



**EUROPEAN UNION  
MINISTRY OF FORESTRY AND ESTATE CROPS**

**FOREST FIRE PREVENTION AND CONTROL PROJECT**



**VEGETATION FIRES IN INDONESIA:  
THE FIRE HISTORY OF THE SUMATRA  
PROVINCES 1996-1998 AS A PREDICTOR OF  
FUTURE AREAS AT RISK**

**Ivan P. Anderson, M. Roderick Bowen, Ifran D. Imanda and Muhnandar**

Balai Inventarisasi dan Perpetaan Hutan Wilayah II  
and  
Kanwil Kehutanan dan Perkebunan, Palembang

**May 1999**



This is one of a series of reports prepared during 1999 by the Forest Fire Prevention and Control Project. Together they cover the field-level prevention, detection and control of vegetation fires in Sumatra. Titles are:

*Vegetation fires in Indonesia: operating procedures for the NOAA-GIS station in Palembang, Sumatra.* I.P. Anderson, I.D. Imanda and Muhnandar.

*Vegetation fires in Indonesia: the interpretation of NOAA-derived hot-spot data.* I.P. Anderson, I.D. Imanda and Muhnandar.

*Vegetation fires in Sumatra, Indonesia: the presentation and distribution of NOAA-derived data.* I.P. Anderson, I.D. Imanda and Muhnandar.

*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 Muhnandar.

*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 Muhnandar.

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

*The management of forest fires in the timber concessions of Indonesia.* M.V.J. Nicolas and G.S. Beebe (Joint publication with GTZ).

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

*A fire danger rating system for South Sumatra province, Indonesia.* M.V.J. Nicolas, I.P. Anderson and H. Pansah.

FFPCP will also publish reports on;

- the policy, planning and implementation aspects of natural resource management in the province of South Sumatra,
- the role of local communities in fire prevention, and
- environmental education in primary schools.

Copies of these reports are also available in Bahasa Indonesia, and can be obtained from;

The Project Leader, FFPCP, PO Box 1229, Palembang 30000, Indonesia  
Fax number: +62 711 417 137 – Homepage: <http://www.mdp.co.id/ffpcp.htm>

or

Counsellor (Development), Representation of the European Commission, PO. Box 6465  
JKPDS, Jakarta 10220, Indonesia  
Fax number: +62 21 570 6075

## **FOREWORD**

### ***European Commission***

Tropical rain forests cover less than six percent of the surface of the earth, but contain more than 50 percent of the world's biodiversity. Indonesia's forests are considered to be one of the biodiversity centres of the world. However, these vital areas are under threat from over-exploitation, encroachment and destruction because of fire.

The seriousness of the threat to Indonesia's forests has prompted the European Commission to reorient its development co-operation with Indonesia to focus on the sustainable management of forest resources. Based on the Agreed Minutes of a meeting between the Government of Indonesia and the Commission, which were signed in May 1993, the Commission supports a range of projects in the field of conservation and sustainable forest management. The funds for this support have been donated in the form of grants.

The importance of the fire issue cannot be over-emphasised. Estimates have set the economic loss caused by the haze that blanketed the region in 1997 at around Euro 1.4 billion. The loss of wildlife habitat, which will take decades to regenerate or the soil erosion, which is the inevitable result of heavy burning, is too great to be expressed in financial terms.

Because fire prevention and control is such an important issue, the Commission has been willing to support the Forest Fire Prevention and Control Project, which started in April 1995, with a grant of Euro 4.05 million. The long-term objective of the project was to, "*Furnish support, guidance and technical capability at provincial level for the rational and sustainable management of Indonesia's forest resources.*" Its immediate purposes were to evaluate the occurrences of fire and its means of control, to ensure that a NOAA-based fire early warning system would be operational in South Sumatra, and that a forest fire protection, prevention and control system would be operational in five Districts within the province.

In co-operation with local government, representatives of the Ministry of Forestry and Estate Crops and the private sector, the project set out to implement a series of activities that would support the achievement of these purposes. The results of these activities are now made available in a series of technical reports of which this is one. We believe that these professional publications will be of considerable value to those concerned in the forestry, agriculture and land-use planning sectors.

**Klauspeter Schmallenbach**

***Head of the Representation of the European Commission in Indonesia***

## ***Kanwil Kehutanan dan Perkebunan***

Vegetation fires have undoubtedly become a more urgent focus of concern to the regional office of the Ministry of Forestry and Estate Crops in South Sumatra after the widespread smoke haze pollution of 1997. As part of our commitment to sustainable forest management, considerable efforts have been made to prevent fires happening again on such a scale. We hope that in the new spirit of reform the people of South Sumatra will play a greater role in protecting and managing the forests and their resources.

I warmly welcome the FFPCP series of reports on their work from 1995 to 1999. These reports examine in detail the underlying causes of vegetation fires in the province, and this understanding allows us to suggest how numbers may be reduced. The reports also set out methods of prevention, NOAA satellite detection, and control of fires. These are based on methods that have been shown to work under field conditions and when fully introduced will bring practical benefits to us all.

I also hope that the work will serve as a reminder that we need to keep improving our capability to deal with future fires. While good progress has been made, much work still remains to be done before damaging vegetation fires are a thing of the past.

**Ir. Engkos Kosasih**

***Head of the Provincial Forestry and Estate Crops Office, South Sumatra***

## SUMMARY

The occurrence of vegetation fires in the south-central provinces of Sumatra was monitored through the capture and processing of NOAA satellite data from January 1996 to December 1998. The area of interest was initially restricted to the provinces of South Sumatra, Lampung, Bengkulu and Jambi. Riau Province was included from May 1996. The remaining provinces, West Sumatra, North Sumatra and Aceh, received only sporadic coverage during the three year period as satellite image size limitations precluded capture of the entire island of Sumatra.

The NOAA technique only records active fires with a flaming front that exceeds 20 – 30 metres. Small surface fires or ground fires are not recorded nor are fires obscured by thick cloud or smoke cover. Special processing techniques are required to exclude 'false' fires that result from high reflection rather than high temperature.

The total number of vegetation fires detected in Sumatra during any one month was, as is to be expected, strongly influenced by rainfall during the preceding period and during the month. There were up to three hundred times more fires in the peak months (June to October) of 1997 – an exceptionally dry year with no effective rainfall in southern Sumatra from mid-May to mid-November – than in the same months in 1996 and 1998, both average to wet years.

Land-use and land management practices influenced both the numbers and the severity of the fires. Large-scale land clearance – which followed the extraction of timber – by commercial oil-palm companies caused numerous, large, persistent fires in Riau and to a lesser extent in Jambi. And during the three years Riau was by far the most fire-prone province, both in terms of the absolute number of fires detected and on the basis of fires per 100 km<sup>-2</sup>.

Conversion of primary forest is largely completed in South Sumatra, and Lampung Province is largely settled agriculture. Here fires were smaller and more ephemeral; in the main related to pre-growing-season land preparation by small-scale farmers.

While Riau province had the highest number of fires the most ecologically damaging and polluting fires occurred in the wetlands of South Sumatra and Jambi in 1997. These wetlands are predominantly of scrub, grass and patches of degraded secondary forest on peat soils. During the Indonesian fire crisis of 1997-98 an estimated 80 percent of the total smoke haze originated from the wetlands of eastern Sumatra and southern Kalimantan. Past attempts, now abandoned, to drain wetland for agriculture may have contributed to the severity of the fires. Smoke haze, from peat fires, covered much of Sumatra north of Lampung during September, October and early November 1997. This smoke haze drifted north and east over Singapore and Malaysia and caused considerable direct and indirect economic damage.

Compared to the other southern provinces, there were comparatively few fires in Bengkulu during 1997.

In the three provinces - Aceh, North Sumatra and West Sumatra – that were occasionally monitored, the number of detected fires was also low. Exceptions in 1997 and early 1998 by FFPCP included a number of large fires in North Sumatra close to the Riau provincial boundary and a few long-lasting fires in the wetlands of West Sumatra.

The fire history of the island from 1996 to 1998 shows that a wave of fires moved from north to south in each of the three years. Peak fire numbers were highest in Riau in the months before and including July; in Jambi from July to September; in South Sumatra in September; and in Lampung from August to October. In years of average to above average rainfall in Sumatra, e.g. 1996 and 1998, total fire numbers throughout the island peaked between July and September.

Most of these fires are caused by small to large scale agricultural land clearing in dryland areas. In years of average rainfall wetland soils are saturated or flooded throughout the year and are largely unaffected by fire although a few transient grassland fires occur as a result of land preparation for rice cultivation. Frequent rainfall and high humidity reduce atmospheric pollution from both wetland and dryland fires to negligible levels of only local concern.

Progressive loss of forest cover, using fire as the clearance tool, continues in all provinces from year to year under the pressure of economic development and the increase in rural population. This clearance proceeds regardless of how wet the season is: it is often a legitimate activity and will no doubt continue in future years.

Dryland primary forest in the lowlands of Sumatra has already been destroyed, apart from a few relicts. More than 50 percent of the primary forest that existed in Sumatra in 1980 was lost by 1985. Closed primary forest is now restricted to intermittent cover on the Bukit Barisan highlands that form the western backbone of the island, and a patchy distribution of swamp forest along the eastern coastal wetlands. The highland area of forest remained largely intact over the 1980-1985 period. Few NOAA detected fires were recorded over the last three years suggesting that the area is still largely forest covered. The highlands have been considered too steep for agricultural and forestry activities and have thus for the moment, avoided the ravages of elsewhere.

Based on the past fire history, the future outlook can broadly be predicted as, 'More of the same but with some regional variation'. Fewer large persistent fires are likely in South Sumatra and Jambi as land clearance nears completion. Riau still has very considerable areas scheduled for conversion to plantations and fire numbers will probably remain similar to those in recent years. If the 'less exploited' provinces of North Sumatra, West Sumatra and Aceh are opened for large scale development, fire numbers can be expected to rise sharply.

Future fire damage in the extensive and ecologically sensitive eastern coastal wetland zones – and in the smaller western zones – will also continue if their mis-use persists. As these areas are the major source of smoke haze, widespread pollution can be expected in drought years.

There are a few encouraging signs. Government spokesmen have suggested that no new areas of natural forest will be allocated for plantations - although the preservation of the large areas already allocated seems not to be assured – and that existing decrees that ban the use of fire to clear land will be enforced. Public opinion and political pressure from Indonesia's neighbours may also help to reduce fire numbers in future years.

The way forward must be based on sound land-use planning integrated with the strict conservation of natural resources to preserve habitats at risk.

# DEFINITIONS

## Vegetation Fires, Hot-spots, Wildfires and Smoke Haze

The term '**forest fire**' is widely used - it occurs in the title of FFPCP - but, when referring to Indonesia, is often misleading. Fires on land within the natural forest estate - in legal terms 'forest' - often burn little except grassland and scrub. In areas outside forest-land, it is again agricultural waste, land-clearance and low-value vegetation, which are most vulnerable to fire. Fires in these non-forested areas are sometimes referred to as land fires. This term can also be misleading if confused with ground fires that burn organic material (e.g. peat) beneath surface fires. NOAA satellite imagery is incapable of distinguishing fires that burn trees from those which do not. The term **vegetation fire** is thus preferred, and is used throughout the five reports which cover the capture, processing, interpretation and presentation of NOAA-derived fire data.

**Wildfire** is used for a vegetation fire that is out of control. It does not suggest that the fire was ignited by lightning or other natural means - only a fraction of a percent is.

**Hot-spots** indicate the location of vegetation fires as seen on a computer monitor or printed map, or when referred to by their co-ordinates. It is a populist term introduced early in the use of NOAA imagery to detect vegetation fires, and is now well understood by all. Acceptance of the more obvious term 'fire-spot' has been resisted, as its introduction has inevitably been proposed by interests wishing to suggest that many hot-spots do not indicate fires. In this they are mistaken. For all practical purposes a **hot-spot** is **synonymous** with a **fire-spot**. Hot-spot is thus used throughout all FFPCP reports.

**Smoke** is defined by the Deutsches Institut für Normung (DIN) as, 'A visible aerosol resulting from combustion'; **haze**, by the World Meteorological Organisation, as 'Where the visibility is reduced owing to dry particles'. Neither term is used uniformly in the literature on vegetation fires in Indonesia and FFPCP has thus chosen to use the general phrase '**smoke haze**' throughout its reports.

## Table of Contents

Foreword	ii
Summary	iv
Definitions	vii
Table of contents	viii
<b>1. Introduction</b>	<b>1</b>
<b>2. Fire History of the Sumatra Provinces, 1996-1998</b>	<b>3</b>
Aceh	3
North Sumatra	3
Riau	3
Jambi	6
South Sumatra	7
West Sumatra	7
Bengkulu	7
Lampung	7
An overview	8
<b>3. The Future</b>	<b>9</b>
The inland areas	9
The coastal wetlands	10
<b>References</b>	<b>12</b>
<b>Abbreviations and Acronyms</b>	<b>15</b>
Annex 1. <b>Monthly Trends in the Occurrence of Vegetation Fires in Riau, Jambi, South Sumatra, Bengkulu and Lampung Provinces in 1997</b>	16
Annex 2. <b>Monthly Trends in the Occurrence of Vegetation Fires in Riau, Jambi, South Sumatra, Bengkulu and Lampung Provinces in 1998</b>	19
Annex 3. <b>Monthly Hot-Spot Maps for South and Central Sumatra 1996, 1997 and 1998</b>	22

# 1. INTRODUCTION

Alarmed by the number of wildfires in 1992 the Ministry of Forestry and Estate Crops with the European Union, set up the Forest Fire Prevention and Control Project (FFPCP) in Palembang, South Sumatra. As part of its wider remit, FFPCP acquires NOAA data and uses these data to detect vegetation fires in Sumatra. The NOAA system began operating in January 1996.

FFPCP monitors fires on a daily basis in five of the eight Sumatra provinces (Map 1) - Riau, Jambi, South Sumatra, Bengkulu and Lampung. The remaining provinces, West Sumatra, North Sumatra and Aceh, receive sporadic coverage since satellite image size limitations preclude capture of the entire island.

