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CAUSES OF PEATSWAMP FOREST DEGRADATION IN BERBAK NP, INDONESIA, AND RECOMMENDATIONS FOR RESTORATION

Water for Food & Ecosystems Programme project on: "Promoting the river basin and ecosystem approach for sustainable management of SE Asian lowland peatswamp forests: Case study Air Hitam Laut river basin, Jambi Province, Indonesia."

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by Wim Giesen
ARCADIS Euroconsult

Part of the project on
"Promoting the river basin and ecosystem approach for sustainable management of SE Asian lowland peat swamp forests: Case study Air Hitam Laut river basin, Jambi Province, Indonesia."

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Abbreviations, acronyms & glossary

AHD	Air Hitam Dalam
AHL	Air Hitam Laut
asl	Above Sea Level
CCFPI	Climate Change, Forests and Peatlands in Indonesia (project)
CIFOR	Center for International Forestry Research (based in Bogor)
CPI	Caltex Pacific Indonesia
cukong	Local term for broker, mainly used in a negative sense
DANCED	Danish Cooperation for Environment and Development
dbh	Diameter at breast height (= forestry term)
Dinas Kehutanan	Forest Service
FFPCP	Forest Fire Prevention and Control Project
FRIM	Forest Research Institute Malaysia
GEF	Global Environment Facility
GIS	Geographic Information System
ha	Hectares
HLG	*Hutan Lindung Gambut* (Peat Protection Forest)
HP	*Hutan Produksi* (Normal Production Forest)
HPH	Hak Pengusahan Hutan (Forest Concession Right)
HPT	*Hutan Produksi Terbata* (Limited Production Forest)
HTI	Hutan Tanaman Industri (Industrial Tree-crop Estate)
IPB	*Institut Pertanian Bogor* (Agricultural Institute Bogor)
IUCN	International Union for the Conservation of Nature and Natural Resources (World Conservation Union)
jelutung	*Dyera* species; in the PSF of eastern Sumatra this is *Dyera lowii* (Apocynaceae)
JICA	Japan International Cooperation Agency
kempas	*Koompassia malaccensis* (Leguminosae)
KSDA	*Konservasi Sumber Daya Alam* (Conservation of Natural Resources) department representing PHPA (now PKA) in the provinces
LIPI	National Science Agency Indonesia
Nipa	*Nypa fruticans* (Arecaceae)
NP	National Park
NTFP	Non-Timber Forest Product
OKI	Ogan-Komering Ilir district (in South Sumatra)
PHPA	*(Direktorat Jenderal) Perlindungan Hutan dan Pelestarian Alam* (Directorate General of) Forest Protection and Nature Conservation; now DG of Nature Conservation
PSF	Peat Swamp Forest
PT.	Limited Company

PT. DHL	Dyera Hutan Lestari (plantation concession company with a 8,000 ha area located at Sungai Aur, near Berbak NP; main species planted are *jelutung,* with some *pulai*).
PT. PDIW	Putra Duta Indah Wood (logging concession company with a concession to the west/southwest of Berbak NP
PT. SDR	Satia Djaya Raya (now defunct logging concession company)
pulai	*Alstonia* species ; in the swamp forests of Berbak NP this is predominantly *Alstonia pneumatophora* (Apocynaceae)
PUSDALKARHUTLA	*Pusat Pengendalian Kebakaran Hutan dan Lahan* (Centre for Prevention of Forest and Land Fires)
ramin	*Gonystylus bancanus* (Thymelaeaceae)
rasau	*Pandanus helicopus* (Pandanaceae)
RIL	Reduced Impact Logging (Malaysian system, esp. Sarawak)
sere	Ecological term for a series of plant communities resulting from the process of succession. Various types exist, depending on type of disturbance or influence, e.g. fire sere, xerosere, hydrosere.
SM	Simpang Melaka
SMPSF	Sustainable Management of Peat Swamp Forests in Peninsular Malaysia (project)
SRS	Silviculture/Rehabilitation Specialist
Sungai (or sungei)	River
TM	Thematic Mapper (type of Landsat stellite image)
TPTI	Indonesian selective logging process
WI-IP	Wetlands International – Indonesia Programme
YAPENTA	*Yayasan Pembangunan Tanjung Jabung* (Tanjung Jabung Development Foundation)

Background

This study is a component of the project on "Promoting the river basin and ecosystem approach for sustainable management of SE Asian lowland peat swamp forests: Case study Air Hitam Laut river basin, Jambi Province, Indonesia" (a.k.a. Air Hitam Laut project), funded by the Netherlands Government as part of the Water for Food and Ecosystems Programme. Implementation of the Air Hitam Laut project is lead by the International Agricultural Centre (IAC) in Wageningen, the Netherlands, in cooperation with ARCADIS Euroconsult (Arnhem, the Netherlands), Alterra – Green World Research (Wageningen), Wetlands International (Wageningen and Bogor), Waterloopkundig Laboratorium (WL | Delft Hydraulics) and the Landbouw Economisch Instituut (LEI/Wageningen). In Indonesia, the project cooperates with the Ministry of Forestry, Ministry of Environment, Ministry of Public Works, BAPPEDA (Provincial Planning Bureau), University of Jambi, Agricultural University of Bogor and the University of Sriwijaya, Palembang. Regionally, the project collaborates with the Global Environment Centre, based in Kuala Lumpur.

The goal of the Air Hitam Laut project is defined as: *The project will assess the nature and impact of human activities on the functioning of the greater Berbak ecosystem, analyse the hydrology of the Air Hitam Laut river, and the dependency of the coastal communities on the ecosystem health. This will provide improved understanding of the hydrological and ecological functioning of South-east Asian lowland peat swamp forests, and contribute to an enhanced baseline for policy and decision making in relation to integrated management of peat swamp river basins in the tropics, and in particular the Berbak National Park.*

The bulk of the Air Hitam Laut project focuses on hydrological assessments, analysis and modeling, with smaller inputs devoted to socio-economic studies, policy analysis and awareness, and ecology-*cum*-peat swamp forest regeneration. The Terms of Reference for the 25-day input of the peat swamp forest ecologist focuses on:

- Assessment of recent developments with respect to existing reforestation techniques in peatlands and their potential for improvement;
- Assessment of the requirements for reforestation interventions in Berbak NP;
- Recommendations on sustainable options for rehabilitating burnt and logged peat swamp forest in the mid-upper catchment of the Air Hitam Laut river basin and the centre of Berbak National Park;
- Support to the preparation of a peat swamp forest rehabilitation programme; and
- Support for the development of capacity building activities for concession holder and NP staff in reforestation techniques and peat swamp management.

The peat swamp forest ecologist carried out fieldwork in Indonesia from 30 September to 24 October, of which three weeks were spent in Jambi. This output is to provide a basis for practical restoration attempts by the Silviculture/Rehabilitation Specialist (Iwan Cahyo Wibisono), who will continue up until the end of the project (late 2004). The report will also provide a basis for two students of Wageningen Agricultural University (Pieter Leenman and Pieter van Eijk) and two students of Jambi University (Dian Febriyanti and Muhammad Fadli) who will carry out ecological studies on burnt peat swamp forest in Berbak in January-April 2004.

Summary

Chapter one provides an introduction to the peat swamp forests of Southeast Asia, including a brief overview of past studies, remaining area of this habitat (33 million ha, of which 82% in Indonesia), and a general description of features. It also provides an introduction to floristics and vegetation of Southeast Asian and Sumatran peat swamp forests> It also focuses on plant species diversity, with up to 240 species in a single location, but usually in the range of 35-130 tree species occurring in a single 1-5 ha plot. A recent history of this habitat in Southeast Asia is given, indicating the rapid rate at which peat swamp forests have disappeared due to felling, fires, and conversion to agriculture or pulpwood plantations. In 1993, only 2% of Sumatra's former peat and freshwater swamp forests was both gazetted in the Protected Area system and remained in a good condition – this can only have declined further since then. An introduction is provided to the 185,000 ha Berbak National Park, which is the focus of this study and is located in the coastal zone of Jambi Province, Sumatra. Berbak NP mainly consists of two habitat types – freshwater swamp forest and peat swamp forest – that extend over 60,000 hectares (32% of the park) and 110,000 hectares (59%), respectively. Large fires – mainly in the mid-1990s – have lead to significant loss of these habitats. A description is given of habitats and Park history.

Chapter two focuses on the present condition of Berbak NP, split into two sections: one providing an assessment based on previous studies and satellite imagery, the second based on field work carried out as part of the present study. Others report that about 17,000 ha (roughly 10%) of the Park has been affected by recent fires (esp. 1997-98). Analysis of satellite imagery confirms this, but shows that significant disturbances in the Park between 1983 and August 1997 created the conditions that lead to the highly destructive fires of September 1997, and again in 1998. Most of these disturbances appear to be linked to illegal logging, as indicated by a pattern of clearing and thinning of canopy cover. Field work carried out in October 2003 shows that illegal logging still appears to be nothing short of rampant throughout the Park: 26 illegal logging camps – most operational – were observed in the Park along the upper Air Hitam Laut river. Sawn timber was observed along the river, in camps, and being loaded from the AHL onto lorries on PDIW's rail system, which at present is the main outlet of timber and logs being poached from the western side of Berbak NP. Similarly, timber poaching was observed to be common and active along the Air Hitam Dalam.

Chapter three attempts to assess the causes of peat swamp forest degradation in Berbak NP. Previous analyses do not identify a single cause, but instead identify a host of contributing factors including lowering of water levels by transmigrants, fires escaping from agricultural fields and fires used by poachers, illegal logging, clearing by fishermen, unsustainable use of resources (esp. *jelutung* and *nipa*), insufficient patrolling and enforcement, unclear boundaries and (linked to the latter) conversion to agriculture. The direct cause of the 1997-98 fires is often reported to be 'unknown'. Based on an analysis of satellite images and field work, however, it can be concluded that the most significant threat by far is posed by illegal logging activities in the National Park. Large-scale destructive fires that occurred at Berbak NP in 1997-98 appear to be directly linked to illegal logging that occurred in the same locations in the preceding decade. These activities largely went unnoticed/unreported, as they were being carried out in areas that were inaccessible to park staff. However, they can

be clearly observed on satellite images dating from this period. A likely sequence of events leading to the present level of degradation is provided, along with an assessment of whom / which companies were involved.

Chapter four provides an overview of what is known about natural regeneration of peat swamp forests in Southeast Asia in general, and Sumatra in particular. It recognizes various degradation seres, and plant species characteristic of secondary peat swamp habitats. It also provides an overview of past and ongoing attempts at peat swamp forest restoration, both in the region (notably in Thailand, but also Vietnam and Malaysia) and in Indonesia. Attempts in Thailand were initiated more than 40 years ago and appear to be successful, while other initiatives in the region remain at a pilot stage. Various attempts at replanting degraded peat swamp forest have been carried out in and around Berbak NP, but all are small scale and can be regarded as trials only: there is no active restoration or rehabilitation programme ongoing. An exception to this is the *jelutung* and *pulai* plantation of PT. Dyera Hutan Lestari (PT. DHL). This study identifies species that have a high survival or recolonisation rate and may be considered for restoration activities at Berbak NP. These species include *Alstonia pneumatophora* (pulai), *Combretocarpus rotundatus* (tanah-tanah), *Dyera lowii* (jelutung), *Elaeocarpus petiolatus, Eugenia spicata* (gelam tikus), *Ganua motleyana, Gluta wallichii* (rengas), *Gonystylus bancanus* (ramin), *Licuala paludosa* (palas), *Macaranga pruinosa* (mahang), *Mallotus muticus* (perupuk), *Neolamarckia cadamba* (bengkal/medang keladi), *Palaquium* spp. (nyatoh), *Pandanus helicopus* (rasau), *Pholidocarpus sumatranus* (liran), *Shorea pauciflora* (meranti rawa), and *Syzygium (Eugenia) cerina,* (temasaman). Issues regarding species provenance, nurseries, planting regimes and timing, and tending requirements are described.

Chapter five provides recommendations for which degraded areas within Berbak NP are to be targeted by the restoration programme. These include the Mid-upper catchment of the Air Hitam Laut river, the central Air Hitam Laut burnt area (about 12,000 ha), and the Simpang Melaka burnt area (4,000 ha).

Chapter six provides recommendations for the Project's peat swamp forest restoration programme, focusing on species identification, site identification, the use of trial areas, where and how to establish nurseries, and how to improve the actual (ongoing) restoration programme itself. A draft budget, implementation schedule, and draft terms of reference are provided.

Chapter seven provides recommendations for capacity building in reforestation techniques and peat swamp management. Because of proven lack of genuine interest, any investment in capacity building of the logging concessionaire (PT. PDIW) is considered a waste of scarce resources, better spent on other components of the Project. Training of National Park staff is proposed for i) establishing and managing the two nurseries, to produce material for replanting in Berbak NP; and ii) planting techniques and managing replanted areas.

Chapter eight provides conclusions drawn from the various chapters, and is followed by a list of references and appendices on: i) field work itinerary, ii) site survey results, iii) site characteristics, iv) bird observations, v) list of plant species common in burnt areas, vi) ToR for the Silviculture/Rehabilitation Specialist, and vii), a photographic summary.

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CHAPTER 1 Introduction

1.1 INTRODUCTION TO SOUTHEAST ASIAN PEAT SWAMP FORESTS

1.1.1 BRIEF INTRODUCTION TO PEAT SWAMP FORESTS IN SOUTHEAST ASIA

General

Peat swamp forests of Southeast Asia have long been poorly studied, and our current knowledge of their composition, dynamics and ecology remains incomplete in spite of a surge in studies during the past decade. For a long time, Anderson (1963, 1972, 1978) and Brünig (1973, 1990), summarised by Whitmore (1984) were the only widely known studies on this habitat. Less well known were a series of papers by Coulter (1950, 1957), Wyatt-Smith (1959, 1961) and Lee (1979) in Malaya, and by Dutch foresters (e.g. van der Laan, 1925; Bodegom, 1929; Boon, 1936; Sewandono 1937, 1938), botanists (Endert, 1932; van Steenis 1938, 1957; Kostermans, 1958) and soil scientists (Polak 1933, 1941; Schophuys, 1936; Driessen, 1978; Andriesse, 1986) in Indonesia.

During the past decade-and-a-half interest in this habitat increased significantly, culminating in a series of workshops and symposiums:

- *1987: Tropical Peat and Peatlands for Development*, held in Yogyakarta, and sponsored by the International Peat Society and the Indonesian Peat Association.
- *1991: 2nd International Symposium on Tropical Peat and Peatlands for Development*, held in Kuching and published as a book in 1992.
- *1992: Workshop on Integrated Planning and Management of Tropical Lowland Peatlands*, held in Cisarua, Indonesia, 3-8 July 1992, and published by the IUCN Wetlands Programme in 1996 (Maltby *et al.*, 1996).
- *1995: International Symposium on Biodiversity, Environmental Importance and Sustainability of Tropical Peat and Peatlands*, held in Palangkaraya, Central Kalimantan, 4-8 September 1995, with proceedings published by Samara Publishing Ltd. (Rieley & Page, 1997).

The total area of peat swamps in Southeast Asia are estimated by Rieley *et al.* (1996) to be about 33 million hectares, of which the vast majority in Indonesia (82%), Papua New Guinea (8.8%) and Malaysia (8.3%), with smaller areas in the Philippines (240,000 ha), Vietnam (183,000 ha) and Thailand (65,000 ha; Nuyim, 2000). However, these figures probably represent maximum areas as vast tracts of peat swamp forest have been subjected to clearing, drainage and conversion throughout the region during the past two decades.

Most of the peat swamp forests in Southeast Asia have developed in or near coastal plains during the past 5,000-10,000 years, either developing in fresh or brackish waters overlying marine sediments, or in depressions between rivers somewhat further inland. In these areas water tables are permanently high and peat depth may be as much as 24 metres, although depths usually range from 4-8 metres. pH's are generally low, usually ranging from 3.0-4.5. In many areas peat domes have developed, whereby the central areas are raised and their only source of water is rainwater.

According to Whitmore (1984), most of the tree families of lowland evergreen dipterocarp rain forest are found in the peat swamp forest, except for the Combretaceae, Lythraceae, Proteaceae, Styraceae and Palmae (Arecaceae)[1]. This habitat has few endemics, probably due to the fact that most areas are less than 11,000 years old. According to Rieley and Achmad-Shah (1996), plants found in tropical peat swamp forest are usually restricted to this type of habitat. In spite of this, however, few species are endemic to the peat swamp forest of a single country. The authors list seven species, all of which are restricted to either Thailand or Malaysia. Following Wyatt-Smith (1959 and 1963), Ibrahim and Chong (1992) regard this forest as uniquely adapted to waterlogging, poor nutrients and high acidity of the soil. They add that very few of the tree species are found outside this habitat, but according to Corner (1994), floristics do not bear this out. They list 50 species for the Kuala Langat peat swamp forest in Peninsular Malaysia, but at least 38 of these occur, apparently indiscriminately, in freshwater swamp forests of Johore (Corner, 1994). Brünig (1973) also shows that floristically there is a significant overlap between peat swamp forests and so-called heath forests (*kerangas*) in Sarawak and Brunei, with 146 tree species common to both habitats, including 11 of the 15 dipterocarps recorded.

Tree species diversity for Southeast Asian lowland forests vary significantly, among others depending on location, habitat and plot size. For 1.0 hectare plots, tree diversity in Malesian plots listed by Whitmore (1984) vary from 70 to more than 220 species. Compared to dry lowland rain forest, however, species diversity of peat swamp forests is relatively low. In Sarawak and Brunei, a total of 1800-2300 tree species occur in dry lowland forest while a total of only 234 tree species have been recorded in peat swamp forests (Whitmore, 1984). Nevertheless, vegetation of lowland peat swamps in Southeast Asia may be diverse, with communities having up to 240 plant species (e.g. in Rieley *et al.,* 1994; Shepherd *et al.,* 1997). At the other end of the spectrum are species-poor communities dominated by one or only a few species, for example, the *Combretocarpus rotundatus* dominated central domes in Sarawak described by Whitmore (1984), or degradation seres described by Giesen (1990) in South Kalimantan. Examples of species diversity in Southeast Asian peat swamp forests:

- Disturbed mixed peat swamp forest in South Kalimantan: 20 tree species (range 9-51); *Shorea balangeran* degraded peat swamp forest: 10 tree species (range 2-14), *Combretocarpus rotundatus* degraded peat swamp forest: 7 tree species (range 3-12); Giesen (1990).
- Giesen and van Balen (1991a) noted 103 species in a rapid survey of peat swamp forests on Pulau Padang, Riau, with tree species varying from 17 (padang or pole forest) to 37 (mixed peat swamp forest) along transects of 100m. Total species diversity ranged from 94 in the mixed peat swamp forest to 37 in the padang forest.

[1] Apparently contradicting this is the fact that 28 palm species have been recorded in Berbak NP (Giesen, 1991), although most of these may occur in peripheral, swamp forest and riperian habitats.

- 54 tree species (27 families) recorded in a 3.8 ha plot of primary peat swamp forest in Kuala Langat, Peninsular Malaysia (Shamsudin & Chong, 1992).
- 95 tree species (35 families) recorded in a 4.5 ha plot at Sungai Karang, Peninsular Malaysia (Schilling, 1992, in Ibrahim, 1997).
- 30 common tree species and 50 rarer tree species in 37 30x30 metre (=3.33 ha) plots in peat swamp forests of Brunei (Stoneman, 1997).
- 132 tree species (39 families) recorded in a 5 ha plot of peat swamp forest in Pekan, Pahang, Peninsular Malaysia (Ibrahim, 1997), with the highest diversity being in the Lauraceae (14 species), followed by the Euphorbiaceae (13), Guttiferae (12), Rubiaceae (11) and Myristicaceae (9).
- 130 tree species recorded in a variety of peat swamp forest habitats in the Sungai Sebangau region of Central Kalimantan, Indonesia (Shepherd *et al.*, 1997).
- 131 plant species in all were recorded at three peat swamp forest sites in Riau, Sumatra, ranging from 68-78 spp at each 2-8 ha site (Mogea & Mansur, 2000); there were five dominant species: *Calophyllum soulattri, Campnosperma coriaceum, Gonystylus macrophyllus, Palaquium hexandrum, Shorea uliginosa.* Herbs were dominated by *Asplenium nidus, Crinum asiaticum, Gleichenia linearis, Lygodium* sp., *Nepenthese ampullaria, Nephrolepis biserrata, Nephrolepis exceltata* and *Scleria laevis.*
- 44 tree species were recorded by Purwaningsih and Yusuf (2000) on a 1.6 ha peat swamp forest site, 15-20 m asl, in Kluet, South Aceh, dominated by *Gluta renghas,* along with *Shorea palembanica, Parinarium corymbosum, Sandoricum emarginatum, Garcinia celebica, Eugenia sexangulata, Horsfieldia crassifolia, Mangifera longipetiolata* and *Litsea gracilipes.*

Peat swamp forests are often regarded as being low in biodiversity. However, a full 20% of freshwater fish species found in Peninsular Malaysia are found in streams of this habitat, and this is thought to be mainly due to the occurrence of various microhabitats (Ahmad *et al.*, 2002). Some fish species are unique to this habitat and can be regarded as threatened due habitat loss. Although much peat swamp forest has been lost to logging and fire, it remains the dominant habitat in most of the current range of the false gavial *Tomistoma schlegelii*, which is found only in Sumatra, Borneo and Peninsular Malaysia and is listed as Vulnerable on the IUCN Red Data List (Bezuijden *et al.*, 2001). It is also the preferred habitat of the hairy nosed otter *Lutra sumatrana,* Storm's stork *Ciconia stormi,* white-winged wood-duck *Cairina scutulata,* grey-headed fish-eagle *Haliaeetus ichthyophaga*, and the largest remaining habitat for Bornean populations of orangutan *Pongo pygmaeus* (Meijaard, 1997).

Sumatran swamp forests

The first studies on Sumatran peat swamp forests were carried out in the 1930s by the foresters van Bodegom (1929), Boon (1936) and Sewandono (1937, 1938), who mainly worked in what is now Riau province. Their papers record general observations on the ecology and management of logging concessions. Sewandono (1937) noted that forests decreased in stature when proceeding from the periphery towards the centre of a peat dome, with species such as dipterocarps and *Palaquium* decreasing and *Calophyllum* and *Tristania* increasing in abundance. He also noted that central areas of islands in the Bengkalis region were characterised by an abundance of *Eugenia's, Tristania, Calophyllum* species, *Tetramerista glabra, Campnosperma* and *Shorea* species, with sedges dominating the undergrowth. Most of these latter areas had stunted trees, although (according to Sewandono, 1938) there did not appear to be a link with peat depth.

The first detailed ecological study on Sumatran peat swamp forests is that by Silvius *et al.* (1984) in Berbak NP (then Berbak Game Reserve). This landmark study focused on a wide range of aspects of peat swamp and freshwater swamp ecology, including soils, vegetation and fauna (see 1.2.1). Detailed studies have been also carried out in peat swamps in Padang Sugihan NP in South Sumatra and Pulau Padang in Riau by Brady (1997), who mainly focused on peat development processes and models of peat accumulation. Some rapid ecological surveys were carried out in Sumatran peat swamp forests in 1990-91 by Giesen (1991) and Giesen and van Balen (1991a, 1991b). In their overview of peat swamp forest vegetation, Rieley and Achmad-Shah (1996) note that tree species common to all peat swamp forests are (in decreasing order of abundance) *Garcinia* spp., *Shorea* spp., *Palaquium* spp. and *Campnosperma auriculata*.

1.1.2 RECENT HISTORY OF SE ASIAN PEAT SWAMP FORESTS

General

Although large tracts of peatland remain, peat swamp forests in Southeast Asia have been reduced to a fraction of their former area. Braatz *et al.* (1992) report that by 1990, 54.6% of all wetland and marsh ecosystem had been lost in the Indo-Malayan realm – much of this habitat formerly consisted of swamp forest. With most of the remaining peat swamp forests occurring in Indonesia and Malaysia, developments in these two countries is particularly pertinent to the conservation and sustainable use of these ecosystems.

Of the 1.45 million hectares of peat swamp forest remaining in Malaysia, more than 80% occurs in Sarawak. Of the 200,000 hectares remaining in Peninsular Malaysia, more than 160,000 hectares is found in Pahang state, mostly in one contiguous area. Recent developments (e.g. felling of former Virgin Jungle Reserves) have lead to the disappearance of some of the last remaining peat swamp forests in Selangor and Johore.

Indonesian swamp forests

Most of western Indonesia's[2] swamp forests have not fared well during the past decades, and much has disappeared, either being converted for agriculture (esp. rice paddies) or tree crop estates (HTI, e.g. oil palm), or having been severely degraded and abandoned (e.g. large tracts of sedge-fern *belukar*). Many areas of deep peat were earmarked for conversion (inappropriately, according to Silvius & Giesen, 1996), which permitted clear-felling of vast tracts of land following a first round of selective logging (TPTI). The sale of timber and logs from clear-felled areas was usually more than sufficient for the following investment, for example, in plantation crops such as *Acacia* or oil palm, and subsequent failure of these ventures did not result in bankruptcy of the companies involved. The Forestry Department has just completed a round of evaluation of HTI estates and will cancel the concessions of those considered to be unviable. A large number are expected to be affected.

[2] Apart from Papua, where vast tracts still remain, eastern Indonesia has only a very limited area of swamp forest.

Production forests (HP, HPT)[3] in peat and freshwater swamp areas have on the whole not fared much better and have been poorly to very poorly managed by concession holders (HPHs). After a first round of selective logging by the HPH, these forests have usually been subjected to continued rounds of illegal logging, leading to severe degradation and often to (repeated) fires. Once an area is severely degraded, the HPHs often request a change of status of the area to that of HTI, after which the area is clear-felled and planted with estate crops.

Ostensibly, large areas of swamp forest are protected in a number of reserves in Western Indonesia, for example Berbak NP (Jambi), Way Kambas NP (Lampung), Tanjung Putting NP (Central Kalimantan), and Danau Sentarum NP (West Kalimantan). On the whole, protection is limited and widespread poaching of timber resources is rampant in all reserves, all of which have also suffered from fires. This used to be a problem during the Suharto era, but has increased significantly since 1998, with the advent of decentralisation. According to the head of the Forestry Service (Dinas Kehutanan) in Jambi province, poaching of timber has increased six fold since 1998.

Sumatran swamp forests

According to Giesen (1993, 1994), peat swamp and freshwater swamp forests in Sumatra formerly covered an area of 92,865 km², but by 1982-3 only two-thirds (63,790 km² or 68.7%) remained. By 1988 this had decreased to 57,506 km² (61.9% of original area), of which only 8,683 km² (9.3%) could be considered primary forest. Similar figures for Jambi show that of the original area of 8,813 km², only 2,604 could be considered primary forest by 1988, of which most occurred in and around what is now Berbak NP[4]. By 2003, most of the logging concession companies have discontinued operations as the resource has been depleted, and the logging industry is now largely the realm of rogue companies. Peat swamp forests – most of which had the status limited production forest (HPT) or peat protection forest (HLG) – have been severely degraded, converted (e.g. for pulp production), and have been the locus of widespread fires that have been common in lowland Sumatra since the mid-1990s.

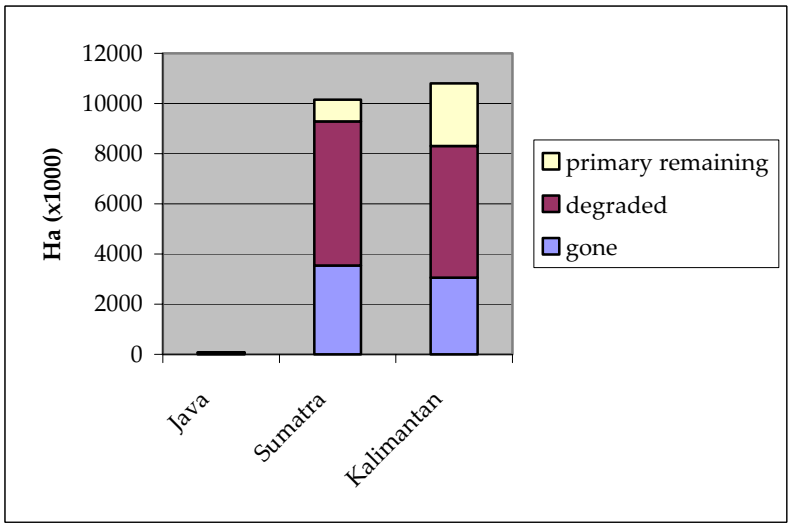


FIGURE 1.1
Peat swamp forests in Western Indonesia, 1988-90 (based on Giesen, 1994).

[3] HP = Hutan Produksi or (normal) production forest; HPT = Hutan Produksi Terbatas or limited production forest ; most peat swamp forest is included in the HPT category.

[4] At the time Berbak's status was that of Wildlife Reserve.

In 1993, 187,050 hectares of undisturbed peat and freshwater swamp forest had been incorporated into the Indonesian Protected Area system, of which 80% occurred in Berbak. (Giesen, 1993; Silvius & Giesen, 1996). A further 433,000 hectares of former peat swamp forest and freshwater swamp forest were located in gazetted reserves, but much had already been degraded or disappeared altogether. By 1993, only 10% of the former peat and freshwater swamp forests occurred in Kurumutan Baru Nature Reserve (Riau), while that of Padang Sugihan Wildlife Reserve (South Sumatra) and Giam-Siak Kecil Wildlife Reserve (Riau) had disappeared altogether.

By 1993, only 2% of Sumatra's former peat and freshwater swamp forests was gazetted in Protected Areas and remained in a good condition. As noted above, illegal logging has increased significantly (reportedly six fold) since 1998, and as a result it is expected that very little intact swamp forest remains outside the Berbak NP area, and even that has been affected (see below). Since the early 1990s, widespread wildfires have added a new dimension to peat swamp management, and according to Tacconi (2003), a total of 308,000 hectares of peat swamp and freshwater swamp forest burnt in Sumatra alone during the 1997-98 fires.

1.2 INTRODUCTION TO BERBAK NP

1.2.1 BRIEF DESCRIPTION OF THE NATURAL CONDITIONS OF THE PARK

The following description is mainly derived from Silvius et al. *(1984), with some additions from Giesen (1991), or based on the current study.*

Berbak NP is located in the coastal zone of Jambi Province, Sumatra, and extends over an area of approximately 185,000 hectares (Figure 1.2). Berbak forms part of the vast alluvial coastal plain of eastern Sumatra, that is assumed to have formed about 5,000 years BP. Evidence indicates that sea levels have dropped about two metres during the past 5,000 years, with sediments – mainly supplied by the Batanghari River – accumulating along the accreting coastline. On the highly weathered sediments, peat has formed, with an average age of about 4,500 years, and in some areas with a depth of more than 20 metres (Scholtz, 1983). Berbak is very flat, and at no point is the elevation more than about 15 metres.

