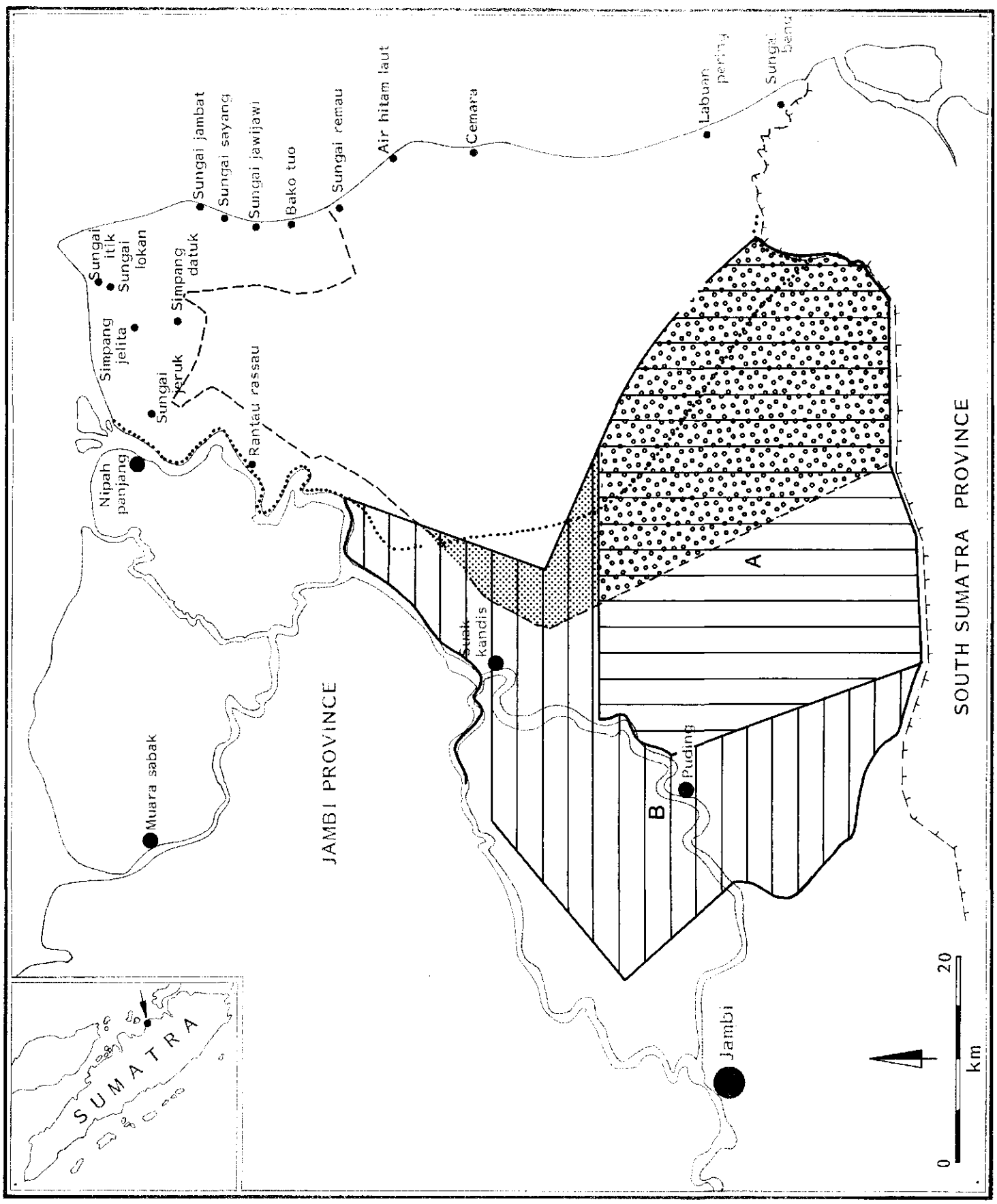
B concession area of PT Satya Jaya Raya: 97.000ha

concession area within the 1974 reserve boundary: 12.500

concession area within the 1974 reserve boundary: 55.000

..... reserve boundary according commission decree of 1935, 190.000ha

---- present reserve boundary according to PHPA Jambi, 190.000ha



6.3.2 **Present situation**

After the opening of the three new settlements in 1971/1972, the total converted acreage soon increased from 1000 ha (1972) to 6500 ha in 1976 (Figure 16) (2). This is 3.4% of the total reserve area. The reclaimed area in 1983 was estimated to be 16 700 ha (or 8.8% of the total reserve area) (Figure 17) (3). Most of the extension is due to a large forest fire, which destroyed nearly 3400 ha virgin forest, during the dry season of 1982. In 1983, new reclamations occurred only sporadi, mainly in the fire- destroyed zone. In desa Simpang Datuk, some new parits (drainage system 6.4.2) have been constructed recently (Photo 18).

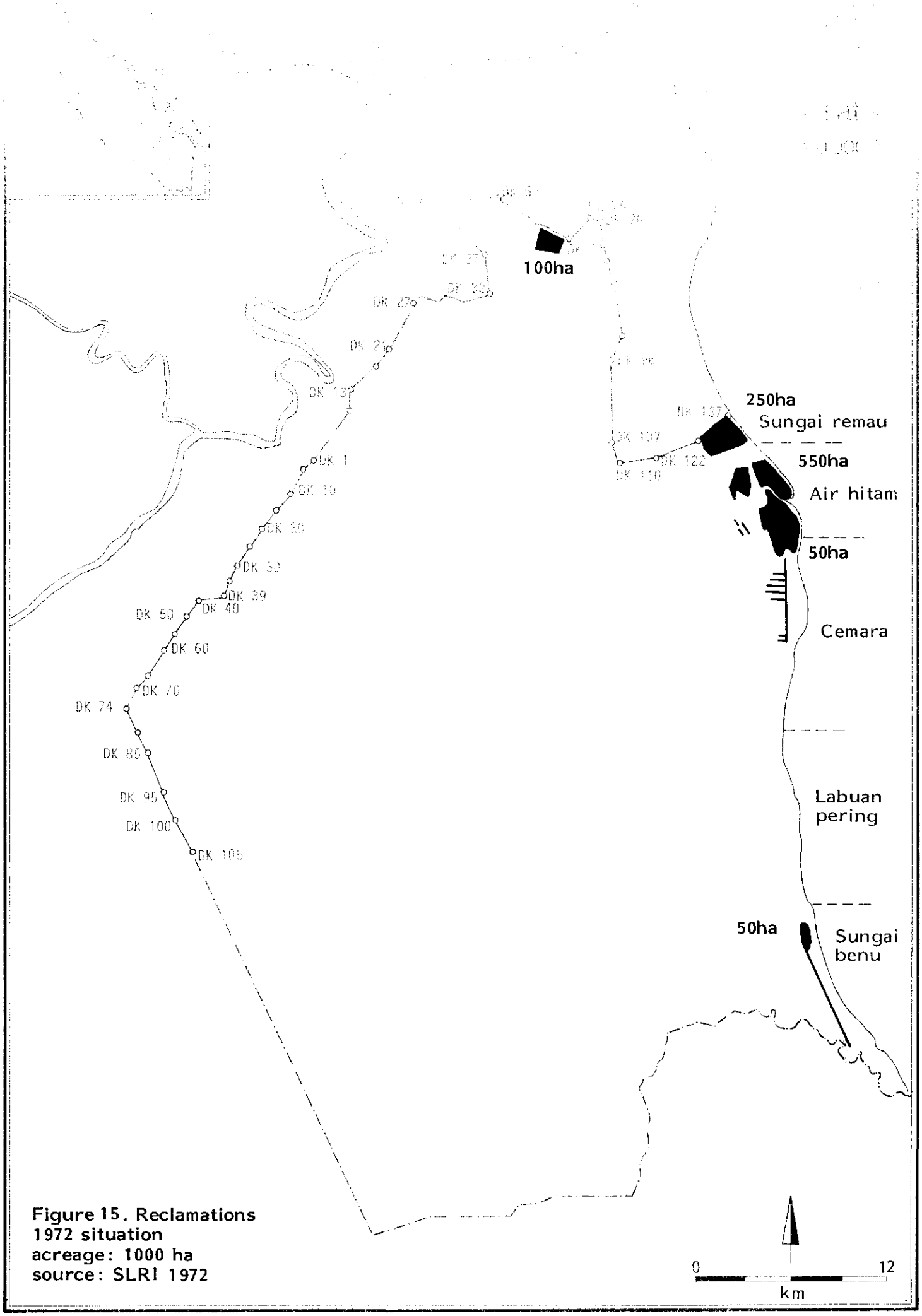


Figure 15. Reclamations
1972 situation
acreage: 1000 ha
source: SLRI 1972

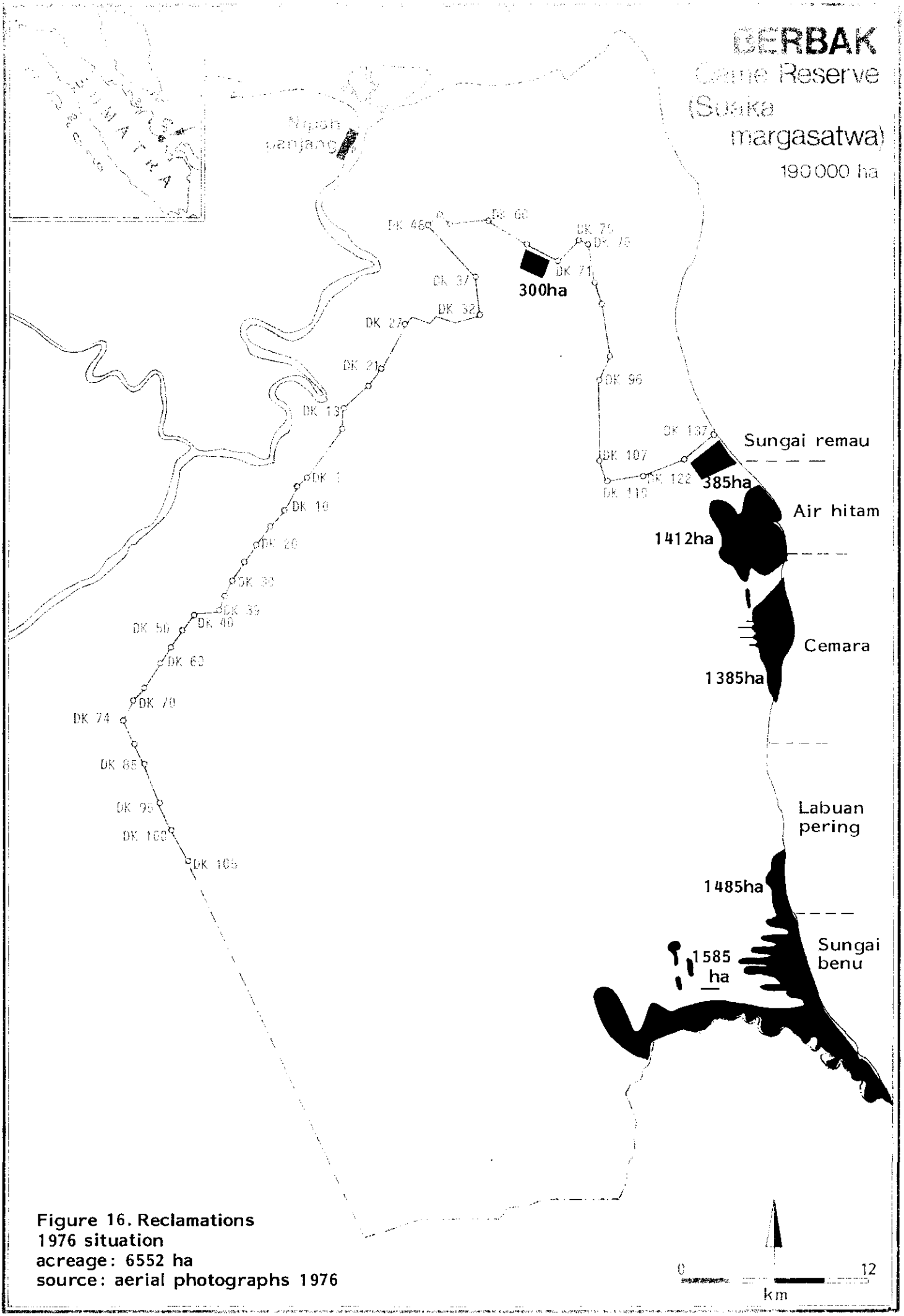


Figure 16. Reclamations
1976 situation
acreage: 6552 ha
source: aerial photographs 1976

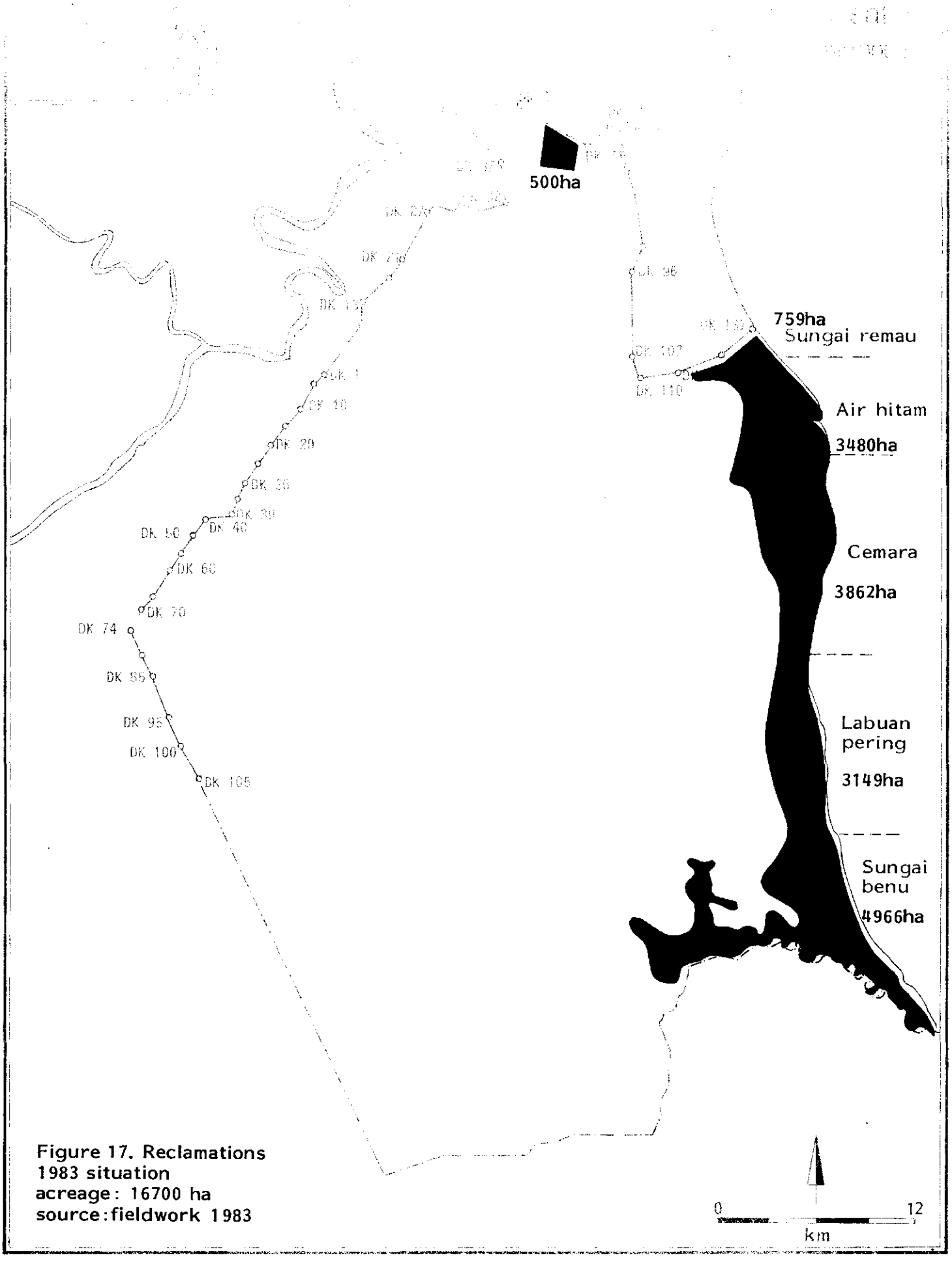


Figure 17. Reclamations
1983 situation
acreage: 16700 ha
source: fieldwork 1983

6.3.2.1 Population

The inhabitants in the reserve within the 1974 boundaries number about 6000 (Table 11).

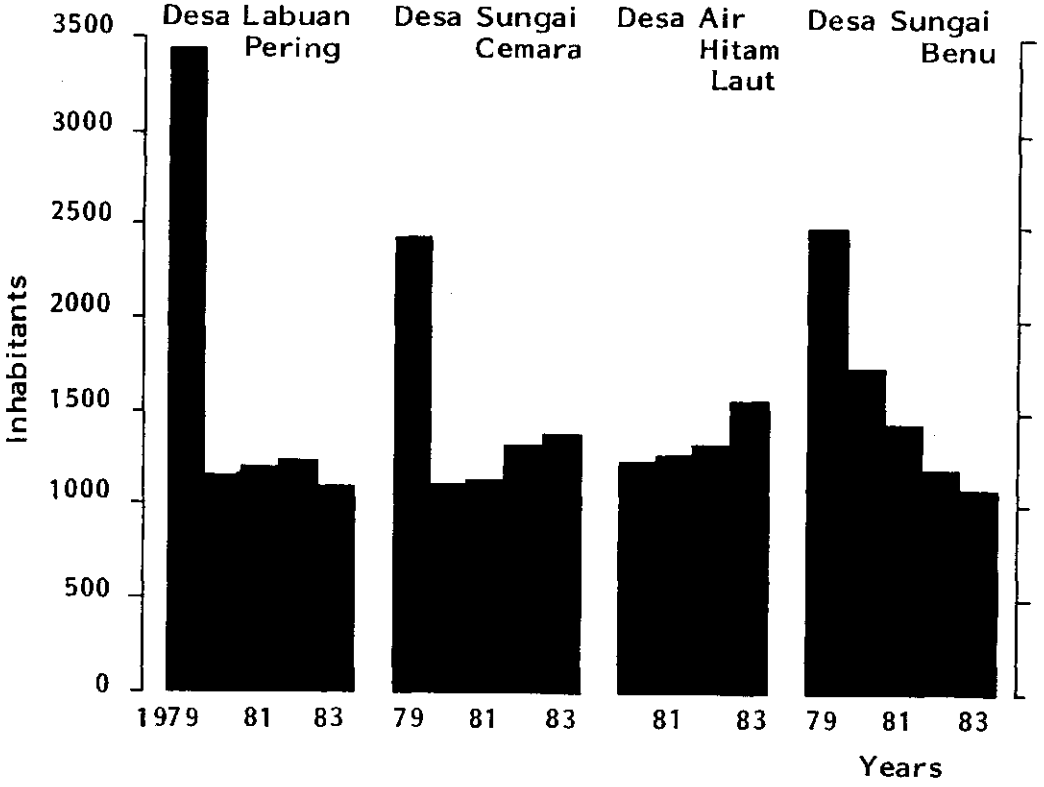
Table 11 Number of inhabitants per village
Source: Biro Pusat Statistik Jambi 1984 and supplementary data from the Camat office November 1983

	Simpang Datuk		Sungai Remau		Air Hitam Laut	Cemara	Labuan Pering	Sungai Benu
	total	inside reserve	total	inside reserve				
♀♀	1593	n.a.	442	n.a.	719	645	512	586
♂♂	1663	n.a.	438	n.a.	849	745	580	571
Total	3256	300[a]	880	300[a]	1568	1390	1092	1157

a : own estimation
n.a. = not available

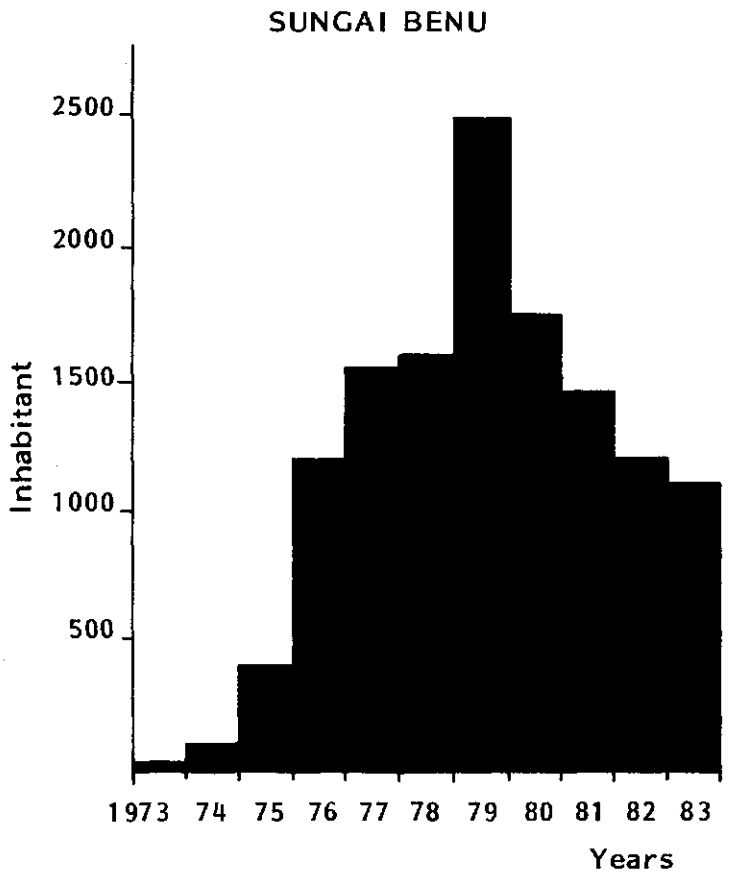
The population figure in the various villages did not steadily increase. Several disappointing rice crops (6.4.2.6) lead to a sharp drop of the population between 1978 and 1980 (Figure 18 and 19). Especially in desa Sungai Benu this tendency seems to develop further, due to severe inundations of brackish water, which destroy the standing crop (6.4.2.4) (Figure 19). In desa Cemara the situation is stabilizing, after several good harvest years (Figure 18).

Population figures of 1980-1983 in desa Air Hitam show a slow continuous growth. Data before 1980, to show the population drop between 1979 and 1980, were not available. From 1979 onwards, farmers from the remote parits along S. Air Hitam moved to the pasar (village centre) near the coast. Actually nine parits have been abandoned (Table 12), and this internal migration seems to continue. The farmers got employed as fishermen. At present 81% of the working people of desa Air Hitam Laut is involved in fishery activities, before 1980 only 13% (6.4.1).



Source: Kantor Camat Nipah Panjang & Kantor Penghulu Sungai Benu

Figure 18 Population course in the four coastal villages.



Source: Kantor Penghulu Sungai Benu

Figure 19 Population progress between 1971-1982 of desa Sungai Benu.

Table 12 Present distribution of inhabitants of desa Air Hitam Laut.
Source: Air Hitam Municipality October '83.

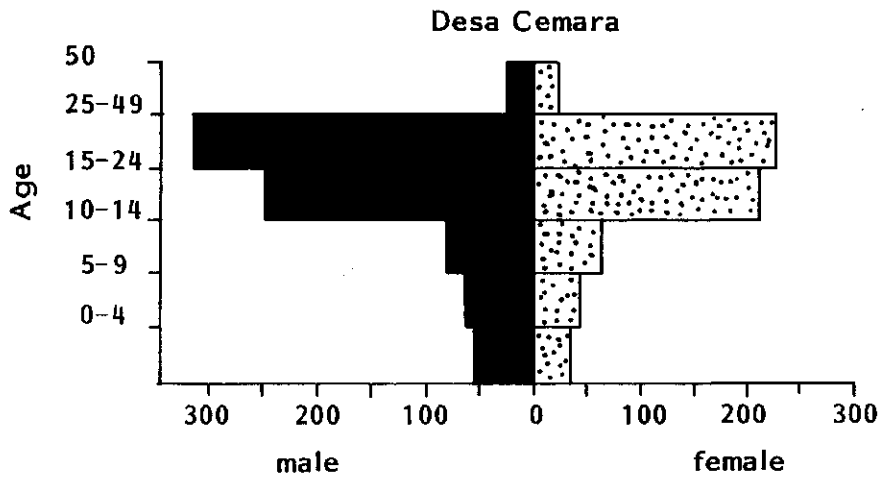
parits on right side		parits on left side of the river	
parit gantung	27	parit gantung	140
p. 1 kanan	21	p. 1 kiri	132
p. melintang	59	p. melintang	33
pasar	579		
p. 2 kanan	77	p. 2 kiri	79
p. 3 "	69	p. 3 "	40
p. 4 "	34	p. 4 "	38
p. 5 "	61	p. 5 "	-
p. 6 "	-	p. 6 "	-
p. 7 "	-	p. 7 "	-
p. 8 "	-	p. 8 "	96
p. 9 "	-	p. 9 "	-
p. 10 "	-	p. 10 "	72
Total	873		630

Population statistics of desa Sungai Benu were available from the first reclamation, starting in 1971/1972 until the present situation (Figure 19).

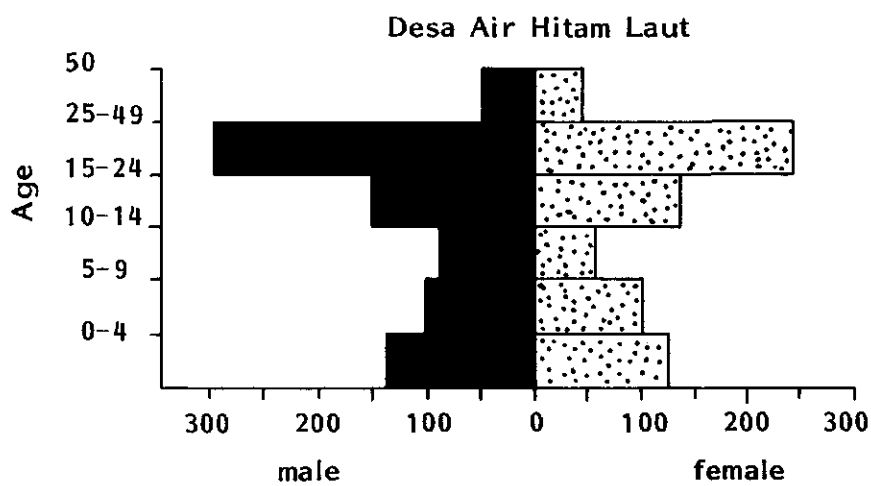
The population figures reflect the development during the first years of reclamation. During the initial period, only a few families were willing to take the risks to fell the trees and to clear the land. As the first harvest showed reasonable results, other farmers got encouraged to join the efforts in opening the area. In one year (1976) the population increased from 400 to 1200.

Age distribution

The greater part of the inhabitants in the four coastal villages, is of the age class 15-24 years or 25-49 years (Figure 20).



Source: Kantor Kep. Desa Sungai Cemara



Source: Kantor Kep. Desa Air Hitam Laut

Figure 20 Age and sex distribution of desa Air Hitam Laut and desa Cemara, situation September 1983

The majority of the people in the village is young, and therefore it is to be expected, that the population will increase in the near future. This depends, however, on the conditions of living. In desa Air Hitam Laut (Figure 20), where recently circumstances for living have been improved (6.4.2), the population growth is apparently more rapid. For 1982 the growth rate was 5% and the first 9 months of 1983 show a growth rate of 17%.

6.3.2.2 Facilities

The four coastal villages, although situated inside a reserve, have the features of an Indonesian "desa". Local government set up police and army stations (Pos Polri and Pos Babinsa). The central government even implemented primary schools. Each village has a primary school (SD-inpress) run by teachers provided by Jakarta (Photo 19).

The Government agency Dinas Perkebunan financed some agricultural projects, like granting coconut credits. This agency constructed and administered an experimental coconut plantation in desa Sungai Benu (4). But on the whole, these Buginese farmers improve and develop their village on their own, with an amazing perseverance. Several public facilities were established by mutual assistance (gotong royong system) and defrayment: e.g. the construction of roads, electricity or the sponsoring of the highschool teachers (SMP-school) (Photo 20) (Table 13).

In desa Air Hitam Laut, the municipality has planned to open a regional health centre (Puskesmas) and a regional weekly market in 1984. In 1985 the first senior highschool classes (SMA) are scheduled. It is obvious that the present situation and the planned developments for desa Air Hitam Laut as a regional centre attract the inhabitants to stay and work. These favourable circumstances in desa Air Hitam Laut also keep staying people in the nearby situated villages: desa Cemara, desa Sungai Remau, desa Labuan Pering, desa Sungai Benu.

villagename		Simpang Datung	Sungai Remau	Air Hitam Laut	Cemara	Lakuan Pering	Sungai Benu
Year of colonization		1965	1966	1966	1973	1970	1973
Inhabitants '83		3256	860	1568	1390	1092	1157
SCHOOLS	Number of SD schools	2	1	2	1	1	1
	SMP school			1			1
ELECTRICITY	Number of generators	2	1	4	1	1	1
	% of houses connected	n.a.	n.a.	75%	15%[b]	9%	25%
	number of houses	>25[a]	177[a]	297	292[a]	230	245
HEALTH SERVICE	local physicians(Menteri)	0	0	1	0	0	0
	midwifes (Bidan)	1	0	2	1	0	0
	birth-control (K.B.)	0	1	1	1	1	0
TRADE	hairdressers	0	0	3	0	1	1
	tailors	0	0	3	0	3	2
	goldsmiths	0	0	1	1	1	1
	woodcarvers	0	0	10	0	0	6
	shopkeepers	3	1	10	6	8	7
	transport businesses	0	0	7	4	9	5
LUXURY GOODS	televisions	n.a.	n.a.	23	2	5	9
	radios	n.a.	n.a.	27	n.a.	51	20

n.a. : not available; a: figure from 1980; b: own estimation

Table 13 Facilities in several villages, situation 1983.
Source: Interview surveys 1983; Biro Pusat Statistik Jambi 1984

6.4 Landuse within the reserve

6.4.1 Introduction

Agriculture and, more recently, fishery are the principal kinds of land use in the Berbak reserve. During the first years of reclaiming the coastal area, a majority of the Buginese migrants was involved in agricultural activities just as they used to do in Sulawesi. The environmental conditions, however, differ considerably (tidal swampland versus low mountain area). Besides agriculture, some families were active in trade. As the agricultural situation turned out to be unfavourable at several places in their villages, some farmers could earn their living from fishing activities. Especially in desa Air Hitam Laut, the transfer from agriculture to fishery is striking (6.4.3).

Table 14 Employment of inhabitants in the four coastal villages.
Source: Biro Pusat Statistik Jambi 1980a, 1984.

		Air Hitam Laut		Cemara		Labuan Pering		Sungai Benu	
		number	%	number	%	number	%	number	%
families in agriculture									
	1980	220	78%	255	95%	242	91%	249	93%
	1983	29	9%	250	91%	240[a]	90%	230	89%
families in fishery									
	1980	39	13%	2	1%	7	3%	0	0%
	1983	260	81%	5	2%	3	1%	4	2%
other activities[b]	1980	23	8%	10[a]	4%	15	6%	20	7%
	1983	31	10%	20	7%	25	9%	25	9%
Total number of families	1980	282		267		264		269	
	1983	320		275		268		259	

a: own estimation

b: like merchant, shopkeeper, tailor, goldsmith, civil servant

In the following paragraphs, the kinds of landuse will be discussed.

6.4.2 **Agriculture**

When opening coastal swamp lands, Buginese farmers have reclaimed forest, mainly for rice and coconut cultivation. Secondary crops like vegetables and fruit trees (Appendix 14) are grown for local consumption only.

Coconut cultivation already guarantees the farmers a stable income after about 10 years, when the production of nuts attains a annual level of $\pm$ 60 nuts per tree per ha (5). During the first three years of plantation, rice plants can be grown between the young palms. When the palms are older, too much sunlight will be intercepted to continue rice cultivation underneath the trees. Then farmers will open new land for their rice cultivation. Depending on the size of the families, the farmers aim to cultivate an area of 2-6 ha land ($\frac{3}{4}$ part for coconut and 1/4 part for rice).

To select suitable arable land, the Buginese farmers take full account of such as soil and vegetation. A vegetation with nibung (Oncosperma tiggilarium) or jawi-jawi trees is indicates suitable areas. Peat of more than 1 m thick is avoided as this is unsuitable for either rice or coconut cultivation. But occasionally these soils are used for pineapple and maize cultivation. To drain the swamplands and to get rid of the acid peatwater, they dig canals or 'parits'. This system of tidal swampland development, practised by the Buginese, is also known from the Banjarese farmers in South Kalimantan (Collier 1980). More recently the activities of Buginese farmers in the Upang Delta in South Sumatra have been studied in a MAB-project (MAB 1983).

Parit system in Berbak

The leaders of the farmers first plotted the several positions of all parits within the future village area. The felling of the trees and the digging of the parits were done by individual farmers, who intended to have their arable land adjacent to a particular parit. The bare land becomes the property of the farmers after they have reclaimed the forest.

The felled trees were burned at the end of the dry season. The farmers could not sell the logs, because hauling was to difficult and there were no sawmills operating in the neighbourhood. The parits are 1500 to 2000 depa long, according to the measuring system of the Bugis. They use the arm length of their leader. One depa is about 1.75 metres. So one parit is about 2500 to 3400 m in length, 2 m wide and 15 m deep (Photo 21). Perpendicularly to this parit, the farmers dig secondary canals at regular intervals of 30 depa (± 50 m). These canals are 150 depa (250 m) (Figure 21a). Thus a farmer starts with approximately 1.25 ha, locally called 0.5 lembar.

Two types of parit systems can be distinguished in Berbak;

1. parits that drain directly to:
   - the river (system occurring in desa Air Hitam Laut (Figure 21a + Figure 22);
   - the sea (system partly occurring in desa Sungai Benu);
2. parits that drain all through a main parit.
   This main parit may drain either to the sea (desa Cemara, desa Labuan Pering) or to the river (desa Sungai Benu) (Figure 21b).

