

**FOREST FIRE PREVENTION AND CONTROL PROJECT
DEPARTEMEN KEHUTANAN
KANTOR WILAYAH PROPINSI SUMATERA SELATAN**

FIRE ZONES AND THE THREAT TO THE WETLANDS OF SUMATRA, INDONESIA

Ivan P. Anderson and M. Roderick Bowen



**EUROPEAN UNION
MINISTRY OF FORESTRY**



November 2000

Cover Ferdinand Lubis. Photograph, Ivan Anderson. Fire in the wetlands of Padang Sugihan Wildlife Reserve to the east of Palembang, South Sumatra province, in September 1999.

Acknowledgements

SPOT Quicklook satellite images were provided by the Centre for Remote Imaging, Sensing and Processing at the National University of Singapore (<http://www.crisp.nus.edu.sg/crisp.html>). We are grateful to the Centre for allowing us access to these images and for permission to reproduce them in this report. Copyright for SPOT data is held by Centre National d'Etudes Spatiales, France.

We thank the Japan International Cooperation Agency funded Forest Fire Prevention Management Project for providing hot-spot data for January and February 1999 when the Palembang NOAA receiving system was out of operation while buildings were renovated.

Produced through bilateral co-operation between

GOVERNMENT OF INDONESIA
MINISTRY OF FORESTRY

EUROPEAN UNION
EUROPEAN COMMISSION

Natural Resources International Limited
BCEOM
CIRAD-Foret
Scot Conseil

Financing Memorandum B7-5041/1/1992/12 (ALA/92/42)
Contract Number IDN/B7-5041/92/644-01

This report was prepared with financial assistance from the Commission of the European Communities. The views expressed herein are those of the project and do not represent any official view of the Commission.

Project Reports

Fourteen reports were prepared during 1999 and 2000 by the Forest Fire Prevention and Control Project. Together they cover the field-level prevention, detection and control of vegetation fires in Sumatra and examine the policies and practices that underlie the continuing fires within the island. Titles in the series are:

Vegetation fires in Indonesia: operating procedures for the NOAA-GIS station in Palembang, Sumatra. I.P. Anderson, I.D. Imanda and Muhndandar. (January 1999)

Vegetation fires in Sumatra, Indonesia: the presentation and distribution of NOAA-derived data. I.P. Anderson, I.D. Imanda and Muhndandar. (January 1999)

Vegetation fires in Indonesia: the interpretation of NOAA-derived hot-spot data. I.P. Anderson, I.D. Imanda and Muhndandar. (March 1999)

The training of forest firefighters in Indonesia. M.V.J. Nicolas and G.S. Beebe (Joint publication with GTZ). (April 1999)

Fire management in the logging concessions and plantation forests of Indonesia. M.V.J. Nicolas and G.S. Beebe (Joint publication with GTZ). (April 1999)

A field-level approach to coastal peat and coal-seam fires in South Sumatra province, Indonesia. M.V.J. Nicolas and M.R. Bowen. (April 1999)

Vegetation fires in Indonesia: the fire history of the Sumatra provinces 1996 - 1998 as a predictor of future areas at risk. I.P. Anderson, M.R. Bowen, I.D. Imanda and Muhndandar. (May 1999)

Vegetation fires in Sumatra, Indonesia: a first look at vegetation indices and soil dryness indices in relation to fire occurrence. I.P. Anderson, I.D. Imanda and Muhndandar. (May 1999)

Environmental education - with special reference to fire prevention - in primary schools in the province of South Sumatra, Indonesia. With 'Desa Ilalang', a story for children in Bahasa Indonesia. M. Idris, S. Porte, J.M. Bompard, F. Agustono (illustrator) and staff of FFPCP and Kanwil Kehutanan dan Perkebunan, Palembang, in collaboration with Kanwil Departemen Pendidikan dan Kebudayaan Tk I, South Sumatra. (July 1999)

The sustainable development of tree crops and the prevention of vegetation fires in South Sumatra Province, Indonesia. Jungle rubber. A. Gouyon. (August 1999)

Land management in South Sumatra Province, Indonesia. Fanning the flames: the institutional causes of vegetation fires. J.M. Bompard and P. Guizol. (September 2000)

Anthropogenic fires in Indonesia: a view from Sumatra. M.R. Bowen, J.M. Bompard, I.P. Anderson, P. Guizol and A. Gouyon. Reprinted from, 'Forest fire and regional haze in Southeast Asia' Editors M. Radojevic and P. Eaton. Nova Science, New York, USA (June 2000)

Vegetation fires in Sumatra, Indonesia: reflections on the 1999 fires. I.P. Anderson, I.D Imanda, and Muhndandar (August 2000)

Fire zones and the threat to the wetlands of Sumatra, Indonesia. I.P. Anderson and M.R. Bowen (October 2000)

Printed copies of the first five reports are also available in Bahasa Indonesia.

English language copies of the first five reports are available only on the FFPCP homepage <http://www.mdp.co.id/ffpcp.htm> Summaries of all reports can be found at the same location. Printed copies of reports six to fourteen and those in Bahasa Indonesia can be obtained from:

The Project Leader, FFPCP, PO Box 1229, Palembang 30000, Indonesia.

Fax number: +62 711 417 137

or

The Counsellor (Development), Representation of the European Commission, PO. Box 6465 JKPDS, Jakarta 10220, Indonesia.

Fax number: +62 21 570 6075

A daily overview map that shows the locations of vegetation fires in Sumatra can be found on the FFPCP homepage.

SUMMARY

The use of fire as a tool to clear land for agriculture is a long established practice in Indonesia. And, when used by farmers in years of average or above average rainfall, the practice poses little threat to the environment. We have shown in previous papers, and return to the theme here, that in Sumatra the extensive use of fire by estate crop companies to clear thousands of hectares, in the main for oil palm, is a much more worrying problem.

The wetlands of Sumatra cover over 11 million hectares, equivalent to 23 percent of the total land surface. By far the largest swamplands are found in Riau province – 4.75 Mha – and South Sumatra, 3.2 Mha. The east coast wetlands of the island are of the greatest importance for the conservation of their unique and/or endangered plants and animals. In recognition of this by 1998, 544 000 ha were already gazetted by government as protected areas and a further 597 000 ha were officially proposed as sanctuary areas.

Of these gazetted areas Way Kambas in Lampung is now heavily degraded, the forests in Padang Sugihan in South Sumatra, once seen as an important bird and elephant sanctuary, is completely destroyed by logging followed by fire, and Berbak National Park in Jambi is under considerable pressure. The fate of the remaining reserves is not known.

Deep peat (+2 m) deposits are found in all provinces except Bengkulu. These areas are difficult to drain to a degree that allows cropping without excessive loss in volume through oxidation and shrinkage, and even if drainage is technically successful, it increases fire hazard to an unacceptably high level and places around 500 t C ha⁻¹ at risk for every metre depth of peat.

Periods of smoke haze pollution, some of it spreading to Malaysia and Singapore, are now regular events and are likely to become more severe in the immediate future.

Transmigration programmes and estate crop companies moved into these swamps despite their low soil fertility, poor infrastructure and their history of agricultural failure. And the invasion of the wetlands of Sumatra has gone forward largely driven by the shortage of dryland areas that remain unimpeded by smallholder land-rights and by the opportunity to extract the valuable commercial swamp timber species whose sale off-sets the development costs of the estate companies.

There is a strong correlation between fire numbers / area burnt and the land clearing activities of oil palm companies and Sumatra has been hard-hit when compared to Kalimantan and elsewhere in Indonesia.

Based on limited SPOT imagery, NOAA fire occurrence data, published information on the oil palm industry, and on field visits, we guess that in each of the last four non-ENSO years (i.e. 1996, 1998, 1999 and 2000) a few hundreds of thousands of hectares have been burned for agricultural purposes in Sumatra. Of this figure, most represents repeat clearance by smallholder farmers while a few tens of thousands of hectares, the opening-up of new land by estate crop companies. Out of the new land opening we further guess

that most was in the wetlands of the island. At least 2 M ha of land in Sumatra have been deliberately cleared by fire over the last ten to fifteen years.

Seven major fire zones are identified in Sumatra. These are the (i) North Sumatra – Riau border, (ii) Kampar River wetlands of Riau, (iii) coastal wetlands of the West Sumatra – North Sumatra border, (iv) West Sumatra - Bengkulu coastal wetlands, (v) Batanghari River wetlands of Jambi adjacent to Berbak National Park, (vi) inland swamps of South Sumatra, and the (vii) coastal wetlands of South Sumatra.

Six of the seven fire zones have a common feature in that they are in peat-rich wetlands. They are thus on soils that are considered by the local people as unsuitable for either traditional forms of agriculture or settlement.

There is also a commonality as to the reasons for, and the sequence of events that lead to, the establishment of a fire zone. The process is well illustrated by the development of the dryland fire zone that straddles the Riau – North Sumatra border and also the fire zone in the Kampar River wetlands of Riau. The same general process also seems to have taken place in the two west coast wetlands and in the South Sumatra interior wetlands fire zones, i.e. in five of the seven fire zones described. Steps in the chain are:

- With few inhabitants, and none in a position to object in the seventies, the land was designated as Permanent Production Forest.
- Large parcels of land were then allocated by government to logging concession companies.
- Prolonged, heavy and unsupervised logging by the companies, compounded by extensive illegal cutting by local people and outside interests, devastated the forests.
- As a consequence of the devastation government reclassified the areas as Conversion Forest.
- This move attracted the attention of regionally-based entrepreneurs who eagerly sought plantation licenses, took over the forests and removed all the residual timber, which was frequently of considerable value.
- The same groups then clear-felled, burned, and planted the ground to estate crops.

The burns have been, and remain, numerous, frequent, persistent pollution-causing and concentrated within specific areas. The result is a fire zone.

The story in the coastal wetlands of South Sumatra illustrates a different process that has led to the creation of the sixth fire zone. The chronicle starts in the late sixties.

- Grandiose plans - largely funded by the World Bank - were made to resettle thousands of landless families from the ‘inner islands’ of Java, Madura and Bali on the ‘unoccupied’ tidal lowlands of the province. The schemes were designed to allow transmigrants to cultivate wetland rice for food and sale.
- To this end over 300 000 ha of good quality swamp forest were systematically felled, and the timber sold.
- The residual non-commercial species and scrub were cut and burned.
- A complex and extensive system of drainage-cum-irrigation canals was dug.
- Resettlement of the transmigrants started soon afterwards and, despite steadily mounting evidence of the difficulties faced by the settlers on infertile land and with periodic shortages of drinking water, continued spasmodically until the early nineties.

- However the thousands of families that were planned never arrived while some transmigrants moved on.
- The canal system - incidentally - provided ready access to the remaining unlogged forests.
- Legal and illegal logging systematically then depleted these forests.
- The transmigration scheme fell into semi-dereliction.
- What remained were many thousands of hectares of fire-prone sedge and grassland on the former transmigration sites plus equally large areas of variously degraded, and fire-vulnerable, swamp forest.
- The transmigration programme and the logging aided by the *el Nino* fires of 1987, 1991, 1994 and 1997 progressively destroyed over 90 percent of the swamp forests that had once covered the land south of the Musi River.

What remains is a fire zone of sedges, grasses, herbaceous and woody scrub and sparse *Melaleuca* woodland. The rehabilitation of this vast area is now a major challenge.

‘Intermediate’ between the cases of Riau and the South Sumatra coastal wetlands is the process that led to the fate of the Batanghari River wetlands of Jambi; the seventh and last of the fire zones within Sumatra. These are ecologically one of the most important wetlands sites in South East Asia and consequently 175 000 ha are designated as the Berbak National Park. The sequence of events that led to the formation of this fire zone are:

- Logging concessions to the west of the Berbak Park 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-out the logs.
- Extensive illegal cutting, again with canalization, began outside and now extends somewhat within the National Park.
- Around 17 000 ha (10 percent) of the Park were destroyed by fires in 1997. Who and why the fires were lit are not known.
- This grassland nucleus caused by the 1997 fires coupled with the boundary felling and illegal logging has opened the whole Park to destruction by fire in the next *el Nino* year.

Turning to the status of the seven fire zones noted here, the *North Sumatra – Riau Border Fire Zone* has been the major, and the clearly and easily definable, focus of vegetation fires in Sumatra over the last four years. The zone encompasses swamplands as well as one of the few extensive tracts of dryland lowland forest that remain in Sumatra, and as such, has been recommended for conservation.

Over the last five years some 30 percent of the fires detected in Sumatra have been in Riau province. [Indeed, Riau in all probability routinely has the greatest frequency of vegetation fires of any province in Indonesia in terms of number of fires per square kilometre.] The province is quickly and rampantly logging its remaining forests. The dryland forests are now nearly exhausted and attention has already turned to the swamp forests. Like the dry areas, the land is then converted to other purposes, mainly oil palm. Conversion is a major and planned component of Riau’s development strategy and we estimate that if burning is allowed to continue at its present level, the fire and smoke haze

problem in the province will draw to an end in five years as the planting-up of the estates is completed. Neither the lowland forest nor the proposed conservation area will survive.

Large-blocks of fires have been detected in the *Kampar River Wetlands of Riau* since July 1996. Plantation development straddles the borders of three districts and occupies over 250 000 ha. It is one of the largest on-going clearances in Sumatra.

Fires associated with large-scale land clearing in the fire zone of the *West Coast Wetlands of the West Sumatra - North Sumatra Border* were first detected in mid-1996. Again the burning takes place in logged forest concessions in the process of conversion to another land use; and, as elsewhere, probably for oil palm.

A few fires were first detected in the *West Coast Wetlands of West Sumatra - Bengkulu* provinces in 1996 but numbers rose sharply in the fire zone from mid-1997. As elsewhere the fires are associated with forest concessions but here their purpose is not known with certainty; some may have been wildfires. This wetland, along with that previously described, together make up most of the small west coast wetlands of the island.

The *Wetlands that Border the River Batanghari in Jambi Province* were badly damaged by wildfires in 1997. They are now at high risk from fire in years with an extended dry season when they will act as the seat for further fires. These new fires will, in turn, further encroach on the fragmented remains of the natural wetland vegetation. And, as the sequence progresses, *Berbak National Park* will come under an increasing threat from fire. The Park is largely in a peat swamp and suffered fire damage in 1997. It is one of two wetlands in Indonesia that is internationally agreed as a site of the greatest scientific importance.

The *Inland Swamps of South Sumatra Province* were recognized as a fire zone in 1997 and those that lie to the west have been entirely burnt in just three years. A second interior wetland to the centre of the province was burned in 1999. Why the fires were lit is not known with certainty but they can safely be presumed to mark the start of another estate development. There were no further fires in the inland swamps over the next twelve months and it remains to be seen if new fires will be started.

The sequence of events that led to the development of the *Coastal Wetlands of South Sumatra* fire zone has been noted above. Since 1997 there has only been one fire of consequence in the zone, although this covered 14 000 ha and lasted from mid-June to the end of September 1999 when it was extinguished by rain. It is now certain that the fire was set deliberately to clear land allocated for a new estate development in a former logging concession. The 1999 hot-spot cluster was bigger than any group detected in Sumatra during the 1997 fire crisis. The zone, which covers more than 2 million hectares, remains highly vulnerable.

Forecasts about the course of vegetation fires in Sumatra are, like all predictions, uncertain. What is not clear is how much of the land already allocated to the plantation industry remains to be burned in the immediate future. And, how much of the land applied for but not yet granted by government will eventually go to oil palm. An additional total of 1.0 M ha to be cleared by fire in Sumatra alone seems a conservative estimate.

Over the next five years we are confident that:

- The numbers of fires detected at any one time, and over the calendar year as a whole, will continue to be directly controlled by the rainfall: the wetter the year, the fewer the fires.
- There will be few or no wildfires in Sumatra in years of average or above average rainfall.
- Considerable numbers of wildfires will burn during the next *el Nino* year.

We also expect with some confidence that:

- Land clearance fires set by the oil palm industry will continue for the next several years in at least five of the seven zones described in this report.
- Smoke haze pollution will continue episodically each year and much of the smoke haze that originates in Riau will continue on occasion to drift across to Singapore and Peninsular Malaysia.
- However as the available uncleared and newly cleared land in each of the seven fire zones becomes fully planted, fire numbers in that zone will fall.
- The formation of new fire zones will be largely determined by the land-use policy of the new provincial governments and, to an extent, by the economics of the oil palm industry: no firm predictions can be made.
- A new 'fire-balance' will eventually be reached within Sumatra as a whole and fire numbers will return to their pre-1996 level in years of average rainfall.