Berbak is mainly drained by the Air Hitam Laut River system and its main tributaries the Simpang Kubu and the Simpang Melaka, which lie almost entirely within the park. These are blackwater systems, draining peat domes, that have a pH of 3.5-3.9 and are naturally oligotrophic. The Benuh River, which forms the southern boundary of the park, also drains peat dome areas and is similar to the aforementioned rivers. The Air Hitam Dalam River to the northwest differs from the other rivers in the park as it also receives floodwaters[5] from the Batanghari River that are markedly richer in silt and nutrients.

Until the mid-1980s, Berbak mainly consists of two habitat types – freshwater swamp forest and peat swamp forest – that extend over 60,000 hectares (32% of the park) and 110,000

[5] On 15-16 October 2003, Batanghari River waters were observed to be flowing *into* the Air Hitam Dalam River; these waters were coloured a milky brown, unlike the tannin/tea coloured waters of the Air Hitam Laut River.

hectares (59%), respectively. Other habitats included riverine (<1%), beach swale (<1%) and mangrove (about 8%) habitats. Since then, however, two major changes have taken place. Firstly, the mangrove and beach habitats were reclaimed by Buginese settlers along the coast in a process that was already well underway in 1983/4. These areas were later degazetted and replaced by extensions on the landward side that included additional peat swamp habitat. Secondly, large fires – mainly in the mid-1990s – lead to the loss of significant areas of peat swamp forest and freshwater swamp forest (see chapter 2), leading to large areas being colonized by secondary and pioneer plant species.

Physiognomically, the stature of primary vegetation in the Air Hitam Laut area (Simpang Kanan, Simpang Melaka, Simpang Kubu) is similar to that of Air Hitam Dalam. Riparian vegetation attains a height of 15-20(-25) metres, while swamp forest is usually 30-40 metres tall, with occasional emergents. In the central Air Hitam Laut region, the riparian forest is fringed by a zone of *Pandanus helicopus (rasau),* which may be anything from a few metres wide to a wide zone choking the entire river and preventing river transport. Aquatic vegetation is generally absent in the Air Hitam Laut area, apart from free-floating *Hanguana malayana*[6] *(bakung)*, which forms dense mats that – as with the pandans – may choke the entire river. In some areas small patches of bladderwort *Utricularia exoleta* occur, while in burnt areas sedges (mainly *Thoracostachyum* and *Scleria* species) and grasses may abound. *Nypa fruticans* occurs along the Air Hitam Laut until about 600 metres upstream of the confluence with the Simpang Melaka, where it gives way quite abruptly to *Pandanus helicopus.*

Pandanus helicopus and *Hanguana malayana* both occur in the Air Hitam Dalam area, but are much less common and do not form impenetrable barriers such as along the Air Hitam Laut. Seasonally, waterhyacinth *Eichhornia crassipes* (*eceng gondok*) is found, being transported into the system by inflowing waters from the Batanghari River. Riparian forests along the Air Hitam Dalam are very different from that of the Air Hitam Laut – species found along the former include trees such as *Barringtonia racemosa*, *Barringtonia reticulata, Cerbera odollam, Dillenia excelsa*, *Elaeocarpus* spp., *Fagraea crenulata, Ficus microcarpa, Flacourtia rukam, Gluta renghas, Hibiscus tiliaceus, Kleinhovia hospita, Lagerstroemia speciosa* and *Pometia pinnata,* and grasses such as *Phragmites karka* and *Saccharum spontaneum.* On the whole, vegetation in the Air Hitam Dalam region is much richer in species than the Air Hitam Laut region, and this is also reflected in freshwater swamp forests and peat swamp forests.

In general, freshwater swamp forest at Berbak is characterised by the presence of large *pulai Alstonia penumatophora* trees, along with a host of tree species including *Antidesma montanum, Baccaurea bracteata, Blumeodendron tokbrae* and an abundance of *Licuala paludosa* palms. In moderately deep peat areas, *punak Tetramerista glabra* is common, along with *bengkal Neolamarckia cadamba*. Tree species common to both freshwater swamp forest and peat swamp forest are *Koompassia malaccensis, Diospyros bantamensis* and *Stemonurus secundiflorus.* A total of 261 flowering plant species hare been recorded at Berbak NP, of which 67% are trees and shrubs, with liana's accounting for a further 17% and herbs and epiphytes 8% each (Giesen, 1991). Plant species found at Berbak NP that are protected by Indonesian Law (Noerdjito & Maryanto, 2001) include the Red Sealing-wax Palm *Cyrtostachys lakka,* the large fronded palm *Johannesteysmannia altifrons,* and (surprisingly) the mangrove species *Excoecaria agallocha* (*buta-buta*).

[6] Described by Silvius *et al.* (1984) under its old taxonomic name, *Susum anthelminicum*.

At least 227 bird species have been recorded at Berbak, including nine hornbill species, and rare species such as milky stork *Mycteria cinerea*, white-winged wood-duck *Cairina scutulata*, and Storm's stork *Ciconia stormi*. Mammals recorded at Berbak include Sumatran rhino *Dicerorhinus sumatrensis*, Malay tapir *Tapirus indicus*, Sumatran tiger *Panthera tigris* and sun bear *Helarctos malayanus*. Reptiles include the rare river terrapin *Batagur baska*, and two crocodilians, false gavial *Tomistoma schlegli* and estuarine crocodile *Crocodylus porosus*.

1.2.2 BRIEF HISTORY OF THE PARK

Berbak was first gazetted as a protected area in 1935, when it was proclaimed a 'wildreservaat' (i.e. game reserve) by a decree by the Governor General of the Netherlands-Indies on 29 October 1935. The (then) Indonesian Directorate General of Forest Protection and Nature Conservation (PHPA)[7] began management activities in Jambi in 1972, and boundary demarcation of Berbak was completed by 1974. Nevertheless, there were still some areas of dispute at the time, including overlap with logging concessions and encroachment by Buginese settlers along the coast. Management at provincial level by PHPA is carried out via KSDA (*Balai Konservasi Sumber Daya Alam*, or the Natural resource Management office), that established a reserve headquarters in Nipah Panjang in 1975, and field offices ('resorts') at Air Hitam Laut (1975), Air Hitam Dalam, Sungai Benuh and Simpang Datuk (all 1983; see Figure 1.2). Apart from these four resorts, a network of guard posts (*pos jaga*) were also established, notably at Simpang Melaka and Simpang Kanan.

A first management plan was developed in 1991-1992 for Berbak Game Reserve as part of the Sumatra Wetlands Project, executed jointly by PHPA and the Asian Wetland Bureau. It was recognised as Indonesia's first Ramsar wetland of international importance, on 8 April 1992, and was the target of several management-oriented projects in the mid-1990s (mainly focusing on sustainable bufferzone development). Under the new ministerial decree on forestry (No. 185/Kpts-II/1997) dated 31 March 1997, Berbak's status was upgraded to that of national park, and management handed over from KSDA to the Provincial National Park Unit (*Taman Nasional*) section of the Forestry Department in 1998. *Taman Nasional* have maintained the infrastructure established by KSDA, expanding this with several boats and replacing 90% of former reserve staff.

[7] PHPA is now the Directorate General of Nature Protection and Conservation (NPC)

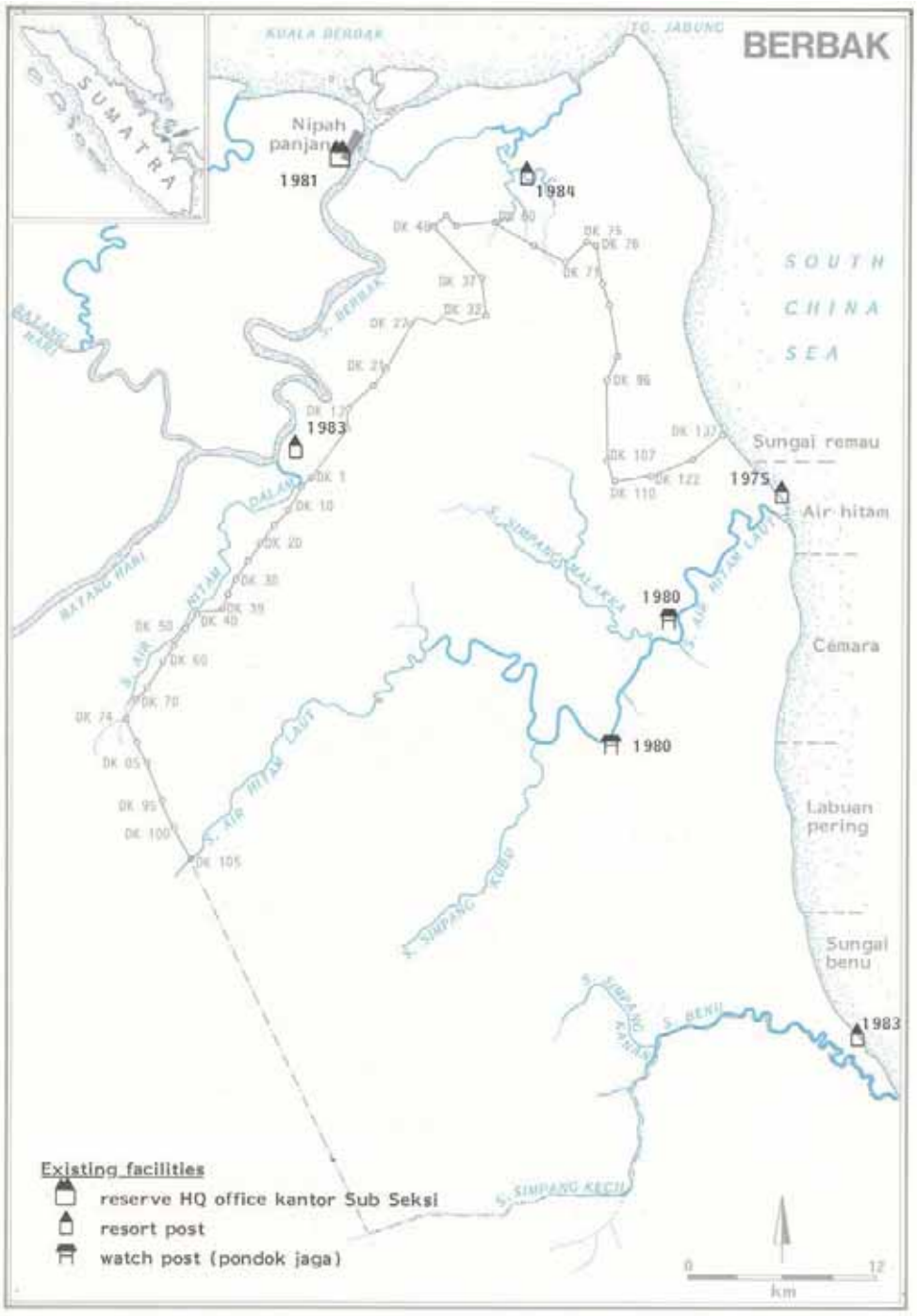


FIGURE 1.2
Map of Berbak NP, adapted from Silvius *et al.,* 1984.

CHAPTER 2 Assessment of present condition of Berbak NP

2.1 CONDITION OF BERBAK NP AS REPORTED BY OTHERS

Management Plan for Berbak NP

Wetlands International – Indonesia Programme produced a management plan for Berbak NP (WI-IP, 2000). This plan includes sections on degradation of the park due to fires, and refers to two major fires in Berbak NP in the 1990s, namely in 1994 and 1997. It goes on to state that these forest fires took place during a prolonged dry season related to the El-Niño phenomenon (Table 2.1). Surveys were carried out in 1998 in order to assess impacts, concluding that an estimated 18,000 ha (or about 11% of the park) of peat swamp forest burnt during the 1997 fires in three isolated locations inside the park.

TABLE 2.1
Monthly rainfall figures recorded at Kenten, Palembang

YEAR	Monthly Total (mm)											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1996	244	292	304	231	53	271	173	99	126	303	314	294
1997	139	292	319	336	215	65	6	4	0	6	124	330
1998	207	165	402	282	177	137	181	119	213	137	310	390
48 year average (1951-98)	240	247	322	283	181	136	125	113	143	197	303	331

Source: Anderson *et al.* (1999)

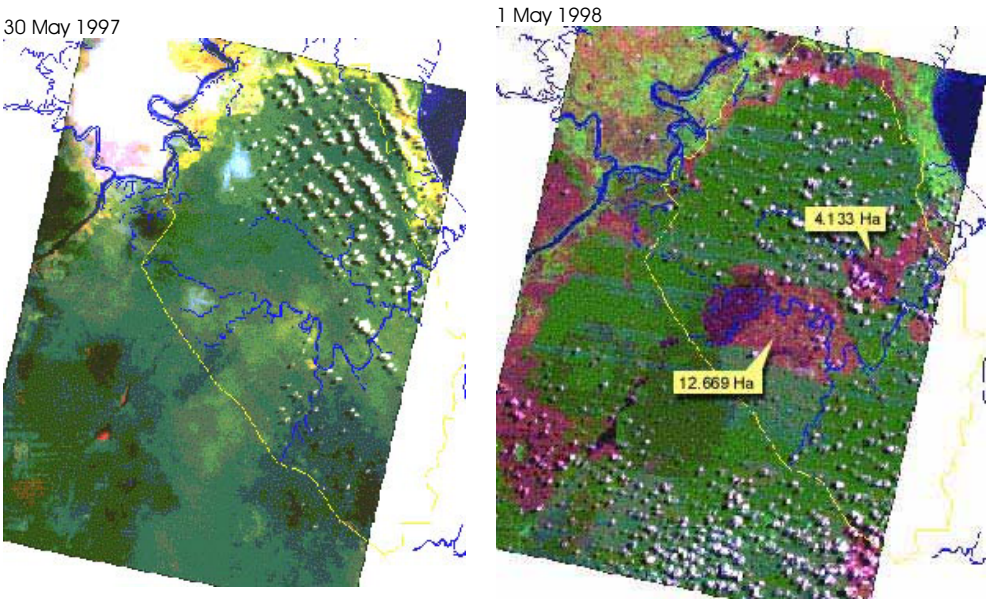
Forest Fire Prevention and Control Project

Anderson and Bowen (2000) recognise seven major fire zones in Sumatra, of which one – the Batanghari River Wetlands and Berbak NP – encompasses the Air Hitam Laut peatlands. Around 17,000 ha or about 10% of the park was destroyed by fires in 1997. The grassland nucleus caused by the 1997 fires coupled with the boundary felling and illegal logging has opened up the whole park to destruction by fire in the next El Niño year. Based on imagery from September 2000. at least 10% of the Park has been damaged by fire.

Conservation Information Forum (WARSI) Indonesia

According to the Indonesian Conservation information Forum (WARSI; www.warsi.or.id), 3,406 hectares had been cleared and burned to the north of Berbak NP by the 1st of May 1998, after the 1997 El Niño. At the same time, two large fires had significantly affected the core of the park: one extending over 12,669 hectares along both sides of the Air Hitam Laut, upstream of the Simpang Kubu, the second covering 4,133 hectares on both banks of the Simpang Melaka River (see Figure 2.1, adapted from the WARSI website).

FIGURE 2.1
AREAS BURNT IN THE 1997-1998 EL NIÑO YEAR



(adapted from the WARSI website; www.warsi.or.id)

Assessment by Wetlands International

Wetlands International – Indonesia Programme carried out a DGIS[8]-funded study on the burnt areas in 2002 (WI-IP, 2002). According to the report on this study, "fire has changed the properties of the peat swamp forest ecosystem in Berbak. Closed canopy of tall trees with lower vegetation on the forest floor has been replaced by a mosaic of open patches of burnt stands dominated by pioneer species consisting of grass and shrubs. Regeneration of pioneer species has been detected by the emergence of several typical pioneer species in peat swamp forest such as the occurrence of *Macaranga*. Repeated and frequent fire events will eventually alter the ecosystem in the direction of a grass swamp ecosystem or open secondary swamp forest." It goes on to describe the large, central burnt area along the Air Hitam Laut, which " was estimated at around 12,000 ha. It was reported that during the rainy season it was covered by water which made it look like a large open lake, and that during the dry season some fire resistant plant species with a height of almost 4 metres (locally known as "mahang"; = *Macaranga*) appeared." According to Lubis (2002), of the 294,314 ha of peatland in Berbak and the surrounding area (i.e. the bufferzone), 211,024 of peat swamp forest is still left, representing a loss of about 28%.

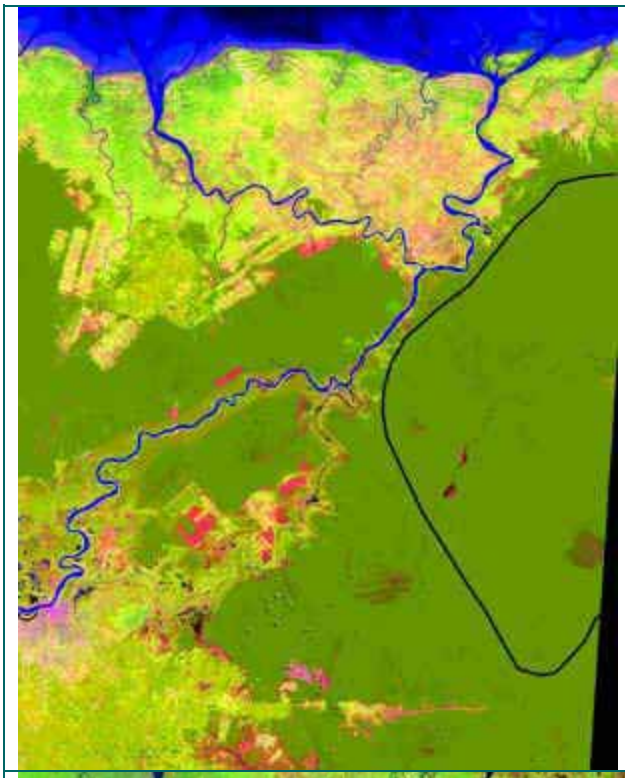
[8] Netherlands Directorate General of Foreign Aid.

2.2 ASSESSMENT OF CONDITION OF BERBAK NP BASED ON SATELLITE IMAGERY

In order to assess development within and around Berbak over the past two decades, a time series of Landsat satellite images from 1983-2002 were obtained from the Landsat website (http//www.landsat.org) as quick looks, and as processed images from CIFOR in Bogor. These were assessed for changes in land use/land cover in and around Berbak NP. From these, the following emerges (see Figure 2.2).

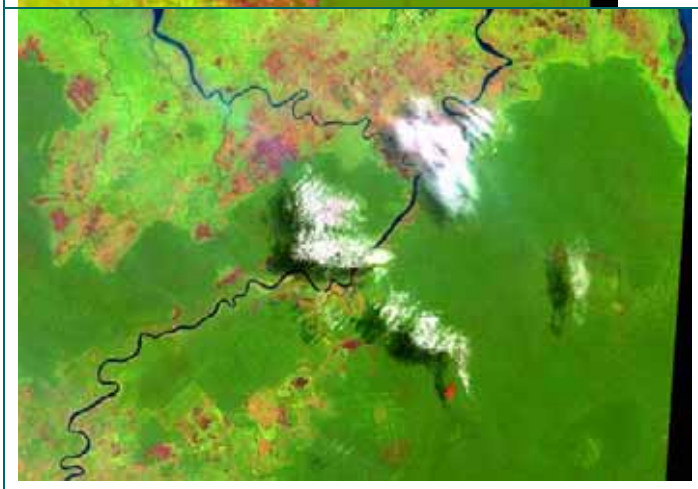
FIGURE 2.2
Satellite images of Berbak NP, showing changes from 1983-2002.

Images	Date & notes
	**16 April 1983 (fig. 2.2a)** Clouds obscure much, but one may conclude that Berbak NP appears to be (largely) intact.
	**9 June 1989 (fig. 2.2b)** The large central part of Berbak NP along the Air Hitam Laut has a paler appearance, indicating a difference compared to adjacent areas (darker green) and possible disturbance (see Figure 2.3)



16 May 1992 (fig. 2.2c)

Apparent are some small fires (red) along the Air Hitam Laut, upstream of the large area burnt in 1997/1998, but well within the park. The image is too unclear to conclusively assess disturbance along the central AHL area.

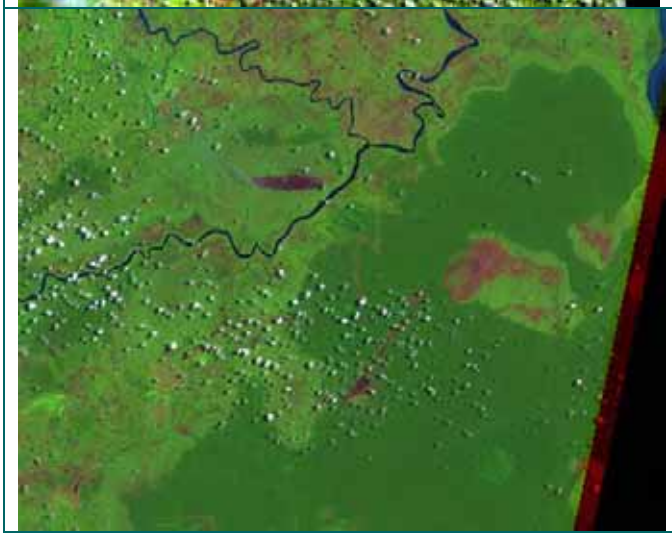


18 August 1997 (fig. 2.2d)

This image was taken just before the major 1997 El Niño fires, which started in September. Note along AHL: small fires (red), pale green vegetation (possibly indicating secondary vegetation and/or clearing); and a rectangle of clear-felling at Simpang Kubu. For detail of latter see fig. 2.4.

1 May 1998 (fig. 2.2e)

Widespread fire damage is visible on the 1998 image (red), showing that a large central area along AHL has burnt again in 1998, along with smaller patches along the upstream section of AHL, a large area along the Simpang Melaka, the upper part of the Air Hitam Dalam, and the downstream part of AHL close to AHL village. Black line indicates approximate boundary of Berbak NP.



1 September 1999 (fig. 2.2f)

By 1999, secondary vegetation had developed on most of the large burnt areas in Berbak (pale green), but new fires (red) had again affected 10-30% of the disturbed areas along the AHL and Simpang Melaka. Note the ongoing fire at Sungai Aur (N. of Batanghari).

8 August 2002 (fig. 2.2g)

Although the image is somewhat obscured by clouds, the same pattern as in 1999 emerges, with some central areas in Berbak being subjected to recent (2002) burning (red), and the rest covered with secondary vegetation (pale green).

It would appear that between 1983 and August 1997 (fig.'s 2.2a and 2.2d), significant disturbances occurred within the park, leading up to the highly destructive fires of September 1997, and again in 1998. The 1989 image (fig. 2.2b) already shows what appears to be a paler vegetation, but this is not visible on the 1992 image (fig. 2.2c), which is less clear. An enlarged black-and-white detail of the 1992 image (16 May) adapted from www.eelaart.com is provided in Figure 2.3. This image – on which the approximate area burnt in 1997 is indicated by means of a thick black line – clearly shows that the area that was later burnt had a finer grained vegetation, indicating smaller canopy size, than the surrounding vegetation. It also shows some open areas directly along the AHL, and used logging trails to the west of the AHL.

Most peat swamps have evidence of concentric forest zones, of which the innermost in extreme cases comprise stunted trees commonly of markedly xeromorphic aspect (Whitmore, 1984). Sewandono (1938) discovered a similar phenomenon when studying the peat swamps of Bengkalis Island, off the coast of Riau. He found that when heading inland from the coast, the cover of herbaceous terrestrial species and small palms increased, including species such as Zingiberaceae, Cyperaceae, Araceae, *Eleiodoxa (Salacca) conferta, Licuala*, some rattans, *Cyrtostachys lakka* and *Pandanus*. Where trees had been felled there was an abundance of Cyperaceae and ferns. In the middle of the islands he discovered many dead and dying trees, that were often diminutive in size, and a dense undergrowth mainly consisting of sedges. Sewandono recorded no evidence of fires, nor did the phenomenon appear to be linked with increasing peat depth. Since then, studies have indicated that extreme nutrient deficiency in central parts of ombrogenous peat domes can lead to such patterns (Whitmore, 1984). However, as this central part of the AHL straddles the river system this seems an unlikely explanation, and a more logical explanation for the observed pattern is that illegal logging had degraded the central AHL forests already by 1992, and that logs were being transported out of the National Park via the logging trail.

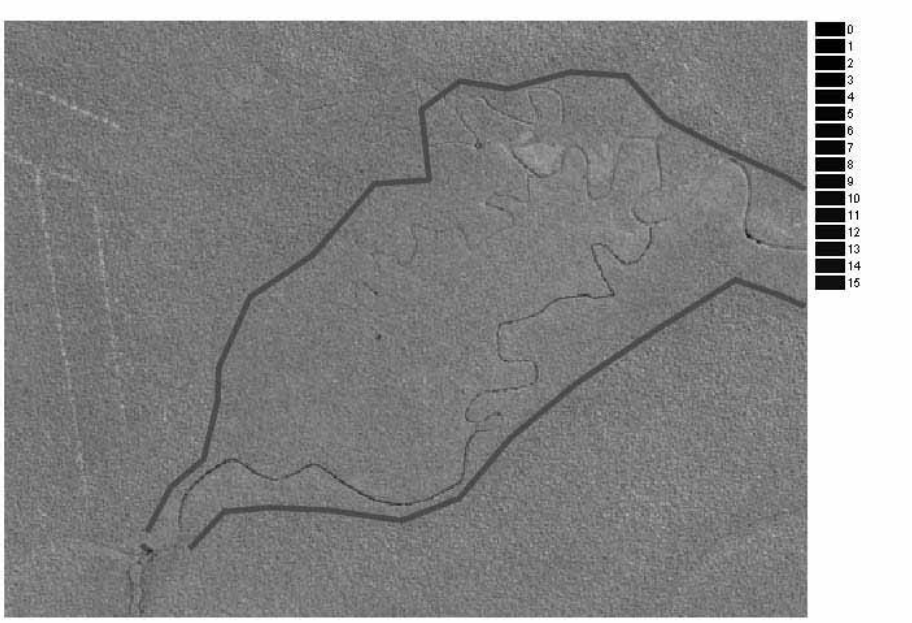


FIGURE 2.3
Disturbances along the central Air Hitam Laut, 16 May 1992.

The image dating from 18 August 1997 (fig. 2.2d) – taken just before the catastrophic fires, shows some signs of disturbance that may have been the direct cause. An enlargement of this image (fig.2.4) shows that some smaller fires had already occurred along the Air Hitam Laut between Simpang "T" and Simpang Kubu, and that a rectangle of 120-150 hectares had been cleared at Simpang Kubu. These are clear signs of disturbance and human activities in the park's core area, and are likely to be directly responsible for the occurrence of the catastrophic fires. The cleared rectangle is already showing signs of revegetation (most of it is pale green in colour), and this may have been cleared 1-2 seasons before August 1997.

FIGURE 2.4
Disturbances along central Air Hitam Laut area, 18 August 1997.

2.3 FIELDWORK AND OBSERVATIONS OF STATE OF HABITATS AT BERBAK NP

2.3.1 FIELDWORK METHODOLOGY

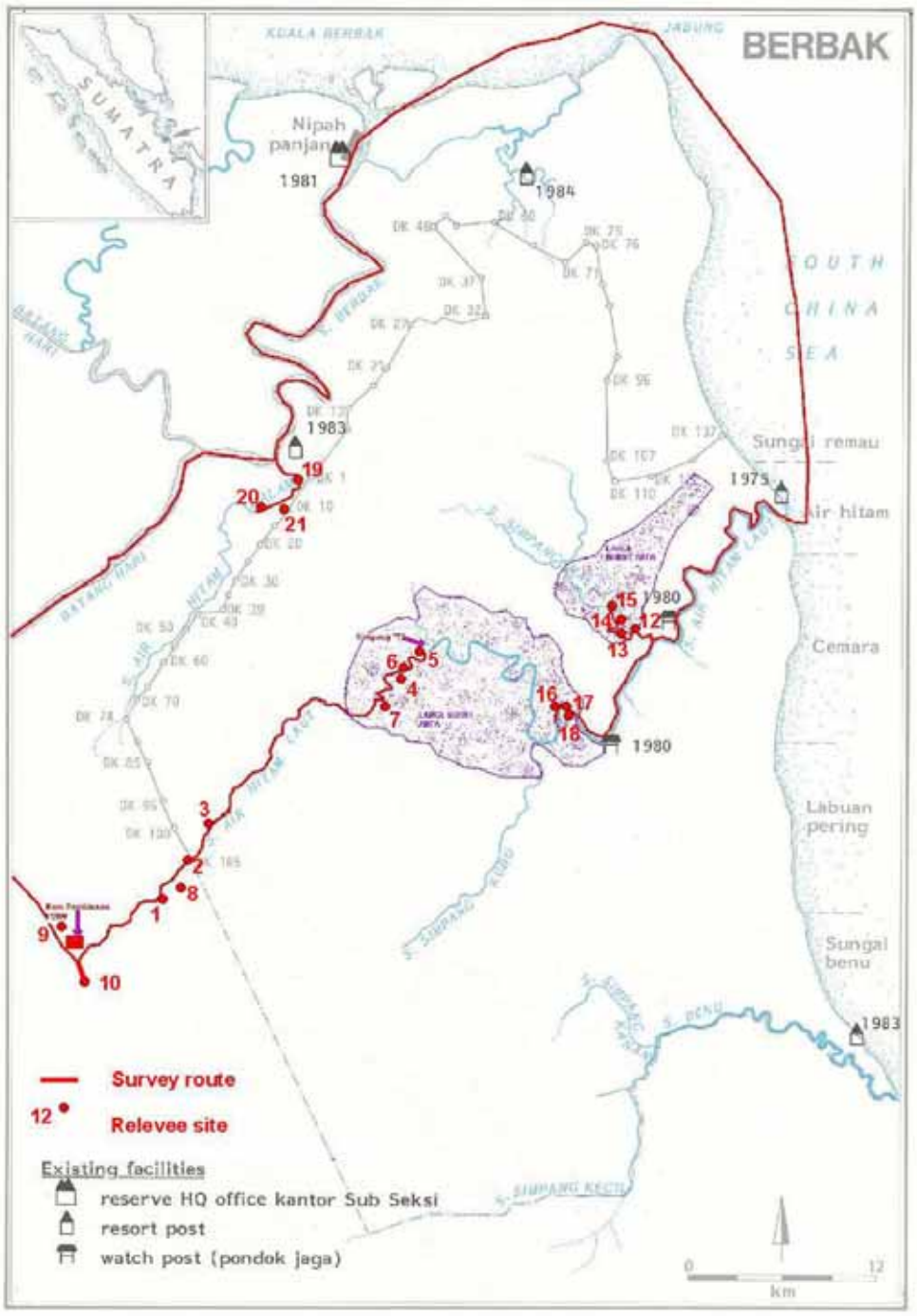
Fieldwork was carried out in and around Berbak NP in October (see attached itinerary, Appendix 1 and Figure 2.5), entering the Park from the following three main access routes:

- western side, via the logging trail of PT Putra Duta Indah Wood along the Air Hitam Laut River up to where it is completely blocked by *bakung* (*Hanguana malayana*) at Simpang "T" (from 4-8 October);
- eastern side, via the coast and up the Air Hitam Laut up to where it is completely blocked by *bakung* (*Hanguana malayana*) and *rasau* (*Pandanus helicopus*) just downstream of Simpang Kubu; also up the Simpang Melaka River to where it is blocked by a similar vegetation (from 10-14 October); and
- north-western side, up the Air Hitam Dalam, to the areas that have been burnt in 1991, 1994 and 1997/8 (from 16-17 October).