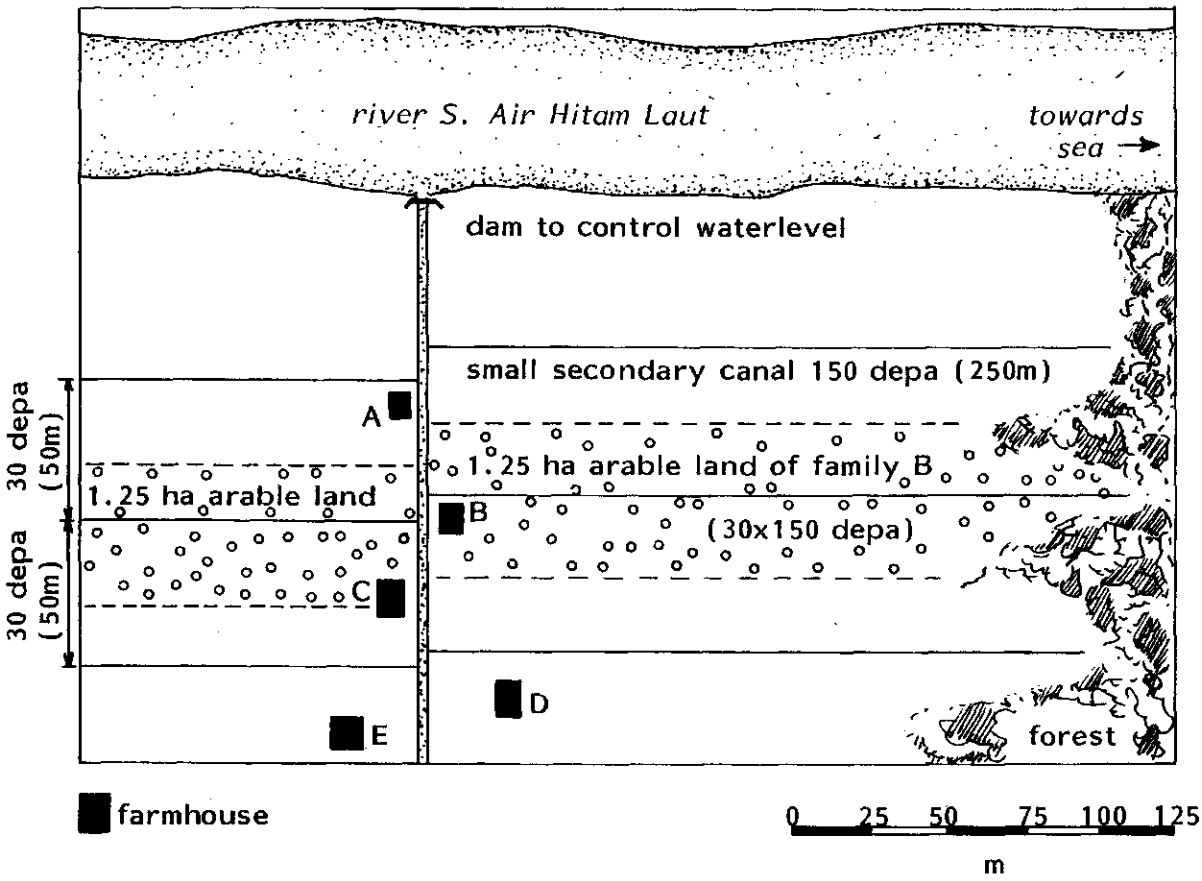


Figure 21a Parit system, situation desa Air Hitam Laut

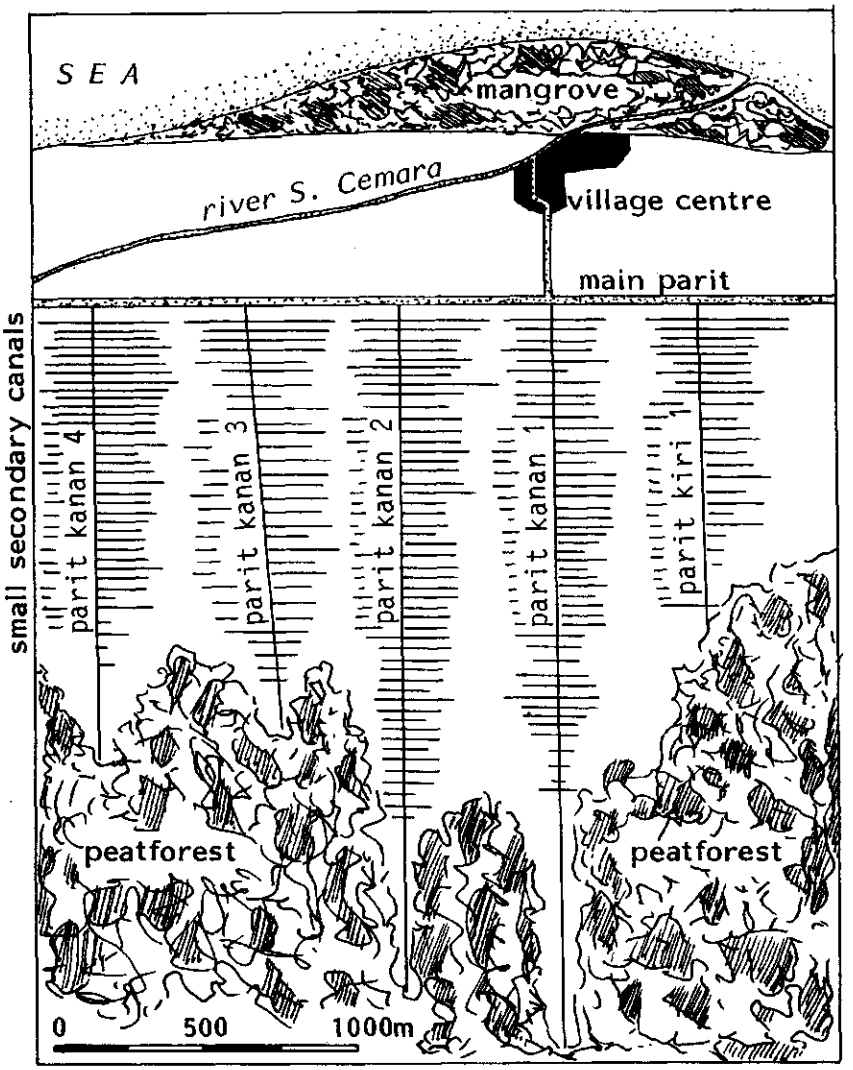


Figure 21b Parit system, situation desa Cemara

At the beginning of each parit, near the place where it drains into the river, the sea or the main parit, the farmers usually construct dams made of clay and palm leaves. Sometimes also the secondary canals have small dikes, with the help of which farmers can control the waterlevel in the parits. In the dry season, when there is hardly any water supply from the forest at the end of the parits, there is a risk of brackish water inflow during high tide. Sea water is driven far up in the river and in the main parit. The dams prevent this inflow in the parits. In the wet season, the regulable dams block up the parits full of rainwater from the forest and the fields in such a way, that rainwater will inundate the fields (Photo 22). In this way favourable circumstances are provided for the cultivation of rice. Because of the insufficient fresh water supply in the dry season, only one rice crop is possible. The parit is also used for the transportation of agricultural products, i.e. bags of unpolished rice to the rice-mill work (Photo 23).

As each village has its own particular soil and environmental conditions, its landuse will be discussed separately.

6.4.2.1 Desa Air Hitam Laut

The main crop cultivated in this village is coconut. Coconut plantations cover 600 ha of the total agricultural area of about 3100 ha (Municipality of desa Air Hitam Laut 1983). These plantations were mostly planted some 8-10 years ago. Farmers report an average yearly yield per ha of about 8000 nuts (or 1000 kg copra). These figures are comparable with data stated by Driessen & Sudewo (1977). The total production of coconuts in this village will probably increase in the coming years, as new areas have recently been planted. The local government supports the cultivation of this crop by granting coconut credits (6). The municipality of desa Air Hitam Laut is intending to build some smoke-houses, for the production of copra. Making copra by themselves is more profitable than the sale of nuts (Collier 1980). In spite of these promising circumstances, some farmers complain of low yield and crop damage which can be explained by the following reasons:

1. The location of the plantations is too close to the sea (brackish soil conditions) (Photo 24).
2. Plantations are laid out on acid sulphate soils.

3. Crop damage is caused by wild pigs (Sus scrofa) and sun bear (Helarctos malayanus), visiting the plantations (this is why parit 6 kiri has been abandoned).

The area under rice cultivation covers 21 ha. Farmers stated that at some places the drought obvious by the occurrence of cracks (Photo 25), hinders the cultivation of rice. These dry conditions may be due to the location of the parits, which are dug perpendicularly to the river S. Air Hitam Laut. Because of this construction (Figure 22), the first parits on the left side (parit gantung, parit melintang, parit 1+2), have a sufficient freshwater supply from the peat forest. Farmers, who had their arable land at the end of these parits, were the first ones to abandon their fields and to move to the village centre (at the mouth of the river) in 1979.

Another crop cultivated in desa Air Hitam is nangka (Arctocarpus heterophyllus). Other crops are cultivated on a subsistence level (Appendix 14). Occasionally there is an export of coconuts (and on a smaller scale of nangka fruits) to Nipah Panjang, Bangko, and Palembang.

6.4.2.2 Desa Cemara

In desa Cemara there are some better conditions for agriculture, possibly caused by more suitable soils (5.6.3.1). Also the position of the parits seems to be better, compared with the situation of desa Air Hitam Laut. All parits start deep in the peat forest, at an average distance of 4 km from the sea. The parits mouth through a main parit in the tidal creek S. Cemara (Photo 26 and Figure 21b). There is a 2.5 m difference in height between the end of the parit and the mean sea level. Consequently, in the wet season, the freshwater supply from the forest is substantial. The water management of the fields is easy, with the help of small dikes in the parits.

In Cemara, the Buginese cultivate their rice mainly on the marine clays (Photo 27). Until now, they have avoided the clay covered with more than 1 m peat in depth. But because of draining, the peat layers of the arable lands near the peat forest will shrink slowly, which makes that farmers will be able to expand their rice cultivation towards the peat forest. Already 450 ha is under wet-rice cultivation. Harvests are relatively good; annual yields up to 5 ton polished hulled rice per ha have been recorded. The average yield figure seems to be 3 ton hulled rice per ha (7) which is good if one takes into account that no

fertilizer and pesticides are used and that only long-age local rice (so called kwatik), varieties are planted. Yields of the last years increased. The first three years after reclamation of the area (1975-1977) the rice yields were small.

Farmers stated that acid conditions of the shallow peat layer limited the first crops. After leaching the acid peat, the production of rice increased. From 1978 on, the harvest increased and a surplus of hulled rice was traded in Nipah Panjang. Principally along the main joint parit, the farmers cultivate coconut (125 ha) and nangka. When shallow to medium thick peat layers occur (0.5 m-3 m), the land normally is used for cultivation of cassave (Manihot esculenta), banana (Musa sp.) (Photo 28). On peat of 3 m pineapple (Ananas comosus) and maize (Zea mays) are cultivated (Photo 29). These crops are planted for local consumption but sometimes products are sold to people in the village. Since 1982, farmers cultivate pineapple on a large scale (20-30 ha) (Photo 30), probably to sell the fruits at the market of Nipah Panjang.

6.4.2.3 Desa Labuan Pering

The environmental conditions are broadly the same as in desa Cemara. Nearly 30% of the whole agricultural area is covered with peat (Appendix 4). Moderate to shallow peat layers cover the area from parit 5 up to 10 kanan. From parit 5, the peat turns off towards the northwest.

Another soil type is the marine clay deposition. Coconut and banana cultivation give rather good yields on these soils. On some places, jarosite is apparent, indicating too acid conditions. Where no jarosite occurs (parit 1, 2, 3, 4 kiri), stable rice yields are possible. Till 1980, a surplus was exported to other villages. But due to three relativey dry years (1980, 1981, 1982), rice yields decreased. Because of these droughts, several families left these parits for other places after 1979.

The total rice cultivation for Labuan Pering covers 575 ha of wet rice fields. On the shallow peat (<1 m), farmers plant sweet potato (Ipomea batatus), pineapple, chilli (Capsicum frutescens). On the moderate to deep peat (1-3 m) maize, pumpkins (Cucurbita maxima), watermelon (Colocynthis citrullus) and pineapple are grown.

Remarkable for desa Labuan Pering are its extensive banana and coconut plantations. At present, 1091 ha of the total 1901 ha agricultural land are under coconut cultivation. The total surface of the banana

plantations is not known, but it is evident that main revenue is provided by the sale of bananas. Especially the pisang tanduk (a Musa variety) is cultivated, as this variety is to be kept fresh for more than two weeks, which is necessary for transportation to places like Bangko and Palembang (Photo 31).

6.4.2.4 Desa Sungai Benu

This village resembles desa Labuan Pering, as the main soil type consists of the same marine deposition. The peat cover is very shallow or has already disappeared because of agricultural activities (burning and drainage). The only area known with a moderate to thick peatlayer (1-3 m) is found near Sungai Arau. It covers about 100 ha; this is less than 4% of the total agricultural area.

The agricultural situation seemed to be less favourable since the arable land on the lower situated parts of the village were regularly inundated. Calamities caused by riverwater inundations lasted several weeks in the parits near Sungai Arau during the first three years of reclamation (1975-1978) which resulted in a total abandonment of this area by the farmers. This is why the population of desa Sungai Benu between 1977 and 1980 dropped from 2432 to 1138 (Figure 19). The area of parit 3, 4 and 5 kanan, which is situated on the lower banks of the Sungai Benu has suffered occasionally from inundations by brackish water in the rainy season. The flood of January 1983 was severe, lasting one month and destroying all rice fields (325 ha); it also affected the banana trees and even the coconut plantations. Relying on the statements of the farmers, they expect these inundations every year in the wet season. To prevent further calamaties, the municipal authorities ordered to dig a canal to cut off the river course of the S. Sungai Benu. In this way, the drainage of the parits will be speeded up. The digging of this canal (parit lapis) took place during 1983.

On the more elevated parts of this village, coconut and banana have been planted (parit 6 kanan up to the boundary with desa Labuan Pering). Yields from these plantations seemed to be reasonable.

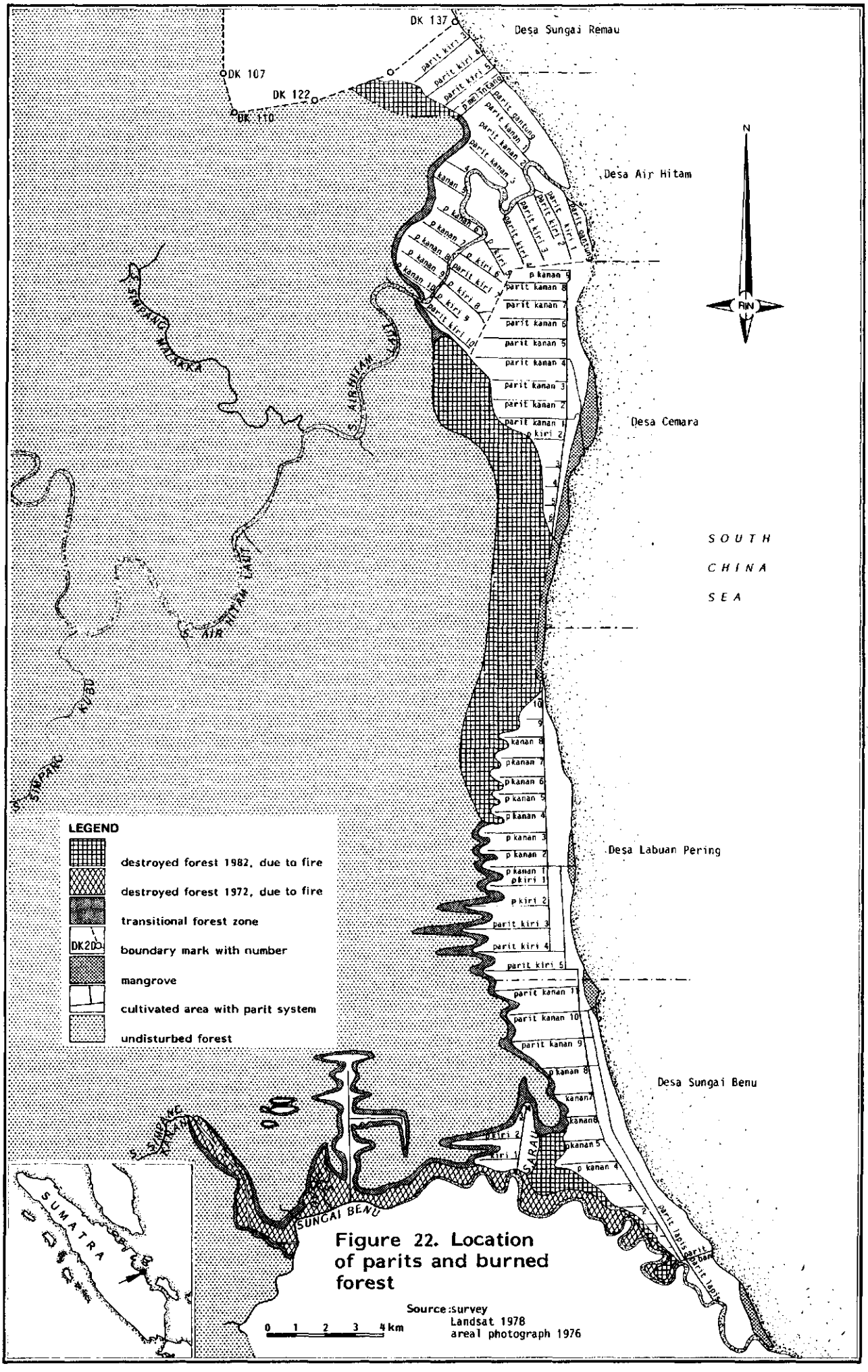


Figure 22. Location of parits and burned forest

Source: survey
Landsat 1978
areal photograph 1976

6.4.2.5 Burned areas

Two big forest fires have attacked the primary swamp forest of the Berbak reserve. In 1972 and 1983 a total of 4000 ha of forest ended in smoke.

The fire of 1972 along the banks of the river Sungai Benu (Photo 32), took place at the time of the reclamation of desa Sungai Benu. The immediate cause of this blaze, affecting more then 1000 ha undisturbed forest, is unknown, but the drought during the dry season of 1972 was quite severe. Only 249 mm rainfall was registered at the Meteorological station of Jambi, from May up to November 1972.

The fire of 1982 was far more devastating, lasting three months (September-November 1982). At least 3000 ha of forest were burned (Figure 22). This occurred along the transitional zone (arable land-forest), except for desa Simpang Datuk in the north and at some places in desa Labuan Pering (Photo 33). The fire was probably caused by uncontrolled burnings of cultivated land after the harvest. According to Raleigh Blouch, WWF mammalogical Consultant, who visited the reserve in October 1983, small patches of good forest are left in between the desa Cemara and desa Labuan Pering (Blouch, pers. inf.). But the area on the whole seemed quite disturbed (Photo 34). As already mentioned (1.4.5), the Indonesian Archipelago has been suffering from severe droughts during 1981 and 1982. These droughts can be expected every 3-6 years. Therefore, it might be expected that more forest will burn down in the coming decades, due to neglectful burning of arable land, at the end of the dry season.

In desa Cemara clearings for agricultural purposes took place (200-250 m) inside the burned forest zone of 1982 (Photo 29).

6.4.2.6 Assessment of agricultural development

If we compare the production and income figures of the five main agricultural products (Table 15) known for the villages inside the reserve area, it is clear that these products provide the farmers with a sufficient income.

However, some remarks must be made in view of the data in table 15.

Table 15 Production figures and socio-economic requirement for the five main agricultural products.
Source: interview surveys, Biro Pusat Statistik Jambi 1980, Collier 1979a, Oldeman et al. 1982, Driessen & Sudewo 1977.

1. *Agriculture by small holders with low capital resources, traditional management, high labour intensity, farms 1-6 ha.*

Produce	main: rice	maize	coconut	banana	pineapple
	second: cassave, coconut	rice, cassave, pineapple	rice cassave	rice cassave	maize, cassave
	minor: nangka	melon	nangka	nangka	banana, melon
	livestock: chicken, goat	chicken	chicken, goat	chicken, goat	chicken
Market orientation	foodplantation mostly subsistence	idem	idem	idem	idem
	market off-take: surplus on rice	idem	idem	idem	idem
	commercialization: <80% of yield	idem	idem	idem	idem
Capital intensity	low, sometimes pesticides are purchased	idem	idem	idem	idem
Labour intensity	high, almost all handlabour (male only)	idem	idem	idem	idem
	sometimes labour forces are hired during harvest times	no labour forces required	no labour forces required	idem	idem
Technology employed	improved seed (C.4, I.R.5.), sometimes	local varieties	idem	idem	idem
	pesticides (Sevin, leboysid, themick)	no pesticides	idem	idem	idem
Infrastructure requirements	agricultural advisory service, fertilizers market off-take, road construction	idem	idem	idem	idem
Income level (1983 prices)	425 000 Rp/ha.yr	163 800 Rp/ha.yr	500 000 Rp/ha.yr	903 000 Rp/ha.yr	540 000 Rp/ha.yr
Optimal production ($ha.yr^{-1}$)	600 kaleng gabah = 3 ton hulled rice (1 kg: 200 Rp) - 500 kg own use	1300 kg; 1 kg: 140 Rp - 130 kg own use	1000 kg copra = 10 pikul	10 ton or 3300 banteng 1 banteng= 350 Rp	5-8 ton fruits 1 fruit= 20 Rp
	-2500 kg-15% loss (payment in nature for transport and milling)	-1170 kg-10%	1 pikul= 50 000 Rp	-10% own use -10% transport	15 000 fruits/ha.yr
source	interviews Collier (1979[a]) Driessen (1977) Oldeman (1982), Biro Pusat Statistik Jambi (1980)	interviews Driessen(1977)	interviews Collier (1980)	interviews Driessen (1977)	interviews Driessen (1977)

- 1300 kg of dry grain maize per hectare is an average yield on moderate to deep (burnt) peat according to reports on maize on peat by Driessen & Sudewo (1977). However, the net return from maize farming is not sufficient for the farmers. An income level more than Rp 400 000 per year is considered to be necessary for the daily expenses. Rp 400 000 = 400 US$. Maize cultivation is therefore only a second

crop.

- Also pineapple is of minor importance at the moment. Less than 100 ha have been planted. But it might be expected that the total acreage under pineapple cultivation soon will be enlarged, as this crop has shown to grow profitably, on moderate peat. Essential for the pineapple yield is a short-term sale. The fruits taint quickly and a cannery industry is lacking. Because the fruits are used for local consumption, a good infrastructure is essential.
- The net return of banana cultivation is Rp 903 600 and not realistic for the actual situation. A commercialization of 60% of the surplus on fruits is already considerable (Driessen, pers. inf.). Therefore, a normal income level about Rp 500 000 seems to be more likely.
- During our survey we encountered several environmental problems that seriously restrict the optimal production:
  1. Recurrent catastrophic droughts destroyed a major part of the rice and banana fields in several desas. Very dry seasons are to be expected every 3-6 years and crop failure is computed one year in five, due to the lack of sufficient watersupply (Center for Natural Resource Management and Environmental Studies 1978). Anyhow, lack of freshwater in the dry season is the critical constraint for a double cropping.
  2. Inundations of brackish water are a major problem for the farmers which have their arable land on the lower situated parits in desa Sungai Benu.
  3. Agricultural pest outbreaks in some years destroyed the rice yields. At the end of several parits, the isolated forest clumps are a refuge for mammalian pests. Visits of wild pigs (Sus scrofa) and the sun bear (Helarctos malayanus) have been destructive for coconut plantations at several parits.
     Abandoned farmlands (i.e. between desa Air Hitam Laut and desa Cemara) serve as a pest reservoir for nearby farmed areas.
  4. Incomplete control over weeds in rice fields leads to gradual dominance by rhizomous forms (i.e. Scirpus sp.) which are difficult to eradicate (Hanson & Koesobiono 1979) (Photo 43). According to Sanchez (1976), the primary reason to abandon soils (with a high-base-status) is because of a lack of effective weed control.
- There is a lack of chemical applications, funds are not available and the system of cooperative fertilizer stores (KUD; Kooperasi Unit

Desa) is absent in Berbak.

6.4.2.7 Soil suitability in relation to agriculture

For the different soil types, a preliminary assessment of the suitability for agriculture will be discussed.

Mineral soils

The unripe clays in the tidal area, which are regularly flooded with salt or brackish water, are not suitable for agriculture. The high amounts of sodium and the lack of good aeration of the soil hinder crop growth. The physical properties of the soil are also a negative aspect, soft mud is not a favourable habitat for plant roots to grow. Marine clays, outside the tidal influence, have better properties for agriculture.

Texture and structure

The texture of the soils is not very heavy. Most soils have a clay percentage of 30-50, which is not limiting for plant growth. However, a lighter texture, e.g. clay loam or sandy clay loam, provides better conditions.

The physical ripening, as a result of draining of the soils, caused a better developed soil structure, which increases the suitability. Near desa Air Hitam Laut, the soils are drained too deep, the topsoil is too dry and shows cracks in dry periods. A too dry topsoil is not favourable for plant growth.

Chemical properties

The most determining property of the mineral soils in relation to suitability for agriculture is the extent of acidification of the soil. Acid sulphate soils with a pH lower than 3.5 have poor agricultural suitability. Not only the extreme acidity hinders plant growth, but some ions (Fe^{2+}, Al^{3+}) are present in quantities which are toxic to most plants. Soils with a pH_{H2O} lower than 3.5 are present in Berbak, i.e. near desa Air Hitam Laut and desa Labuan Pering. Most soils of desa Labuan Pering and desa Cemara having somewhat higher pHs are therefore more suitable for agriculture.

The base saturation of the marine clays is rather high. The ECEC is dominated by Ca^{2+} and Mg^{2+}. A high base saturation indicates a high soil fertility.

The riverine clays along the S. Air Hitam Laut tend to have a lower base saturation. The ECEC is more dominated by Al^{3+} and H_3O^+, which makes these soils less suitable.

The soils along the S. Sungai Benu are unsuitable because they are inundated with freshwater throughout the whole year. The lower parts of the parits 3, 4 and 5 kanan in desa Sungai Benu are subject to brackish water inundations.

Peats

Peat with a thickness of <1 m can be suitable for agriculture. Shallow peat has rather favourable physical properties for plant growth. The supply of water is sufficient as the water storage capacity of peat is high.

Reclamation and cultivation of peat soils always lead to irreversible subsidence of the peat. Deep draining and prolonged drying should be avoided because they leads to a drastic deterioration of the initially favourable physical properties of the peat.

In Berbak the peat covers a pyritic mineral subsoil, which will acidify if exposed to the surface. This process has occurred near desa Labuan Pering and desa Sungai Benu, where soils lost their shallow peat layer, due to cultivation.

The chemical properties of the peat are less favourable: a low pH and low amounts of nutrients. Deep peats, with a thickness of 1.5 m and more, are unsuitable. Both physical and chemical properties are unfavourable for most crops. The bulk density is very low (<0.15 g/dm^3) which makes reclamation and cultivation difficult. The pH is low and the peats are oligotrophic.

Resuming we can state that parts of the marine clays are more or less suitable for agriculture. But the riverine clays seem to be less suitable. On shallow peat, cultivation of crops is possible but deep peats are unsuitable.

Reclamation of the coastal area by the local population is to be expected up to 5 km inland. The main problem for a good management of the soils is to maintain an adequate drainage system in order to avoid too severe drying and acidification of the topsoil.

However, for a profound evaluation of the soil suitability more samples of the topsoils must be analysed and more actual information on the pHs of the topsoils is needed. Based on our data we can only give a very rough evaluation.

6.4.3 **Fishery**

Besides some fishing activities on a small scale by farmers in their parits or in desa Cemara along the shore during high tide, a major group of farmers now receive their main income from sea fishery. River fishery is of minor importance. Only 16 families are involved. It is restricted to the S. Sungai Benu. Since the establishment of a PHPA guard post in desa Air Hitam Laut, fishing activities on the Sungai Air Hitam have been stopped.

6.4.3.1 River fishery

The two main rivers: S. Sungai Benu and S. Air Hitam Laut are, although very acid (3.2), rich in fish. On economically valuable basis, 34 fish species have been identified (Appendix 15), a.o. belido (Notopterus nonopterus) important for the 'krupuk' processing. Other traded species are: betok (Anabas testudineus) and tapah (Wallago niostonia), which was mentioned to have an average weight of 60-150 kg. According to the local fishers, a complete list of all occurring fish species in these two rivers will outnumber 60 species. Several species are linked to a specific level of salinity, e.g. only at the mouth of the river one finds the brackish species betutu (Macrognathus aculeatus) and juara (Pangasius micronema).

There are six fisher settlements along the banks of the S. Sungai Benu, far riverupwards. Three settlements are situated on the reserve side. The 16 families are fully dependent for their income on river-fish catch, as they are not active in agriculture. The people, all from the South Sumatra province, live mostly in semi-permanent, shabby stilted houses at these remote places (Photo 35). They can catch 4-5 kg a day, using several fishing utensils: nets tied on fences across the river, fish-traps and line and hook. The catch is life-stored in bamboo baskets. Bait is obtained by operating little tuguks (lift nets). By using line and hook, the fishermen sometimes unintendedly catch the protected freshwater turtle Orlitia borneensis. The turtles are not eaten by these Islamitic fishermen, so the catch is purely accidental.

The life-stored fish is sometimes sold to a trader from Palembang, or otherwise, it goes once in every three months to the fish auction in Palembang. Extra earnings are occasionally made by the catch of pythons (Python reticulatus) or even by the illegal capture of crocodiles (Crocodillus porosus) or false gavials (Tomistoma schlegeli).

6.4.3.2 Sea fishery

Sea fishery appeared to be an increasingly economical activity, after the establishment of two fish companies, one in desa Air Hitam Laut (1979-1980) and one in desa Sungai Benu (1983). These companies set up cold-storage buildings, making it possible to trade and store high valuable but soon tainting species like shrimps. At present, frozen shrimps are transported with large boats (50 ton) from the two reserve villages to Tanjung Balai in Riau province, from where they are exported to Singapore and Japan.

The mangrove and the estuarine zone, as nutrient-rich ecosystems, are of utmost value since they function as nurseries and feeding grounds for many marine invertebrates and fishes (Christensen & Delmendo 1978). Especially, the economically valuable shrimp species spawning off-shore use mangroves as refuge and feeding ground during their immature stage (Martosubroto & Naamin 1977; Torro 1978). Throughout the year, fishermen operate their 0.5-3 ton motorboats (pompongs). The most important catching season is during December-May, when shrimps are abundant near the shore. Before 1980, only five inhabitants in desa Air Hitam Laut owned a boat for transportation service or some sea fishing. Nowadays, the river near the village centre is full with boats. The village's fishing fleet numbers 256 pompongs (Photo 36, 37). During the shrimp season, up to 100 boats from nearby villages, including fisher boats from desa Kampung Laut (80 km distance) moor and shelter in the mouth of the river.

The municipality of desa Air Hitam Laut supports these temporary fishing activities with the construction of some Nibung-stilted platforms for night's lodging along the river (Photo 38).

The reports of desa Air Hitam Laut on traded fish showed in 1980-1982 a sharp increase in fish production (Table 18). These figures are only indicative whereas real production are much more higher because not all catches are registered.

We estimate catches 6-7 times higher than the reports of the Municipality (Table 16). These figures are based on statements made by fishermen in desa Air Hitam Laut: 200 operating boats during the shrimp season of 1982 with an average monthly catch of 40 kg shrimps (first

class). During the peak months, December and January, catches of 60-70 kg (first class) are possible. But the average catch of first class shrimps during the whole season, seemed to be 240 kg per boat.

Table 16 Fishery production of desa Air Hitam Laut (ton) 1980-1982.
Source: Municipality of Air Hitam Laut, 1983.

year	1980 (a)	1981 (a)	1982 (a)	1983 (b)
marine fish				
Shrimp Class I	1.9	4.7	7.5	48
Class II	6	9	25	160
Class III	17	26	50	320

a according to Municipality of Air Hitam Laut, 1983
b according to fishermen
Commercial value of sea fish: 150 Rp/kg
(1000 Rp = 1 US $) Shrimp Class I : 4000 Rp/kg
1983 prices Class II : 750 Rp/kg
Class III : 150 Rp/kg

6.4.3.3 Fishery production

Cost-benefit calculation
If we convert the average production of shrimps (per operating boat) into a gross profit, the seasonal (six months period) gross return will be Rp 1 800 000 (Table 17).
The catches other than shrimps are mostly not traded and are used for local consumption. Any possible earning from these catches is left out in this calculation, as they are of economic minor importance.

Table 17 Gross return per operating fishing boat (1983 prices).
Source: Interview surveys 1983.

shrimp-production class	production (kg)	return (Rp)
Class I	240	960 000
Class II	800	600 000
Class III	1 600	240 000
		Rp 1 800 000

To calculate the operating expenses and the net return, we took into account that:

- during the dry season (May until November) the fishermen go out fishing far less often than in the wet season. Earnings during this period hardly outnumber the operating expenses and therefore are not further considered in the calculations,
- during the wet season they go out fishing 20 days per month. They spend 8 or 9 days on repairing the fishing nets (gear) and on the maintenance of their boats,
- these boats, in general: length 8 m, width 1.5 m, depth 0.5 m, carry 2-4 crew members, including the captain, mostly all belonging to one family (Photo 37).

The fishermen have initial purchase expenses of Rp 1 330 000 (Table 18) and yearly writings-off of Rp 497 000. The yearly operating expenses are therefore Rp 797 000 (Table 18). Thus we calculate the net return per family as Rp 1 003 000 (Table 19). Compared with income levels from other kinds of land use, this is a very high amount.

Table 18 Purchase expenses of fishing boats of desa Air Hitam Laut.
Source: Interview surveys with head of a fishing company, fishermen, village leader

Purchase expenses for an average 1 ton boat	
- initial purchase expenses (without motor)[a]	350 000
- motor (60 cc)[b]	630 000
- towing boat from Nipah Panjang to desa Air Hitam	30 000
- installation of motor	50 000
- gear purchase[c]	270 000
(1983 Rp prices, 1000 Rp=1 US$)	Rp 1 330 000

a: wooden boats have a lifetime of about four years
b: writing off period for board motor: 12 years
c: fishing gear must be renewed every season

Table 19 Net return per family in desa Air Hitam Laut.
Source: Interview surveys with head of fishing company, fishermen, village leader, PHPA 1983.

Gross return/year	Rp 1 800 000
Operating expenses/year	
- petroleum 2500 Rp/day	
(20 days/month x 6 months	300 000
- writings-off year	497 000
Net return/year	Rp 1 003 000

6.4.3.4 Assessment of fishing development

The production figures on shrimps catched along the coastal area of Berbak are very promising and attractive (Table 16). Within 3 years (1980-1983) nearly 90% of the farmers of desa Air Hitam Laut changed their agricultural activities into full-time fishery (Table 14) as shrimp yields are very rewarding and give economic benefit on a short term.

However, despite these good shrimp yields that bring prosperity in the

coastal villages, it is highly questionable whether this production can be maintained in the long run, when more and more farmers from neighbouring desas join the fishing fleet.

There are some severe future problems waiting. The Director of Planning of the Indonesian Department of Fisheries very succinctly described this problem:

> "Fish capture is concentrated along the north coast of Java and the east coast of Sumatra in the Strait of Malacca. Most of the fishing gear used by the artisanal fisheries are traditional types. Fishing intensity is very high and concentrated in certain coastal areas, without any special measures being taken to prevent fishing of juveniles or other damaging practices".
>
> "Continuous operations have resulted in a degree of over-fishing, creating critical areas from the viewpoint of the potential of the resources, as well as affecting the socio economic condition of the fishermen" (H. Atwowasono in: Collier et al. 1979).