The accent of the report is on vegetation fires within Sumatra but it is government's and individuals' 'profit now' land-use policies and practices that are the cause of forest loss; fire zones are only the signal.

TABLE OF CONTENTS

Acknowledgements	i
Disclaimer	i
Project Reports	ii
Summary	iv
Table of Contents	ix
1. PREAMBLE	1
A failure to communicate	1
Remotely-sensed data	2
Data overload	2
The climate	2
A lack of willpower	3
Decentralisation dangers; the boundaries conundrum	4
2. PATTERNS OF FIRE IN SUMATRA	5
3. SEVEN MAJOR FIRE ZONES	7
Location of the zones	7
Wetland commonality	8
The establishment of five of the seven fire zones – the ‘general’ model	8
The case of the South Sumatra coastal wetlands – the sixth fire zone	8
The formation of the seventh fire zone - the Jambi example	9
4. THE NORTH SUMATRA – RIAU BORDER	10
Riau: the fire, smoke and oil palm province	10
The border fire zone	10
5. KAMPAR RIVER WETLANDS OF RIAU	13
6. COASTAL WETLANDS OF THE WEST SUMATRA – NORTH SUMATRA BORDER	16
7. THE WEST SUMATRA – BENGKULU COASTAL WETLANDS	18

8. BATANGHARI RIVER WETLANDS AND BERBAK NATIONAL PARK, JAMBI PROVINCE	20
9. INLAND SWAMPS OF SOUTH SUMATRA	23
10. COASTAL WETLANDS OF SOUTH SUMATRA	26
The wetlands fire zone	26
An overview of vegetation and land-use in the coastal swamps	27
11. THREATS TO THE WETLANDS	36
Wetlands of Sumatra	36
Deep peats	36
Invasion of the wetlands	37
The oil palm plantation industry in Sumatra	38
12. AND THE FUTURE?	40
The fires so far	40
The fires to come	40
13. REFERENCES	42
14. ABBREVIATIONS AND ACRONYMS	46

1. PREAMBLE

A Failure to Communicate

It is clear from press reports and from statements issued by international organizations and by national and provincial government officials that there remains much confusion as to the causes of vegetation fires in Indonesia, their seriousness and what should or can be done to lessen their numbers. We find this worrying. Three long-term forest fire projects are based in Indonesia¹ and much has been learnt since the widespread fires of 1994 and 1997-98. But it seems that the projects are failing to make their findings and recommendations known, both to those who shape policy and to those who are charged with fire prevention and control at field level.

A number of messages need to be clearly understood.

- All vegetation fires in Indonesia are started by man².
- The fires are deliberately lit to clear land for arable farming, for new estate crops or, on occasion, to aid hunting, fishing, etc.
- It follows that those who start the fires do not wish to extinguish them before they have done their work and appeals for them to do so will fail.
- Few of the thousands of fires - some ten or less in Sumatra - that are detected in years of *average* rainfall need to be fought and extinguished to avoid serious environmental or economic damage.
- Only in drought years do numerous fires escape control and become wildfires that need to be extinguished.
- Resources are inadequate to control fire numbers in drought years and priority must be given to avoiding and, if that is not possible, suppressing fires on peat soils in wetland areas³.
- The wetlands of Sumatra are under intense pressure from both legal and illegal logging and from conversion to estate crops. These wetlands are ecologically valuable as well as being particularly sensitive to disturbance, and land-use policy should be changed to ensure their conservation.

¹ FFPCP (EU), IFFM (GTZ) and FFPMP (JICA)

² Only vested interests in the logging and plantation industries suggest that lightning strikes are responsible, and the small number of vegetation fires in Sumatra and Kalimantan that are ignited by exposed burning coal seams is insignificant within the overall picture.

³ In Sumatra, wetland covers some 11 Mha (RePPProT, 1988) of which 3.3 Mha of peat soils 2 m to more than 10 m deep lie in Riau, accounting for 27 percent of Indonesia's peatland total (PEMDA, 1999).

Remotely-Sensed Data

At the technical level this report, and a number of others in the FFPCP series, show that remotely-sensed fire data far from being inadequate as some government agencies claim, are in fact well suited to recognising and locating the source of the larger, persistent fires. These are the only fires that require the attention of the fire control authorities and the commercial land-holders.

What NOAA data lack in spatial accuracy (within 3 km of the true position) they gain in the frequency of data capture (Sumatra three or four times a day). The resulting time-series of ongoing fire heat-signatures (hot-spots), coupled with smoke plumes clearly show where the priority fires lie. The NOAA data are sufficient in themselves although they are greatly enhanced when combined with readily available high resolution SPOT data provided by CRISP. The land conversion activity behind the fires is often visible on the SPOT images.

Data Overload

Hot-spot coordinates were until recently sent by FFPCP to all the provincial offices in Sumatra of Dinas and Kanwil Kehutanan and to BAPEDALDA - as they had been since the 1997 fire crisis. However, the same offices also receive similar, although not identical, fire location data from two other sources; JICA-FFMP and BAPEDAL. (The variance arises from the use of differing fire detection algorithms and different processing parameters).

It is now clear that too much fire information is being provided to these government field offices and that this excess causes confusion and sows doubt as to the validity of all the data. It does not, as intended, provide a clearer picture of the fire situation in the districts of Sumatra.

With this in mind, FFPCP no longer supplies unsolicited data by e-mail and data are now sent only on specific request. The project will, however, continue to place at least four NOAA fire-location maps a week on the FFPCP homepage.

The Climate

The eastern plain of Sumatra extends from Lampung in the south to as far north as North Sumatra. The northern part of the plain (North Sumatra and Riau) has a weak bimodal rainfall distribution of the equatorial type with a relatively dry interval in February and again during June and July. However, even in these drier periods the monthly precipitation usually exceeds 100 mm, an amount that approximates to the monthly potential evapotranspiration in the humid tropics. The vegetation does not therefore dry-out in most years.

Holmes (1998) analysed rainfall data from several stations in Riau, one with records that extended back to 1902. He concluded that the region is unlikely to experience severe droughts as it is to the north of the zone most affected by a dearth of rain in ENSO years.

And indeed, in the ENSO years of 1972, 1977, 1982, 1987, 1991, 1994 and 1997 there were only one or two dry months (<100 mm) in Riau. In 1994 alone was there a run of four dry months. The 1997 drought was not severe in Riau and the province was not seriously affected by wildfires at a time when the desiccated coastal wetlands of Jambi and South Sumatra were ablaze.

From, roughly speaking, south of the equator, the eastern plain has a single dry season that lasts from July to October. The dryness becomes most pronounced by Lampung as the climate approaches the Java-type with several consecutive dry months that receive an average of less than 100 mm rainfall. Long spells of dry weather are therefore more likely in the south of Sumatra (Oldeman, 1979). The wet season in these more southerly parts runs from November to March / April.

Within the plain as a whole, rainfall increases from the coast westwards to the Barisan mountain range. West of the mountains the climate is wetter than to the east.

Fire numbers at any one time are, as must be expected, heavily influenced by the amount of rainfall over the preceding weeks: an obvious correlation that we have dealt with in previous reports.

A Lack of Willpower

The national and the provincial land and fire-management authorities invariably express dismay at the recurrence of smoke haze. They claim that:

- The remotely-sensed fire location data are not sufficiently accurate.
- It is impossible to decide from mapped data whether the fires are on estate land, smallholder land or community-owned land because their maps are out of date or at the wrong scale.
- Field checking is difficult because of lack of transport, poor communication between provincial headquarters and outstations, and lack of maps or ability to use maps effectively to locate fire.
- They have no advice to offer land developers (small or large) on how to clear land for planting without the use of fire. Therefore all fires are treated incorrectly as 'wildfires' that should be extinguished, and;
- Manpower and equipment to control fires are not available or, if available, the District and Sub-District fire response units lack the authority to take any action in the field.

We recognise the difficulties faced by local authorities but there is much that could be done. The laws that govern the setting of vegetation fires need thorough revision. At present it is unclear under what circumstances, if any, fire can be used to clear land. And if a charge of unlawful burning is being considered it is uncertain as to who can be charged: the land owner, the concession holding company, the land clearance contractor working for the concession holder, or simply the named individual who physically lit the fire. The existing confusion makes it easy for the regulating authorities – who themselves are poorly defined in law – to claim that responsibility lies with others. As a result, no decisive action is taken.

Decentralisation Dangers; the Boundaries Conundrum

The well known – and much remarked – absence of accurate maps is a daunting handicap to the formulation of wise land-use policy, to land-use planning and to the field management of natural resources. The government decision to grant substantial provincial autonomy from 1 January 2001 (Laws Numbers 22/1999 and 25/1999) will again highlight the problem. Warnings have already been given that the benefits that should accrue to Province and District authorities through the devolution of fiscal and revenue retention rights to exploit natural resources will be complicated by the absence of the clear, physical demarcation of Province, District and Sub-District administrative boundaries. (Deputy Chief, BAKOSURTANAL, quoted by Jakarta Post, 11 September 2000).

Two examples from field experience illustrate the point.

- There is a 7 km discrepancy between the officially mapped and the physically marked boundary between the provinces of North Sumatra and Riau along the Dumai – Medan road near Bagan Batu as noted by FFPCP in August 2000.

- The *Acacia mangium* pulpwood plantations of Barito Pacific (PT. Musi Hutan Persada) in South Sumatra spread over 5 Districts and 26 Sub-Districts (Ir. Harjono Arisman, Deputy Manager, PT. MHP). It is doubtful if any of the District offices hold reliable maps that show boundaries.

Three of the seven major fire zones identified in Sumatra by FFPCP are close to, or overlap, province boundaries: in all likelihood this is coincidence, but where administrative responsibility is in doubt the administrations response to fire is further weakened.

2. PATTERNS OF FIRE IN SUMATRA

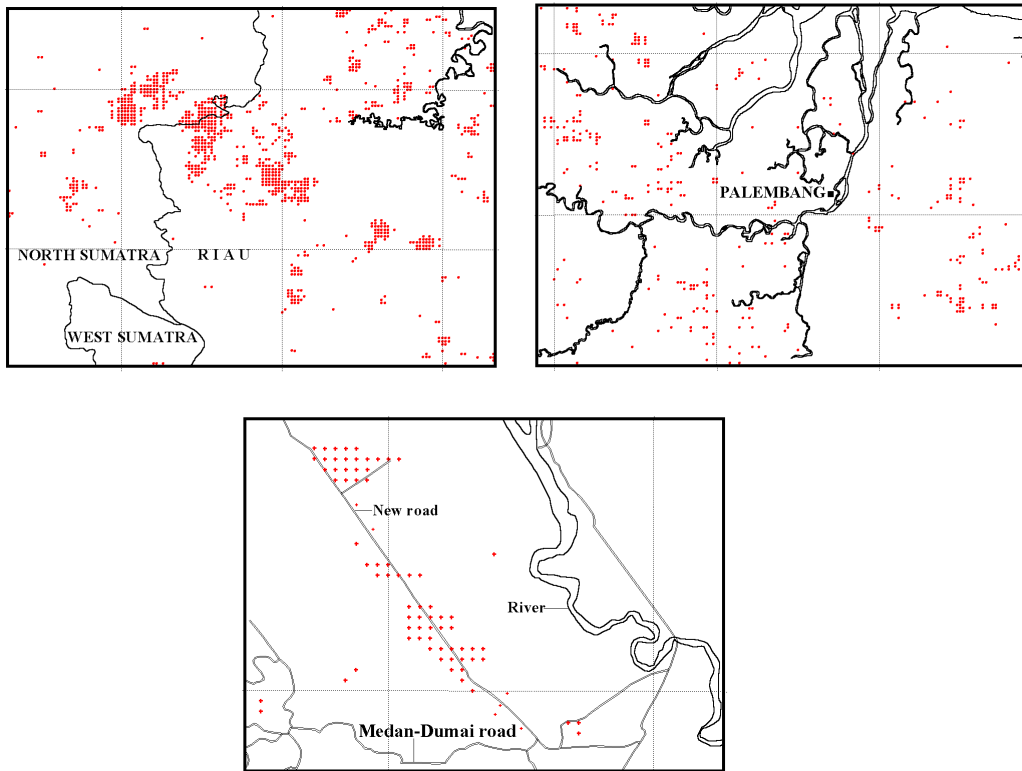
Examples of the three main patterns of fire recognised on NOAA images of Sumatra are shown in Map 1. These fires differ in scale, type of vegetation being burnt and in the reasons for burning.

Large persistent fires (Map 1a) have over the past few years, been a characteristic of Riau provinces although they are also seen in Jambi, Bengkulu, West Sumatra and North Sumatra. They were, and remain, associated with commercial land clearing for the oil palm estates that are a major component of Indonesia's development strategy. In due course it is expected that the fire / smoke problems will lessen or disappear in any one area as planting-up of the estates is completed. Very few fires are detected in Sumatra during the night, but those that are detected usually signify the presence of larger land clearing fires for estate crops.

In the drylands of South Sumatra and Lampung, with their more mature agricultural landscapes and where nearly all forest has already gone, fires are mostly ephemeral and related to small-scale agricultural land clearing timed in anticipation of the start of the wet season (Map 1b). These fires cause no serious pollution and do little ecological damage in an environment that is already far removed from its natural state.

Linear fire patterns are found throughout Sumatra in close association with roads, rivers banks and with artificial drainage lines in the wetlands. They are linked to settlement and small-scale land development activities (Map 1c).

Map 1. The effects of different land-use on the pattern of vegetation fires detected by NOAA 12 and 14, (a) hot-spot clusters typical of fires associated with large-scale forest clearance for plantation agriculture in Riau and North Sumatra. Fires may burn for several days depending on the weather – composite data for June 1998, (b) dispersed ephemeral fires lasting no more than three hours during the afternoon and typical of plot burning by long-established – mainly rubber - smallholders in South Sumatra during the agricultural burning months of August and September – composite data for the first two weeks of September 1999, and (c) linear fires that mark the course of new roads with adjacent land being settled in 2 ha blocks allocated by the local village head (*Kepala Desa*); these strips of land are being cleared of forest, burnt and planted to oil palm – Riau, June 1999 (See also the linear burning pattern associated with roads in Plate 1). Approximate scales (a) and (b) 1:2.8 million, (c) 1:100 000.



3. SEVEN MAJOR FIRE ZONES

Location of the Zones

The satellite monitoring of fires in Sumatra started in 1996 and since then fire numbers in each year have been shown to follow a climatically determined progression (Anderson *et al.*, 1999; Anderson, Imanda and Muhandar, 2000).

Seven major fire zones have now been identified in Sumatra as a result of this continuity of monitoring and are characterized as, 'areas where clusters of persistent fires have been detected over the last four to five years'. The zones are located in parts of the provinces of North Sumatra, Riau, Jambi, West Sumatra, Bengkulu and South Sumatra (Map 2). Only the extremities of the island, Aceh and Lampung provinces, have been free of fire zones although the wetlands of Lampung (Way Kambas) and Aceh (Singkil and Babah Rot) have all suffered fire damage. The latter peat swamps, that lie on the west coast, were partially cleared by fire in the early nineties for a transmigration scheme and for oil palm plantations (Rijksen, Diemont and Griffith, 1997).

Map 2. The seven major fire zones of Sumatra. Circles indicate the general location of each zone and the fire symbols show the sites of specific fires described in the text.



Wetland Commonality

Six of the seven fire zones have a common feature in that they are in peat-rich wetlands. They are thus on soils that are considered by the local people as unsuitable for either traditional forms of agriculture or settlement - but may nevertheless be used by them for other income-generating purposes.

The Establishment of Five of the Seven Fire Zones – The ‘General Model’

There is also a commonality as to the reasons for, and the sequence of events that lead to, the establishment of a fire zone. The process is well illustrated by the development of the dryland fire zone that straddles the Riau – North Sumatra border and also by the similar events that led to the fire zone in the Kampar River wetlands of Riau. The same general process seems to have taken place in the two west coast wetlands, as well as in the South Sumatra interior wetlands fire zone, i.e. in five of the seven zones described here.