In all three areas, known burnt sites (as previously identified on the satellite images) were visited, and rapid surveys were conducted at each site. This involved recording the soil type, indications of (recent) flooding (e.g. depth), total vegetation cover, total tree cover, plus a record of all macrophytic plant species found at the site with an indication of abundance (+=present; ++= common; +++=dominant). For comparison, rapid surveys were also conducted in riparian/swamp forest vegetation. Plant species not immediately recognised were photographed and a herbarium specimen collected (72 specimens in all, some in duplicate). Specimens were later dried at the laboratory of the Hydrology Department of the University of Jambi, and taken to Bogor for identification. For the latter, use was made of the Flora Malesiana (esp. for Anacardiaceae, *Brackenridgea*, Lentibulariaceae, *Nepenthes, Scleria* spp.), Whitmore and Tantra (1986, for local tree names), Piggott (1988, for *Gleichenia* and *Nephrolepis*), Giesen (1992, esp. for grasses and sedges) and Whitmore (1973, for palms) for the identification of a number of key species. The remainder (52 specimens) were submitted to the Herbarium Bogoriense for identification.

A record was also kept of bird species observed at each site, as it was hypothesized that they might play a role in seed dispersal. Bird species were identified using Binolyt 10x28 DCF waterproof binoculars, and referring to MacKinnon and Phillipps (1993). A photographic record was made of each field trip, especially of the regenerating burnt areas and of key plant species, and a CD with 372 digital photographs was provided to the head of Berbak NP (Mr. Istanto), the project's coordinator in Jambi (Mr. Iwan Tricahyo Wibisono) and Wetlands International – Indonesia Programme (Mr. Nyoman Suryadiputra). Unfortunately, exact locations (latlongs) of each site surveyed could not be provided due to malfunctioning of the consultant's GPS from the first day onward. However, as most burnt areas are easily identifiable on recent satellite images, these sites can be indicated with an acceptable degree of accuracy.

FIGURE 2.5
Survey route and relevee sites



2.3.2 FIELDWORK RESULTS

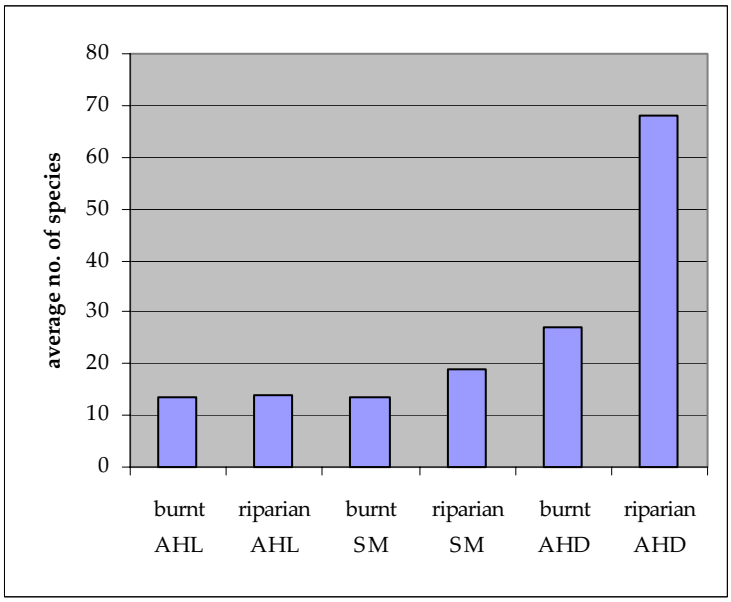
Survey results are summarised in the following four tables:

- Site survey results (Annex 2)
- Summary of site characteristics (Annex 3)
- Bird observations (Annex 4)
- Species common in burnt areas (Annex 5),

– while a ToR for the Silviculture/Rehabilitation Specialist is provided in Annex 6, and a photographic summary – especially covering the survey sites and key species – is provided in Annex 7.

In all, 142 plant species belonging to 57 families and representing 119 genera were identified during the rapid surveys (Annex 3). On average, 18.6 species were identified per site surveyed, varying from only 2 species (site 1; a repeatedly burnt site) on the upper AHL, to 68 species (site 19, riparian) on the Air Hitam Dalam. It must be noted, however, that the number of species recorded at site 8, and to a lesser extent at site 9, were not exhaustive but indicative. On the whole, there is little difference in species diversity between burnt sites and riparian vegetation in the Air Hitam Laut and Simpang Melaka area, while in the Air Hitam Dalam area riparian vegetation is about twice as biodiverse (Figure 2.6). There is a marked difference in diversity between Air Hitam Laut and Simpang Melaka on the one side, and Air Hitam Dalam on the other side, and the latter is 2-4 times as diverse, depending on the condition of the site.

FIGURE 2.6
Plant species diversity in various habitats and locations



AHL = Air Hitam Laut; AHD = Air Hitam Dalam; SM = Simpang Melaka

A total of 87 plant species were recorded at the burnt sites (see Annex 2), of which 26 species can be considered common in these areas (i.e. occurring at more than two sites; see Annex 5). These include 11 tree species, 6 climbers, 3 ferns, 3 sedges 2 palms and 2 grasses, listed below in Table 2.2. Burnt areas are often characterised by a prolific growth of a limited number of species. In the upstream Air Hitam Laut area and along the Simpang Melaka,

most sites are dominated by the ferns *Stenochlaena palustis* and *Blechnum indicum*, often accompanied by sedges *Thoracostachyum bancanum, T. sumatranum* and *Scleria purpurescens* and *Pandanus helicopus.* In the downstream section of the large burnt area along the Air Hitam Laut, near Simpang Kubu, secondary vegetation is dominated by *Macaranga* and palms (esp. *Licuala*). Burnt areas along the Air Hitam Dalam are characterised by the presence of many saplings, and dense thickets of bamboo and Zingiberaceae. Figs (*Ficus* spp.) are a common feature in many burnt area, although not always the same species are involved, and they may be present as either climbers (often starting as epiphytes) or small trees.

TABLE 2.2
Plant species common in burnt areas

No.	Habit	Species
1	Trees	a. *Alstonia pneumatophora* b. *Combretocarpus rotundatus* c. *Diospyros siamang* d. *Elaeocarpus petiolatus* e. *Eugenia spicata* f. *Ficus* spp. g. *Macaranga pruinosa* h. *Mallotus muticus (Coccoceras borneense)* i. *Neolamarckia cadamba (Anthocephalus indicus)* j. *Pandanus helicopus* k. *Syzygium (Eugenia) cerina*
2	Shrubs	a. *Gigantochloa sp.* b. *Melastoma malabathricum*
3	Climbers	a. *Ficus* spp. b. *Flagellaria indica* c. *Lygodium microphyllum* d. *Morinda philippensis* e. *Stenochlaena palustris* f. *Uncaria glabrata*
4	Palms	a. *Licuala paludosa* b. *Pholidocarpus sumatranus*
5	Sedges	a. *Scleria purpurescens* b. *Thoracostachyum bancanum* c. *Thoracostachyum sumatranum*
6	Grasses	a. *Hymenachne acutigluma* b. *Paspalum conjugatum*
7	Ferns	a. *Blechnum indicum* b. *Lygodium microphyllum** c. *Stenochlaena palustris**

* Note that these two climbing ferns appear twice in this list.

The burnt areas varied widely in terms of total vegetation cover and tree cover (Annex 3). At some sites of repeated burning (sites 3, 7, 10) the total vegetation cover was very low, and not more than about 5-10 %. These same sites also had virtually no tree cover (all <1%). In

all, though, total vegetation cover in the burnt sites averaged at 67%, while that of riparian habitats, primary peat swamp and selectively logged peat swamp was close to 100%. Tree cover in the non-burnt sites varied from 1-10% in the riparian habitats, and was 90-100% in the primary and selectively logged peat swamp sites. Most trees found in the burnt areas appeared to be newly established (esp. *Alstonia* and *Macaranga*), but it was also observed that *Mallotus (Coccoceras), Combretocarpus* and *Eugenia* species were resprouting from previously established and partly charred trunks. Although most of the *Alstonia* specimens seen appeared to have established from seed stock, it was observed that this species is also capable of resprouting from fire-damaged trunks. Both of the palm species found in burnt areas – *Licuala paludosa* and *Pholidocarpus sumatranus* – appear able to withstand fires, and especially large specimens of *Pholidocarpus* were observed remaining in several former peat swamp areas now virtually devoid of tree cover due to (repeated) fires.

Annex 4 (bird observations) lists 45 species observed during field surveys. Of these 45 species, almost half (20 species) were observed in the burnt areas. Species found in the burnt areas are predominantly invertebrate (esp. insect) and fish feeders, which together comprise more than three-quarter of the species encountered (Figure 2.7). This is not vastly dissimilar to the pattern for all habitats combined (Figure 2.8).

FIGURE 2.7
Bird feeding behaviour in burnt areas

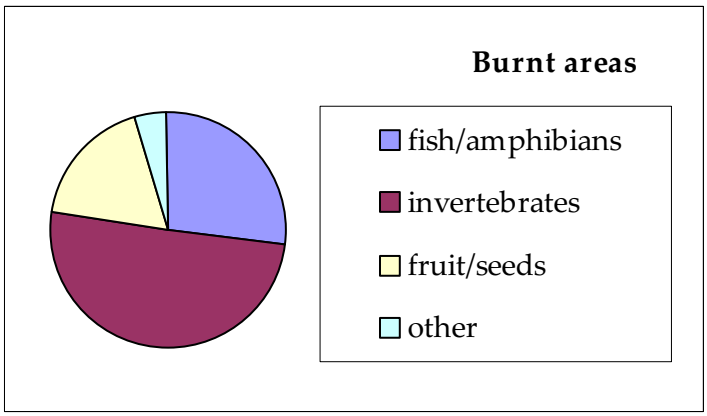
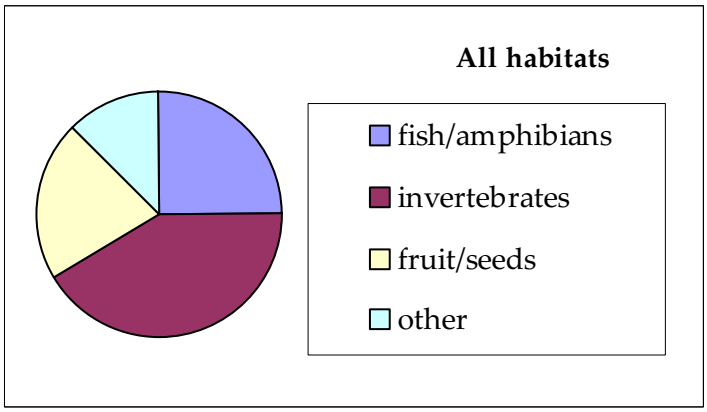


FIGURE 2.8
Bird feeding behaviour in all habitats combined



2.3.3 GENERAL OBSERVATIONS DURING FIELDWORK

Floristics

As already indicated by Giesen (1991), a comparison of the three main rivers in the area – Air Hitam Laut (AHL), Air Hitam Dalam (AHD) and Simpang Melaka (SM) – shows a significant difference between the AHL and SM on the one hand, and the AHD on the other hand. The AHL and SM are dominated by dense groves of *Pandanus helicopus*, often together with *Hanguana malayana* and a variety of Myrtaceae. River transport is often blocked by *Pandanus* and *Hanguana,* that in some areas may form impenetrable barriers (e.g. between Simpang Kubu and Simpang "T"). Conspicuously absent along the AHL and SM are typical near coastal riparian species such as *Cerbera odollam, Fagraea crenulata, Ficus microcarpa, Flacourtia rukam, Gluta renghas, Hibiscus tiliaceus, Kleinhovia hospita, Lagerstroemia speciosa* and *Pometia pinnata,* all of which *are* found along the AHD. On the whole, the AHD is vastly richer in terms number of species found than either the AHL or SM.

Changes since 1990

During surveys conducted by the consultant in December 1990 (Giesen, 1991) along the Air Hitam Dalam, lower Air Hitam Laut and Simpang Melaka, there was little sign of tree felling along the last two rivers, but evidence of significant tree felling going on along the Air Hitam Dalam. At the same time, there was no evidence of burning or wildfires occurring or having occurred in the area. This has taken a dramatic turn for the worse since then, however, as there is evidence for illegal logging in almost all areas (see below), and there are vast tracts of former forest that have been burnt during the past decade (see 2.1 and 2.2).

Illegal logging

Illegal logging appears to be nothing short of rampant throughout the Park. On the upper section of the Air Hitam Laut river, 8 *pondok* camps were observed on 6-7 October between PDIW's *Kem Pembinaan* and the border of Berbak NP, while a further 26 camps were observed *in the Park*, between the border and Simpang "T" (located in the centre of the large burnt area on the AHL). Some camps have only one *pondok,* while some have as many as six or seven. Most of these camps are used for illegal logging activities, although they are also used by fisherfolk and *jelutung* collectors. An exception are the three camps in the burnt area (e.g. near Simpang Raket and Simpang "T") that are used only by fisherfolk now that forests have disappeared over a vast area since the 1997 fires. Sawn timber of *kempas Koompassia malaccensis, meranti Shorea* spp., *ramin Gonystylus bancanua* and *punak Tetramerista glabra* was observed along the river, in camps, and being loaded from the AHL onto lorries on PDIWs rail system, which is the main outlet of timber and logs being poached from the western side of Berbak NP. According to Mr. Istanto (Head of Berbak NP in Jambi), a major drive was last undertaken against illegal logging from the western part of the NP in 2001, but the persons involved reacted violently and were well-armed (with rifles and *parang*), attacking staff and burning down <part of> PDIW's *Kem Pembinaan*.

Similarly, timber poaching was also observed on 16-17 October along the Air Hitam Dalam, with two rafts of timber (one consisting of sawn *meranti,* the other consisting of *ramin*) lying ready for transport out of the Park. The forests along the AHD have a very open canopy, and everywhere there are signs of entry into the forest (trails, slip marks, some sawn remains of timber). Large *pompongs* (e.g. from Sungai Rambut) were observed to readily enter the Park via the new gate. The sawn timber was later observed to be transferred from

pompongs to Buginese vessels waiting for cargo on the Batanghari River, not far upstream from AHD and Sungai Rambut.

There were few signs of poaching of timber along the lower course of the Air Hitam Laut, apart from some trees having been felled near the *Pos Jaga* (guardpost) at Simpang Melaka. However, as there are numerous canals entering into the swamp forest from the coast, there is no direct need for poachers to use the AHL as a conduit for poached timber. Recent satellite images (e.g. Landsat TM image of 18 September 2002) clearly show signs of thinning of the forests between Air Hitam Laut village and the burnt areas along the Simpang Melaka and central AHL (see Figure 2.2).

Evidence of logging in burnt areas?

No sign of logging was found in the surveyed burnt areas, but this absence of evidence does not mean evidence of absence, as such signs can easily be obscured by the large amounts of unburnt fuel and prolific growth of secondary vegetation, especially of ferns and shrubs. Also, moving around in such areas is difficult to very difficult, as large amounts of fallen tree trunks, often completely overgrown by ferns, provide a significant obstacle to any kind of movement.

Large burnt area near Simpang "T"

As indicated in 2.2 and Figure 2.3, the large burnt area along the AHL appeared to have a different vegetation (notably smaller canopy size) than surrounding areas already well in advance of the 1997-1998 fires. Soil at Simpang "T" was found to consist primarily of clay, with some (shallow?) peat. In addition to regrowth of secondary vegetation, quite a number of dead trees remained standing at Simpang 'T' (see Photo 12, Annex 7). These appear to be small and straight, supporting satellite image evidence that trees in this area were small in stature.

CHAPTER 3 Cause(s) of peat swamp forest degradation in Berbak NP

3.1 ASSESSMENTS BY OTHERS

3.1.1 GENERAL ASSESSMENTS

Swamp forests in general in Southeast Asia

According to Van Steenis (1957), "Fire is one of the greatest enemies of the swamp forest, as during exceptionally dry years – which occur regularly about every 5 years <not so exceptional> in the everwet parts of Malaysia – this types of forest is definitely inflammable and is attacked by fishermen. … There is no doubt that the extensive open spaces now occupied by the floating grass-mats in the lake districts of Borneo were once swamp forest areas." Fire has sometimes a distinctly selective effect in swamp forests, leading to gregarious stands of fire-resistant species."

Greater Berbak-Sembilang Integrated Coastal Wetland Conservation Project

According to Wetlands International – Indonesia Programme (2001), the main threats in the Berbak NP area are:

- Forest fires, caused by:
  - Transmigrants excavating drainage canals and lowering water tables.
  - Logging, leading to degradation of the PSF.
  - Small fires (e.g. for cooking) getting out of control.
  - Fishermen clearing sites for fishing.
  - Farmers preparing sites for cultivation, and fires used getting out of control.
- Illegal logging. Mainly in the logging concessions outside the proposed <Berbak-Sembilang> national park.
- Unsustainable use of resources, especially *jelutung* (in Sungai Merang area in South Sumatra), and *nipa* leaves (in the Sungai Bungin area).
- Poaching. Mainly of crocodiles (*Crocodylus porosus* and *Tomistoma schlegelii*), monitor lizards (esp. *Varanus salvator*), snakes (Elephant-trunk snake *Acrochordus javanicus*, Sunbeam snake *Xenopeltis unicolor*, Reticulated python *Python reticulatus*) and the occasional stork (Milky Stork *Mycteria cinerea*, Lesser Adjutant *Leptoptilos javanicus*).
- Land conversion.

- Unclear boundaries.
- Insufficient patrol system and law enforcement.
- Use of cyanide for fishing.

Management Plan for Berbak NP

The Management Plan produced for Berbak NP by Wetlands International – Indonesia Programme (WI-IP, 2000), reports that the fires of 1994 and during a prolonged dry season, related to the El-Niño phenomenon, and that *jelutung* and wood poachers – some from the Sembilang area – were responsible for initiating these and other remote fires. The plan also identifies 'local communities' and immigrants as being the cause of these problems.

Fire Assessment by Wetlands International

Wetlands International – Indonesia Programme carried out a DGIS[9]-funded study on the burnt areas in 2002 (WI-IP, 2002). Regarding causes, the report adheres to conclusions drawn by others (on various fire-related projects in the province), listing an array of possible culprits such as farmers, plantation estates, 'cigarettes and camp fires' of illegal loggers and fishermen, or wildlife poachers burning the forest to flush out the animals they wanted to catch.

Forest Fire Prevention and Control Project

Anderson and Bowen (2000) recognise seven major fire zones in Sumatra, of which one – the Batanghari River Wetlands and Berbak NP – encompasses the Air Hitam Laut peatlands. According to these authors, the sequence of events that led to the formation of this fire zone are as follows:

- Logging concessions to the west of the Berbak NP and spontaneous Bugis settlers along the coast and rivers to the east heavily damaged considerable areas of swamp forest. The destruction was both direct by over-intensive cutting and indirect by the digging of canals to float the logs out.
- Extensive illegal cutting, again with canalisation, began outside and now extends somewhat within the National Park.
- Around 17,000 ha or about 10% of the park was destroyed by fires in 1997. According to Anderson and Bowen, how and why the fires were lit is not know.
- The grassland nucleus caused by the 1997 fires coupled with the boundary felling and illegal logging has opened up the whole park to destruction by fire in the next El Niño year.
- Based on imagery from September 2000: at least 10% of the Park has been damaged by fire. Reports of widespread illegal logging of ramin (*Gonystylus bancanus*) in the Park.

Project Inception Workshop

According to the participants of the project planning workshop held in Jambi on 21-22 May 2003 (Klaas & Gevers, 2003), :

- Illegal logging in Berbak NP particularly targets species such as *jelutung*, *ramin* and *kempas*.
- Logging is mainly carried out by outsiders from South Sumatra province, using chainsaws provided by local *cukong*.

[9] Netherlands Directorate General of Foreign Aid.

- Illegally logged trees are usually transported via hand-made canals, particularly in the Labuhan Pering village area where these canals[10] were first constructed in 1972 by YAPENTA, to support economic activities and to be used to transport agricultural products or as irrigation canal. In 1998 the canals were extended by another 3.5 kilometres[11] and then primarily used to transport logs and timber poached from Berbak NP. These new canals were developed by *cukong* consisting of former and still active government officials, such as AIRUD and sectors of the police department. Villages involved are Telaga Lima, Labuan Pering, Air Hitam Laut, Pematang Raman, Sungai Kapas, Sungai Aur And Sungai Cemara.

3.1.2 HOTSPOT ANALYSES

Hotspots prior to and during the 1997 fires

Anderson *et al.* (1999) provide an overview of hotspots in Sumatra from 1996-1998, and these maps indicate the existence of the following hotspots in and around Berbak NP between January 1996 – January 1999:

- October 1996: northeast Berbak NP, on coast
- December 1996: PDIW area, near Kem Pembinaan.
- July 1997: on coast: AHL village
- August 1997: many areas, throughout most of PDIW, central AHL, northern central area, AHL village area, S. Benuh
- September 1997: same as in August, but fewer hotspots
- May 1998: AHL village

Recent hotspots

30 September 2003 had the greatest number of hotspots so far this year – 428 hotspots, of which 21 within Berbak NP, and 4 at PT Putra Duta Indah Wood (pers. comm., Messrs. Kiswanto and Soeparman[12]). Up to that date there had only been 11 hotspots in the Park during the previous 9 months. On the map seen at their office, it could be observed that the hotspots in the Park are located mainly in a cluster along the north-western border, to the mid-west, along the upper Air Hitam Laut, and near Sungai Benuh. By the 2nd of October 2003 it had rained, and all hotspots in the Park had disappeared.

3.2 ASSESSMENT BASED ON PRESENT FIELD OBSERVATIONS

A wide variety of non-timber forest products (NTFPs) are harvested in Berbak NP, including *jelutung*, honey, fruit and rattan. Also, the area has long been populated by fisherfolk that mainly target large species such as *Wallago* catfish and snakeheads *Channa* species. These are kept in cages and sold as fresh fish to traders. Turtles – especially *Orlitia bornense* – are also caught and sold to Chinese traders. Although these activities add to a general disturbance in the park, lead to the decline or disappearance of certain species, and their presence may be the direct cause of accidental fires, harvesters of NTFPs and fisherfolk are not considered to be the main threat to the integrity of the park.

[10] 2.5 km long, 3 metres wide and 70 cm deep.

[11] 150 cm wide and 50 cm deep.

[12] Ir. Joko Fajar Kiswanto (Coordinator) & Mr. O. Soeparman (technical head), Pusat Pengendalian Kebakaran Hutan dan Lahan (PUSDALKARHUTLA), 3 October 2003.

The clearing observed on the satellite image of 18 August 1997 (Figure 2.4) remains puzzling. Being a clear rectangle of 120-150 hectares it has obviously been cleared by human hands – but for which reason? The area is too large for helicopter landing pads (these are usually 1-2 ha) or even a temporary oil industry field camp (the national oil company Pertamina has carried out exploratory activities in the area). Also, the area is seasonally deeply flooded and has absolutely no potential for agriculture. Staff of KSDA formerly based at Berbak when this was still a Wildlife Reserve reported that a few hectares were cleared at Simpang Kubu for shifting cultivation (*ladang*), but that the person involved was apprehended on time after only a few hectares had been cleared, and forced to leave the area. Although the time appears about correct (these staff report the mid-1990s for this event), a 'few hectares' is not consistent with an area of 120-150 hectares.

Although some fires spread into the park from adjacent agricultural land (esp. in the northern part of the park, and along the coast), most of the major fires at Berbak NP do not appear to have been caused by farmers. This is especially the case for the large, central burnt area along the Air Hitam Laut, and perhaps also holds for the fires at Simpang Melaka and to the south near the Benuh River.

The most significant threat by far is posed by illegal logging activities *in the National Park*, which are rampant, of a very significant scale, and present in most parts of the park. From the magnitude of these activities it is clear that this is well organised and funded – 26 logging camps along the upper part of the Air Hitam Laut, in the NP alone. From various sources the consultant has understood that the driving force behind illegal logging are the local administration (at Kabupaten level, e.g. the Bupati), police and army, probably supported by local businessmen. From analysis of satellite imagery, it is obvious that all burnt areas were degraded – in all likelihood by illegal logging[13] – prior to destructive fires. Given the rate of forest disappearance in Berbak NP, the park is rapidly losing its value to conservation and might be considered 'lost' if current activities are not curbed and are allowed to continue for another decade.

Illegal logging seems to have been most active in four areas: i) central Air Hitam Laut; ii) Simpang Melaka; iii) Benuh River, and iv) Air Hitam Dalam. Each of these areas appears to be targeted by a different group:

i) Air Hitam Laut. Because of infestation with *Pandanus helicopus* and *Hanguana malayana* (see below) it is impossible to export logs or timber out of the large, central part of AHL (where 12,000 hectares of forest were burnt in 1997) via the river, and the only option is that these were taken out via a logging rail system. There are two rail systems in the upper part of the AHL, namely that of PDIW and that of PT. Satia Djaya Raya (SDR). The rail system of PDIW was extended up to the AHL *after* the 1997 fires, so this seems an unlikely candidate. PT SDR (based at Sungei Aur), however, was investigated in 1990 following illegal incursions into north-western Berbak in 1988-1990. A KSDA team investigated the illegal logging activities, found that SDR had entered the park by more than 1 km (by logging rail), that linked up with AHL river. This was reported to the Ministry in Jakarta, and as a result all of the permits were revoked by the Minister (including *izin areal, izin fabrik, izin industrian*) – this although the then Governor of Jambi was part-owner of PT SDR. PT SDR left

[13] This is confirmed by reports from KSDA staff formerly based at Berbak.

the area immediately, but all of their infrastructure was left behind in the field, and according to local sources, the rails were still being used until recently. On the 1992 satellite image (fig. 2.3) one can see that this rail system extends up to the AHL. In October 2003, 26 camps – most of them belonging to illegal loggers – were observed along the Air Hitam Laut between the border of Berbak NP and Simpang 'T' in the central burnt part of the AHL. Rafts of poached timber were being taken out of the park via the AHL up to the rail system of PDIW, from where they were further transported via 'lorries' on the PDIW rail system.

ii) Simpang Melaka. On the satellite images (Fig. 2.2) one may observe that the area along the Simpang Melaka that was burnt in 1997, is contiguous with a larger burnt area that extends right up to the coast. There have been various reports of local farmers extending irrigation and drainage canals from the coastal zone into the park (this already began decades ago; see Silvius *et al.* 1984). These canals also form a possible conduit for transport of illegal timber out of the park.

iii) Benuh River. PDIW illegally encroached upon Berbak NP in 1990 in the Sungei Benuh area, at Simpang Kiri. They were caught red-handed by KSDA staff and forced to leave, but apparently no permits were revoked. Since then, illegal activities have resumed, reportedly mainly by groups operating out of adjacent South Sumatra.

iv) Air Hitam Dalam. Illegal logging has been ongoing for decades in this area, mainly being carried out by small operators out of Sungai Aur and Sungai Rasau villages, near the confluence with the Batanghari River. Sawn timber is smuggled out of the park in *pompongs* (large, diesel-powered boats), and transferred to large *pinisi* vessels lying in wait on the Batanghari River.

The two largest burnt areas – the central Air Hitam Laut and the Simpang Melaka area – are largely inaccessible from the downstream side because of vast mats of floating *Hanguana malayana* and *Pandanus helicopus* vegetation. This was already the case in 1983 (Silvius *et al.*, 1984) and 1990 (Giesen, 1991), and is not *caused* by the fires, although the abundance of dead trees in the water and the release of nutrients at the time of the fires may have made access even more difficult. In all likelihood, these areas were subject to illegal logging because they were inaccessible from the downstream side, where KSDA (and later *Taman Nasional*) staff are based, and could therefore avoid scrutiny from park staff.

3.3 LIKELY HISTORY/SCENARIOS LEADING TO PRESENT CONDITION OF BERBAK NP

Likely sequence of events at Berbak NP

Related to the burning of the Core Zone along the Air Hitam Laut and Simpang Melaka rivers.

1. Pristine Forest phase – up to the mid-1980s.
    a. 1983: forest appears intact – still pristine.
2. Large-scale illegal logging and burning phase – mid to late 1980s to mid-1990s.
    a. Satellite images of 1989 and 1992 show that the core area has a vegetation that has a very fine grain, indicative of small canopies, compared to adjacent areas. This vegetation in all likelihood consists of secondary scrub (*belukar*), following logging and burning. Large-scale illegal logging seems the cause, and the probable route of access is via the logging trail of

PT SDR, that runs from the Batanghari River (at Sungai Aur) to the Air Hitam Laut, just upstream of what is now the large, central burnt area. Illegal logging at Simpang Melaka appears to be occurring by means of access from the coast (via canals).

b. 1994. The Berbak Management Plan (Wetlands International – Indonesia Programme, 2000) mentions the occurrence of fires in Berbak NP in this year.

3. Second stage of large scale illegal activities & associated fires – 1996-1997.
   a. Two relatively small (<200 ha) areas are burnt along the central part of the Air Hitam Laut in August 1997, and a cleared rectangle of about 120-150 hectares is visible at Simpang Kubu.
   b. 1997 September: large-scale highly destructive fires occur in the central part of the Core Zone of the park, probably linked with the events of August 1997. Two main patches burn, one along the Air Hitam Laut extending over 12,000ha, the second along the Simpang Melaka extending over 4,000ha.
4. Period of annual fires – 1999 to present.
   a. Widespread illegal logging takes place along the Air Hitam Laut, upstream of the central core area, making use of PT PDIW's rail system, which was extended up to the AHL in 1998.
   b. 1998: Both AHL and SM burnt areas burn again early in 1998, as is evident on an image dating from May 1998.
   c. 1999: some areas show signs of secondary regrowth, but one third of the core zone has reburnt again, especially along the Air Hitam Laut (evident on image of 1 September 1999). Similar burning has also occurred at the burnt patch along the Simpang Melaka.
   d. 2002: an image from 13 May shows burning of at least one third of the central core zone, but none in the Simpang Melaka area. A second image dating from 18 September shows that by then, fire had also occurred once more at Simpang Melaka.
   e. 2003: an image dating from 16 May shows some recent burning in the central Core Zone – due to excessive cloud cover, the extent cannot be deduced.