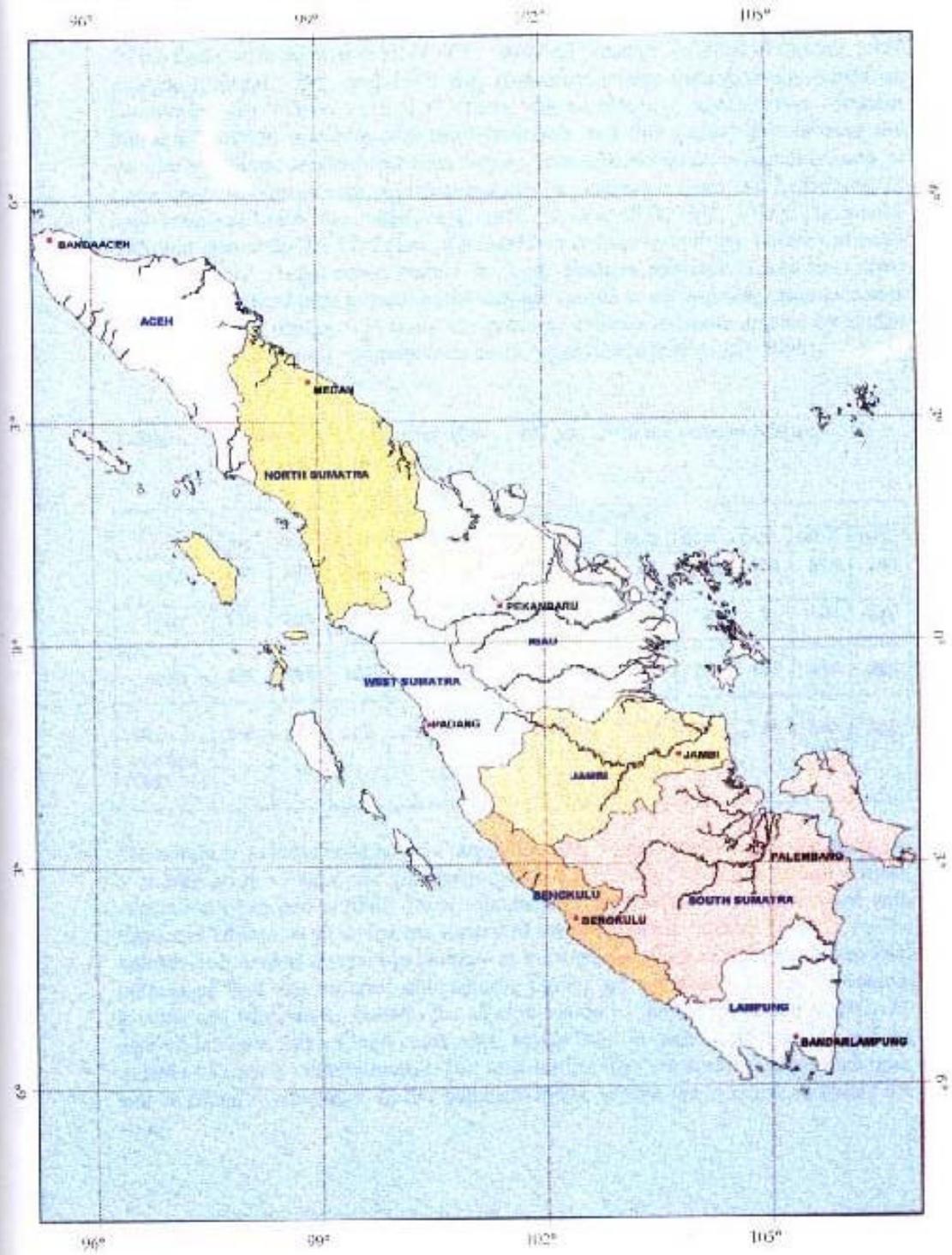
Vegetation fires in Sumatra are monitored by three other NOAA stations within Indonesia; the JICA-sponsored Forest Fire Prevention and Management Project, GTZ-funded Integrated Forest Fire Management Project, and BAPEDAL through LAPAN. JICA has published data that refer mainly to the incidence of fire in the Way Kampas National Park in Lampung province (Ueda *et al.* 1998). Publications from GTZ give an excellent interpretation of the fires in Kalimantan, their main area of interest, but little on Sumatra. LAPAN is the official government body responsible for the monitoring of vegetation fires throughout the archipelago. LAPAN provided summaries on the BAPEDAL internet site in 1997 and has released a limited set of figures on fire occurrence that include data for Sumatra (MoE/UNDP, 1998). However, the number of fires reported by LAPAN is far fewer than by other stations and the data appear to have been compressed; CIFOR (1998) also comments on the generalisation of LAPAN data.

A brief overview of vegetation fires in Indonesia, including Sumatra, has been given by EUFREG (1998). This review made use of data provided by FFPCP and the EU-funded Forest Inventory and Monitoring Project. Stolle (1998) and Makarim *et al.* (1998) give similar resumes of the 1997 Sumatra fires also based on hot-spot data distributed by FFPCP and other providers.

As has been forcibly pointed out by Schindler (1998), “High-tech monitoring exercises in Indonesia are totally out of balance with the equally necessary and important dirty fieldwork”. The accuracy of this statement is recognised by FFPCP. Satellite monitoring is used as one tool in a programme that is designed to reduce the number and severity of vegetation fires in the target province of South Sumatra, and to improve the efficiency of agencies to control those fires that do occur. Monitoring is not an end in itself.

The lack of a central authority able to forward information on fire locations to District and Sub-District levels is noted by Basyruddin *et al.* (1998) as a major failing. To avoid this FFPCP supplies fire location data directly to the Fire Control Centres set-up in the District Forestry Offices (Dinas Kehutanan) in five Districts within South Sumatra (Anderson, Imanda and Muhnander, 1999). Staff of the same offices are also supported through the supply of firefighting equipment and ‘hands-on’ training in its

Map 1 Sumatra provinces and provincial capitals



use. Although direct data supply removes one obstacle, it is the view of FFPCP that nationally, little progress will be made until the general field-based capacity to fight fires is strengthened.

Of the three years monitored by FFPCP, 1996 was ‘average’ in terms of rainfall, 1997 was exceptionally dry, and 1998 was somewhat wetter than average, based on Palembang data (Table 1). In 1997 there was no effective rainfall over southern Sumatra between mid-May and mid-November and this greatly exacerbated the number of serious uncontrolled fires. Smoke haze affected most of Sumatra north of Lampung, Singapore and southern peninsular Malaysia from the beginning of September until mid-November (Legg, 1998; Levine, 1998; Heil, 1998). The smoke pollution caused by the 1997 fires in Sumatra came largely from the burning of peat-land in eastern coastal areas, mainly in South Sumatra province. These fires drew international attention as a result of the damage caused to ecologically important sites (Bompard, 1997; Rieley, 1998) and the potential damage to health created by smoke haze rich in carcinogens and small-size particulates (Dieterle and Heil, 1998).

**Table 1.** Monthly rainfall totals for 1996, 1997 and 1998 recorded at Kenten, Palembang (BMG data).

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

The numbers, severity and timing of vegetation fires within each province are related to a combination of land-use (in particular conversion of forest to estate crops), vegetation types and rainfall. These relationships are described and illustrated with maps and tables that show the fire history of the provinces monitored by FFPCP. The number of hot-spots detected in Sumatra in the three years accurately reflects the total number of fires that occurred although the figures are not identical. [See Anderson, Imanda and Muhnandar (1999a) for an explanation of the interpretation of NOAA-derived hot-spot data]. Cloud cover often masks fires on each satellite image and the number of fires is underestimated. But long-lasting fires are detected more than once and cause an overestimate in fire numbers. However, the fire occurrence trends are valid.

## 2. THE FIRE HISTORY OF THE SUMATRA PROVINCES, 1996-1998

A summary of all the hot-spots detected in the provinces of Riau, Jambi, Bengkulu, South Sumatra and Lampung from 1996 to 1998 is given in Table 2. Monthly trends in the occurrence of vegetation fires in the same provinces are summarised in Annex 1 for 1997 and in Annex 2 for 1998. Composite hot-spot maps for Sumatra for 1996, 1997 and 1998 are presented in Annex 3.

### Aceh

Aceh was only occasionally monitored during the dry seasons owing to NOAA image size limitations and the need for regular coverage of South Sumatra. Those fires that were detected were few and ephemeral, even during the 1997 drought. The EU-funded Leuser Development Project concludes that fires are not a serious problem within the province, although twelve forest concessions that operate in the buffer zone of the national park give cause for concern (Monk, *pers. comm.*). The risk of vegetation fires is undoubtedly reduced by high rainfall in August and September north of 3°30'N - related to the movement of the jet-stream - and the relatively large areas of undisturbed forest. The loss of primary forest in Aceh in recent years has been less - about 30 percent between 1980 and 1985 - than in the other provinces of Sumatra where the loss exceeded 50 percent (Whitmore, 1990).

### North Sumatra

The eastern coastal plain of North Sumatra has fertile soils (Fisher, 1964) and is easily accessible. It was the first area outside Java to be developed by the Dutch for plantation crops (the *cultuurgebied*) and the province now has a mature agricultural-based economy at low risk of fire. And, indeed, few fires were detected in agricultural areas from 1996 to 1998.

Outside the agricultural zone there were regular vegetation fires in both 1997 and 1998. Most of the fires were in the wetlands that border Riau - and in dry-land areas further south, again close to the Riau provincial boundary. The fires were in, or adjacent to, forest concessions and are assumed to be associated with post-logging land clearance to convert the area to estate crops.

### Riau

Over the three years 1996 to 1998 Riau was the most fire prone province, although in 1997 the highest absolute number of fires that were detected occurred in South Sumatra when smoke prevented the detection of many fires in Riau. The seasonal pattern varied somewhat from year to year and the peak fire month was July in 1996 and 1997, and March in 1998.

**Table 2.** Number of hot-spots detected each month in the provinces of South Sumatra, Jambi, Riau, Bengkulu and Lampung in 1996, 1997 and 1998

Province	Year	Month											
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
South Sumatra	1996	43	37	107	no-data	90	93	550	939	1196	162	102	52
	1997	60	108	47	26	78	1534	2871	9096	27994	15035	3694	220
	1998	83	35	14	10	22	16	36	37	569	106	112	3
Jambi	1996	58	38	265	no-data	76	368	1020	526	115	123	152	205
	1997	115	69	3	17	110	1333	2045	2103	4529	1203	562	303
	1998	85	66	36	86	76	97	90	82	164	20	150	9
Riau	1996	No-data	no-data	no-data	no-data	205	443	2949	582	307	181	1251	149
	1997	747	193	442	108	2719	2455	4042	2726	1843	691	71	46
	1998	883	2931	3232	1288	712	1525	638	131	278	371	972	103
Bengkulu	1996	0	3	16	no-data	74	150	176	105	2	6	0	0
	1997	0	16	6	1	40	254	322	1042	247	1137	48	184
	1998	4	27	0	2	15	28	49	1	9	3	7	0
Lampung	1996	0	2	3	no-data	56	24	69	104	36	25	31	1
	1997	38	4	1	11	14	171	406	2616	10471	6926	398	13
	1998	6	0	1	2	8	6	12	9	39	21	10	5

The reason for the large number of fires in Riau and their seasonal unpredictability is not known with certainty. It is probable that many, particularly the largest, are related to land clearance for oil-palm estates. The province has an exceptionally high area (some 70 percent) of land allocated to concession companies (INTAG data), and once the valuable timber has been harvested, conversion follows (see chapter 3). Land developers use fire whenever weather conditions permit, and several days free of rain clouds are often followed by a rapid increase in the number of fires - regardless of the time of year. Such a development of fires during June 1998 is shown in Map 2.

The distribution of hot-spots can be divided into single spots/small clusters and large clusters. Large clusters of fires were noted to the south and west of Dumai and to the west of Pekanbaru. They include a significant proportion of night fires that are almost certainly associated with land clearance for large-scale plantation development.

As elsewhere in Sumatra, small-scale farmers anticipate the start of the growing season by preparing land with fire during the driest months of the year. In Riau this clearance is from July to October and adds significantly to the total number of fires, although not necessarily to their seriousness.

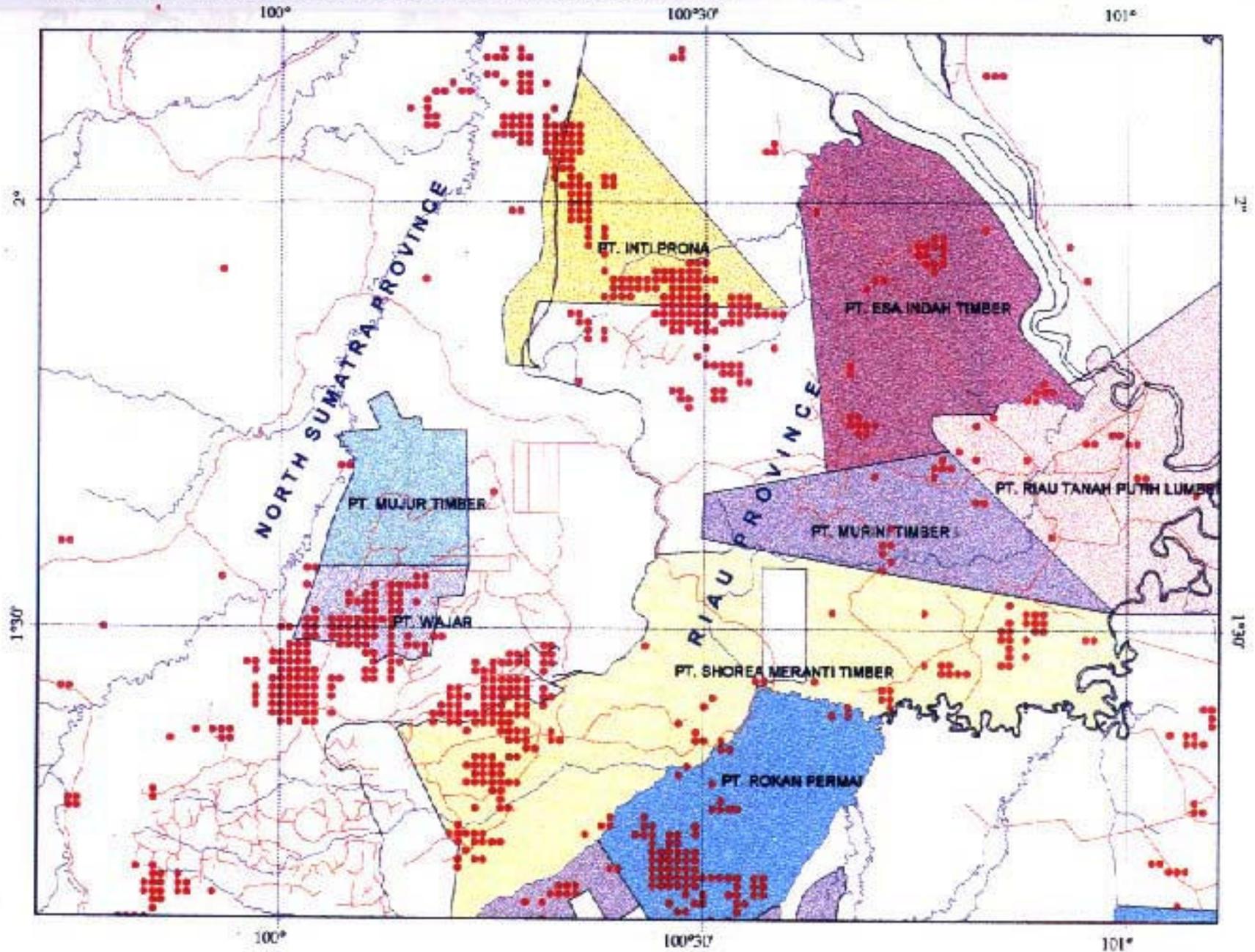
In drought years the numbers of fires and their severity - with the smoke haze they cause - are undoubtedly increased by the predominance of peat wetlands in the province. Appreciable areas have been drained for agriculture and subsequently abandoned and as the peat dries out during a prolonged dry period such areas become a severe fire risk (Nicolas and Bowen, 1999). In all years small surface fires often occurred close to the larger artificial drainage lines which, in turn, frequently run parallel with the few roads that penetrate the swamps. These small fires may have been the startpoint for the more serious sub-surface fires that followed in 1997.