- With few inhabitants, and none in a position to object in the seventies, the land was designated as Permanent Production Forest.
- Large parcels of land were then allocated by government to HPH.
- Prolonged, heavy and unsupervised logging by the companies, compounded by extensive illegal cutting by local people and outside interests, devastated the forests.
- As a consequence of the devastation government reclassified the areas as Conversion Forest.
- This move attracted the attention of regionally-based entrepreneurs who eagerly sought licenses from government, took over the forests and removed all the residual timber that was often of considerable value.
- The same business groups then clear-felled, burned, and planted the ground to estate crops.

The fires have been, and remain, numerous, frequent, persistent, pollution-causing and concentrated within a particular area. The result is a fire zone.

The plantation crop of choice over the past five years has been, and remains, oil palm although some companies (in particular the parastatal, PT. Inhutani V) appear to be seeking exotic pulp and / or indigenous tree species that will grow on problem-soils. No new rubber estates of any size were established in the same period.

The Case of the South Sumatra Coastal Wetlands – the Sixth Fire Zone

The story in the coastal wetlands of South Sumatra illustrates a different process that has led to the creation of the sixth fire zone. The chronicle starts in the late sixties.

- Grandiose plans - largely funded by the World Bank - were made to resettle thousands of landless families from the ‘inner-islands’ of Java, Madura and Bali on the ‘unoccupied’ tidal lowlands of the province. The perception was that the transmigrants would cultivate wetland rice for subsistence and sale.
- To this end over 300 000 ha of good quality swamp forest were systematically felled, and the timber sold.

- The residual non-commercial species and scrub were cut and burned.
- A complex and extensive system of drainage-cum-irrigation canals was dug.
- Resettlement of the transmigrants started soon afterwards and, despite steadily mounting evidence of the difficulties faced by the settlers on infertile land with periodic shortages of drinking water, continued spasmodically until the early nineties.
- However the thousands of families that were planned never arrived while some transmigrants moved on.
- The canal system provided easy access to the remaining unlogged forests.
- Legal and illegal logging systematically depleted these forests.
- The transmigration scheme fell into semi-dereliction.
- What remained were many thousands of hectares of fire-prone sedge and grassland on the former transmigration sites plus equally large areas of variously degraded, and fire-vulnerable, swamp forest.
- The transmigration programme and the logging aided by the *el Nino* fires of 1987, 1991, 1994 and 1997 progressively destroyed over 90 percent of the swamp forests that had once covered the land south of the Musi River.

Today a mosaic of sedges, grass, herbaceous and woody scrub and sparse *Melaleuca* woodlands cover the land. All are very susceptible to fire in drought years, and the rehabilitation of this vast area is now a major challenge.

The Formation of the Seventh Fire Zone - Jambi Example

‘Intermediate’ between the cases of Riau and the South Sumatra coastal wetlands is the process that has led to the fate of the Batanghari River wetlands of Jambi, the seventh, and the last of the fire zones within Sumatra. These are ecologically one of the most important wetlands sites in South East Asia and consequently 175 000 ha are designated as the Berbak National Park. The sequence of events that led to the formation of this fire zone are:

- Logging concessions to the west of the Berbak Park and spontaneous Bugis settlers to the east heavily damaged considerable areas of swamp forest. The destruction was both direct - caused by over-cutting - and indirect caused by the digging of canal systems to float out the felled logs.
- Extensive illegal cutting, again with canalization, began outside and now extends somewhat within the National Park.
- Around 17 000 ha (10 percent) of the Park were destroyed by fires in 1997. Who and why the fires were lit are not known. The burn scar remains clearly visible on a SPOT Quicklook image of September 2000.
- This grassland nucleus caused by the 1997 fires coupled with the boundary felling and illegal logging has opened the whole Park to destruction by fire in the next *el Ninor*.

Further dense trans-boundary smoke haze pollution seems assured as most of the Jambi swamplands fire zone are underlain by an exceptionally thick and ancient layer of peat.

The destruction of the often endangered and / or unique plants and animals has already been excessive and seems most likely to continue in each of the seven fire zones. It is however the desire by government and individuals for immediate profit achieved at the expense of the environment that is the cause of forest loss: fire zones are only the signal.

4. THE NORTH SUMATRA – RIAU BORDER

Riau; the Fire, Smoke and Oil Palm Province

Fifty percent of Riau is swamp, mainly peatland, and it is these swamps that are the focus of forest conversion. There are 261 registered oil palm estates in the province and allocated concessions are thought to cover 1 – 2 Mha out of 5 Mha that are still officially listed as Conversion Forest. The first, and by now established, estates are on dryland; the new developments are nearly all on wetland. Land-clearing fires in partially drained peat swamps produce copious smoke as the intended surface fires ignite the underlying organic soil. Once started the underground fires are infamously difficult to suppress (Nicolas and Bowen, 1999).

Around 30 percent of the fires detected in Sumatra over the last five years have been in Riau although the province has only 20 percent of the land area. The province thus has one of the highest frequencies of vegetation fires in any province in Indonesia.

The fires themselves are of less concern to official opinion in Indonesia, Singapore and Malaysia than the resultant smoke haze although, as noted above, the wetlands are ecologically rich and fragile. A considerable number of fires were detected in Riau province in May 1997, February - March, June and November 1998, in April and July 1999 and in March and July 2000. On each occasion Peninsular Malaysia and Singapore were affected to varying degrees by the smoke haze.

The Border Fire Zone

The North Sumatra – Riau border zone has been the major, and the clearly and easily definable, focus of vegetation fires in Sumatra over the last four years. The zone encompasses one of the few extensive tracts of dryland lowland forest that remain in Sumatra. The forest is now being heavily logged and, in many cases, clear-felled and burnt. It was an area that was recommended for conservation by Whitten *et al.* (1987).

The many clusters of hot-spots, in particular along the part of the border that lies between Dumai and Medan, from May to July 1999 are clearly visible in Map 3. The reticulation of tracks in the same area indicates that the forest has been logged and is now being cleared by chainsaw and fire. The process will doubtless continue over the next few years as it is planted to estate crops. Neither the lowland forest nor the proposed conservation area will survive. Similar, although smaller, fire clusters lie in Riau to the east of the main fire zone.

An area of 4 800 km² is demarcated on the map. The number of night-time hot-spots within this reference area is shown in Table 1 together with the numbers within Sumatra

as a whole. The figures show that during three months in 1999, 566 fires were recorded in the fire zone on NOAA night-time images. This is a startling 19 percent of all such fires in Sumatra concentrated into just 1 percent of the area of the island. [Night fires are used in the example as they indicate the longer-lasting burns that are associated with commercial land clearance – see Chapter 2.]

The demarcated rectangle lies within the region used by CRISP to illustrate the use of SPOT imagery to detect plantation fires in southeast Asia. (See website, <http://www.crisp.nus.edu.sg/crisp.html>). Plate 1, taken from the CRISP website, covers the central part of the area. The land cleared by fire since 1996 (green) corresponds closely with the distribution of NOAA-detected hot-spots over the three year period. The rectangular planting blocks within the new estates are clearly visible as are the road systems that appear as white lines within the blocks. The road grid within a newly established estate is seen in the lower-right of the image. The dark-red area in the bottom left of the image remains forested but is being logged. Land for a short distance to each side of the winding east – west road in the center of the picture has been cleared and burnt by new settlers who are sponsored by land speculators.

The border of the two provinces has been a place of conflict over land rights for at least ten years. Hoshour (1995) described how funds and facilities designated for transmigration projects were manipulated and resulted in embittered relations between spontaneous Batak migrants, Javanese transmigrants and local residents. A few of the fires may be a symptom of this residual tension, although land disputes are now more frequently between plantation companies and local farmers who complain that the planters have encroached on their village lands. The resolution of all disputes is hampered by ill-defined boundaries.

Map 3. The fire zone that straddles the Riau - North Sumatra border. A hot-spot composite image for May, June and July 1999. The rectangular box delimits an area of 4 800 km², roughly one percent of the area of Sumatra.

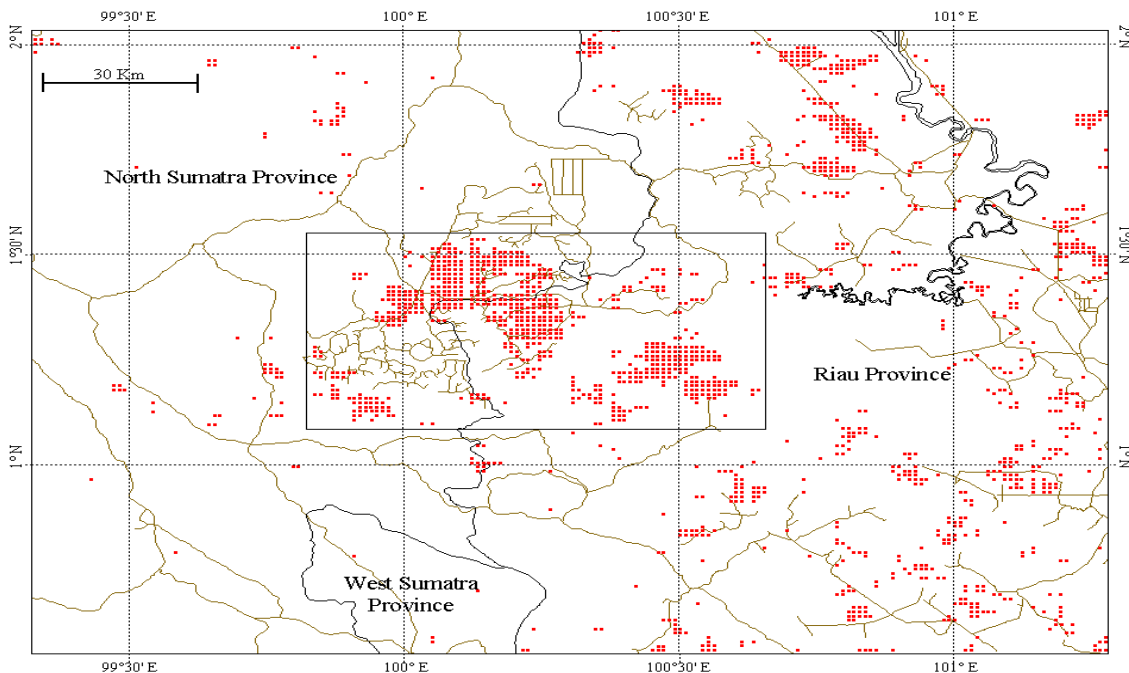


Table 1. The number of hot-spots detected using night-time NOAA data that lie within the box delineated in Map 3 of the North Sumatra – Riau border zone compared to the numbers detected throughout Sumatra as a whole in May, June and July 1999.

Month of detection 1999	Number of hot-spots in Sumatra (477 000 km ²)	Number of hot-spots in delineated area (4 800 km ²)	Percentage of hot-spots falling within the delineated area
May	313	187	60
June	804	200	25
July	1790	179	10
May-July	2907	566	19

Plate 1. SPOT Quicklook image (21 July 1999) showing part of the Riau – North Sumatra border region that lies within the delineated box in Map 3. Areas cleared by fire appear in green.



5. KAMPAR RIVER WETLANDS OF RIAU

Large-blocks of fires have been detected in the Kampar River region of Riau province since July 1996. Peak burning months have subsequently been in January, March, May and June 1997, February and March 1998, July 1999 and in March 2000. Smoke haze that arises from this area periodically affects Singapore that lies some 100 km to the northeast.

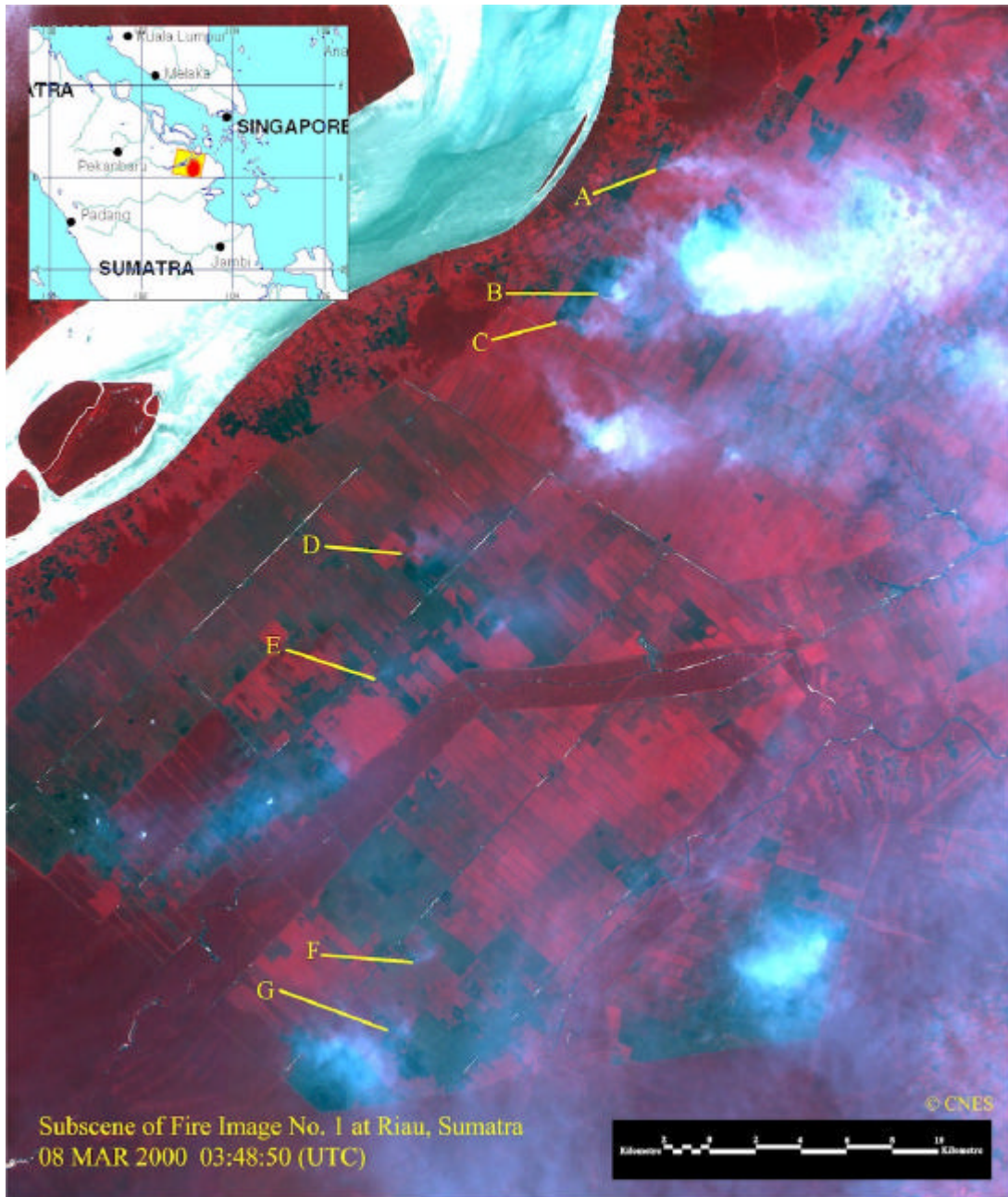
Plantation development straddles the borders of three districts, Kampar, Indragiri Hulu and Indragiri Hilir. The development occupies over 250 000 ha and is one of the largest on-going clearances in Sumatra. The progression of clearance and the burning of the estate planting blocks over four years is clearly shown by the distribution of hot-spots detected in 1996, 1997, 1998 and 1999 (Map 4).

Fine-details of the development of the estate are clearly seen on a SPOT image (Plate 2). This image was supplied by the Government of Singapore to the Government of Indonesia in March 2000, as evidence that estate land clearing in the wetlands of Riau was the primary source of the smoke haze problem. There have been very few fires in the area since then. We assume that this indicates that the land preparation phase is nearly complete – rather than that the companies have responded to the complaint.