3.4 CONCLUSIONS & DISCUSSION

Cause of degradation

The large-scale destructive fires that occurred at Berbak NP in 1997 appear to be linked to large-scale illegal logging that occurred in the preceding decade. These activities largely went unnoticed, as they were being carried out in areas that were inaccessible to park staff, but can be deduced from satellite images from this period. As large-scale illegal logging continues unchecked, the future of Berbak NP is likely to include further destructive fires, and a further decline of the conservation value of the park. Ongoing activities aimed at curbing further decline of the park appear to be largely ineffective. Firstly, they focus on motivating local communities not to encroach upon the integrity of the park, while the main illegal activities in the park are being carried out by outsiders and not by local communities. <There are exceptions, such as in the Air Hitam Dalam area, but this certainly holds for most of the park.> Secondly, when targeting local government, it is assumed that lack of

awareness, poor training, and lack of resources is leading to mismanagement (*vie* Management Plan for Berbak NP, and WI-IP, 2002). Judging from the scale of illegal logging and the reported role of local government in these activities, one may include that i) they are aware of the value of the park, but mainly see this in terms of the value of standing timber; and ii), mismanage existing resources in order to extract resources from the park (e.g. the extending of canals in order to create better access).

Direct effects on habitats

At present, a true fire sere (vegetation type) has not yet emerged at Berbak NP, but likely to consist of a combination of surviving species, along with pioneer species. Following large-scale fires, only a few plant species survive, as this phenomenon is uncommon under natural conditions and selective pressures for this characteristic have generally been absent. Species that may survive one or more fires include:

- palms (*Pholidocarpus, Licuala*), which have their growth points in the upper regions that may be out of reach of the flames. Fire seres dominated by palms are common in South America (so-called 'palmares' or palm savannahs[14]; Walter, 1979), and palm tolerance of burning was noted by Nuyim (2003) in Thailand, where especially sago palms were found to survive fires;
- species with a thick, protective bark such as *Combretocarpus rotundatus,* several *Eugenia's* (and possibly *Melaleuca cajuputi;* however, the latter has as yet not been recorded in Berbak NP); and
- species that resprout from the roots, such as *Mallotus muticus*[15], *Combretocarpus rotundatus* and *Elaeocarpus petiolatus*.

This list is not exhaustive, and extensive surveys in burnt areas are likely to identify more surviving species. The ability of these species to survive fires will of course depend on the nature of the fires (e.g. how hot, which in turn depends on fuel, humidity, wind, etc…), and how often these fires occur.

In addition to surviving species, burnt areas are characterised by a secondary vegetation dominated by fast-growing pioneer species such as the trees *Alstonia pneumatophora, Syzygium* spp. (esp. *S.cerina), Ficus* spp., *Macaranga* spp., *Neolamarckia cadamba*. and *Pandanus helicopus*, climbers such as *Morinda philippensis, Stenochlaena palustris* and *Uncaria glabrata,* ferns such as *Blechnum indicum, Lygodium microphyllum* and *Stenochlaena palustris*, and sedges/grasses such as *Hymenachne acutigluma, Paspalum conjugatum, Scleria purpurescens* and *Thoracostachyum* species. As fires are likely to have killed most seeds *in situ*, the seeds/fruits of most of these species are likely to have been transported via wind (e.g. *Alstonia penumatophora*) and water (e.g. *Syzygium, Morinda, Pandanus*). In the Air Hitam Dalam area, many more species are involved as this area is floristically much richer. Characteristics of Indonesian pioneer species are listed in Table 3.1, which may be used as a guide to identify other potential pioneer species. Tomita *et al.* (2000) found that *Melaleuca* recolonising burnt peatland arrived as wind-borne seeds, while *Blechnum, Stenochlaena* and *Lepironia* large recovered from their subterranean parts (see 4.1.1).

[14] According to Walter (1979), palms are resistant to fire because they possess no damageable cambium. The dead leaves sheathing the trunk are burned, and the outermost vascular bundles are charred, but the resulting layer of carbon acts as an insulation against later fires. The apical meristem, surrounded by young leaves, survives.

[15] Formerly known as *Coccoceras borneense.*

TABLE 3.1
Characteristics of pioneer species

Characteristic	Adaptation
Seeds	▪ ▪ ▪ for germination (esp. cracking & absorbing water) ▪ woody, while still borne on the mother plant (e.g. *Leptospermum, Melaleuca*)
Growth	▪
Flowering	▪ independent of the season ▪
Morphology	▪ layers - fire resistant, able to protect the cambium against heat; species include: *Melaleuca, Fragraea fragrans, Morinda tinctoria* ▪ remaining around young shoots – protects against frost and/or fire; possessed by many sedges (*Gahnia, Fimbristylis sericea*) ▪ *aquatica, Grewia*) ▪ ▪ ▪ bulbs, or specially adapted roots or shoots ▪ *Randia dumetorum*
Soils and roots	▪
Climate	▪

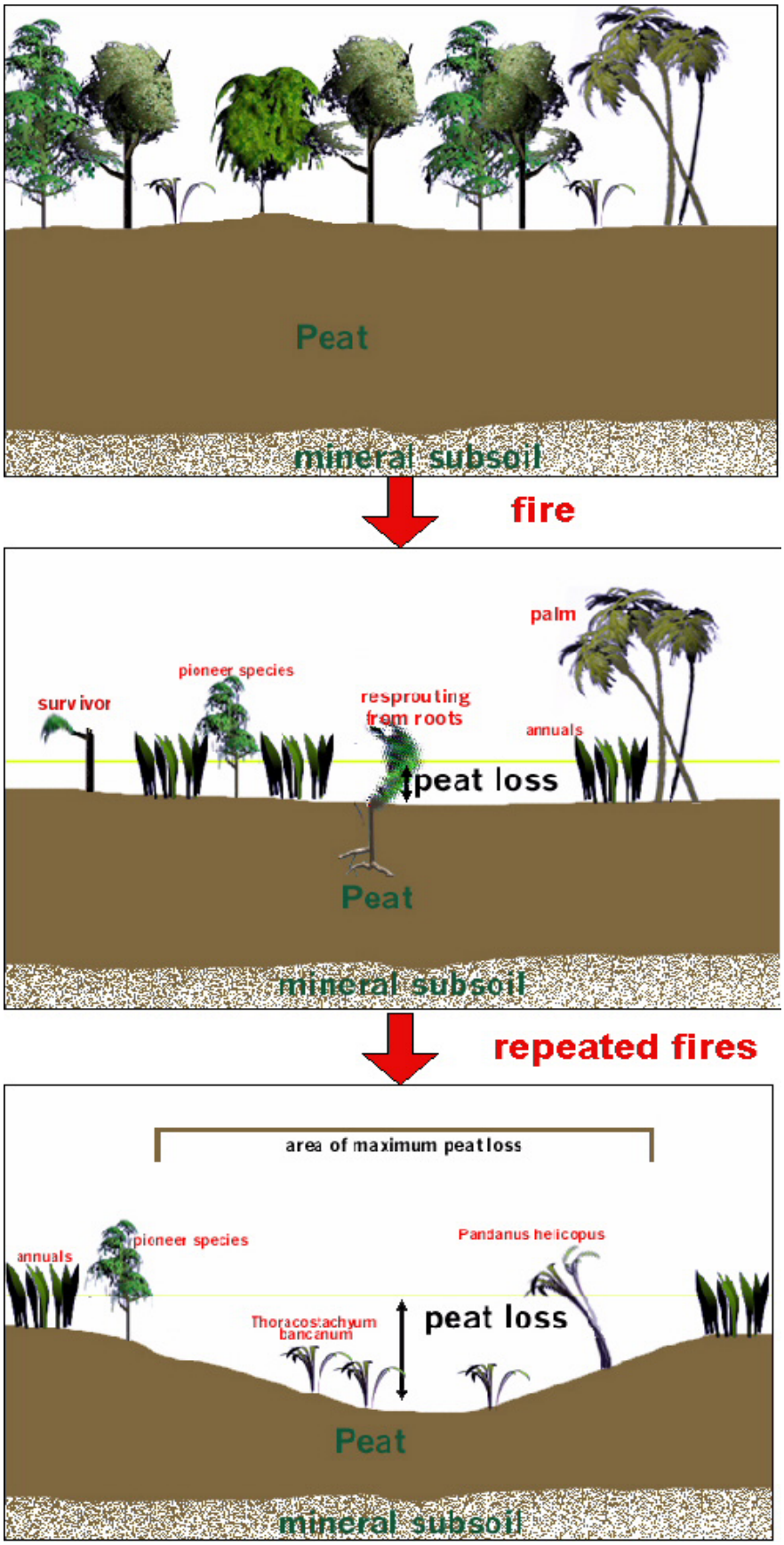
Source: Van Steenis (1941)

FIGURE 3.1
Hypothetical succession following fires in peat swamp forest in Berbak NP

Mixed peat swamp forest in undisturbed areas: characterised by many tree and shrub species, and a limited herbaceous layer.

A fire in mixed peat swamp forest leads to a decline in the peat layer, and habitats characterised by survivers (e.g. Combretocarpus rotundatus, *palms), resprouting from surviving roots, and occurrence of pioneer shrubs/trees and annuals.*

Repeated fires leads to a loss of survivor species, and an increase in pioneer species and especially annuals. Where fires have significantly reduced the peat layer, prolonged deep flooding may lead to the arise of seasonal lake habitats, where only Pandanus helicopus *and* Thoracostachyum bancanum *occurs.*



In addition to the eventual emergence of s true fire sere, the occurrence of repeated fires will also lead to the emergence of (seasonal) lake habitats (see Figure 3.1). Usup *et al.* (2000) typically report a loss of 100-150 cm of peat in the areas studied in Central Kalimantan, but in Berbak NP this loss appears to have been less, more in the range of 50-100 cm. As peat layers are burnt, it will become more and more difficult for peat swamp forest species to establish themselves in the degraded areas, as the depth and duration of flooding will become inimical to their growth. The emergence of the peat swamp lake habitat can already be observed along the Air Hitam Laut, where the only species that can be found in areas that have burnt repeatedly are *Pandanus helicopus* and *Thoracostachyum bancanum*. *Pandanus helicopus* may float and thereby survive deep, prolonged flooding, while *Thoracostachyum bancanum* dies off aboveground during floods, and later resprouts or re-emerges from the abundant 'seeds'. Satellite images taken in the wet season show that large areas are covered with extensive water bodies, and reports by others (e.g. Wetlands International – Indonesia Programme, 2002) indicate that the central burnt area along the Air Hitam Laut 'appears like a lake during the wet season'. Kostermans (1958) considers the shallow lakes of Kayu Agung (near Palembang in South Sumatra) to have formerly been peat areas. The string of lakes that have developed along the Siak Kecil River in Riau (Giesen and van Balen, 1991b), have probably also developed after burning had removed (part of) the peat layer nearest to the river.

CHAPTER 4 Peat swamp forest restoration opportunities

4.1 DEGRADATION SERES AND NATURAL REGENERATION OF PEAT SWAMP FOREST IN SOUTHEAST ASIA

SERES
A series of plant communities resulting from the process of succession. Various types exist, depending on type of disturbance or influence, e.g. fire sere, xerosere, hydrosere.

According to Van Steenis (1957), nothing was known at the time about (fire) seres in peat swamp forests, although Kostermans (1958) tried to rectify this by providing some initial notes. The occurrence of fire seres in humid Southeast Asian peat swamp forests is an anomaly. As Rieley *et al.* (1996) point out, most pristine tropical peat swamps are permanently wet, with the water table close to, or above, the surface throughout the year. Fluctuation of the water table in an ombrogenous peat swamp in Sarawak, for example, was 19 centimetres in the centre and 10 centimetres near the edge, throughout the year. Also, relative humidity is high: in wet season this is 90-96% both in forested and gap areas, and in the dry season this is 80-84%. However, it is obvious that fire (and other degradation) seres have emerged, and have been subjected to various studies/targeted by various management regimes during the past decades. Summaries are provided below.

4.1.1 DEGRADATION SERES & REGENERATION IN THE REGION

Malaysia

According to Wyatt-Smith (1959) there is a comparative wealth of natural regeneration of all sizes of economic species in the peat swamp forests of Malaysia. He notes, however, that even a slight drop in the mean water table may result in changes to the species composition of the forest, with plants that are more suited to the drier soils succeeding those of the original wetter conditions. Thus *Tetramerista glabra* and *Gonystylus bancanus* often do not regenerate following logging. However, *Koompassia malaccensis, Calophyllum retusum* and *Shorea* spp. do well – so good timber crop can be expected in regenerated forest.

Natural regeneration and reforestation studies in the peat swamp forests of Sarawak by Lee (1979) found that in the *Alan Batu* forest, the amount of *Shorea albida* dropped from 28% to 2% over a period of 17 years, as *S. albida* seedlings are quickly out competed after logging. Fast-growing species such as *Xylopia coriifolia, Litsea* spp. and *Cratoxylon* spp. increase significantly after logging, while those with medium rates of growth such as *Dactylocladus stenostachys, Ganua* spp. and *Shorea inaequilateralis* showed about 20% increase in distribution. Slower growing species such as *Combretocarpus rotundatus, Melanorrhoea* spp. (now *Gluta*), *Palaquium* spp. and *Gonystylus bancanus* decreased in distribution by about 30%.

Silvicultural treatment aimed at eliminating vegetation competing with a potential tree crop, appear to have a stimulating effect (as measured after 10 years) on growth of fast growing species such as *Cratoxylon* spp., *Dryobalanops rappa, Shorea* spp. and *Dactylocladus bancanus*.

Whitmore (1984) describes secondary vegetation types in peat swamp areas. *Melaleuca cajuputi* is an understorey tree that become gregarious after repeated burning, owing to thick, loose, corky bark, and the production of root suckers and coppice shoots. In Malaysia, species commonly associated with *Melaleuca cajuputi* are *Alstonia spatulata, Cratoxylum cochinchinense, Excoecaria agallocha, Fagraea fragrans, Ilex cymosa, Macaranga pruinosa, Ploiarium alternifolium, Randia dasycarpa, Scleria* species and *Stenochlaena palustris*.

Whitmore (1984) found that following logging of *Shorea albida-Gonystylus-Stemonurus* forest in Sarawak, *Shore albida* presence dropped from 28% to 2% as seedlings were killed by competition. In contrast, fast growers such as *Cratoxylon, Litsea* species and *Xylopia coriifolia* had greatly increased; medium growers such as *Dactylocladus stenostachys, Ganua* species and *Shorea inequilateralis* increased by 20%, and slow growers such as *Combretocarpus rotundatus, Gluta* species, *Palaquium* species and *Gonystylus bancanus* decreased by about 30%. In the *Shorea albida-Litsea-Parastemon* forest type, natural regeneration of *Shorea albida*, and other large trees such as *Litsea crassifolia* and *Combretocarpus rotundatus* is mainly vegetative, by suckers or coppice shoots. This forest then has no value for timber, but low extraction costs and high volume makes it valuable for chips or pulp. Extensive pure stands of *Macaranga pruinosa* and *Campnosperma coriaceum* in Malaysia of same-sized trees with an even canopy are believed to represent stages in a secondary succession back to mixed swamp forest after clearing (Whitmore, 1984).

Appanah *et al.* (1989) note that in peat swamp forests of Peninsular Malaysia there is an increase in the regeneration of *Shorea* species, *Koompassia malaccensis* and *Calophyllum retusum* after final felling or when the surrounding forest is converted to agriculture. This increase has been attributed to the desiccation of the forest, favouring these species at the expense of species such as *Gonystylus*

According to Bruenig (1990), commercial tree felling results in a drastic shift in species composition in favour of species which are tolerant to sudden change, such as *Cratoxylon arborescens,* but not species such as *ramin Gonystylus bancanus*. The latter is a naturally slow starting species, and in silvicultural trials, reacted poorly to felling and release operations. In renegerating areas with even canopies there is a risk of a dense, slender pole vegetation resulting which is susceptible to wind damage. Another hazard of commercially felled areas is that of nutrient loss by interrupting the nutrient cycle. Growth can be almost static in secondary growth areas in Borneo (e.g. dominated by *Ploiarium*), where monitored secondary forest showed almost zero growth even after 30 years.

Under post-logging conditions in peat swamp forests in Malaysia, Ibrahim (1996) reports that cleaning operations are required to reduce competition for sunlight and nutrients. Where this does not occur, disturbed peat swamp forests are rapidly dominated by fast growing species such as *Macaranga.* In Sarawak, defective and weakened trees are removed by means of girdling and liberation in the first year after logging, and again after 10 years. Some enrichment planting has been carried out, especially of *Gonystylus bancanus* in Sarawak, but no routine silvicultural treatments are performed in logged-over peat swamp forest in Peninsular Malaysia. Seedlings and small trees of commercial trees tend to cluster

around the mother tree, and removal of the latter in uncontrolled logging operations results in serious damage <to progeny>, and reduced opportunities for natural regeneration. Enrichment planting is probably the most logical solution if natural regeneration fails to restock degraded peat swamp forest. The main problems associated with enrichment planting of peat swamp forests is obtaining an adequate seed supply of selected species, the remoteness of planting areas, and a lack of process planting techniques in areas which contain much undecomposed organic matter.

Brunei Darussalam

In his study on secondary succession in logged over peat swamp forest dominated by *Shorea albida,* at Sungei Damit, Belait, Kobayashi (2000) found that natural regeneration of *Shorea albida* forests following logging operations is poor. After a four year recovery period he found that less than 10% of the former *Shorea albida* forests were likely to recover as *S. albida* forest, while more than 80% was found to be heavily colonised by *Pandanus andersonii* and *Nepholepis biserrata* and developing into a shrub-fern vegetation.

Thailand

Only a relatively small area (64,000 ha) of peat swamp forest remains in Thailand (Hankaew, 2003). Whereas a total of 437 angiosperms were recorded in primary peat swamp forest, only 82 species are found in secondary, degraded peat swamp forests. The latter are dominated by *Melaleuca cajuputi* and are characterised by the presence of many Cyperaceae. Peat swamp forest disturbed by repeated fires loses all or most of its peat layer, and underlying clay soils are invariably potential acid sulphate soils. Upon exposure to the air these become strongly acidic, and this favours *Melaleuca,* which is generally tolerant of such conditions. If fires are not only incidental, *Melaleuca*–dominated communities may be replaced by a further degraded Cyperaceae 'grassland'.

Mixed peat swamp forests are generally of two types, one dominated by *Eugenia kunstleri*, the second dominated by *Ganua motleyana.* Upon opening of the canopy, for example, by felling of trees, the vegetation becomes dominated by *Macaranga pruinosa.* Further disturbance and especially fires then leads to the fourth community type already described, dominated by *Melaleuca cajuputi.* Herbaceous species commonly associated with the latter secondary vegetation are *Cyperus* spp., *Lepironia articulata, Lygodium microphyllum, Medinilla crassifolia, Melastoma decemfidum, Nepenthes gracilis, Stenochlaena palustris* and various grasses.

According to Hankaew (2003), recovery of disturbed peat swamp forests via natural succession occurs via the following stages:

- *Melaleuca cajuputi* community type
- *Macaranga pruinosa* community type
- *Eugenia kunstleri – Goniothalamus giganteus – Macaranga pruinosa* community sub-type
- *Eugenia kunstleri – Ganua motleyana* community sub-type
- *Ganua motleyana – Xylopia fusca* community type.

For natural regeneration to occur, it is most important that fires are prevented, and other factors appear to be secondary to this.

Tomita *et al.* (2000) studied in detail the natural regeneration process of *Melaleuca*–dominated peat swamp forest in southern Thailand following a severe fire. The area studied had been drained, cleared, abandoned and burnt, after which the area was rapidly colonised by *Melaleuca cajuputi,* along with *Melastoma malabathricum,* a host of ferns including *Blechnum indicum, Stenochlaena palustris* and *Lygodium microphyllum,* and the

sedges *Lepironia articulata* and *Scleria sumatrana.* According to Tomita *et al.* (2000), who studied dispersal and recovery in great detail, these species either arrived as wind-borne seeds (*Melaleuca*) or from surviving subterranean clones (*Lepironia, Blechnum*). In the three year study, *Melaleuca* was observed to grow very rapidly, increasing to a height of 2-3 metres, covering much of the quadrats analysed, and out-competing other species after only 1.5 years.

Papua New Guinea

According to Eden (1973), the current distribution of savannah and grassland in southern Papua is not wholly consistent with environmental conditions, and he concludes that these habitats have been formed as a result of clearing and burning, perhaps influenced by recent climatic fluctuations.

4.1.2 DEGRADATION SERES & REGENERATION IN INDONESIA

Indonesia in general

In their assessment of the TPTI selective logging system in Indonesia, Dwiyono and Rachman (1996) conclude that this system does not always allow regeneration, due to:

- poor felling techniques which severely damage young/valuable trees;
- use of young trees (20-30cm dbh class) to construct logging tracks, ramps, etc..;
- some tree species produce seed only once a decade or so;
- suppression of preferred species by other (less valuable) species;
- luxuriant growth of climbers, creepers or rattans; and
- appropriateness of enrichment planting not examined and suitable species unknown.

As a result of felling, there is a decrease in old and large trees, with higher densities of younger and smaller ones as a result. In peripheral peat swamps, *Shorea* species tend to dominate regrowth, while in most open places (e.g. along extraction routes) *Cratoxylon arborescens, C. glaucum* and *Dactylocladus stenostachys* are pioneer species colonizing newly available space. On the whole, such fast growing trees become dominant in the regenerating peat swamp forest. Regeneration is also often quite patchy, and forest stands are often replaced by low growing species such as ferns and shrubs. Other changes noted by Dwiyono and Rachman are structural changes, a reduced structural diversity, and changes in micro-climate.

South Kalimantan

Giesen (1990) considers that virtually all vegetation types in the Sungai Negara wetlands of South Kalimantan are of a secondary nature, derived from primary types by tree felling and burning. Mixed freshwater swamp forests were found to have all been converted to *Melaleuca cajuputi* (*gelam*) [16]dominated swamp forest, sedge and grass swamp or rice paddies, a process that was already observed and noted early in the 20th century. Elsewhere (West Kalimantan, East Kalimantan) freshwater swamp forest is observed to be converted to

[16] *Melaleuca cajuputi* is an understorey tree in the primary swampforest (Whitmore, 1984).

a vegetation dominated by *Shorea balangeran*. This also appear to have been the case in South Kalimantan, and historic accounts record *gelam* and *S. balangeran* fire seres being replaced by sedge, fern and grass swamps. Giesen (1990) notes that the herb layer of degraded wetlands often dominated by *Stenochlaena palustris* and *Blechnum indicum.*

Giesen (1990) further describes five types of secondary peat swamp forests (fire seres) derived from mixed peat swamp forest that formerly included *Gonystylus bancanus,* dipterocarps and wild mangoes. These five types are:

- *Eugenia* – dominated fire/logging sere.
- *Shorea balangeran* – dominated fire/logging sere.
- *Combretocarpus rotundatus* – pure stands; also a fire sere, possibly intermediate between the former two.
- *Melaleuca cajuputi* swamp forest – possibly a next degradation stage, following a long history of fires in peat swamp forests on acid sulphate soils.
- Sedge and grass swamp – final stage of degradation. Many species of sedge (*Cyperus, Scleria, Eleocharis, Fimbristylis, Fuirena, Scirpus, Rhynchospora*) and grass (*Ischaemum, Echinochloa, Phragmites, Rottboellia*), and invasive *Mimosa pigra* shrubs.

Central Kalimantan

Kostermans (1958) reports that species such as *Alstonia, Campnosperma* and *Ctenolophon lophopetalum* only develop alongside *Combretocarpus rotundatus* if burning is not too frequent. Both *Shorea balangeran* and *Combretocarpus rotundatus* appear to be stimulated by fire, and show a marked tendency towards gregariousness, each forming nearly pure stands.

According to Rieley *et al.* (1996), Bornean dipterocarps are not only tolerant of shade in early stages of growth, but develop faster under these conditions. Opening up of the canopy during logging operations may therefore have adverse effects on these species. Regeneration of burnt areas may be hampered by falling timber, and Rieley *et al.,* (1996) found that "since the <Kalimantan> fires ended there has been a constant collapse of burned trees to the forest floor causing damage to new growth."

In their assessment of the effects of the 1997/98 forest fires and deforestation in Central Kalimantan, D'Arcy and Page (2002) found that mixed peat swamp forest lost about 75% of tree density in burnt areas, compared to a maximum loss of 40% in selectively logged areas. Primary forest had the highest mean number of saplings per plot, while burnt areas had the highest mean dbh. Interestingly, they found that *Combretocarpus rotundatus* is one of the main species able to survive fires (see 4.3.1). Forest fires can greatly restrict the regeneration of an area through the deterioration of seed banks, the reduction in plants that normally resprout post disturbance, and a decline of soil fertility due to the loss of organic material.

An IPB study of the recovery of a large area of former peat swamp forest at Kelampangan, Central Kalimantan, has produced some interesting results. A 1 ha plot of 100 by 100 metres was studied over the course of several years after the 1997 fires. Immediately after the fires it was concluded that all species had died, apart from two specimens of *jelutung Dyera lowii* that had miraculously escaped. In the first four months after the fire, very little regeneration occurred except for resprouting of *Combretocarpus rotundatus,* and it was therefore concluded that the seed bank in the peat soil had also been killed. By May 2003, i.e. 6 years after the

fires, Simbolon *et al.* (2003) found that there were 1158 individual trees (with a dbh of 15 cm or more) growing in the plot. 103 tree species were identified, dominated by *Combretocarpus rotundatus, Cratoxylon arborescens, Palaquium gutta, Shorea teysmanniana* and *Syzygium ochneocarpa*. Common species (in terms of number) were: C. arborescens (256 indiv.), *S. teysmanniana* (104), *S. ochneocarpa* (50), *Horsfieldia crassifolia* (47) and *Campnosperma squamatum* (46). On the whole, the investigators were surprised by the vigorous regrowth. According to Simbolon (pers. comm., 2003), the seeds did not arrive by wind, as most are too heavy, and they were probably brought by birds and mammals, or by floodwaters. However, the latter happened only once since the IPB team began monitoring the area. One must note, however, that the plot is located only 300 metres from a patch of good peat swamp forest. Simbolon expected dbh to have recovered by 30-40 years, but full floristic recovery would take more than 100 years, and perhaps even several hundred years. In any case, this will depend on the proximity of good forest as a source of seeds.

A WWF-Indonesia team conducted an initial fire impact study in the peat swamp forests of Tanjung Puting National Park, Central Kalimantan in December 1997[17]. They found that the average number of tree species declined from 60 per hectare in unburned areas to fewer than 15 after burning, that the total number of trees that survived the burn is highly correlated with the degree of prior disturbance, and that areas that had burned twice or more generally were devoid of trees. Peat swamps differ from other forests in that fires can travel below the ground surface killing trees by destroying their root systems.

Sumatra

Kostermans (1958) regarded the lakes at Kayu Agung in South Sumatra as being the result of peat disappearance due to extensive burning. Giesen and van Balen (1991b) describe the lakes along the Siak Kecil River in Riau, which forms part of a large peat dome where the deepest peat in Indonesia has been recorded – 24 metres. The string of lakes along the Siak-Kecil – like pearls on a string – and the ongoing peat degradation and burning strongly suggest that the lakes are in the process of being formed due to peat degradation.

4.2 ATTEMPTS AT PEAT SWAMP FOREST RESTORATION IN SOUTHEAST ASIA

4.2.1 Peat swamp FOREST RESTORATION IN SOUTHEAST ASIA

Peat swamp forest restoration and rehabilitation in Thailand

Although Thailand has little peat swamp forest (<65,000ha) compared to Malaysia and Indonesia, it has the most experience and longest history of peat swamp forest restoration and rehabilitation in the region. Some of these efforts date back to more than 40 years (see below), while those of the Royal Forest Department (RFD) date back more than a decade. In all, about 640 ha had been restored by 1999 (Nuyim, 2000).

[17] http://www.iffm.or.id/How_are_forests.html

Village-based efforts at reforestation have been undertaken in Thailand, for example, at Phru Kantulee[18]. Phru Kantulee was heavily degraded and largely drained for rice paddies, when 40 years ago efforts began to convince local villagers of the importance of restoring this area. Each village household was asked to manage 30-40 'rai' (1 rai measures about 40 by 40 metres), improve by means of planting and prevent outsiders from cutting trees. Almost 400 rai has been revised and reforestation efforts have turned rice paddies and fruit orchards into one of South Thailand's most pristine peat swamp forests. The area is important for supplying water to adjacent orchards, and has become an important area for both fish and wildlife. Reportedly, the project has been so successful that the swamp is now being considered for listing as a wetland of national and international importance.

According to Urapeepatanapong and Pitayakajornwute (1996), programmes initiated by the RFD in the 1990s that are relevant to PSF restoration and rehabilitation include:

- Silvicultural traits of peat swamp forest trees project; this was initiated to identify which species have the greatest potential for regeneration and plantations.
- Species selection experimental project; focused on 15 tree species (*Acacia mangium, Baccaurea bracteata, Dialium patens, Eugenia kunstleri, Eugenia oblata, Fagraea fragrans, Ganua motleyana, Litsea johorensis, Melaleuca* spp., *Polyalthia glauca, Stemonurus secundiflora*), to determine appropriate methods for reforestation.
- Soils improvement for tree planting, examining fertility constraints for five species (*Baccaurea bracteata, Eugenia kunstleri, Eugenia oblata, Macaranga* spp., *Polyalthia glauca*) under different fertiliser conditions.
- Growth rate studies under different plant spacings (1x1, 2x2, 3x3, 4x4 metres) for five species (*Baccaurea bracteata, Blumeodendron kurzii, Eugenia kunstleri, Syzygium obloatum (Eugenia oblata), Macaranga* sp.).
- Nursery techniques study, for raising seedlings on forest floor, tested on four palm species: *Areca triandra, Cyrtostachys lakka, Eleiodoxa (Salacca) conferta* and *Licuala spinosa.*
- Relationship between weeds and growth rates study, to study effects of different weeding regimes (every 1,2,4 or 6 months) on the growth of *Macaranga* sp. planted in 20x20 metre plots.

In order to develop reforestation techniques for degraded peat swamp and sand dunes in Narathiwat, Southeast Thailand, physiological characteristics of *Melaleuca cajuputi* Powell were studied (Satohoko *et al.*, undated). *Melaleuca cajuputi* is a main pioneer species in peat swamp and sand dune habitats in the Narathiwat region. *M. cajuputi* germinated, survived and grew well under flooding conditions, and its seeds did not lose their germination capacity even after heating to 100°C for one hour. These characteristics are advantageous for *M. Cajuputi* to grow and develop in peat swamps.

According to Nuyim (2003), dominant tree species in primary peat swamp forest are *Syzygium pyrifolium, Ganua motleyana, Campnosperma coriaceum, Macaranga pruinosa, Calophyllum teysmannii, Neesia malayana, Endiandra macrophylla, Syzygium obatum, Sterculia bicolor, Stermonurus secundiflorus, Syzygium muelleri* and *Baccaurea bracteata*. Dominant tree species in secondary peat swamp forest are *Melaleuca cajuputi* and *Macaranga pruinosa.*

[18] www.BangkokPost.com, 5 February 2003

Peat swamp forest degradation has mainly occurred due to drainage, followed by subsequent fires. Following fires, three scenarios may follow: i) *Melaleuca cajuputi* regrowth area; ii) *Macaranga* spp. regrowth area, and iii). no tree regrowth. Fruits of *Melaleuca* are opened by the high temperatures that occur during fires, and the seeds are dispersed to the ground, so it is not surprising that this species is a dominant pioneer following fires. The areas dominated by *Macaranga* are a bit puzzling, as *Macaranga* species are rarely found in these area before fire damage, and Nuyim recommends that *Macaranga*'s seed disperse system needs to be studied.