During our survey, we have seen that the remaining mangrove forests are under great pressure and, if not fully protected, these last fringes will be reclaimed within ten years. The removal of mangrove certainly will reduce the spawning habitats and nursery grounds, as there has been shown a direct relationship between mangrove areas and shrimp production (Martosubroto & Naamin 1977).

6.4.4 **Hunting**

No recent poaching activities have been reported except besides the capture of false gavials (Tomistoma schlegeli) on the Sungai Benu. In the early Fifties and Sixties, according to a former local authority, there was some rhino and tiger-poaching, by people from Singapore.

In the mid-Seventies, people from Palembang tried to hunt crocodiles along the S. Air Hitam Laut. "A camp was already set up inside the reserve, but PPA prevented the start of the hunting operation" (de Wulf & Rauf 1982). In 1982 again people from Palembang tried to hunt crocodiles, but PHPA interventions stopped hunting operations.

Over the past ten years several tigers have been shot by the police. Tiger attacks on humans or livestock occured in all the five villages. Tigers' prey species such as wild pigs are quite abundant in the agricultural areas, to it is unavoidable that tigers will roam near the villages. So far PHPA has not developed any effective policy for dealing

with this problem.

6.4.5 **Forestry**

6.4.5.1 Production forest

The reserve borders two production forests in the west (Figure 14). Because of inaccurate reading of the original decree of 1935, the directorate of the Forestry Department concerned with the assignment of production areas (Directorate Bina Program Kehutanan) allocated two areas with a sizable overlap within the reserve (PHPA 1982a). A total 67 500 ha of the Reserve area (35.2% of the whole acreage) has been scheduled as production forest.

The wood company PT Satya Jaya Raya has been allocated a forest concession of 97 000 ha (Figure 14) (6). Selective logging operations started in 1978. Logged species included ramin (Gonostylus sp.), meranti species (Shorea sp.), jelutung (Dyera costulata), gelam (Eugenia sp.), and durian (Durio carinatus).

Several logging extracting rails were constructed partly in the reserve area (Figure 14). Logs were felled as far as 200 m from the rails and were hauled by hand transport to the lorries. Regarding the demarcation of 1935, there is a double overlap of a total 4 062 ha (PHPA 1982a). However, considering the newly marked boundaries of 1974 (made by the Brigade Planologi), which are more realistic, the total overlap acreage of this wood company with the reserve area is 12 500 ha (PHPA 1982a).

Logging operations, which took place within the reserve in 1982, stopped after intervention by a team of PHPA Central office (PHPA 1982a). The 29 km railroads beyond the 1974 boundaries have been dismantled.

HPH Harapan Baru Wood Company was allocated in 1979 an area of 100 000 ha (Figure 14) (7). In 1973, the company executed some preliminary surveys near S. Simpang Kubu. An inquiry was carried out, to screen the possibilities for transporting logs on the reserve rivers, S. Simpang Kubu and S. Air Hitam Laut. This operation soon stopped, after PHPA got notice of it. Until now, no further logging operations have been enforced, because other ways of transporting the logs seem to be too difficult. The overlap with the 1935 demarcation line has been estimated

10 937 ha (PHPA 1982a). Regarding the 1974 boundaries, the total overlap is 55 000 ha (PHPA 1982b).

Awaiting the final decisions on the new boundary settlements by a team of local and central government agencies (PHPA, Forestry, Agriculture, Planology), which will evaluate the whole boundary sources of the reserve, no woodlogging activities in the 67 000 ha overlap area are scheduled. If the outcome of this evaluation will be the legalization of the 1974 boundaries, the forestry agreement relating this overlap will be cancelled (PHPA Jambi, pers. inf. 1983).

The two concession claims will expire after 20 years (1994 concerning the PT Satya Jaya Raya and 1999 concerning the HPH Harapan Baru Wood Company). Then the areas will revert to the Forestry Department, which can give it a new destination as protected (regenerating) forest area (PHPA Jambi, pers.inf.).

6.4.5.2 Small-scale sawmills activities

Along the Sungai Benu, four small sawmills are operating, managed by some South Sumatran people (Figure 23). They all obtained licenses from the Industry Agency of the South Sumatran province. The owners of the sawmills do not possess concession areas. It is difficult to determine where the processed logs are hauled, in- or outside the reserve, as there is nearly no control by the PHPA (Photo 39).

At some 5 km streamupwards on the Sungai Simpang kanan, illegal logging has been carried out from 1980 until 1983. Seven families from Palembang settled down in 1980 and started logging operations. Some 500 logs of 4 m each (meranti, ramin, durian) were cut by means of chain saws. Hauling had to be delayed until the wet season of 1983, when transport was more feasible due to the flooded forest and swamps along the river.

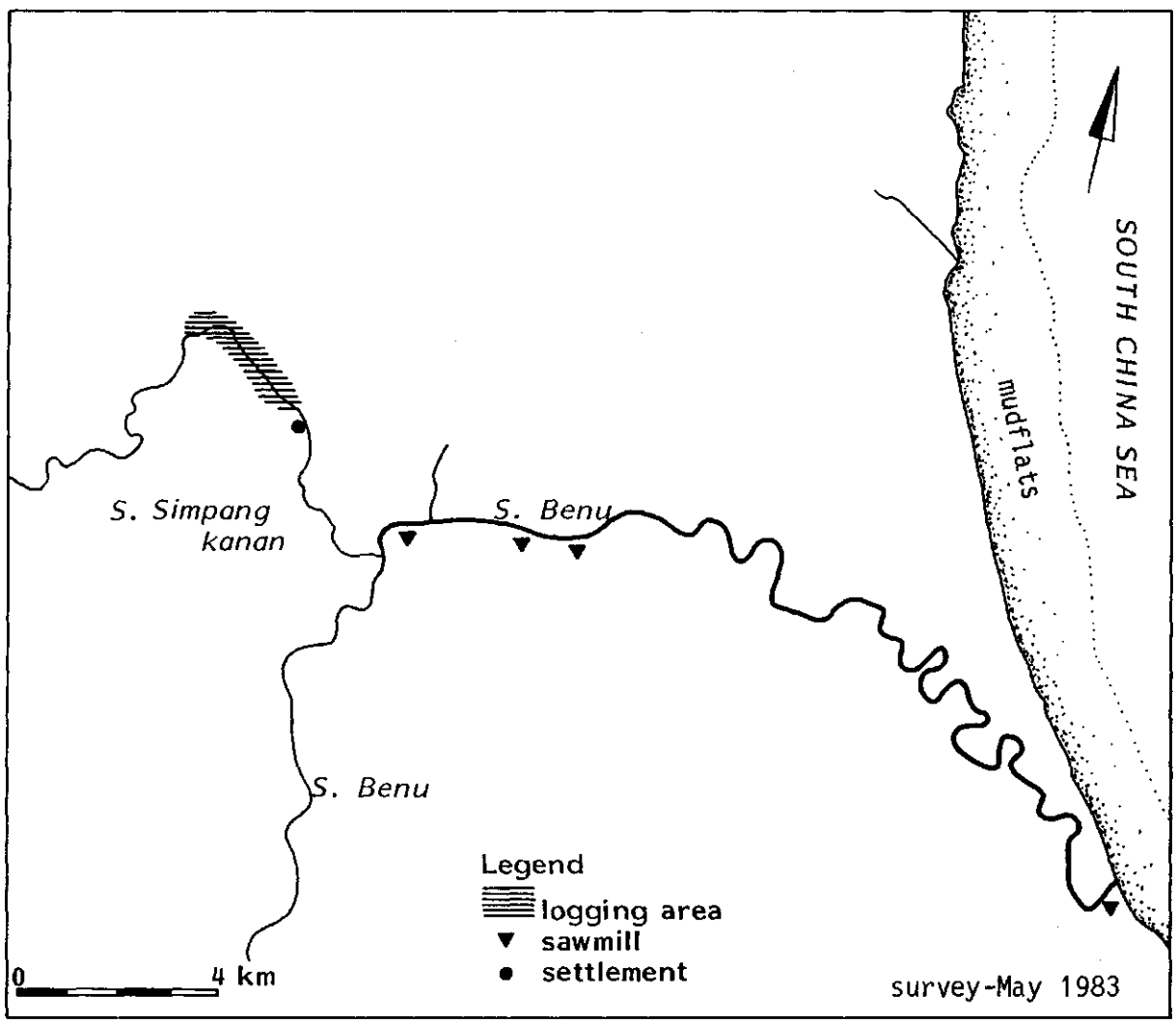


Figure 23 Location of sawmills and illegal logging operations.

6.4.5.3 Collecting of forest products

The lowland forests of South East Sumatra harbour a rich, wide range of natural resources. Small-scale exploitation of these renewable resources is tolerable if there is no severe impact on the ecological integrity of the reserve. Some multiple functions of the wood are:

- construction materials;
- fuel wood;
- valuable timber species;
- tree species with horticultural and pharmacological potention

Construction materials

local name	Latin name	parts used	use
nipah	Nypa fructicans	leaves	roofing (photo 40)
nibung	Oncosperma tiggilarium	stems	scaffolding, fish-platforms (Bagans)
bambu	Bambusa sp.	stems	thatching, storing, mats
api-api	Avicennia sp.	stems nets	framework for fishing
rotan	Korthalsia sp.+Calamus sp.	strings	thatching
palm serdang	Livistonia rotundifolia	leaves	roofing, more durable than Nypa leaves
rassau	Pandanus sp.	stems	framework for boats
meranti	Shorea sp.	latex	as glue, repairing boats

Situation in Berbak:

On small-scale, people still collect these materials near their villages. Nibung has been exploited on a larger scale in 1983; 14 rafts of 15 poles each (total value > 2 Million Rupiah) were ready for transport to Kuala Tungkal (Photo 41). PHPA could confiscate the logs. The offenders were sentence imprisonment during 1984.

Fuel-wood

Most people of the rural areas still cook on nearby hand-collected wood or charcoal (Photo 42).

Situation in Berbak

Although the mangrove forests of Berbak have nearly all disappeared, due to reclamations and landslides, people still collect fuel wood in the small patches of the remaining mangrove forest (desa Cemara, desa Labuan Pering, desa Sungai Benu). This exploitation can be destructive for this ecosystem in the near future, but the rate of deforestation is not known. The villagers also collected fuel wood of the burned zone (Photo 42).

Valuable timberspecies

local name	Latin name	use
pulai	Alstonia pneumatophora	manufactering of apple-boxes[a]
renghas	Gluta sp.	construction of dug-outs, very durable[a]
-	Jackia ornata	one of the best wood-species[a]
gelam	Eugenia sp.	durable wood[a]
tenggris	Kompassia malaccensis	durable wood[a]
meranti	Shorea sp.	durable wood class 2-3[b], window frames
ramin	Gonostylus sp.	not durable wood class 4, used in doors, broom-sticks[b]
durian	Durio carinatus	durable wood class 2, house construction[b]

a: Endert 1920

b: durability classification:

class 1 very durable >25 years

class 2 durable 25-15 years

class 3 moderate durable 15-10 years

class 4 durable to a small extent 5-10 years

Source: interview surveys 1983; Endert 1920; Heilwig 1981; Slegers 1984.

Situation in Berbak

There is almost no timber collection near the villages. Most of the timber used for house construction or the building of boats, is bought from one of the sawmills along the S. Sungai Benu.

Tree species with horticultural and pharmacological potential

Whitmore (1971) lists the following species, known for peat swamp forests, with a horticultural potential (and gene pool reservoir potention): Mangifera sp., Durio sp., Baccaurea sp., Artocarpus sp. Trees with a pharmacological potential: Alstonia sp., Dyera sp. Other trees used by the villagers are: Quassia indica (pahit pahit) and Scaevola fructicans, but a more detailed survey is necessary to give a complete list.

notes

1. Calculation based on the Side Looking Radar Imagery produced by Westinghouse E.R.M.
   Mosaic of the Djambi area, scale 100 000 approx. May 1972. Mosaiced by Hunting Survey LTD.
   This mosaic could be studied at the National Coordination Agency for Surveys and Mapping, Bakosurtanal at Cibinong, Java (Indonesia).
2. Calculations computed from aerial photographs (Roof 8299, Run 53, Roof 8328, Run 52, date: 18-4-1976) studied at Bakosurtanal (see 1).
3. Small patches of undisturbed and partially disturbed forest between the parits have been included in this calculation. These forest clumps do not form a viable ecosystem anymore as their acreage is too limited.The figure is based on our field survey and on aerial photographs.
4. For the project of stimulating the cultivation of export crops (Proyek Rehabilitasi Perluasan Tanaman), 2 ha (6 banteng) in 1979 have been planted with coconut, between parit 9 and 10 of desa Sungai Benu. This plantation has been marked by barbed wire. Because of the objections of PHPA against the construction of this plantation inside a reserve area, the government agency Dinas Perkebunan stopped further support.
5. The farmers plant some 175-200 seedlings on every ha. After 10 years the annual yield per ha is some 10 000 nuts or 30 pikul (100 kg) copra.
6. Farmers of desa Air Hitam Laut could obtain coconut seedlings for 50 Rp each. Coconut credits were also granted in desa Labuan Pering and desa Sungai Benu.
7. Farmers give their yields in terms of kaleng gabah (rice bags) filled with unhulled rice before processed in one of the operating ricemill works. The average yield figure was reported 600 kaleng gabah (11 kg/kaleng, Collier 1979b) per 0.5 lembar (1.25 ha). This is approximately 3 ton hulled rice per ha. Because there are very high yield figures, we controlled our reports at the Agricultural Service in Nipah Panjang. A team of this agency which made an agricultural survey in 1982 in desa Cemara, could confirm those high yield figures.
8. Based on the forestry agreement of 9-3-1974, signed by the Minister of Agriculture.
9. Based on the forestry agreement of 1-8-1979, signed by the Minister of Agriculture.

6.5 Conclusions

1. Six Buginese settlements are located inside the reserve, of which two overlap partly (desa Sungai Remau, desa Simpang Datuk) and 4 entirely (desa Air Hitam Laut, desa Cemara, desa Labuan Pering, desa Sungai Benu).
   The reclaimed area in 1983 is estimated to be about 16 700 ha (or 9%) of the total reserve area including 4 000 ha of virgin farest which have been destroyed during 1972 and 1982 as a result of forest fires.
2. The main landuse is the cultivation of rice and coconut. In the village Labuan Pering, banana is cultivated as the main product. For the draining of the tidal swampland people make use of the typical 'parit' system.
3. Crop yields can be rather good. In desa Cemara, annual rice yields of about 3 ton.ha^{-1} are reported. Cultivation of coconut and banana also give reasonable results.
   Not everywhere agriculture is successful. Limitations are:
   - bad soil conditions, i.e. occurrence of acid sulphate soils;
   - flood hazards (in desa Sungai Benu);
   - crop damage by pigs and sun bears;
   - pests, caused by insects and rats;
   - recurrent catastrophic droughts.
4. Sea fishery, mainly on shrimps, is an increasing economic activity. People in desa Air Hitam Laut and desa Sungai Benu tend to change from agriculture to sea fishery, providing them a better income. Nevertheless it is highly questionable whether this fishing intensity will be maintained in the long run. An increase of fishery activities might lead to overfishing.
5. Woodlogging occurs only on a small scale. However, in the western part, concession areas of two woodlogging companies have an overlap with the reserve area. At present, these areas are not in production.
6. We could confirm the occurrence of the Kubu tribe for Berbak. According to the PHPA, there are still 150 Kubus living inside the reserve.

7 NATURE CONSERVATION AND MANAGEMENT

7.1 Conservation values

vegetation

Berbak is unique for its vast acreage of still undisturbed peat swamp forest. the flora of which shows a great similarity to that of the lowland Dipterocarp forest (Whitmore 1975). Also in Berbak we found the typical members of the Dipterocarpa family (Shorea sp.), which are highly valuable timber species. But in spite of this floristic similarity, the peat-swamp forest has its own characteristic forest formations and floristic composition, which are related to the great range of habitat conditions. Besides, the peat vegetation in Berbak is not of the 'padang' forest type that Anderson (1964) described for peat swamp forests in Riau, but it has its own features. These particular peat forest formations of the Berbak reserve are of great conservation value. Moreover, the Berbak reserve is the most extensive peat swamp so far included within reserves in Indonesia (MacKinnon 1982), in fact in the whole Pacific region. Although there were originally nearly 10 million ha of peat-swamp and freshwater-swamp forest along the Sumatran east coast, only a few reserves have been established until now (Table 20).

Although the Nature Conservation Servic PHPA is a fast growing institution (Figure 24) with yearly increasing budget and personnel, the establishment of some new swamp reserves at the east coast of Sumatra is not be expected, as this will overlap numerous transmigration programmes and forest concession areas (MacKinnon 1982b). So far only one swamp reserve, Kerumatan Baru, has been established in the Riau province. This reserve has a comparable rich wildlife as the Berbak reserve including tiger, tapir and gibbons, but it lacks the important habitat chain of mangrove forest backed by peat swamp forest, as it is not located along the coast.

Table 20 Habitat types in the provinces Riau, Jambi, South Sumatra and Lampung.
Source: Mackinnon 1982

province	habitat type	original acreage (ha)	present area (ha)	within reserves, including proposed ones (ha)
Riau	mangrove forest	680 000	470 000	12 000[1)]
	peat-swamp forest	4.500 000	3.200 000	346 000[1)]
	freshwater-swamp forest	520 000	125 000	10 000[1)]
Jambi	mangrove forest	165 000	90 000	20 000 *
	peat-swamp forest	840 000	600 000	150 000[2)]*
	freshwater-swamp forest	130 000	65 000	20 000[2)]*
S.Sumatra	mangrove forest	230 000	115 000	10 000[3)]
	peat swamp forest	1.720 000	670 000	30 000[3)]
	freshwater-swamp forest	2.170 000	190 000	0
Lampung	mangrove forest	20 000	3 000	1 500[4)]
	peat-swamp forest	0	0	0
	freshwater-swamp forest	400 000	30 000	30 000[4]

1) 67% of the reserves in Riau have a proposed status

2) located in the Berbak game reserve
The only large existing peat swamp reserve is the Kerumatan Baru, declared as Nature Reserve in 1979 with an acreage of 120 000 ha of which 100 000 with peat swamp forest habitat.

3. within the dropped proposal of the Terusan Dalam Reserve (40 000 ha)

4. located in the Way Kambas Game Reserve, this reserve has no peat swamp forest!

* By our estimation Berbak had approximately 110 000 ha of peat forest, 60 000 ha of freshwater-swamp forest and 2 000 ha of mangrove forest

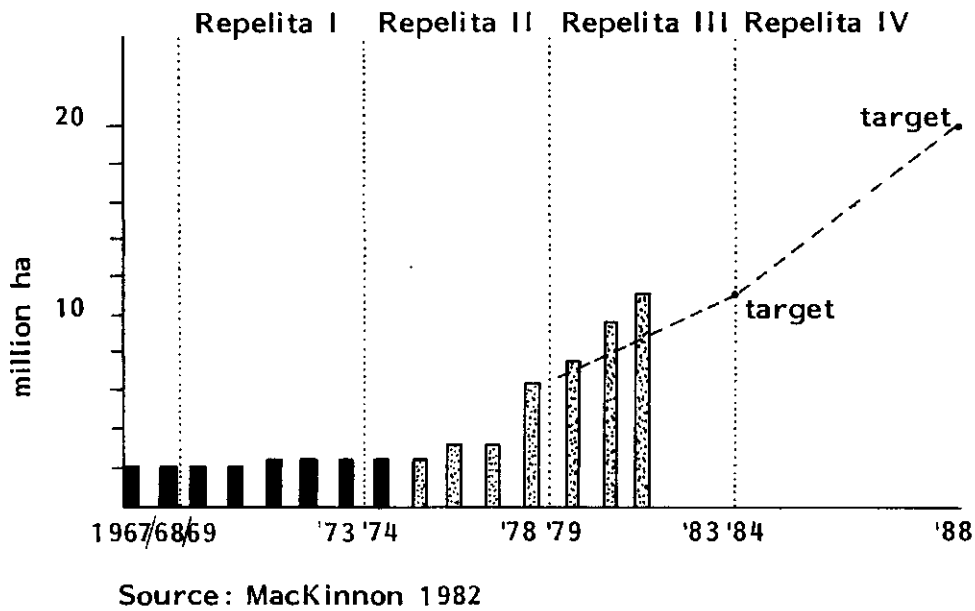


Figure 24 Established and planned areas of nature reserves during Repelita I-IV.

fauna

The Berbak reserve, with its wetland habitats (rivers, tidal creeks, swamp forest), is rich in wildlife including some typical lowland species such as tapir and two types of crocodile (Crocodilus porosus and Tomistoma schlegeli). It has a rich primate population due to the abundance of all kinds of fruit trees in the swamp forest. Five species have been identified, including the siamang (Symphalangus syndactylus). The occurrence of this species for the southeastern Sumatra swamps was doubted so far in primate literature (de Wulf and Rauf 1982).

Berbak's avifauna is rich. During six months of fieldwork already 225 species could be observed, including 11 Kingfisher species (Alcedinidae) and 9 hornbills species (Bucerotidae).

Berbak's vital role as a resting place and feeding ground for migrating waders has already been discussed (5.3). Along the tidal mud flats of desa Cemara, 31 waders species (including herons and egrets) have been observed. The international importance of preserving the

wetlands in tropical countries, especially as resting place for migrating waders, is more and more recognized (1).

To the IUCN Red Data Books deal with fauna species all over the world suspected to become extinct. The Berbak reserve harbours nine listed species (Table 21).

Table 21 IUCN Red Data Book species, occurring in Berbak.
Source: IUCN Red Data Books, vol. I, II, III (1974)

mammals	common name	category[1)]
Panthera tigris sumatrana	Sumatran tiger	endangered
Tapirus indicus	tapir	endangered
Lutra lutra	Sumatran common otter	rare
Birds		
Egretta eulophotes	Chinese egret	vulnerable
Ciconia episcopus stormi	Storm's stork	indeterminate
Ibis cinereus	milky stork	vulnerable
Rhinoplax vigil	helmeted hornbill	indeterminate
Reptiles		
Crocodylus porosus	estuarine crocodile	vulnerable
Tomistoma schlegeli	false gavial	endangered

1) for defenition of categories see note (2).

The IUCN Red Data Book must be assessed as based on only brief information on the present status. Because of rapid habitat destruction in the Sumatran lowland forest, some more species might be admitted in the near future (F. Rozendaal, pers.comm.).

National Conservation evaluation

In the National Conservation Plan for Indonesia, a FAO/UNDP project (MacKinnon 1982), an attempt has been made to assess the conservation values of all Indonesian reserves (including the Berbak game reserve).

The assessment of priorities in the FAO report is based on three types of evaluation:

1. importance of the habitat with respect to preservation of genetic resources;
2. socio-economic justification;
3. management feasibility.

The results of the overall evaluation stressed the maintenance of Berbak as a protected area, as it got a high score for each category mentioned above.

In conclusion we can say that Berbak is of high conservation value as it possesses various habitats, necessary for the preservation of viable population of some most endangered fauna species.

7.2 Threatening developments

More than one third of the pristine 190 000 ha acreage of the Berbak reserve, 67 500 ha virgin forest (Figure 14), is in immediate danger as this area has been allocated as forest concession (6.4.3.1). If the Ministry of Forestry does not recognize the reserve's demarcation line of 1974 as the new legal boundary, and the two forest agreements will not be cancelled, logging operation might start again. Besides the sizable loss of the original reserve area, the logging operations, which are scheduled near the sources of the S. Air Hitam Laut, certainly affect a major part of the basin area of this river (including the river parts in the remaining reserve area).

At present, 16 700 ha (or 8.8% of the reserve area) coastal swamp land along the coast, have been reclaimed by Buginese farmers. Favourable circumstances for agriculture, including drainage and absence of acidity in the mineral soils (with a low amount of pyrite) have been established (6.4.2.7). Therefore, it must be expected that more coastal land, upto 5 km inland, will be reclaimed, if this is not prevented by the authorities. The presence of four villages has several negative impacts for the reserve:

1. An undisturbed succession from mangrove forest along the coast to peat forest cannot be found anymore.
2. Forest fires in 1982, probably as a result of neglectful burning of arable land after the harvest at the end of the dry season, destroyed already 3 400 ha partly undisturbed peat forests. Especially during

excessively dry years the risk of fires, affecting the forest behind the agricultural land, is high.

3. The parits, made by the Buginese farmers, start deep in the forest; they probably lower the water level in the dome-shaped peat and threat the peat forest as such.
4. The location of desa Air Hitam Laut and desa Sungai Benu, near the mouth of the two rivers S. Air Hitam Laut and S. Sungai Benu, means a direct destruction of the resting, feeding and breeding grounds of the endangered fauna species Crocodilus porosus. If the occupation of this area is continued, it can be expected that these fauna specie soon will disappear.
5. Over the last years, several Sumatran tigers, occasionally occurring in the direct surroundings of the coastal villages, have been shot by the police (PHPA pers.comm.). The Sumatran tiger's territory is linked with areas abundant in wildlife. In Berbak, abundant wildlife was found along the coastal area, especially in the former mangrove fringe and it is still present along the banks of the rivers S. Sungai Benu and S. Air Hitam Laut (5.2). Because the Buginese have occupied a major part of the coastal zone and a part of the banks of the two rivers, these reclamations resulted in a lost of habitat of the range-sensitive Sumatran tiger.
6. Collecting of fuel wood swallows Berbak's remaining mangrove fringe near desa Cemara and affects this important ecosystem more and more.

River fishery activities might threaten unintentionally the population of the freshwater turtle (Orlitia borneensis). This turtle is protected under the current Indonesian conservation law (PHPA pers.comm.). The increasing number of settlers on the southern bank of the river S. Benu and increasing activities on this river (i.e. boat transport, logs hauling transport, river fishery) can be destructive for the endangered false gavial (Tomistoma schlegeli). The threatened species, of which the ecology, habitat preference, and distribution are not well-known (MacKinnon pers.comm.), has been subject to capturing over a long period, despite its protected status under Indonesian law.

7.3 Management

7.3.1 History of conservation

When in the mid-Seventies, the Buginese settlers opened land near the S. Sungai Remau and along S. Air Hitam Laut, these new reclamations could not be prevented. The PHPA started their management activities in the Jambi province only since 1972, and in the first years of operation, facilities and manpower for law enforcement were limited. Between 1969 and 1972, one officer belonging to the Forestry Department was assigned for protection of all the provincial reserve areas.

This officer took some sweeping measures, by allocating new boundaries for the Berbak reserve (Photo 45). Anticipating new incursions of coastal settlers, especially in the Tanjung Jabung area, the Service excluded some 42 000 ha, for the largest part already cleared arable land in the north. Adjacent to the western boundary, an area of the same size was appointed, to be included in the reserve. Boundary demarcation was executed from 1969 till 1974. However, several boundary disputes arose from this new demarcation, as this never got legalized and ratified by the Minister of Agriculture (3). The same applies for the (original) boundaries, based on the establishment decree of 1935. Even these first boundaries wait for ratification (4). Due to the Japanese war and the chaotic post-war independence entanglements, these procedures for Berbak were never carried out.

At the time of boundary demarcation (1969-1974), reclamations went on near S. Sungai Remau and S. Air Hitam Laut. These new villages were not excluded from the new reserve boundaries. The leaders of the settlers even started procedures to legalize their activities. The villages requested the Agricultural agency of the Jambi province to consent the opening of tidal land near the mouth of the S. Air Hitam Laut in 1965 (5). District officials of the Camat administration made in the mid-Seventies, on its own initiative, a 5 km inland boundary. Although the Camat officials has no authority to establish such boundaries inside reserves, the measure proved effective, as this 5 km demarcation was never surpassed. The municipalities of the four coastal villages still claim this 5 km inland boundary, as the border of the area falls under their authority.

In 1975, PHPA tried to reach an agreement with the village leaders and the local government (Marga leader) to freeze further reclamations inside

the reserve and to discourage newcomers to settle in the reclaimed areas, but this plan failed (6).

The Service succeeded in resettling farmers, who reclaimed burned forest near S. Sungai Rasau (along the S. Sungai Benu) in 1976. PHPA recently got support from the provincial authorities, to prevent further interference in the reserve. In December 1982, the Governor of Jambi informed personally the villages deputies during a special meeting, that no further reclamations or extension of arable land would be permitted. Furthermore he stressed that is was not allowed anymore to facilitate new settlers to work and stay in the four reserve villages. The village leaders are held responsible for the execution of these regulations. It was stated by the governor, that his address should not be interpreted as a legalization of the 5 km inland boundary made by the Camat administration, but more as an attempt to stabilize the process of extension and spreading. The local government has announced that a team of several governmental agencies (PHPA, Forestry, Agriculture and representatives of the provincial adiministration) will carry out a survey in 1984-1985, to propose a final demarcation. Before the central government confirms the team's proposals about the policy towards the coastal area, PHPA will not resettle the four villages or settle new boundaries.

7.3.2 **Present management**

Currently the PHPA is organized through regional offices, the so-called Balais. These Balais are responsible for the nature conservation administration within several provinces. Under the authority of the Kepala Balai functionates the Kepala Sub-Balai, one for every province. Although the PHPA is administered within the Ministry of Forestry, with its own regional offices in every province, the PHPA is operating independently. Through the chain of Balai offices there is a direct liaison with the Under-Secretary office in Bogor (Figure 25).

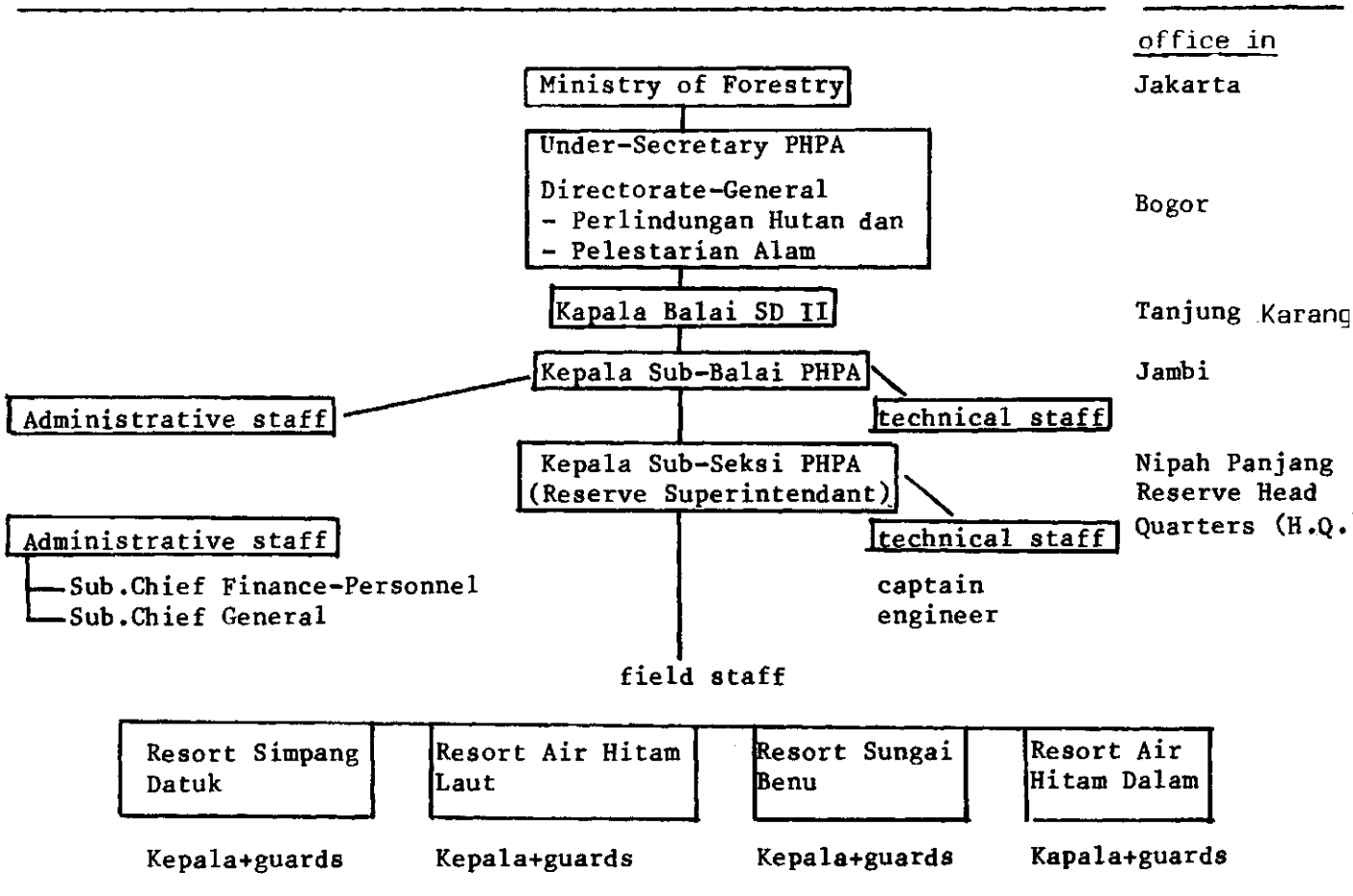


Figure 25 Administrative infrastructure of the Berbak game reserve.
Source: PHPA Jambi

The Berbak game reserve's personnal numbers 11 field-workers permanently stationed in four field offices or resorts, and 7 officers working at the Reserve Headquarters in Nipah Panjang, under the responsibility of the Kepala Sub-Seksi or Reserve Superintendant.

Year	1972	'73	'74	'75	'76	'77	'78	'79	'80	'81	'82	'83
Total Jambi Province including office Sub-Balai	1	2	4	12	12	12	12	38	38	38	45	63
Subdivision for office Kepala Sub-Seksi				3	3	3	4	4	4	8	8	8
Resort Air Hitam Laut				2	2	2	3	3	3	3	3	4
" Air Hitam Dalam										x	x	3
" Sungai Benu										x	x	3
" Simpang Datuk										x	x	2

x: non-permanent patrols of reserve H.Q. in Nipa Panjang

Figure 26 Personnel commission development PHPA, Jambi province;
Source: PHPA Jambi

7.3.3 **Facilities and communication**

Buildings

PHPA has of several field stations for a daily permanent management (Photo 44, Figure 27). In the villages Air Hitam Laut, Air Hitam Dalam and Sungai Benu, PHPA recently constructed three guard posts. The construction of a post for desa Simpang Datuk is scheduled. The guard post of desa Air Hitam Laut has been established already in 1975. It includes a well built landing-stage for large motor vessels. Next to the office, there is a house constructed for the head or this resort.

Along the S. Air Hitam Laut, there are two watch posts (Pondok jaga) built in 1980. These unoccupied shelters, can functionate well for research workers in the field. The landing stages, which were made of Nibung poles, have decayed thoroughly and must be rebuilt.