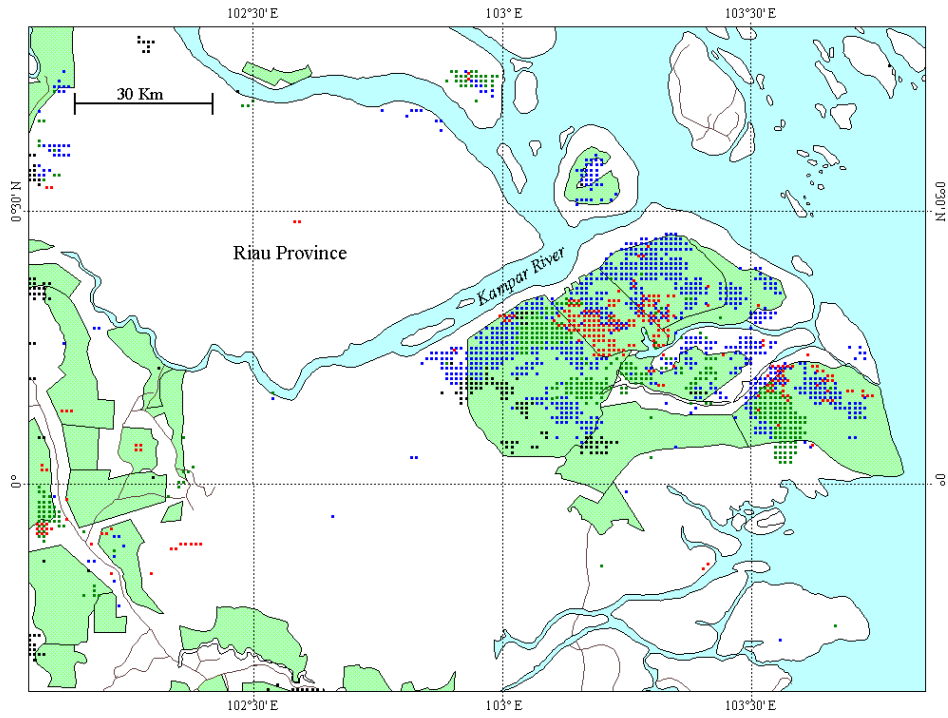
A Case Study

According to BAPEDAL, several companies, at least one of which is registered in Malaysia, are clearing land in the Kampar River wetlands. The estate crop, thought to be oil palm, is being planted on peat up to 16 m deep. The concession of the Malaysian company is reported as 84 000 ha to be cleared over four years; clearance was nearly complete by October 2000. (Ir. Ardhi Yusuf, BAPEDAL Wilayah, Pekanbaru, Riau)

Plate 2. SPOT image of 8 March 2000 showing part of a large estate crop development in the coastal wetlands of Riau bordering the Kampar River. Red areas are vegetated and planting blocks that tend to run from northeast to southwest are bordered by a system of large canals that shows as straight, white lines. Burnt areas are in black and a number of the burning blocks are identified (A to G).



Map 4. The Kampar River fire Zone, Riau province. Former HPH are shaded in green. Fires detected in July 1996 are shown in red, June 1997 (green), February - March 1998 (blue) and July 1999 (black).



6. COASTAL WETLANDS OF THE WEST SUMATRA - NORTH SUMATRA BORDER

Fires associated with large-scale land clearing in West and North Sumatra were first detected in May and June 1996 and were common in February and June 1997, February, June and July 1998, April, May and July 1999 and in June and July 2000. As in the Kampar estuary area, the burning occurred in logged concessions in the process of conversion to another land use; and as elsewhere, probably for oil palm. The distribution of fires during the months of June and July 1998, June and July 1999, and again in June and July 2000 are shown in Map 5.

SPOT images (Plate 3) from 19 August 1996 and 3 May 1999 show burn scars as green. Few areas of natural wetland vegetation (dark red) to the left of the image, now remain and the little that does is likely to be burnt-over in the near future.

Map 5. The West Sumatra – North Sumatra coastal wetlands fire zone. Former HPH are shaded in green. Fires detected in June and July 1998 are shown in blue, those in June and July 1999 in red, and the June and July 2000 fires in green.

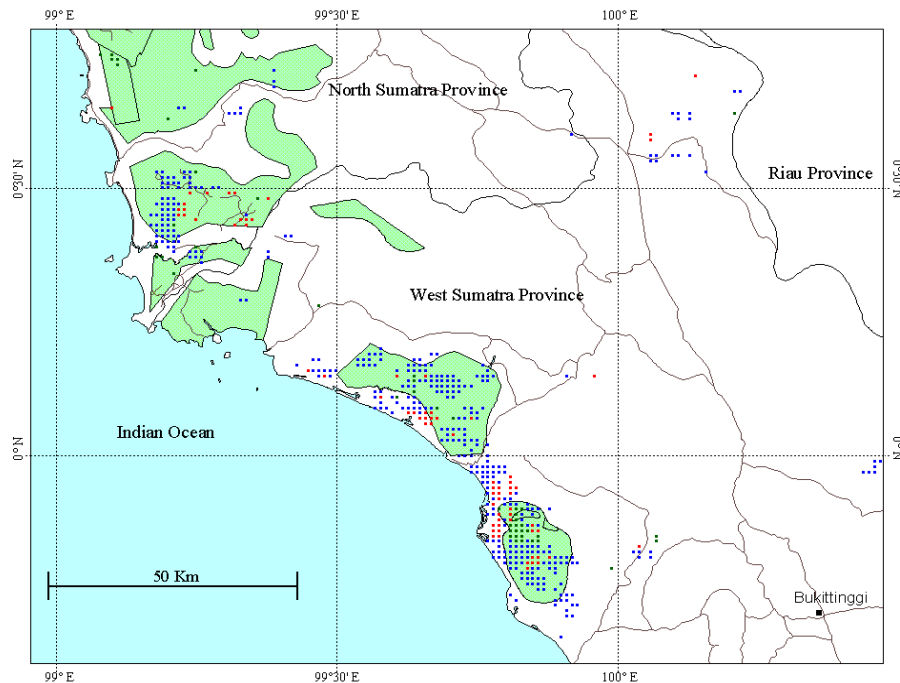
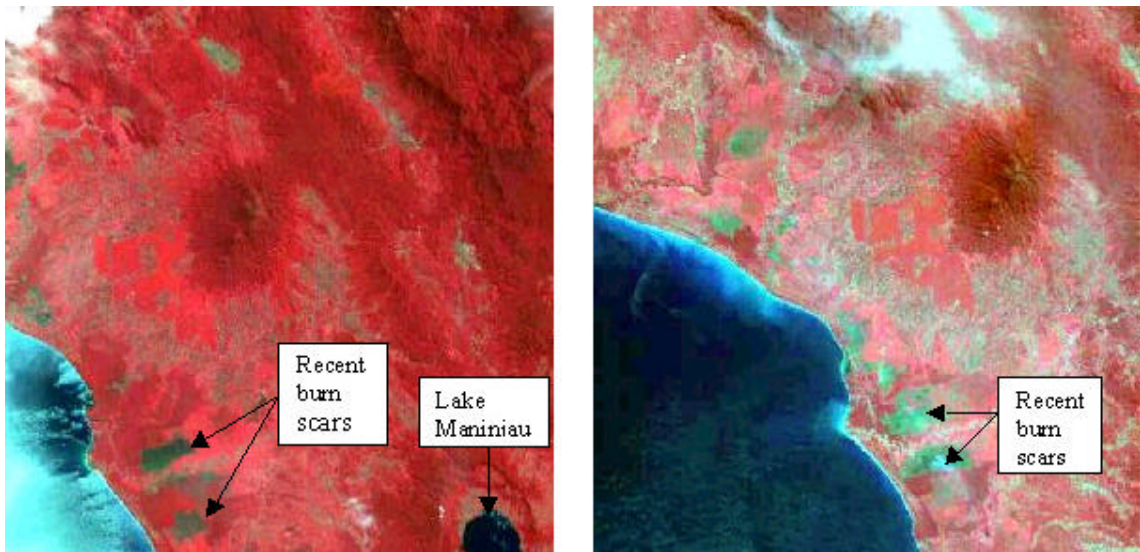


Plate 3. SPOT Quicklook images of parts of West Sumatra and North Sumatra provinces for 19 August 1996 (left) and 3 May 1999 (right). Burn scars in the coastal wetlands show as green patches.



7. THE WEST SUMATRA – BENGKULU COASTAL WETLANDS

A few fires were first detected in the coastal wetlands of West Sumatra and Bengkulu provinces in March 1996 but numbers rose sharply from June to August 1997. Further fires burned from May to July 1998 and again in April, June and July 1999 (Map 6). SPOT imagery (Plate 4) supports the hot-spot data.

As elsewhere the fires are associated with forest concessions but here their purpose is not known with certainty; some may have been wildfires. This wetland, along with that previously described which bridges the North and West Sumatra province border, together make up most of the small west coast wetlands of the island. Only in Aceh do these wetlands remain more or less free of fire damage although as previously noted, those of Barbah Rot and Sinkil have been degraded and rampant illegal logging is reported in the west coast swamps of Gunung Leuser National Park (EIA, 1999).

Map 6. The West Sumatra - Bengkulu coastal wetlands fire zone. Former HPH are shaded green. Fires detected in June 1997 are shown as green spots, those in May – July 1998 in blue, and from May – July 1999 in red.

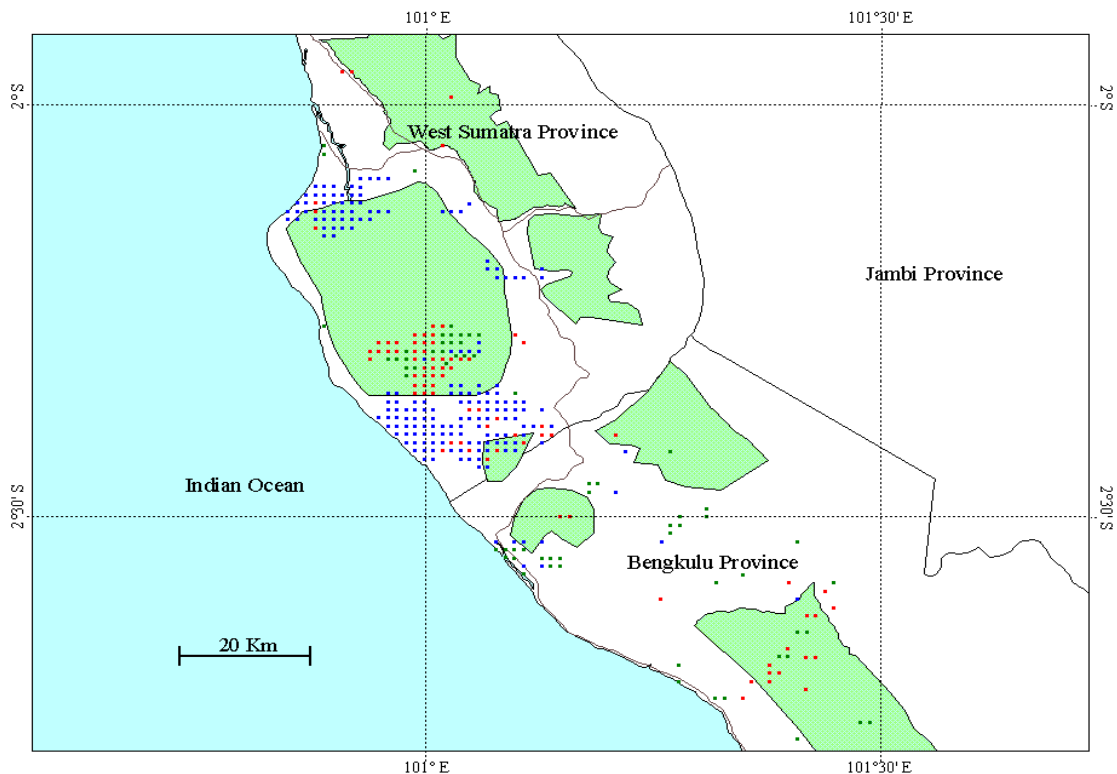
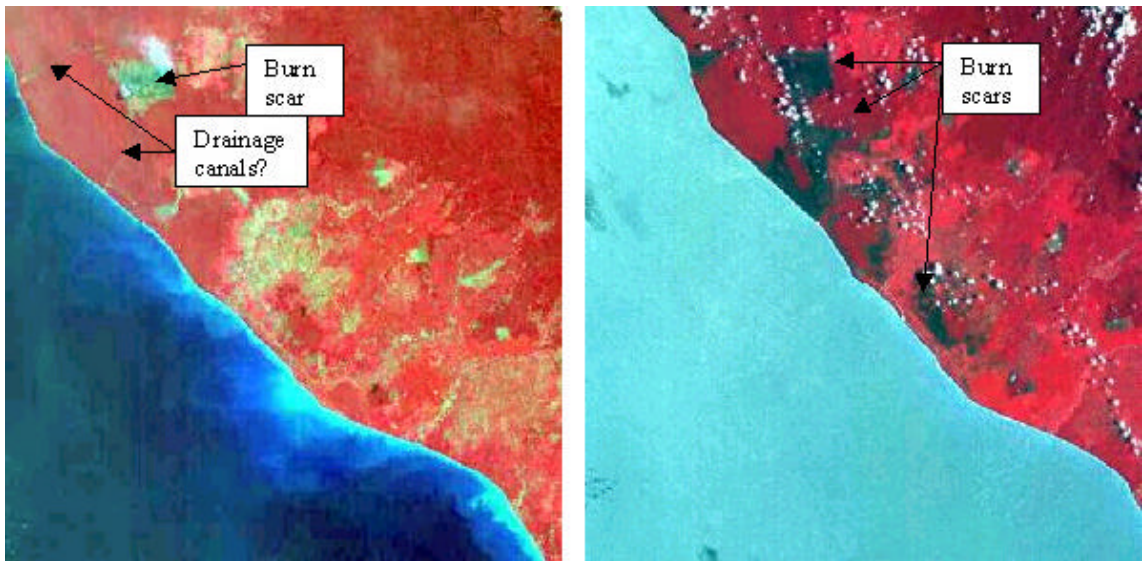


Plate 4. SPOT Quicklook images of parts of West Sumatra province close to the border with Bengkulu. Burn scars show as green or black in the coastal wetlands. Left, 17 June 1997; right, 11 February 1998.



8. BATANGHARI RIVER WETLANDS AND BERBAK NATIONAL PARK, JAMBI PROVINCE

The swamps that border the River Batanghari have peat deposits up to 3 m deep. The swamps were assessed by RePPPProT (1988) as unsuitable for a wide range of crops and cropping systems that include wetland arable, agroforestry and oil palm. However land development for commercial tree crop plantations in Jambi province is rapidly moving into these wetland forests, promoted by an increasing shortage of dryland unfettered by land tenure complications.

East of Jambi town the wetlands of the Batanghari were badly damaged by wildfires in late 1997 (Plate 5). They are now at high risk from fire in years with an extended dry season when they will act as the seat for further fires. These new fires will, in turn, further encroach on the fragmented remains of the natural wetland vegetation. And, as the sequence progresses, Berbak National Park will come under an increasing threat from fire.

The fires detected on both day and night NOAA images over a period of several weeks in August 1999 are shown in Map 7. The source of the fires was yet again found to be linked to large-scale forest conversion but in this instance the trees *Dyera polyphylla* and *Alstonia* sp. (the former for latex, the later for pulpwood) were being introduced in and around land controlled by the state enterprise PT. Inhutani V. The concession was first logged prior to 1986 and any timber species that remained would have been removed before the 1999 fires were set. The Park is also largely in a peat swamp, and like the neighboring swamps, suffered fire damage in 1997. (See NOAA data overlay on Plate 6). Berbak is one of only two 'Ramsar-listed' wetland sites in Indonesia. (i.e. an internationally agreed site of the greatest scientific importance decided at a Convention held in Ramsar, Iran, in 1991. Indonesia ratified the treaty in 1992.)

SPOT images of September 2000 used as a base for the hot-spot information show that at least 10 percent of the Park has now been damaged by fire. Considerable land clearing and logging activities on the Park boundaries are also visible on the image. JICA (2000) reports the view of a local NGO that there is widespread illegal logging of ramin (*Gonystylus bancanus*) within the Park.

Plate 5. SPOT Quicklook image of 1 February 1999 showing the Batanghari River area, Jambi province. The scars of fires that burnt in 1997 show as bluish-purple patches.