Nuyim (2003) found that native palm species (esp. sago, *Metroxylon sagu*) have very strong tolerance to fire and easily recover their growth; he considers that they may be useful as a barrier for fire protection. Areas that a repeatedly burnt, however, are soon dominated by *Melaleuca cajuputi*. Because of this, natural regeneration of deforested (mainly fire damaged) peat swamp areas therefore seems to lead to *Melaleuca* forests, and therefore assisted reforestation is required for recovery of original peat swamp forest.

Reforestation techniques have been developed for peat swamp areas by the Royal Forest Department during the past 10 years, which has replanted a total area of 640 hectares. Experience during these ten years of reforestation has shown that the following species are most suited: *Ganua motleyana, Melaleuca cajuputi, Syzygium oblatum, Syzygium pyrifolium, Sterculia bicolor, Sandoricum beccarianum, Alstonia spathulata, Calophyllum teysmannii, Ixora grandifolia* and *Alstonia spathulata*.

Nuyim (2000) reports that under natural conditions, peat swamp forest trees appear to grow best on naturally occurring mounds. In restoration programmes, the effect of artificial mound construction was tested on five species, and it was found that trees grew better on mounds than the same species planted in untreated areas. Tree height of *Syzygium* species, for example, was found to be almost double on mounds compared to unmounded areas (Nuyim, 2000; 2003). However, as mound cconstruction is expensive, Nuyim recommends further studies before recommending this for larger areas. Application of organic or chemical fertiliser and liming did not have any significant effects on growth. Regular (monthly) weeding, however, significantly improved stem diameter, stem biomass and branch biomass (at rates of 2-6x), but survival percentage, tree height, and width of crown were not affected.

Peat swamp forest restoration and rehabilitation in Malaysia

PSF restoration activities in Malaysia are still at an early stage, and to date are limited to trials and small-scale activities undertaken by the Forestry Department and FRIM (pers. comm., Ismail Parlan, 2003[19]). The project on *Sustainable Management of Peat Swamp Forest in Peninsular Malaysia* (SMPSF) was initiated in September 1996 and had a duration of 3 years.[20] This was a bilateral project between the governments of Malaysia and Denmark, and was implemented by the Forestry Department of Peninsular Malaysia and DANCED (Danish Cooperation for Environment and Development). The project's main objective was to

[19] FRIM, Malaysia.

[20] http://www.usm.my/bio/peat swamp/abstracts/Palle_Havmoller.html

ensure that sustained social, economic and environmental benefits are derived from the management of the peat swamp forests. Baseline studies were carried out in and around the heavily logged over peat swamp forest areas in North Selangor (70,000 ha) and still untouched peat swamp forests in Pahang (80,000ha). The studies have focused on silviculture and forest management, growth and yield, ecology, hydrology and socio-economics. Field activities have included establishment and monitoring of peat swamp plots, conducting of reduced impact logging trials (RIL), rehabilitation trials in disturbed areas, thinning intensity trials, flora and fauna inventories and collection and monitoring of hydrology data, socio-economic survey and GIS - mapping including forest zoning and infrastructure. Guidelines for integrated, sustainable management of peat swamp forests have been produced, to form the basis for the production of 10 years management plans for the two different peat swamp forests areas.

As part of the SMPSF project, the Forest Research Institute Malaysia (FRIM) has been involved in the production of PSF planting materials, and the rehabilitation of degraded PSF. Planting trials were carried out in previously burnt grassland areas, secondary forests, logging trails, and fern vegetation, in order to provide guidelines to forest managers on PSF restoration. FRIM also has plans for larger scale trials in secondary *Macaranga* forest.

The trials on replanting of *Imperata cylindrica* (alang-alang) grassland areas were carried out on an area of 1.55 ha in the Raja Musa Forest Reserve in Kuala Selangor, Peninsular Malaysia (Ismail *et al.,* 2001). Six indigenous PSF species were used: *Anisoptera marginata* (Mersawa paya), *Calophyllum ferrugenium* (Bintangor gambut), *Durio carinatus* (Durian paya), *Madhuca motleyana* (Nyatoh ketiau), *Gonystylus bancanus* (Ramin melawis) and *Shorea platycarpa* (Meranti paya). Four planting techniques were tried: open planting, open planting with mulching, open planting with topsoil and open planting with nursery trees. These techniques were tried for all six species under three different relative light intensities (RLI): 100%, 70% and 30%. Results show that the most cost effective approach is open planting, using *A. marginata, M. motleyana, G. bancanus* and *S. platycarpa,* which have survival rates of 73-92% under these conditions. Other planting techniques do not result in significantly higher survival rates; also, *C. ferrugineum* and *D. carinatus* have a low survival rate and require low to moderate RLIs.

Peat swamp forest restoration and rehabilitation in Vietnam

Melaleuca-dominated peat swamp forests in the Mekong Delta were largely destroyed during the Vietnam-American war by chemical defoliants, napalm and bombing, and more recently by clearing for agriculture, and draining by canals and for road construction (Maltby *et al.,* 1996). In 1991, the IUCN Wetlands Programme was asked by the Vietnamese authorities to provide technical assistance to rehabilitate *Melaleuca* dominated swamps in An Giang province. Since 1975, considerable efforts were made in re-establishing 50,000ha of *Melaleuca*, but by the mid-1990s only 3,000ha remained, due to a combination of:

- poor management (broadcast seeding; no thinning; build-up of litter leading to fire hazard; canals used as fire breaks provide unwanted access; poor seed stock used),
- social problems (few economic alternatives to exploiting newly established *Melaleuca* stands; intentional fires; preference for agriculture to *Melaleuca*),
- land use conflicts (short-term benefits from even poor rice harvests appear better than long-term benefits from *Melaleuca;* central government support for agriculture

and irrigation/drainage; little coordination between government departments), and

- lack of financial resources (insufficient funds for successful rehabilitation and management of *Melaleuca* stands).

The IUCN programme aimed at tackling these issues, for example, by better land use planning, improving inter-agency coordination, improved seed selection, thinning regimes, reduction of fire hazard, improvement of water management, and provision of financial assistance.

U Minh Thuong NP

Building upon efforts initiated by IUCN and the Royal Holloway College, *Melaleuca* peat swamp restoration activities at U Minh Thuong National Park have been carried out with assistance from BirdLife International since 1997 (BirdLife International, 2002). The main problem has been devastation by fires, which was the focus of a workshop held in Ho Chi Minh City in June 2002. Key conclusions reached at this workshop were that:

- no new canals should be constructed in the area, and a new hydrological management regime is needed, in order to keep the peat wet all year round;
- *Melaleuca* forest should be allowed to regenerate by itself. Re-seeding is not necessary, as *Melaleuca cajuputi* is a robust species, tolerant of fire, drought and poor soils. It rapidly re-grows and colonises areas after fire.
- Fire is part of *Melaleuca* ecology. Hydrological restoration is essential for the proper control, management and use of fire.

Peat swamp forest restoration and rehabilitation in Indonesia

Kalimantan

The project on *Rehabilitation of peatlands and establishment of sustainable agro-system in Central Kalimantan*, carried out under the LIPI – JSPS Core University Program on "Environmental Conservation and Land Use Management of Wetland Ecosystems in Southeast Asia", focused on the rehabilitation of intensively disturbed peat swamp forest areas in Central Kalimantan (Takahashi *et al.*, 2001). Activities include trial planting of 0.75ha of disturbed PSF under different regimes (with and without clearing, fertilizer application, and mounds) and with different species (*Shorea balangeran, S. pinanga, S. seminis, Peronema canescens, Palaquium* sp.), and observations on natural regeneration in a fixed sample plot of 50m² affected by wildfire, compared with a non-affected reference plot of 100m². Trials indicate that *Shorea balangeran* and *Palaquium* are best suited for replanting, as they have considerably higher survival rates (65-100%) compared to the other species (6-65%), and this seems irrespective of preparation techniques. Also, both species appear to be suited to heavily disturbed areas affected by repeated fires, and do not require innoculation by mycorrhizal fungi.

Riau, Sumatra

Bogor Agricultural University (Institut Pertanian Bogor/IPB) carried out a restoration programme (Implementation of Native Forest Restoration pilot project) for PT Caltex Pacific Indonesia in 2002, in the Duri and Minas Oil Field Operation areas in Riau province. The programme has five objectives, namely to:

- ensure that the nursery is developed correctly in terms of lay-out, capacity, supporting facilities and equipment; and supporting seedling growth;

- provide technology transfer to CPI's re-vegetation field personnel re-vegetation including native species selection and their planting stock propagation techniques;
- develop a re-vegetation plan and strategy that considers the varied conditions of proposed restoration areas (including degraded peat areas, heavily disturbed secondary forest, moderately disturbed secondary forest);
- provide technical assistance for implementation of the re-vegetation activities for restoration program.
- develop Standard Operating Procedures for key nursery operation, re-vegetation activities and monitoring.

Activities involved a preliminary study on selecting native pioneer species as catalytic species to speed up recolonization of heavily degraded and moderately degraded land (including peat swamp) after oil extraction operations (pers. comm., Yadi Setiadi, 2003[21]). Among the species tested, *Macaranga hypoleuca* (potted seedling) and *Hibiscus* sp. (stem cuttings) seem to be best adapted to poor, degraded peat sites. IPB are still monitoring their survival, growth performance, root development, recolonization of native species, crown recovery and litter production. In addition to this, IPB are also evaluating the mycorrhizal status of pioneer species grown in peat swamps, as this may help early seedling establishment in peatlands. They are also expanding their programme by selecting native pioneer species and developed propagation techniques, as this seems very imprortant in support of the peat rehabilitation programme.

Prior to the activities with IPB (2001-2003), PT Caltex Pacific Indonesia developed activities in the same locations with the private firm PT. Hatfindo Prima. These aimed at establishing and operating the nursery, and developing a plan and strategy for forest restoration by considering variations in local conditions in the degraded areas.

4.2.2 RESTORATION ATTEMPTS IN AND AROUND BERBAK NP

Various attempts at replanting degraded peat swamp forest have been carried out in and around Berbak NP, but all are small scale and can be regarded as trials only: there is no active restoration or rehabilitation programmme ongoing. An exception to this is the *jelutung* and *pulai* plantation of PT. Dyera Hutan Lestari (PT. DHL), as this company has successfully replanted large areas – a significant achievement given the constraints. However, the latter remain plantations and are virtually monocultures rather than mixed forests characteristic of the former natural vegetation.

PT Dyera Hutan Lestari

PT. Dyera Hutan Lestari (PT. DHL) has a concession area of 8,000 hectares near Sungai Aur, of which 7,200 hectares can effectively be used. The aim of the company is to establish a viable *jelutung Dyera lowii* plantation in a secondary, degraded peat swamp. In the first year of operation, 1991-1992, 60 hectares were planted, followed by 260 hectares in 1992-1993, and 593 hectares in 1993-1994. Initially, enrichment line planting in secondary scrub was carried out using *Dyera lowii, Gonystylus bancanus* and *Endospermum diadenum* (Muub, 1996), but although relatively successful this was soon switched to clearing followed by line planting. Survival rates have been high – on the whole more than 90%, and growth has been

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rapid: an average girth increment of more than 2 centimetres per year has been recorded. PT DHL has also begun tapping latex, and trials tappings under different regimes have been carried out.

In spite of this apparent success, there have been many pitfalls. Firstly, investments in infrastructure have been high because of the difficulty of access in the peat swamp forest. Secondly, obtaining a sufficient supply of *jelutung* seeds has proven to be difficult, as *Dyera lowii* flowers and sets seed only every 4-5 years, and during operations seed has been set only in 1993 and 1997. (PT. DHL has a large and professional, 2-hectare nursery at its main field station along the Batanghari River.) Thirdly, security is a problem, and company staff have been threatened and attacked on various occasions, for example, by local illegal loggers caught felling 'mother trees' in the PT DHL concession area. Lastly, there is the issue of wildfires. In 1997, 7,000 hectares burnt including 1,769 hectares of *jelutung* plantation, due to a fire that began in the adjacent HPH PT. Kamiaka Surya. In June 2003 a second fire raged through PT DHL's concession, burning 5,000 hectares including 1,775 hectares of *jelutung* and *pulai* plantation; this fire began at an illegal sawmill located along the Batanghari 1 kilometre upstream of the concession area. Interestingly, not all *jelutung* trees were killed by the 1997 fire, and it was observed that >10% survived.

PT Putra Duta Indah Wood

According to the Management Plan for Berbak NP (WI-IP, 2000), PDIW's efforts at reforestation appear to be economically motivated rather than aiming to restoration of the natural peat swamp forest. Lubis (2002), reports that efforts by PDIW for restoration of degraded areas since 2001 have focused on planting *meranti rawa Shorea pauciflora, durian burung Durio carinatus, ramin* and *jelutung.*

The consultant visited the nurseries of PDIW, both at their main camp at Suka Berajo (on 4 October 2003) and at their field camp (*Kem Pembinaan*) on 5 October 2003. The Suka Berajo nursery included a wide array of species indigenous to peat swamp forests such as *ramin Gonystylus bancanus, rengas Gluta* (formerly *Melanorrhoea*) *wallichii, jelutung Dyera lowii, meranti rawa Shorea pauciflora, nyatoh Palaquium* sp., *durian Durio carinatus, tanah-tanah Combreocarpus rotundatus* and *punak Tetramerista glabra.* Most of these seedlings were wildlings gathered as seedlings in the forest and tended further in the nursery. However, the nursery is tiny (providing for only 10-20,000 seedlings at most) given the area requiring replanting (PT PDIW's concession area measures at least several tens of thousands of hectares). Also, the focus seems to have moved to commercial species of interest to local villagers, such as papaya, cocoa, duku, mengkudu and kemiri.

The nursery at Kem Pembinaan is larger, with three shaded seedbed areas catering for >30,000 seedlings, but even this is far too small for a full-scale reforestation drive. Also, while species such as *jelutung, nyatoh, rengas, ramin* and *arang-arang* are being raised, PDIW appears to be placing a major emphasis on planting the exotic *Acacia crassicarpa.* Several replanted areas were visited along the rail linking Suka Berajo and Kem Pembinaan – none of these sites provided evidence of PDIW's restoration of natural peat swamp forest. At some sites, *Acacia crassicarpa* was the main species being planted, while at other sites canals had been excavated prior to planting (of *rengas* and *Acacia*) in order to lower the water table and reduce flooding.

PT Wana Teladan

In addition to PDIW and PT DHL, a third private company has been involved in reforestion attempts in peat swamps of Jambi Province, namely PT Wana Teladan. This company planted *pulai Alstonia penumatophora* in peat swamp areas, but has now apparently stopped all activities (pers. comm., H. Rosera[22]).

Department Kehutanan and Berbak NP

According to H. Soemarna (pers. comm., 2003[23]) a 1 ha trial plot (plot percobaan) of burnt former peat swamp forest was replanted along the Air Hitam Laut River in 2001-2002. Trees were planted on the burnt peat, and not on mounds. Two species were planted: *jelutung Dyera lowii* and *pulai Alstonia pneumatophora*. Seedlings were obtained locally, and from Pemerinta Daerah (Local Government), while locals assisted with the planting. Mr. Soemarna has not seen the results, and does not know of an evaluation report – he fears that because they weren't planted on mounds that all succumbed during subsequent floods.

Two trial plantings carried out in 2002 by the Forestry Department at the burnt area along the Simpang Melaka river in Berbak NP, namely at:

- a 1 hectare site in the first, smaller burnt area to the east of the Simpang Melaka river, closest to the confluence with the Air Hitam Laut; and
- 5 hectares, in the middle of the large burnt area, also to the east of the Simpang Melaka.

At both sites a combination of *pulai, jelutung* and *medang* were planted at a density of one seedling per 10 m². Seedlings were planted directly in the soil, straight into the soil[24], without mound construction. Seedlings were small (in the case of *jelutung* and *medang*), and about 1m tall in the case of *pulai*. Seedlings were not of a high quality as most were from cuttings rather than seeds. The seedlings were taken from the polybag before planting, which occurred in August (1 ha site) and December (5 ha site) 2002. A quick survey of both areas on 12 October 2003 revealed that seedling mortality is close to or at 100%, probably due to long, deep flooding (about 1.2-1.3 m, as observed on marks left on trees). According to a local fisherman living near the site (Pak Leman), a few seedlings may have survived at the far end of the 5 ha plot (not observed). A proposal for replanting trial areas in the large, central burnt area along the Air Hitam Laut has been submitted to the central government by Berbak NP staff for approval and funding for 2004.

South Sumatra

Two other companies in South Sumatra province Ogan-Komering district have tried restoration of PSF, namely PT Sribunian and PT SBA Wood. The emphasis is on changing the status of the sites to Industrial Plantations (HTI), and planting has focused on *Acacia,* rubber and oil palm. Evaluation by Lubis is that rehabilitation is geared towards improving economic gains, rather than ecological restoration, and that this process is supported by the Forestry Department and local universities.

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[22] Mr. Hamri P. Rosera (Director of Production, PT. Dyera Hutan Lestari), 3 October 2003.

[23] Mr. H. Soemarna, Wakil Kepala (Acting/Deputy Head) of Berbak NP; 2 October 2003.

[24] Largely mineral, with patches of shallow peat, at the 5 ha site; shallow peat at the first 1 ha site.

CCFPI

The Climate Change and Fire Prevention in Indonesia project is undertaking trial replanting in the western part of Berbak NP, along the Air Hitam Laut. Use is made of the PT. PDIW nursery located at *Kem Pembinaan*, and local community members are involved. At the time of the survey in the area (5-8 October 2003), mound construction was ongoing (see Photo 24, Annex 7), but planting had not yet started. Three types of areas have been chosen for the reforestation programme: i) open areas, ii) areas with some regrowth occurring, and iii) areas with a cover of shrubs/small trees. In all, 20 hectares will be treated. In October 2003 there were five teams preparing mounds, on which later (once the wet season has truly arrived) seedlings were to be planted from the PDIW nursery. Each team will prepare 4,000 mounds, so in all 20,000 trees will be planted (about 1000/ha). In practice, 50 centimetre tall mounds are built on the highest parts of the micro-topography, and the edges of the mound supported (e.g. by compacting or adding some branches) to prevent rapid erosion. Species to be planted are *jelutung Dyera lowii, ramin Gonystylus bancanus, temasam Eugenia* spp., *punak Tetramerista glabra, tanah-tanah Combreocarpus rotundatus,* and *rengas Gluta wallichii.*

4.3 IDENTIFICATION OF PROMISING SPECIES FOR RESTORATION PROGRAMMES

4.3.1 RECOGNISED BY OTHERS

Traditional forestry approaches to reforestation in Indonesia (e.g. Soekotjo, undated), focus primarily on dipterocarps, *Pinus merkusii* and exotics such as *Acacia mangium, Pinus radiata* and various eucalypts. Species used in various reforestation and rehabilitation programmes in Southeast Asia including Indonesia are listed below in Table 4.1. Of these, nine species have both been successfully planted and are known to occur at Berbak National Park, namely *Alstonia pneumatophora (pulai), Combretocarpus rotundatus (tanah-tanah), Dyera lowii Ganua motleyana, (jelutung), Gluta wallichii (rengas), Gonystylus bancanus (ramin), Macaranga* sp. (*mahang), Palquium* sp. (*nyatoh*) and *Shorea pauciflora (meranti rawa).*

TABLE 4.1
Species used in PSF reforestation in SE Asia

Species	Family	Performance **	Occurs at BNP	Author/ company*	Location/ country
Alstonia pneumatophora	Apoc.	++	+	PT.DHL	Jambi
Anisoptera marginata	Dipt.	++		2	Malaysia
Baccaurea brateata	Euph.	++		1	Thailand
Calophyllum ferrugineum	Gutt.	±		2	Malaysia
Combretocarpus rotundatus	Rhiz.	++	+	PT.PDIW	Jambi
Dialium patens	Legum.	±		1	Thailand
Durio carinatus	Bomb.	±	+	PT.PDIW 2	Jambi Malaysia
Dyera lowii	Apoc.	++	+	PT.DHL PT.PDIW	Jambi
Eugenia kunsterli	Myrt.	++		1	Thailand
Ganua motleyana aka *Madhuca motleyana*	Sapot.	++	+	1,2	Thailand, Malaysia
Gluta wallichii	Anac.	++	+	PT.PDIW	Jambi
Gonystylus bancanus	Thymel.	++	+	PT.PDIW, 2	Jambi Malaysia
Hibiscus sp.	Malva.	++		5	Riau
Litsea johorensis	Laura.	±		1	Thailand
Macaranga hypoleuca	Euph.	++		5	Riau
Macaranga sp.	Euph.	++	(+)	1	Thailand
Melaleuca cajuputi	Myrt.	++		2,3	Thailand Vietnam
Palaquium sp.	Sapot.	++	(+)	PT.PDIW	Jambi Kalimantan
Peronema canescens	Verb.	±		4	Kalimantan
Polyalthia glauca	Annon.	++		1	Thailand
Shorea balangeran	Dipt.	++		4	Kalimantan
Shorea pauciflora	Dipt.	++	+	PT.PDIW	Jambi
Shorea pinanga	Dipt.	±		4	Kalimantan
Shorea platycarpa	Dipt.	++		2	Malaysia
Shorea seminis	Dipt.	±		4	Kalimantan
Stemonurus secundiflora	Icacin.	±		1	Thailand
Syzygium oblatum (Eugenia oblata)	Myrt.	++		1	Thailand
Tetramerista glabra	Theac.	±	+	PT.PDIW	Jambi

* 1 = Urapeepatanapong and Pitayakajornwute (1996); 2 = Ismail *et al.*, 2001
3 = Maltby *et al.*, 1996 4 = Takahashi *et al.*, 2001
5 = Setiadi, pers. Comm. 2003

** ++ = grows well ; ± = does not grow well.

Alstonia pneumatophora* Backer ex den Berger** ***pulai

Alstonia is a member of the Apocynaceae (see Photo 28, Annex 7), characterised by a milky latex (as *jelutung*, another member of this family) and paired seed pods. According to the Tree Flora of Malaya (vol. 2, p.11), this species may attain a height of up to 39 metres and a girth of 240 centimetres. Found in freshwater swamp forests and peat swamp forests of Peninsular Malaysia, Sumatra, Borneo and Sulawesi. Observed in field to have small, fluffy seeds that are easily dispersed by wind. Often found as a pioneer in burnt and disturbed habitats (observed during present survey). Fast growing, with soft wood that is used for pencils and boxes.

Combretocarpus rotundatus* (Miq.) Danser** ***tanah-tanah

Combreocarpus is a monotypic genus of the Rhizophoraceae[25], found in Sumatra, Banka, Belitung and on Borneo, from sealevel to about 100 m asl (Ding Hou, 1958; see Photo 25, Annex 7). It was also previous found in Johore, but is now regarded as extinct in Peninsular Malaysia (Kochummen, 1989). *C. rotundatus* is a gregarious species of coastal swamps, mixed swamps, *padang paya*, and *kerangas* heath forests. According to Ding Hou, *Combretocarpus rotundatus* tends to coppice vigorously, for example after felling, and branches of wind-blown trees may easily take root. He also notes that when an old tree disintegrates, 4-6 young trees may take its place. Kostermans (1958) reports that *Combretocarpus rotundatus* appears to be stimulated by fire. D'Arcy and Page (2002) found that "In the burnt forest, the largest number of trees that survived the fires, albeit with scarring, were *Combretocarpus rotundatus*. This species has an extremely thick bark that allows scorching of the outer lignified layer, without damage to underlying vascular and cambium tissues. The data indicate, however, that only large trees were able to survive.' During present survey, often observed in secondary vegetation of burnt areas.

Dyera lowii* Hook.*f. ***jelutung***

This is the swamp forest and peat swamp forest *jelutung*, closely related to and often confused with *Dyera costulata*, which is a dryland species. As *Alstonia,* it is a member of the Apocynaceae and is characterised by white latex and paired pods. *Dyera lowii* is common in peat swamp forests of Sumatra, Malaysia and Borneo, where it may either form a canopy/emergent species or form part of the understorey stratum. On Borneo it is often found together with Alan *Shorea albida.* Apart from the latex, which is used in chewing gum, the wood is highly valued for the production of high quality pencils. It flowers irregularly, probably only every 4-5 years. In nurseries, it does not germinate if the seed is not planted upright, with the rachis pointing down. Most of the latex is harvested from wild populations, which are becoming increasingly scarce, and much is now poached from populations remaining in protected areas such as Berbak NP.

***Ganua motleyana* (de Vr.) Pierre ex Dubard**

Formerly also known as *Madhuca motleyana,* this species is a member of the Sapotaceae, as is *Palaquium*. The species is common in both freshwater and peat swamp forests of Thailand, Peninsular Malaysia, Sumatra and Borneo. It is a medium to very large tree, attaining a height of up to 40 metres, and a girth of more than 2.5 metres. Not obserbed in burnt areas during the present survey.

Gluta wallichii* (Hook.*f.*) Ding Hou** ***rengas

Gluta is a genus belonging to the Anacardiaceae (Ding Hou, 1978), most of which have an irritating clear resin that turns black after exposure to air (hence the former name of this genus: *Melanorrhoea*). Rengas is a generic name for various *Gluta* species, plus some other genera in the family. However, only a few are commonly found in peat swamp forests, and *Gluta wallichii* is sometimes also referred to as *rengas manuk*, which was also used by locals for this species during fieldwork. *Gluta wallichii* is a large tree, growing up to 45 metres tall and a trunk diameter of 70 centimetres. Identified using Department of Forestry (1986). Being replanted by PT. PDIW (see Photo 18, Annex 7).

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[25] Some plant taxonomists place the genus *Combretocarpus* in the family *Anisophylleaceae* together with the genus *Anisophyllea.* However, the author prefers to adhere to the opinions of Ding Hou (1958), Hutchinson (1959), Hsuan Keng (1983), Heywood (1993) and Kochummen (1989), who recognise both genera as members of the Rhizophoraceae.

Gonystylus bancanus* (Miq.) Kurz** ***ramin

Gonystylus bancanus is a gregarious, (formerly) often dominant tree of lowland freshwater swampforest and peat swamp forest. The species – a member of the Thymelaeaceae family (Airy-Shaw, 1953) – occurs in Indonesia (Sumatra, Kalimantan and Papua) and Malaysia (Peninsular Malaysia, Sarawak and Sabah). Usually in coastal peat and freshwater swamps (on sandy soil), but also in dryland areas up to 100 metres asl (Airy-Shaw, 1953). Once the premier species harvested in these habitats, it is now vastly over-exploited in most areas and has become heavily depleted (www.unep-wcmc.org/species/tree_study/asia). It is listed as Vulnerable by IUCN, and logging of this species has been banned in Indonesia since 2000. Not observed in burnt areas during the present survey.

Macaranga* species** ***mahang

Macaranga species belong to the Euphorbiaceae family, and are all fast-growing, short-lived pioneer species. Many are associated with ants, and have special secreting glands and/or hollow stems to accommodate these 'guests'. A number of species are regularly found in peat swamp forests, and some (e.g. *Macaranga hypoleuca*) have been used in replanting trials. Wyatt-Smith (1959) reports that *Macaranga maingayi* (=*M. pruinosa*) is interesting ecologically as it is dominant in natural succession ten years or so after the felling of any low-lying wet forest including peat swamp forest; under these circumstances it can form an almost complete upper canopy 9-15 metres. Several species have also been recorded in the past at Berbak NP, namely *Macaranga conifera* and *Macaranga triloba* (Giesen, 1991). During the present surveys, three *Macaranga* species were collected and identified by the Herbarium Bogoriense as *Macaranga pruinosa* (Miq.) M.A., *Macaranga* cf. *semiglobosa* J.J.Sm. and *Macaranga motleyana* (M.A.) M.A.. Commonly observed in burnt areas during the present survey (See Photo's 13 and 14, Annex 7).

Palaquium* sp.** ***nyatoh

As with *Ganua, Palaquium* is a member of the Sapotaceae, and is characterised by a thick, milky latex – this is tapped from some species and sold as *gutta percha.* There are about 20-30 *Palaquium* species in Sumatra, of which at least eight are known to occur in swamp forests (*P. burckii, P.confertum, P.hexandrum, P.macrocarpum, P.ridleyi, P.rostratum, P.semaram, P.xanthochymum*). The most common species in peat swamp forests is *Palaquium ridleyi.* This is a large tree, up to 40 metres tal and with a girth of 3 metres (Tree Flora of Malaya, vol. 1, p.426).

Shorea pauciflora* King. J.R.** ***meranti rawa

Meranti rawa is a large, buttressed dipterocarp. The identity is uncertain, as according to Ashton (1982), this species occurs on "deep soils on undulating ground and hills below 700m". However, this is the identity given by PDIW and CCFPI, and until this is locally collected and identified by a trained botanist, the name *Shorea ?pauciflora* will be used.

In addition to species used in reforestation of degraded peat swamp areas, other species useful for replanting may also be recognised based on a description of their characterisctics. Van der Laan (1925), for example, recognises a number of "weed species of wet areas", such as *Campnosperma macrophylla, Combetocarpus rotundatus, Elaeocarpus petiolatus, Fagraea crenulata, Polyalthia, Shorea balangeran* and *Trema orientalis*. These are generally occurring, fast growing pioneer species, and are likely to be promising for restoration programmes. Lee (1979) observed *Melaleuca 'leucadendron'* (in all likelihood *Melaleuca cajuputi*) in Alan (*Shorea albida*) peat swamp forests of Sarawak. This species has not yet been identified at Berbak, but

as it is very common in freshwater swamps of adjacent South Sumatra (e.g. OKI and Kayu Agung), it may also eventually be found here as well.

4.3.2 IDENTIFIED DURING THE PRESENT SURVEY

During the present survey, the following trees and palms were identified as being common in burnt areas (see Table 2.2), and therefore of interest to future restoration programmes in Berbak NP:

- trees: *Alstonia pneumatophora, Combretocarpus rotundatus, Elaeocarpus petiolatus, Eugenia spicata, Ficus spp., Macaranga pruinosa, Mallotus muticus* (also known as *Coccoceras borneense), Neolamarckia cadamba, Pandanus helicopus, Syzygium* (*Eugenia) cerina*;
- palms: *Licuala paludosa* and *Pholidocarpus sumatranus.*

Some of these tree species have already been described above (in 4.3.1) as they are being used in other reforestation programmes. Species not listed in 4.3.1 are described in relative detail below.

***Elaeocarpus petiolatus* Wall. Ex Steud.**

Giesen (1991) identified the following *Elaeocarpus* species at Berbak NP: *Elaeocarpus glaber, E. littoralis, E. oxypyren, E. palembanica* and *E.* cf. *palembanica. Elaeocarpus petiolatus* is one of the most common lowland species of this genus, being very common in old secondary forest, forest edges and low hills from India to Borneo (Tree Flora of Malaya/IV-p.92).