The persistence of the 1997 fires into 1998 may be partly attributable to these deep-rooted sub-surface fires in Riau that continued to burn after the end of the 1997 drought. The sub-surface fires may then have acted as nuclei for new surface fires when drier weather returned. Re-ignition - along with large-scale land clearance - may explain the periodic and rapid increases in fires and smoke haze observed in February, March and November 1998, and most recently in April 1999.

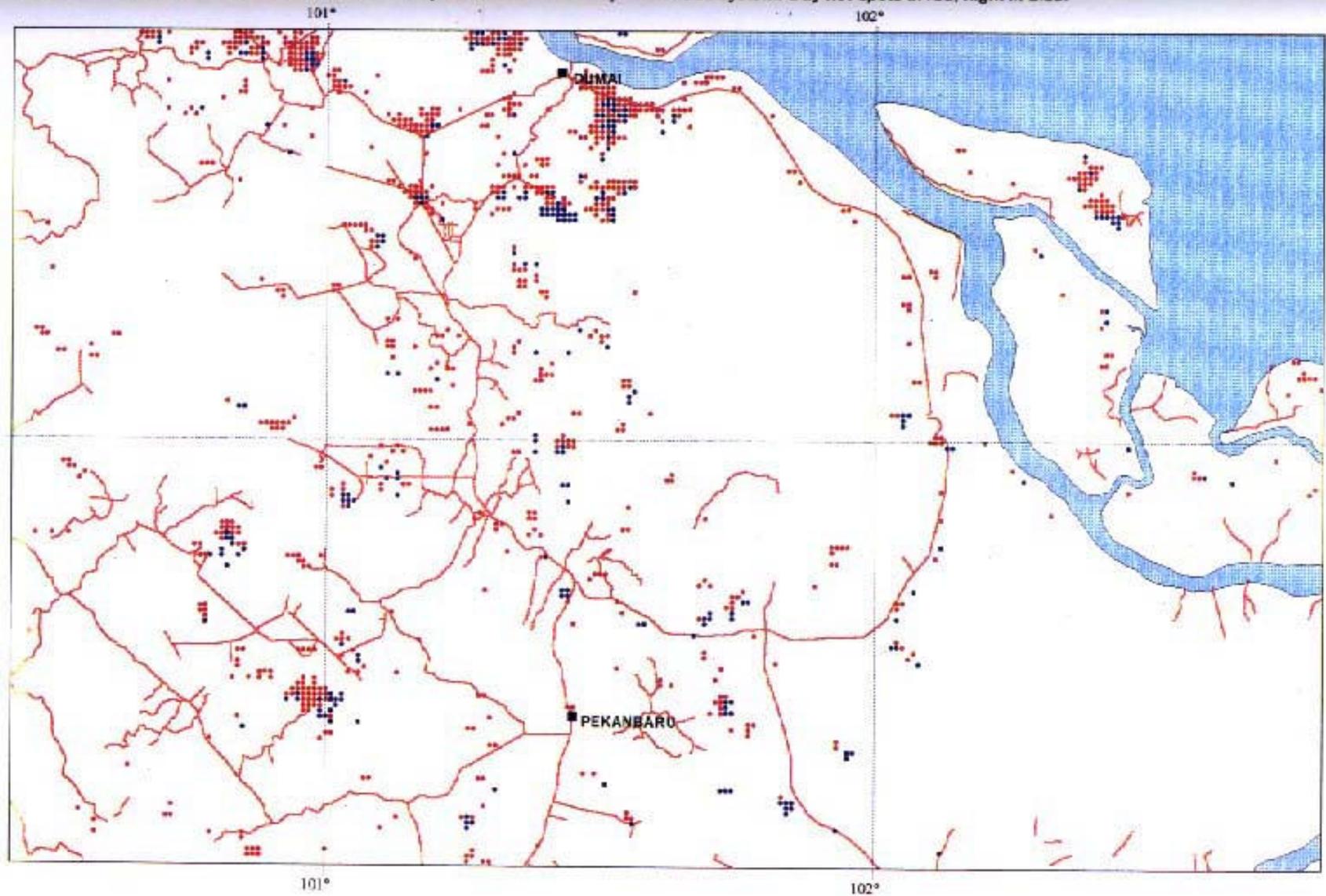
**Table 3.** Number of fires detected within specified distances from roads - Riau, February 1998

Distance from road	Number of hot-spots detected	
	Day	Night
Less than 1 km	420 (14%)	68 (10%)
Less than 3 km	1064 (36%)	184 (26%)
Less than 5 km	1526 (52%)	284 (40%)
More than 5 km	1405 (48%)	427 (60%)
<b>Total number of hot-spots detected</b>	<b>2931</b>	<b>711</b>

Map 2. Fires detected in Riau and North Sumatra Province during June 1998



Map 3. February 1998 hot-spot distribution in Riau province in relationship to the road system. Day hot-spots in red, night in blue.



FFPCP took part in an air surveillance exercise arranged by BAPEDAL in mid-November 1998. Numerous small but particularly smoky ground fires that are not detected on NOAA imagery were seen between Pekanbaru and Dumai - an area of partially drained and deforested wetland (Plate 1). They caused a moderately severe haze that affected both eastern Riau and Singapore for several days.

**Plate 1.** Ground fire, Riau Province November 1998.



The relationship between the number of fires in February 1998 and the road system in Riau during February 1998 is shown in Map 3 and Table 3. There is not a particularly close correlation with under 15 percent of fires apparently within one kilometre of a road. In fact the 'true' percentage may be considerably higher as not all the provincial roads are recorded on the available maps and it is likely that motorable tracks run through almost all the conversion areas. (There is a similar lack of up to date large-scale maps for all provinces.)

## **Jambi**

Between 1996 and 1998 the number and timing of vegetation fires in Jambi was 'intermediate' between the patterns in Riau and South Sumatra – the provinces that border Jambi to north and south. The peak fire months were July to September, somewhat later than in Riau and earlier than in South Sumatra. Around half the province is allocated as timber concessions, a lesser percentage than Riau but greater than South Sumatra (INTAG data).

Field checks in 1996 showed that the larger, clustered and persistent fires were caused by land clearance for tree crops, mainly oil palm. In late 1997, the wetlands east of

Jambi town, which include parts of Berbak National Park, were badly affected by wildfires. Ueda *et al.* (1998) reported that the first fires appeared to start in grassland and secondary forest, and then spread to the peat as this dried-out. There was above average rainfall in 1998 and no serious fires in the province.

## **South Sumatra**

September was the main month for vegetation fires in South Sumatra, although numbers varied each year; 28 000 hot-spots were detected in September 1997, some fifty times the number for 1998.

In 1997 numerous fires burnt from early June - predominantly in dry-land areas – lit by settled farmers for small-scale land clearance. They caused little smoke haze. Numbers decreased after August, presumably as all the desired land had been prepared by this time. In the average rainfall years of 1996 and 1998 most of the fires in South Sumatra were ephemeral and did not persist from one day to the next. In all years there was also a number of wildfires in fallow scrub re-growth (*semak / belukar*).

The extended drought of 1997 dried-out the coastal wetlands in MUBA and OKI Districts. Many surface and sub-surface peat soil fires burnt in these areas from the start of September to mid-November and caused widespread smoke pollution. In 1996 and 1998 the wetlands were unaffected, apart from transient grassland fires.

## **West Sumatra**

West Sumatra includes part of the Bukit Barisan highlands and the province has a high, well distributed rainfall. There are two sizeable coastal wetland areas, one bordering Bengkulu, the second extending from Padangpang to the North Sumatra border. Parts of both these wetlands lie in forest concessions and were the sites of intermittent but long-lasting fires in 1997 and 1998, almost certainly lit for land clearance to convert to plantations. Fires were uncommon elsewhere in West Sumatra.

## **Bengkulu**

The physiography and climate of Bengkulu province are similar to those in West Sumatra. Most fires occurred in July and August, but numbers were always low. Bengkulu has a high, evenly distributed rainfall, mainly intact forest cover on the Bukit Barisan and small coastal plain wetlands. It is thus a province of low fire risk.

## **Lampung**

Lampung, like North Sumatra, has a settled agricultural economy and is, in general, a low fire risk province. Fire numbers are greatest from August to October and arise from small-scale agricultural land clearing. They cause little damage or pollution.

Serious fires did, however, occur in Lampung in late 1997 on the narrow strip of coastal wetlands and threatened the Way Kambas National Park. Ueda *et al.* (1998) noted that grassland fires first appeared in the Park in August and were followed by

burns in secondary forest cleared in the early 1980's. By October fires were present in the peat swamp forest and destroyed areas undamaged by earlier logging.

## An Overview

The monthly trends in the occurrence of vegetation fires in the five most affected provinces of Sumatra are summarised in Annex 1 (1997) and Annex 2 (1998). The pattern of fires in 1996 was similar to the pattern in 1998 and the results are thus not presented here.

The fire history of the island from 1996 to 1998 shows that a wave of fires moved from north to south in each of the three years. Peak fire numbers were highest in Riau in the months before and including July; in Jambi from July to September; in South Sumatra in September; and in Lampung from August to October. The total number of fires detected and the number of fires per unit area in the five provinces monitored regularly in 1998 are shown in Table 4.

**Table 4.** Total number of fires and number of fires per 100 square kilometres in five Sumatra provinces in 1998.

Province	Area (ha <sup>2</sup> )	Total number of hot-spots	Number of hot-spots 100 km <sup>-2</sup>
Riau	9 514 300	13064	14
Jambi	4 901 300	961	2
South Sumatra	10 226 400	1043	1
Bengkulu	2 116 800	145	0.7
Lampung	3 352 200	119	0.4

Riau had by far the largest number of fires and the peaks of fire activity were intermittent. In 1998 there was a major peak in February-March and minor peaks in June and November. Smoke haze from Riau affected Singapore in February and March and again in November. A similar analysis for 1997 would be interesting but the data are biased by the masking effect of thick smoke from September to November.

However fire numbers alone are not a true reflection of ecological and economic damage. The more important measure of 'value destroyed' is much more closely paralleled by the extent of large-scale land conversion and by the total area of swamp forest destroyed.

### 3. THE FUTURE

#### The Inland Areas

Many of the persistent fire clusters in Riau and Jambi seen on the NOAA imagery were caused by large-scale conversion of logged forest into oil-palm plantations. Annual land conversion in Jambi is now slowing as the most suitable areas are already cleared and the number of large fires may decrease in future years.

In Riau between 1984 and 1997 the area under oil-palm increased from 39 800 ha. to 521 800 ha. 1997 (BPS, 1997 quoted by MoE/UNDP, 1998) and large scale conversion seems set to continue.

Forest areas in Riau and elsewhere in Sumatra already reserved for development by the non-forestry sector are considerable (Table 5).

**Table 5.** Land areas (ha<sup>2</sup>) in each Sumatra province scheduled for conversion to non-forest use.

Province	Land area (ha <sup>2</sup> ) scheduled for conversion	
	BPS	CIC
Aceh		16 000
North Sumatra		34 000
Riau	97 000	63 000
West Sumatra	14 200	34 800
Jambi	22 300	16 200
South Sumatra	15 000	12 000
Bengkulu		1 200
Lampung		
<b>TOTAL</b>	<b>148 500</b>	<b>177 200</b>

The figures given in the table originate from CIC (1997) and BPS (1997), and while sources in the oil-palm industry in Sumatra refuse to quote targets for their own companies, all suggest that the official figures are unrealistically low. 'At least ten times higher' is the generally expressed view. It thus seems certain that many large fires will continue in Riau and are likely to spread to North Sumatra, West Sumatra and Aceh as these provinces are 'opened up'.

Under pressure of public opinion, the Minister of Forestry and Estate Crops was quoted in the national press in early 1999 as saying that no new areas of natural forest were to be opened up for plantations. (It is assumed that land already allocated will be converted). Further statements from the Minister also suggest that he wishes to enforce the Presidential Decree of 1997 and that companies must not use fire to clear land for plantations. The number of large-scale fires may be expected to decrease in the longer term if these policies are carried out.