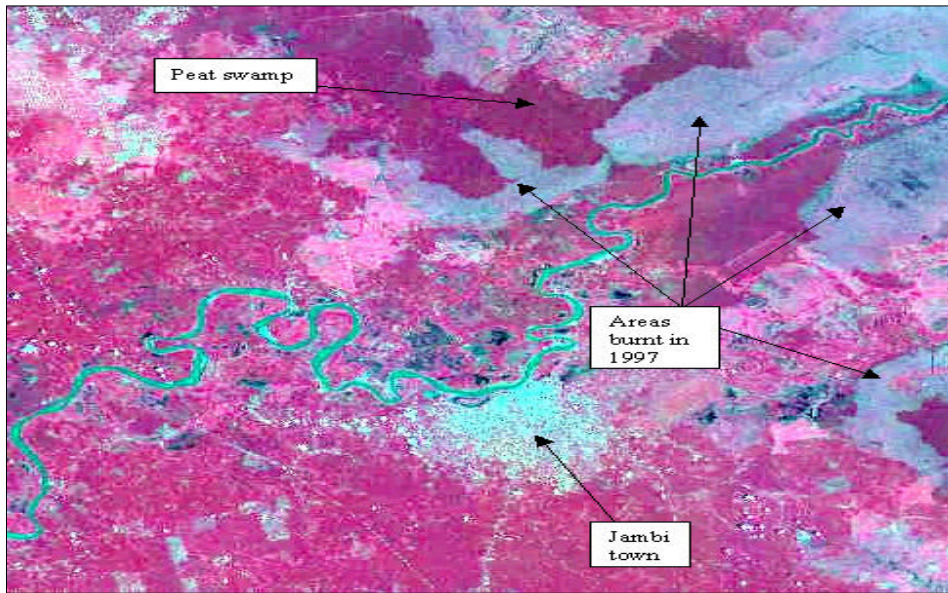
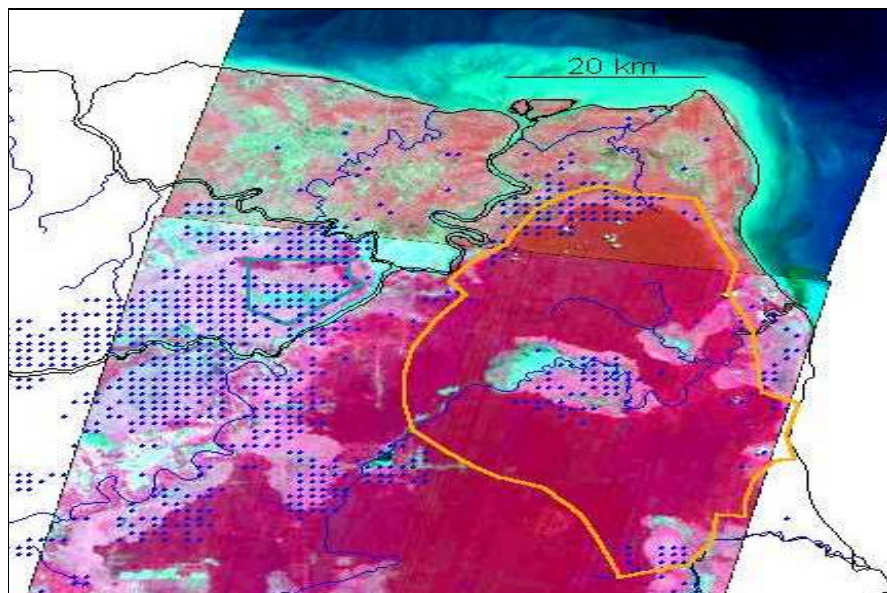
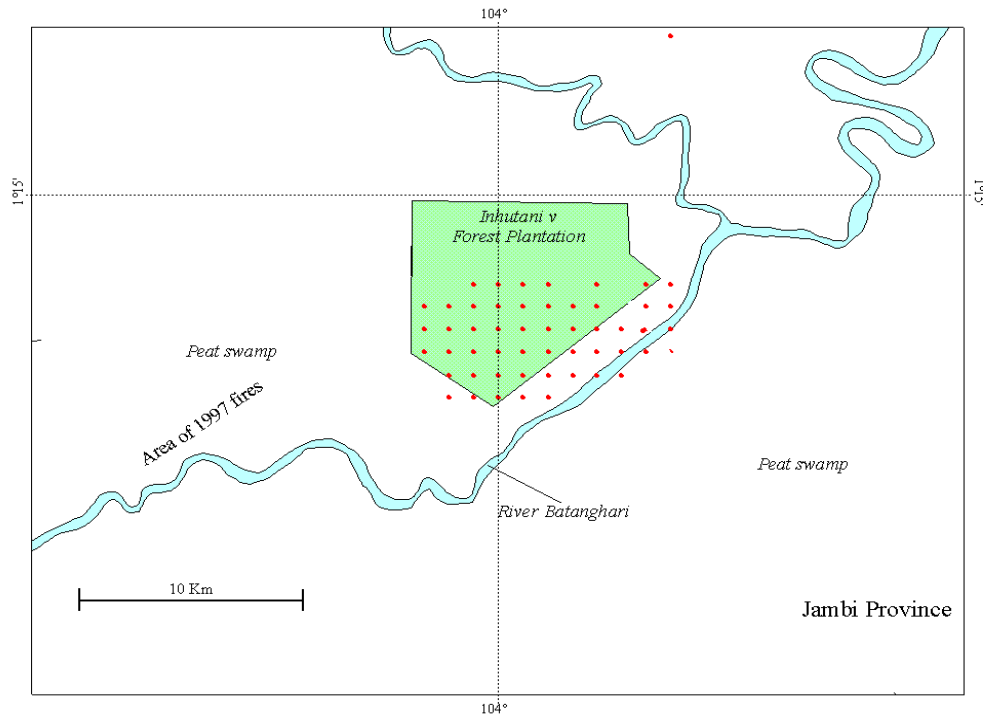


Plate 6. SPOT Quicklook image mosaic of 11 September 2000 showing the Batanghari River and Berbak National Park, Jambi province. The Park is outlined in yellow. Superimposed on the SPOT image, as blue dots, are the locations of fires detected in September 1997. Swamp forest appears as dark red



Map 7. The Batanghari River fire zone, Jambi province. The area shaded green is the HPHTI concession of PT. Inhutani V. Fires detected in August 1999 are shown as red spots.



The hot-spot cluster is coherent and accurately reflects the *pattern* of burning although there is a bias in location error to the south and east by some two to three kilometres. Such location biases are inherent to the Palembang NOAA system and are discussed more fully by Anderson *et al.* (1999a).

A Case Study

Smoke haze was moderately severe up to 5 km downwind of the peat fires at the time of a visit to the HPHTI on 4 September 1999. The manager of the estate explained that 1 030 ha of the 1 300 ha originally planted were destroyed by fire in 1997. Fire is still used to clear land in the estate although it is recognised that the peat soils pose a serious risk of unwanted fire spread. To reduce the incidence of ground fires and to maintain greater control of the fire, no more than 10 ha is burnt at any one time and ferns are subsequently planted as a cover crop. The fires that caused the extensive smoke haze during August 1999 were claimed to have been lit by fishermen clearing grass around pools.

9. INLAND SWAMPS OF SOUTH SUMATRA

There were only three fires of any consequence in 1999 in South Sumatra province from amongst the thousands of agricultural and other minor ephemeral fires detected (e.g. roadside fires and the burning of fallow growth to protect standing crops within an often complex mosaic of land uses). Two of the three major fires were in inland swamps. (The third was in the coastal swamps – see Chapter 10).

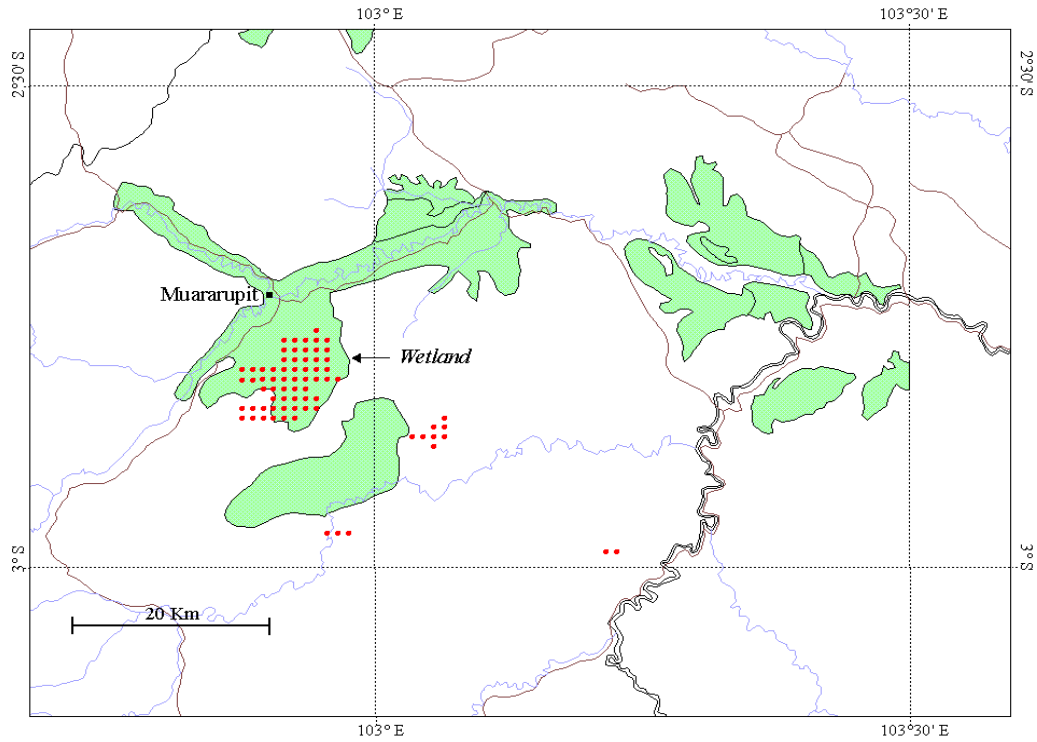
The first of these important 1999 fires was in the wetlands near Muararupit, to the west of the province. The fire was originally started in mid-1997 (Map 8) and continued to be re-lit and the area burnt continued to expand periodically in 1998. The estate company persisted and cleared along the eastern margins of the wetland using fire throughout September 1999 (Map 9). The result was that the entire wetland was burnt in three years.

The corresponding SPOT image for the 30 June 1997 (Plate 7a) shows the burning wetland and its smoke plume in the northwest corner of the image. A more detailed image of the fire from 10 July 1997 (Plate 7c) clearly shows the pattern formed by the planting blocks within the estate. By August 1998 most of the wetland in this area had been consumed by fire (Plate 7b).

The second fire of consequence in the interior wetlands was established on 22 July 1999 in the backswamps of the Musi River near Babat in the centre of the province (Map 9). Why the fire was lit is not known with certainty but it can safely be presumed to mark the start of another estate development. This fire reappeared intermittently until 22 September 1999.

There were no further fires in the inland swamps over the next twelve months. We do not know if this is because (a) development of the estates is complete, (b) the amount of land already cleared was sufficient to meet the year 2000 planting target, or (c) current low prices for palm oil with the cash-flow difficulties this brings to the companies, caused the suspension of new clearing in 2000.

Map 8. Fires detected in the wetlands (green) near Muararupit, South Sumatra province, on 30 June 1997. The main fire area corresponds to the burn scar shown in Plate 7c.



Map 9. Fires detected in the wetlands near Muararupit and near Babat, South Sumatra province in September 1999.

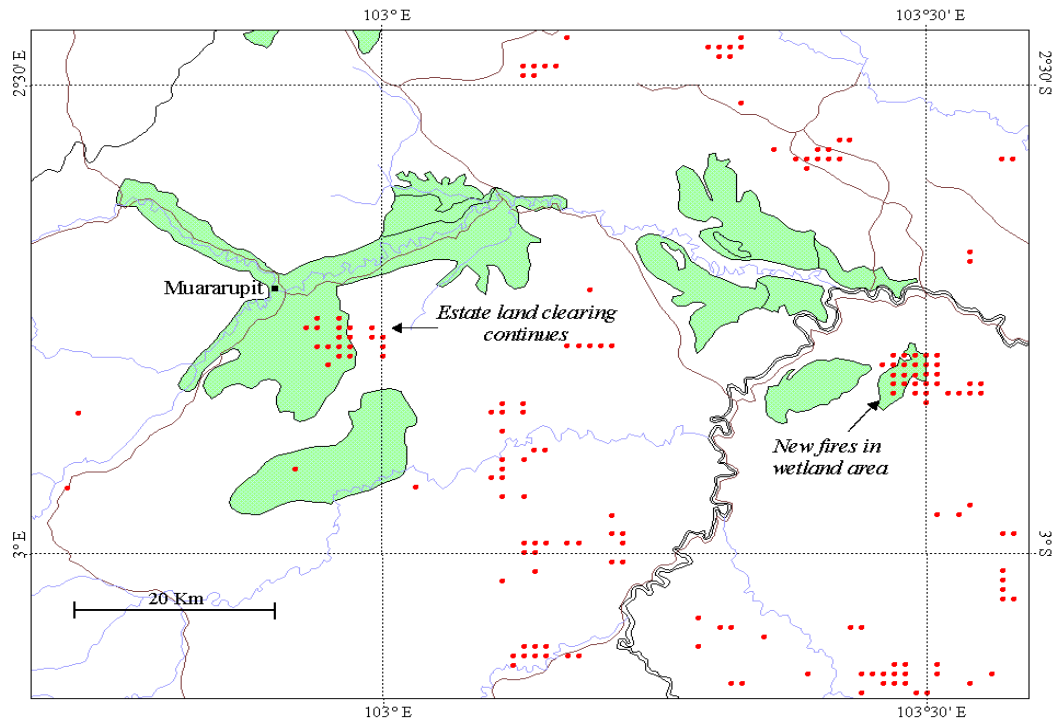
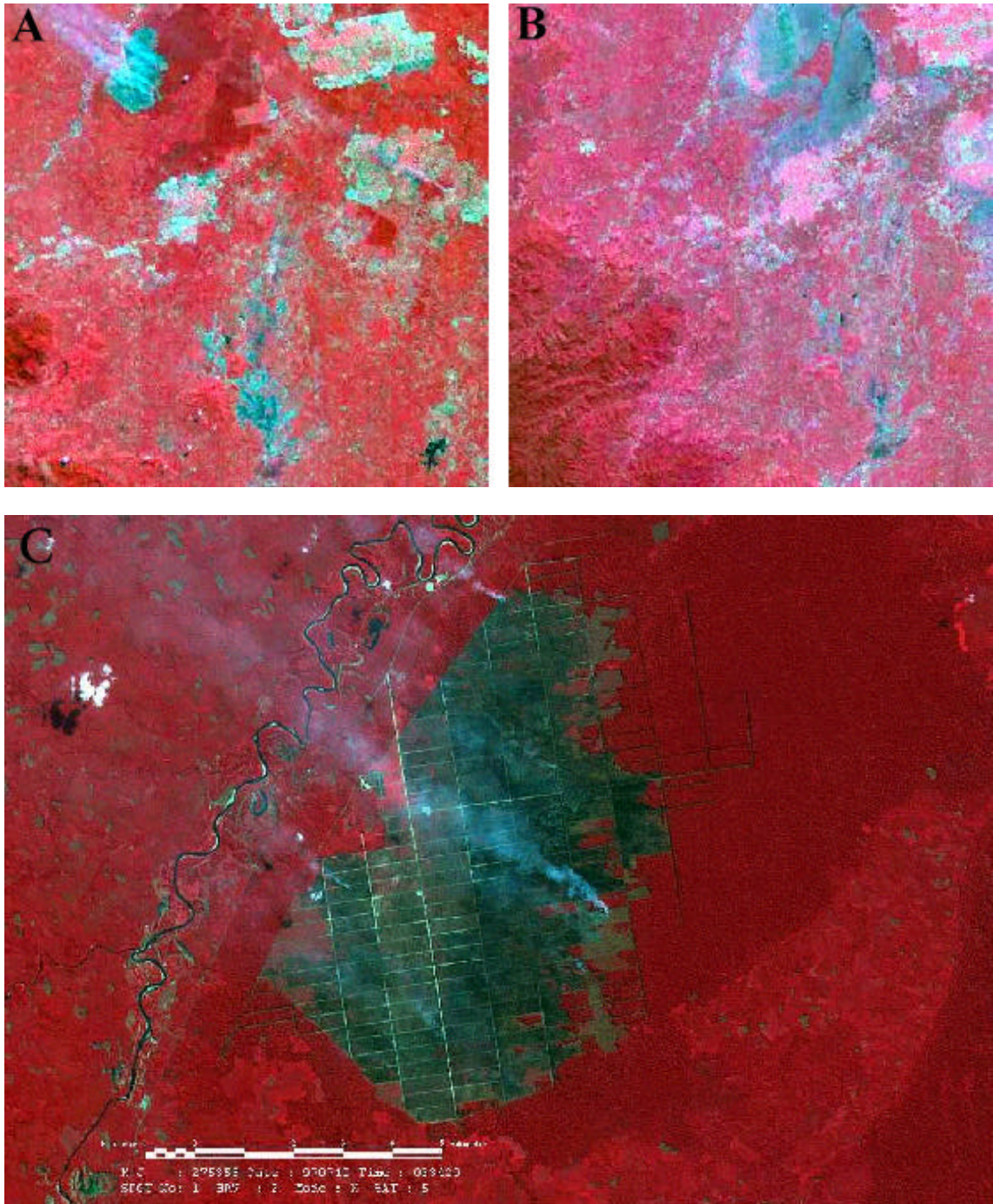


Plate 7. SPOT images showing areas to the west of South Sumatra province. The fires and smoke plumes that originated from the swamp areas near Muararupit on (a) 30 June 1997 (b) 10 August 1998, and (c) 10 July 1997 are clearly visible. In Plate 7c wetland vegetation is shown in dark red; light red indicates secondary dryland vegetation with scattered burn scars related to smallholder land clearing; the road between the river and the plantation is the Trans-Sumatra highway. The area burnt by the estate company was some 6 000 ha in June 1997 and had increased greatly by the end of 1999.