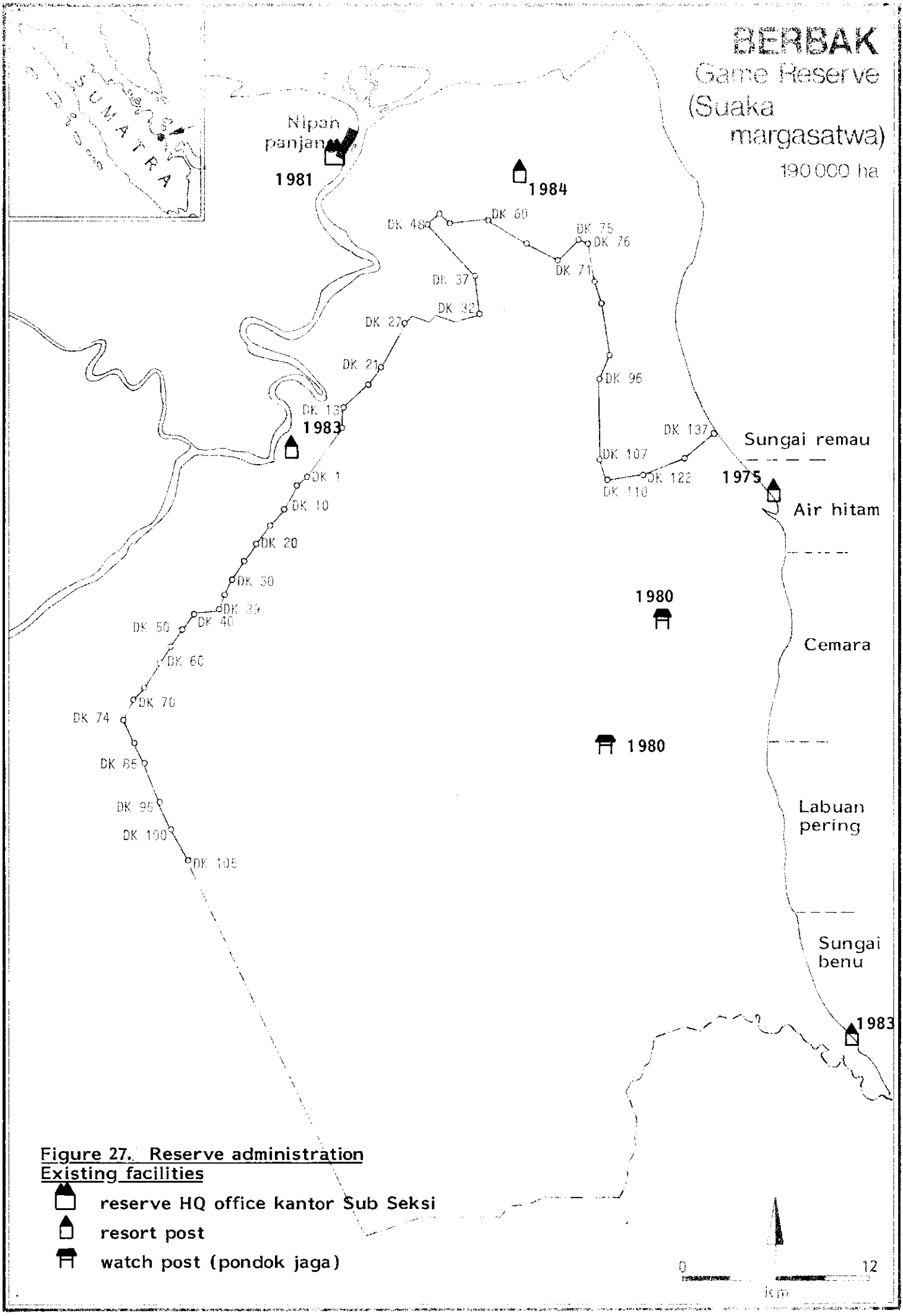


Figure 27. Reserve administration
Existing facilities

- reserve HQ office kantor Sub Seksi
- resort post
- watch post (pondok jaga)

transport

In Jambi, there is a 50 h.p. fibreglass speedboat available. In view of the high transport costs, this boat is used only for special field trips. It enables a very quick access (only six hours from Jambi to the PHPA-guard post of desa Air Hitam Laut).

At the reserve H.Q. in Nipah Panjang, there is a 20 h.p. diesel boat the motor of which is in good condition, but the wooden barrel must be renewed, as it is too leak to be maintained any longer.

At the guard post of desa Air Hitam Laut, there is a 25 h.p. open wooden speedboat that is also in bad condition.

For 1984, two new diesel boats (six and seven h.p. pompongs; local fishing-boats) are scheduled to be purchased. They will be used for the connection between Resort Sungai Benu, Resort Air Hitam Dalam with the Reserve H.Q. in Nipah Panjang. Besides, PHPA is planning to have several bicycles for patrolling along the reclaimed areas.

communication

Currently there is no radio communication (SBB) between the various resort posts with the reserve H.Q., and of these H.Q. with the Sub-Balai office in Jambi. The local government in Nipah Pajang recently set up radio connection posts in desa Sungai Benu and desa Sungai Jambat (just outside the reserve). In principle, PHPA can use these transmitters for sending messages, but anyway there still is no direct communication with the resort in desa Air Hitam Laut.

7.3.4 Staff duties

Until now management consists mainly of a permanent occupation and maintenance of the three resort posts. As these posts are not provided with transportation facilities, management is restricted to nearby patrols to control activities of the farmers around the villages. However, the functioning of the 12 guards, though hindered in their duties by the lack of good communication and transportation means, may not be underrated. Since the establishment of the resort in Air Hitam Laut no fishing activities on the river S. Air Hitam Laut took place any longer. Also the tapping of latex from jelutung trees (Dyera costulata) and the collection of rattan were stopped.

One guard is in charge of the daily control of possible crocodile poaching. With his motorized houseboat, he watches over the S. Air Hitam

Laut. Poaching control on the S. Benu river is excluded from this surveillance. This will be an important task for the guards on duty at the newly opened resort Sungai Benu.

The presence of the several resorts and the regular patrolling by the guards (some of them recruited from the Buginese people in desa Air Hitam Laut) have a warning and discouraging effect, preventing possible new encroachments by farmers.

Besides patrolling, other staff duties are boundary maintenance, placing signboards, reporting offences (illegal removing of timber and other forest products), and sometimes guiding visitors (tourists or scientist). Four PHPA guards had a special training as Forestry Police officer (Kehutanan Polisi), and are now qualified to arrest tresspassers and to confiscate arms and traps, but the guards do not act without the help of the police. Since 1981, the PHPA guards are no longer authorized to carry fire-arms.

7.3.5 **State of boundaries**

During 1983 hardly anything has been done for the maintenance of the artifical boundaries (through the forest) at the western part of the reserve. Control and clearing have been carried out only from the boundary marks DK1 up to DK 60 (Figure 27) in the north, near desa Simpang Datuk, starting oktober 1983. The remaining boundaries are in a bad state: many boundary-markers are lost and the boundary paths have been totally overgrown by rattans and shrubs.

7.3.6 Reorganization

As a part of the comprehensive reorganization programme of the Forestry Department scheduled for 1984/1985, also the regional agencies of Forestry (Dinas Kehutanan and Nature Conservation Service (PHPA)) have been evaluated and will be reorganized. The provincial office of the PHPA in Jambi will loose its independant status and will come under the authority of a mastering Forestry agency (Kantor Wilayah Departemen Kehutanan) to strengthen a well-planned regional forestry policy (Departmen Kehutanan 1983).

Also for the PHPA office in Jambi, there is a major reorganization programme scheduled. As the Kerinci reserve will be allocated as a National Park, administered by a separate Sub-Balai office, there will be a new Sub-Balai office for the Berbak reserve.

7.3.7 **Management improvements**

Management administration and law enforcement for the Berbak reserve started after 1972. Due to inadequate budgets for provision of necessary staff and quarters during the first years, management could not be executed well. But the situation is gradually changing. The management of the reserve could be improved a lot if Bogor could/would support the Sub-Balai by implementing budgets for:

1. sufficient transport and communication facilities
   Each resort should have its own vessel for regular patrol and should have radio connection with reserve H.Q. in Nipah Panjang.
2. maintenance and running expresses for boats
   The present transport equipment is in a bad state since engines and motor have not been maintenained regularly. Drums with fuel are mostly absent at the various posts so that unused engines rust away.
3. boundary maintenance
   Until now a monthly budget for (and written into) the routine duties of the guards is lacking.
4. Extra allowance guards
   Guards must be willing to work in remote places for only a small salary. Thus, a good motivation is needed. A sufficient monthly budget for travelling is therefore a prerequisite. Guards must also be provided with the minimum basic equipment, if they are to operate effectively and they need adequate quarters, supplied with sufficient accomodation facilities.

Notes

1. At the second conference of contracting parties of the Ramsar Convention (Convention on Wetlands of International Importance) held at Groningen, the Netherlands 7-12 May 1984, a new plan of action was launched to help less developed nations (by provision of special assistance) to conserve vital wetlands (IUCN, Press Release 1984). Moreover, IUCN and WWF will initiate a special program on Southeast Asian Wetlands, starting January 1985.
   Since 1983, IWRB (International Waterfowl Research Bureau) and ICBP (International Council for Bird Preservation) are involved in the international Southeast Asia Wader study with some special programmes for Indonesia.
2. The IUCN Red Data book mentions 4 categories:
   - endangered: species in danger of extinction and whose survival is unlikely if the causal factors continue operating;
   - vulnerable: species believed likely to move in the endangered category in the near future if causal factors continue;
   - rare: species with a small world population that are at present not endangered or vulnerable, but at risk;
   - indeterminate: species that are suspected of belonging to one of the first three categories but for which insufficient information is currently available.
3. Since May 1983, when a major reorganization took place within the Ministry of Agriculture, the Under-Secretary of Forestry with the Directorate for Nature Protection and Conservation (PHPA) was upgraded to a separate ministry level. PPA is now operative as Directorate General of Forest Protection and Nature Conservation (PHPA). Boundary recommendations are now legalized by the Minister of Forestry.
4. The legal procedure for a modification or allocation of reserve boundaries includes the legalization, through a decree of boundary regulations, succeeded by marking of these boundaries in the field. This is a task of the Planological agency of the province.
   The boundary regulations are issued by a special Boundary Regulation Committee, consisting of central (from Forestry and Agriculture Department) and local government representatives.
   Only after the decree is signed by all parties involved and approved by the Minister of Forestry, the reserve boundaries are fully

legalized (Van Strien 1978).

5. Letter dated 8 October 1965 (request for opening 10 ha tidal land). Repeated in 1971, with the support of the Kabupaten administration of Tanjung Jabung. Both letters never got answered.
6. Agreements were made for every parit and undersigned by all parties involved (PHPA, Marga, head of the parit), except by the village leader who took offence at this procedure.

7.4 Conclusions

1. The Berbak game reserve is of high conservation value:
   1. it is the most extensive peat swamp reserve, so far included within reserves in Indonesia;
   2. it possesses various habitats, necessary for the preservation of a viable population of some endangered fauna species, including tiger, tapir and two reptile species;
   3. it has excellent wetland habitats, rich in wildlife (both mammals and birds);
   4. it plays a vital role as a resting place and feeding ground for migrating palearctic waders.
2. Some threatening developments are identified:
   1. The new boundaries of 1974, settled by the Brigade Planologi (Planological Agency of the province) have not yet been legalized and ratified by the Minister of Forestry. This has resulted in the issu of two forest concessions on Berbak's west side, with a total overlap of 67 000 ha (or nearly one third of the reserve area).
   2. The coastal settlements occupy about 16 700 ha (or 9%) of the reserve's area (included are the parts disturbed by the two forest fires of 1972 and 1982).

      The presence of four villages has several negative impacts on the conservation values of the reserve, discussed in 7.2.
3. Management activities in the Berbak game reserve started in 1969. In the last years, adequate budgets for provision of necessary staff and quarters have been supplied, although some extra budgets for transport and radio connection appear to be urgent.

8 MANAGEMENT OPTIONS

8.1 The coastal settlements

With respect to the population inside the coastal settlements, three strategies to protect the reserve are possible.

1. consolidation
2. resettlement
3. concentration

This three options correspond with the PHPA own proposal for the coastal area which was draw up and adressed to the Governor of Jambi province and PHPA central offices in Bogor (PHPA 1984).

ad 1 **Consolidation of the present situation**

Permitting agricultural activities up to 3 km from the coast, with the following restrictions:

- prohibiting any clearing and woodcutting inside the remaining mangrove forest,
- prohibiting the settlement of new comers in the four villages,
- prohibiting temporarily operating fishermen from nearby villages to stay and work in desa Air Hitam Laut and Sungai Benu, during the shrimp season. PHPA will not allow the lodging of fishermen along the S. Air Hitam Laut or on the banks of S. Benu.

PHPA shall execute a more strict control in the coastal villages. Resort posts in desa Cemara and Labuan Pering must be opened as soon as possible.

The policy of the local and central government concerning the inhabitants must be directed to a further stimulation for the farmers willing to leave. Emigration programmes to Sulawesi must be considered, as it is known that local authorities of the Kecamatan Kolako, Southeast Sulawesi, have already complied with individual requests of farmers from desa Air Hitam Laut.

ad 2 **resettlement**

The resettlement of all inhabitants within the reserve is the most consequent management strategy with possibly fast results for the preservation of the habitats found within the reserve (from mangroves to peat swamp forest). On the other hand, the resettlement programme, with some far-reaching social and economic consequences, will bring about serious

problems.

ad 3 **concentration**

By concentrating the inhabitants in some parts of the coastal area, about 10 000 ha (or 60% of the presently occupied and by fire disturbed zone) will be abandoned. The abandoned areas will regenerate in the long run as forest. Some of the people, who have to resettle, will be able to find work as fisherman in desa Air Hitam Laut and desa Sungai Benu. Others have to leave for new areas. The local government must work out a resettlement programme in close cooperation with PHPA for those farmers who have to leave (compensation of transport costs and for indemnification of lost land and yields). Below the situation per village is outlined (Figure 28).

desa Air Hitam Laut:

- resettle farmers from parit gantung
  reason: - stimulation of natural regrowth of mangrove zonation
  - protection of the tidal mudflats of Air Hitam Laut
  - opportunity for the estuarine crocodile (Crocodilus porosus) to breed on the sandy riverlevees near the coast.
- resettle farmers from parit 3, 4, 5, 6, 7, 8, 9, 10 along both sides of the S. Air Hitam Laut
  reason: - Along these parits, only a few families still are engaged in agriculture. Several parits (6.3.2.1) have already been abandoned. The remaining activities are difficult to control.

desa Cemara

- resettle farmers from parits living more than 2 km from the main parit.
  reason: - to restrict agricultural activities within a 3 km zone from the sea and preventing the spreading of ladang burnings into the fire-risking (already burned) transitional zone.
- resettle farmers from parits south of parit 1 (parit 2, 3, 4, 5 kiri)
  reason: - to stimulate the regrowth of the mangrove forest south of desa Cemara, and to promote the natural succession from mangrove forest to swamp forest.

desa Labuan Pering

- resettle farmers from parits more than 2 km from the main parit.
- resettle farmers from the parits north of parit 5.

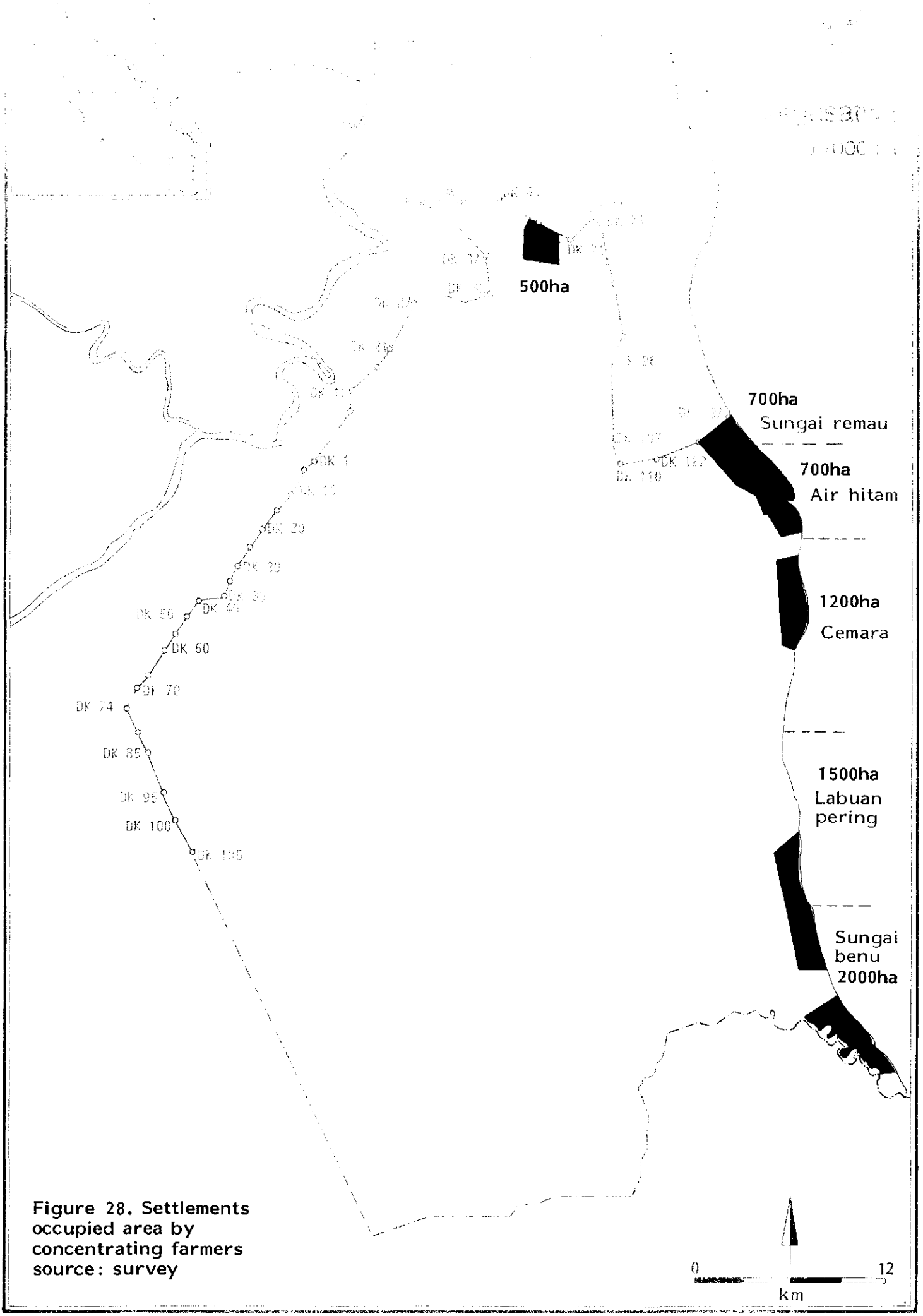


Figure 28. Settlements occupied area by concentrating farmers source: survey

reason: - to stimulate regrowth of mangrove forest and promote the natural succession from mangrove forest to swamp forest. From desa Labuan Pering towards Cemara, there will be a belt of approximately 15 km long mangrove forest
- preventing forest blaze along the risk-bearing transitional zone.

desa Sungai Benu

- resettle parit 3, 4, 5.

reason: - the low-lying fields are every year bothered by very destructive brackish inundations, destroying rice fields and other crops. Parts of these parits have been abandoned already.

8.2 Boundary re-shaping

An earlier recommendation to enlarge the Berbak reserve in southern direction by the inclusion of a 40 000 ha large coastal area in the South Sumatran Province, has been rejected (MacKinnon 1982). This area, Turusan Dalam, also consists of peat swamp and of an extensive area with mangroves. However, the area has recently been occupied by settlers and large reclamations schemes have been carried out. Furthermore, large timber concessions have been granted (MacKinnon 1982) within the proposed area. Also from the management-point of view, it is not very practicale to have a reserve administered by two provinces. For these reasons it was concluded that extension of Berbak towards the south is not feasible (MacKinnon 1982). However, we recommend the southern boundary of the reserve to include the whole course of the river Sungai Benu (as far streamupwards as the 1974 boundary turns away from the river). At present, the river belongs to the South Sumatran province. Inclusion of the river within the reserve area will enable a strict protection of the river's ecosystem.

Extensions, adjacent to the present western boundary of 1979, to include the sources of the S. Air Hitam Laut, are only feasible after the timber concession of HPH Harapan Baru Wood will expire in 1999. As this is a long-term solution and irreparable interference could be already come off, it is strongly advised that PHPA , together with central and local government agencies, will re-negotiate the forest agreements with this timber company to cancel at least a 43 400 ha southeastern part, in order to avoid a possible disturbance (Figure 29). It must be marked that the logging company concerned, did not yet succeed in logging operations as hauling of the logs seemed to be too difficult (PHPA, Jambi, pers.comm.).

The only extension feasible to be implemented at short notici, is the proposal in the Berbak-FAO management plan 1982: it concerns a 3,160 ha area in the north of the present boundary marks DK 13-DK 74. Here by the S. Air Hitam Dalam will become a natural boundary. This amendment, provides a better workable management, i.e. law-enforcement along Berbak's N.W.-boundaries (Figure 29)

8.3 Status of the reserve

8.3.1 Present status as game reserve

Under current legislation, game reserves (Suaka Margasatwa) should meet the following criteria (based on the decree of the Minister of Agriculture, 8 August 1981):

1. the area should be a living and breeding site of wildlife species which are in need of conservation;
2. the area should have a diverse wildlife and a high population of the species concerned;
3. the area should be important for particular migrant species;
4. the area should be sufficiently large as habitat for the wildlife concerned.

Within a game reserve the following activities are prohibited, according to the present laws: (See note 1)

1. to endorse activities which may cause damage of the habitat and disturbance of the peaceful life of animals living there.
2. to hunt or to disturb any species of animals living there.
3. to carry hunting equipment, to make camp fire or to graze domestic animals.

These prohibition orders are different for two types of zone which have been distinguished within game reserves; a traditional use zone (with allowance for the collection of minor forest products) and a wilderness zone. (These zones differ with respect to the activities allowed (Table 22). Prohibition orders for the very restricted Nature Reserve (Cagar Alam) are also added. From this table it must be concluded that Berbak should retain its status of a game reserve, making it possible to continue further scientific research programmes like:

- monitoring long term diversity changes of conspicuous fauna species;
- flora inventories.

It is not realistic to go ahead with recommendations for a feasible assignment of different zones for the Berbak reserve. This can only be done after reviewing the results of the boundary committee with regard to the occupied coastal area.

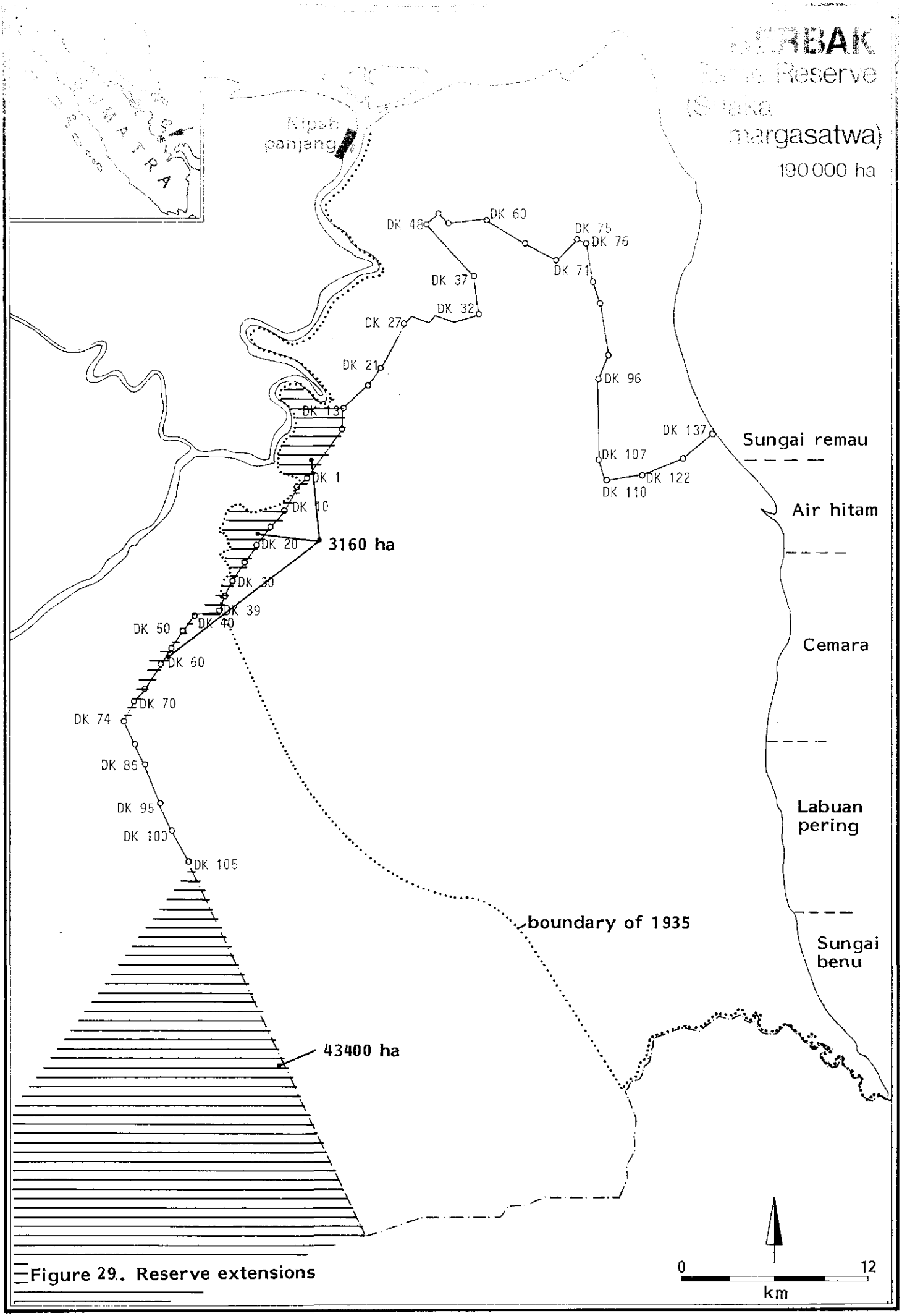


Figure 29. Reserve extensions

Table 22 Activities allowed or restricted in four different classes of conservation-zones. Source: FAO (1981a).

zones within Indonesian reserves		human settlement	conversion to agriculture	commercial logging	cutting timber for own use (dead wood)	collecting rattan	collecting bamboo, fruits, honey	hunting with fire arms	traditional hunting	traditional fishing	planting of tree crops	habitat management	construction of tourist buildings	scientific collecting	scientific measurements	tourist visiting
Game reserve (Suaka Margasatua)	- traditional use zone	-	-	-	+	?		-	?	+	-	+	-	+	+	+
	- wilderness zone	-	-	-	-	-		-	-	-	-	+	-	+	+	-
Nature reserve (Cagar Alam)	sanctuary zone	-	-	-	-	-		-	-	-	-	-	-	-	+	-

legend: - never permitted
+ always permitted
? sometimes permitted

8.3.2 **Berbak as a National Park**

The Berbak reserve has been identified to be viable for long term development, to become a National Park during Repelita VI (1989-1994) (MacKinnon 1982). The Berbak reserve fits in the international criteria outlined for National Parks by IUCN (1974):

1. A National Park is a relatively large area, where one or several ecosystems are not materially altered by human exploitation and occupation, where plant and animal species, geomorphological sites and habitats are of special scientific, educative and recreative interest or which contains a natural landscape of great beauty; and
2. where the highest competent authority of the country has taken steps to prevent or eliminate as soon as possible exploitation or occupation in the whole area and to enforce effectively the respect of ecological, geomorphological and aesthetic features which have led to its establishment; and
3. where visitors are allowed to enter, under special conditions, for inspirational, educative, cultural and recreative purposes.

However some limiting circumstances occur:

1. The Berbak reserve is not within short distances from Indonesian major population centres or from touristic routes. The area has never been visited by tourists, except some interested bird watchers.
2. Also inside the reserve, access is difficult and the possibilities to see wildlife are very limited.
3. At this moment a major part of the mangrove forest, formerly one of Berbak's most important ecosystems, has nearly completely irrecoverable been destructed.

Therefore it is recommended that the Berbak reserve should be excluded from a future status as National Park.

8.3.3 **Berbak as a Biosphere reserve**

Currently seven reserves have been selected as a Biosphere reserve in Indonesia (MAB 1983) under the Biosphere reserve effort of project no. 8: Conservation of Natural Areas and of Genetic material they contain (Table 23). The project forms a part of UNESCO's Man and Biosphere Programme (MAB), which started in 1970 (IUCN 1974; UNESCO 1974). MAB "provides a formal interdisciplinary and intergovernmental mechanism for bringing together and coordinating diffuse national and international research, conservation training activities" (Krugman & Phares 1978).

The specific aims of the MAB are (UNESCO 1974):

1. conservation and appropiate preservation of selected areas;
2. base line environmental research;
3. education.

The establishment of a Biosphere Reserve in the swamp areas of the Sumatran east coast has been mentioned several times (Hanson & Koesoebiono 1979).

As Biosphere Reserves need not to be National Parks (Franklin 1977, Colbert 1976), the present status of the Berbak reserve as a game reserve is not a constraint. Although no special funds are available for Biosphere Reserves to enable a more restrict preservation management, it will stimulate international recognition of the Berbak reserve and it will encourage scientist to do research (i.e. monitoring programmes) in the reserve area. It should therefore be recommended that the selection of Berbak as a MAB reserve will be implemented as soon as possible.

Table 23 Indonesian Biosphere reserves. Source: MAB 1983

name of area	present status	acreage(ha)	assigned as MAB
Tanjung Puting	National Park	205.000	1977
Lore Lindu	National Park	131.000	1977
Komodo	National Park	59.000	1977
Gn.Gede Pangrango	National Park	15.000	1977
Gunung Leuser	National Park	946.400	1981
Siberut	National Park	6.000	1981

8.3.4 **Berbak as a Wetland reserve**

Nowadays more and more attention is paid internationally on the vital role of wetlands as refuge for wildlife. To preserve the natural characteristics of the wetlands and to stress the fact that these values often transcend frontiers i.e. as fouraging area or roosting sites for migratory birds, led in 1971 to the designation of the Ramsar Convention (called in full: Convention on wetlands of International importance especially as waterfowl habitat). According to the convention, each country which is party to the agreement designates suitable wetlands for inclusion in a list op areas of international importance: the world list of wetlands. So pledging to preserve their wetlands and obleying to give its protection international legal status.

So far 36 countries have join the Convention. Indonesia is willing to assess. At the second conference of the contracting parties in Groningen, The Netherlands (7-12 May 1984), Indonesia was represented by a observer of PHPA. In his address to the Conference, the Berbak game reserve was mentioned as one of the examples of Indonesian nature reserves with wetland features (see note 2). It is esspected that Indonesia soon will sign the Ramsar Convention resulting in the admission of the Berbak game reserve to the World list.

Notes

1. Based upon the Nature Protection Ordinance (1941) and the Nature Monuments and Wildlife Reserves Ordinance (1932) New laws are being prepared by PHPA (Visser 1979).
2. Some nature reserves mentioned as having wetland features: Berbak, Way, Kambas and Paddang Sugihan (Sumatra), Tanjung Puting (Kalimantan) and Lorentz

(Irian Jaya) (Huug Bake pers.inf.).

8.4 Conclusions

1. It is recommended that the reserve boundaries of 1974, plotted by the Brigade Planologi are ratified as soon as possible. The consequence of this legalization will be that the two forest concessions, with a total area of 67 000 ha within the Berbak reserve, are cancelled as far as the logging areas are situated within the 1974 boundaries.
2. It is recommended that a team central and local government agencies, including PHPA authorities, investigate the situation of the now occupied coastal area to set new boundaries on the east side.
3. It is recommended to enlarge the reserve in the north with 3 160 ha as already suggested in the FAO management plan for the Berbak reserve (de Wulf & Rauf 1982). The S. Air Hitam Dalam would then become the natural boundary.

   It would be advisable for PHPA to discuss with the timber company HPH Harapan Baru Wood the possibilities to exclude 43 400 ha from the forestry agreement of 9 March 1974. This area should be included in the reserve. This will safeguard the sources of the S. Air Hitam Laut against possible negative ecological impacts, due to logging and hauling activities in this area.
4. The Berbak reserve should retain its status as game reserve (Suaka Margasatwa). It is not advisable to upgrade the reserve in the long run to a National Park. The Berbak reserve has been selected as MAB biosphere reserve. It is recommended to implement this status. The Berbak reserve fully deserves this international 'reserve award' as it holds unusually rich and unspoiled habitats nearly nowhere else protected.
5. The implementation of a zonation, thus allowing spatial difference in degrees of protection, has not yet been worked out. This should be done after reviewing the results of the boundary committee of PHPA and Central Government departments, which will evaluate management feasibility concerning the occupied coastal area.
6. It is recommended that Indonesia soon will access to the Ramsar Convention. The Convention's terms require that, upon assession New Parties submit a description of a wetland to be entered on the list of Internationally important Wetlands. The Berbak game reserve should be given top priority for allocation as wetland reserve.

9 RECOMMENDATIONS ON RESEARCH

To develop a better management of the Berbak reserve on an ecological sound basis, more research is needed on several aspects.
The research done was limited to the eastern part of the reserve. Moreover the subjects geomorphology, soils and vegetation have not been treated in detail and little attention was given to the fauna.
Recommendations for future research are listed below, this list however does not necessarily indicate priorities of research.

Geomorphology and soils

- the genesis of the peats; including hightreadings of the peatdoom, thickness of the peat and an investigation of the mineral subsoil below the peat;
- a semi detailed investigation of the agricultural potential of the coastal area of Berbak, emphazising the distribution of (potential) acid sulphate soils;
- a soil map (1 : 100 000) of the reserve.

Vegetation

- research on floristic composition, structure and dynamics of the vegetation types, with emphasis on the vegetation on deep peat and in the western part;
- research on the relation soil/vegetation; which soil properties (bulk-density, chemical properties) are linked with the fysiognomy of the vegetation, why did we not find a 'padang' forest on deep peat;
- research on the relation between vegetation and other environmental factors e.g. extent and duration of inundation by fresh water;
- a vegetation map of the reserve (1:50.000).

Fauna

- detailed inventories on fauna species;
- research on the ecology of fauna species, especially the threatened species (e.g. estuarine crocodile, false ghavial, tiger, tapir and rhino);
- more detailed research on the significance of the coastal mudflats for the avifauna as a resting place for waders during the migrating period and the 'wintering' period (November-March);

- research on bird species in the fresh water swamps.

Human activities

- research concerning the question to which extent the drainage canals (parits) in the coastal area are draining the hinterland and does this process threaten the peats;
- a landevaluation study for the whole reserve, with emphasis on the reclaimed coastal area. More data on soils, crops and the agro-economic situation of the settlements are needed for such an evaluation;
- more detailed research on the impact of the several human activities (agriculture, fishing and woodlogging) upon the reserve;
- research on the possible impact of continueing mangrove felling on shrimp- and fish catchings;
- a detailed assessment of the fire damage on the peat forest by means of aerial photographs.

Management

- research on the consequences of the three proposed management strategies concerning the settlements inside the reserve.