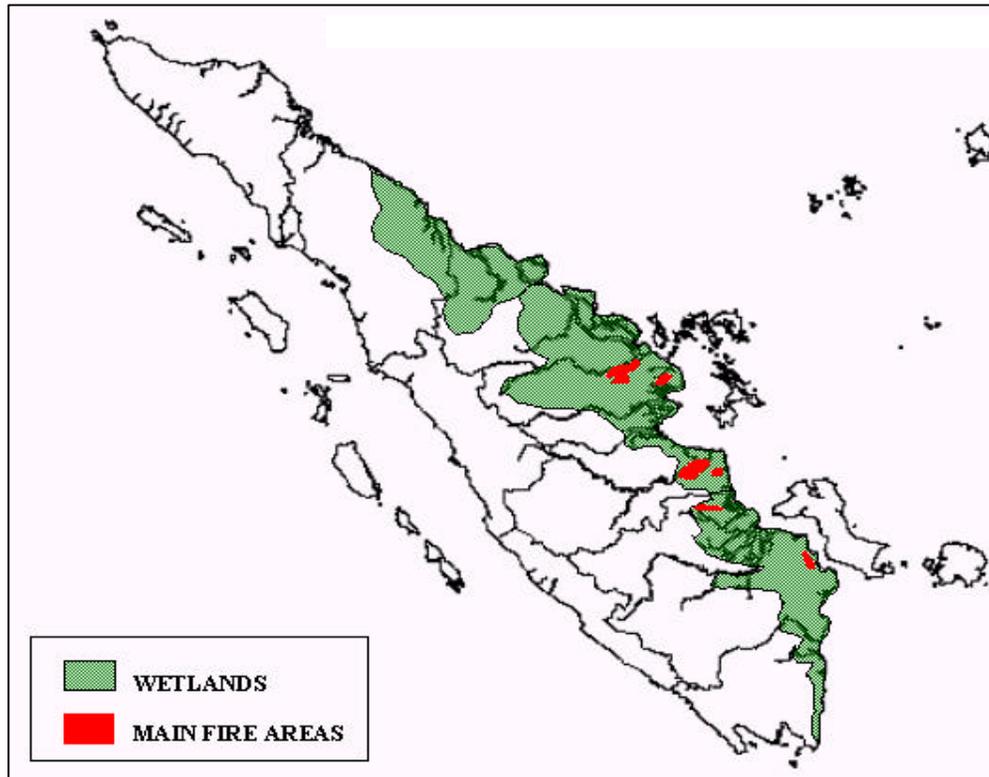
More than 50 percent of the primary forest that existed in Sumatra in 1980 was already lost by 1985 (Whitmore, 1990). And by the late 1980s dryland primary forest in the lowlands of Sumatra had been destroyed, apart from a few relicts.

In South Sumatra further conversion of the secondary forest to rubber and pulpwood plantations was also largely completed by the mid-nineties and thus a major source of fires has been eliminated. But less damaging fires are likely to continue as older 'jungle' rubber is replaced by high-yielding clones or by oil-palm.

### The Coastal Wetlands

Wetland vegetation is at greatest risk from fire during periodic years of extended drought (Map 4). Within the last two decades serious fires associated with drought occurred in 1982-1983, 1987, 1991-1992, 1994-1995 (Meijaard and Dennis, 1997) and 1997.

**Map 4.** The locations (red) of major fires in 1997 in the wetlands (green) of Sumatra



The wetlands of Sumatra have never been 'fire-proof' and there is a limited history of fire occurrence in the coastal (and inland) wetlands before the 1980s. However there is no doubt that frequency, numbers and severity have risen steadily exacerbated by unsustainable land-use and exploitative forest management practices that began in the late 1960s.

Legal and illegal logging activities have fragmented the closed canopy forest and most of the remaining areas are allocated to logging companies. The present vegetation is a mosaic of grassland, shrubland, open woodland and rare relicts of the natural closed forest cover. All are vulnerable to fire.

Of all Indonesia's provinces, South Sumatra has received the largest influx of transmigrants, and some 800 000 people have been resettled since the late 1960s. Around 30 000 ha. of pristine coastal peat swamp forest in South Sumatra were 'reclaimed' starting in 1969 (van Dis, 1986) and at least 28 000 people were settled on tidal swamp schemes east of Palembang (Danielsen and Verheugt, 1990). Intended for tidal rice cultivation, these schemes were never conspicuously successful and in some cases have failed completely. Extensive macro-drainage channels were excavated at the time and have caused a general reduction in the dry season watertable over large areas.

Extensive fallows which are an integral part of the low-intensity land-use systems practiced on peat soils have increased the fire risk. Excessive drainage has caused the formation of acid sulphate soils that further reduce soil fertility to a point where much of the land cleared for agriculture has been abandoned. The hygrophytic grasses and shrubs that colonised the land add to the fire risk. Many areas now burn annually as fires spread into them from garden plots adjacent to fishing villages on the banks of the rivers.

Similar misuse of the coastal wetlands is evident throughout Sumatra. Fire risk, negligible under the natural vegetation of this ecosystem, has increased in all areas disturbed by widespread legal and illegal logging and on land converted to agricultural purposes (Brinn, 1992). Further extensive disturbance of the wetland vegetation is currently being caused by infrastructure associated with oil and gas field exploration and production.

The way forward must be based on sound land-use planning integrated with strict conservation of natural resources to preserve habitats currently at risk (Danielsen and Verheugt, 1990). It may already be too late to save the coastal wetlands of South Sumatra. However, there is still time to conserve the 'less developed' wetlands to the north in Jambi and Riau if rational planning procedures were developed and logging controlled.

## REFERENCES

Anderson, I.P., Imanda, I.D. and Muhndandar. (1999). *Vegetation fires in Sumatra: the presentation and distribution of NOAA-derived data*. Forest Fire Prevention and Control Project, Palembang. Ministry of Forestry and Estate Crops and European Union, Jakarta.

Anderson, I.P., Imanda, I.D. and Muhndandar (1999a). *Vegetation fires in Indonesia: the interpretation of NOAA-derived hot-spot data*. Forest Fire Prevention and Control Project, Palembang. Ministry of Forestry and Estate Crops and European Union, Jakarta.

Basyiruddin, A., Sutanto, A., Biller, A., Graham, B.J. and de Carlo, L. (1998). *Analysis of forest and land fire suppression capabilities – Riau, Jambi and South Sumatra*. Paper presented to the Asian Development Bank - ASEAN, Expert Group Meeting on the 'Inventory and Analysis of Forest and Land Fire Suppression Capability. 24 November 1998. The ASEAN Secretariat, Jakarta.

Bompard, J.M. (1997). *Promoting farmers involvement in forest fire prevention*. Forest Fire Prevention and Control Project, Palembang. Project report number 25.

Brinn, P.J. (1992). *Recommended development area 99, South Sumatra. Rapid appraisal report*. Regional Physical Planning, Map Improvement and Training Project. Land Resource Planning Component. Ministry of Transmigration, P.T. Nasuma Putra Consulting Engineers and Natural Resources Institute, UK. 43 pp.

CIC (1997). *Studi tentang industri dan perkebunan kelapa sawit Indonesia*. P.T. Capricorn Indonesia Consult Inc., Jakarta.

CIFOR (1998). *A review of fire projects in Indonesia 1982-1998*. Center for International Forestry Research, Bogor, Indonesia. 112 pp.

Danielsen, F. and Verheugt, W. (1990). *Integrating conservation and land-use planning in the coastal region of South Sumatra, Indonesia*. The Directorate General of Forest Protection and Nature Conservation (PHPA) and Asian Wetland Bureau (AWB-Indonesia).

Dieterle, G. and Heil, A (1998). *Impacts of large scale forest and land fires in Indonesia 1997 on regional air pollution*. Paper, International Cross Sectoral Forum on Forest Fire Management in South East Asia. Indonesia National Planning Agency, Japan International Cooperation Agency and International Tropical Timber Organization. 7-8 December 1998. Jakarta.

Dis, van M.M.U. (1986). *The art of lowland development*. Theme 1. *Land and water management* (pp. 34-53). In: Symposium on lowland development in Indonesia. Jakarta, Indonesia, 24-31 July 1986. ILRI, Wageningen, The Netherlands.

EUFREG (1998). *Assessment of the 1997 fires in Indonesia*. European Union Fire Response Group (EUFREG). European Union and Ministry of Forestry and Estate Crops, Jakarta, Indonesia.

Fisher, C.A. (1964). *South-east Asia. A social, economic and political geography*. Methuen, London. 831 pp.

Heil, A. (1998). *Fire-related transboundary haze and air pollution in south-east Asia in 1997*. Proceedings, Workshop on Fire Hazards, Transboundary Haze and Sustainable Forestry in East Asia and the Pacific. EDIEN-World Bank, Surabaya, Indonesia. 9-12 December 1998.

Legg, C.A. (1998). *1997 fires in Indonesia: satellite remote sensing for mapping and monitoring*. Paper, International Cross Sectoral Forum on Forest Fire Management in South East Asia. Indonesia National Planning Agency, Japan International Cooperation Agency and International Tropical Timber Organization. 7-8 December 1998. Jakarta.

Levine, J. (1998). *Gaseous and particulate emissions released to the atmosphere during forest fires: a case study of Kalimantan and Sumatra, Indonesia in 1997*. Proceedings, Meeting on Health Guidelines for Forest Fire Episodic Events. World Health Organization, 6-9 October 1998, Lima. Peru.

Makarim N., Arba'i Y. A., Deddy A. and Brady M. (1998). *Assessment of 1997 land and forest fires in Indonesia: national coordination*. Indonesian Environmental Impact Management Agency (BAPEDAL) and Collaborative Environmental Project in Indonesia (CIDA-CEPI). 7 pp.

Meijaard, E. and Dennis, R. (1997). *Forest fires in Indonesia: bibliography and background information*. World Wildlife Fund, Amsterdam, The Netherlands.

MoE / UNDP. (1998). *Forest and Land Fires in Indonesia*. Volume 1, *Impacts, Factors and Evaluation*. 185 pp. Volume 2. *Plan of Action for Fire Disaster Management*. 119 pp. The State Ministry for Environment Republic of Indonesia, and United Nations Development Programme, Jakarta.

Nicolas, M.V. and Bowen, M.R. (1999). A field-level approach to peat and coal seam fires in South Sumatra, Indonesia. Forest Fire Prevention and Control Project, Palembang. Ministry of Forestry and Estate Crops and European Union, Jakarta.

Ramon, J. and Wall, D. (1998). *Fire and smoke occurrence in relation to vegetation and land use in South Sumatra Province with special reference to 1997*. Forest Fire Prevention and Control Project, Palembang. Project report number 47.

Rieley, J. (1998). Peat forests facing extinction from crisis-hit profiteers. The Jakarta Post, 19 December 1998. Jakarta, Indonesia.

Schindler, L. (1998). *The Indonesian fires and SE Asian haze 1997/98: review, damages, causes and necessary steps*. Paper presented at the, Asia-Pacific Regional Workshop on Transboundary Atmospheric Pollution, 27-28 May 1998, Singapore.

Stolle, F. (1998). *The 1997 Sumatra fires*. Paper presented at the, Workshop on Fire Hazards, Transboundary Haze and Sustainable Forestry in East Asia and the Pacific. EDIEN-World Bank, Surabaya, Indonesia. 9-12 December 1998.

Ueda, T., Prakoso, J.H., Takai, W., Suseno, D.P.Y. and Usman, A.B. (1998). *Monitoring forest fires using meteorological satellite information*. Paper, 'International Cross Sectoral Forum on Forest Fire Management in South East Asia. Indonesia National Planning Agency,' Japan International Cooperation Agency and International Tropical Timber Organization. 7-8 December 1998. Jakarta.

Whitmore, T. C. (1990). *An introduction to tropical rain forests*. Oxford University Press.

## ABBREVIATIONS AND ACRONYMS

AWB	Asian Wetlands Berau
BAPEDAL	Badan pengendalian Dampak Lingkungan (Environment Impact Prevention Agency)
BPS	Biro Pusat Statistik (Central Statistical Office)
CIC	Capricorn Indonesia Consult Incorporated
CIFOR	International Center for Forrestry Research
EU	European Union
EUFREG	European Foreast Response Group
FFPCP	Forest Fire Prevention and Control Project (EU)
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit (German Agency for Technical Coopearation)
HPH	Hak Pengusahaan Hutan (Forest Concession)
INTAG	Inventarisasi dan Tata Guna Hutan (Forest Inventory and Land Use)
JICA	Japanese International Cooperation Agency
LAPAN	Lembaga Penerbangan dan Antariksa Nasional (National Aviation and Space Agency)
MoE	Ministry of Environment
MUBA	Musi Bannyuasin (name of a District in South Sumatra)
NDVI	Normalised Difference Vegetation Index
NOAA	National Oceanic and Atmospheric Administration
OKI	Ogan Komering Ilir (name of a District in South Sumatra Province)
P.T	Perseroan Terbatas (Limited Company)
UNDP	United Nations Development Programme

## ANNEX 1 Monthly Trends in the Occurrence of Vegetation Fires in Riau, Jambi, South Sumatra, Bengkulu and Lampung Provinces in 1997

### Riau Province

MONTH (1997)	RIAU PROVINCE
January	More fires than in the other provinces monitored. A number of particularly large, persistent fire clusters in the south-east.
February	Occasional fires. The large January clusters no longer evident.
March	Clusters in the south east reappear. Few fires elsewhere.
April	Very few fires
May	A large number of fires west of 102°E. To the east, large fire clusters south of the Sungai Kampar estuary
June	Similar fire pattern to May but an increased number of fires.
July	Same pattern with a further increase in fire numbers. The month of maximum fire activity.
August	Slight decrease in number of fires, but pattern of occurrence persisted.
September	Further decrease in fire numbers. Smoke cover affected most of the province and probably reduced the number of fires detected.
October	Occasional fires. Smoke cover persisted.
November	Very few fires
December	Very few fires

### Jambi Province

MONTH (1997)	JAMBI PROVINCE
January	Occasional fires
February	Occasional fires
March	Very few fires
April	Very few fires
May	Occasional fires
June	Start of fire season. Several large fire-clusters presumed to be associated with land clearing activities
July	Similar fire pattern to June. Field inspection confirmed that hot spot clusters were associated with large-scale land clearing
August	General increase in the number of fires. Large-scale land clearing continued. Few fires in the west.
September	Month of maximum fire activity. Some fires in the west but the largest hot-spot clusters concentrated east and north-east of Jambi town in areas of wetland including Berbak National Park. Jambi Province badly affected by smoke
October	Apparent decrease in the number of fires but detection inhibited by smoke cover. Several hot-spot clusters in west. Large clusters persisted in the wetlands east of Jambi town
November	Large fire-clusters north and east of Jambi; few fires elsewhere.
December	Occasional fires