10. COASTAL WETLANDS OF SOUTH SUMATRA

The Wetlands Fire Zone

Tree deaths caused by the 1997 drought and fire in the coastal wetlands of South Sumatra are pictured in Plate 8. All logging concessions were affected and salvage extraction continued throughout 1998 and 1999 (Plate 9). The great fires of late 1997 were finally doused by heavy rainfall and a rising watertable in the early months of 1998⁴.

No further fires burnt until 18 June 1999 when a fire was detected to the east of Palembang. This was to be the third fire of note in the province in 1999. [The first two are described in Chapter 9.]. The initial stages gave no cause for alarm and the fire appeared to have died with the onset of periods of persistent rain in mid-July. However it re-appeared at the end of the month and slowly spread northwestwards throughout August to affect three logged-out forest concessions. The progression of the fire in relation to weather conditions, as measured by a drought index, is shown in Figure 1. The index rose from low to moderate fire danger level in the two weeks before 1 August – the date on which the fire took serious hold – and into the high danger level in the middle of the month, three weeks before the fire reached its peak. The fire was extinguished by rainfall at the end of September – the start of the rainy season in southern Sumatra.

The area was over-flown by helicopter at the height of the fire on 15 September (cover photograph) when it was evident that many thousands of hectares had already been burnt. SPOT Quicklook images subsequently showed a very clear fire-scar (Plate 10) that some 14 000 ha had been affected (Anderson, Imanda and Muhnandar, 2000).

It is now certain that the fire was set deliberately to clear land allocated for a new estate development in the former HPHs although it was initially considered as a wildfire. It was one of the largest vegetation fires seen to date in Sumatra and the resultant hot-spot cluster was bigger than any group detected throughout the 1997 fire crisis. The large smoke plume caused by the fire (Plate 11) dispersed to the northwest across the mouth of the Musi River and fortuitously did not affect Palembang or any other major town.

⁴ The drought index for the remainder of 1998 and up to May 1999 had remained low until June 1999 when it approached the high danger level. (There were 23 dry-days in June 1999 - although total rainfall was 156 mm, 28 mm above the Palembang average - and was the harbinger of the province's marked dry season.)

An Overview of Vegetation and Land-Use in the Coastal Swamps

Laumonier (1997) gives a recent comprehensive overview of the vegetation and land-form in Sumatra, including those of the coastal wetlands, while Soepraptohardjo and Driessen (1976) deal with the problems of agriculture on deep peats in the region.

Primary swamp forest covered a striking 3 890 000 ha of South Sumatra in 1900. By 1982 this figure had fallen to 860 000 ha (McKinnon and Artha, 1982, quoted by Danielsen and Vergheugt, 1990) and had further slumped to 290 000 ha by 1989.

Logging accounted for much of this dramatic loss, although substantially aided by the setting-up of official transmigration schemes that 'reclaimed' 300 000 ha of pristine swamp forest from 1976 to 1984 (van Dis, 1986). Measurements taken from the base maps used by Danielsen and Verheugt (1990) indicate that a reticulation of 600 km of navigation and primary canals were used to achieve this objective. Field visits in mid-2000 showed that the majority of these canals remained open and vary in width from 10 m to 25 m at the top of their U-shaped profile; they are up to 5 m in depth. The primary system is supported by (?) thousands of kilometers of secondary and tertiary channels many of which are now weed-choked. With the loss of the forest has come a substantial decrease in the numbers of many already endangered mammals and birds.

The flora of the two sub-districts Pampangan and Tulung Selapan within the coastal wetlands of Ogan Komering Ilir district, South Sumatra, was described in general terms by J.M. Bompard in September 1997 as part of a wider study that examined ways in which smallholder farmers might be encouraged to prevent fires. The results were originally written-up in two internal FFPCP project reports (Anon, 1997 and 1997a). Relevant sections are reproduced here as they give a recent insight into the vegetation of these heavily exploited lands.

In the three years since the original reports were prepared at the height of the 1997 *el Nino* fires, the remaining forests continued to be logged to extinction, legally until July 2000 and illegally throughout the period.

Figure 1. The progression of a major fire, as monitored by the number of hot-spots (blue) detected on each day's NOAA afternoon imagery, in the coastal swamps of South Sumatra from mid-June 1999 until quenched by rains at the end of September 1999. The drought index for the corresponding period is shown in red.

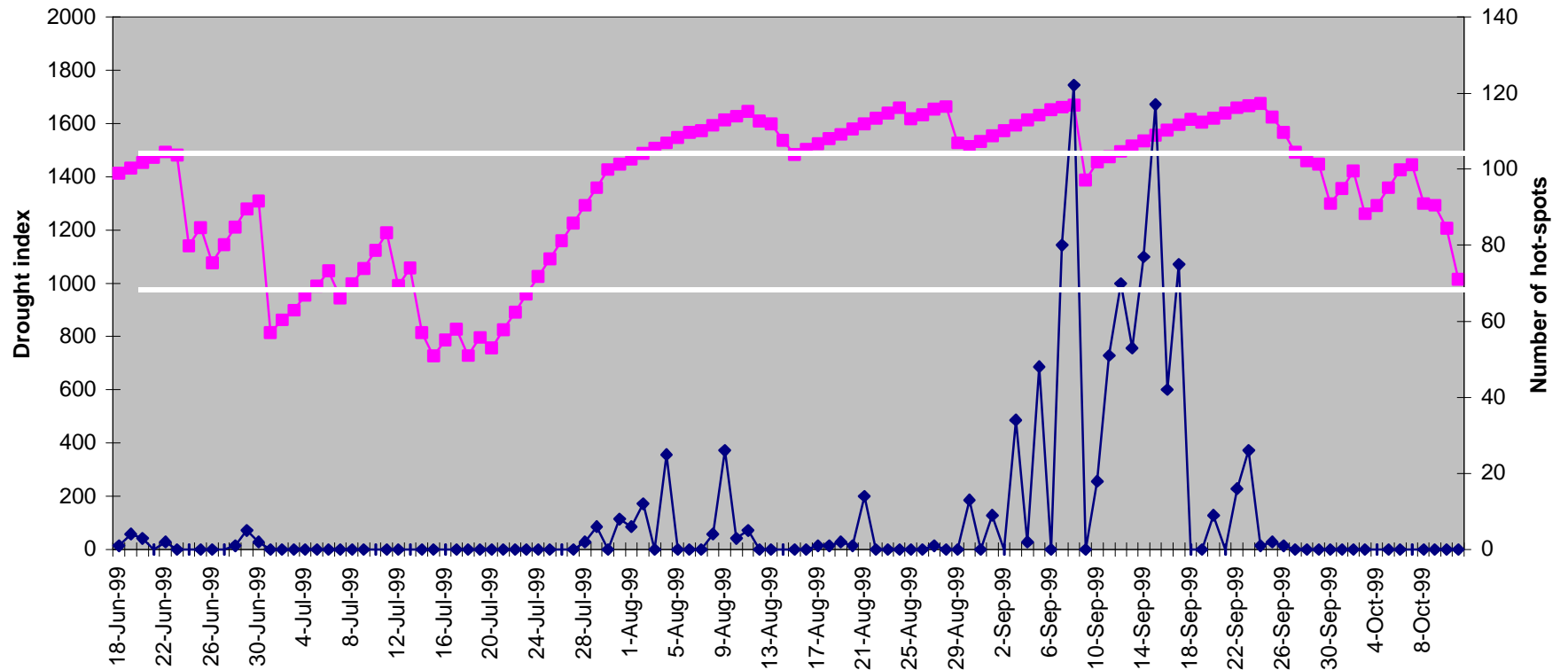


Plate 8. Dead swamp forest in the coastal wetlands of South Sumatra province to the east of Palembang killed by the 1997 drought and fires - photographed in September 1998. The small patches of trees (picture center) that escaped the devastation of 1997-98 are unlikely to survive future fires.



Plate 9. Salvage logging in September 1999 in a forest concession in the coastal wetlands of South Sumatra destroyed by the major fires of 1997. One of the many canals used to extract the logs can be seen running from the top-left to the bottom-center of the picture.



Plate 10. SPOT Quicklook image mosaic of 13 May 2000 showing part of the coastal wetlands in Ogun Komering Ilir District east of Palembang with the burn scar (black) caused by the June – September 1999 fire. Superimposed on the images are the night-time NOAA fire pixels (yellow) detected from 1- 14 September 1999.

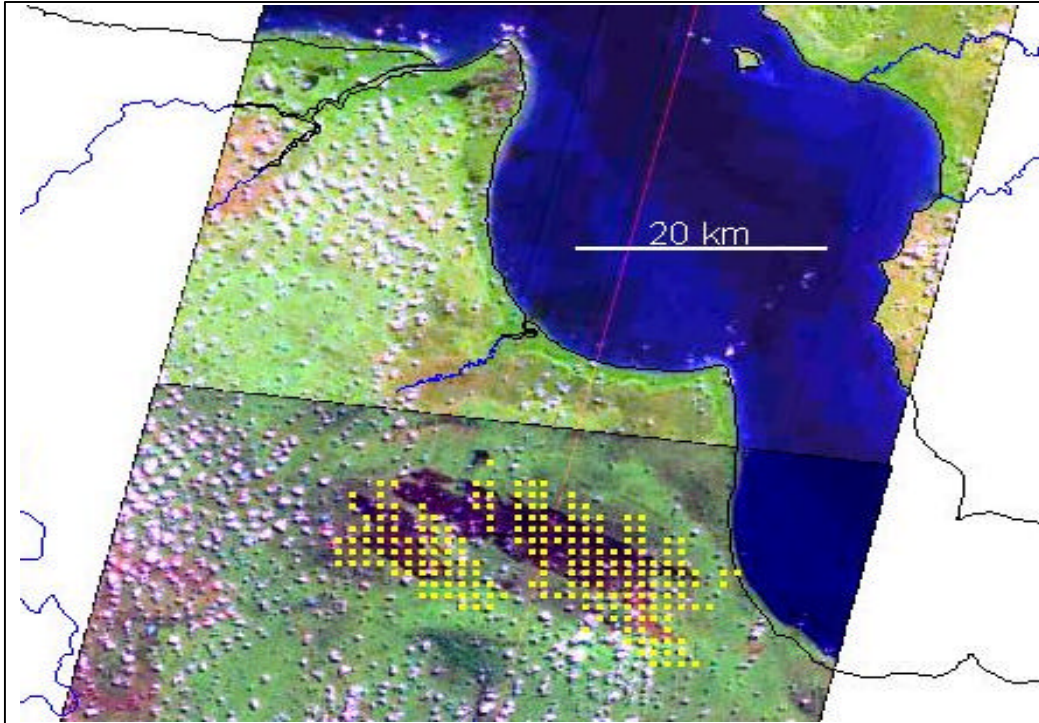
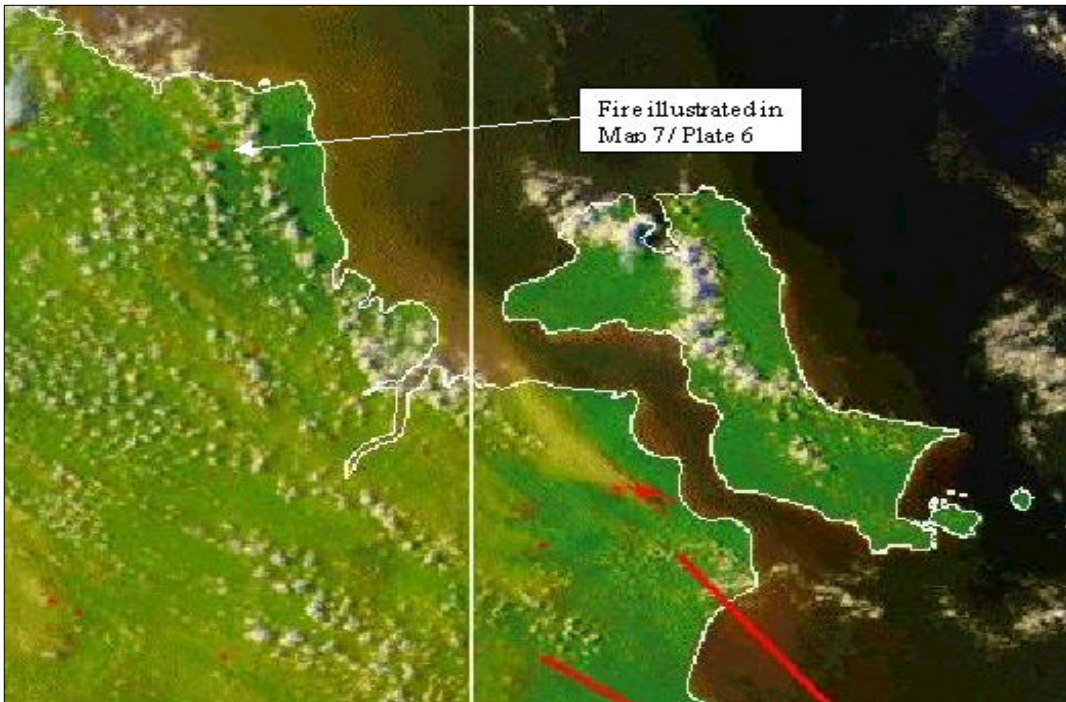


Plate 11. NOAA 14 image of 15 September 1999. The coastal swamps of South Sumatra east of Palembang, showing a major fire and associated smoke plume.



Vegetation And Land-Use Within The Coastal Wetlands Of Ogan Komerling Ilir, South Sumatra.

after

Jean Marie Bompard

Vegetation

The wetlands of Ogan Komerling Ilir (OKI) are part of the coastal swamplands that form an extensive, semi-continuous belt along the east coast of Sumatra. The vegetation cover varies considerably dependent on topography and climate and, not least, on disturbance by man. The description given here thus applies only to the swamps of the two sub-districts of Pampangan and Tulung Selapan.

Behind the coastal mangrove belt the natural vegetation of this wide swampy zone - which is permanently or seasonally flooded - lies a mosaic of plant communities. The major vegetation types are freshwater-swamp forest and peat-swamp forest, with their sequence of transitional zones related to the micro-topography and the depth of the peat layer. There are also secondary swamp-forest communities, such as grassy-swampland and *Melaleuca* forest. Small patches of 'padang forest', characterized by very poor sandy soils where Myrtaceae are common, are found on the edge of the swampy area near Tulung Selapan.

It is almost certain that the extensive swampy grass plains result from regular burning. They are dominated by sedges, mostly Cyperaceae such as *Scleria levis* and *Rhynchospora corymbosa*, and shrubs that can withstand prolonged floods. *Imperata cylindrica* (*alang-alang*) is found mostly in *Melaleuca cajuputi* (*gelam*) forests and on drained land reclaimed for agriculture. The main grass species in the vast area of periodically inundated grassland (*lebak*) near the village of Deling is *Lepironia articulata*.

Grasslands and peat-lands are highly fire-prone in droughts. And at the height of the 1997 fires, even floating grasses close to riverbanks (e.g. *Brachiaria mutica* and *Hymenachne amplexicaulis*) were seen burning.