Eugenia spicata* Lamk.** ***gelam tikus

This member of the Myrtaceae is usually found along rivers, including streams in peat swamp areas. Can either be shrubby or a small tree, usually less than 10 metres tall (Corner, 1988), but occasionally up to 18 metres (Tree Flora of Malaya, vol.3 p.217). Usually flowers profusely and nearly all year round – small white flowers, and small white fruit, readily taken by frugivorous birds, tupai and squirrels. Found resprouting after fires, and colonising (riparian edges of) burnt areas along the Air Hitam Laut.

Syzygium cerina* Hend.** ***temasaman

Synonym: *Eugenia cerina* Hend. Giesen (1991) identified the following *Eugenia/Syzygium* species at Berbak NP: *Eugenia chloroleuca, E. jambos, E. punctata, E.* cf. *pseudosubtilits, E. spicata, E. zippeliana, Syzygium antisepticum, S.cumini, S.lineatum, S.racemosum, S.zeylanicum.* Other *Syzygium* species identified during the present study are *S.* cf. *nigricans* and *S. setosa.* Described in the Tree Flora of Malaya and by Corner (1988) as being common in lowland swamp forests and along rivers, from Penang to Singapore, Sumatra and Borneo.

Licuala paludosa* Griff.** ***palas

Licuala paludosa is one of several fan palms found in swamps of lowland Sumatra; however, unlike the similar *Licuala spinosa* the swamp fan palm is unarmed and does not have an array of spines along the petiole (see Photo 1, Annex 7). In all, there are about 25-30 species of *Licuala* in Sumatra, of which several may occur at any one locality. All are small, and *Licuala paludosa* – found throughout Southeast Asia – may form dense clumps of up to about 4 metres tall. It is fairly common in some former burnt areas, and it appears likely that the species survives fires rather than being an invading pioneer following burning of a site. Synonyms include *Licuala amplifrons, L. oxleyi, L. paniculata* and *L. auricutiaca*.
http://www.pacsoa.org.au/palms/Licuala/paludosa.html

Macaranga pruinosa* (Miq.) M.A.** ***mahang

Typical for lowland freshwater and peat swamps on Borneo (Airy Shaw, 1975), W. Malaysia (Corner, 1988) and called *Macaranga maingayi* Hk.f. in all older Malaysian publications (Tree Flora of Malaya, vol. 2; see Photo 13, Annex 7). Occasionally on dry land, at least on Borneo. It is the *Macaranga maingayi* refered to by Wyatt-Smith (1959) as being interesting ecologically as it is dominant in natural succession ten years or so after the felling of any low-lying wet forest including peat swamp forest; under these circumstances it can form an almost complete upper canopy 9-15 metres. Extensive pure stands of *Macaranga pruinosa* in Malaysia of same-sized trees with an even canopy are believed to represent stages in a secondary succession back to mixed swamp forest after clearing (Whitmore, 1984). Upon opening of the canopy of peat swamp forest in Thailand, for example, by felling of trees, the vegetation becomes dominated by *Macaranga pruinosa* (Hankaew, 2003).

Mallotus muticus* (Muell.Arg.) Airy Shaw** ***perupuk

Mallotus muticus (also known as *Coccoceras borneense*) is a member of the Euphorbiaceae, common in both freshwater swamp forests and peat swamp forests. It has characteristic, large pneumatophores that may extend for up to more than 1 metre out of the substrate (Photo 26, Annex 7). Skin contact with it's bark may cause irritation and/or violent rashes. Found in Borneo, Sumatra and Peninsular Malaysia. A tall tree, up to 35 metres, found in primary and secondary lowland vegetation, up to an altitude of 300 metres, on river banks, in swamps, usually on clayey soils and alluvium (Airy Shaw, 1975).

Neolamarckia cadamba* (Roxb.) Bosser** ***bengkal

Neolamarckia cadamba (also known as *Anthocephalus cadamba, A.indicus, A. chinensis, Nauclea indica)* is a member of the Rubiaceae. The species is a very common species in Peninsular Malaysia, where it commonly occurs in secondary forest, lowland forest and along river banks and in swampy areas (Corner, 1988). Found from India through Southeast Asia, Sumatra, Borneo, up to New Guinea. It is a fast growing pioneer species that may be up to 30 metres (Corner, 1988) or even 40 metres tall (Tree Flora of Malaya, vol. 4, p.381-382). Frequently gregarious, up to an elevation of 1,000 metres; seeds dispersed by bats. Good source of pulpwood and for plywood, sort and pliable, occasionally grown in plantations.

Pandanus helicopus* Kurz.** ***rasau

This is one of the commonest members of the screwpine family (Pandanaceae) in Southeast Asia, being common in waterways from Peninsular Malaysia to Sumatra., Borneo and Sulawesi (http://users.bart.nl/~edcolijn/floraputing.html; Giesen *et al.,* 1991). Stems are much branched and 5-7(8) metres tall, 8-10 centimetres diameter. Forms dense thickets in rivers, often for many kilometres, completely blocking waterways (Ridley, 1925; p.77). *Pandanus helicopus* colonises and dominates in deeply flooded areas, including burnt areas where a significant layer of peat has disappeared. Propagation can be both from fruit (which is not present all year round) and from vegetative cuttings.

Pholidocarpus sumatranus* Becc.** ***liran

Pholidocarpus sumatranus is known from Sumatra only, where it occurs both in west Sumatra and along the east coast (http://www.pacsoa.org.au/palms/Pholidocarpus/index.html). Of the six species of this genus, it is the only one known from Sumatra. It is a tall palm, distinguishable from *Livistona saribus* (also known as *liran*, occasionally confused with *serdang*, the local name for *Livistona* fan palms) by the deeply incised leaves and the larger, characteristic fruit. Often one of the few surviving species found in burnt swamp forest areas (see Photo 12, Annex 7).

4.4 REQUIREMENTS FOR REPLANTING PROGRAMMES

Species & provenance

The restoration/rehabilitation programme at Berbak NP should focus on the following tree and palm species: *Alstonia pneumatophora, Combretocarpus rotundatus, Dyera lowii, Elaeocarpus* sp.43, *Eugenia spicata, Eugenia* sp.8, *Ganua motleyana, Gluta wallichii, Gonystylus bancanus, Licuala paludosa, Macaranga pruinosa, Mallotus mutica, Neolamarckia cadamba, Palaquium* sp., *Pandanus helicopus, Pholidocarpus sumatranus* and *Shorea pauciflora* (*meranti rawa*). Seeds, fruits and cuttings of these species should be of local provenance (i.e. obtained locally in or around Berbak NP), as specimens of the same species taken from other populations may have other characteristics (e.g. not as well adapted to flooding and/or being resistant to fires).

Nurseries

At least two new nurseries should be established for restoration/rehabilitation programmes, namely: i) near the newly refurbished National Park resort office near the mouth of the Air Hitam Dalam, and ii) in the lower course of the Air Hitam Laut, between Air Hitam Laut village and the park border. NP staff should be trained in nursery management and propagation techniques and involved from the beginning, while local community members should be recruited for planting trials and eventual replanting programmes. The nurseries will need to be established in areas that are not subject to prolonged, deep flooding (although some flooding would be permissible), and should be able to eventually increase to a size of about 1-2 ha. Netting will be required for shading, along with plastic sheeting for establishing beds, polybags, trays, soil for planting medium, fertiliser and labels. Training should be provided by a skilled person – intensively during nursery establishment, and intermittently thereafter to solve possible problems encountered. A small boat (*ketek*) will be required for obtaining propagules, and for transport of seedlings during trials. Various trials will be needed, as knowledge of propagation of peat swamp forest species is limited, although it appears that propagation by seeds, from wildlings, and from vegetative cuttings are all viable methods for most species (Ismail & Shamsudin, 2003). Training may be provided by nursery staff of PT. PDIW or PT. DHL, for example at their own nurseries. The western part of the park can be covered from the PT. PDIW nursery located at *Kem Pembinaan*, as is currently being done by CCFPI planting trials. Although this dependence on PDIW is not ideal, it does not make any sense to establish a new, independent nursery as long as Berbak NP does not have a resort in this part of Berbak. The two proposed nurseries should be established as soon as possible, so that the first seedlings will become available by the middle of 2004, and trial planting can be undertaken.

Planting regime & timing

Trials will need to be carried out to assess the best planting regime and timing of replanting. Trials carried out by Forestry Department staff in 2002 along the Simpang Melaka had a failure rate of almost 100%, so it would appear that planting without mounds just before the wet season is not ideal. Mound-planting trials being carried out by the CCFPI project in the south-western part of the park has only just begun, and results will not be available until the middle of 2004. By that time the first seedlings may become available from the CCFPI mound trials. It is recommended, however, that more systematic trials be undertaken as well, as the CCFPI approach (locate higher ground, add about 50cm of 'soil' and plant) may not lead to clear results applicable elsewhere. Although choice of seedling, timing of

planting, adding of fertiliser, and possible tending of seedling after planting are important, flooding regime of the site being planted appears to be the most important factor determining success of replanting.

A more systematic approach would be to identify the level of maximum flooding at a given site, and in planting trials plant seedlings at various levels relative to this reference. For example, if the maximum flooding level is +1.35 metres, trials should be carried out by constructing a series of mounds that attain levels of, for example, zero, +0.25, +0.50, +0.75, +1.00, +1.25, +1.35, +1.50 metres (say, 20-50 mounds at each level, for each species being tried), all measured relative to the maximum flooding depth. The aim of this would be to find an optimum mound level for each species, where this has a good/acceptable survival rate. For one species, for example, a survival rate of 100% may be attained at 1.50 metres, but at 0.75 metres it may still have a survival rate of 95%. Given the cost of mound construction, mounds of 0.75 metres may therefore be the optimum

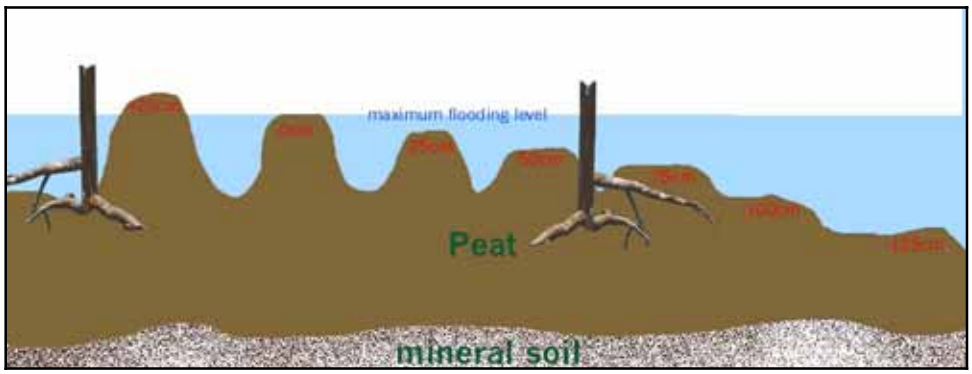


FIGURE 4.1
Recommended mound trials, with mound levels varied relative to the maximum level of flooding

The consultant initially had some misgivings about the construction of mounds, as such structures seemed "unnatural" and appeared to be adding to the level of disturbance. However, as attention was paid to this aspect, it became apparent that mounds were a natural phenomenon in the swamp forests of Berbak NP, especially in freshwater swamp forests, where virtually all large trees appear to be located on natural elevations in the micro-topography. What appears to be occurring in such swamps is that when a tree topples (e.g. during a storm or after dying), a mound of soil is raised by the roots. This is then colonised, and as such an elevation reduces the level of flooding while at the same time providing access to nutrients (raised soil and a decomposing tree), trees colonising these natural mounds are probably more successful. Over the course of time, a swamp forest may therefore have a hummocky appearance, with most large trees occurring on natural mounds (Photo 23, Annex 7).

Tending of seedlings

Apart from varying species and mound size, trials should vary size of seedlings, timing of planting (e.g. end of wet season, dry season, beginning of wet season), amount of fertiliser applied (none, small amount, significant amount), and amount of tending (clearing prior to planting, clearing again after 6 months and one year). This way, an optimum strategy can be identified, both for individual species and for the overall planting programme.

Burnt areas are often characterised by a profuse growth of ferns and climbers (Photo 16, Annex 7). While this may help prevent fires by rapidly providing a dense ground cover that reduces desiccation, such a dense growth may smother tree seedlings and retard or even prevent regeneration of peat swamp forest. Especially species such as the climbing fern *Stenochlaena palustris* was be troublesome, as it not only forms a dense ground cover, but may also climb and smother larger saplings as well. Some tending of replanted areas is therefore probably required, at least to clear the growth on and immediately around the young trees. Recommended is that this is done upon planting, and again after 6 and 12 months.

CHAPTER 5 Recommendations for restoration of degraded peat swamp forest at Berbak NP

5.1 MID-UPPER CATCHMENT OF THE AIR HITAM LAUT RIVER BASIN

The areas outside Berbak NP but within the bufferzone area – the Hutan Produksi Terbatas (HPT; Limited Production Forest) and the Hutan Lindung Gambut (HLG; Peat Protection Forest), have both been heavily logged by PT. PDIW and are in the process of being stripped clear of all utilisable timber by many groups of illegal loggers.[26] There is no difference between limited production forest (HPT) and peat protection forest (HLG), both have been equally heavily damaged. No actions are being undertaken to stop illegal logging, and poachers make free and frequent use of PT. PDIW's infrastructure to take timber out of the area – indeed, all timber poached in the western part of Berbak NP, and the adjacent HPT and HLG are taken out of the area via PT. PDIW's rail system. As this process continues unabated, it is only a matter of time before fires break out and this area is degraded even further.

PT. PDIW's attempt at reforestation of 'selectively logged' areas is very limited in scope (i.e. only covering a small, readily accessible area), and appears to be window dressing only. Much of what has been replanted has been done with the exotic *Acacia crassicarpa*, and done in conjunction with lowering of the water table by means of canals excavated explicitly for this purpose. This is in complete violation of Forestry Department regulations, as the forest is to be allowed to recover as a natural forest, and at most this natural regeneration process is allowed to be assisted by means of enrichment planting. Lowering of the water table further increases the fire risk in the area. It is reported that PT. PDIW (together with Local Government) has applied for a change of status of the concession area from HPT to that of Conversion Forest, in order to establish a pulpwood plantation. In their application, Local Government has reportedly stated that "peat layers are thin and negligible", although average peat depth is more than six metres.

[26] A total of 8 illegal logging camps were seen between PT. PDIW's *Kem Pembinaan* and the border of Berbak NP. A further 26 camps were seen from the border up to Simpang 'T', i.e. within the Park.

At present, restoration of this area is not the primary concern. What urgently needs to be done is:

i) Immediately halt illegal logging activities in the area. As the main outlet for illegally felled timber is PT. PDIW's rail system, the best option for protection of remaining forests is to close dismantle the rail system as soon as possible. This should not pose significant problems with PT. PDIW, as their logging operations are completed, the company describes itself as 'dormant', and their licence is up for renewal or cancellation next year. As two canals run parallel to the rail system, these must also be filled in so that this does not provide an alternative route. This process should be checked, as when PT. SDR was evicted from what is now the Berbak NP bufferzone in 1990-91, it simply left its infrastructure in place, and logging continued under another guise.

ii) Lobby the Ministry of Forestry in Jakarta to prevent the change in status of the area from HPT to that of Conversion Forest. This area is one of the last production forest areas in lowland Jambi Province, and given the peat depth generally unsuitable for the establishment of pulpwood plantation. Also, conversion will involve drainage, and this will have highly significant negative impacts on Berbak NP.

iii) Establish a Berbak NP (Taman Nasional) presence in the western half of the Park. At least one well-staffed *resort* needs to be established on the western side of the Park, in the PDIW area, where there is currently *no* BNP presence. Boats, housing, office, radios, operational budget will be required. Also, apart from a small, inconspicuous border post (*pal batas*) there is no signage indicating that one is entering Berbak NP from the western side.

Parallel to this, trials need to be carried out to assess the possibilities and best approach for reforestation of degraded areas, so that once the area has been safeguarded, restoration activities can commence. However, unless i) and ii) have taken place, it is useless and a waste of resources to invest in peat swamp forest restoration in this area.

5.2 CENTRE OF BERBAK NP

Within Berbak NP, two main areas that warrant immediate attention when it comes to restoration and rehabilitation of peat swamp forest, namely the central Air Hitam Laut burnt area (about 12,000 ha), and the Simpang Melaka burnt area (4,000 ha).

Air Hitam Laut

The central Air Hitam Laut burnt area forms a major part of the Core Zone of Berbak NP, and unless regulations are changed or the Core Zone status is transferred to another (more intact) part of Berbak NP, restoration activities are not permitted. Forests to the west and southwest of this burnt area are still actively been felled by many teams of illegal loggers, (see footnote 24) and unless this process is halted, it is not recommended that efforts be invested in reforestation and peat swamp forest restoration (see 5.1). Trials should, however, be carried out so that when prospects have improved, large-scale restoration may commence. Once illegal felling appears to have more-or-less stopped it would be worthwhile investing in large-scale restoration activities. The best approach for the large central area in the park would be to directly involve local communities, and replant these areas with indigenous species, including ones that are locally considered as 'useful', such as *jelutung*. Local communities involved in the replanting should be granted the right to exploit

these non-timber forest product resources sustainably, and boundaries of which areas may be used by which village should be clearly defined. At present, this approach is not possible, for various reasons: replanting is not allowed in core zones, and such rights cannot be granted. Apparently, a proposal for such an approach has been submitted by Berbak NP management to their headquarters, and this is currently being discussed within the Ministry. While trials should of course be conducted at various sites, to test species, planting regimes and provide examples, large scale restoration should only occur once the area can be regarded as 'secure', as if planted areas should subsequently burn within a few years, this may mean the end of local support and input.

Simpang Melaka

The Simpang Melaka burnt area does not form part of the Core Zone of Berbak NP, and regulations of what can and cannot be undertaken are less strict. The Forestry Department has already undertaken (unsuccessful) reforestation trials in this area in 2002, and wants to undertake additional trials in 2004. As in the Air Hitam Laut burnt area, however, illegal logging must be halted prior to large-scale investment in restoration. Most poached timber appears to be taken out of the area via canals to the east – these should be investigated and sections that have encroached upon the part filled in. Also, patrolling by Park staff should also include patrolling of this part of the coast, to ascertain that these canals remain closed, and that the remaining canals are not be used for similar purposes.

A nursery for providing seedlings for both trial plantings and for restoration activities is to be established between Air Hitam Laut village and the Park border (see 4.4). This is to be managed and operated by Berbak NP staff, while replanting programmes are will need to be based on temporary recruitment of local community members. As in the Air Hitam Laut area, the planting of indigenous species that are useful to the local community (such as *jelutung*) should be considered, so that the granting of local exploitation of NTFPs may be considered in order to generate local interest in restoration programmes and protection of the Park.

CHAPTER 6 Recommendations for the Project's peat swamp forest restoration programme

6.1 RECOMMENDATIONS FOR IMPROVEMENT OF THE EXISTING PROGRAMME

Based on the present assessment of the conditions at Berbak NP, restoration/rehabilitation of degraded peat swamp forest at Berbak NP will require the following:

i) Species identification. Species suitable for restoration programmes at Berbak have been identified and are being used by locally based companies and projects (e.g. PT.PDIW, PT. DHL, CCFPI). Some additional species have also been identified by the present study, but this needs to be refined to identify further additional species suitable for restoration and rehabilitation. This will be continued by two Dutch students who are scheduled to carry out an ecological study in the first quarter of 2004, focusing on natural regeneration process in burnt areas. Two Indonesian students are to focus on modes of seed dispersal – this will also help identify which areas may restore unassisted under natural circumstances, or at least understand the underlying processes.[27]

[27] SEED DISPERSAL study. Natural regeneration of peat swamp forests in burnt sites is to a large degree dependent on the arrival of seeds/fruit, as fire destroys most – if not all – of the seed stock in the soil. Also, only a few species survive fires and resprout from charred trunks or roots. Seed dispersal is mainly via three avenues: wind, water and via wildlife. Peat swamps that are regularly flooded probably receive most (floating) seeds via incoming waters, while wind and wildlife dispersal may play a more important role in areas that are rarely flooded. Seeds and fruits of common peat swamp forest species are to be studied and an assessment made of the main mode of dispersal. Seeds and fruit can be tested for buoyancy (can they float? And for how long?). Are they adapted for wind dispersal (light, with wings, hairs, and other adaptations for drifting in the wind)? Are they readily ingested by animals and can they germinate after passing through the digestive tract? Do they stick to feathers or fur? For each type of dispersal (wind, water, wildlife), a scoring system is to be developed (e.g. 1=none; 5=very likely mode of dispersal), and each seed/fruit given a score. For example, *pulai* (*Alstonia pneumatophora*) has small, light seeds adapted for wind, but they also can float somewhat; wind score =5; water score=3; wildlife score=1.

ii) Site identification. Vast areas (>20,000 ha) in Berbak NP are heavily degraded and all degraded sites may potentially be targeted by restoration programmes. However, funds are limited, and there are various constraints to such a 'blanket' approach:

a. Legal. Restoration programmes are currently not permitted in the central core zone of Berbak NP (along the Air Hitam Laut). Secondly, planting of useful NTFP species in restoration programmes (for later use by local communities involved in restoration) is also not permitted. These issues are being addressed by Berbak NP staff in Jambi, and Taman Nasional in Jakarta.

b. Social. Restoration programmes at Berbak NP will be impossible to implement without active participation of the local communities, as Taman Nasional does not have the staff or resources to implement planting, and local community support is required to ensure that replanted areas are well tended. Once sites are selected on a physical basis (see below), discussions must be held with local communities to identify their willingness to participate. This will depend on possibilities to provide some form of incentive (e.g. the outcome of a), above). Such discussions should be held by the Silviculture/Rehabilitation Specialist, perhaps assisted by Berbak NP staff.

c. Physical. Not all degraded areas are equally suitable for restoration. Some sites may be able to regenerate naturally (e.g. due to proximity of natural forest), while some are so degraded and deeply flooded that significant investments are required (e.g. very tall mounds) for restoration. One of the outputs of the Dutch student project will be a decision support system to guide the selection process, based on physical criteria. The Indonesian students are to focus on modes of seed dispersal – this will also help identify which areas may restore unassisted under natural circumstances, or at least understand the underlying processes.

d. Site selection plan. Once a), b) and c) are completed or have been clarified, a site selection plan may be developed by the Silviculture/Rehabilitation Specialist, together with Berbak NP staff. This plan should focus on high priority areas first (high value, high chance of success) and be realistic:, i.e. being aware that not all areas can be restored, and operating within the budgetary, time and human constraints. One major caveat is required here, and that is that large-scale restoration/rehabilitation should *not* take place unless illegal logging is brought to a halt (see v) below). This major hurdle must be cleared, otherwise any investment in restoration is a waste of funds, and may squander local community goodwill.

iii) Trials. These can and should be carried out parallel to the above, as information and experience regarding the performance of species, planting and tending techniques is urgently required. These trials should be carried out by the Silviculture/Rehabilitation Specialist, supported by 1-2 field assistants, Berbak NP staff, and members of the local community. Trials should focus on:

a. Sourcing. Identification of suitable sites/populations for sourcing seeds, fruits, cuttings of each species to be used in planting trials.

b. Propagation techniques, both in nurseries and for planting in the field: with/without clearing, using various levels of fertiliser application, various forms of shading, etc…

c. Tending: determining which level of tending is required once seedlings have been planted in the field
d. Hydrology. Trials using various mound levels relative to maximum flooding need to be carried out to determine an optimum mound level (for each species; see 4.4).
e. Regular reporting on monitoring and evaluation. Trial planting to be carried out in readily accessible and tended areas, which are to be regularly evaluated and reported on, so that timely adjustments in techniques can be carried out.
f. Apart from evaluation reports, one of the main outcomes of the trials is to be a "Manual for restoration/rehabilitation of degraded peat swamp forests", that includes guidelines on silvicultural techniques, species selection and propagation, and site selection. This is to be produced by the Silviculture/ Rehabilitation Specialist.

iv) Nurseries. As indicated in 4.4, At least two new nurseries should be established as soon as possible for restoration/rehabilitation programmes, namely: a) near the newly refurbished National Park resort office near the mouth of the Air Hitam Dalam, and b) in the lower course of the Air Hitam Laut, between Air Hitam Laut village and the park border. NP staff should be trained in nursery management and propagation techniques and involved from the beginning, while local community members should be recruited for planting trials and eventual replanting programmes. The nurseries will need to be established in areas that are not subject to prolonged, deep flooding (although some flooding would be permissible), and should be able to eventually increase to a size of about 1-2 ha. Netting will be required for shading, along with plastic sheeting for establishing beds, polybags, trays, soil for planting medium, fertiliser and labels. Training should be provided by a skilled person – intensively during nursery establishment, and intermittently thereafter to solve possible problems encountered. A small boat (*ketek*) will be required (at each nursery) for obtaining propagules, and for transport of seedlings during trials. A section on propagation techniques and nursery establishment and management is to be included in the manual mentioned in iii.f.

v) Restoration/rehabilitation programme. This is to be based on the site selection plan and the outcome of the trials, but will also be strongly dependent on local willingness to participate and the availability of funds. With the exception of PT. DHL's *jelutung* plantation, only trial planting has been carried out in and around peat swamp forests at Berbak NP to date. The present project will also not be able to achieve more than trials as well, as there are too many uncertainties regarding species suitability, planting methodology, tending required after planting. More importantly, the situation in and around Berbak NP is not conducive to a large-scale replanting programme, as illegal logging is widespread and rampant. This will need to be controlled before any significant investment is made in restoration. Such a programme should be developed by the SRS towards the end of the current project.

The rehabilitation/restoration programme developed by the Project and presented at the Inception Workshop in Jambi on 21-22 May 2003, identified eight activities that are to be carried out at Berbak NP. These are commented on in Table 6.1. A Terms of Reference for the Silviculture/Rehabilitation Specialist is provided in Annex 6.

TABLE 6.1
Comments on the present rehabilitation programme

Activity identified during inception workshop	Comments
1. Survey to identify Rehabilitation Sites in BNP. a. Physical survey b.Social survey related to rehabilitation activity. Target of the survey: i) identification of indigenous species; ii) identification of appropriate sites for rehabilitation; iii) supporting data, consisting of soil, depth of peat, vegetation, etc; iv) perception and willingness to rehabilitate; and v) grouping of rehabilitation sites into zones.	Dutch students will focus on 1.i, and the Silviculture/Rehabilitation Specialist (SRS) should focus on discussions with local community members (1.iv) and the production of a site selection plan (1.ii/1.v).
2. Formulating of rehabilitation plan. This is to include a work plan for rehabilitation including: silviculture techniques, appropriate species, schedule, budget, etc.	One of the main outputs of the project is to be a "Manual for restoration/rehabilitation of degraded peat swamp forests", which should largely be drafted by the SRS, with inputs from other specialists.
3. Community empowerment in villages surrounding BNP. Community awareness of the importance of rehabilitation.	While awareness creation will occur during discussions with the SRS, a fully-fledged awareness programme is uncalled for until initiation of a large-scale restoration programme; this is beyond the scope of present project.
4. Rehabilitation training for villagers surrounding BNP.	This will occur when local community members are involved in restoration trials and nursery establishment/management. Further training is beyond the scope of present project.
5. Ex-burnt forest rehabilitation in BNP; a. seedling production; b. planting; c. tending.	Apart from nursery establishment and trials planting, this is beyond the scope of present project.
6. Provide small grant to villagers to carry out rehabilitation in degraded peatlands.	While some incentive is required to generate local interest in participating in restoration trials and nursery establishment, simply providing grants to locals for peatland rehabilitation is unlikely to be effective and is not advised.
7. Monitoring and Evaluation.	M&E forms an essential part of any project or programme, and is vital in order to learn from restoration trials, nursery establishment, and species selection programme.
8. Inventory of existing seedlings in Hutan Lindung Gambut (peat protected forest), Taman hutan raya (grand forest park), and BNP; to determine the treatment for each site; is there a need or no need for "enrichment planting. Present forest condition of peat swamp forest, Tahura , Berbak National Park identified.	Unnecessary and not advised, apart from a rapid assessment of each site targeted by the site selection programme prior to restoration trials.

6.2 BUDGET AND RECOMMENDED WORK PLAN FOR THE CURRENT PROJECT

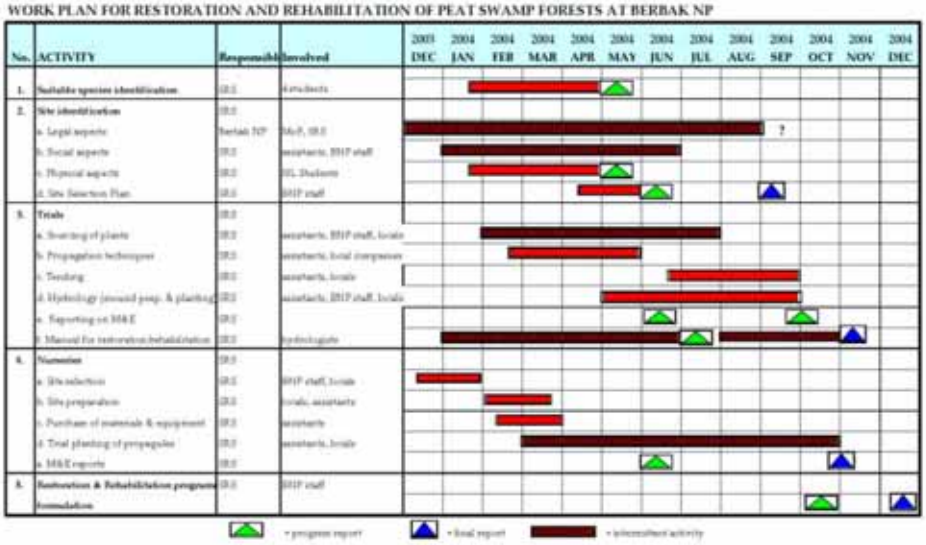
As described in 6.1, activities of the Silviculture/Rehabilitation Specialist should concentrate on site identification for trials, implementation of restoration trials, and the establishment of nurseries. In addition, species selection is to be refined, and this can best be done by drawing upon the studies that are to be carried out by the Dutch and Indonesian students in the first quarter of 2004. A proposed budget for the restoration and rehabilitation programme is provided in table 6.2, and a proposed time table for implementation is given in table 6.3.