## South Sumatra Province

MONTH (1997)	SOUTH SUMATRA PROVINCE
January	Very few fires
February	Very few fires
March	Very few fires
April	Very few fires
May	Very few fires
June	Start of fire season. Large clusters developed north of Baturaja, near Muara Rupit and in Kabupaten MUBA near Nyarang
July	Persistence of above clusters with increased number of hot spots associated with small-scale agriculture land preparation
August	Generally increased number of fires. Small fire clusters appeared in Pampangan HPH wetlands
September	Month of maximum fire activity with only the western and south-western extremes of South Sumatra generally fire free. A small percentage of the hot spots are considered to be non-fires as a result of high soil temperature. Considerable smoke, particularly in Pampangan and MUBA
October	Reduction in number of fires throughout dry-land areas, as most land already burnt over. Focus of fires in the wetlands of Pampangan and MUBA and these areas continued to be a major source of smoke.
November	Considerable reduction in total number of hot spots but large clusters persisted in the wetland areas, notably in P.T. SBA Wood Industries. Drought ended in mid-month and smoke rapidly suppressed by rainfall. End of fire season
December	Very few fires. Occasional hot-spots detected at sites of former large clusters in Pampangan

## Bengkulu Province

MONTH (1997)	BENGKULU PROVINCE
January	No fire activity
February	Very few fires
March	Very few fires
April	Very few fires
May	Occasional fires in the north.
June	A few fire clusters in HPH west of 102°E
July	Similar fire pattern to June
August	Maximum period of fire activity in the province, but few fires compared to Riau.
September	Marked reduction in the number of fires. Most occurred to the south of the province
October	Apparent increased number of fires compared to September
November	Occasional fires
December	A large cluster of fires in wetlands in the coastal area bordering West Sumatra Province

## Lampung Province

MONTH (1997)	LAMPUNG PROVINCE
January	Very few fires
February	Very few fires
March	Very few fires
April	Very few fires
May	Very few fires
June	Occasional fires north of 5°S
July	More fires north of 5° S
August	Many hot spots north of 5°S but these were discounted as fires and considered to be a result of high soil temperatures.
September	As August.
October	As August but genuine fires appeared to be common in wetlands along the east coast
November	Very few fires but fires did continue in a wetland promontory just north of 5°S
December	Very few fires

## ANNEX 2 **Monthly Trends in the Occurrence of Vegetation Fires in Riau, Jambi, South Sumatra, Bengkulu and Lampung Provinces in 1998**

### **Riau Province**

MONTH (1998)	RIAU PROVINCE
January	As January 1997; a significant number of fires compared to the other provinces monitored. Several persistent fire clusters in the wetlands south of the Kampar estuary, and near Dumai
February	A general increase in the number of fires which in the main, affected the same areas as in January.
March	As February; the continued peak period for fires during 1998.
April	A slight decrease in fire numbers.
May	The main fire centres shifted to the province boundary with North Sumatra
June	Increased fires along the North Sumatra boundary and fires re-appeared in the Kampar area
July	A slight decrease in the number of fires.
August	Occasional fires
September	Occasional fires
October	The number of fires increased particularly along the boundary with North Sumatra
November	The number of fires continued its increase and smoke haze appeared from wetland fires
December	Occasional fires

### **Jambi Province**

MONTH (1998)	JAMBI PROVINCE
January	Occasional fires
February	Occasional fires
March	Very few fires
April	Occasional fires
May	Occasional fires
June	Occasional fires
July	Occasional fires, particularly in the west, to the south of the Sungai Hari
August	Similar to July
September	Month of maximum fire activity, but restricted to central Jambi with no fires in the western highlands or the eastern wetlands.
October	Very few fires
November	Increase in fire activity in central Jambi
December	Very few fires

### South Sumatra Province

MONTH (1998)	SOUTH SUMATRA PROVINCE
January	Very few fires. Occasional hot-spots in the wetlands of Pampangan at the sites of the major 1997 fires.
February	Very few fires. Pampangan fires ended.
March	Very few fires
April	Very few fires
May	Very few fires
June	Very few fires
July	Very few fires
August	Very few fires
September	Month of maximum fire activity mainly associated with small scale agricultural land preparation. Fires detected in most area except the highlands to the west and in the wetland areas
October	A similar pattern to September but a decreased number of fires
November	Large cluster of hot-spots detected near Muara Rupit. Elsewhere very little fire activity
December	Very few fires

### Bengkulu Province

MONTH (1998)	BENGKULU PROVINCE
January	Very few fires
February	Very few fires
March	Very few fires
April	Very few fires
May	Very few fires
June	Very few fires
July	Some fires in the northern half of the province
August	Very few fires
September	Very few fires
October	Very few fires
November	Very few fires
December	Very few fires

## Lampung Province

MONTH (1998)	LAMPUNG PROVINCE
January	Very few fires
February	No fire activity
March	Very few fires
April	Very few fires
May	Very few fires
June	Very few fires
July	Very few fires
August	Very few fires
September	Slight increase in the number of fires in northern Lampung
October	Very few fires
November	Very few fires
December	Very few fires