Local Population

The area is largely unsuitable for traditional agriculture and population density is low with the few long-established villages, such as Penyambungan Dalam, located on the edge of the swampy zone.

The main sources of income are illegal logging, fishing, especially in the dry season, *ladang* [non-irrigated agriculture] and *sonor* rice production. The 1998 rice harvest was estimated at 40 000 t from 30 000 ha of *padi sonor* in Ogan Komerling Ilir and 10 000 ha in Musi Banyuasin. The timber is floated-out along canals and transported by river in the rainy season when water levels are highest.

Transmigration Settlements

The reclamation of the swamps, including the shallower peat-swamps, to provide farmland for transmigrants involved digging canals for drainage and the cutting and burning of the vegetation. The work began in 1968 with the Cinta Manis (4 000 ha) and the Upang Delta (15 000 ha) programmes. It continued in the early 1990's with Air Sugihan Kiri (45 000 ha) and Air Sugihan Kanan (36 500 ha) in the east of the delta as far as the Saleh and Sugihan rivers. Some 55 000 families were settled on 300 000 ha of reclaimed marshlands (Charras and Pain, 1993).

Agricultural development of tidal swamplands carries a high risk (Burbridge *et al.*, 1981) and the many problems encountered in the reclamation of the coastal peat swamps are underlined by Soepraptohardjo and Driessen (1976). The latter authors note that, "The chemical poverty of most coastal peats is notorious. In addition, the physical properties of these peats, which were generally considered favourable for plant growth, are in fact only marginal, even after reclamation".

Only a limited number of food crops (cassava, maize and banana) can be produced more or less satisfactorily on the low fertility, acidic soils (pH 3.0 – 4.0). However cassava fields are commonly severely damaged by wild pigs, and banana plantations by elephants that raid from the Padang Sugihan Reserve.

Transmigrants also have to endure particularly difficult living conditions and a limited supply of fresh water. Conditions worsen even more in the dry-season when the reduced flow of fresh water in the rivers allows seawater to penetrate further upstream and increases the salinity of both the soil and the drinking water. The transport of people and goods by water or land is difficult and expensive.

Many transmigrants must rely on off-farm employment, either locally in the timber industry, in Palembang, or in the oil palm plantations of South Sumatra and Jambi.

Non-Timber Forest Products

A few non-timber forest products are collected for home-consumption or for the local market, but have much less economic significance than timber.

The edible heart of an unidentified palm, locally called *palas*, is collected and sometimes sold at the market in Palembang; that of *Oncosperma cf. Tigillarium (nibung)* is also occasionally eaten. The leaves of *Nypa frutucans (nipah)* are used for house thatching.

The beaten and woven stems of a tube sedge (Cyperaceae) *Lepironia articulata (purun)*, are commonly used to make small, cheaply-sold, mats (*klaso*) in the southern part of the area. The village of Pedamaran is a major production centre.

The bark of *Syzygium palembanicum*, locally called *samak* meaning ‘that which tans’, is used to make dying nets and fish traps. There appears to be little or no tapping of *Dyera polyphylla* (*swamp jelutung*) for its latex. Wild fruits of *Artocarpus rigidus* (*suren*) and the chestnuts of *Castanopsis innermis* (*barangan gundul*) are occasionally collected for home consumption.

Timber Species

As noted above, timber is a major, usually illegal, source of income wherever commercial species remain. The species list given below is based on information collected during interviews and is not exhaustive.

Species	Local name	Family
<i>Alstonia spp.</i>	Pulai gading/p. gabus	Apocynaceae
<i>Camptosperma spp.</i>	Terentang	Anacardiaceae
<i>Combretocarpus rotundatus</i>	Perepat	Anisophylleaceae
<i>Cratoxylum spp.</i>	Ngruggan	Hypericaceae
<i>Dyera polyphylla</i>	Jelutung paya	Apocynaceae
<i>Fagraea crenulata</i>	Marbirah	Loganiaceae
<i>Fagraea fragrans</i>	Tembesu	Loganiaceae
<i>cf Ganua motleyana</i>	Ketiau	Sapotaceae
<i>Gluta sp./Melanorrhoea sp.</i>	Rengas	Anacardiaceae
<i>Gonystylus bancanus</i>	Ramin	Thymeleaceae
<i>cf. Jackiopsis ornata</i>	Seluman	Rubiaceae
<i>Lagerstroemia ovalifolia</i>	Bungur	Lythraceae
<i>cf Lophopetalum sp.</i>	Kerupuk	Celastraceae
<i>Melaleuca cajuputi</i>	Gelam	Myrtaceae
<i>Ploiarium alternifolium</i>	Beriang	Bonnettiaceae
<i>Shorea spp.</i>	Meranti psys	Dipterocarpaceae
<i>Tristaniam spp.</i>	Pelawan	Myrtaceae

Melaleuca cajuputi is used locally for poles and as a roof support when pouring concrete. The biggest trees rarely exceed 15 cm diameter with 5 m of free bole. Beams (0.1 x 0.1 x 4 to 5 m) are cut for transport to Palembang where they sold for Rp 2 000 in 1997.

The main species logged by local people in the deep swamps (*rawang*) in Lebung, Hitam, Penangoan Duren, are *Gonystylus bancanus*, *Shorea spp.* and *Combretocarpus rotundatus*, the wood of which remains useable even after burning.

Timber species that grow on the dryland (*talang*) in the area are listed below.

Species	Local name	Family
<i>Alstonia scholaris</i>	Pulai pelawi	Apocynaceae
<i>Cinnamomum parthenoxylon</i>	Medang lese	Lauraceae
<i>Fagraea fragrans</i>	Tembesu	Loganiaceae
<i>Lagerstroemia speciosa</i>	Bungur	Lythraceae
<i>Peronema canescens</i>	Sungkal	Verbenaceae
? <i>Vatica spp.</i>	Resak	Dipterocarpaceae

The few forests that remain in the drylands are logged during the dry season. *Alstonia scholaris* and *Peronema canescens* are the two commonly traded species in Tulung Selapan sub-district.

Fagraea fragrans is fire-resistant, can grow on wetter sites, and is used, amongst other purposes, for house construction. The woods of *Lagerstroemia ovalifolia* and *L. speciosa* are very durable and used to build houses and make coffins.

Production Forest

The greatest part of the area is classified as Permanent Production Forest. Seven logging concessions – three still active in 1997 - originally controlled nearly 500 000 ha. Forests on deep peat were the most heavily logged. Logging started in the late 1970's or early 1980's and the concessions are transected by a light-railway system to transport the logs. Almost all the valuable species, e.g. *Gonostylus bancanus* (*ramin*) that were once common, have been harvested. Second-quality, lightweight timber species, e.g. *Camptosperma spp.*, (*terentang*) are now being logged. [Since July 2000 licenses have expired or been revoked and the former concession areas are now under the management of PT. Inhutani V]

Illegal Logging

Illegal logging, often sponsored by wealthy local people or those from more distant towns, provides the main income for most villagers in the southeast of the area, as well as for many outsiders who benefit from the weak control exercised by the Forestry Service. The lack of control on illegal logging is infamous in Tulung Selapan, from where logs can be directly shipped to Java., It is improbable that the situation will be readily controlled. [A surprisingly large coastal freighter was anchored on the peat-stained Sugihan River when FFPCP made a field visit on 17 September 2000: illegal sawn timber its likely cargo although many of the illegal sawmills were seen abandoned as all trees of any commercial value had been cut.]

Padang Sugihan Wildlife Reserve

The Padang Sugihan Wildlife Reserve of - officially - 75 000 ha was established in April 1983 between the Air Sugihan and Air Padang rivers some 35 km from the coast. A transmigration settlement was planned and then abandoned, but not before the area was transected by drainage canals (PHPA-AWB, 1988). The original freshwater swamp forest and peat swamp forest in the reserve have been logged. The reserve is now a habitat for elephant herds driven from more densely populated regions of the province. [At the time of the field visit in September 2000, 42 head were held captive around the Sugihan Centre, with a further 20 at nearby Sebogor. Over 100 are said to remain at large, divided into three groups, in the of OKI and Musi Banyuasin Districts. (Head of Elephant Training Centre, Air Sugihan, *pers com.*)]

Sembilang Wildlife Reserve

The proposed Sembilang Wildlife Reserve covers an area of 380 000 ha in South Sumatra province and includes much of the Sembilang – Banyuasin – Musi river delta, including the 75 000 ha. Terusan Dalam dan Daerah Sekitarnya Wildlife Reserve. [KSDA, Palembang, currently propose a reduced area of 205 750 ha for the Sembilang reserve].

This extensive locale holds one of the largest peat and non-peat swamp forests in Indonesia. It also possess an up to 35 km wide belt of mangrove forests along the coast and vast stretches of mudflats, which form an important wintering territory for many wading birds and a spawning and nursery site for fish and shrimps. Sembilang is considered one of the most important waterbird territories of the Indo-Malayan region. Some 35 globally endangered species are found inside the proposed wildlife reserve borders (Wetlands International Asia Pacific Indonesia Programme <http://www.wetlands.or.id/sumatra.htm>)

11. THREATS TO THE WETLANDS

Wetlands of Sumatra

The wetlands of Sumatra cover over 11 million hectares of the island, equivalent to 23 percent of the total land surface (Table 2). By far the largest swamplands are found in Riau - 4.75 M ha - with those in South Sumatra covering 3.2 M ha, far greater both as total areas and as percentages than in the other six provinces.

Table 2. Wetland areas (ha) in each of the provinces of Sumatra.

Province	Area (ha)	Area of swampland as a percentage of the area of the province
Aceh	609 700	11
North Sumatra	951 800	13
West Sumatra	258 700	5
Riau	4 756 600	50
Jambi	976 100	20
Bengkulu	29 600	1
South Sumatra	3 159 700	31
Lampung	351 100	10
Sumatra	11 093 300	23

Source: data derived from RePPProT (1988).

Deep Peats

Deep peat (+2 m) deposits are found in all provinces except Bengkulu (Table 3). Those in the west coast wetlands appear to be young in geomorphological terms and do not show the concentric pattern of vegetation growth that characterizes the domed peats of the east coast swamps. These peat domes are typical features of many of the larger and older swamp areas of southeast Asia (Whitmore, 1975) and the peat varies in depth from a minimum of 2 m at the convex margins to 10 m or more at the raised centre (RePPProT, 1988).

The large fire in the coastal wetlands of South Sumatra in 1999 (Chapter 10) was centred on a 50 000 ha peat dome. The forest on the dome was one of the last areas to be cut in the coastal swamps of South Sumatra, preserved for a few extra years by the difficulty of operating on deep peats.

Table 3. Areas of peat (ha) over 2 m deep in Sumatra and their degree of fire damage as of October 2000. (Data on areas derived from RePPPProT, 1988).

Province	Area (ha)	Fire damage based on NOAA detected Fires
Aceh	4 000	Slight
North Sumatra	55 300	Moderate
West Sumatra	78 000	Severe
Riau	1 673 300	Slight
Jambi	50 300	Slight
Bengkulu	0	
South Sumatra	83 000	Severe
Lampung	1 200	Severe
Total	1 945 100	

A second, larger, dome straddles the South Sumatra - Jambi border and connects with the +10 m deep peat formations of the Berbak National Park (Chapter 8) (Silvius *et al.* 1984). This dome is now the only sizeable area with relatively undisturbed peat-swamp forest that remains in southern Sumatra. However the portion that lies within South Sumatra is being cut by an HPH and SPOT Quicklook satellite imagery of September 2000 (Plate 6) strongly suggests that the segment of the dome that lies within Jambi, and indeed the part that falls within Berbak National Park itself, are both under attack from illegal loggers. The cutting will doubtless further affect the integrity of the Park that is already under threat from land clearance by coastal Bugis communities, HPH that intrude into the western part of the reserve, and from plantation establishment fires (Map 7).

Deep peat areas are widely regarded as being unsuitable for agriculture or agroforestry. They are infertile and are also difficult to drain to a degree that allows cropping without excessive loss in volume through oxidation and shrinkage. And even if drainage is technically successful, it increases fire hazard to an unacceptably high level and places around 500 t C ha⁻¹ m⁻¹ at risk. The politics of wetland exploitation in South Sumatra province are considered in detail by Bompard and Guizol (1999).

Invasion of the Wetlands

The east coast wetlands of Sumatra have been seen by many (e.g. MacKinnon and Setiono, 1983; Silvius, Simons and Verheugt, 1984) as of the greatest importance for the conservation of their often unique and/or endangered plants and animals. In recognition of this nearly 544 000 ha were already gazetted by government and a further 597 000 ha were officially proposed as sanctuary areas (Table 4) at the time the RePPPProT reports were published in 1988.

In the twelve years since 1988 few, if any, of the proposed sites were gazetted and most are no longer undisturbed habitats. Of the gazetted areas Way Kambas in Lampung is heavily degraded, the forest in Padang Sugihan in South Sumatra, once seen as an important bird and elephant sanctuary, is now completely destroyed by logging followed by fire, and Berbak in Jambi is under considerable pressure. The fate of the remaining reserves is not known.

Table 4. Areas (ha) of the eastern coastal swamplands of Sumatra officially protected and those proposed for conservation in 1988.

Province	Number of reserves gazetted	Total area (ha) reserves gazetted	Number of reserves proposed	Total area (ha) of proposed reserves
Aceh	0	0	1	17 000
North Sumatra	1	15 675	1	2 900
Riau	4	148 200	10	371 500
Jambi	2	181 500	0	0
South Sumatra	1	75 000	1	205 750
Lampung	1	123 500	0	0
	9	543 965	13	597 150

Source; RePPProT (1988).

Good water management is the key to successful land reclamation, but subsistence farmers in Sumatra have yet to show that they are able to deal with the intricacies of such a system. An apparent paradox of swamp development for agriculture is that it is often periodic drought, not flooding, that drives farmers from their land in coastal regions of Indonesia, and thus the land into the arms of illegal logging barons. It remains to be seen whether the estate crop companies will be more fortunate - with their considerable investment - in cultivating these areas in the longer-term.

Why were transmigration programmes located there and why are estate crop companies now moving into these swamps that are apparently so unpromising from an agricultural viewpoint? Soil fertility is very low, infrastructural development is difficult and expensive, and there is a history of agricultural failure where transmigration schemes were attempted.

Despite these clear disadvantages, the reasons for this invasion of the wetlands of Sumatra by the transmigration programme and the oil palm estates are not hard to find. Prime among them was, and still is, the shortage of dryland areas that remain relatively unimpeded by smallholder land-rights. A secondary, although still important, consideration from the viewpoint of the oil palm companies is that development costs can be offset against the valuable commercial swamp timber species extracted before the land is cleared.

The Oil Palm Plantation Industry in Sumatra

Under the New Order regime, traditional land rights were ignored and large blocks of partly-settled drylands were made available to companies to develop plantations. Under the current more transparent and less repressive government, companies would rather avoid conflict with their small but increasingly vocal neighbours. However it remains open to question as to just how free from local land claims the wetlands will prove to be. A low population density does not necessarily imply an absence of long-standing land ownership or, especially, land-use rights (e.g. fishing rights and the collection of non-timber forest products).

Three recent publications deal with the oil palm plantation industry in Indonesia. The first, produced by CIC (1999), is a wide-ranging compilation of statistical data. The second by Casson (1999) uses much the same source figures but draws on a far wider literature and new research to place the rapid expansion of the industry in a political and economic context. The third article (Aditjondro, in press) is strongly condemnatory in tone but provides a wealth of information on the ownership and political connections of the major oil palm companies.

As noted by the two previous authors and by FFPCP (Bowen *et al.* 2000: Anderson, Imanda and Muhndar, 2000) amongst others, there is a strong correlation between fire numbers / area burnt and the land clearing activities of oil palm companies. The island of Sumatra has been particularly hard-hit as shown by the estimated areas planted to oil palm in the eight provinces of Sumatra when compared to areas in Kalimantan, and in Irian Jaya / Java / Sulawesi (Table 5).

Table 5. Areas (ha) estimated to be planted to oil palm in Sumatra in 1999 compared to areas established in Kalimantan and elsewhere in Indonesia.