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Riverside vegetation dominated by Nypa fructicans
This species indicates temporarily brackish-water conditions.

1

Riverside vegetation dominated by Pandanus tectorius.
This species indicates freshwater conditions.
(At the back of the Pandanus the riveredge forest appears with a height of 40 m)

2

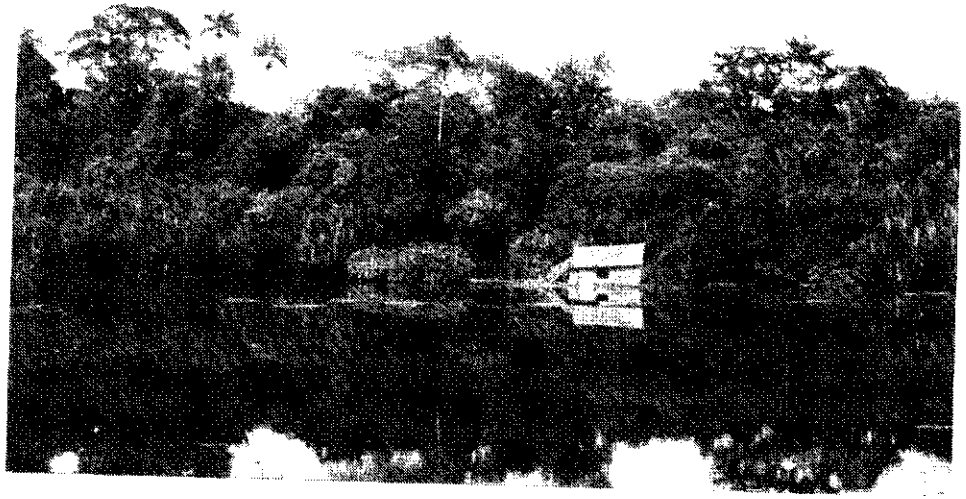
Riverside vegetation with Pandanus tectorius and bakung (Susum anthelminticum), a floating riverweed with a height of 2 m.
Its mats can entirely block the river and it is important for the false gavial (Tomistoma schlegeli) as resting place.

3

Lianas are very common in the swamp and peat forest.

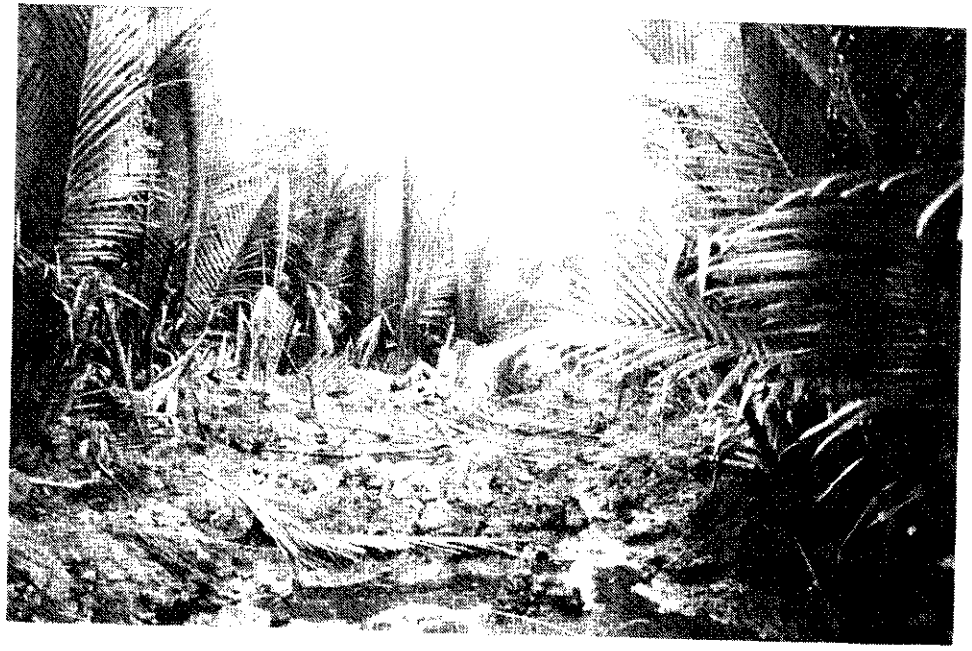
4

Behind the riverside vegetation the riveredge forest appears with on the higher levees the Nibung (Oncosperma tiggilarium), a large palm with a high economic value.



5

Mangrove of Nypa fructicans. Lobsterhills are abundant It is an important habitat of the otter (Lutra lutra)



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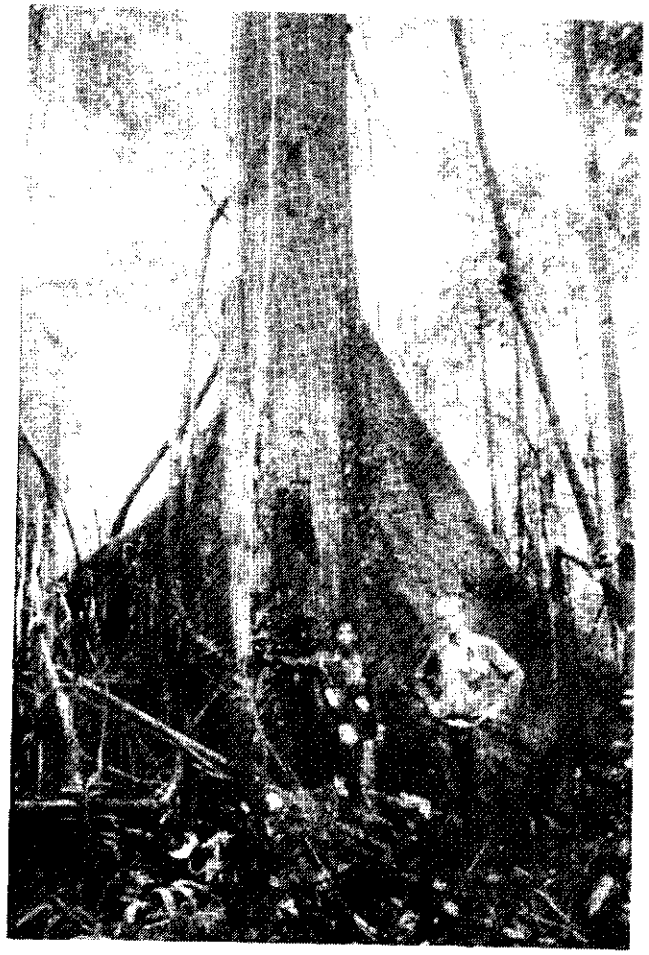


7

Large buttresses of a meranti (Shorea spec.) in freshwater-swamp forest.

Freshwater-swamp forest.
The basal area is largely determined by Alstonia pneumatophora.
The undergrowth consists of rattans and saplings.

8

Knee-shaped pneumatophores of Alstonia pneumatophora in freshwater-swamp forest.

9

Peat-swamp forest on a 10 m deep peat dome. The forest is 35 m high. The undergrowth consists of 'Keladi'.

10

The palm Licuala valida can dominate the undergrowth of the riveredge forest and freshwater-swamp forest.

11

In the swamp and peat-forest, flying buttresses are regularly found.

12

Lobsterhills are very common in the mangrove. They determine for a great part the micro relief and have a large influence on the soil because of the bioturbation.

13

Accreting mangrove vegetation dominated by Avicennia intermedia.

Sungai Cemara, a mangrove creek near desa Cemara. In front (left), the flying buttresses of Rhizophora mucronata are very typical.

14

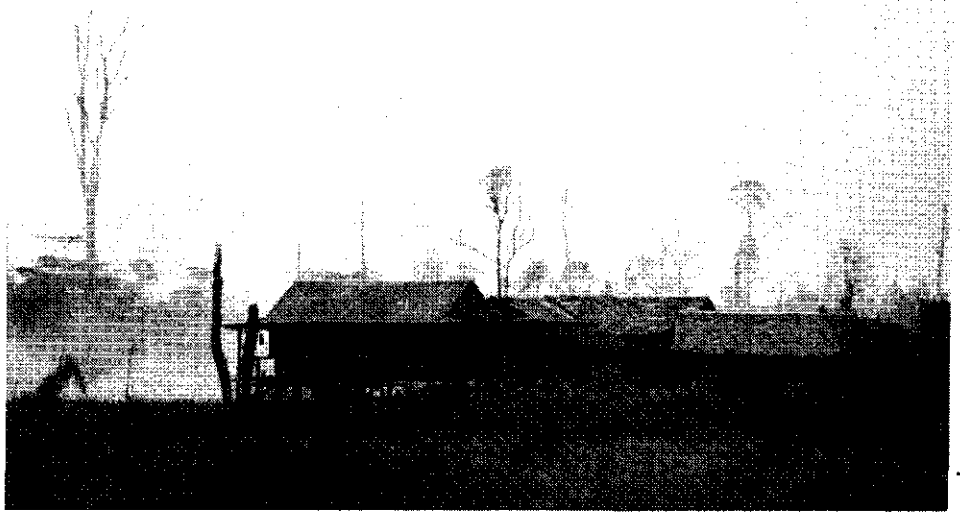
15

16

Mangrove forest with Avicennia intermedia A. officinalis and A. alba

Dry-beach forest with Casuarina equisetifolia. The undergrowth consists mainly of grasses. The transition to the wet mangrove (on the left) is sharp.

17



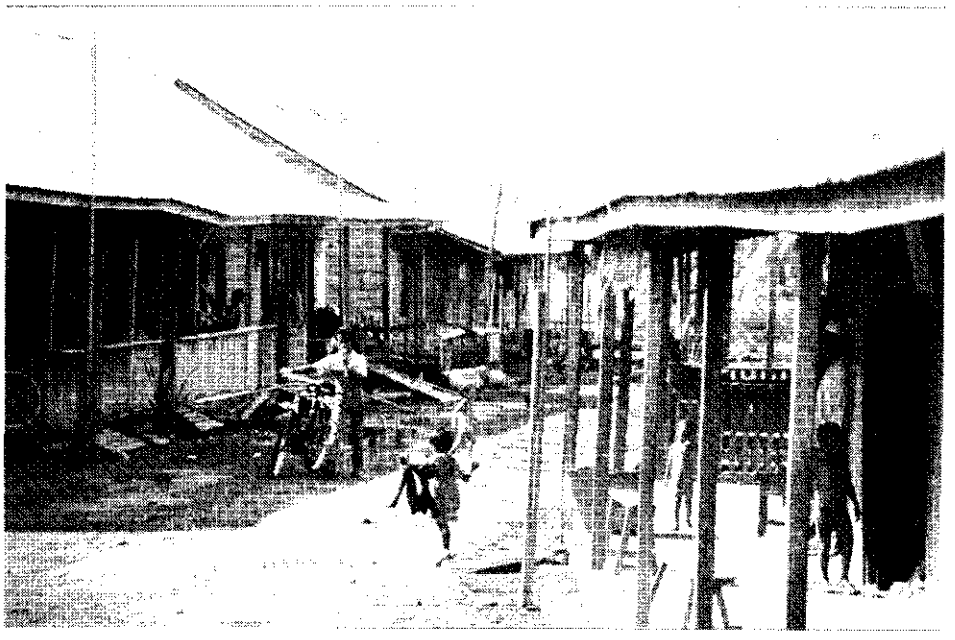
18

In desa Simpang Datuk some new parits have been constructed recently; settlement along parit 4. desa Simpang Datuk.

On the left: smoke from burning fields.

19

Impres, primary school desa Air Hitam Laut.



20

Centre of desa Sungai Benu shops on each side of the street.

Parit 3 kanan of desa Sungai Benu.
In front young coconut cultivation and ricefields.

21

Dams block up the draining of the parits. Rainwater will stay on the fields; desa Cemara parit 1 kanan.

22

Transport of bags with unhulled rice to a hull Main parit of desa Cemara.

On the left farmhouse.

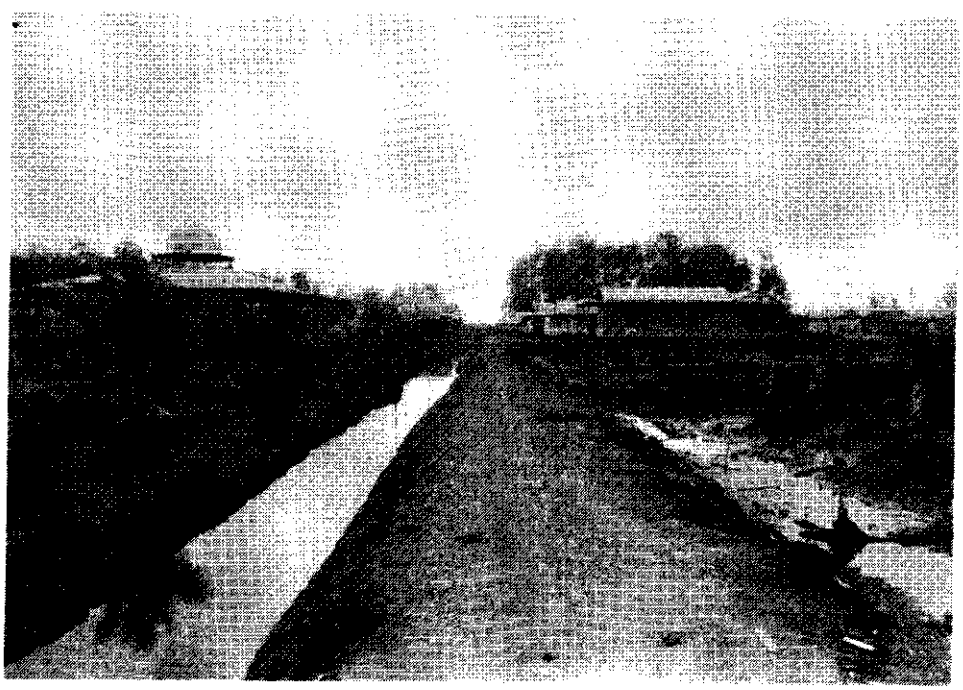
23

Young coconut plantation under too wet and brackish conditions, desa Labuan Pering.

24

Newly abandoned farmfield with many drought cracks, desa Air Hitam Laut on the left shelter.

25



Centre of desa Cemara on the left mosque and main parit.

26

27

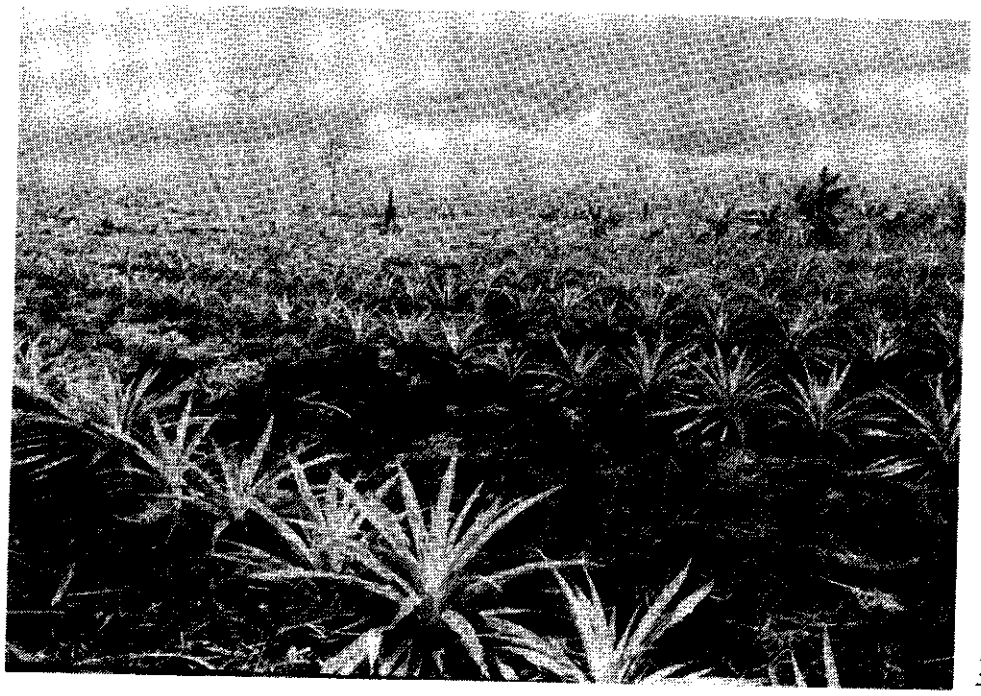
Young rice crops and coconut trees on marine soils, desa Cemara.

28

Young banana trees in reclaimed burned forest on peat of 2.5 m thickness, desa Cemara

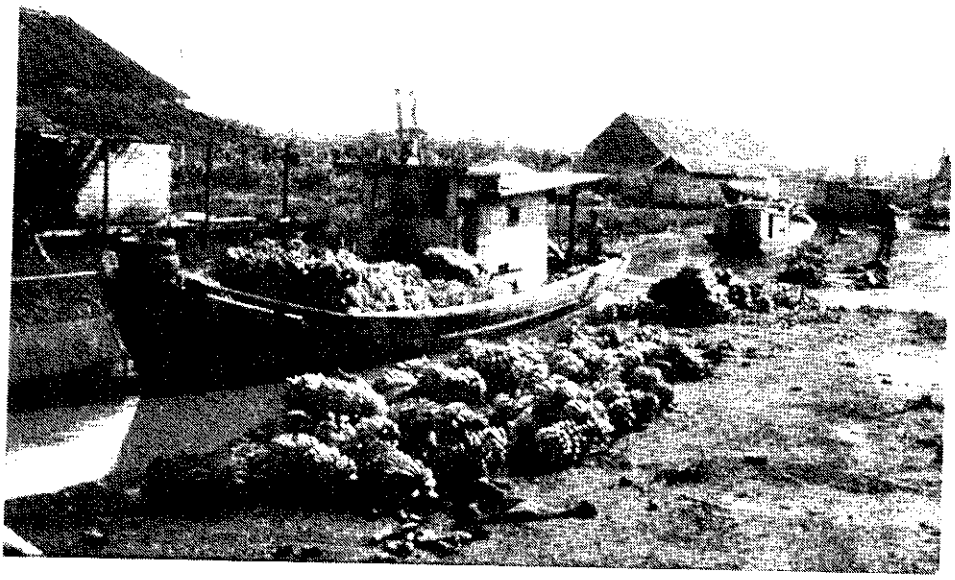
29

Newly reclaimed land in burned forest zone, desa Cemara. Sparse maize cultivation and pineapple on peat of 3 m thickness



Pineapple plantation on peat, desa Cemara.

30

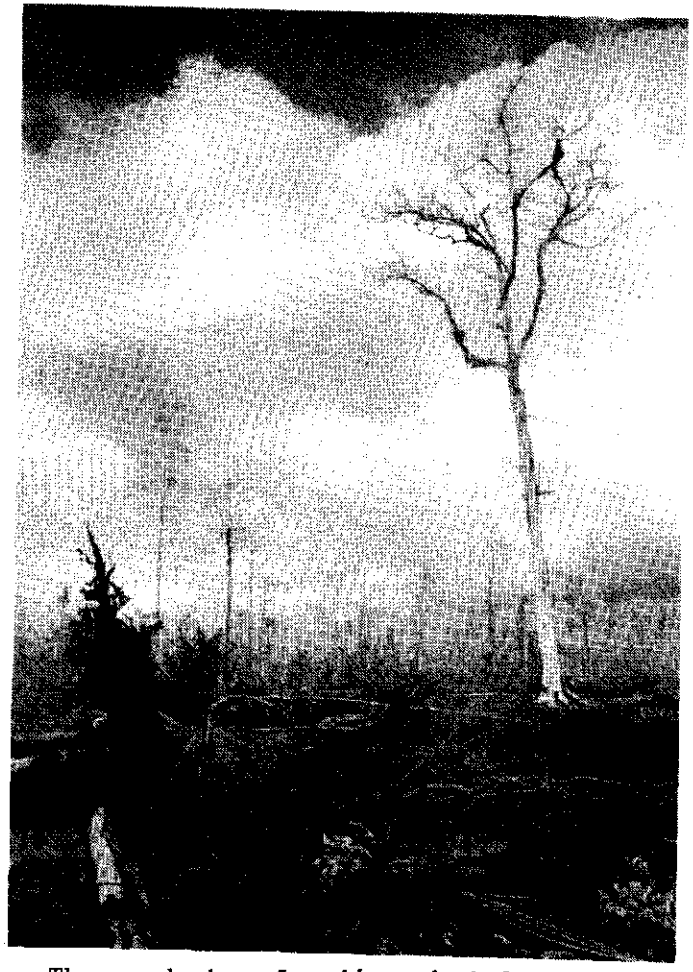


Shipping of banana fruits (Pisang tanduk) transport to Bangko, desa Labuan Pering.

31

Burned forest of 1972 along the S. Benu.

32



33

Thousands ha of undisturbed forest were destroyed due to the fire of 1982, desa Cemara.

Regenerating forest in burned zone of 1982; Macaranga triloba is the most pioneering species; desa Cemara.

34

A fisher settlemer along the S. Benu, on the right side a lift net (tuguk)

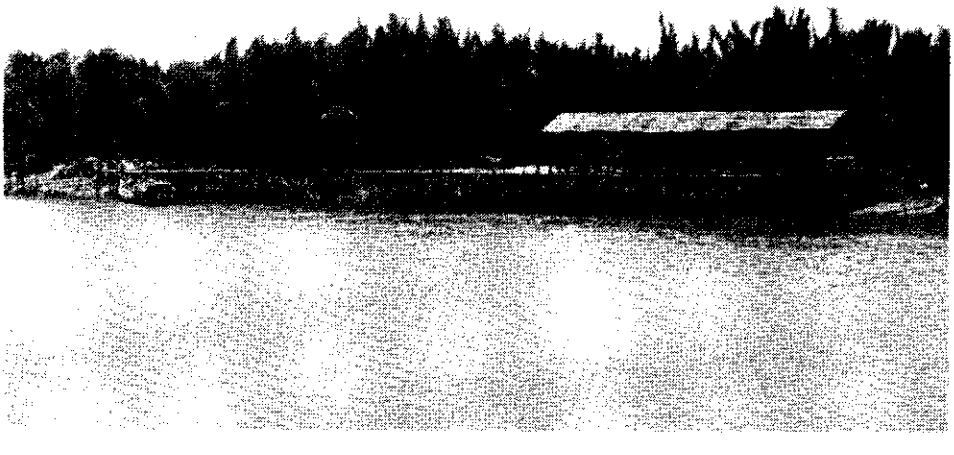
35

36

Pompongs and houses of fishermen (on Nibung poles) near parit 2, desa Air Hitam Laut.

37

Settlement near parit 1, desa Air Hitam Laut, during low tide.



38

Construction of Nibung-stilted platforms for temporary fishermen, desa Air Hitam Laut.

39

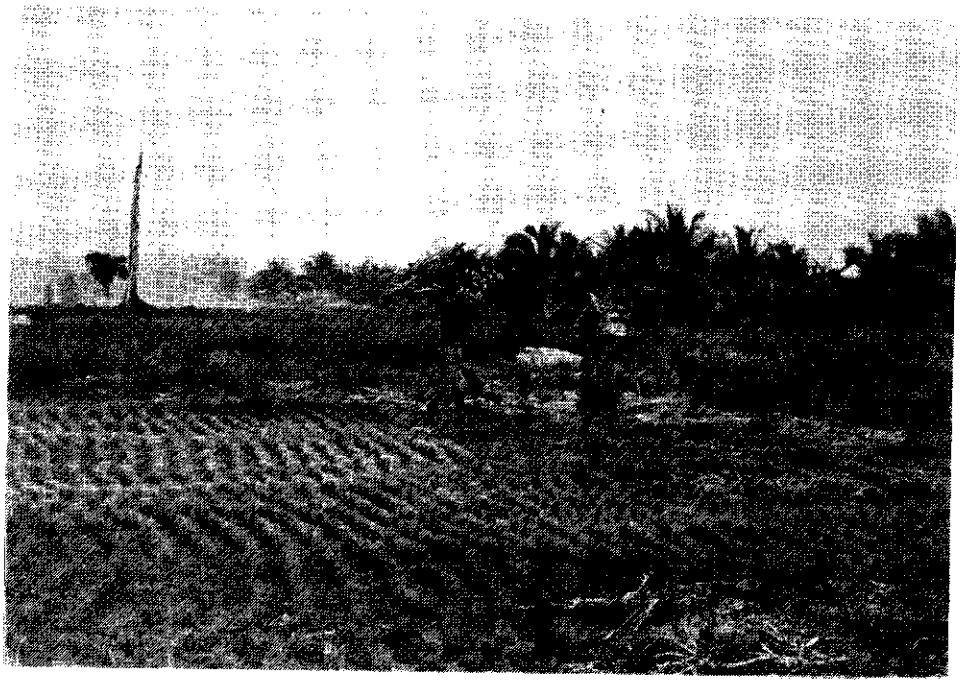
One of the four small sawmills along the S. Benu, log-rafts (mainly meranti), waiting for processing.

40

Nypa leaves are used for roofing.

Transport of Nibung poles, desa Hitam Laut.

41

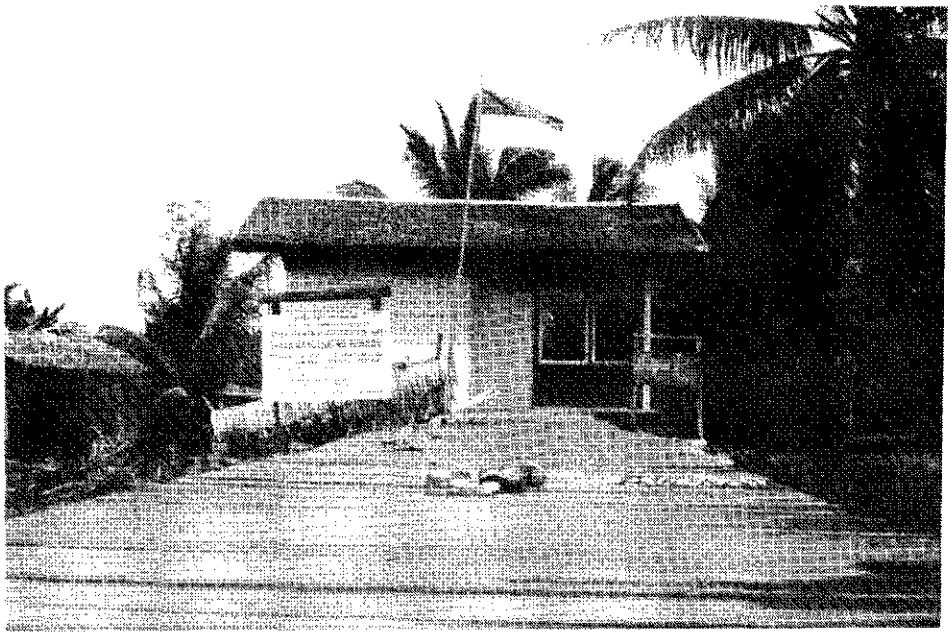


Collecting fire-wood from the burned forest near desa Cemara.

42

Clearing the fields, before planting rice, desa Cemara.

43



Resort Air Hitam Laut was the first established quarter in 1975.

44

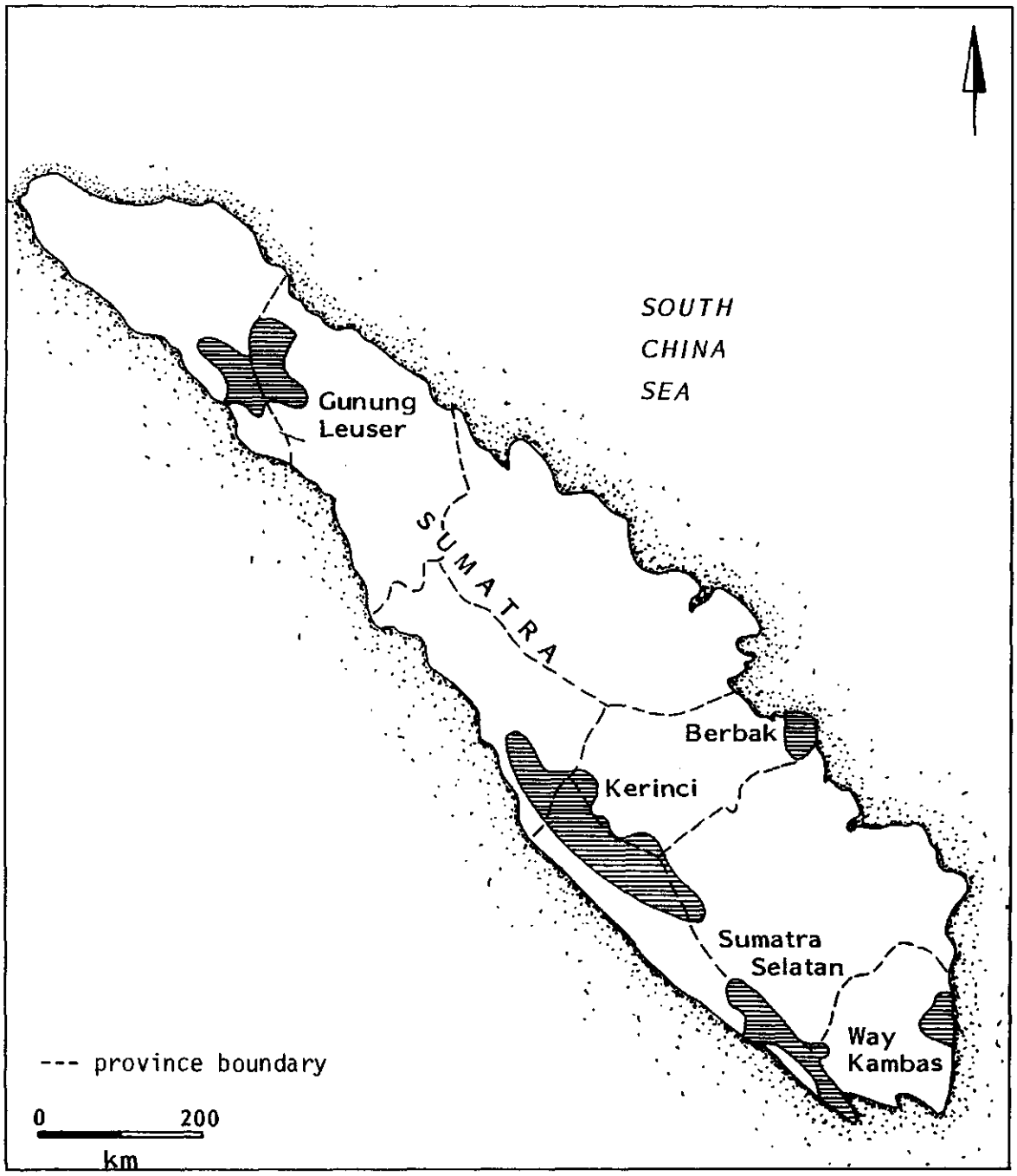
The forestry agency placed some sign boards in several villages near the reserve boundary during 1969-1974. Sign boards in desa Simpang Datuk.

45

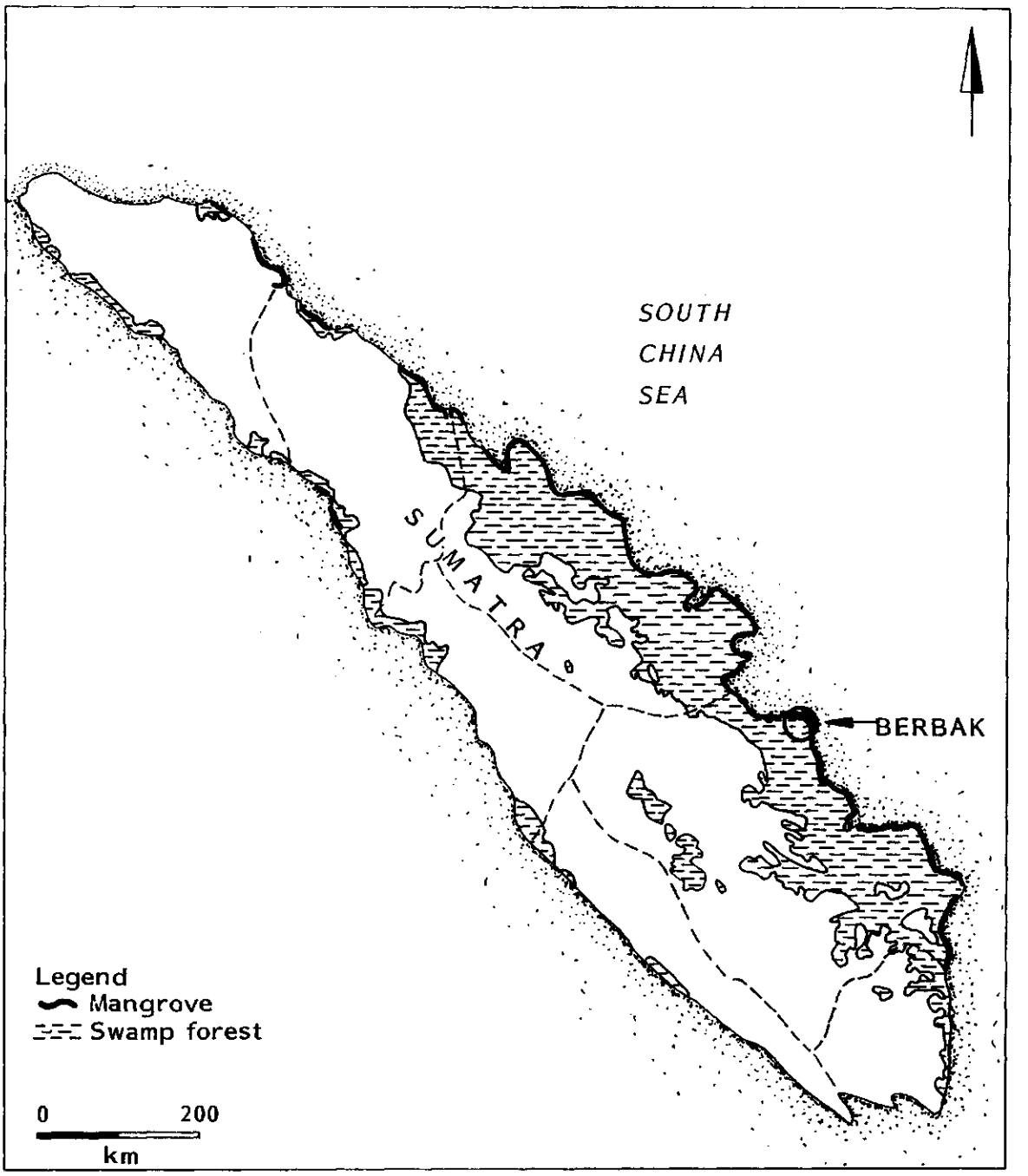
The mudflats in front of the coast of Berbak are important as feeding grounds for waders. The sandy beach functions as a high-tide resting place. On the photo a flight of Black-tailed Godwits (Limosa limosa).