## ANNEX 3

### **Hot-Spot Maps for South and Central Sumatra for 1996, 1997 and 1998**

MONTHLY FIRE MAPS

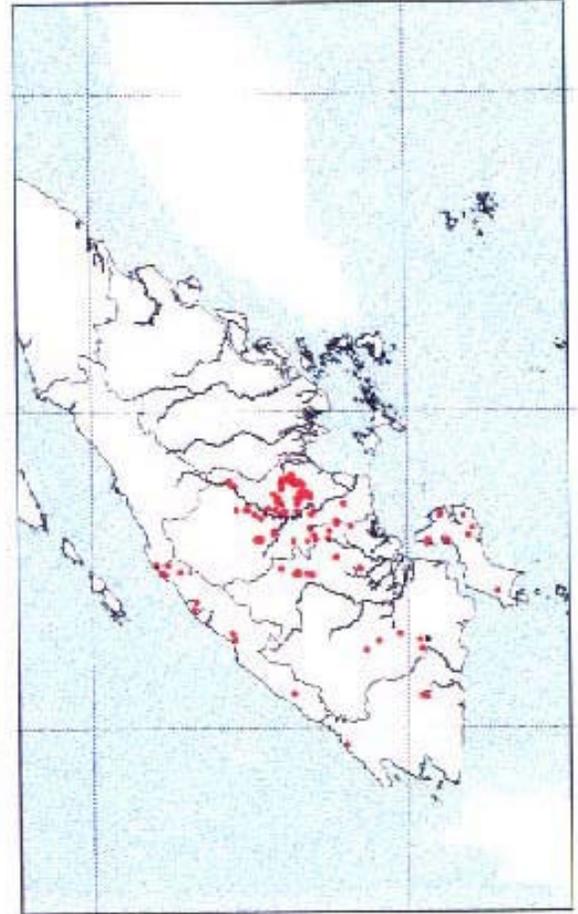
JANUARY 1998



FEBRUARY 1998



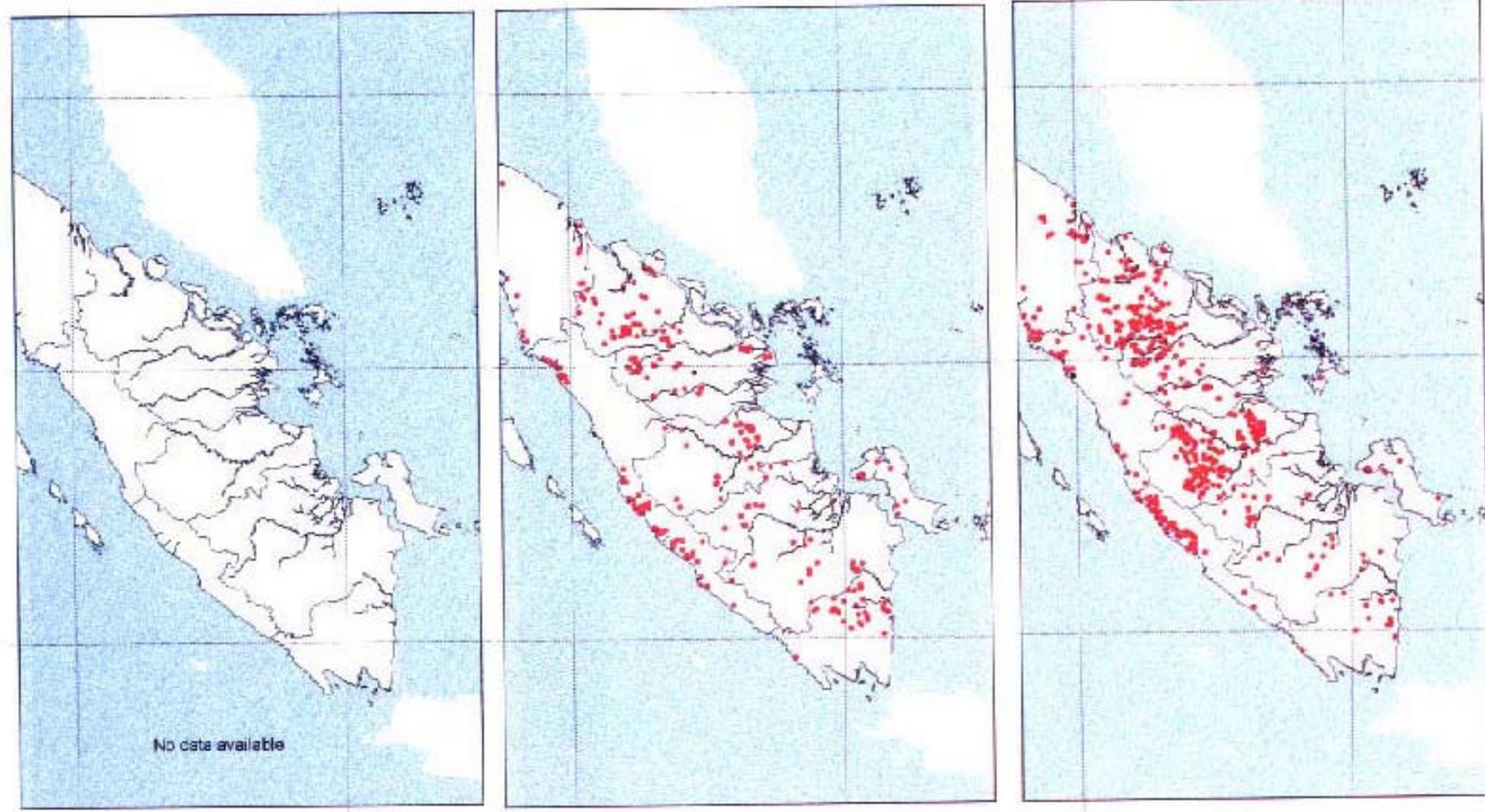
MARCH 1998



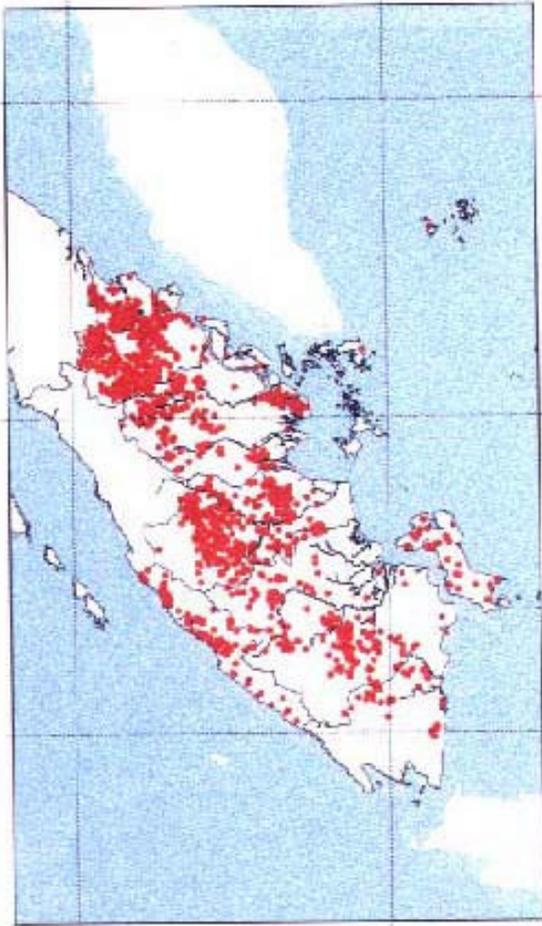
APRIL 1996

MAY 1996

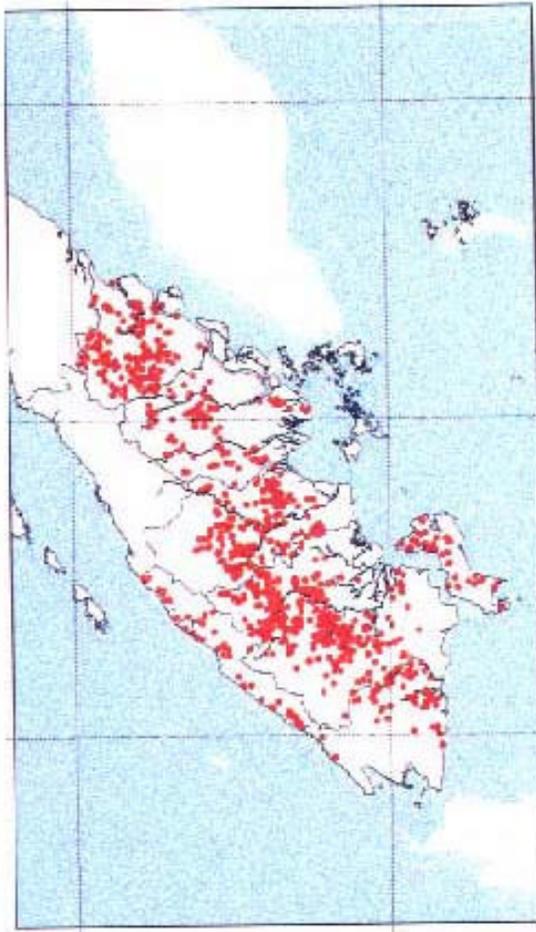
JUNE 1996



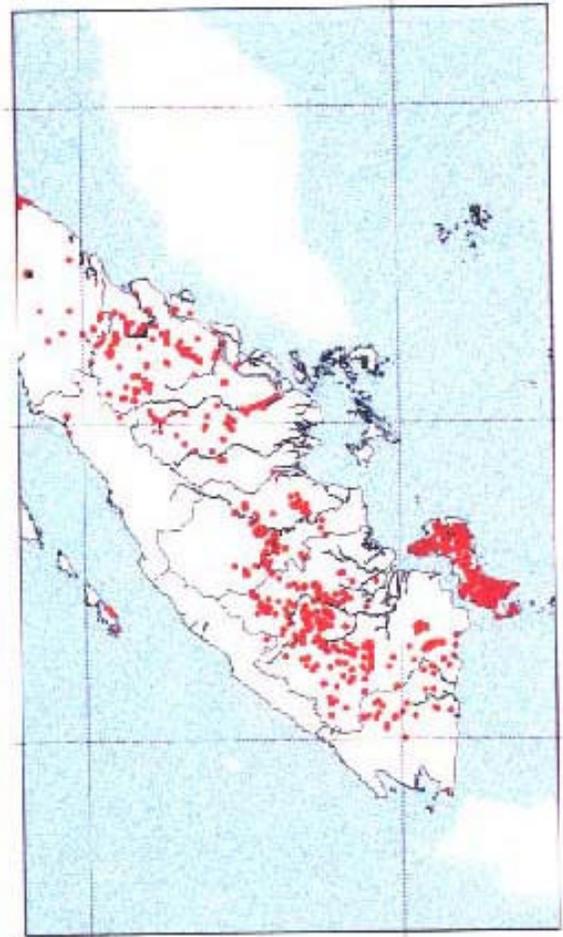
JULY 1996



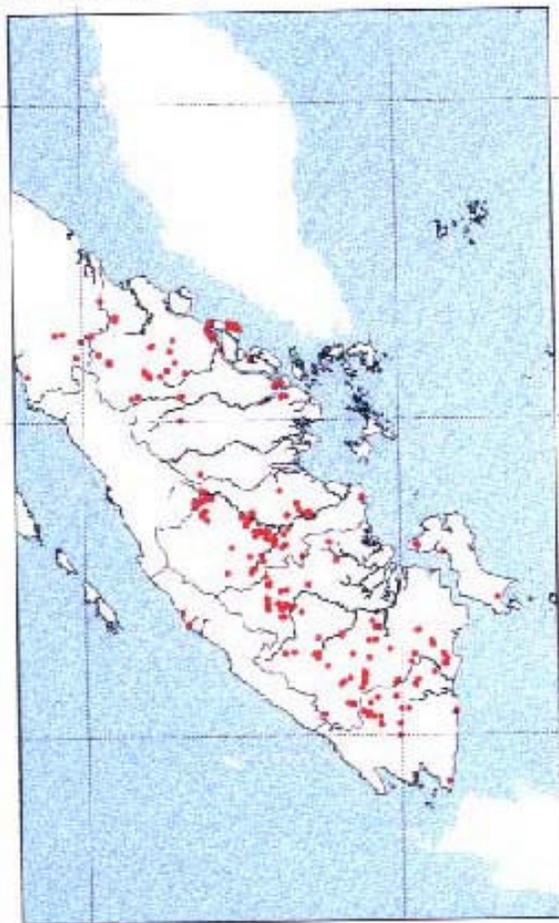
AUGUST 1996



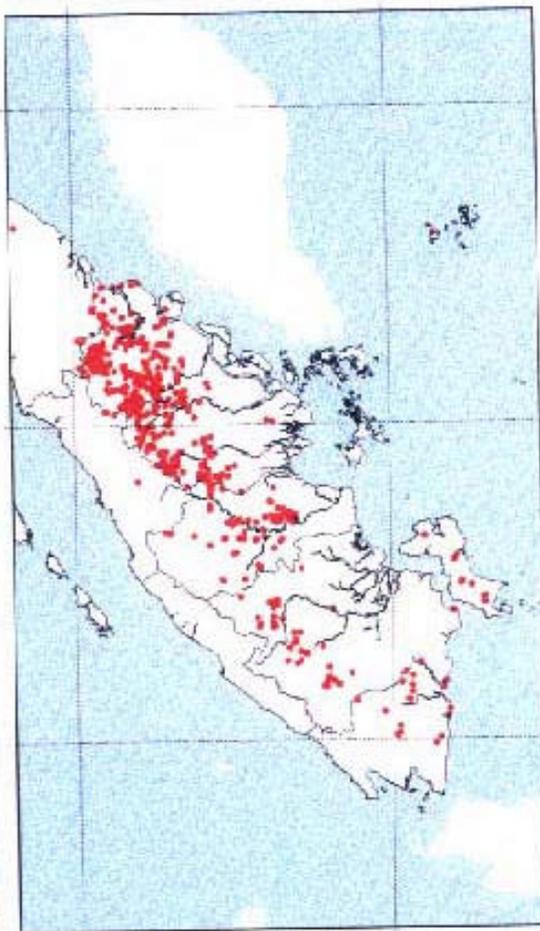
SEPTEMBER 1996



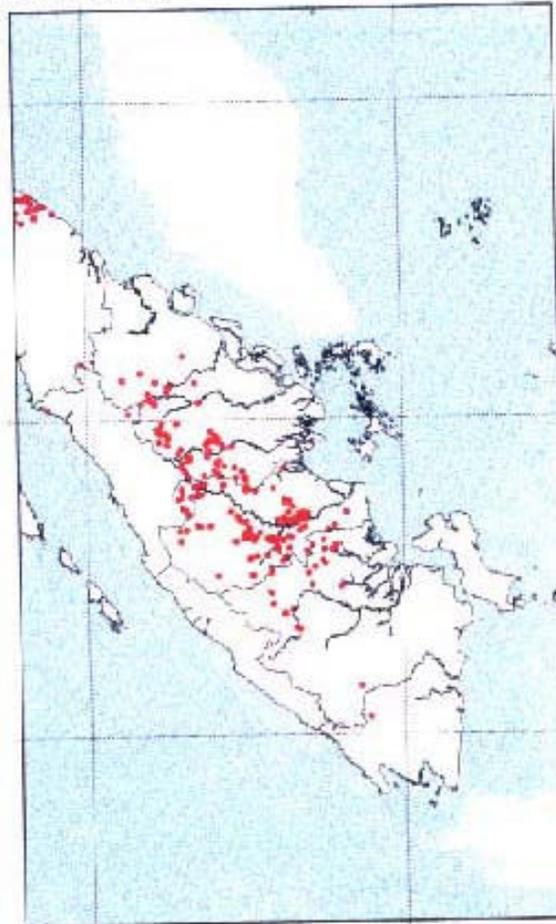
OCTOBER 1996



NOVEMBER 1996

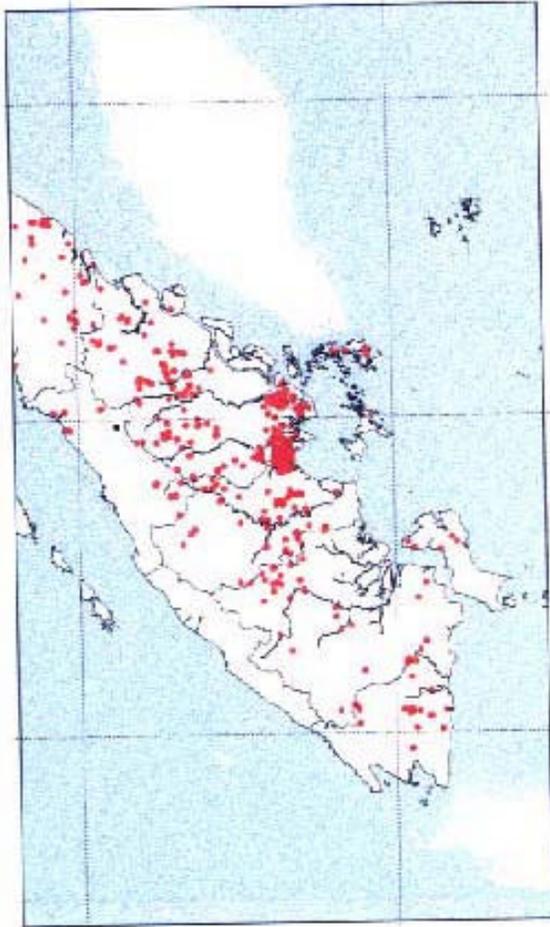