TABLE 6.2
Budget for the restoration & rehabilitation programme

No.	ACTIVITY	Items covered	US$	Indonesian Rupiah equivalent
1.	**Suitable species identification**	support for 2 Indonesian students	1500	Rp12.450.000,00
		identification of species at Bogor Herbarium	1500	Rp12.450.000,00
		Subtotal 1:	*3000*	*Rp24.900.000,00*
2.	**Site identification**			
	a. Legal aspects	meetings	200	Rp1.660.000,00
	b. Social aspects	transportation, awareness material, meetings	2000	Rp16.600.000,00
	c. Physical aspects	*ketek*, fuel, maps	3500	Rp29.050.000,00
	d. Site Selection Plan	meetings, transportation	1200	Rp9.960.000,00
		Subtotal 2:	*6900*	*Rp57.270.000,00*
3.	**Trials**			
	a. Sourcing of plants	transport, daily labour	3000	Rp24.900.000,00
	b. Propagation techniques		7000	Rp58.100.000,00
	c. Tending		5000	Rp41.500.000,00
	d. Hydrology	construction of mounds at various levels, planting	15000	Rp124.500.000,00
	e. Reporting on M&E	Report production	200	Rp1.660.000,00
	f. Manual for restoration/rehabilitation	Report production, including colour prints	3500	Rp29.050.000,00
		Subtotal 3:	*33700*	*Rp279.710.000,00*
4.	**Nurseries**			
	a. Site selection	compensation & transportation	12500	Rp103.750.000,00
	b. Site preparation	clearing, mulching, netting, field camp	5000	Rp41.500.000,00
	c. Purchase of materials & equipment	fertilisers, polybags, sprays, obat, shovels, pruners, secateurs, bags, rope	2500	Rp20.750.000,00
	d. Trial planting of propagules	daily wages	7500	Rp62.250.000,00
	4. M&E reports	reports	350	Rp2.905.000,00
		Subtotal 4:	*27850*	*Rp231.155.000,00*
5.	**Restoration & Rehabilitation programme formulation**	draft and final report	1000	Rp8.300.000,00
		Study tour(s)	2500	
		Assistants (field assistant + support staff)	4900	Rp40.670.000,00
		TOTAL	79850	Rp662.755.000,00

TABLE 6.3
Work Plan for the restoration & rehabilitation programme

WORK PLAN FOR RESTORATION AND REHABILITATION OF PEAT SWAMP FORESTS AT BERBAK NP



CHAPTER 7 Recommendations for capacity building in reforestation techniques & peat swamp management

7.1 LOCAL CONCESSION HOLDER

The ToR of the consultant states that he should "Support the development of capacity building activities for concession holder and National Park staff in reforestation techniques and peat swamp management". However, there appears to be a lack of genuine interest by PT. PDIW in peat swamp forest restoration (e.g. the company's minimal investment to date, inappropriate techniques used[28], and it's proposal to convert the area), and PDIW also appears to be involved in illegal logging activities in Berbak NP (at a minimum, by default, by allowing teams of illegal loggers to use its rail system). The consultant therefore considers any investment in capacity building of PT. PDIW as a waste of scarce resources, better spent on other components of the Project.

7.2 NATIONAL PARK STAFF

National Park staff are to be closely involved in the restoration and rehabilitation programme, and will be ultimately responsible for implementing the programme beyond the life of the Project. Training will be required for:

- establishing and managing the two nurseries, to produce material for replanting in Berbak NP; and
- planting techniques and managing replanted areas.

Most of this will be achieved by on-the-job training, i.e. provided by the SRS, who will involve Berbak NP staff in all field activities. Berbak NP should appoint staff who are to be primarily responsible for these field activities, notably one staff member at Air Hitam Dalam resort, and a second at Air Hitam Laut resort. At the same time, one staff member based in Nipah Panjang park field hq and one based in Jambi should also be involved. The latter are to be responsible for coordination within Park administration, and need not to be

[28] Especially the widespread planting of the exotic *Acacia crassicarpa*, and the excavation of drainage canals in the few areas that have been replanted are considered totally inappropriate.

physically involved, but only have an understanding of activities to be undertaken. The SRS will produce a manual for peat swamp forest restoration, in cooperation with other specialists on the Project, and this will include techniques for sourcing of material, propagation, nursery establishment and management, replanting of degraded areas, and tending and further management of replanted areas.

In addition to on-the-job training, Berbak NP staff may also receive training by apprenticeship at an already established nursery in the area, for example at PT. DHL or PT. PDIW. The former would seem most suitable, as this is by far the more professional example in the area.

Provided that trial results are positive and that both client (PT. Caltex Pacific Indonesia) and implementing agency (IPT, Bogor) agree, a study tour to the trial areas in Riau by the SRS and several staff of Berbak NP may also be considered.

CHAPTER 8 Conclusions

1. Peat swamp forests of Southeast Asia have long been poorly studied, and our current knowledge of their composition, dynamics and ecology remains incomplete in spite of a surge in studies during the past decade. During the past decade-and-a-half interest in this habitat increased significantly.

2. Although large tracts of peatland remain, peat swamp forests in Southeast Asia have been reduced to a fraction of their former area. By 1990, 54.6% of all wetland and marsh ecosystem had been lost in the Indo-Malayan realm – much of this habitat formerly consisted of swamp forest. With most of the remaining peat swamp forests occurring in Indonesia and Malaysia, developments in these two countries is particularly pertinent to the conservation and sustainable use of these ecosystems.

3. Most of western Indonesia's swamp forests have not fared well during the past decades, and much has disappeared, either being converted for agriculture (esp. rice paddies) or tree crop estates (HTI, e.g. oil palm), or having been severely degraded and abandoned (e.g. large tracts of sedge-fern *belukar*). Peat swamp and freshwater swamp forests in Sumatra formerly covered an area of 92,865 km², but by 1982-3 only two-thirds (63,790 km² or 68.7%) remained. By 1988 this had decreased to 57,506 km² (61.9% of original area), of which only 8,683 km² (9.3%) could be considered primary forest. Logging and conversion has continued in these habitats since then. By 2003, most of the logging concession companies have discontinued operations as the resource has been depleted, and the logging industry is now largely the realm of rogue companies. Peat swamp forests – most of which had the status limited production forest (HPT) or peat protection forest (HLG) – have been severely degraded, converted (e.g. for pulp production), and have been the locus of widespread fires that have been common in lowland Sumatra since the mid-1990s.

4. A significant proportion (>3/4's) of the remaining peat swamp forest in Jambi province occurs in Berbak NP. The part has, unfortunately, been degraded since 1990, mainly due to illegal logging and fires. Fires occurred in 1994, and major fires occurred again in 1997, destroying >12,000ha in the central, core area of the Park along the Air Hitam Laut, and ±4,000ha along the Simpang Melaka River. It is estimated that at least 25% of the Park has been affected by ilegal logging and subsequent fires.

5. A wide variety of non-timber forest products (NTFPs) are harvested in Berbak NP, including *jelutung*, honey, fruit and rattan. Also, the area has long been populated by fisherfolk that mainly target large species such as *Wallago* catfish and snakeheads *Channa* species. Although these activities add to a general disturbance in the park, lead to the decline or disappearance of certain species, and their presence may be the direct cause of accidental fires, harvesters of NTFPs and fisherfolk are not considered to be the main threat to the integrity of the park.

6. The main cause of the fires appears to be illegal logging – analysis of satellite images from 1983-2003 shows logging disturbance occurring in areas that were later burnt. In spite of an upgrade in status to that of National Park following the 1997 fires, illegal logging is still rampant and widespread in Berbak NP. During October 2003, 26 illegal camps – mainly being used by illegal loggers – were recorded in the Park along the upper course of the Air Hitam Laut River alone. Active signs of illegal felling were also recorded at the Air Hitam Dalam and along the Simpang Melaka. Reportedly, local government, military and police are actively involved in illegal logging, along with local entrepreneurs. HPH's also share in the blame for illegal logging activities. Most of the illegal logging in the core zone of the Park prior to the 1997 fires made use of the infrastructure put in place by PT. SDR, while current illegal logging along the upper course of the Air Hitam Laut makes full and unimpeded use of PT. PDIW's rail system, which is the only outlet for timber poached in the western part of the Park.

7. The current survey visited Berbak NP from three sides: upper Air Hitam Laut (via PT. PDIW's rail system and along the river), lower Air Hitam Laut and Simpang Melaka (via the coast), and the Air Hitam Dalam (via the Batanghari River). In all three areas, known burnt sites (as previously identified on the satellite images) were visited, and rapid surveys were conducted at each site. The consultant had previously visited the latter two areas in 1990, and concludes that the changes in these areas (and degradation of the Park) during the past 13 years have been very significant.

8. In all, 142 plant species belonging to 57 families and representing 119 genera were identified during the rapid surveys. On average, 18.6 species were identified per site surveyed, varying from only 2 species (site 1; a repeatedly burnt site) on the upper AHL, to 68 species (site 19, riparian) on the Air Hitam Dalam. On the whole, there is little difference in species diversity between burnt sites and riparian vegetation in the Air Hitam Laut and Simpang Melaka area, while in the Air Hitam Dalam area riparian vegetation is about twice as biodiverse. There is a marked difference in diversity between Air Hitam Laut and Simpang Melaka on the one side, and Air Hitam Dalam on the other side, and the latter is 2-4 times as diverse, depending on the condition of the site.

9. A total of 87 plant species were recorded at the burnt sites, of which 26 species can be considered common in these areas. These include 11 tree species, 6 climbers, 3 ferns, 3 sedges 2 palms and 2 grasses. Burnt areas are often characterised by a prolific growth of a limited number of species. In the upstream Air Hitam Laut area and along the Simpang Melaka, most sites are dominated by the ferns *Stenochlaena palustis* and *Blechnum indicum*, often accompanied by *Pandanus helicopus* and the sedges *Thoracostachyum bancanum, T. sumatranum* and *Scleria purpurescens.* In the downstream section of the large burnt area along the Air Hitam Laut, near Simpang Kubu, secondary vegetation is dominated by *Macaranga*

and palms (esp. *Licuala*). Burnt areas along the Air Hitam Dalam are characterised by the presence of many saplings, and dense thickets of bamboo and Zingiberaceae.

10. The burnt areas varied widely in terms of total vegetation cover and tree cover. At some sites of repeated burning, total vegetation cover was very low and not more than about 5-10 %. In all, though, total vegetation cover in the burnt sites averaged at 67%, while that of riparian habitats, primary peat swamp and selectively logged peat swamp was close to 100%.

11. Tree cover in the non-burnt sites varied from 1-10% in the riparian habitats, and was 90-100% in the primary and selectively logged peat swamp sites. Most trees found in the burnt areas appeared to be newly established (esp. *Alstonia* and *Macaranga*), but it was also observed that *Mallotus, Combretocarpus* and *Eugenia* species were resprouting from previously established and partly charred trunks. Both of the palm species found in burnt areas – *Licuala paludosa* and *Pholidocarpus sumatranus* – appear able to withstand (limited) fires.

12. In addition to the eventual emergence of s true fire sere, the occurrence of repeated fires is expected to lead to the emergence of (seasonal) lake habitats. As peat layers are burnt, it will become more and more difficult for peat swamp forest species to establish themselves in the degraded areas, as the depth and duration of flooding will become inimical to their growth. The emergence of the peat swamp lake habitat can already be observed along the Air Hitam Laut, where the only species that can be found in areas that have burnt repeatedly (and are deeply flooded) are *Pandanus helicopus* and *Thoracostachyum bancanum*.

13. Although Thailand has little peat swamp forest compared to Malaysia and Indonesia, it has the most experience and longest history of peat swamp forest restoration and rehabilitation in the region. Some of these efforts date back to more than 40 years, while those of the Royal Forest Department date back more than a decade. Examples from Vietnam and Malaysia are limited and most consist of trials still at an early stage. There has been very little restoration and rehabilitation of peat swamp forests in Indonesia, and the few examples available (e.g. *Rehabilitation of peatlands and establishment of sustainable agro-system in Central Kalimantan*, and IPB's reforestation of degraded areas for PT Caltex Pacific Indonesia in 2002, in the Duri and Minas Oil Field Operation areas in Riau province) are little more than trials. Various attempts at replanting degraded peat swamp forest have been carried out in and around Berbak NP, but all are small scale and can be regarded as trials only: there is no active restoration or rehabilitation programmme ongoing. An exception to this is the *jelutung* and *pulai* plantation of PT. Dyera Hutan Lestari (PT. DHL), as this company has successfully replanted large (albeit monoculture) areas (>1700 ha) – a significant achievement given the constraints. Two trial plantings were carried out in 2002 by the Forestry Department at the burnt area along the Simpang Melaka River in Berbak NP, on a 1-ha and on a 5-ha site, using *jelutung, pulai* and *medang*. However, both areas had a 100% mortality rate, probably due to deep, prolonged flooding. CCFPI is carrying out trials using mounds (October 2003) to overcome the flooding problem, but these are only just being planted at present, and results will not be available until mid-2004.

14. About 28 species are used in various reforestation and rehabilitation programmes in Southeast Asia, and of these, nine species have both been successfully planted and are known to occur at Berbak National Park, namely *Alstonia pneumatophora (pulai), Combretocarpus rotundatus (tanah-tanah), Dyera lowii Ganua motleyana, (jelutung), Gluta wallichii (rengas), Gonystylus bancanus (ramin), Macaranga* sp. (esp. *M. pruinosa - mahang), Palquium* sp. (*nyatoh*) and *Shorea pauciflora (meranti rawa).* During the present survey, the following trees and palms were identified as being common in burnt areas, and therefore of interest to future restoration programmes in Berbak NP:

- trees: *Alstonia pneumatophora, Combretocarpus rotundatus, Elaeocarpus* sp.43, *Eugenia spicata, Eugenia* sp.8, *Ficus spp., Macaranga pruinosa*, *Mallotus muticus* (also known as *Coccoceras borneense), Neolamarckia cadamba ('Nauclea'* sp.47), *Pandanus helicopus;*
- palms: *Licuala paludosa* and *Pholidocarpus sumatranus.*

15. Restoration of the concession areas adjacent Berbak NP is not of primary concern at present, but what urgently needs to be done is:

- Immediately halt illegal logging activities in the area. As the main outlet for illegally felled timber is PT. PDIW's rail system, the best option for protection of remaining forests is to close and dismantle the rail system (and associated canals) as soon as possible.
- Lobby the Ministry of Forestry in Jakarta to prevent the change in status of the area from HPT to that of Conversion Forest (the latter is being lobbied by PT. PDIW and Local Government).
- Establish a Berbak NP (Taman Nasional) presence in the western half of the Park (notably absent at present).

16. Based on the present assessment of the conditions at Berbak NP, restoration and rehabilitation of degraded peat swamp forest at Berbak NP will require the following:

1. Species identification, of species suitable for restoration programmes.

2. Site identification. Vast areas (>20,000 ha) in Berbak NP are heavily degraded and all degraded sites may potentially be targeted by restoration programmes. However, funds are limited, and there are various constraints to such a 'blanket' approach, including legal, social and physical contraints. These will need to be addressed, followed by the subsequent production of a Site Selection Plan.

3. Trials. Trials should be carried out by the Silviculture/Rehabilitation Specialist, supported by 1-2 field assistants, Berbak NP staff, and members of the local community. Trials should focus on sourcing, propagation techniques, tending techniques, (coping with changes in) hydrology, regular reporting on monitoring and evaluation, and the production of a "Manual for restoration/rehabilitation of degraded peat swamp forests'.

4. Nurseries. At least two new nurseries should be established as soon as possible, one in the lower Air Hitam Laut area, the second near the mouth of the Air Hitam Dalam.

5. Restoration/rehabilitation programme. This is to be based on the site selection plan and the outcome of the trials, but will also be strongly dependent on local willingness to participate and the availability of funds. More importantly, the current situation in and around Berbak NP is not conducive to a large-scale replanting programme, as illegal logging is widespread and rampant. This will need to be controlled before any significant investment is made in restoration.

17. As there appears to be a lack of genuine interest by PT. PDIW in peat swamp forest restoration, and PDIW also appears to be involved in illegal logging activities in Berbak NP, any investment in capacity building of PT. PDIW is considered a waste of scarce funds, better spent on other components of the Project.

18. National Park staff are to be closely involved in the restoration and rehabilitation programme, and will be ultimately responsible for implementing the programme beyond the life of the Project. Training will mainly be required for establishing and managing the two nurseries, to produce material for replanting in Berbak NP; and planting techniques and managing replanted areas.

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ANNEX 1 Itinerary

Date	Location	Activities
29 September	Amsterdam – Jakarta	Leave home base at 06:30, flight MH 711 from Amsterdam to Kuala Lumpur at 12:00.
30 September	Jakarta – Bogor	Arrive in Jakarta Cengkareng at 10:30, and in Bogor at 12:30. Meeting at Wetlands International – Indonesia Programme office from 15:00-17:30. Meet and discuss project with Nyoman Suryadiputra and Yus Rusila Noor.
1 October	Bogor	08:30 WI-IP meet with Nyoman and Pak Dibyo. 10:00-11:00 Bogor Herbarium, meet with: ▪ Herwint Simbolon (research scientist LIPI) to discuss regeneration plot monitoring ▪ Ms. Afriastini (plant taxonomist of herbarium) to discuss plant identification 1:30-14:30 CIFOR, meet with: ▪ Takeshi Toma (Scientist Rehabilitation of Degraded Tropical Forest Ecosystems), discuss rehabilitation programme & evaluation study ▪ Daniel Murdiyarso (Scientist), discuss past activities on forest fire programme in Jambi/Sumsel ▪ Tini Gumartini (Research Assistant of TT) ▪ Nia Sabarniati (Communications Administration)
2 October	Bogor – Jambi	Leave Bogor for Cenkareng airport at 07:00; flight Mandala 020 to Jambi at 10:50; arrive Jambi 12:00, check in at Hotel Tepian Ratu. Meet with Iwan Tricahyo Wibisono (Yoyok), responsible for the project's rehabilitation programme. 14:00-15:00, Dinas Kehutanan, meet with ▪ Ir. Gatot Moeryanto (Kepala Dinas) 15:00-16:00, meet at Taman Nasional, meet with: ▪ H. Soemarno (Wakil Kepala TN) ▪ Mr. Rohman Fauzi (field staff Berbak NP) Meeting with Yoyok & Pak Farit (TN) 19:30-20:45 to discuss field work itinerary, further meetings, and student involvement.
3 October	Jambi	08:30-9:45 meeting at BP-DAS (formerly RLKT): ▪ Ir. H. Ahriman Ahmed (head) to discuss problems associated with reforestation, previously and under the current decentralisation programme. 09:45-10:30 meeting with PUSDALKARHUTLA, met: ▪ Ir. Joko Fajar Kiswanto (Coordinator)

		▪ Mr. O. Soeparman (technical head), to discuss fire monitoring programme, and # fires in Berbak NP. 10:30-11:15 meeting at Bappeda, with: ▪ Ir. Helbar (MTP), to discuss land use issues in and around Berbak NP 11:30-12:15 meeting at PT Dyera Hutan Lestari, met: ▪ Mr. Hamri P. Rosera (Director of Production), to discuss their jelutung *Dyera lowii* plantation on deep peat near Sungai Aur, along the Batanghari River.
4 October	Jambi-BNP (western section)	10:00-11:00 meet Ir. Hari Subagyo, Alas Kusuma Group (PT Putra Duta Indah Wood). 12:45 leave Jambi for Suka Berajo, ±60km from Jambi; arrive 13:45; take boat (*pompong*) from there to PDIW's Log Pond Camp located along the Sungei Kumpei (10 minute journey). Visit camp nursery. Leave camp at 19:00 by logging rail (*naik lori*) to PDIW's Kem Pembinaan, located 13 km from the Log Pond Camp; arrive 20:30. Spend night at Kem Pembinaan. Field team = WG, Iwan Tricahyo Wibisono & Hendarto (both WI) & Habibi (TNB).
5 October	BNP (western section)	Leave Kem Pembinaan at 07:00 with a small *ketek*, boatsman is Dawi M. from Pematang Ram; team further includes Kadri (PDIW). Survey a number of burnt sites, and spend the night at Kem Panjang, a location with 6 *pondok* (huts), about 1.5 km from the large burnt area in the BNP core zone.
6 October	BNP (western section)	07:00: Travel to Simpang "T", located at the centre of the burnt core zone area, and survey burnt sites on the way back to Kem Panjang. Stop at Kem Raket for lunch and discussion with fishermen and the *Pemadam Kebakaran TN. Berbak* (BNP's fire-fighting team). Spend night at Kem Panjang.
7 October	BNP (western section)	Leave Kem Panjang at 07:15; stop at hydrology transect #3 in 'intact' forest (the site is in fact being illegally logged); meet up with the hydrology team and two Dutch guests (including Henk Wösten, Henk Ritzema). Travel to Kem Pembinaan. Visit and survey hydrology transects 1 & 2 in afternoon. Spend night in Kem Panjang.
8 October	BNP-Jambi	07:30, leave Kem Pembinaan by *lori.* Visit PDIW's reforestation sites – *Acacia crassicarpa* and *rengas* – on the way to the Log Pond Camp. Arrive at LPC at 10:00; take boat to Suka Berajo, spend the better part of an hour locating a vehicle to take us to Jambi. Arrive in Jambi at 12:30; spend night in Abadi Hotel.

9 October	Jambi	09:00-10:00 meeting at Dinas Pertambangan dan Energi (Mining & Energy Service); meet with: ▪ Ir. Akhmad Bakhtiar Amin, Kepala Dinas, to discuss possible mining activities in and around BNP. 10:15-11:30, meeting at the KSDA office with ▪ Aziz Sembiring (ex head of Berbak Wildlife Reserve, before it became a NP; now kepala Seksi Wilayah 2, Batanghari) & Pak Saring (KSDA) to discuss past activities / disturbances in/around BNP. 12:00-13:45: meeting and lunch with the field team to prepare/discuss the next field trip. Prepare field notes for report.
10 October	Jambi-Nipah Panjang	By vehicle to Suak Kandis (80 km from centre of Jambi township); from there take project speedboat to Nipah Panjang. Arrive early afternoon. Arrange large boat (*pompong*) for trip to Air Hitam Laut the next day. Discussions with Berbak NP staff (esp. Pak Ismail) at the park headquarters.
11 October	Nipah Panjang-Air Hitam Laut-Simpang Melaka	Leave Nipah Panjang by *pompong* at 09:00 (awaiting incoming tide), arrive at Air Hitam Laut at 14:15. Meet with Kepala Desa to discuss itinerary. Meet with BNP Air Hitam Laut Resort staff (including Ponimon, Farit). Move on to Simpang Melaka to spend the night (some on the boat, some in the *pos jaga* / guardpost).
12 October	Simpang Melaka	Survey of the burnt areas along the Simpang Melaka, the riverine forest, and the trial planting areas of the Forestry Department. Spend night as on 11 October.
13 October	Simpang Melaka-Air Hitam Laut	Survey of burnt areas along the Air Hitam Laut in the direction of Simpang Kubu.Return to Air Hitam Laut village in the late afternoon – spend the night at the 'Resort' office.
14 October	Air Hitam Laut-Nipah Panjang-Jambi	Leave Air Hitam Laut by *pompong* at 06:00; arrive at Nipah Panjang at 11:00. Visit the Berbak NP office. Travel back to Jambi by speedboat, arriving mid-afternoon.
15 October	Jambi	Morning: field note compilation + meeting with Yoyok. Afternoon: meeting from 14:30-15:30 with: ▪ Istanto (Kepala Balai TN Berbak), and ▪ Indra Arinal (WI-IP Sumatra Site Coordinator for the CCFPI project), to discuss changes Berbak NP. Late afternoon meeting with Agus (University of Jambi, Hydology Department) to discuss drying of herbarium samples at their laboratory.

16 October	Jambi-Air Hitam Dalam	08:30 leave for Air Hitam Dalam by speedboat. Visit PT Dyera Hutan Lestari; meet with manager Mr. Bambang Handoko; discuss management issues, and visit the nursery. Head for AHD; visit new BNP AHD resort (under construction); survey riparian section of AHD. Spend night at DHL field station.
17 October	Air Hitam Dalam – Jambi	Leave for AHD at 07:00; travel by sampan and survey burnt areas. Return to DHL at 14:00. Visit *jelutung* plantation with field operations manager, Mr. Tulus. Leave for Jambi at 16:00, arriving at 18:30. Spend evening handling herbarium samples.
18 October	Jambi – Bogor	Morning: work on field notes and produce photo CDs of Berbak NP for Yoyok and Mr. Istanto, head of TN. Meet with Pak Nyoman (WI-IP) at 13:30-14:00. Join CCFPI evaluation workshop from 14:00-16:00. Leave for Jakarta via Merpati at 17:40, arriving 19:00. Arrive in Bogor at 21:00.
19 October	Bogor	Treat herbarium samples with methylated spirits. Work on field notes, and draft outline for final report.
20 October	Bogor	Visit Herbarium Bogoriense to submit herbarium samples from Berbak NP. Work on draft report at Wetlands International office. Return to herbarium in afternoon to collect dried samples of specimens to be identified by the consultant.
21 October	Bogor	Identification of subset of herbarium samples at the Wetlands International office, using flora's available at the office (e.g. Flora Malesiana). Work on draft report.
22 October	Bogor	Works on draft report at the Wetlands International office. Visit Bogor Herbarium; check specimens and leave note on which priority species to concentrate on for identifcation.
23 October	Bogor	Early morning: work on report. Rest of day = leave.
24 October	Bogor	Leave.
25 October	Bogor-JKT-Kuala Lumpur	Meeting with Faizal Parish (Global Environment Center) from 09:00-10:00. Leave for airport at 10:15. Flight to Kuala Lumpur (MH720) at 15:00. Arrive at KL at 18:00; work on report until 22:00. Flight MH 016 to AMS leaves at 23:45.

ANNEX 2 Site survey results: relevees

ANNEX 2.

Site survey results: relevees

				Relevee Sites																		
Family	**Species**	**Coll.**	**Local name**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**
Amaryllidaceae	*Crinum asiaticum*		?																			+		
Anacardiaceae	*Campnosperma auriculata*		terentang		+						+	+			+									
Anacardiaceae	*Gluta renghas*		rengas																			+		
Anacardiaceae	*Gluta wallichi*		rengas (-manuk)				+				+	+		+							+	+		
Anacardiaceae	*Mangifera foetida*		mangga hutan																			+		
Annonaceae	*?*		pisang-pisang																+		+			
Apocynaceae	*Alstonia pneumatophora*		pulai				+	+	+		+	+		+					++				+	
Apocynaceae	*Cerbera odollam*		?																			+		
Apocynaceae	*Dyera lowii*		jelutung								+	+	+	+										
Apocynaceae	*Palaquium* sp.		balam								+													
Araceae	*Lasia spinosa*		?													+						+		
Araliaceae	*Schefflera* sp.						+																	
Arecaceae	*Calamus* sp.		rotan																			+		+
Arecaceae	*Caryota mitis*		?																			+		
Arecaceae	*Eleiodoxa (Salacca) conferta*		asem payau									+												
Arecaceae	*Korthalsia ?flagellaria*		rotan									+						+				+	+	
Arecaceae	*Licuala paludosa*		palas														+	+	++			++		
Arecaceae	*Pinanga salicifolia*	*#29*	?														+				+	+		
Arecaceae	*Oncosperma horridum*		?														+							
Arecaceae	*Oncosperma tigillaria*		nibung													+								
Arecaceae	*Pholidocarpus sumatranus*		liran					+							+		+							

Family	Species	Coll.	Local name	Relevee Sites																			
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Asclepiadaceae	*Dischidia nummularia*		?									+	+											
Aspleniaceae	*Asplenium nidus*		?								+													
Asteraceae	*Mikania micrantha*		?																				+	
Asteraceae	*Crassocephalum crepidioides*	*#68*	?																				+	
Asteraceae	*Emilia sonchifolia*	*#69*	?																				+	
Bambusidae	*Gigantochloa* sp.	*#62*	bambu					+															++	+
Blechnaceae	*Blechnum indicum*	*#12*	pakis				+					++	+	++	+++				++		++		++	
Blechnaceae	*Stenochlaena palustris*		pakis			++	++	+	+++	++		++	+	+++	+++	++	+++	++	+++	++	+++		++	++
Bombaceae	*Durio carinatus*		durian burung kedondong								+	+												
Burseraceae	*?*		hutan																				+	
Clusiaceae	*Garcinia* sp.		asem-asem								+	+							+		+			
Combretaceae	*Terminalia catappa*		ketapang																			+		
Connaraceae	*Connarus* sp.	*#32*	?															++						
Cyperaceae	*Cyperus halpan*		?													+						+		
Cyperaceae	*Mapania cuspidata* var. *cuspidata*	*#63*	?																				+	
Cyperaceae	*Rhynchospora corymbosa*	*#35*	?													+								
Cyperaceae	*Scirpus grossus*		?																			+		
Cyperaceae	*Scleria purpurascens*	*#14+15*	?					++	++	+				+	+		++	+				+	+	+
Cyperaceae	*Scleria sumatrana*	*#13*	?					+																
Cyperaceae	*Scleria terrestris*	*#19*	?									+		+										
Cyperaceae	*Thoracostachyum bancanum*		?	+++	+	+						+	+	+							+	+		
Cyperaceae	*Thoracostachyum sumatranum*		?			+			++							++		+	+	++		+		+

Family	Species	Coll.	Local name	Relevee Sites																			
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Dilleniaceae	*Dillenia serrata*																					+		+
Dilleniaceae	*Dillenia excelsa*	*#55*	simpur																			+		+
Dipterocarpaceae	*Shorea palembanica*	*#59*	gelabak																			+		
Dipterocarpaceae	*Shorea pauciflora*		meranti rawa								+	+			+									
Ebenaceae	*Diospyros* sp.	*#58*	kayu hitam																			+		+
Ebenaceae	*Diospyros siamang*	*#18*	arang-arang						+		+	+	+	+				+			+			
Euphorbiaceae	*Aleurites moluccana*		kemiri																				+	
Elaeocarpaceae	*Elaeocarpus palembanicus*	*#43*	?											+										
Elaeocarpaceae	*Elaeocarpus petiolatus*	*#23*	?																	+	++	+	+	+
Euphorbiaceae	*Bridelia stipularis*	*#51*																				+		
Euphorbiaceae	*Croton caudatus*	*#52*																				+		
Euphorbiaceae	*Macaranga pruinosa*	*#6*	mahang				+		+					+	++		+		++		++	+	+	+
Euphorbiaceae	*Macaranga* cf. *semiglobosa*	*#17*	mahang sarang semut sarang									+		+								+	+	
Euphorbiaceae	*Macaranga motleyana*	*#66*	semut																			+	++	+
Euphorbiaceae	*Mallotus muticus (Coccoceras borneens*		perupuk				+		+				+	+			+		+					
Flacourtiaceae	*Flacourtia rukam*		rukam																			+		+
Flagellariaceae	*Flagellaria indica*		?				+		+								+						+	
Flagellariaceae	*Hanguana malayana*		bakung		+		++	+												++				
Gleicheniaceae	*Dicranopteris linearis*	*#33*													++				+++					
Hypericaceae	*Cratoxylon ?arborescens*		gerongang								+													
Hypolepidaceae	*Pteridium aquilinum*		?					+															+	
Icacinaceae	*Stemonurus secundifolius*		pasir-pasir																				+	
Lauraceae	*?*		medang								+	+												
Lecythidaceae	*Barringtonia reticulata*	*#31*	putat				+	+	+							+				+		+		