46

Appendices



Appendix 1. Large conservation areas of Sumatra



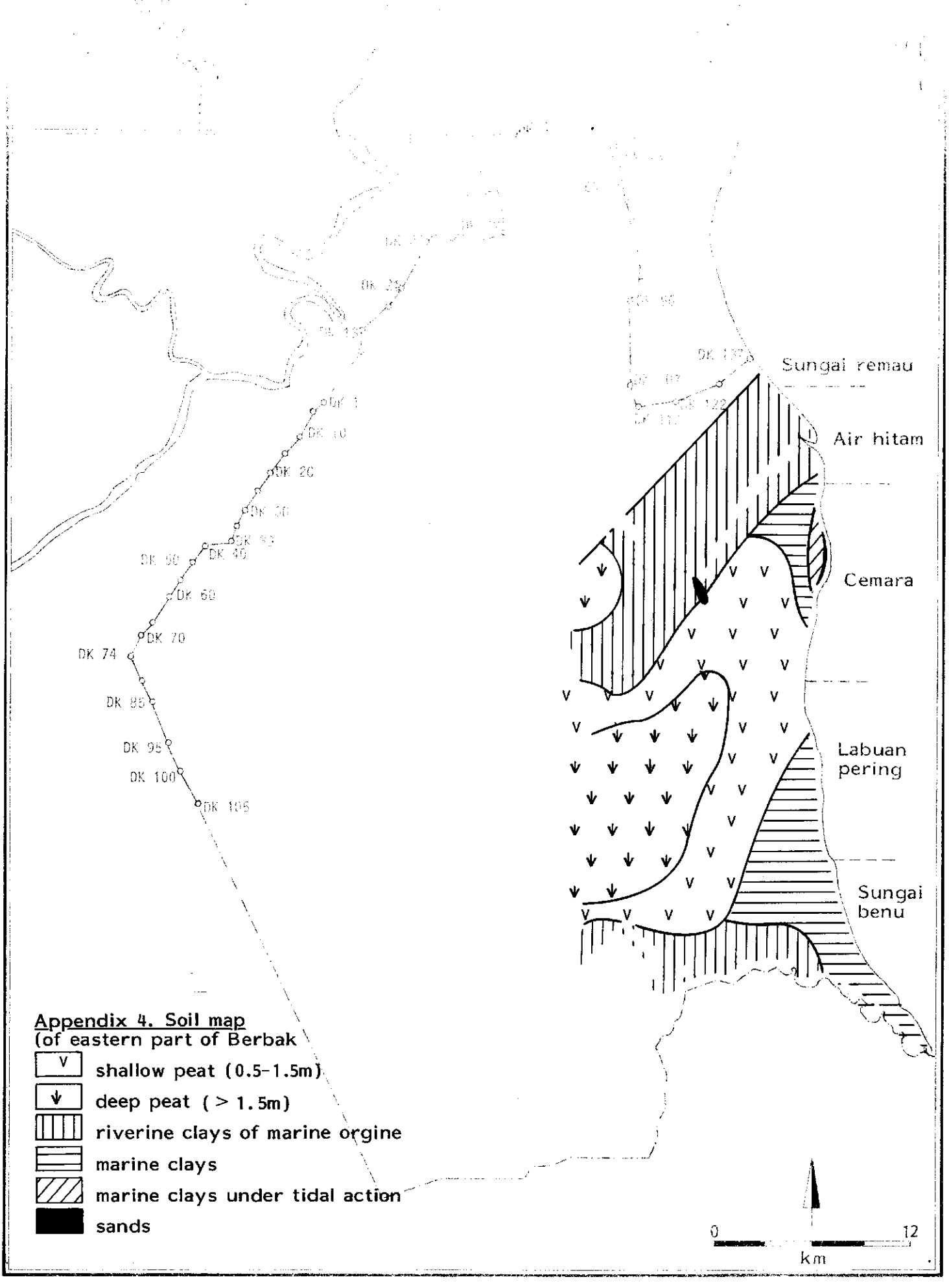
Appendix 2. Mangrove and swampforest along the eastcoast of Sumatra

Appendix 3: Amount of rainfall in Jambi province, 1980 t/m 1983.

	January		February		March		April		May		June		July		August		September		October		November		December		Total	
	mm	day	mm	day	mm	day	mm	day	mm	day	mm	day	mm	day	mm	day	mm	day	mm	day	mm	day	mm	day	mm	day
1. Air Hitam Laut																										
1980			251		251	14	45	16	414	17	87	12	230	16	164	14	348	16	137	18	202	13	277	17	2406	153
1981	30	6	127	9	93	9	336	14	239	17	119	13	177	10	86	4	153	15	137	12	129	13	456	21	2082	143
1982	217	9	136	10	183	13	341	5	111	9	43	11	33	6	41	4	6	2	125	10	100	10	541	23	1877	122
1983	582	20	49	5	7	6	134	8	142	13	270	13	255	12	125	10	133	6	123	7	312	17	181	8	2313	125
1984	296	18	199	16	371	15	212	13	118	13	109	7	125	9	182	15	183	11								
2. Rantau Rassau																										
1981	97	5	234	8	123	10	266	15	322	9	114	9	150	5	124	7	161	16	138	9	144	7	450	15	2323	115
1982	106	9	236	10	126	11	273	14	163	11	48	3	26	2	31	1	150	4	103	5	203	6	301	6	1769	822
1983	664	11	9	3	32	4	112	7	287	12	134	7	98	1	83	9	119	12	257	14					1795	80

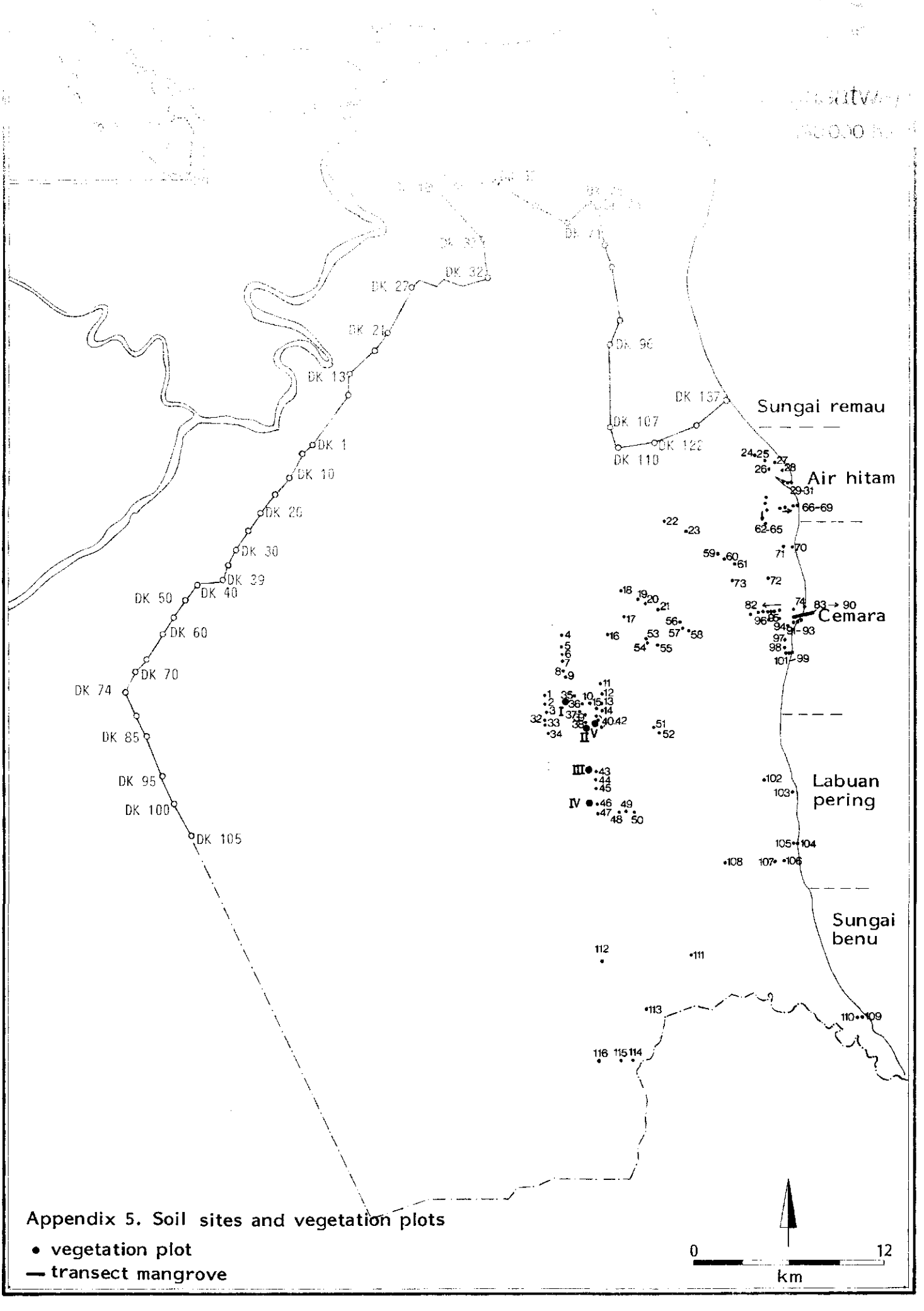
Source: Dinas Pertanian Tanaman Pangan Propinsi Jambi (Agricultural Service Jambi Province)

- Kantor Resort Air Hitam, PHPA Jambi



Appendix 4. Soil map
(of eastern part of Berbak

- shallow peat (0.5-1.5m)
- deep peat (> 1.5m)
- riverine clays of marine orgine
- marine clays
- marine clays under tidal action
- sands



Appendix 5. Soil sites and vegetation plots

• vegetation plot

— transect mangrove

Appendix 6: Description of soil profiles

nr.	depth(cm)	horizon	parent material/geomorphology	roots + org. matter	n-value	mottling	watertable (cm)	vegetation/landuse	remarks
1	0- 50	Cg	Levee clay 10YR 5/3	much	<0.7	common 5YR 5/8	-50	forest	northern levee of Sungai Air Hitam Laut
	50-150	CG	clay 10YR 3/3	few	1 -1.4				
2	0- 8	Ab	Levee clay 10YR 4/3	much	0.7-1		-20	forest	reduced, low levee close to the river more reduced. Contains much org. material
	8- 23	Cg	clay 10YR 4/3	much	"	few, 5YR 5/8			
	23-150	CG	clay 10YR 4/3	few	"				
3	0- 30	Ah	Levee clay 10YR 3/3	very much	0.7-1		0	forest	
	30- 60	CG	clay 5YR 5/2	"	1.0-1.4				
	60-150	CG	clay 10YR 3/2	much	"				
4	0- 40		Peat sapric peat				-40	forest	northern side of Sungai Air Hitam Laut
	40-120		hemic peat						
	120-300		fibric peat						
5	0- 40		Peat hemic peat, dark brown 5YR 3/2				-45	forest	at a distance of about 250 m the peat dome begins. A real levee is not developed. At high tide, fresh-water inundates the forest
	40- 90		hemic peat						
	90-300		fibric peat						
6	0- 20		Peat sapric peat. 5YR 3/2				-50	forest	
	20- 60		sapric peat						
	60-300		hemic peat						
7	0- 40		Peat hemic peat				-50	forest	
	40-110		hemic peat						
	110-300		hemic peat						
8	0- 10		Peat sapric peat, 5YR 3/2				-32	forest	
	10- 50		hemic peat, black						
	50-280		hemic peat						
	280-300	CG	clay, 10YR 6.5/1		1.0-1.4				
9	0- 10		Peat sapric peat, with some clay				- 5	forest	
	10-100		very peaty clay 10YR 2/2		0.7-1.0				
	100-300		clay, 10YR 2/2	much	1.0-1.4				
10	0- 10		Levee hemic peat				±10-40	forest	low levee, outer bend of Sungai Air Hitam Laut
	10-100	CG	clay 10YR 5/2						
11	0- 3	Ao	Levee very humic clay	very much					
	3- 50	Cg	clay, 10YR 5.5/2	few	<0.7	many, 7.5YR 5/6	-52	forest	northern levee of Sungai Air Hitam Laut
	50-100	G2	clay, 10YR 6/2	few	<0.7				
	100-200	G2	clay, 10YR 4/1	few	0.7-1.0				
12	0- 8	Ao	Levee very humic clay 5YR 2.5/2	very much			-42	forest	little pronounced levee, lower at a short distance of the river
	8- 20	Cg	clay, 7.5YR 4/2	much	<0.7	few, 7.5YR 4/6			
	20-100	G1	clay, 10YR 3/3	few	0.7-1.0				
	100-200	G2	clay, 10YR 5/2	few	0.7-1.0				
13	0- 5	Ao	Levee humic clay	many roots			-42	forest	
	5- 30	Cg	clay, 10YR 3/3	much	0.7-1.0	few, 5YR 5/8			
	30-120	G2	clay, 10YR 3/3	few	1.0-1.4				
	120-200	G2	clay 5Y 4/1	few	1.0-1.4				
14	0- 6	Ao	Levee very humic clay	very much			-14	forest	
	6- 34	G1	clay, 7.5YR 3/2	few	1.0-1.4				
	34-100	G2	clay, 10YR 3/2	much, fibric	"				
	100-200	G3	clay, 10YR 5/2	very few	"				
15	0- 50	Ao	Levee hemic peat				-10	forest	
	50-100	G	clay						

nr.	depth(cm)	horizon	parent material/geomorphology	roots + org.matter	n-value	mottling	watertable (cm)	vegetation/landuse	remarks
16	0- 15	Ao	Backswamp very humic clay				-10	forest	
	15- 50	G	clay 10YR 2/2 with peat	much	1.0-1.4				
	50- 80	G	clay, 10YR 4/3 with sapric peat	very much	1.0-1.4				
	80-200	G	clay, 10 YR 4/2	some humic material	1.0-1.4				
17	0- 18	Ao	Backswamp very humic clay				- 8	forest	
	18- 35	G	clay, 10 R 2/2	rather much					
	35- 65	G		few	half ripe (1.0-1.4)				
	65-100	G	clay, 10YR 3/3	"					
	100-280	G	clay, 10YR 4/1	"					
18	0- 30	Ao	Backswamp humic clay 10YR 3/3	very much			-15	forest	
	30- 70		clay, 10YR 4/3	sapric/humic	1.0-1.4				
	70-120		peaty clay						
	120-160		clay, 5YR 2,5/2		1.0-1.4				
19	0- 3	AL	Levee hemic material				-50	forest	
	3- 50	Cg	clay, 10YR 6/3		0.7-1.0	many, 5YR 5/8			
	50-250	G	clay, 10YR 6/3		0.7-1.0				
20	0- 8	AL	Levee humic clay 5Y 3/2				-28	forest	
	8- 30	G1	clay, 10YR 3/3	much	0.7-1.0				
	30-200	G2	clay, 10YR 3/2	little	1.0-1.4				
21	0- 6	Ah	Levee humic clay 7.5YR 3/2	much	<0.7	many, 7.5YR 4/6	-42	forest	
	40- 80	G1	clay, 7.5YR 3/2	little	<0.7				
	80-150	G2	clay, 10YR 4/2	little	0.7-1.0				
22	0- 40	AL	Backswamp very humic clay, 10YR 3/2	very much	<0.7		-20	forest	
	40-120	G1	clay, 10YR 5/3	little	<0.7				
	120-200	G2	clay, 10YR 4/1	little	0.7-1.0				
23	0- 15		Backswamp humic clay, 10YR 25/2	very much			- 3	forest	
	15-100		clay, 10YR 4/3		0.7-1.0	few, 7.5YR 4/6			
	100-300		clay, 10YR 5/1		1.0-1.4				
24	0- 20	Cg1	Coastal plain humic clay, 10YR 3/2	roots		few, 10YR 5/6	-56	abondoned coconnut plantation, with much alang-alang	
	20- 60	Cg2	clay, 10YR 3/3	black org. material	0.7-1.0	few, 10YR 5/6			
	60-120	G	clay, 10YR 3/2		1.4-2.0				
25	0- 13	Ap	Coastal plain humic clay, 10YR 3/2				-54	coconut, coffee, nangka cultivation	
	13-100	Cg	clay, 10YR 4/3	little, org. matter	0.7-1.0	very few mottling (black)			
	100-140	G	clay, 10YR 4/1		1.0-1.4				
26	0- 13	Ap	Coastal plain humic clay 10YR 3/2		0.7		-44	coconut, coffee cultivation	
	3- 80	G1	clay, 10YR 4/3		0.7-1.0				
	80-140	G2	clay, 10YR 3.5/1		1.0-1.4				

nr.	depth(cm)	horizon	parent material/geomorphology	roots + org.matter	n-value	mottling	watertable (cm)	vegetation/landuse	remarks
27	0- 45	Ap	Coastal plain crumbly clay 5YR 5/1				-40	burned ladang with bananas	
			clay, 10YR 7/2	much org.mat.	0.7-1.0				
	100-200	G2	clay, 5Y 5/1		0.7-1.0				
28	0- 10	Ap	Coastal plain humic clay, 10YR 2/1				- 5	coconut (3 year)	
	5- 40	G1	clay, 10YR 5/3	much	1.0-1.4				
	40-200	G2	clay, 10YR 5/1		1.0-1.4				H_2S smell
30	0- 5	C1	Coastal plain loamy sand, 5YR 4/6				+100-23 (tidal movements)	beach	tidal fluctuation
	5- 80	C2	sandy clay, 5YR 3/1		1.0-1.4	common, 5 YR 4/6			
	80-200	C3	clay, 5Y 4/1		1.0-1.4				
31	0- 60	C1	Coastal plain fine sand, 10YR 3/1	black org. matter			tide 0	beach	tidal fluctuation
	60-110	C2	clay, 5Y 3/2	layer of humic	1.0-1.4				
	110-200	C3	clay, 5Y 3/1	peat 110-115 cm	1.0-1.4				
32	0- 4	Ah	Levee very humic clay				-45	forest	Oxidized levee, in outerbend of Sungai Air Hitam Laut. Southern side of river
	4- 45	Cg	clay, 10YR 7/1.5		<0.7	many, 10YR 5/8			
	45-200	G	clay, 7.5YR 7/2		0.7-1.0				
33	0- 2	AL	Levee crumbly, humic clay 10YR 4/3				-25	forest	"
	2- 25	Cg	clay, 10YR 6/2		<0.7	many, 5YR 5/8			
	25-200	G	clay, 10YR 3/3		0.7-1.0				
34	0- 20	AL	Levee crumbly, humic clay, 7.5YR 3/2				-40	forest	"
	20- 40	Cg	clay, 10YR 6/1		<0.7	few, 5YR 5/4			
	40-200	G	clay, 10YR 4/3		1.0-1.4				
35	0- 35	A1	Levee clay, 10YR 3/3 peaty	very much org.matter	0.7-1.0			forest (plot BI)	reduced levee, at innerend of Sungai Air Hitam Laut
	35-150	G1	clay, 10YR 4/2	much	0.7-1.0				
	150-450	G2	clay, 10YR 4/2	little	1.0-1.4				
36	0- 5	AL	Levee crumbly clay, 10YR 4/6				-50	forest	oxidized levee
	5- 40	Cg1	clay, 10YR 6/8 and 10YR 6/1	common	<0.7	many, 2.5YR 5/8			
	40- 70	Cg2	clay, 10YR 6.5/1	common	<0.7	many, 5YR 5/8			
	70-100	G1	clay, 10YR 5/2	few	0.7-1.0				
	100-250	G2	clay, 10YR 3/1	common	1.0-1.4				
37	0- 5	AL	Levee crumbly clay, 10YR 6/7				-15	forest	
	5- 30	Cg	clay, 10YR 6/2		<0.7	many, 2.5YR 3/6 5YR 5/8			
	30-150	G	clay, 10YR 4/3	0.7-1.0	0.7-1.0				
38	0- 15	AL	Levee humic crumbly clay 5YR 3/2	very much			-50	forest (plot BII)	
	15-100	C1G	clay, 10YR 4/3	much	0.7-1.0				
	100-350	C2G	clay, 10YR 3/1	synsedimentary	0.7-1.0				
	350-450	C3G	clay, 5Y 4/1	not	1.0-1.4				

nr.	depth(cm)	horizon	parent material/geomorphology	roots + org.matter	n-value	mottling	watertable (cm)	vegetation/landuse	remarks
39	0- 10	AL	Levee clay, 10YR 3/3	many roots	<0.7		-20 - -40	forest	high, oxidized levee
a+b	10- 40	A/C	clay, 10YR 6/8	"	<0.7	many, 10YR 4/6 along roots			
	40-100	Cg	clay, 10YR 6/8 and	present	0.7-1.0	10YR 4/6			
	100-300	C1G	clay, 10YR 8/1	synsedimentary org. matter	1.4-2.0				
	300-450	C1G	silty clay and fine sandy loam, 5Y 4/1	absent	1.4-2.0				
40	0- 5	A1	Levee very humic clay, 10YR 4/4	many roots	<0.7		-40	forest (plot BV)	
	5- 15	C1G	clay, 10YR 6/2	many roots	<0.7	>50% 10YR 6/6 and 7.5YR 5/6			
	15- 35	C2G	clay, 10YR 6/2	much org.mat.	<0.7	many 10YR 5/7,2.5YR 4/6			
	35- 60	Cg	clay, 10YR 6/2	much org.mat.	0.7-1.0	along coats few 10YR 5/7, 2.5YR 4/6			
	60-250	CG	clay, 10YR 5/2	present till 2 m	1.0-1.4				FeS present
41	0- 20	C1	Levee clay, 10YR 6/1	much org. matter	>2.0				layer of reduced, unripe clay, upon oxidized, riper horizon
42	0- 12	AL	Levee humic clay, 7.5YR 3/2	very much	0.7-1.0		-55	forest (plot Franken/Roos)	
	12- 55	Cg	clay, 10YR 3/3		0.7-1.0	many, 5YR 4/6			
	55-100	CG	clay, 10YR 3/3		1.0-1.4				
	100-200	C2G	clay, 10YR 2.5/1		1.0-1.4				
43	0- 30		Peatdome sapric peat				-30	forest plot BIII	
	30-250		fibric-hemic peat						
	250-300		clay, 10YR 4/1	present	1.0-1.4				
44	0-320		Peatdome fibric-humic peat				-40	forest	
	320-400		clay, 10YR 3/1	few	1.4-2.0				
	400-430		clay, 2.5Y 5/2		>2.0				
45	0-500		Peatdome fibric peat				-30	forest	
46	0-900		Peatdome fibric peat				-35	forest (plot BIV)	
47	0->500		Peatdome fibric peat				-30	forest	
48	0-910		Peatdome fibric peat						
	910-930		clay, 2.5Y 5/2		>2.0		-20	forest	
49	0->700		Peatdome fibric peat				±-30	forest	
50	0->700		Peatdome fibric peat				±-30	forest	
51	0- 20	C1G	Peatdome very humic clay, 2.5YR 2,5/2				-50	forest	
	20- 50	C2G	clay, 5YR 2.5/2	very much org.matter	1.4-2.0				
	50-100		humic peat						
	100-150	C3G	clay, 5YR 2.5/2	very much	1.4-2.0				

nr.	depth(cm)	horizon	parent material/geomorphology	roots+ org.matter	n-value	mottling	watertable (cm)	vegetation/landuse	remarks
52	0- 12	AL	Peatdome very humic clay				-48	forest	
	12- 40	C1G	peaty clay, 5YR 2.5/2		1.4-2.0				
	40-250		hemic peat						
	280-300	C2G	clay, 10YR 4/1	much	>2.0				
53	0- 3	AL	Levee clay, 10YR 3/4	roots	<0.7		-43	forest	high, oxidized river-levee
	3- 43	Cg	clay, 10YR 4.5/2		<0.7	many, 7.5YR 5/8			
	43-200	CG	clay, 10YR 4/2		0.7-1.0				
54	0- 2	AL	Levee clay, 10YR 5/4		<0.7		-50	forest	"
	2- 50	Cg	clay, 10YR 5/6 and 10YR 4.5/2		<0.7	many, 7.5YR 4/6			
	50-200	G	clay, 10YR 4.5/2		0.7-1.0				
55	0- 15	AL	Levee humic, crumbly clay, 10YR 5/6	much	<0.7		-70	forest	"
	15- 70	Cg	clay, 10YR 7/2		<0.7	many, 7.5YR 5/8			
	70-200	G	clay, 10YR 2/3		0.7-1.0				
56			Levee (probably relict beachridge)						
	0- 90	C1	fine sand, 10YR 4/4				-180	forest	
	90- 95	C2g	clay, 10YR 7/1			few, 5YR 5/8-10YR 6/8			
	95-150	C3	loamy, fine sand, 10YR 4/6						
	150-170	C2g	loamy sand, 10YR 2/1	much humic matter		few, 5YR 5/8			
	170-300	C5	loamy fine sand, 7.5YR 3.5/0						
57			Levee (probably relict beachridge)						probably a relict sandy beachridge
	0- 10	C	fine sand, 10YR 4.5/4	many roots			-200	forest	
	10-160	C	fine sand, 10YR 5/6						
	160-165	C	fine sand, 10YR 4/6, 10YR 5/3, 7.5YR 3/4						
	165-170	C	clay, 10YR 4/1 and fine sand 10YR 4/6						
	170-225	C	loamy sand, 10YR 3/3.5						
	225-300	C	sand, 10YR 4/1						
58			Levee (probably relict beachridge)						
	0- 60	C	fine sand, 10YR 4/3	many roots			-200	forest	
	60- 95	C	fine sand, 10YR 6/3						
	95-100	C	clay, 5Y 6.5/1			few, 5YR 5/8			
	100-150	C	clay, 10YR 7/1 and fine sand 10YR 6/3			common, 5YR 5/8			
	150-180	C	clay, 7.5YR 3/2			few, 5YR 5/8			
	180-200	C	sandy clay, 7.5YR 4/1						
59	0- 10	Ap	Levee crumbly clay, 7.5YR 3/2	many roots	<0.7	many, 5YR 3/4	-25	rice	
	10-105	Cg	clay, 10YR 3/3		<0.7	many, 5YR 5/6, 7.5YR 4/6			
	105-150	G	clay, 5Y 2.5/1		0.7-1.0				
60	0- 5	Ap	Levee crumbly clay, 10YR 5/3		<0.7		-31	rice	
	5- 23	Cg	clay, 10YR 4/3	present	<0.7	many, 5YR 5/8			
	23-120	G	clay, 10YR 5/3		0.7-1.0	many, 5YR 5/8, 10YR 6/6			
61	0- 27	AL	Levee very peaty clay, 10YR 2/2				- 5	burned forest (Summer 1982)	
	27- 62	G1	clay, 10YR 3/3	much	0.7-1.0				
	62-150	G2	clay, 10YR 4/2		0.7-1.0				

nr.	depth(cm)	horizon	parent material/geomorphology	roots + org.matter	n-value	mottling	watertable (cm)	vegetation/landuse	remarks
62	0- 30	Cg	Levee clay, 10YR 3/3	present	1.0-1.4	common, 7.5YR 4/6; 7.5YR 7/6	tidal fluctuation ± 0-50	Nypa fructicans zone	pH 4.7
	30-150	G	clay (no structure), 5Y 2.5/2		1.0-1.4				pH 6.0
63			Coastal plain						
	0- 10	Ap	crumbly clay, 10YR 3/3		<0.7		-30	abandoned (1 year) rice field	
	10- 90	Cg	clay, 10YR 4/3	much	<0.7	many, 7.5YR 5/6			
	90-200	G	clay, 10YR 4/1		1.4-2.0				
64			Coastal plain						
	0- 5	Ap	clay, 10YR 3/2	much,+ roots	<0.7		-70	abandoned rice field	
	5- 85	Cg	clay, 10YR 3/2	present	<0.7	many. 7.5YR 4/6			
	85-120	G1	clay, 5YR 3/2	much	0.7-1.0				
	120-200	G2	clay, 10YR 4/1		1.4-2.0				
65			Coastal plain						
	0- 40	Ap	clay (peaty), 5YR 2/5	much	0.7-1.0		-40	abandoned field (6 years ago) secondary vegetation	pH 3.4
	40-100	G1	clay, 10YR 5/3	much	1.0-1.4				pH 3.5
	100-200	G2	clay, 10YR 4/1	much	1.4-2.0				pH 4.7
66			Coastal plain						
	0- 32	Ap	clay, crumbly, 10YR 3/2	much	<0.7		-42	abandoned (1 year) rice field	pH 3.7
	32- 95	Cg	clay, 10YR 4/3	much	0.7-1.0	few, 7.5YR 5/8			pH 4.0
	95-200	G	clay, 10YR 4/1	present	0.7-1.0				
67			Coastal plain						
	0- 15	Ap	crumbly clay, 10YR 3/2	much	<0.7		-90	abandoned field	
	15-110	Cg	clay, 10YR 3/3	much	<0.7	many. 7.5YR 5/8			pH 3.9
	110-200	G	clay, 10YR 4/1		1.0-1.4				pH 5.7
68			Coastal plain						
	0- 30	AL	humic clay, 10YR 3/3	much, sapric and some fibric		common, 5YR 4/6	-24	secondary vegetation (herbs and some shrubs)	
	30- 70	C	hemic-fibric peat with some clay, 10YR 3/3	hemic-fibric	1.0-1.4				
	70-200	C	percentage of clay higher, 10YR 3/3	hemic org. mat.	1.0-1.4				
69			Coastal plain						
	0- 15	AL	peat with clay, 10YR 4/1		1.0-1.4		tidal fluctuation +20 - -20	Nypa zone along the beach	
	15- 30	C1G	clay, 10YR 3/1	present	1.4-2.0				
	30-200	C2G	clay, 10YR 3/1	"	>2.0				strong H_2S smell
70			Coastal plain						
	0- 4	Ah	humic clay, 10YR 4/3	roots	1.4-2.0		-22 (tidal fluctuation)	mangrove vegetation	
	4- 15	C	clay, 2.5Y 3/0	very much	1.4-2.0				
	15- 30	Cg	sandy clay, 2.5Y 4/0	very much,		many. 7.5YR 5/4			
	30-200	G	fine sand, 10YR 3/1	+ roots					
	30-200	G	fine sand, 10YR 3/1						
71			Coastal plain						
	0- 20	Ap	crumbly clay, 10YR 3/6	much	<0.7	many. 7.5YR 5/6	-40	agriculture (10 year) rice	
	20- 80	Cg	clay, 10YR 6/2	much	<0.7	many. 7.5YR 5/6			
	80-200	G	clay, 10YR 5/1	little	1.0-1.4				

nr.	depth(cm)	horizon	parent material/geomorphology	roots + org.matter	n-value	mottling	watertable (cm)	vegetation/landuse	remarks
72			Accreting coast						
	0- 20		sapric peat					rice-coconut	
	(see 73)		clay, 7.5YR 3/2						
73			Accreting coast						
	0-100		sapric peat				-20	rice-coconut	
	100-180	CG	marine clay		1.4-2.0	FeS (laminated)			
	180-230	IIAg/CG	marine clay, 5GY 6/1	few roots	1	'green' mottles, 5G 4/2			
	230-300	G	marine clay, 5GY 6/1	absent	1.4-2.0				
74			Coastal levee						
	0- 25	Ag/Cg	marine clay 10YR 7/2	some roots	1	few, 5YR 5/8, also FeS	-10 - +75	Sonneratia is dominant. Avicennia intermedia and some Rhizophora spec.	
	25- 40	CG	marine clay, 10YR 7/2		1.4-2.0				
	40- 60	HG	coarse sands, containing shell remnants	absent					
75			Accreting coast						
	0- 20	A1	clay, 10YR 4/3			2.5YR 5/8			
	20-120	G	"green clay, 5GY 4/1	few					shell remnants
76			Accreting coast						
	0- 40	A1	marine clay, 10YR 5/1			many, 10YR 4/6		coconut cultivation	
77			Accreting coast						
	0- 20	O2	peat			mottles along roots 7.5YR 4/6 in parit: 5Y 8/8		rice/coconut	
	20- 60	I	marine clay, 7.5YR 4/5						
	60-100	II	marine clay, 5Y 4/1						
	100-150	III	'green' clay, 5GY 4.5/1	absent					
78			less than 20 cm peat (see 80 en 81)					rice	rice
79			peat on jarosite layer					rice	
80			Accreting coast						
	0- 80		peat					mixed crops cassave, ananas, banana	
	80-130	I Cg	clay, 5Y 4/1	present	1.4-2.0	jarosite only in parit			
	130-180	II CG	clay, 5GY 5/1	absent	1.4-2.0	FeS (laminated)			
81			Accreting coast						
	0-150		peat					"	
	150-180	I Cg	marine clay	present	1.4-2.0				
	180-450	II CG	'green' clay, 5G 5/1	absent	1.4-2.0				
82			Accreting coast						
	0-150		peat, hemic-sparic					banana/ananas	
	150-210	II	clay peat, 5YR 3/3	present	<2				
	210-280	II b	peat						
	280-330	IV	clay, 2.5Y 5/2	few	<2	FeS laminated with syn-sedimentary ofg.matter			
	330-350	V	'green' clay	absent					
83			Beachridge						
	0- 42	Ic	homogenous, fine sand, 10YR 3/2	some shell remnants			32	Casuarina equisetifolia	pH 7.1
	42- 70	IIc	fine sand, 10YR 3/1	coarse shell remnants					pH 7.4
									no. 83 and 88 are located between the beach and the Sungai Demara (eastward of the river)

nr.	depth(cm)	horizon	parent material/geomorphology	roots + org.matter	n-value	mottling	watertable (cm)	vegetation/landuse	remarks
83a			Beachridge						
	0- 22		sandy loam, dark grey, 5Y 4/1				10	+ grasses	
	2- 22	I Cg	loamy sand, 5Y 3/1	many fine roots + shell remnants		black spots (few) common, 7.5YR 4/6			pH 6.9
	22- 60	II C	middle fine sand, 10YR 3/1	few roots; shell remn.		black spots (few)			pH 7.2
84			Backswamp						
	0- 20	Cg	clay loam, 2.5Y 4/2	many fine roots	1.4-2.0	many, 7.5YR 3/4	2	Mangrove	
	20- 23	I	transition zone with less mottling						
	23- 45	II CG	clay-loam, 2.5YR 1/3			black spots (few)			
	45	III C	middle fine sand	shell remn.					pH 6.7
85			Backswamp						
	0- 20	Cg	clay, 5Y 4/1	many fine roots	1.0-1.4	black spots (many) many, 7.5YR 3/4	4		
	20-	IIC	middle sand, 10YR 3/1						
86			Backswamp						
	0- 70	I C	sand, middle fine, 10YR 3/3	few roots			75	Casuarina equisetifolia	pH 7.2
	70- 80	IIC	sand, middle fine, 10YR 3/3	layer with many shell remnants					
87			Backswamp						
	0- 55	A/Cg	loamy clay, 10YR 3/1	many fine roots		many, 5YR 4/6	46		
	5-	IIC	sand						
88			Backswamp						
	0- 15	A/Cg	clay, 10YR 4/2	many fine roots	1.0-1.4	black spots, many 7.5YR 4/6	20		
	15- 80	IIC	clay, 5G 2/1						
	80.	IIIC	sand	shell remn.					pH 6.9
89			Backswamp						
	0- 10	A/Cg	clay, 10YR 3/2	many roots	1.4-2.0	common, 7.5YR 4/6		Mangrove	pH 5.7
	10- 90	CG	clay, 5Y 4/1	many roots	1.4-2.0	10% black mottling			pH 6.4
	90-100	IIC	sand, with limestone, 5Y 4/1	no roots					
	100-350	IIIC	clay, 5Y 4/1 and some sandlayers, 5Y 2.5/2	no roots	1.4-2.0				pH 7.1 no. 89-90 are located westward landinward from the river Sungai Cemara (backswamp)
89a			Backswamp						
	0- 15	A/Cg	clay, 10YR 3/2	many roots	1.4-2.0	common, 7.5YR 4/6		Mangrove	
	15-100	CG	clay, 5Y 4/1		1.0-1.4				pH 7.0 H_2O smell
	100-180	IICG	clay, 5Y 4/1, some sand-layers, 5Y 3/2		1.4-2.0				pH 7.1