DECEMBER 1996

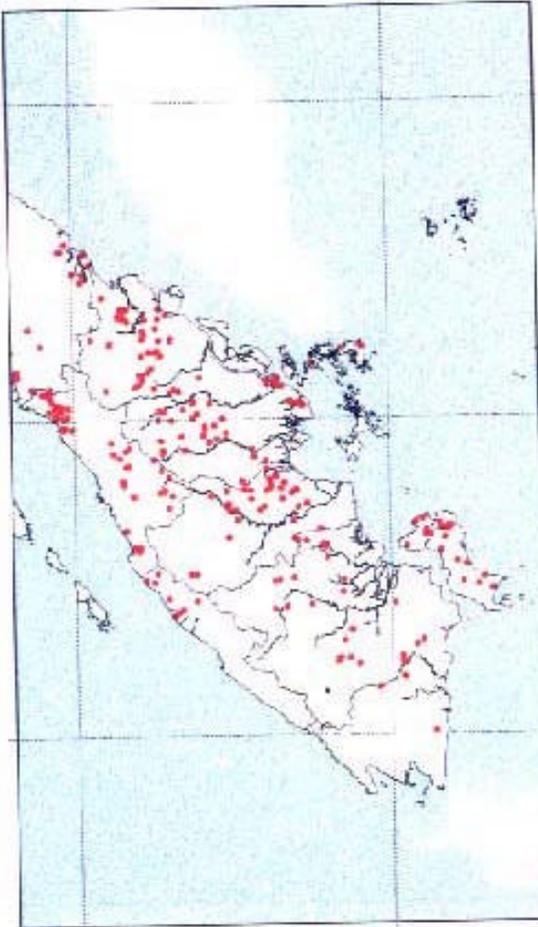


MONTHLY FIRE MAPS

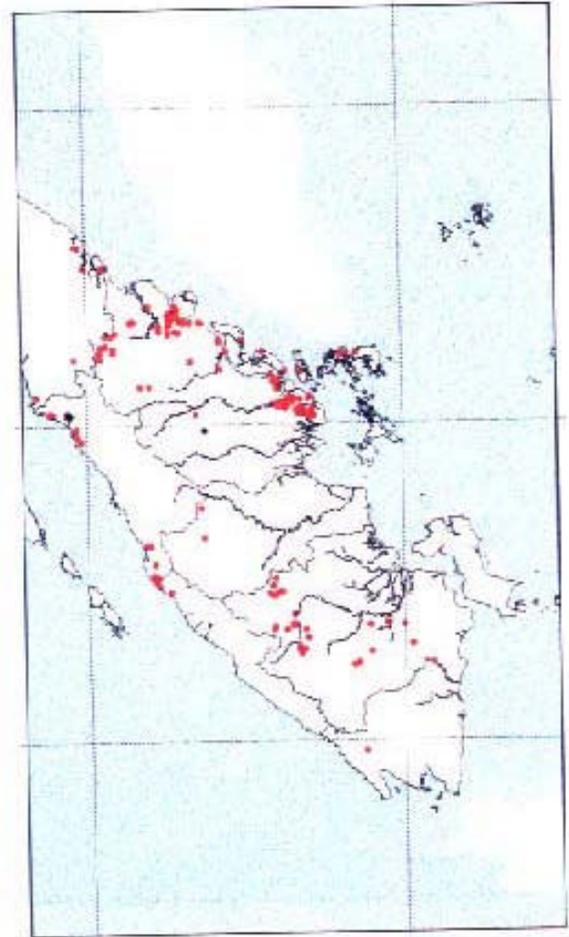
JAN. JARY 1997



FEBRUARY 1997



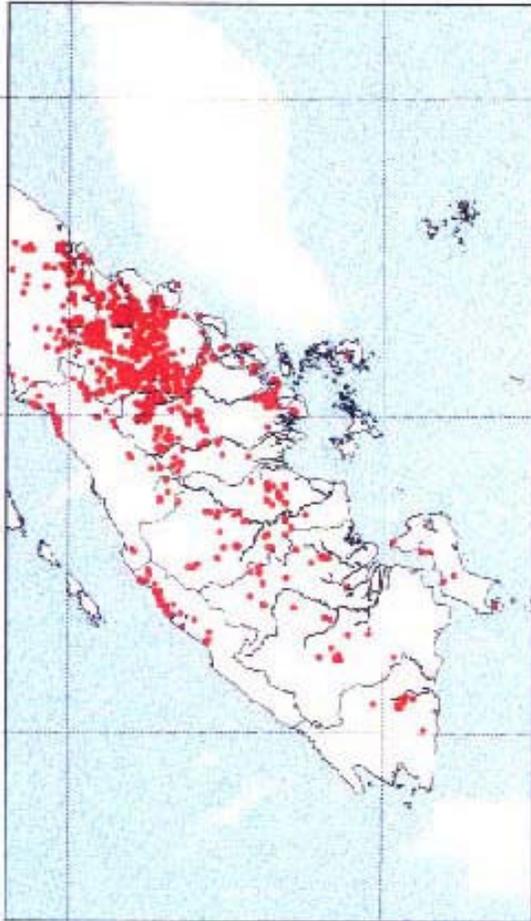
MARCH 1997



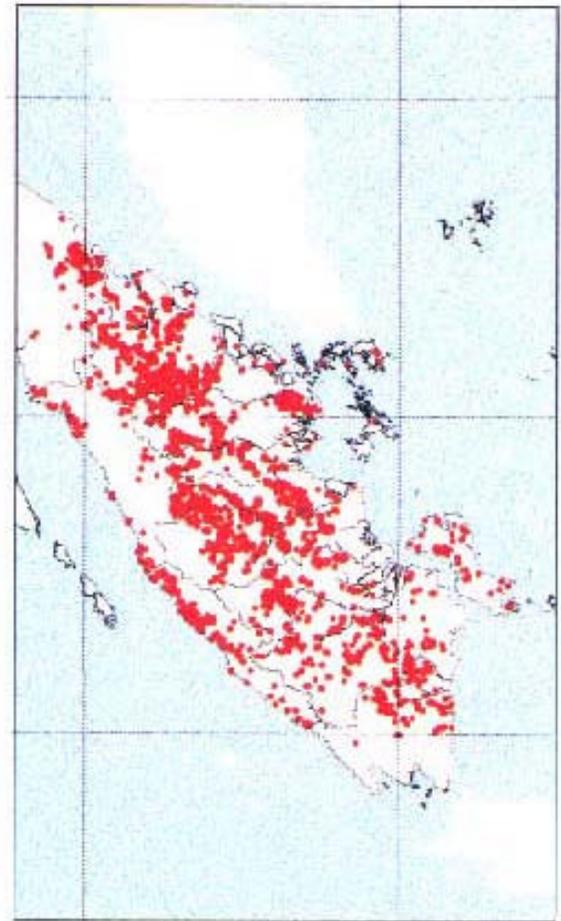
APRIL 1997



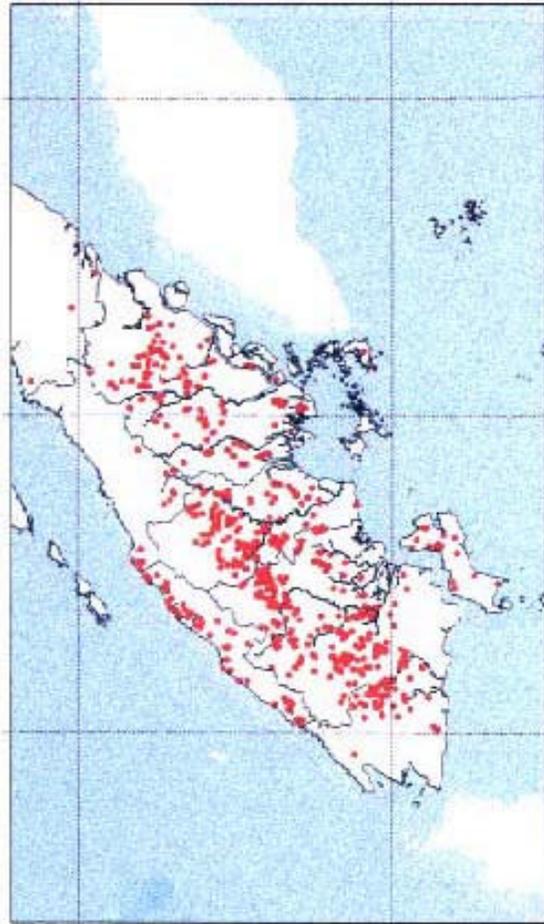
MAY 1997



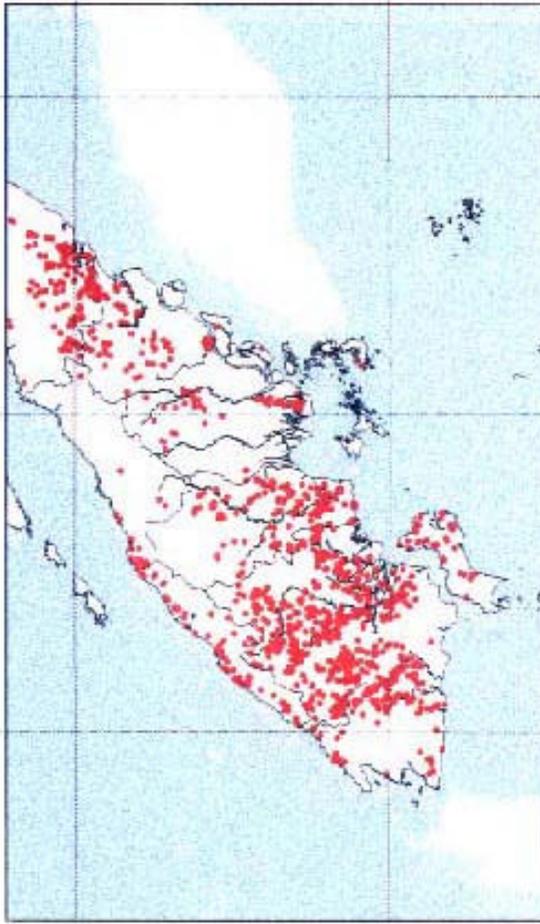
JUNE 1997



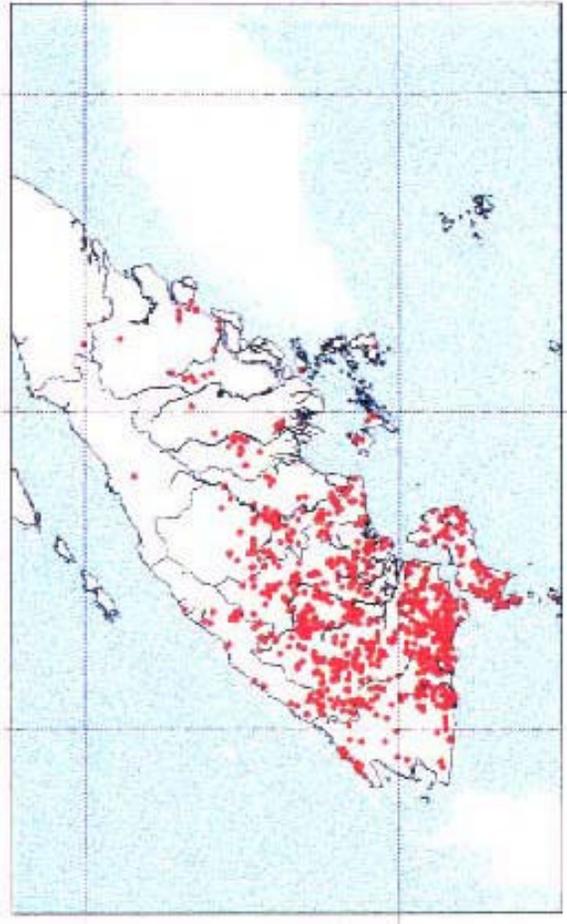
JULY 1997



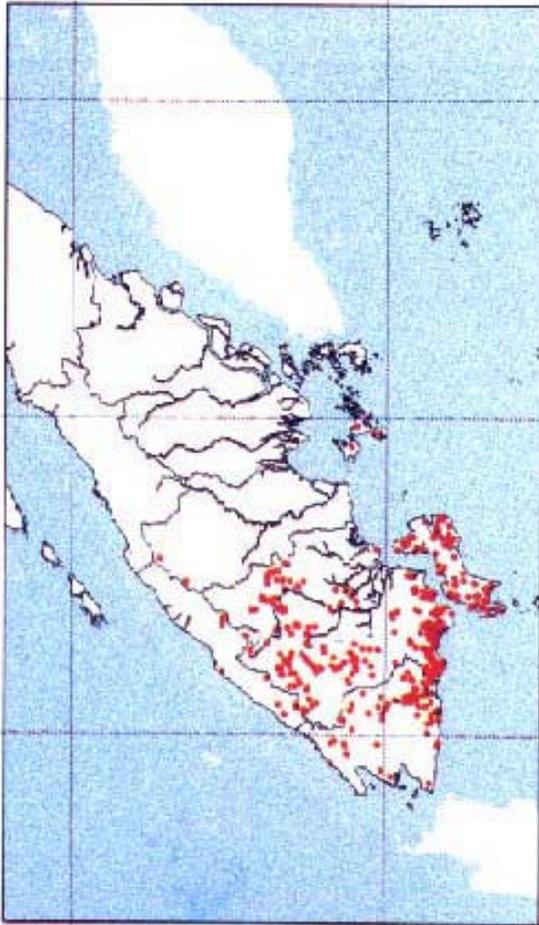
AUGUST 1997



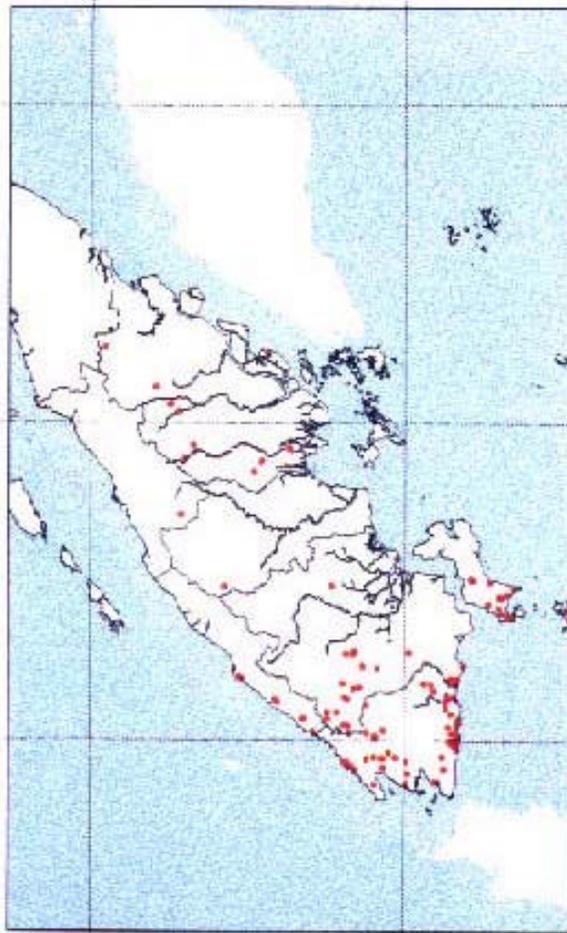
SEPTEMBER 1997



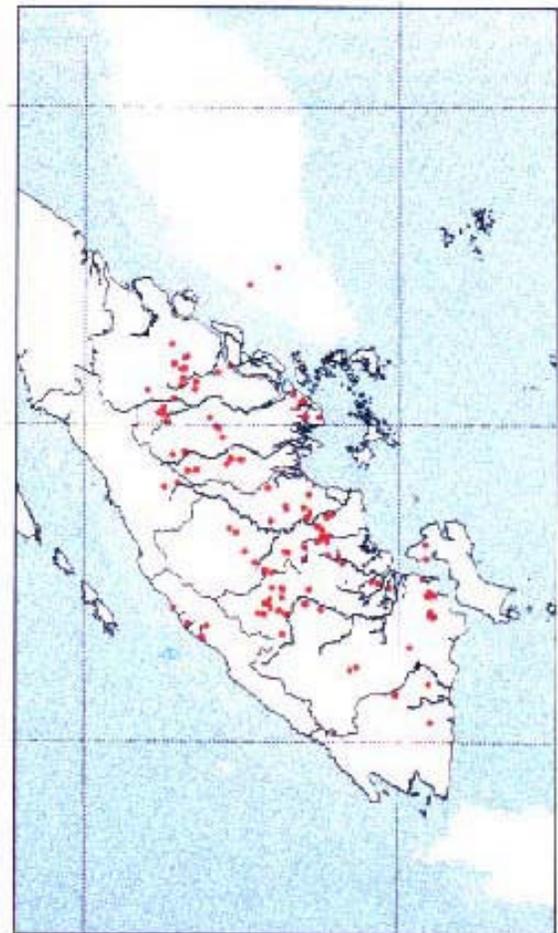
OCTOBER 1997



NOVEMBER 1997

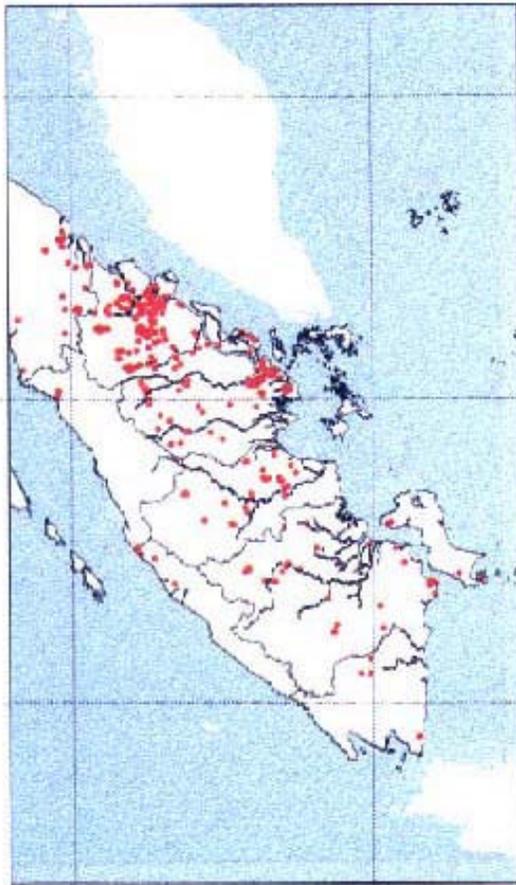