Family	Species	Coll.	Local name	Relevee Sites																		
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Lecythidaceae	*Barringtonia racemosa*	*#57*	putat																			+		
Leguminosae	*Archidendron clypearia*		?									+	+											
Leguminosae	*Derris heterophylla*	*#30*	?													+								
Leguminosae	*Derris tetraphylla*	*#60*	kacang-kacang																			+		
Leguminosae	*Koompassia malaccensis*		kempas								+													
Lentibulariaceae	*Utricularia exoleta*		?													+				+				
Lythraceae	*Lagerstroemia speciosa*		bungur																			+		
Malvaceae	*Hibiscus tiliaceus*		waru																			+		
Malvaceae	*Thespesia populnea*		waru																			+		
Marantaceae	*Donax canaeformis*	*#67*	berembang																			+		+
Melastomaceae	*Medinilla ?motleyi*	*#7*	?		+	+	+									+								
Melastomaceae	*Melastoma affine*		harendong																		+			
Melastomaceae	*Melastoma malabathricum*		harendong					+	+					+	++		+		+	+	++			
Melastomaceae	*Memecylon myrsinoides*	*#40*														+								
Moraceae	*Artocarpus elasticus*		terap																			+	+	
Moraceae	*Ficus deltoidea*	*?27+28*	ara											+		+		+				+		
Moraceae	*Ficus globosa*	*#24*	ara											+				+						
Moraceae	*Ficus microcarpa*		beringin																			+		
Moraceae	*Ficus sumatrana*		ara																					+
Moraceae	*Ficus sundaica*	*#41*	ara																	+				
Moraceae	*Ficus* sp. 1		ara				+					+												
Moraceae	*Ficus* sp. 2	*#45*	ara																	+				
Moraceae	*Poikilospermum suaveolens*	*#9*	arah hantu				+					+				+						+		
Moraceae	*Poikilospermum scortechinii*	*#61*	?																			+		
Myristicaceae	*Myristica iners*	*#56*	?																			+		+
Myristicaceae	*?*		?									+												

				Relevee Sites																		
Family	**Species**	**Coll.**	**Local name**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**
Myrtaceae	*Eugenia spicata*		temasaman		+						+	+	+	+		+						+		+
Myrtaceae	*Eugenia* sp.2		?			+																		
Myrtaceae	*Syzygium cerina*	*#8*	?			+	+	+	+				+	+	+		+		+	+		+		
Myrtaceae	*Syzygium setosa*	*#20*	?									+												
Myrtaceae	*Syzygium zippelianum*	*#39*	?													+								
Nepenthaceae	*Nepenthes mirabilis*		?									+		+										
Nephrolepidaceae	*Nephrolepis biserrata*	*#34*	pakis		++		+	+								+						+		+
Ochnaceae	*Brackenridgea palustris*	*#37*	?arang-arang													+								
Pandanaceae	*Freycinetia* sp.		?								+	+										+		
Pandanaceae	*Pandanus helicopus*		rasau	++	++	+	+++	+					+			+				+++		+		
Poaceae	*Hymenachne acutigluma*	*#11*						++		+						++	+++	++						
Poaceae	*Imperata cylindrica*		alang-alang					+++															++	
Poaceae	*Paspalum conjugatum*	*#10*						++										+++					++	+
Poaceae	*Phragmites karka*		?																			++		
Poaceae	*Saccharum spontaneum*		gelagah																			+		
Polygonaceae	*Polygonum barbatum*		?																			+		
Polypodaceae	*Drynaria quercifolia*		? eceng				+																	
Pontederiaceae	*Eichhornia crassipes*		gondok																			+		
Pteridaceae	*Acrostichum aureum*		piai													+						+		
Rhamnaceae	*Zizyphus calophylla*	*#70*																				+	+	+
Rhizophoraceae	*Carallia brachiata*		tenggeris																		+			
Rhizophoraceae	*Combretocarpus rotundatus*	*#16*	tanah-tanah						+				+	++										
Rosaceae	*Parastemon urophyllum*		malas																		+			
Rubiaceae	*Gardenia tubifera*	*#46*	asem-asem																+					
Rubiaceae	*Ixora blumei*	*#36*	kopi-kopi												+						++	+		+

				Relevee Sites																		
Family	**Species**	**Coll.**	**Local name**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**
Rubiaceae	*Morinda philippensis*	*#4*	?			+							+	+										
Rubiaceae	*Mussaendopsis beccariana*	*#53*																				+		
Rubiaceae	*Neolamarckia cadamba*		bengkal			+													+				++	+
Rubiaceae	*Psychotria montensis*		?		+						+											+		
Rubiaceae	*Timonius flavescens*	*#26*	?											+										
Rubiaceae	*Uncaria glabrata*	*#3*	akar elang		+	+	+					+			+		+	+	+		+	+		+
Rutaceae	*Acronychia porteri*	*#2*				+																		
Rutaceae	*Evodia aromatica*	*#21*					+					+		+								+		
Sapindaceae	*Pometia pinnata*		matoa																			+		
Sapotaceae	*Ganua motleyana*	*#49*																				+		
Schizaceae	*Lygodium microphyllum*		?					+	++						++			+	++		++		++	++
Theaceae	*Thea* sp.	*#64*																				+		
Theaceae	*Tetramerista glabra*		punak								+	+												
Thymelaeaceae	*Gonystylus bancanus*		ramin								+		+											
Verbenaceae	*Premna ?corymbosa*		?																			+		
Verbenaceae	*Teysmanniodendron hollrungii*	*#54*	?																			+	+	+
Verbenaceae	*Teysmanniodendron pteropodum*	*#65+5*	gak														+					+		+
Verbenaceae	*Teysmanniodendron simplicifolium*		?																			+		
Vitaceae	*Cayratia trifolia*		?																			+		
Vitaceae	*Tetrastigma lanceolarium*	*#50*	?																			+		
Zingiberaceae	*Nicolaia speciosa*	*#72*	puak																				+	+
?Rubiaceae	*?*	*#38*														+								
		#42	kacang-kacang																		+			
			medang seluang																			+		+
			pagar																		+			
TOTAL number of species:				2	9	11	19	18	13	3	18	28	14	24	13	21	15	13	17	12	19	68	27	27

site 1	burnt area, 3 km upstream of BNP boundary	5 October
site 2	riparian zone, between 1 and 3, along river	5 October
site 3	burnt area, large area within BNP, several km upstream of border	5 October
site 4	riparian zone, along AHL in burnt core zone	6 October
site 5	burnt area Simpang "T"	6 October
site 6	2nd site in burnt core, 2 km southwest of Simpang "T"	6 October
site 7	Simpang Raket burnt area (part of core area)	6 October
site 8	IF#1 (first hydrology transect, in 'undisturbed' forest) (NOTE: not exhaustive survey)	7 October
site 9	IF#2 (second hydrology transect, in 'selectively' logged forest)	7 October
site 10	IF#3 (third hydrology transect, in logged and burnt area)	7 October
site 11	burnt and regrown area between two PDIW camps	8 October
site 12	Simpang Melaka 1st burnt area on eastern bank	12 October
site 13	riparian zone, along Simpang Melaka river in burnt area	12 October
site 14	about 1 km (from SE) into large burnt area along Simpang Melaka	12 October
site 15	5 ha replanting trial area in middle of burnt area along Simpang Melaka	12 October
site 16	burnt area Air Hitam Laut, east bank, 3 km into large burnt area approached from downstream side (coast)	13 October
site 17	riparian zone, along AHL river in large burnt area	13 October
site 18	burnt area Air Hitam Laut, west bank, 2 km into large burnt area approached from downstream side (coast)	13 October
site 19	riparian zone along the Air Hitam Dalam	16-17 October
site 20	first large area on east bank, burnt in 1997	17 October
site 21	first area on west bank burnt in 1994 (closer to Batanghari than site 20)	17 October

ANNEX 3 Summary of site characteristics

site #	type of site	% tree cover	vegetation cover	burning	soil	flooding
1	degraded peatswamp forest	0*	40-50	repeated	deep peat	deep
2	riparian habitat	1	100	edge effects	mineral?	very deep
3	degraded peatswamp forest	<1	5-10	repeated	deep peat	deep
4	riparian habitat	10	100	edge effects	mineral?	very deep
5	degraded former freshwater swampforest	1-2	100	repeated	clayey, some peat pockets	deep
6	degraded peatswamp forest	<1	90	repeated	peat	deep
7	degraded peatswamp forest	<1	5-10	repeated	peat	deep
8	"primary" peatswamp forest	90-100	100	none	deep peat	moderate (<0.5m)
9	selectively logged peatswamp forest	90	100	none	deep peat	moderate (<0.5m)
10	heavily degraded peatswamp forest	<1	<5	at least once	deep peat	deep (>1.2m)
11	degraded peatswamp forest	<1	90-100	repeated	deep peat	moderate to deep
12	degraded peatswamp forest	5(-10)	100	at least once	peat	moderate to deep
13	riparian habitat	2-5	100	edge effects	mineral?	very deep
14	degraded peatswamp forest	<1	80-90	repeated	peat	deep
15	degraded peatswamp forest	<1	50	repeated	clayey, some peat pockets	deep (1.2-1.3m)
16	degraded peatswamp forest	1	100	at least once	peat	deep
17	riparian habitat	5(-10)	100	edge effects	mineral?	very deep
18	degraded peatswamp forest	1-2	90-100	at least once	peat	deep
19	riparian habitat	90-100	90-100	none	mineral (clay)	very deep
20	degraded freshwater swampforest	10-20	80-90	1997?	clay	50 cm
21	degraded freshwater swampforest	40	70-80	1994	clay	50 cm

* only *Pandanus* cover of several %

ANNEX 4 Bird observations

ANNEX 4.
Bird observations at Berbak NP, October 2003

No.	Species*	Common name*	Date of observation (-s)	Approximate location***	Habitat type			Primary food source			
					(peat-) swamp-forest	Riparian	Degraded / burnt habitat	Fish, amphibians, crustaceans	Insects & other invertebrates	Fruit & seeds	Other
1	*Alcedo atthis*	Common Kingfisher	5, 12 October	AHLhulu/ hilir		+		+			
2	*Alcedo meninting*	Blue-eared Kingfisher	5 October	AHL hulu		+	+	+			
3	*Anhinga melanogaster*	Oriental Darter	7 October	AHL hulu		+		+			
4	*Anthracoceros albirostris*	Oriental Pied Hornbill	5 October	AHL hulu	+					+	
5	*Anthracoceros malayanus*	Asian Black Hornbill	11,12 October	AHL hilir, SM	+					+	
6	*Ardea purpurea*	Purple Heron	5,6,13 October	AHL hulu, hilir			+	+			
7	*Artamus leucorhynchus*	White-breasted Wood-Swallow	6 October	AHL hulu		+	+		+		
8	*Butorides striatus*	Striated Heron	7,13 October	AHL hulu, hilir		+		+			
9	*Cairina scutulata*	White-winged Duck	13, 16 October	SM confl.; AHD	+				+	+	
10	*Centropus sinensis*	Greater Coucal	12 October	SM hilir	+	+			+		
11	*Chloropsis venusta*	Blue-masked Leafbird	7 October	AHL hulu	+				(+)	+	
12	*Ciconia stormi***	Storm's Stork	17 October	AHD	+			+	+		+
13	*Collocalia fuciphaga*	Edible-nest Swiftlet	10 October	AHL hilir, SM		+	+		+		
14	*Copsychus saularis*	Magpie Robin	5,12 October	AHL hulu, SM	+	+	+		+		
15	*Corvus enca*	Slender-billed Crow	6 October	AHL hulu	+						+
16	*Cymbirhynchus macrorhync*	Black-and-red Broadbill	16 October	AHD		+			+	+	
17	*Dicrurus hottentottus*	Hair-crested Drongo	5 October	AHL hulu	+				+		
18	*Dicrurus paradiseus*	Greater Racket-tailed Drongo	6 October	AHL hulu		+	+		+		
19	*Dryocopus javensis*	White-bellied Woodpecker	12,13 October	SM, AHL hilir	+	+	+		+		
20	*Ducula aenea*	Green Imperial-Pigeon	11 October	AHL hilir, SM	+					+	
21	*Eurystomus orientalis*	Dollarbird	daily	most locations		(+)	+		+		
22	*Gracula religiosa*	Hill myna	12 October	SM	+		+		+	+	

No.	Species*	Common name*	Date of observation (-s)	Approximate location***	Habitat type			Primary food source			
					Primary (peat-) swamp-forest	Riparian	Degraded / burnt habitat	Fish, amphibians, crustaceans	Insects & other invertebrates	Fruit & seeds	Other
23	*Halcyon smyrnensis*	White-throated Kingfisher	5 October	AHL hulu		+		+			
24	*Haliastur indus*	Brahminy Kite	6 October	AHL hulu		+	+	+			+
25	*Hirundo rustica*	Barn Swallow	6 October	AHL hulu		+	+		+		
26	*Hypothymis azurea*	Black-naped Monarch	17 October	AHD		+			+		
27	*Ichthyophaga ichthyaetus*	Grey-headed Fish-Eagle	6,13,17 October	AHL hulu, hilir	+	+	+	+			
28	*Ixobrychus cinnamomeus*	Cinnamon Bittern	12 October	SM hilir		+		+	+		
29	*Ketupa ketupa*	Buffy Fish-Owl	12 October	SM hilir		+		+			
30	*Leptoptilos javanicus***	Lesser Adjutant	6 October	AHL hulu		+	+	+			+
31	*Loriculus galgulus*	Blue-crowned Hanging-Parrot	12 October	AHL hilir, SM	+		+		+	+	
32	*Megalaima rafflesii*	Red-crowned Barbet	7 October	AHL hulu	+	+				+	
33	*Merops philippinus*	Blue-tailed Bee-Eater	daily	most locations		(+)	+		+		
34	*Microhierax fringillarius*	Black-thighed Falconet	6 October	AHL hulu	+	+			+		+
35	*Muscicapa* sp.	Flycatcher	5,6 October	AHL hulu		+	+		+		
36	*Nectarinia* sp.	Sunbird	13 October	SM confluence	+	+					+
37	*Pelargopsis capensis*	Stork-billed Kingfisher	5 October	AHL hulu		+	+	+			
38	*Psittacula longicauda*	Long-tailed Parakeet	11 October	most locations	+	+	+			+	
39	*Pycnonotus simplex*	Cream-vented Bulbul	13 October	SM confluence		+			(+)	+	
40	*Rhinomyias* sp.	Jungle-Flycatcher	7 October	AHL hulu	+				+		
41	*Rhipidura javanica*	Pied Fantail	5,7,12 October	AHL hulu, SM	(+)	+			+		
42	*Spilornis cheela*	Crested Serpent-Eagle	6,12 October	AHL hulu, SM	+	+	+				+
43	*Streptopelia chinensis*	Spotted Dove	6,7 October	AHL hulu		+	+			+	
44	*Todirhamphus chloris*	Collared Kingfisher	13 October	AHL hilir		+		+			
45	*Treron* sp.	Green-Pigeon	daily	most locations	+					+	

* names follow MacKinnon & Phillipps (1993); **observed flying overhead; ***AHL = Air Hitam Laut; AHD= Air Hitam Dalam; SM = Simpang Melaka

ANNEX 5 Species common in burnt areas

ANNEX 5.
Plant species common in burnt areas

Family	Species	Habit	Coll.	Local name	Relevee Sites													times observed
					1	3	5	6	7	10	11	12	14	15	16	18	20	21	
Apocynaceae	*Alstonia pneumatophora*	tree		pulai			+	+			+				++		+		5
Arecaceae	*Licuala paludosa*	palm		palas									+	+	++				3
Arecaceae	*Pholidocarpus sumatranus*	palm		liran			+					+	+						3
Bambusidae	*Gigantochloa* sp.	shrub	*#62*	bambu			+										++	+	3
Blechnaceae	*Blechnum indicum*	fern	*#12*	pakis						+	++	+++			++	++	++		6
Blechnaceae	*Stenochlaena palustris*	climbing fern		pakis		++	+	+++	++	+	+++	+++	+++	++	+++	+++	++	++	13
Cyperaceae	*Scleria purpurascens*	sedge	*#14+15*	?			++	++	+		+	+	++	+			+	+	9
Cyperaceae	*Thoracostachyum bancanum*	sedge		?	+++	+				+	+					+			5
Cyperaceae	*Thoracostachyum sumatranu*	sedge		?		+		++						+	+			+	5
Ebenaceae	*Diospyros siamang*	tree	*#18*	arang-arang				+		+	+			+		+			5
Elaeocarpaceae	*Elaeocarpus petiolatus*	tree	*#23*	?												++	+	+	3
Euphorbiaceae	*Macaranga pruinosa*	tree	*#6*	mahang				+			+	++	+		++	++	+	+	8
Euphorbiaceae	*Mallotus muticus (Coccocera*	tree		perupuk				+		+	+		+		+				5
Flagellariaceae	*Flagellaria indica*	climber		?				+					+				+		3
Melastomaceae	*Melastoma malabathricum*	shrublet		harendong			+	+			+	++	+		+	++			7
Moraceae	*Ficus* spp.	tree, climber	*many*	ara				+			+			+					3
Myrtaceae	*Eugenia spicata*	tree		temasaman						+	+							+	3
Myrtaceae	*Syzygium cerina*	tree	*#8*	?		+	+	+		+	+	+	+		+				8
Pandanaceae	*Pandanus helicopus*	small tree		rasau	++	+	+			+									4
Poaceae	*Hymenachne acutigluma*	grass	*#11*				++		+				+++	++					4
Poaceae	*Paspalum conjugatum*	grass	*#10*				++							+++			++	+	4
Rhizophoraceae	*Combretocarpus rotundatus*	tree	*#16*	tanah-tanah				+		+	++								3
Rubiaceae	*Morinda philippensis*	climber	*#4*	?		+				+	+								3
Rubiaceae	*Uncaria glabrata*	climber	*#3*	?		+						+	+	+	+	+		+	7
Rubiaceae	*Ixora blumei*	tree	*#36*	kopi-kopi								+				++		+	3
Rubiaceae	*Neolamarckia cadamba*	tree		bengkal		+									+		++	+	4
Schizaceae	*Lygodium microphyllum*	climbing fern		?			+	++				++		+	++	++	++	++	8

ANNEX 6 Terms of reference for SRS

The Silviculture/Rehabilitation Specialist (SRS) is to be responsible for the development of the peat swamp forest restoration and rehabilitation programme at Berbak NP, the supervision of support staff and students involved in this programme, and close coordination of these activities with Wetlands International – Indonesia Programme in Bogor and Berbak NP administration in Jambi.

Specifically, the SRS will focus on:

1. Species identification. Species suitable for restoration programmes at Berbak have already been identified and are being used by locally based companies and projects (e.g. PT.PDIW, PT. DHL, CCFPI). Some additional species have also been identified by Giesen (2003), but this needs to be refined to identify further additional species suitable for restoration and rehabilitation. This will be continued by two Dutch students who are scheduled to carry out an ecological study in the first quarter of 2004, focusing on natural regeneration process in burnt areas. Two Indonesian students are to focus on modes of seed dispersal – this will also help identify which areas may restore unassisted under natural circumstances, or at least understand the underlying processes. The SRS will supervise these student activities, and following these studies, identify a final selection of species. This is to be reported in a progress report. A reference herbarium collection is to be established by the SRS, supported by the students; this should be made at least in duplicate, with one set sent to Bogor Herbaium for identification, and a second set retained in Jambi. The latter should be transferred to Berbak NP (Jambi hq) after the project has been finalised.

2. Site identification. Vast areas (>20,000 ha) in Berbak NP are heavily degraded and all degraded sites may potentially be targeted by restoration programmes. However, funds are limited, and there are various constraints to such a 'blanket' approach.

2.1 Legal constraints. Restoration programmes are currently not permitted in the central core zone of Berbak NP (along the Air Hitam Laut). Secondly, planting of useful NTFP species in restoration programmes (for later use by local communities involved in restoration) is also not permitted. These issues are being addressed by Berbak NP staff in Jambi, and Taman Nasional in Jakarta. The SRS is to liaise with BNP administration on this matter, and report on developments in progress reports.

2.2 Social limitations. Restoration programmes at Berbak NP will be impossible to implement without active participation of the local communities, as Taman Nasional does not have the staff or resources to implement planting, and local community support is required to ensure that replanted areas are well tended. Once sites are selected on a physical basis (see 2.3), the SRS is to hold discussion with local community representatives to identify villagers' willingness to participate. Berbak NP staff are also to be involved in these discussions as much as possible, and the outcome is to be reported on in progress reports.

2.3 Physical constraints. Not all degraded areas are equally suitable for restoration. Some sites may be able to regenerate naturally (e.g. due to proximity of natural forest), while some are so degraded and deeply flooded that significant investments are required (e.g. very tall mounds) for restoration. One of the outputs of the Dutch student project will be a decision support system to guide the selection process, based on physical criteria. The Indonesian students are to focus on modes of seed dispersal – this will also help identify which areas may restore unassisted under natural circumstances. The SRS is to supervise these student activities in the field.

2.4 Site selection plan. Once a), b) and c) are completed or have been clarified, a site selection plan may be developed by the Silviculture/Rehabilitation Specialist, together with Berbak NP staff. This plan should focus on high priority areas first (high value, high chance of success) and be realistic:, i.e. being aware that not all areas can be restored, and operating within the budgetary, time and human constraints.

3. Trials. These can and should be carried out by the SRS parallel to 1 and 2, as information and experience regarding the performance of species, planting and tending techniques is urgently required. Support for implementation of these trials will be provided by 2 field assistants (to be recruited b y the SRS), Berbak NP staff, and members of the local community. Trials should focus on:

a. Sourcing. Identification of suitable sites/populations for sourcing seeds, fruits, cuttings of each species to be used in planting trials.
b. Propagation techniques, both in nurseries and for planting in the field: with/without clearing, using various levels of fertiliser application, various forms of shading, etc…
c. Tending: determining which level of tending is required once seedlings have been planted in the field
d. Hydrology. Trials using various mound levels relative to maximum flooding need to be carried out to determine an optimum mound level (for each species; see 4.4).
e. Regular reporting on monitoring and evaluation. Trial planting to be carried out in readily accessible and tended areas, which are to be regularly evaluated and reported on, so that timely adjustments in techniques can be carried out.
f. Apart from evaluation reports, one of the main outcomes of the trials is to be a "Manual for restoration/rehabilitation of degraded peat swamp forests", that includes guidelines on silvicultural techniques, species selection and propagation, and site selection. This is to be produced by the Silviculture/ Rehabilitation Specialist in draft form by July 2004, and finalised by the end of November 2004.

4. Nurseries. Two new nurseries are to be established as soon as possible for restoration/rehabilitation programmes, namely: a) near the newly refurbished National Park resort office near the mouth of the Air Hitam Dalam, and b) in the lower course of the Air Hitam Laut, between Air Hitam Laut village and the park border. The SRS is to begin with site selection as soon as possible, together with Berbak NP administration, and involving local community representatives. The nurseries will need to be established in areas that are not subject to prolonged, deep flooding (although some flooding would be permissible), and should be able to eventually increase to a size of about 1-2 ha.

NP staff are to be provided on-the-job training in nursery establishment, management and propagation techniques, and are to be involved from the beginning. Training should be

provided intensively during nursery establishment, and intermittently thereafter to solve possible problems encountered. It should be made clear from the beginning that the nurseries are to be fully transferred to Berbak NP administration at the end of the project, and BNP commitment should be verified early in this process. Local community members should be recruited for planting trials and eventual replanting programmes.

The SRS will be responsible for supervision of site preparation, and the pruchase of equipment and materials required. E.g., netting will be required for shading, along with plastic sheeting for establishing beds, polybags, trays, soil for planting medium, fertiliser and labels. A small boat (*ketek*) will be required (at each nursery) for obtaining propagules, and for transport of seedlings during trials. The SRS is to draft a section on propagation techniques and nursery establishment and management; this is to be included in the manual mentioned in 3.f.

5. Restoration/rehabilitation programme. This programme is to be drafted by the SRS towards the end of the project, with a draft completed by the end of October 2004, and a final draft programme ready by December 2004. This programme is to be based on the site selection plan and the outcome of the trials, but will also be strongly dependent on local willingness to participate and the availability of funds.

ANNEX 7 Photographic summary

PHOTO 1.
Primary swamp forest along the Simpang Melaka

PHOTO 2.
Primary swamp forest along the Air Hitam Dalam is at least twice as rich in species as the Air Hitam Laut and Simpang Melaka forests

PHOTO 3.
The orchid *Vanda hookeriana*, which occurs naturally in *Hanguana malayana* and *Pandanus helicopus* dominated swamps, used to be fairly common, but due to the disappearance of much of this primary habitat it has become quite rare.

PHOTO 4.
Teijsmanniodendron hollrungii (Verb.) is an uncommon tree species of swamp and riverine habitats. At Berbak NP it is found in the Air Hitam Dalam area.

PHOTO 5.
Latex of *jelutung Dyera lowii* is collected from trees and allowed to harden in large box-like molds. It is sold on the regional market in these 20kg blocks (photo taken along Air Hitam Laut). Virtually all *jelutung* is derived from wild trees, which are becoming scarce as primary forests disappear and unsustainable tapping procedures are used.

PHOTO 6.
Many fisherfolk live in Berbak NP, at least on a temporary basis. Large catfish (*Wallago*) and snakehead fish (*Channa*) are kept in cages for sale to traders as fresh fish.

PHOTO 7.
Sawn timber poached from Berbak NP is transported out of the western part of the Park via the rail and lorry system of PT. Putra Duta Indah Wood. Each day large quantities were observed being taken along this route. Depicted is where the rail crosses the Air Hitam Laut, near PT PDIW's field camp.

PHOTO 8.
Rafts of sawn timber poached in Berbak NP along the Air Hitam Dalam, were observed being taken out of the area.

PHOTO 9.
At least 17,000 ha of swamp forest in Berbak NP has burnt during the past decade, such as here along the upper reaches of the Air Hitam Laut. Almost all of this appears to be linked to illegal logging in the Park.

PHOTO 10.
Repeatedly burnt areas are deeply flooded during the wet season, and the only species that survive are the sedge *Thoracostachyum bancanum,* and *Pandanus helicopus* (background), depicted here along the upper reaches of the Air Hitam Laut.

PHOTO 11.
The Air Hitam Laut is blocked by a very dense growth of floating *bakung Hanguana malayana*, along much of its length, from Simpang T (depicted here) to Simpang Kubu. It is virtually impassible for boats.

PHOTO 12.
Regrowth of the large central burnt area along the Air Hitam Laut, here near Simpang T. Note the small size of the still standing trunks, the undergrowth of *Imperata cylindrica,* and the surviving palm *liran Pholidocarpus sumatranus.*

PHOTO 13.
Secondary vegetation on a burnt area along the Simpang Melaka. Note the young *pulai Alstonia pneumatophora* in the foreground, along with *mahang Macaranga pruinosa* (back left) and climbing fern *Stenochlaena palustris* (back right).

PHOTO 14.
Secondary vegetation on a burnt area along the Air Hitam Dalam. Note the profuse growth of wild gingers (*Nicolaia speciosa*) to the left, and *mahang Macaranga motleyana* to the right.

PHOTO 15.
Lareg amounts of combustible material remain in some former peat swamp forest areas affected by fire. This hinders recovery, but also forms a major threat as the danger of future fires looms ahead.

PHOTO 16.
A very dense cover of ferns – here mainly *Stenochlaena palustris*, but also *Blechnum indicum* and *Nephrolepis biserrata* – competes for space with shrubs and trees and may prevent recovery processes.

PHOTO 17.
PT. Putra Duta Indah Wood's nursery at Suka Berajo camp. A second nursery is located at *Kem Pembinaan* - the field camp. Indigenous species are grown, along with some local garden species. Activities in this area are small-scale, certainly compared to reforestation efforts required.

PHOTO 18.
Planting of *renghas Gluta wallichii* along the central part of PT. PDIW's rail system. The approach used by PDIW is one whereby water tables are lowered by means of drainage ditches prior to planting. This is inappropriate and adds to the risk of future fires in the area.

PHOTO 19.
PT. Dyera Hutam Lestari's nursery along the Batanghari River, between Suak Kandis and Sungai Rambut. Grown are mainly *jelutung Dyera lowii* and *pulai Alstonia pneumatophora.* The nursery is large, efficient and of an apprpriate scale.

PHOTO 20.
PT. Dyera Hutan Lestari's 12-year old *jelutung* plantation on deep peat – a former peat swamp forest area. Growth is good, and latext has been tapped on an experimental basis. The greatest threat is form by fire escaping from adjacent areas – two such events over the past decade have wiped out much of what has been invested in this otheriwse very successful operation.

PHOTO 21.
Berbak NP's forest fire fighting unit (*Tim Pemadam Kebakaran*) seen here training at Simpang Raket, along the upstream part of large burnt area along the Air Hitam Laut. Although perhaps effective at managing a small fire that has just been detected, this approach is likely to be totally ineffective in managing large fires that have ravaged the Park during the past decade.

PHOTO 22.
In 2002, Berbak NP staff carried out two trial reforestation efforts in burnt areas along the Simpang Melaka, one covering 5ha, the other 2ha, using *Alstonia, Dyera* and *'medang'*. Mortality of planted seedlings was observed to be 100%, possibly due to planting just prior to a prolonged period deep flooding.

PHOTO 23.
In peat swamp and freshwater swamp forests, many trees appear to thrive best on natural mounds, such as here in swamp forest along the upper Air Hitam Laut. Reforestation trials carried out in Thailand show that growth rates can be twice as high on artificial mounds, but are relatively expensive.

PHOTO 24.
Artificial mound contructed in a burnt peat swamp area in Berbak NP, along the upper part of the Air Hitam Laut, under the CCFPI project. 50-cm high mounds are constructed on the highest points in the microtopography. These are to be planted with indigenous peat swamp forest tree species once water levels drop.

PHOTO 25.
Combretocarpus rotundatus (tanah-tanah) is a promising species for restoration of disturbed peat swamp forest, as it is fire tolerant, grows relatively fast, and readily produces large amounts of seeds.

PHOTO 26.
Another promising species for peat swamp forest restoration is *Mallotus muticus* (*perupuk, a.k.a. Coccoceras bornensis*). This species produces typical pneumatophores, and like *tanah-tanah* it is fire tolerant.

PHOTO 27.
Species of *Eugenia* (a.k.a *Syzygium*) often rapidly colonise disturbed and burnt areas. Fruits float and are easily dispersed by floodwaters. Also, many fruits are also eaten by birds and mammals which also adds to dispersal.

PHOTO 28.
Pulai Alstonia pneumatophora was found to be one of the first colonising species found in burnt areas. *Pulai* trees produce large amounts of seed, which are small, fluffy and easily dispersed by wind over long distances. The tree itself grows rapidly, and may be one of the tallest swamp forest emergents.

PHOTO 29.
The robust sedge *Thoracostachyum sumatranum* is one of the main herb species that rapidly colonises burnt areas.

PHOTO 30.
The fern *Stenochlaena palustris* occurs in both peat and freshwater swamp forests, where it may form a dense ondergrowth or adopt a climbing habit. Dense, prolific growth of this species may slow down the recovery of peat swamp forest if it outcompetes trees and shrubs. On the other hand it also reduces evaporation and lowers temperatures, lowering the fire risk.