nr.	depth(cm)	horizon	parent material/geomorphology	roots + org.matter	n-value	mottling	watertable (cm)	vegetation/landuse	remarks
90			Backswamp						
	0- 30	Ag/Cg	clay, 10YR 3/2	many fine roots	1.0-1.4	black mottling many, 7.5YR 3/4		Mangrove	pH 5.8
	30- 60	G1	clay, 10YR 3/2		1.0-1.4				
	60-120	G2	clay, 10YR 3/2		1.4-2.0				
	120-180	G3	clay, with sandlayers, 5Y 2.5/2		>2.0				
91			Accreting coast						
	0- 10	Ag/Cg	marine clay, 2.5Y 6/2		1	few, 7.5YR 5/8	± +50- -10	Mangrove: Rhizophora	
	10- 15	G	clay, 5GY 6/1	some Rhizophora roots	1.4-2.0	FeS (laminated)		( ) Bruguira	
	15-120	G	clay, 5GY 6/1	many fine roots	1.4-2.0				
92			Accreting coast						
	0- 60	G	clay, 5Y 5/1		>2.0			Mangrove: Avicennia intermedia	
	60-120	IIG	clay, 5Y 6/3	some Avicennia roots	1.4-2.0				
93			Accreting coast						
	0- 40	G	clay, 5Y 5/1		>2.0		+100 - 0		
	40-120	IIG	clay, 5Y 6/3	some Avicennia roots	1.4-2.0				
94			Accreting roots						
	0- 22	Ao	humic material					rice/coconut	
	2- 20	C	clay, 10YR 3/3	much	<0.7				
	20- 70	Cg	clay, 10YR 4/3	much	0.7-1.0	many, 7.5YR 4/6			
	70-150	IIG	clay, 5GY 5/1	present	1.0-1.4				
95			Accreting coast						
	0-180		peat	sapric				ananas	
	180-200	G	clay, grey	little	1.0-1.4				
	200-	IIG	clay, grey/green, 5G 5/1	present	1.0-1.4				
96			Accreting coast						
	0- 22	Ao	humic material					cassave	
	2- 20	G	clay, 10YR 3/3	much	<0.7				
	20- 70	IICg	clay, 10YR 4/3	much	0.7-1.0	common, 7.5YR 4/6			
	70-120	IIIG	clay, 5G 5/1	present	1.0-1.4				
	120-	IIIG	clay, 5GY 5/1	very little	1,0-1.4				
97			Accreting coast						
	0- 20	O	peat					secondary vegetation	
	20- 40	CG	clay, 10YR 3/3	much	1.0-1.4				
	40-150	IICIG	clay, green, 5G 5/1	shell remn.	1.0-1.4	green, glauconiet mottling			
	150-250	C2G	clay, green 5GY 5/1		1.4-2.0				
98			Accreting coast						
	0- 30	O	peat					secondary vegetation	
	30- 60	CG	clay, 10YR 3/3	much	0.7-1.0				
	60-250	IICG	clay, green, 5GY 5/1	little + shell remn.	1.0-1.4				
99			Accreting coast						
	0- 44	CG	clay, 5Y 4/1.5		>2.0		tidal fluctuation	Mangrove	
	4- 75	CG	clay, 5GY 5/1		1.4-2.0				

nr.	depth(cm)	horizon	parent material/geomorphology	roots + org.matter	n-value	mottling	watertable (cm)	vegetation/landuse	remarks
100			Accreting coast						
	0- 20	Hg/Cg	clay, 2.5Y 4.5/2	many roots	1.4-2.0	many, ironpipes, 5YR 4/6	tidal fluctuation	mangrove	
	20- 45	C2g	clay, 5Y 3.5/1.5	less roots		common, 5YR 4/6 + black spots			
	45-150	CG	clay, 5Y 3/1	present		more black mottling			
101			Accreting coast						
	0- 23	Ao	hemic peat					mangrove (transitional zone to secondary vegetation)	
	23- 80	Cg	clay, 2.5Y 4.5/2	very much	1.4-2.0	common, 7.5YR 5/4			
	80-150	CG	"green" clay, 5Y 3.5/1	little	1.4-2.0	black mottling			
102			Accreting coast						
	0- 20	Ao	peat						
	20-25	CG	clay, 10YR 5/3	present	1.0-1.4				
	25- 80	IICg	clay, 10YR 6/3	much	1.0-1.4	common, 10YR 6/8			
	80-130	C2G	clay, 10YR 6/2	present	1.0-1.4				
	130-320	IIIG1	clay, 5GY 5/1	little	1.0-1.4	(glauconiet) common, 5G 5/2			
	320-350	G2	clay, 5GY 5/1	shell remn. (no other org.mat.)	1.0-1.4				
103			Accreting coast grey/brown clay with mottling upon green/grey clay						
104			Accreting coast						
	0- 10	Ag/Cg	clay, 10YR 6/3		1.0-1.4	7.5YR 5/6	+50 - -30	Avicennia	
	10- 50	C1G	clay, 10YR 6/3		1.0-1.4				
	50-100	C2G	clay, 2.5Y 6/2	synsed. org.mat.	1.4-2.0				
	100-200	IICG	"Rhizophora" clay	many fine roots	0.7-1.0				
105			Accreting coast						
	0-110	CG	clay, 10YR 3/2, 10YR 6/3		1.0-1.4			abandoned coconut field	
	110-230	IIG	"Rhizophora" clay	many fine roots	1.0-1.4				
	230-250	IIIG	clay, 2.5Y 6/0	absent	>2.0				
106			Accreting system						
	0- 90	IG	marine clay, 10YR 5/3	present	1.4-2.0			banana/ananas	
	90-	IIG	"green" clay, 5GY 5/1						
107			Accreting system						
	0- 30	C	clay, 10YR 5/3	present	<0.7		+30 - -30	rice	
	30- 90	Cg	clay, 10YR 6/2	present		iron oxid			
	90-	IIG	green clay, 5GY 5/1	absent		"green" mottles			
108			Accreting system						
	0- 30	A	clay, 10YR 4/3	many roots	<0.7			secondary forest	
	30- 50	Cg	clay, 5YR 6/2		1	7.5YR 5/8			
	50- 90	CG	clay, 10YR 6/4	few	1.4-2.0				
	90-110	IIG	clay, 10YR 6/4	absent	1	green mottling, 5G 4/2			
	110-130	IIIG	green clay, 5GY 4/1	absent	1	+ iron mottling			
	130-180	IIIC2G	green clay, 5GY 4/1	absent	1.0-1.4	"green" mottling			
	180-250	"	green clay, 5GY 4/1	absent	1.0-1.4	" "			

nr.	depth(cm)	horizon	parent material/geomorphology	roots + org.matter	n-value	mottling	watertable (cm)	vegetation/landuse	remarks
109			Accreting coast						
	0- 20	G1	clay, 5GY 4/1	absent	>2.0		+50 - -10	coastal mudflat	
	20- 80	Cg	clay, 5Y 3/1	present	1.4-2.0	few, 10YR 5/8		without vegetation	
	80-130	CG	clay, 5GY 4/1	little	1.4-2.0				
	130-225	IICG	clay, 5Y 3/1	present	1.4-2.0				
110			Accreting coast						
	0- 6	Ap	crumby clay, humic		<0.7		-26	coconut	
	6- 65	IC1G	clay, 10YR 3/3	0.7-1.0					
	65-140	C2G	peaty clay, 5Y 3/1	much	1.0-1.4				
	140-225	IICG	clay, 5Y 4.5/0	present	1.4-2.0				
111			Accreting coast						
	0- 20	A	hemic peat				0	forest, near	
	20- 35	V	clay, 10YR 5/3	present	1.4-2.0			secondary vegeta-	
	35- 90	IICg	clay, 10YR 5/1, 5Y 5/2	present	1.0-1.4	many, 10YR 4/6, 7.5YR 5/8		tion (abandoned	
	90-130	IIIG1	clay, 5GY 4/1	absent	1.0-1.4			"parit")	
	130-225	G2	clay, 5GY 4/1, 2.5Y 4/2	absent	1.4-2.0				
112			Backswamp						
	0- 10		hemic peat				5	forest	
	10-115	ICg	clay, 10YR 5/3	much	0.7-1.0	few, 10YR 7/8, 7.5YR 5/8			
	115-200	IICG	clay, 10YR 3.5/1	much	1.0-1.4				
113			Backswamp						
	0- 75		hemic, sapric peat				5	forest	
	75-180	C1G	peaty clay, 10YR 5/3	very much	1.0-1.4	many, 7.5YR 5/8			
	180-225	C2G	peaty clay, 10YR 3/2	" "	1.0-1.4				
114			Backswamp						
	0- 15	AL	hemic, fibric peat				1	forest	
	15- 75	C1G	peaty clay, 10YR 2/2	very much	1.0-1.4				
	75-225	C2G	peaty clay, 10YR 3.5/2	" "	1.0-1.4				
115			Backswamp						
	0- 40		hemic peat				5	forest	
	40- 60	C1G	clay, 10YR 3/3	much	1.0-1.4				
	60 -	C2G	clay, 5Y 3/1	present	1.0-1.4				
116			Backswamp						
	0- 20	AL	very humic clay, 10YR 2/2				28	forest	
	20-105	D	peat, humic-sapric						
	105-225	CG	clay, 10YR 2.5/2	much	1.0-1.4				

Appendix 7: Methods of soil analysis

pH(H_2O_2)

1. 5.0 g moist soil (as received) in 125 ml Pyrex beaker.
2. Add 20 ml 30 percent H_2O_2 slowly.
3. Let stand at room temperature until strong oxidation ceases.
4. Place on hot plate at low heat untill no bubbles are observed.
5. Measure suspension pH with Phillips PW-9418 pH-meter, using a combined glass electrode.

pH(H_2O or $\underline{N}$ KCl)

1. 10 g air dried soil in a 50 ml plastic vial.
2. Add 10 ml aquadest (or $\underline{N}$ KCl).
3. Shake on an electric shaker for 5 minutes.
4. Let equilibrate with atmospheric CO_2 for 30 minutes.
5. Measure suspension pH with Phillips PW-9418 pH-meter, using a combined glass electrode.

Soil Mechanical Analysis (Soil Texture Determination)

Method employed - Hydrometer method using sodium pyrophosphate as the dispersing agent (5 percent W/V).

Organic Carbon

Method employed - Walkley-Black method as described in Selected Method for Soil and Plant Analysis, IITA Manual Series No. 1, 1979, p. 6-7.

$$\text{Organic-C (\%)} = \frac{(\text{me } K_2Cr_2O_7 - \text{me } FeSO_4) \times 0.003 \times 100 \times 1.33}{\text{g of ovendry soil}}$$

Total Nitrogen

Method employed - Regular Semi Micro-Kjeldahl Method, a modified one from that described in IITA Manual Series No. 1, 1979, p. 14.

Available Phosphorus

Method of extraction employed - Bray-2 P Extracting Agent. P in solution was measured with B & L Spectronic-20 at 660 nm (Color development: P-B and P-C solution as described in Wisconsin Soil Testing and Plant Analysis Procedures No. 6 Soil Fertility Series 1970 p. 8-9.

Exchangeable Bases

1. NH_4OAc. pH 7.0 extraction (1:20). 5.0 g air-dry soil was extracted 4 times with N NH_4OAc. pH 7.0. The first one was shaken on an electric shaker for one hour, and centrifuged at 2000 RPM for 10 minutes. The others were shaken with Rotax only. The filtrate was saved for Na, K, Ca + Mg determination.
2. Exchangeable Na^+ and K^+ were directly determined with flame-photometer using the specific filter.
3. Exchangeable Ca^{2+} plus Mg^{2+} was determined volumetrically using EDTA as the standard titrant after elemination NH_4OAc through evaporation on a hot plate and aqua regia treatment (see Chapman H.D. and P.F. Pratt, 1961. Methods of Analysis for Soils, Plants, and Waters, Univ. of California, Div. Agric. Sciences p. 20-21).

Exchangeable Aluminum (plus Hydrogen)

1. Weigh 5.0 g air-dry soil, and pour into a 50 ml polyethylene centrifuge tube (rubber stopper).
2. Add 25 ml N KCl, and shake on an electric shaker for 30 minutes.
3. Centrifuge at 2000 RPM for 10 minutes.
4. Filter with Whatman No. 2 filter paper, and save the filtrate in a 100 ml plastic vial.
5. Repeat the processes as mentioned in points 1-5, except: Do the shaking with Rotax shaker for about 30 seconds.
6. (Al^{+3} plus H^+) = exchangeable acidity determination is done as follows:
   a) Pipette 25 ml of aliquot and pour into a 125 ml Erlenmeier flask. Add 0 drops of phenolphthalin indicator solution
   b) Titrate with standard NaOH 0.1 N reagent.
7. Exchangeable-Al^{+3} in the aliquot is measured as follows:
   a) After exch-Ac. determination, to the same Erlenmeier flask is added a drop of standard 0.1 N HCl to eliminate the red colour from the first titration with NaOH (point 6A)

b. Add 10 ml 4 percent NaF solution - the red colour will appear again
c. Titrate with standard 0.1 N HCl reagent until the red colour disappears.

Moisture Content Determination

1. Moist soil in the container was taken out carefully and placed in an aluminum container.
2. Put in an oven set at 105°C for 3x24 hours - untill a contant weight was obtained.
3. Moisture Content (%) = $\frac{\text{(Moist Wt.) - (Oven-dry Wt)}}{\text{Oven-dry Wt.)}} \times 100$

Effective Cation Exchange Capacity (ECEC)

The ECEC of the soils were calculated by summing up the exchangeable bases plus the exchangeable acidity.

Appendix 9: List of tree species

Complete species list of the five vegetation plots: with amount of occurrence in undergrowth (<5m) and higher structure (>5m)				>5m BV	<5m BV	>5m BI	<5m BI	>5m BII	<5m BII	>5m BIII	<5m BIII	>5m BIV	<5m BIV
Anacardiaceae	:	Campnosperma auriculata	Terentang		1						1	2	1
		Gluta spec.	Rengas									3	
		Manga caesia	Kemang					1	3	1		3	
		Manga quadrifolia	Mangga hutan	15	3	5	50	12	26	7	15	2	7
		Manga spec.	Kemangn						2				
Annonaceae	:	? Polyalthya spec.	Putih putih	14	22	3	15	24	52	29	132	1	
		?	'Smelling unknown'	1				4	50		34	1	6
		?	Jengris						6				
Apocynaceae	:	Alstonia pneumatophora	Pulai					6	1				
		Dyera costulata	Jelutung (nr. 1)					1				10	8
Bombacaceae	:	Durio carinatus carinatus	Durian hutan			1			6		3	1	1
Burseraceae	:	Santiria spec.	Kedongdong	2				1	4		14		
Dipterocarpaceae	:	Shorea cf. platycarpa	Meranti merah	1		12		6		5	1	10	4
		Shorea cf. teysmanniana	Meranti sapat	1		3		4	1	2	5		
		Shorea cf. uliginosa	Meranti bunga								10	2	9
		Shorea spec.	Meranti batuh									3	
		Shorea spec.	Meranti damar	1									
		Shorea spec.					5		2	2	1		
Ebenaceae	:	Dyospyros bantamensis	Polong polong	1		4	5	25	17	39	49	34	9
		Dyospyros buxifolia	Zoar					3	25		1		
		Dyospyros spec.	Polong polong (nr. 2)									2	
Euphorbiaceae	:	Antidesma montanum	Mala			2		27	50				
		? Aporosa spec.	Baru getam	13	10	4	8	6		9	28	6	4
		Baccaurea bracteata	Grongqang (daun besar)	8	2	5		24	40	1	9	5	6
		Baccaurea spec.	Rambai					8	3		7		
		Blumeodendron kurzii	Unknown 1 plot BIV									10	2
		Blumeodendron tokbrai	Alap alap			8	41	26	87	5	78	10	5
		Macaranga triloba	Mahang		5	6		2	3		3		1
		Macaranga spec.	Unknown		1								
		Phyllanthus spec.	Cermai					2	1	6	46		2
Fagaceae	:	? Quercus spec.	Unknown plot BIII							2	5		
Flacourtiaceae	:	Casearia spec.	Unknown plot BV	1									
Guttiferae	:	Callophyllum spec.	Cindai	1	9								
		Mammea spec.	Pagar	15	22	79	61						
Icacinaceae	:	Stemonurus secundiflorus	Daun	1		18	26	16	50	31	68	38	8
Lauraceae	:	?	Bengkal			1			1	19			
		? Actinodaphne	Unknown 17 plot BIII								1		
Leguminosae	:	Kompassia malaccensis	Tenggris			2	35	3		6	4	2	9
Magnoliaceae	:	?	Unknown 4 plot BII									41	4
Marcgraviaceae	:	Tetramerista glabra	Punak							3	5	2	1
Melastomataceae	:	Pternandra galeata	Sanumumun	12	15	8	16	4	46	1	20		2
Meliaceae	:	Aglaia or argentea	Unknown 'meranti'									1	
Moraceae	:	Artocarpus elastica	Keluwi					2					
		Ficus gondaicus	Bringin			2	1						
Myristicaceae	:	Horsfieldia spec.	'Bloedhoen'	4	1			6				5	
		Myristica spec.	Unknown plot BIII									9	
Myrtaceae	:	Eugenia chloroleuca	Unknown plot BII						1				
		Eugenia spec.	Jambu jambu	1	4	1	3					1	8
		Eugenia spec.	Kayu kelat	10		5		5		10		11	
Rhamnaceae	:	Ziziphus callophylla	Sanumumun										
		Ziziphus elegans	Sanumumun										
Rosaceae	:	Parastemon urophyllum	Malas			1		2		9	1		
Rubraceae	:	Myseandopsis beccariana	Simpur					2		3			
		Ixora spec.										9	
Sapindaceae	:	Allophyllus cobbe	Unknown 2 plot BV	11	2								
		Pometia pinnata	Grongqang (daun kecil)				5	8	2	4	6	4	
		Xerospermum spec.	Rambutan hutan			1			5	1	12		1
		Lepisanthus spec.	Cermai (290)				2						
Sapotaceae	:	Madhuca spec.	Jelutung (nr. 2)	2								7	1
		Payena spec.	Bintangur			4		8	3	12	1	17	
Simarubaceae	:	Quassia indica	Pahit pahit		2	5	10		1		1		
Sterculariaceae	:	Sterruleria spec.	Jambu jambu						27				
Thymeleaceae	:	Aquilaria malaccensis	Unknown plot BIII										1
		Gonystylus bancanus	Ramin									2	
Verbenaceae	:	Teysmanniodendron spec.	Jambu jambu			5	32				7	1	
Undeterminate	:		Kayu merah 'Hapit hapit'	1								6	2
			Asam kandis	1								8	1
			Nangqis										3
			Jangka									4	
			Kemang (white latex)									1	
			Gelang tikus	1									
			Kopi hutan				1						
			Others	0		7	5	29		46	96	40	2
Palmae	:	Oncosperma tigqilarium	Nibung	1									
		Livistonia rotundifolia	Palem serdang	2									
		Licuala valida	Palem palas	10		34							
		Nypa fruticans	Nipah										
		Pandanus spec.	Pandanus										
		Pandanus kamii	Pandanus pandang				7		1				
			Slenseng	+	+				17				
			Hassam payau						1				
		Caryota spec.	Rotan enou		1				5				
		Calamus spec.	Rotan beledas		2		17		21		14		
			Rotan manau				1		20				
		Korthalsia/Calamus	Rotan getah		16				62		1		
			Rotan segoh		1		3		20		52		
			Rotan semambu		3								
			Palem pinang	5		16					6		
			Palem merah										
		Korthalsia spec.	Rotan semut										
Graminae	:	Hypolythrum nemorum	'Carex' plus BV		+								much
Herbs			Keladi				2				1		much
			'Tongvarens' (epiphyt)								53		

Plot BV and BI cover 0.1 ha

BII, BIII and BIV cover 0.2 ha

Appendix 9: Description of the vegetation plots

Note: In the following descriptions the vegetation is divided in three height classes, called: Understorey 5-20 m
Middlestorey 20-40 m
Upperstorey 40-60 m
This division is artificial, so these height classes must not be interpreted as distinct vegetation layers.

Description plot BV
Plot size: 20 x 50 m

This plot is located on the oxidized levee in an outerbend of the river Air Hitam Laut. The understorey is quite dense by the occurrence of many rattans and palms (mainly Licuala valida). The canopy is rather open, only a few trees (3,3%) are higher than 35 m.

Pneumatophores are rare and only present in the lower parts of the plot.

The upperstorey (Table 1) consists of Eugenia sp. (Kayu kelat), Shorea teysmanniana and Callophyllum sp. The Callophyllum is typical as it is not encountered elsewhere in the transect. Also the huge palm Oncosperma tiggilarium is characteristic (Figure 8 report) (Photo 5).

The middlestorey (Table 2) is dominated by Polyalthya sp., Baccaurea bracteata and Eugenia sp. The typical species of riverine forest, Mammea sp., is also present but only in a small number. Furthermore, the plot is characterized by the occurrence of Allophyllus cobbe in middle- and understorey.

The understorey contains seven other species occurring in a relatively large number (Table 3), among others Mammea sp. The tree density of this plot is the lowest in the transect ($1200.ha^{-1}$), and only a few trees have a diameter larger than 30 cm, resulting in a low basal area (21,7 $m^2.ha^{-1}$) (Table 6 report). Only a few trees have a Ht/d << 100 (Figure 3a). For the basal area, the important species are Shorea teysmanniana, Madhuca sp., Eugenia sp., Polyalthya sp. and Mammea sp.

Description Plot BI

Plot size: 20 x 50 m

This plot is located on a reduced clay-levee of the river Air Hitam Laut, on an innerbend of this river. The groundwater level is very high. A large part of the plot is often flooded by riverwater. Around some tree trunks there is humus built up by ants, termites and decay of vegetable remains (mostly around trees with stiltroots, buttresses or with pneumatophores near the trunk).

The plot contains many rattans and palms (Licuala valida) which together with the numerous saplings of trees like Mammea sp., makes the understorey quite dense. There is a continuous decrease of many small to few high trees (Figure 3). The canopy is rather open.

The vegetation is dominated by Mammea sp., outnumbering other species in all height classes (Tables 1, 2, 3). In total 43% of the trees > 5 m belong to this species with its many slender loop- or knee-shaped pneumatophores. In the understorey Stemonurus secundiflorus is the second abundant species. Theysmanniodendron sp. seems to be typical as it is not found elsewhere in the transect.

In the middlestorey Macaranga triloba and Aporosa sp. are common. The occurrence of M. triloba might indicate an old disturbance of the vegetation as it is a fast colonizing species.

The upperstorey consists of five species (Table 1), the highest trees being Mammea sp. (50 m), Durio carinatus and Stemonurus secundiflorus (both 45 m).

The plot has a very high tree density, but thick trees are lacking. Only 2 trees have a diameter larger than 60 cm. Only a few trees have a Ht/d << 100 (Figure 3b). In the middlestorey they are even lacking. Still 58% of the basal area is covered by trees with a diameter > 30 cm (8,7% of the trees (Figure 4) Mammea sp. covers 32% of the total basal area.

Description of plot BII

Plotsize: 40 x 50 m

This plot is located in the freshwater-swamp forest on reduced clay, between the riverine forest and the peat-swamp forest.
The understorey is dense. There are many rattans. Outside the plot some areas have an understorey abundant in palms (Licuala valida). The middlestorey above 30 m is rather open. Between 35 and 45 m tree boles are even lacking, thus making this plot the only one with distinct layers (Figure 8 report).

The upperstorey is dominated by six large 'Pulai's' (Alstonia pneumatophora) with scattered boles and a large coverage (Figure 8 report). They are 50-60 m high and at this height accompagnied only by one specimen of Dyera costulata (Table 1).

The middlestorey consists mainly of five species (Table 2). Two of these species (Eugenia sp. and Payena sp.) do occur in the understorey in a low number only, in contrast to Baccaurea bracteata, Polyalthya sp. and Dyospyros bantamensis which are abundant in both middlestorey and understorey.

Besides these, some other species are abundant in the understorey (Table 3), like Blumeodendron tokbrai and Antidesma montanum. The latter is characteristic for the freshwater-swamp forest in Berbak. Common are Stemonurus secundiflorus and Manga quadrifolia.

The tree density is 1405.ha^{-1}. Remarkable is the very high amount of trees with Ht/d << 100 (nearly 44%, Figure 3c). In the middlestorey and upperstorey these trees even outnumber the trees with Ht/d > 100.

The basal area is 51,3 $m_2.ha^{-1}$, which is the highest in the transect. Half of the basal area is covered by the six gigantic Alstonia pneumatophora (Photo 8), which have diameters larger than 100 cm. Besides the enormous trunks this species has a large influence on the physiognomy of the vegetation, with its large kneeshaped pneumatophores which are numerous (Photo 9). The total basal area is covered for 10% by the specimens of Dyera costulata. 73% is covered by trees with a diameter larger than 30 cm (Figure 4). Other species with relatively large basal area-totals are Dyospyros bantamensis and Eugenia sp.

Description of plot BIII

Plot size: 40 x 50 m

This plot is located on 3.5 m deep peat, about 4.5 km from the river. Palms do not occur in the plot (and are rare throughout this vegetation type), but many rattans are found in the subgrowth and understorey. The tree density is partly low (1285/m), though the number of young trees (Ht 5-10 m) is quite high (55%) (Figure 3).

In the understorey (Table 3) three species are abundant: Dyospyros bantamensis, Stemonurus secundiflorus and Polyalthya sp. Aporosa sp, Eugenia sp., Payena sp. and Manga quadrifolia are common. Typical is the occurrence of 'Bengkal' (Lauraceae) which is not found in the other plots. In the middlestorey (Table 2) this is the commonest species, besides Polyalthya sp., Dyospyros bantamensis, Shorea platycarpa and Payena sp.

Noteworth is Pometia pinnata, being absent in the understorey but relatively important in the middlestorey, reaching a height from 28-40 m. Tetramerista glabra, a species restricted to the peat-swamp forest, is present in the middlestorey as well. Outside the plot it occurs also in the upperstorey reaching heights of 50 m.

The upperstorey in the plot contains four species; Kompassia malaccensis (50 m high), Dyospyros bantamensis, Parastemon urophyllum and Pometia pinnata (40 m).

There is a continuous decrease of trees from small to big ones (Figure 3). No distinct layers can be found, but the upperstorey contains only one tree much higher than 40 m, so the middlestorey, which is quite dense, forms the (closed) canopy, due to the many trees with a height of 35-40 m (Figure 8 report).

The percentage of trees with Ht/d << 100 is large in the canopy and gradually decreases in the lower heights (Figure 3d).

The total basal area is 32.7 $m^2.ha^{-1}$ of which 59% is covered by trees with a diameter larger than 30 cm (table 6 report). Only the high specimen of Kompassia malaccensis has a diameter > 80 cm (6 $m^2.ha^{-1}$). Other tree species with a high basal area total are: Dyospyros bantamensis, Baccaurea bracteata, Shorea platycarpa, Tetramerista glabra and Parastemon urophyllum.

Description of plot BIV

Plot size: 40 x 50 m

This plot is located on very deep peat (> 8 m) at approximately 7 km distance from the river.

The vegetation is high (55 m), the upperstorey is rich in species and with scattered crowns resulting in a closed canopy. Of the trees 4.3% is higher than 40 m and 12.7% higher than 30 m (Figure 3). Species of the upperstorey are Dyera costulata, Shorea sp. (Meranti batuh), Durio carinatus, Kompassia malaccensis, Shorea platycarpa, Dyospyros bantamensis, Eugenia sp. and Gluta sp. (table 1). Except for Durio carinatus and Shorea sp. all other species are found in the lower storeys as well.

Also the middlestorey (Table 2) is dense. It is dominated by a species of the Magnoliaceae, with an innerbark smelling strongly like apple. Common species are Dyospyros bantamensis, Dyera costulata, Eugenia sp. and Stemonurus secundiflorus. From Tetramerista glabra two specimens are present.

The understorey (Table 3) is dominated by Stemonurus secundiflorus, Dyospyros bantamensis and the species of the Magnoliaceae. Second abundant are Payena sp., Shorea platycarpa and Blumeodendron tokbrai.

The plot does not contain any palms. Rattans are very rare (Table 6 report). In the subgrowth the herb 'keladi' (local name) is common. There is a continuous decrease in percentage of trees with Ht/d << 100 from the upperstorey to the lower stories (Figure 3e). The basal area is 47.8 $m^2.ha^{-1}$, which is quite high (compared to findings of Anderson for peat forests in Riau: see 4.4.2). Very thick trees do not occur, the thickest trees being specimens of Gluta sp. with diameters of 73 cm and 86 cm. 64% of the basal area is covered by trees with a diameter larger than 30 cm (Figure 4)

14% of the total number of trees). Tree species with the largest basal area totals in this plot are: Dyera costulata, Shorea sp., Durio carinatus, Kompassia malaccensis, Dyospyros bantamensis, Eugenia sp., Gluta sp., and the species of the Magnoliaceae.

Table 1. Total number of trees of the species which occur in the upperstorey (Ht 40-60 m) of one or more vegetation plots.

	BV	BI	BII	BIII	BIV
Oncosperma tiggilarium	+				
Shorea teysmanniana	1				
Callophyllum sp.	1				
Eugenia sp.	1				2
Mammea sp.		3			
Durio carinatus		1			1
Antidesma montanum		1			
Stemonurus secundiflorus		1			
Ficus sondamus		1			
Alstonia pneumatophora			6		
Dyera costulata			1		3
Kompassia malaccensis				2	2
Parastemon urophylum				1	
Shorea sp.					3
Gluta sp.					2
Dyosporys bantamensis				1	1

Table 2. Total number of trees of species occurring in a relatively large amount in the middel storey (Ht 20-40 m) in one or more vegetation plots.

	BV	BI	BII	BIII	BIV
Allophyllus cobbe	2				
Mammea sp.	3	17			
Manga quadrifolia	1	2			
Macarang triloba		6			
Aporosa spec.		3	1		
Stemonurus secundiflorus		2		3	5
Baccaurea bracteata	4	2	4	3	
Polyalthya sp.	7	1	3	5	
Eugenia sp.	5	3	2	2	5
Dyospyros bantamensis		1	4	5	9
Payena spec.		1	3	4	2
Shorea platycarpa	1			4	
Lauraceae (Bengkal)		1		6	
Pometia pinnata				3	
Tetramerista glabra				2	2
Dyera costulata					6
Magnoliaceae (Unknown species nr. 4)					16

Table 3. Total number of trees of species occurring in a relatively large amount in the understorey (Ht 5-20 m), vegetation plots.

	BV	BI	BII	BIII	BIV
Allophyllus cobbe	9				
Pternanora galeata	11	6	4	1	
Mammea sp.	12	59			
theysmanniodendron sp.		5			
Antidesma montanum			27		
Baccaurea bracteata	4	3	20	1	5
Blumeodendron tokbrai		6	26	5	9
Manga quadrifolia	14	3	12	7	2
Polyalthya sp.	7	2	21	24	1
Aporosa sp.	13	1	5	9	6
Eugenia sp.	4	2	3	8	4
Lauraceae (Bengkal)				13	
Stemonurus secundiflorus	1	15	16	28	33
Dyospyros bantamensis	1	3	21	33	24
Payena sp.		3	5	8	15
Shorea platycarpa	1	1	6	1	9
Magnoliaceae (Unknown species nr. 4					25

Appendix 10. List of observations of mammals.

Order: Dermoptera
Fam : Cynocephalidae - Flying Lemur
Species: Cynocephalus variegatus Flying Lemur 'Kubung'
One specimen was observed in freshwater-swamp forest (fig. 12) on 4-5-'83.

Order: Chiroptera - Bats
Fam : Pteropididae
Species: Pteropus vampirus Kalong or Common Flying Fox
Kalongs were occasionally seen flying over the forest.

Order: Primates
Fam : Cercopithecidae - Monkeys
Species: Macaca fascicularis Crab-eating Macaque
Macaca nemestrina Pig-tailed Macaque
Presbytis cristata Silvery leaf Monkey
Fam : Hylobatidae - Gibbons
Species: Symphalangus syndactylus Siamang
Hylobates agilis Dark-handed Gibbon

The Macaca fascicularis is the commonest monkey. Especially at dawn or in the late afternoon, a lot of them can be seen along the riversides, high in the trees, but sometimes also in the Pandanus tectorius vegetation where they feed on the big fruits of these palms. Probably they come to the riversides to drink. We often observed them also deep inside the forest (freshwater-swamp and peat-swamp forest). They are common in the mangrove forest and occasionally they come into the dry-beach forest where they sit in the Casuarina equisetifolia-trees.

The Macaca nemestrina is sometimes seen in the forest along the river Air Hitam Laut.

The Presbytis cristata is common in the mangrove

forest and is often seen in the dry-beach forest. Near desa Cemara we regularly observed a group of 10-20 specimens. In freshwater-swamp forests and peat-swamp forests smaller groups have been seen. Like the macaques they seem to go to the riversides at dawn and in the evening.

From the Hylobatidae we saw and heard most often the Symphalangus syndactylus. Especially at day-break their presence is obvious because of their loud distinct 'morning concerts' serving to localize the different groups and to mark the territories.
Two specimen were seen near S. Simpang Batu Pahat and a group of six specimens was observed in the peat-swamp forest (Figure 12).

The Hylobates agilis was seen only once, in the fresh-water-swamp forest (Figure 12).

Order: Pholidota
Fam : Manidae - Scaly Ant-eaters, Pangolins
Species: Manis javanicus Scaly Ant-eater
De Wulf & Rauf (1982).

Order: Rodentia
Fam : Sciuridae - Squirrels
Species: Sundasciurus tenuis Slender Squirrel
Callosciurus prevostii Prevost's Squirrel
Lariscus insignis Three-striped Ground Squirrel
Petaurista petaurista Red Giant Flying Squirrel
The Callosciurus prevostii is seen quite often in the freshwater swamp and peat-swamp forest.
Sundasciurus tenuis and Lariscus insignis are seen rarely (they are far less striking than the three-coloured C. prevostii).
Petaurista petaurista was observed only once near desa Labuan Pering (Figure 12).