DECEMBER 1997

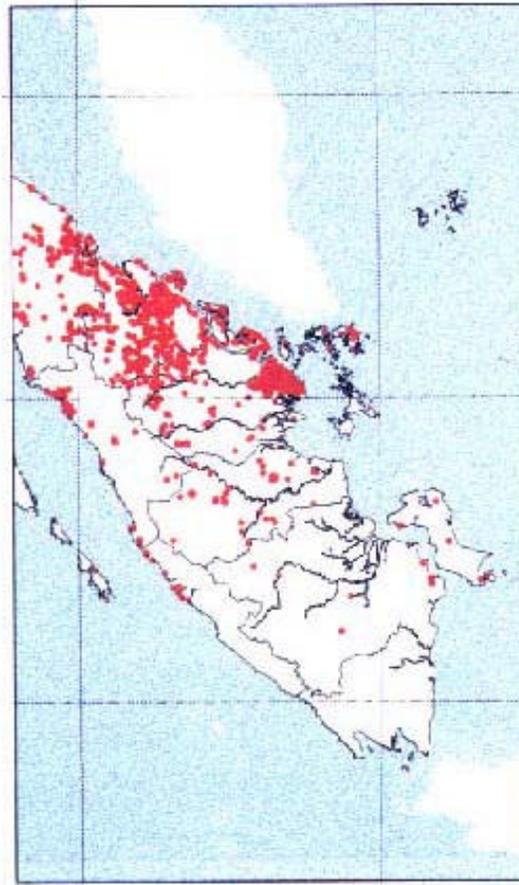


MONTHLY FIRE MAPS

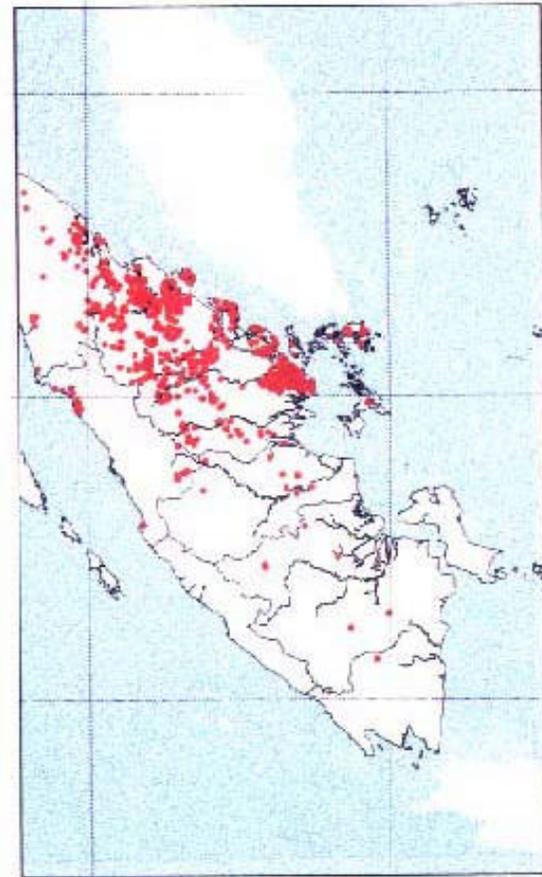
JANUARY 1998



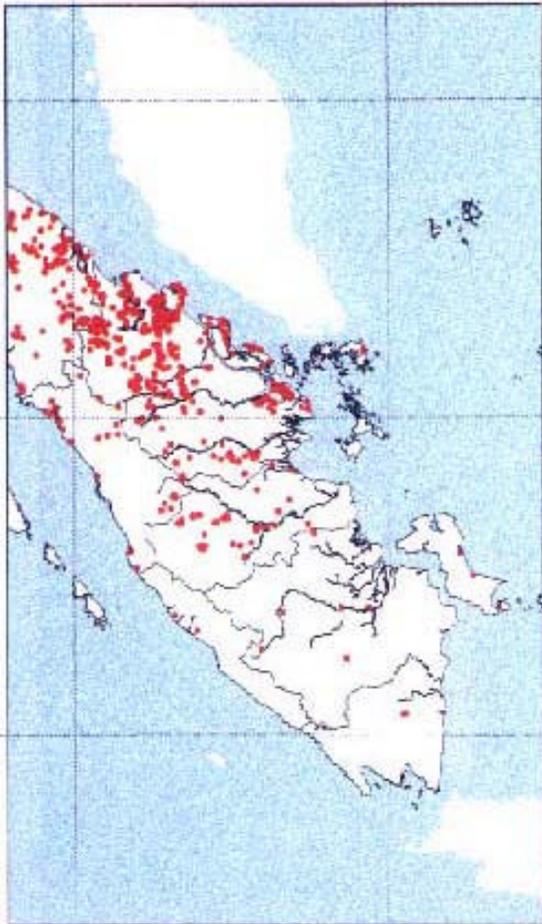
FEBRUARY 1998



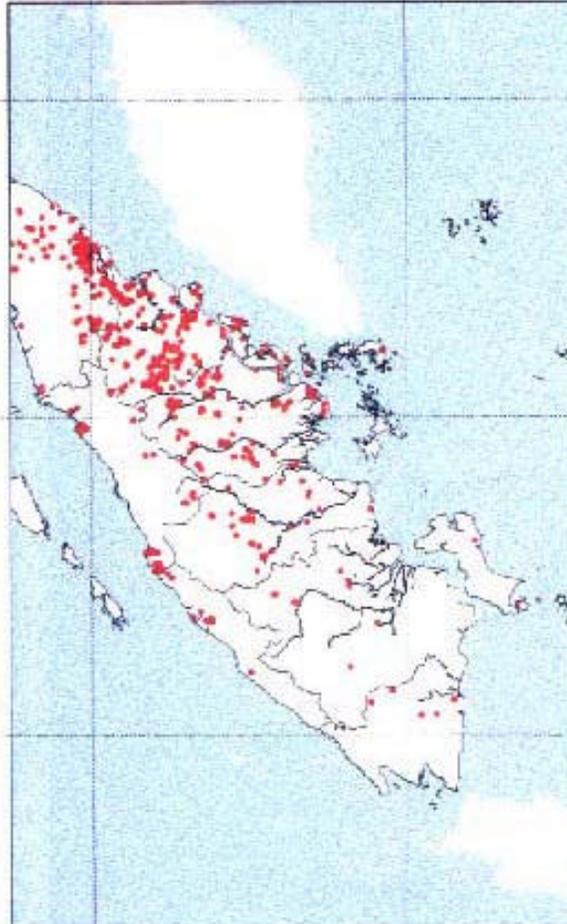
MARCH 1998



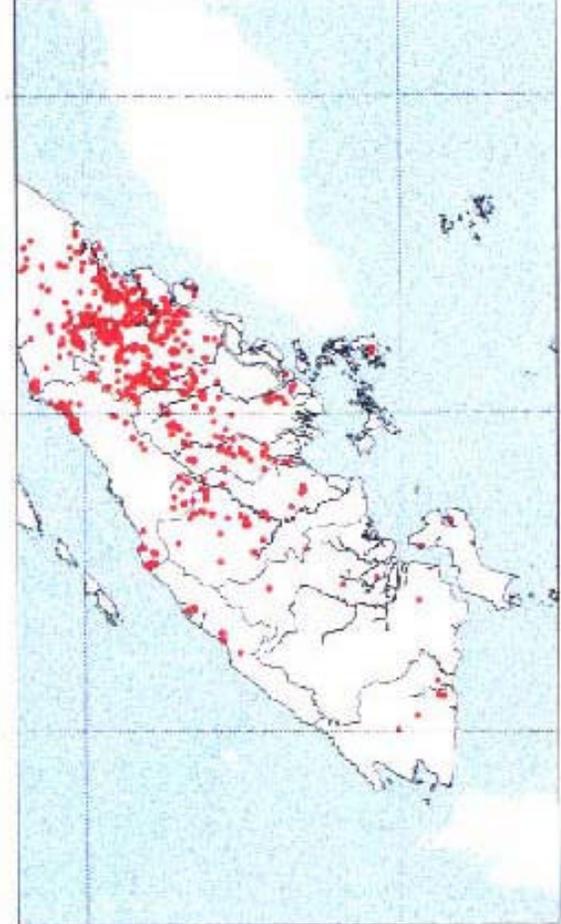
APRIL 1998



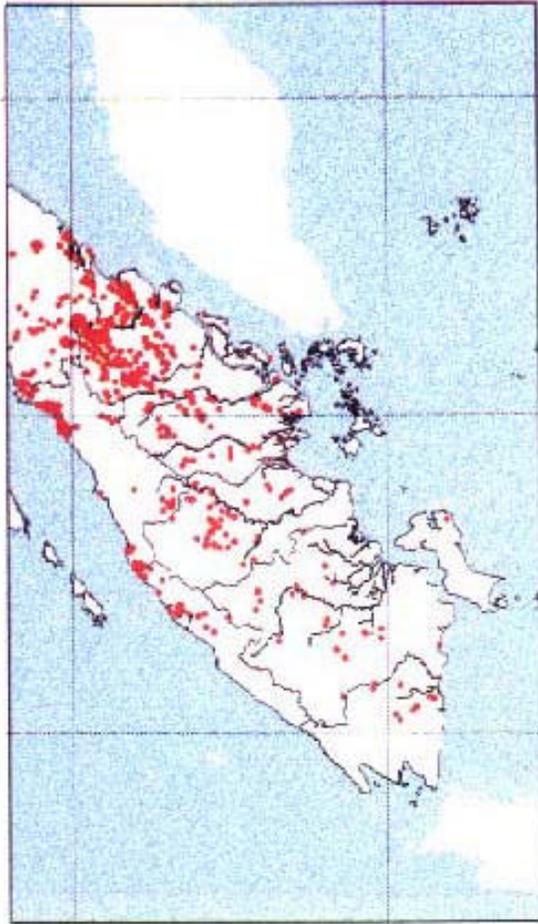
MAY 1998



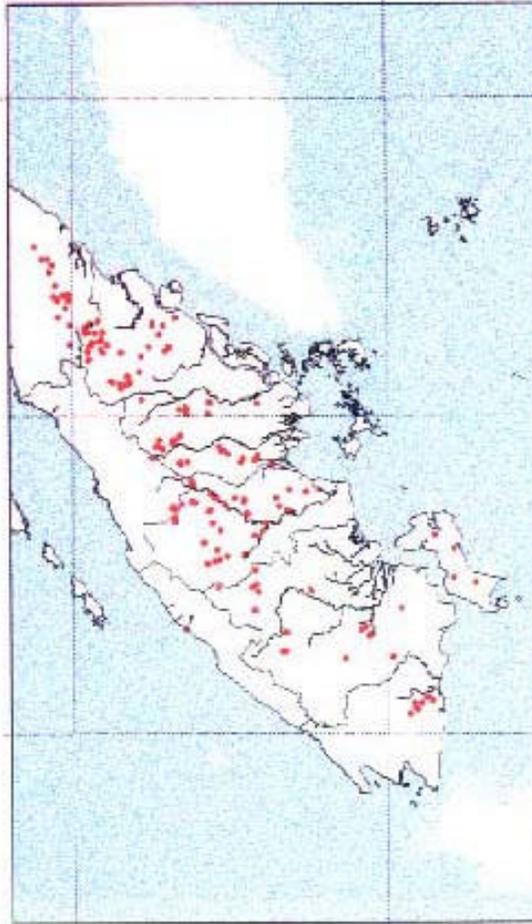
JUNE 1998



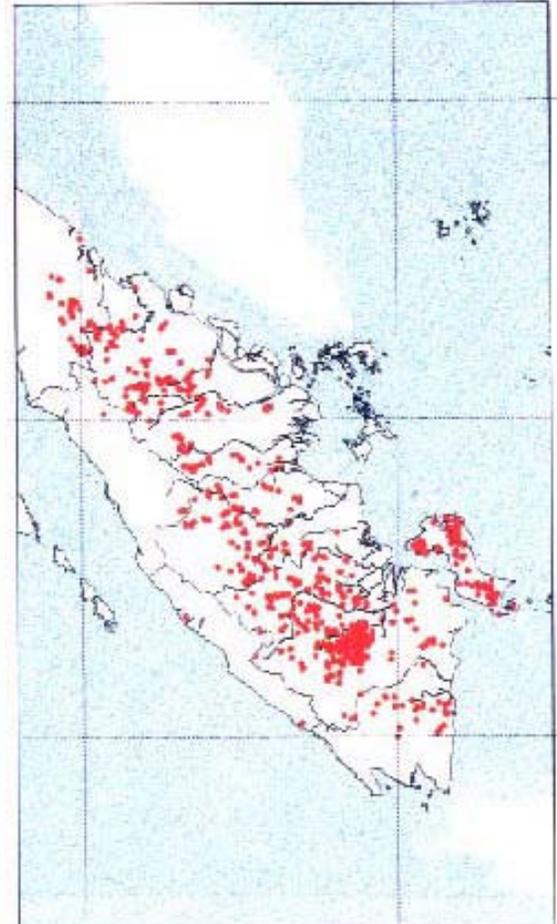
JULY 1998



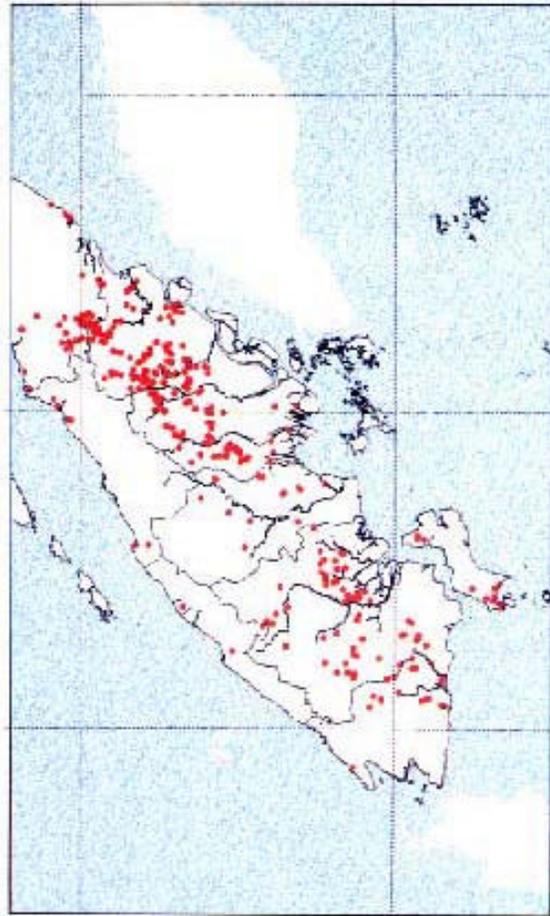
AUGUST 1998



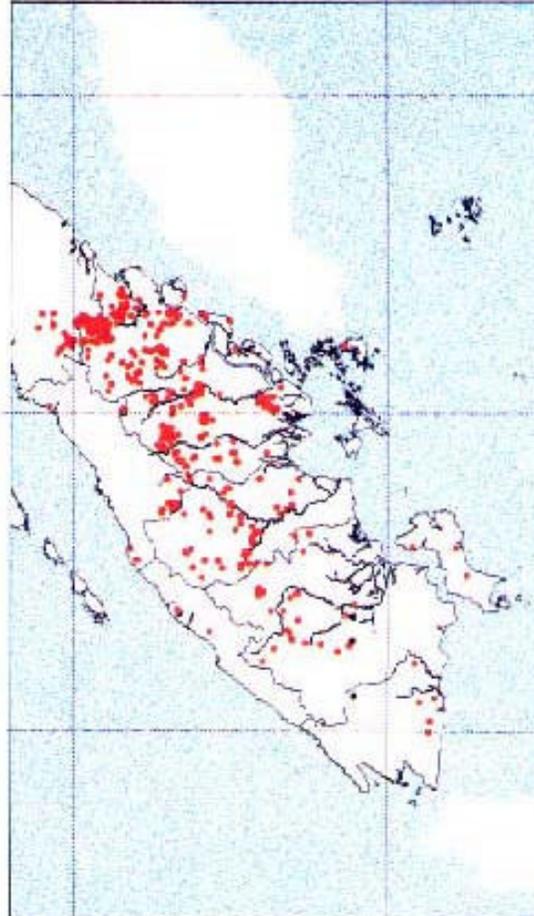
SEPTEMBER 1998



OCTOBER 1998



NOVEMBER 1998



DECEMBER 1998