Province	Areas (ha)	Percentage of total area planted
Aceh	180 300	6.8
North Sumatra	577 000	21.9
West Sumatra	129 000	4.9
Riau	572 000	21.7
Jambi	216 300	8.2
South Sumatra	228 800	8.7
Bengkulu	67 700	2.6
Lampung	45 300	1.7
	2 016 400	76.6
Kalimantan	485 500	18.4
Elsewhere	132 000	5.0
	617 500	23.4
Total	2 633 900	100

Source. Directorate General of Plantations quoted by CIC (1999)

As we and many others have noted, all statistical data in Indonesia are weak and the figures quoted in Table 4 must be treated with considerable caution. The figures do, however, indicate that at least 2 Mha of land in Sumatra have been deliberately cleared by fire to allow the planting of oil palm. Much of the clearance has taken place over the last ten years.

What is not clear is how much of the land already allocated to the plantation industry remains to be burned in the immediate future. And, how much of the land applied for but not yet granted by government will eventually go to oil palm. An additional total of 1.0 Mha to be cleared by fire in Sumatra alone seems to us to be a conservative estimate.

12. AND THE FUTURE?

The Fires So Far

It is impractical to routinely measure the area of land affected by the thousands of fires that burn each year in Sumatra. Routine site inspection is beyond contemplation and continuous higher-resolution satellite monitoring is not available. (Daily NOAA satellite data provide clear information on the locations of fires but not on the areas damaged by fires.)

Shocked by the scale of the fires in the ENSO drought of 1997-98, two organizations made efforts to quantify – based on satellite detected burn-scar measurements – the total area affected by fire. EUFREG (1998) estimated that 1 Mha burnt in Sumatra, mainly in the peat-swamps of South Sumatra and Jambi. A similar exercise by Singapore National University/CRISP (Liew *et al.*, 1998) produced an estimate of 1.5 Mha for Sumatra, again mainly in the east coast swamps.

We estimate that at least 2 Mha of land in Sumatra have been deliberately cleared by fire over the last ten to fifteen years. Based on limited SPOT imagery, NOAA fire occurrence data, published information on the oil palm industry, and on field visits, we guess that in each of the last four non-ENSO years (i.e. 1996, 1998, 1999 and 2000) a few hundreds of thousands of hectares have been burned for agricultural purposes in Sumatra. Of this figure, most represents repeat clearance by smallholder farmers while a few tens of thousands of hectares, the opening-up of new land by estate crop companies. Out of the new land opening we further guess that most was in the wetlands of the island.

The Fires To Come

Predictions are more likely to subject the soothsayer to future scorn as to acclaim and forecasts about the course of vegetation fires in Sumatra are no different in this respect. However armed with five years of detailed fire history in the island, we feel safe in stating that over the next five years:

- The numbers of fires detected at any one time, and over the calendar year as a whole, will continue to be controlled by the rainfall: the wetter the year, the fewer the fires.
- There will be few or no wildfires in Sumatra in years of average rainfall.
- Considerable numbers of wildfires will burn during the next *el Nino* year.

We have drawn attention to the clear link between the extent and timing of land clearing by the oil palm industry and fire numbers, fire locations and smoke pollution. The industry is now set to come out of a three year recession and, as noted by Casson (1999), Sumatra with its established processing facilities and trained labour force will be the first to recover.

There is little sign that central government thinking will change in the immediate future in ways that will lead to a more rational use of land, and thus to fewer fires and coordination between Ministries remains weak. The setting up of the Directorate of Forest and Estate Crop Fire within the Ministry of Forestry is welcomed. Individual provinces may wish to husband their natural resources more wisely when they gain fuller control of their resources in 2001, although the move as we note above, is not without its dangers. Fire prevention and control agencies in the Districts and Sub-Districts remain under-equipped, under-staffed, under-trained and under-funded.

We thus expect with some confidence that:

- Land clearance fires set by the oil palm industry will continue for the next several years in at least five of the seven zones described in this report.
- Smoke haze pollution will continue episodically each year and much of the smoke haze that originates in Riau will continue on occasion to drift across to Singapore and Peninsular Malaysia.
- However as the available uncleared and newly cleared land in each of the seven fire zones becomes fully planted, fire numbers in that zone will fall.
- The formation of new fire zones will be largely determined by the land-use policy of the new provincial governments and, to an extent, by the economics, of the oil palm industry: no firm predictions can be made.
- There will be a very gradual improvement in field-level capability to prevent and control vegetation fires; no effective organization will be in-place before the next *el Nino*.
- A new 'fire-balance' will eventually be reached within Sumatra as a whole and fire numbers will return to their pre-1996 level in years of average rainfall.

RePPPProT (1988) took the view that since in Sumatra, "... all the remaining forested lowland plains and hills will be eventually converted to agricultural production ... [it is wise] to leave the fragile and unique domed peat swamps intact as forested green lungs or sponges between the great rivers. This would be a far-sighted legacy for future generations."

The wisdom of this suggested 'inaction' was however to be ignored; and the less sanguine, although regrettably accurate, view was taken by Danielsen and Verheugt (1990) who predicted no unlogged swamp forest would remain in South Sumatra province by the year 2000. They did not however anticipate even ten years ago that it would vanish. Elsewhere in Sumatra the wetland forests face similar extinction.

We thus feel that the general prognosis for a reduction in fire numbers and smoke haze pollution in the near future is gloomy.

13. REFERENCES

Aditjondro, G.J. (in press). *The driving force of Indonesia's catastrophic forest fires.* Eco-Politics Journal. 1. Department of Sociology and Anthropology, University of Newcastle, Australia.

Anderson, I.P., Bowen, M.R., Imanda, I.D. and Muhndandar (1999). *Vegetation fires in Indonesia: the fire history of the Sumatra provinces 1996 - 1998 as a predictor of future areas at risk.* EU-Forest Fire Prevention and Control Project with Kanwil Kehutanan dan Perkebunan Palembang. European Union and Ministry of Forestry and Estate Crops, Jakarta. 22 pp plus 16 maps and tables.

Anderson, I.P., Imanda, I.D. and Muhndandar (1999). *A first look at vegetation indices and fire danger rating in relation to fire occurrence.* EU-Forest Fire Prevention and Control Project with Kanwil Kehutanan dan Perkebunan Palembang. European Union and Ministry of Forestry and Estate Crops, Jakarta. 12 pp plus Annexes.

Anderson, I.P., Imanda, I.D. and Muhndandar (1999a). *Vegetation fires in Indonesia: the interpretation of NOAA-derived hot-spot data.* EU-Forest Fire Prevention and Control Project with Kanwil Kehutanan dan Perkebunan Palembang. European Union and Ministry of Forestry and Estate Crops, Jakarta. 19 pp plus 3 maps.

Anderson, I.P., Imanda, I.D. and Muhndandar (2000). *Vegetation fires in Indonesia: reflections on the 1999 fires.* EU-Forest Fire Prevention and Control Project with Kanwil Kehutanan dan Perkebunan Palembang. European Union and Ministry of Forestry and Estate Crops, Jakarta. 13 pp.

Anon (1997). *Rattan production and market potential in Sumatra Selatan: a preliminary assessment with special reference to the FFPCP pilot areas.* EU-Forest Fire Prevention and Control Project with Kanwil Kehutanan dan Perkebunan Palembang. Project report number 23. 36 pp.

Anon (1997a). *Promoting farmers' involvement in forest fire prevention.* EU-Forest Fire Prevention and Control Project with Kanwil Kehutanan dan Perkebunan Palembang. Project report number 25. 70 pp.

Bompard, J.M. and Guizol, P. (1999). *Land management in South Sumatra Province, Indonesia. Fanning the flames: the institutional causes of vegetation fires.* EU-Forest Fire Prevention and Control Project with Kanwil Kehutanan dan Perkebunan Palembang. European Union and Ministry of Forestry and Estate Crops, Jakarta. 40 pp plus annexes.

Bowen, M.R., Bompard, J.M., Anderson, I.P., Guziol, P. and Gouyon, A. (2000). *Anthropogenic fires in Indonesia; a view from Sumatra.* In, 'Forest fires and regional haze in Southeast Asia'. M. Radojevic and P. Eaton (editors). Nova Science, New York, USA.

- Burbridge, P., Dixon, J.A. and Bedjo Soewardi (1981).** *Forestry and agriculture: options for resource allocation in choosing lands for transmigration development.* Applied Geography, **1**, 237-258.
- Casson, A. (1999).** *The hesitant boom: Indonesia's oil palm sub-sector in an era of economic crisis and political change.* Program on the Underlying Causes of Deforestation, Centre for International Forestry Research, Bogor, Indonesia. 75 pp
- CIC (1999).** Study on CPO market and oil palm plantation in Indonesia 1999. PT. Capricorn Indonesia Consult Inc., CIC Consulting Group, Jakarta, Indonesia. 318 pp.
- Charras, M. and Pain, M. (1993).** *Phase two: the agricultural colonization of the province of South Sumatra.* 59 –76. In, M. Charas and M. Pain (editors), 'Spontaneous settlements in Indonesia. Agricultural pioneers in southern Sumatra.' ORSTOM – CNRS, and Departmen Transmigrasi. Paris and Jakarta. 405 pp.
- CRISP (1999).** *Centre for Remote Imaging, Sensing and Processing, National University of Singapore.* <http://www.crisp.nus.edu.sg/crisp.html>
- Danielsen, F. and Verheugt, W.J.M. (1990).** *Integrating conservation and land-use planning in the coastal region of South Sumatra, Indonesia.* With contributions from H. Shov, R. Kadarisman, U. Suwarnam and A. Purwoko. The Directorate General of Forest Protection and Nature Conservation, Ministry of Forestry and Estate Crops and Asian Wetland Bureau. Bogor, Indonesia. 207 pp.
- Dis, van M.M.U. (1986).** *The art of lowland development. Theme 1. Land and water management.* 34 – 53. In, 'Symposium lowland development in Indonesia'. International Institute for Land Reclamation in Indonesia. Wageningen, The Netherlands. 24 –31 July 1986.
- Dransfield, J. (1992).** *The ecology and national history of rattans.* 27 – 33. In, 'A guide to the cultivation of rattan'. Wan Razali Wan Mohamed, J. Dransfield and N. Manokaren (editors). Malayan Forest Records Number 35. Forest Research Institute Malaysia. Kuala Lumpur.
- EIA (1999).** *The final cut. Illegal logging in Indonesia's orangutan parks.* Environmental Investigation Agency. <http://www.eia-international.org>
- EUFREG (1998).** Assessment of the 1997 fires in Indonesia. European Union Fire Response Group with the Ministry of Forestry and Estate Crops, Jakarta, Indonesia. 33pp.
- Holmes, D. (1998).** *Rainfall and droughts in Indonesia.* A study for the World Bank. Volume 3a: Sumatra.
- Hoshour, C. (1995).** *Resettlement and politicization of ethnicity in Indonsia.* Proceeding of conference, 'Riau in Transition'. ILAS, Leiden, The Netherlands, 4-6 October, 1995.
- JICA (2000).** *FFPMP update.* **2**, Number 10. Forest Fire Prevention Management Project. Bogor, Indonesia. 7 pp.

Keech, J.J. and Byram, G.M. (1968). *A drought index for forest fire control.* USDA Forest Service, South-eastern Forest Experimental Station Research Paper SE-38.

Laumonier Y. (1997). *The vegetation and physiography of Sumatra.* Kluwer Academic Press, Dordrecht, The Netherlands. 25 pp.

Liew, S., Lim O.K., Kwoh, L.K and Lim, H. (1998). A study of the 1997 forest fires in South East Asia using SPOT quicklook mosaics. Paper presented at the 1998 IEEE International Geoscience and Remote Sensing Symposium, Seattle, 6-10 July.

MacKinnon, J. and Artha, M.B. (1982). *A national conservation plan for Indonesia. Volume II. Sumatra.* National Park Project of the Food and Agriculture Organisation of the United Nations. FA,INS/78/061. Field Report 39. Bogor, Indonesia.

MacKinnon, J. and Setiono, D. (1983). *Recommendations for the development of an elephant reserve in Padang Sugihan, Sumatera Selatan Province.* WWF, Bogor, Indonesia.

Nicolas, M.V.J. and Bowen, M.R. (1999). *A field-level approach to coastal peat and coal-seam fires in South Sumatra province, Indonesia.* EU-Forest Fire Prevention and Control Project with Kanwil Kehutanan dan Perkebunan Palembang. European Union and Ministry of Forestry and Estate Crops, Jakarta. 39 pp.

Oldeman, L.R., Las, I and Darwis, S.N. (1979). *An agroclimatic map of Sumatra.* Contributions from the Central Research Institute for Agriculture, Bogor, Indonesia. Number 52. ISSN 0126-1894. 35 pp.

PEMDA (1999). *Pemerintah Daerah Riau.* [The provincial government of Riau.] <http://www.riau.go.id/pemda/index2.html>

PHPA-AWB (1988). *The Indonesian wetland inventory. Volume 2.* PHPA, Asian Wetland Bureau, Interwader and Edwin. 268 pp.

RePPPProT (1988). *A national overview from the regional Physical Planning Programme for Transmigration.* UK Overseas Development Administration and Directorate BINA Programme, Ministry of Transmigration and Forest Squatters Resettlement, Jakarta, Indonesia.

Rijksen, H.D., Diemont, W.H. and Griffith, M. (1997). *The Singkil swamp: the kidneys of the Leuser ecosystem in Aceh, Sumatra, Indonesia.* 355 – 362. In, 'Tropical peatlands'. J.O. Rileley and S.E. Page (editors). Samara Publishing Limited, Cardigan, UK. ISBN 1 873692 10 2.

Silvius, M.J., Simons, H.W. and Verheugt, W.J.M. (1984). *Soils, vegetation, fauna, and nature conservation of the Berbak Game Reserve, Sumatra, Indonesia.* Research Institute for Nature Management, Arnhem, The Netherlands. 146 pp.

Soepraptohardjo, M and Driessen, P. M (1976). *The lowland peats of Indonesia, a challenge for the future.* 11 – 19. In Proceedings, 'Dutch-Indonesian Technical Cooperation Programme ATA 106, Midterm Seminar'. Tugu, 13-14 October, 1976.

Whitmore, T.C. (1975). *Tropical rain forests of the far east.* Clarendon Press, Oxford. 282 pp.

Whitten, A.J., Damanik, S.J., Anwar, J. and Hisham, N. (1987). *The ecology of Sumatra.* Gadjah Mada University Press Yogyakarta Indonesia. ISBN 979-420-061-1

14. ABBREVIATIONS AND ACRONYMS

AWB	Asian Wetlands Bureau
BAKOSURTANAL	Badan Koordinasi Survei Tanah Nasional (National Coordination Agency for Surveys and Mapping)
BAPEDAL	Badan Pengendalian Dampak Lingkungan (Environment Impact Protection Agency)
BAPEDALDA	Badan Pengendalian Dampak Lingkungan Daerah (Regional Environment Impact Protection Agency)
CRISP	Centre for Remote Imaging, Sensing and Processing at the University of Singapore
EIA	Environmental Investigation Agency
ENSO	El Nino Southern Oscillation
EU	European Union
FFPCP	Forest Fire Prevention and Control Project
FFPMP	Forest Fire Prevention and Management Project
GTZ	Deutsche Gesellschaft fur Technische Zusammenarbeit (German Agency for Technical Cooperation)
HPH	Hak Pengusahaan Hutan (Forest Concession Right)
HPHTI	Hak Pengusahaan Hutan dan Tanaman Industri (Utilisation Right for Industrial Forest Plantation)
IFFM	Integrated Forest Fire Management Project
JICA	Japanese International Cooperation Agency
KSDA	Konservasi Sumber Daya Alam (Natural Resources Conservation Department of the Ministry of Agriculture and Forestry)
LAPAN	Lembaga Penerbangan dan Antariksa Nasional (Indonesian National Institute for Aeronautics and Space)
NGO	Non-Government Organisation
NOAA	National Oceanic and Atmospheric Administration
OKI	Ogan Komering Ilir (a District in South Sumatra)
PEMDA	Pemerintahan Daerah (Provincial Government)
PHPA	Perlindungan Hutan dan Pelestarian Alam (Directorate General of Forest Protection and Nature Conservation) now PKA
PKA	Perlindungan Koservasi Alam (Directorate of Nature Conservation and Protection)
PT	Perseroan Terbatas (Limited Company)
RePPPProT	Regional Physical Planning Programme for Transmigration
SPOT	Systeme pour l'Observation de la Terre
USDA	United States Department of Agriculture
AWB	Asian Wetland Bureau