Fam : Hystricidae - Porcupines

Species: Hystrix brachyura Common Porcupine

De Wulf & Kauf (1982).

Order: Carnivora

Fam : Ursidae - Bears

Species: Helarctos malayanus Sun Bear

Occasionally this animal is seen by farmers in the coconut and nangka gardens. In the forest we never found foot prints. Only once a scratching-mark on a tree is seen (Figure 12).

Fam : Mustelidae

Subfam: Mustelinae - Martens and Weasels

Species: Martes flavigula Yellow-throated Marten.

Tracks were found at three locations (Figure 12).

Subfam: Lutrinae - Otters

Species: Lutra lutra Common Otter

Near desa Air Hitam Laut many tracks were found in the Nypa vegetation. The identification is not sure because L. sumatrana has almost identical foot prints. In the river Sungai Benu otters were regularly seen by fishermen dwelling near S. Simpang Kanan.

Fam : Viverridae - Civets and Mongooses

Subfam: Paradoxurinae - Musangs and allies

Species: Arctitis binturong Binturong

This species is rarely seen. One specimen was confiscated some years ago by the PPA as it was captured by local people in a trap.

Fam : Felidae - Cats

Felini:

Species: Felis bengalenis - Leopard Cat

A track was found in the Nypa-zone near desa Air Hitam Laut (Figure 12).

Pantherini:

Species: Panthera tigris - Tiger

Tracks of the tiger were frequently found in or near the riverine forest, but also in the reclaimed agricultural area along the coast (Figure 12).

Near desa Cemara we found a track of a female with one young. Near desa Air Hitam Laut a track was found (in the Nypa vegetation) only 50 m from the first house of the village street.

On the pematang near S. Simpang Kubu we saw a tiger at 20 m distance. The main territory of the tiger is the freshwater-swamp forest and the riveredge forest, especially on the higher grounds. Because of the numerous boar wild pigs (Sus scrofa), probably the main prey species of the tiger in Berbak, tigers regularly appear near the villages and in the burned forest. In the peat swamp forest nearly no tracks of large mammals were found.

Order: Perissodactyla

Fam : Tapiridae - Tapirs

Species: Tapirus indicus Malay Tapir

The Malay tapir is a typical species of the lowlands. We found tracks in the freshwater-swamp forest and the forest on shallow peat (Figure 12).

Fam : Rhinocerotidae - Rhinocerosses

In 1936 Endert described some observations of the Sumatran rhino Dicerorhinus sumatrensis in Berbak. Wind (1976) mentions fresh footprints of a big-sized rhino, and he does not rule out the possibility of this rhino being the Javanese Rhinoceros sondaicus. No further evidence has been recorded since, but the habitat seems suitable for the secretive Sumatran rhino Dicerorhinus sumatrensis (De Wulf & Kauf 1982). We did not find any evidence for the occurrence of rhinocerosses in Berbak. Noteworthy however is that until now nobody ever reached the western part of the reserve (further west than S. Simpang Kubu), where it still could occur.

The habitat is probably the same as in the eastern part, perhaps even better as the altitude is higher (15 m above sea level).

Order: Artiodactyla

Fam : Suidae - Swines

Species: Sus scrofa Common Wild Pig or Wild Boar

Sus barbatus Bearded Pig

Swines are probably the most important prey species of the tiger. Sus scrofa is obviously abundant, especially on or near the river levees in the riverine and freshwater-swamp forest. Areas with an up-rooted topsoil are found frequently. Especially on and near the pematangs, the population density is high, which is indicated by the numerous gamepaths. Some of these tracks are more than 2 m wide. Wild boars are common also in the coastal area in and near the mangrove. In the young coconut plantations, rice fields and fruittree orchards they can be a real pest, being able to devastate the crops.

Farmers stated that the 'Babi putih', the bearded pig is also a frequent visitor of their fields. In the forest we regularly found footprints distinguished from the normal tracks by their large side. These tracks may concern Sus barbatus.

Fam : Tragulidae - Mouse Deer or Chevrotain (Kantjils)

Species: Tragulus javanicus Lesser Mouse deer

Tragulus napu Larger Mouse deer

Both species of the Kantjils occur in Berbak. The tracks are regularly found in the riverine forest and freshwater-swamp forest. Near desa Air Hitam Laut they were also found in the Nypa-zone (Figure 12). The tracks are very small and therefore only noticeable in smooth clay without a dead-leaflayer or with an only very thin one. Therefore it is very difficult to find them in the peat swamp forest, so we cannot be sure that their distribution/occurrence territory is restricted to the

above mentioned habitats. We saw Kantjils several times but is was too difficult to identify the species.

Fam : Cervidae - Deer

Species: Cervus unicolor - Sambar

Tracks are occasionally found in Berbak where the Sambar seems to be rather rare (Figure 12).

Fam. : Bovidae

Species: Bubalus bubalus - Water Buffalo

Endert (1935) mentioned the occurrence of the wild water Buffalo for Berbak. No further evidence has been recorded since.

Appendix 11 Species list of birds

The observations are done by Marcel J. Silvius in cooperation with Wim J.M. Verheugt.
Included are species from the preliminary bird list made by Ir. R. de Wulf & Rauf (1982).
The observations were done in 1983 in April, May, June and September, October, November.
Data were collected on occurrence and habitat preference.

Numbers preceding the species-name refer to:
- King et al. Birds of Southeast Asia
- Strien N. v. Sumatran Birds

Symbols for habitat:

R	River
RB	Riverbank
FF	Freshwater-swamp forest
PF	Peat-swamp forest
MF	Mangrove forest
DF	Dry-beach forest
SG	Second growth
OC	Open country
B	Beach
MB	Mudflat
SB	Sandy Beach
K	Kampung
(R)	Near river (always in combination with another habitat)
C	Cultivation

Species only observed by Ir. R. de Wulf & Rauf (1982) are marked with &.

	Phalacrocoracidae:		
19	Anhinga melanogaster	Oriental Darter	RB
	Fregatidae:		
22	Fregata ariel	Lesser Frigatebird	S
	Ardeidae:		
25	Ardea cinerea	Grey Heron	RB,MB,SG
26	Ardea purpurea	Purple Heron	R,SG
27	Butorides striatus	Little Heron	RB,MB,MF
32	Egretta sacra	Pacific Reef-Egret	MB,MF(R)
33	Egretta eulophotes	Chinese Egret	B
34	Egretta alba	Great Egret	MF,MB,S
35	Egretta intermedia	Plumed Egret	MF,MB,S
36	Egretta garzetta	Little Egret	MB
41	Ixobrychus cinnamomeus	Cinnamon Bittern	SG,OC(R)
42	Dupetor flavicollis	Black Bittern	&
	Ciconiidae:		
44	Ibis cinereus	Milky Stork	RB,B,SG
49	Ciconia episcopus	Wooly-necked Stork	R,RB
49	Ciconia episcopus stormi	Storms Stork	R,RS
52	Leptoptilos javanicus	Lesser Adjutant	R,RB,SG
	Threskiornithidae:		
53	Threskiornis melanocephalus	Black-headed Ibis	MB
	Anatidae:		
64	Dendrocygna javanica	Lesser Treeduck	&
	Pandionidae:		
95	Pandion haliaetus	Osprey	S,B
	Accipitridae:		
96	Aviceda jerdoni	Jerdon's Baza	FF
97	Aviceda leuphotes	Black Baza	FF(R)
100	Elanus caeruleus	Black-shouldered Kite	SG,OC,B,K
102	Haliastur indus	Brahminy Kite	SG,OC,R,RB,S,

		B,MF	
103	Haliaeetus leucogaster	White-bellied Sea-Eagle	S,B,SG,OC,MF
107	Icthyophaga ichthyaetus	Grey-headed Fish-Eagle	RB,R
114	Spilornis cheela	Crested Serpent-Eagle	K,SG,PF
124	Accipiter trivirgatus	Crested Goshawk	SG,OC
133	Ictinaetus malayensis	Black Eagle	FF,SG,(R)
142	Spizaetus cirrhatus	Changeble Hawk-Eagle	SG,(R)
144	Spizaetus alboniger	Blyth's Hawk-Eagle	FF,SG(R)
145	Spizaetus nanus	Wallace's Hawk-Eagle	FF(R)
	Falconidae:		
148	Microhierax fringillarius	Black-thighed Falconet	SG,MF,FF(R)
155	Falco severus	Oriental Hobby	SG,FF(R)
	Phasianidae:		
161	Melanoperdix nigra	Black Wood-Partridge	FF,PF
164	Coturnix chinensis	Blue-breasted Quail	SG,OC
186	Gallus gallus	Red Junglefowl	&
195?	Argusianus argus	Great Argus ?	FF
	Rallidae:		
206?	Rallina fasciata	Red-legged Crake ?	RB
210	Porzana fusca	Ruddy-breasted Crake	RB
211	Porzana paykullii	Band-bellied Crake	SG
217	Gallinula chloropus	Common Moorhen	&
218	Porphyrio porphyrio	Purple Swamphen	R,(FF)
	Charadriidae:		
231	Pluvialis squatarola	Grey Plover	MB,SB
235	Charadrius alexandrinus	Kentish Plover	SB
236	Charadrius peronii	Malaysian Plover	MB,SB
238	Charadrius mongolus	Mongolian Plover	MB,SB
239	Charadrius leschenaultii	Greater Sand-Plover	SB,MB
	Scolopacidae:		
241	Numenius arquata	Eurasian Curlew	MB,SB
242	Numenius phaeopus	Whimbrel	MB,SB
244	Numenius madagascariensis	Eastern Curlew	MB,SB

245	Limosa limosa	Black-tailed Godwit	MB,SB
246	Limosa lapponica	Bar-tailed Godwit	MB,SB
248	Tringa totanus	Common Redshank	MB,SB
249	Tringa stagnatilis	Marsh Sandpiper	MB,SB
250	Tringa nebularia	Common Greenshank	MB,SB
253	Tringa glareola	Wood Sandpiper	MF
254	Xenus cinereus	Terek Sandpiper	MB,SB
255	Actitis hypoleucos	Common Sandpiper	RS,MB,SB,MF
256	Heteroscelus brevipes	Grey-tailed Tattler	&
257	Arenaria interpres	Ruddy Turnstone	MB,SB
267	Calidris tenuirostris	Great Knot	MB,SB
268	Calidris ruficollis	Rufous-necked Stint	SB
274	Calidris ferruginea	Curlew Sandpiper	SB,MB
277?	Limicola falcinellus	Broadbilled Sandpiper ?	MB,SB
	Glareodidae:		
286	Glareola maldivarum	Oriental Pratincole	OC
	Laridae:		
299	Chlidonias leucopterus	White-winged Tern	S
300	Gelochelidon nilotica	Gull-billed Tern	S,MB,SB
303	Sterna hirundo	Common Tern	S,SB
305	Sterna sumatrana	Black-naped Tern	S
309	Sterna albifrons	Little Tern	R,S,MB,SB
310	Sterna bergii	Great Crested Tern	S,MB,SB
311	Sterna bengalensis	Lesser Crested Tern	SB
	Columbidae:		
323	Treron fulvicollis	Cinnamon-headed Pigeon	RB(FF)
324	Treron olax	Little Green Pigeon	FF,SG
325	Treron vernans	Pink-necked Pigeon	SG,DF
330	Ducula aenea	Green Imperial Pigeon	FF,(R),SG
331	Ducula bicolor	Pied Imperial Pigeon	FF
336.1	Columba argentina	Grey Wood-Pigeon	&
343	Streptopelia chinensis	Spotted Dove	DF,SG,OC
345	Chalcophaps indica	Green-winged Pigeon	&

	Psittacidae:		
349	Psittacula alexandri	Red-breasted Parakeet	&
350	Psittacula longicauda	Longtailed Parakeet	FF(R),SG,PF
353	Psittinus cyanurus	Blue-rumped Parrot	FF(R),SG
355	Loriculus galgalus	Blue-crowned Hanging Parrot	RB,FF
	Cuculidae:		
356	Clamator coromandus	Chestnut-winged Cuckoo	&
373	Surniculus lugubris	Drongo Cuckoo	&
374	Eudynamys scolopacea	Common Koel	RB(FF)
376	Phaenicophaeus sumatranus	Chestnut-bellied Malkoha	MF,SG
378	Phaenicophaeus chlorophaeus	Raffles Malkoha	FF,MF
383	Centropus sinensis	Greater Coucal	RB,DF,SG
384	Centropus bengalensis	Lesser Coucal	SG
	Strigiformes:		
392	Otus bakkamoena	Collared Scops-Owl	FF
399	Ketupa ketupu	Buffy Fish-Owl	MF
403	Ninox scutulata	Brown Hawk-Owl	FF
	Caprimulgidae:		
416	Eurostopodus temminckii	Malaysian-eared Nightjar	FF(R)
419	Caprimulgus macrurus	Large-tailed Nightjar	K,DF
	Apodidae:		
426	Collocalia esculenta	White-bellied Swiftlet	FF(R),K,C,OC
428	Hirundapus cochinchinensis	White-vented Needletail	R,FF
430	Raphidura leucopygialis	Silver-rumped Swift	FF(R)
432	Apus pacificus	Fork-tailed Swift	FF(R)
433	Apus affinis	House Swift	FF(R)
434	Cypsiurus batasiensis	Asian Palm-Swift	FF(R)
	Hemiprocnidae:		
437	Hemiprocne comata	Whiskered Treeswift	RB
	Trogonidae:		
439	Harpactes diardii	Diard's Trogon	PF
441	Harpactes duvaucelii	Scarlet-rumped Trogon	RB,FF

	Alcedinidae:		
448	Alcedo atthis	Common Kingfisher	RB,K(R)
449	Alcedo meninting	Blue-eared Kingfisher	R,FF(R)
450	Alcedo euryzonia	Blue-banded Kingfisher	&
451	Ceyx erithacus	Black-backed Kingfisher	RB,R(FF)
452	Ceyx rufidorsus	Rufous-backed Kingfisher	MF
454	Pelargopsis capensis	Stork-billed Kingfisher	FF(R),MF(R)
456	Halcyon coromanda	Ruddy Kingfisher	FF(R),RB
457	Halcyon smyrnensis	White-throated Kingfisher	SG(R),OC
458	Halcyon pileata	Black-capped Kingfisher	FF(R),B,MF
459	Halcyon chloris	Collared Kingfisher	MF,R,B,SG,OC
460	Halcyon concreta	Rufous-collared Kingfisher	FF(R)
	Meropidae:		
462	Merops philippinus	Blue-tailed Bee-eater	SG,B,FF(R)
464	Merops viridis	Blue-throated Bee-eater	SG,B,OC,MF
	Coraciidae:		
468	Eurystomus orientalis	Dollarbird	RB,SG,FF(R), DF
	Bucerotidae:		
470	Berenicornis comatus	White-crowned Hornbill	FF
472	Anorrhinus galeritus	Bushy-crested Hornbill	FF(R)
474	Rhyticeros corrugatus	Wrinkled Hornbill	FF(R)
475	Rhyticeros undulatus	Wreathed Hornbill	FF(R)
477	Anthracoceros malayanus	Black Hornbill	FF(R)
479	Anthracoceros convexus	Southern Pied Hornbill	FF(R),SG
480	Buceros rhinoceros	Rhinoceros Hornbill	FF(R),PF
481	Buceros bicornis	Great Hornbill	FF,SG
482	Rhinoplax vigil	Helmeted Hornbill	FF,PF
	Capitonidae:		
488	Megalaima chrysopogon	Gold-whiskered Barbet	PF
489	Megalaima rafflesii	Red-crowned Barbet	FF
	Picidae:		
502	Picumnus innominatus	Speckled Piculet	&

513	Picus puniceus	Crimson-winged Woodpecker	FF,PF
516	Picus miniaceus	Banded Woodpecker	FF,MF
519	Dinopium javanense	Common Goldenback	MF,SG
525	Meiglyptes tukki	Buff-necked Woodpecker	FF
526	Mulleripicus pulverulentus	Great Slaty Woodpecker	FF(R)
527	Dryocopus javensis	White-bellied Woodpecker	FF
535	Picoides canicapillus	Grey-capped Woodpecker	SG
536	Picoides moluccensis	Brown-capped Woodpecker	SG
537	Hemicircus concretus	Grey-and-Buff Woodpecker	&
540	Blythipicus rubiginosus	Maroon Woodpecker	FF
542	Chrysocolaptes lucidus	Greater Goldenback	MF
	Eurylaimidae:		
543	Corydon sumatranus	Dusky Broadbill	FF
544	Cymbirhynchus macrorhynchus	Black-and-Red Broadbill	RB,FF
545	Eurylaimus javanicus	Banded Broadbill	FF
	Hirundinidae:		
572	Hirundo rustica	Barn Swallow	FF(R),SG,OC
573	Hirundo tahitica	Pacific Swallow	FF(R),SG
	Campephagidae:		
580	Hemipus hirundinaceus	Black-winged Flycatcher-Shrike	SG
589	Lalage nigra	Pied Triller	&
590	Pericrocotus divaricatus	Ashy Minivet	SG
593	Pericrocotus igneus	Fiery Minivet	DF,FF(R)
598	Pericrocotus flammeus	Scarlet Minivet	FF(R)
	Chloropseidae:		
600	Aegithina tiphia	Common Iora	DF,SG
601	Aegithina lafresnayei	Great Iora	DF
603	Chloropsis sonnerati	Great Green Leafbird	FF
605	Chloropsis cochinchinensis	Blue-winged Leafbird	FF,FF(R),PF
	Pycnonotidae:		
612	Pycnonotus atricepts	Black-headed Bulbul	RB
620	Pycnonotus aurigaster	Sooty-headed Bulbul	&
621	Pycnonotus eutilotus	Puff-backed Bulbul	SG

625	Pycnonotus plumosus	Olive-winged Bulbul	SG
627	Pycnonotus simplex	Cream vented Bulbul	FF(R)
635	Criniger phaeocephalus	Yellow-bellied Bulbul	SG
636	Hypsipetes criniger	Hairy-backed Bulbul	PF
639	Hypsipetes charlottae	Buff-vented Bulbul	SG
	Dicruridae:		
648	Dicrurus annectans	Crow-billed Drongo	RB,FF(R)
649	Dicrurus aeneus	Bronzed Drongo	RB,SG,FF
652	Dicrurus paradiseus	Greater Racket-tailed Drongo	RB,FF,MF,PF, SG
	Oriolidae:		
654	Oriolus chinensis	Black-naped Oriole	DF,SG,C
660	Irena puella	Asian Fairy-Bluebird	FF
	Corvidae:		
675	Platysmurus leucopterus	Black Magpie	SG
678	Corvus enca	Slender-billed Crow	PF-FF
681	Corvus macrorhynchos	Large-billed Crow	FF,SG
	Sittidae:		
699	Sitta frontalis	Velvet-fronted Nuthatch	MF
	Timaliidae:		
712	Pellorneum capistratum	Black-capped Babbler	FF
715	Trichastoma malaccense	Short-tailed Babbler	FF,PF
716	Trichastoma rostratum	White-chested Babbler	FF(R),RB
717	Trichastoma bicolor	Ferruginous Babbler	FF(R)
721	Malacopteron affine	Sooty-capped Babbler	FF
723	Malacopteron magnum	Rufous-crowned Babbler	FF,PF
724?	Malacopteron albogulare	Grey-breasted Babbler ?	PF
756	Stachyris maculata	Chestnut-rumped Babbler	PF
762	Macronous ptilosus	Fluffy-backed Tit-Babbler	FF
772	Garrulax leucolophus	White-crested Laughingtrush	SG,C
808	Pteruthius flaviscapis	White-browed Shrike-Babbler	RB

	Turdidae:		
874	Erithacus cyane	Siberian Blue Robin	&
879	Copsychus saularis	Magpie Robin	SG,DF,C
880	Copsychus malabaricus	White-rumped Shama	FF,PF
881	Copsychus pyrropygus	Rufous-tailed Shama	FF
	Sylviidae:		
938.1	Seicercus grammiceps	Sunda Flycatcher Warbler	&
965	Acrocephalus arundinaceus	Great Reed-Warbler	FF(R),RB
975	Orthotomus sutorius	Common Tailorbird	&
976	Orthotomus atrogularis	Dark-necked Tailorbird	FF,SG
977	Orthotomus ruficeps	Ashy Tailorbird	RB,SG
983	Prinia flaviventris	Yellow-bellied Prinia	DF,SG
987	Cisticola juncidis	Zitting Cisticola	SG,OC,C
	Muscicapidae:		
1006	Rhynomyias umbratilis	Grey-chested Flycatcher	PF
1014	Ficedula zanthopygia	Yellow-rumped Flycatcher	&
1042?	Cyornis turcosa	Malaysian Blue Flycatcher ?	RS,FF(R)
1044	Cyornis rufigastra	Mangrove Blue Flycatcher	MF
1048	Rhipidura albicollis	White-throated Fantail	&
1051	Rhipidura javanica	Pied Fantail	FF(R),RB, MF(R)
1052	Hypothymis azurea	Black-naped Monarch	FF(R),RB
1054	Philentoma pyrhopterum	Rufous-winged Flycatcher	FF(R),PF
1056	Terpsiphone paradisi	Asian Paradise-Flycatcher	FF(R),RB
	Pachycephalidae:		
1057	Pachycephala cinerea	Mangrove Whistler	FF(R),RB,SG, DF
	Artamidae:		
1074.1	Artamus leucorhynchus	White-breasted Wood-Swallow	RB
	Laniidae:		
1077	Lanius tigrinus	Tiger Shrike	SG,OC,C

	Sturnidae:		
1082	Aplonis panayensis	Philippine Glossy Starling	SG,FF(R),OC
1095	Acridotheres javanicus	White-vented Myna	SG,OC,MF
1099	Gracula religiosa	Hill Myna	FF(R),SG
	Nectariniidae:		
1101	Anthreptes malacensis	Brown-throated Sunbird	SG,C
1103	Anthreptes singalensis	Ruby-cheeked Sunbird	SG(R)
1104	Hypogramma hypogrammicum	Purple-naped Sunbird	FF
1107	Nectarinia calcostetha	Copper-throated Sunbird	SG,C
1108	Nectarinia jugularis	Olive-backed Sunbird	MF,SG,C
1114	Aethopyga siparaja	Crimson Sunbird	SG
1117	Arachnothera longirostra	Little Spiderhunter	SG,RB
1119	Arachnothera robusta	Long-billed Spiderhunter	SG,RB
1120	Arachnothera flavigaster	Spectacled Spiderhunter	SG
	Dicaeidae:		
1125?	Prionochilus maculatus	Yellow-breasted Flowerpecker ?	RB
1126	Prionochilus percussus	Crimson-breasted Flowerpecker	SG,FF
1131	Dicaeum trigonostigma	Orange-bellied Flowerpecker	SG,RB
	Zosteropidae:		
1138	Zosterops palpebrosa	Oriental White-Eye	MF,B
	Ploceidae:		
1140	Passer montanus	Eurasian Tree-Sparrow	K
1144	Ploceus philippinus	Baya Weaver	SG,C
1154	Lonchura punctulata	Scaly-breasted Munia	SG,K
1156	Lonchura maja	White-headed Munia	SG,C

Appendix 12. List of observations of reptiles and amphibians.

Reptiles

Turtles : Fam. Testudinidae

Species: Orlitia borneensis
Cyclemys dentata

From the large Orlitia borneensis whose shell can reach a length of nearly 80 cm (De Rooy 1915), two specimen were observed in the river Sungai Benu and one in the S. Simpang Kanan, where they were accidentally caught by local fishermen. One turtle was dead already, and another was severely injured by the fishing gear.
In the river Air Hitam Laut one individual was caught by ourselves when we tried to catch some fish. The Cyclemys dentata was found two times. It occurs in the freshwater--swamp forest, where it leads a semi-aquatic life. There is nearly no information about the vulnerability of both species.

Snakes : Species: Python reticulatus
Bungarius fasciatus
Boiga dendrophila melanota
Cerberus rhynchops
Dendrophis pictus

The Python reticulatus is common in the agricultural areas but in the forest also, where we found a track which was 40 cm wide.
The Bungarius fasciatus and Boiga dendrophila have their habitat in the Nypa-swamp. The Cerberus rhynchops is very common in the mangroves. The Dendrophis pictus was only observed once, in a coconut plantation.

Lizards : Fam. Agamidae

Species: Draco sp.

De Wulf & Rauf (1982).

Fam. Varanidae

Species: Varanus salvator

This large monitor lizard is frequently encountered in the mangrove and along the rivers.

Fam. Lacertidae

Species: Tachydromus sexlineatus Daudin

This species is found in the dry beach forest where it has its habitat in the undergrowth of grasses.

Fam. Scincidae

Species: Mabuia rudis Boulenger

Caught in a pitfall in the riveredge forest.

Crocodiles : Fam. Crocodilidae

Species: Tomistoma schlegeli False Gavial

Crocodilus porosus Estuarine Crocodile

The false gavial occurs in both rivers of the Berbak reserve: the Sungai Benu and S. Air Hitam. According to the PHPA the S. Simpang Malaka is an important crocodile river. The false gavial has its sleeping places in the bakung mats (Susum anthelminticum). It shuns brackish water.

From fishermen living along the Sungai Benu we were told that around 1979 about fifty specimens had been caught. They were sold in Palembang. Since then only few false gavials have been observed in this river (as far as it is navigable; some kms upstream from the Simpang Kanan it is blocked by bakung).

The Estuarine Crocodile occurs near the rivermouths. The last years it is rarely seen. As a great part of its habitat is disturbed by settlements on the river borders and a lot of boat-traffic, the population has probably largely decreased.

Amphibians

No inventory has been made. Only one remarkable species was identified.

Toads : Bufo subasper
This enormous toad (± 15 cm) is seen twice, once in the Bakung in the S. Air Hitam, and once in the S. Simpang Malaka.

It is obvious that the species list of reptiles and amphibians is very incomplete, especially as to snakes, lizards and amphibians. PPA guides told us that also some other large turtle species occur in the rivers. One of these species might be the Batagur baska.

Appendix 13. Preliminary results on insects.

Transect from sandy beach to old dry-beach forest, crossing mangrove.
(Det: H. Siepel; Leg: M.J. Silvius)

	Beach with convulvulaceae vegetation	Young dry-beach forest	Wet mangrove	Old dry-beach forest
Collembola				
Arthropleona	4	2		
Thysanura	6			
Dictyoptera				2
Saltatoria				
Caelifera		9		15
Heteroptera				
Geocorisae		1		
Homoptera				
Auchenorrhyncha		1	2	7
Diptera	1 larvae			
Nematocera	2	2		1
Cyclorapha	1			
Hymenoptera				
Parasitica				1
Aculeata				
Formicoidea	40	12	3	70
Coleoptera				
Carabidae	1	2	1	
Polyphaga	50	4		70
Staphilinoidea	1			1
Curculionidea				1
Larvae	2			
Arachnida				
Acari				5
Araneida	7	3		3
Pseudoscorpionida	1			
Crustacea				
Isopoda	3			
Decapoda		2	14	
Amphipoda		2		
Myriapoda				
Chilopoda	1			

Appendix 14: List of crops, cultivated in the four coastal villages.
Classification according to Driessen, 1977.

	English name	Latin name	Local name	main	secondary	minor
	CEREALS					
1.	Maize	Zea mays	Jagung	X		
2.	Rice	Oryza sativa	Padi	X		
	ROOT AND TUBER CROPS					
3.	Cassava	Manihot esculenta	Ubi kayu	X		
4.	Sweet potato	Ipomoea batatas	Ubi jalar		X	
5.	Yam	Dioscorea alata	Uwi			X
6.	Yam bean	Pachyrrhizus erosus	Bangkuang			X
	OIL CROPS					
7.	Castor	Ricinus communis	Jarak			X
8.	Coconut	Cocos nucifera	Kelapa	X		
9.	Groundnut	Arachis hypogaea	Kacang tanah		X	
10.	Soybean	Glycine max	Kacang kedelai		X	
11.		Melaleuca leucadendra	Kayu patih			X
12.	Sunflower	Helianthus annus	Bunga matahari			X
	FIBRE CROPS					
13.	Cotton	Gossipium obtusifolium	Kapas		X	
	FRUIT AND NUT CROPS					
14.	Banana	Musa sp.	Pisang ambon	X		
			Pisang sembatu		X	
			Pisang sarawak		X	
			Pisang manis	X		
			Pisang mar		X	
			Pisang tanduk	X		
			Pisang puan		X	
22.	Cashew nut	Anacardium occidentale	Jambu monyet		X	
23.	Citrus, lime	Citrus aurantifolia	Jeruk nipis			X
24.		C. hystrix	Jeruk purut			X
25.	Sweet orange	C. sinensis	Jeruk manis			X
26.	Pummelos	C. grandis	Jeruk Bali			X
27.	Durian	Durio zibethinus	Durian makan			X
28.	Hogplum	Spondias cytherea	Kedondong		X	
29.	Jackfruit	Artocarpus heterophyllus	Nangka	X		
30.	Jambu	Eugenia acquea	Jambu air		X	
31.	Melay apple	E. malaccensis	Jambu bol		X	
32.	Guava	Psidium guajava	Jambu biji			X
33.	Mango	Mangifera indica	Mangga			X
34.	Horse mango	M. foetida	Bacang			X
35.		M. odorata	Keweni			X
36.	Mangosteen	Garcinia mangostana	Manggis			X
37.	Papaya	Carica papaya	Papaya		X	
38.	Pineapple	Ananas comosus	Nanas	X		
39.	Rambutan	Nephelium lappaceum	Rambutan		X	
40.	Soursop	Anona muricata	Nangka belanda			X
41.	Star fruit	Averrhoa spp.	Belimbing			X

	English name	Latin name	Local name	main	secondary	mir
	VEGETABLE CROPS					
42.	Green gram	Vigna radiata	Kacang hijau		X	
43.	French bean	Phaseolus vulgaris			X	
44.	Cow pea	Vigna unguiculata	Kacang panjang			X
45.	Celery	Apium graveolens	Seledri, daun sop			X
46.	Chinese spinach	Amaranthus hybridus	Bayam			X
47.	Cocoyam	Colocasia esculenta	Keladi		X	
48.	Eggplant	Solanum melangena	Terong		X	
		many varieties	Terong bulat		X	
			Terong panjang		X	
			Terong kuning		X	
49.	Pumpkins	Cucurbita maxima	Labu kuning		X	
50.	Water melon	Colocynthis citrullus	Semangka		X	
51.	Sweet melon	Cucumis melo	Belewah		X	
52.	Jengkol	Pithecolobium lobatum	Jengkol			X
53.	Kangkung	Ipomoea aquatica	Kangkung		X	
54.	Katuk	Sauropus androgynus	Katuk		X	
55.	Onion	Allium sp.	Bawang			X
56.	Paku	Pleopeltis longistema	Paku			X
57.	Chilli pepper	Capsicum frutecens	Cabe rawit		X	
58.	Petai	Parkia speciosa	Petai			X
59.	Tomato	Lycopersicon esculentum	Tomat			X
	STIMULANTS					
60.	Areca	Areca catecha	Pinang		X	
61.	Betel pepper	Piper betle	Sirih			X
62.	Coffee	Coffea liberica	Kopi		X	
63.		C. canephora	"		X	
64.	Tobacco	Nicotiana tabacum	Tembakau		X	
	SPICES AND FLOWERS					
65.	Basil	Ocimum canum	Kemangi			X
66.	Clove	Eugenia caryophyllus	Cengkeh			X
67.	Ginger	Zingiber officinale	Jahe			X
68.	Kencur	Kaemferia galanga	Kencur			X
69.	Laos	Alpinia galanga	Lengkuas			X
70.	Lemon grass	Cymbopogon citratus	Serai			X
71.	Temu lawak	Curcuma xanthorrhiza	Temu lawak			X
72.	Turmeric	Curcuma domestica	Kunyit			
	MISCELLANEOUS					
73.	Horse tamarina	Leucana leucocephala	Petai cina			X
74.	Pandan	Pandanus sp.	Pandan			X
75.	Sugar cane	Saccharum officinarum	Tebu		X	

Appendix 15: List of the fresh-water fishes

Order/family	Species	Local name
Order : Syenthognathi	Dermogenys sumatranus (Blkr)	julung-julung
fam : Hemirhamhidae		
Order : Ophiostomi		
fam : Mastocembelidae	Macrognathus aculeatus (Bloch)	betutu
	Mastocembelus maculatus (C.V.)	tilan
Order : Percomorphi		
fam : Nandidae	Pristolepis fasciatus (Blkr.)	patung
fam : Toxotidae	Toxotes jaculator (Pall)	sumpit-sumpit
fam : Lutjanidae	Lethrinus miniatus (Blkr.)	lingtjam/selincha
Order : Labyrinthici		
fam : Ophiocephaloidei	Ophiocephalus micropeltus (C.V.)	toman
	Ophiocephalus striatus (Bl.)	gabus
fam : Anabantidae	Anabas testudineus (Bl.)	betok
	Trichogaster leeri (Blkr.)	sepat
	Trichogaster pectoralis (K.)	sepat siam
	Trichogaster trichopterus (Pall)	sepat rawa
	Helostoma temmincki (C.V.)	tembakang
Order : Ostariophys		
fam : Belontiidae	Betta sp.	palo siam
fam : Cyprinidae	Chela oxygastroides (Blkr)	seluang pimping
	Rasbora sp. (? vaillanta (Popta))	seluang bungo
	Leptobarbus hoeveni (Blkr)	jelewat
	Balantiochellus melanopterus (Blkr)	ridi angus
	Puntius bulu (Blkr)	sangang/bulu-bulu
fam : Bagridae	Leiocassis sp.	baung lilin
	Macrones sp.	baung
	Macrones wolffi (Blkr)	sengiring
fam : Siluridae	Wallago niostonia (Vaill)	tapah
	Cryptopterus schilbeides (Blkr)	lais kuning
	Cryptopterus sp.	lais tunggul
	Hemisilurus scleronema (Blkr)	lais hitam
fam : Clariidae	Clarias melanoderma (Blkr)	keli
	Clarias batrachus (L.)	leleh
	Clarias nieuhofi (C.V.)	lembat
fam : Pangasidae	Pangasius micronema (Blkr)	juara/juaro
Order : Synbranchoidei	Monopterus albus (Zuiew)	belut
fam : Synbranchidae		
Order : Malacopterygii		
fam : Notopteridae	Notopterus notopterus (Pall)	belida
Order : Ostariophys		
fam : Bagridae	Leiocassis poecilopterus (C.V.)	keleso/klaso
	Macrobranchium rosenbergh (de Man)	udang galah

source: PHPA Jambi, Fishery Service (Dinas Perikanan) Jambi
ref. : W.H. Schuster (1952). Local common name of Indonesian fishes, Bandung 1952.
uit : Silvius, M.J., H.W. Simons & W.J.M. Verheugt, 1984. The Berbak game reserve, Sumatra, Indonesia; Studies on soils, vegetation, fauna, and nature conservation. - RIN Contributions to research on conservation of natural resources 1984-1.