The Underlying Causes and Impacts of Fires in South-east Asia

Site 2. Menggala, Lampung Province, Indonesia

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Site Report

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by

S. Suyanto[1], Rona Dennis[2], Yayat Ruchiat[1], Iwan Kurniawan[1], Fred Stolle[1], Paul Maus[3] and Grahame Applegate[2]

[1] International Centre for Research in Agroforestry (ICRAF)
[2] Center for International Forestry Research (CIFOR)
[3] United States Forest Service

Map design: Rizki Pandu Permana[1] and Danan Prasetyo Hadi[1]
Copy editing: Erik Meijaard[2]

Corresponding author and contact address:
Grahame Applegate
Center for International Forest Research (CIFOR)
PO Box 6596 JKPWB
10065 Jakarta
Indonesia

Cover photo: Fire in the Industrial Timber Plantation, photo by Yayat Ruchiat

Table of Contents

FIGURES:

TABLES:

ABBREVIATIONS AND TERMS

Adat rights	Traditional ownership or use rights recognized by local law
GIS	Geographic Information System
ha	hectare
km	kilometer
Lahan Satu	The transmigration land that is first cultivated to produce subsistence food and income for the family
Lahan Dua	The secondary transmigration land supposed to provide an income beyond subsistence
Landsat MSS	Landsat Multispectural Scanner. An imaging system found on the first five Landsat satellites. The system collects multispectral data in four non-thermal radiation bands with a spatial resolution of 79 x 79m.
Landsat TM	Landsat Thematic Mapper. A multispectral scanner imaging system on board the Landsat 4,5 and 7 satellites. The imaging system collects multispectral data in seven bands. The six non-thermal band shave a spatial resolution of 30 x 30m, whereas the thermal band has a spatial resolution of 120 x 120m. The temporal resolution is 16 days.
m	meters
sonor	Traditional swamp rice cultivation techniques, relying on the uncontrolled burning of swamps during droughts.

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SUMMARY

Within the framework of the CIFOR/ICRAF/USFS project on underlying causes and impacts of fires in South-east Asia, 8 sites were studied in detail by linking spatial data with socio-economic background information, to provide a solid basis for scientific study of the cause of vegetation fires. This report provides an analysis of causes of vegetation fires in the Menggala area, Lampung Province, Sumatra, Indonesia. The 150,000 ha study area was divided into ecologically different units, i.e. the peneplains and the coastal swamps. The former area is mostly used by large forest plantations and small-scale farming, while land-use in the latter, much wetter area is mostly restricted to swamp rice farming, both by the indigenous inhabitants of the area, spontaneous migrants, and transmigrants as well as plantations. In the peneplains, the four main causes of fire are: land tenure conflicts between local communities and large plantations, the large-scale clearing required for plantation development, the lack of a transparent legal system to address land claims, land 'ownership', and communal rights, and a lack of fire management facilities in plantations. In the coastal swamps area, fire is used as a tool in "traditional" swamp rice cultivation, and as more people become involved with this type of land-clearing the pressure on regenerating swamps increases. Burning on plantation land in the swamp area was also found, but underlying causes could not yet be established. Based on the cause analysis, possible implications for policy changes are discussed.

1. INTRODUCTION

Large-scale fires and associated smoke are an increasing problem in Indonesia and surrounding countries. For instance, major fires occurring in the El Niño years 1982/1983, 1987, 1991, 1994, and 1997/1998 (Dennis, 1999) devastated large areas of forest and caused significant economic losses, both in Indonesia where most fires occurred and in neighboring countries. The economic costs of the 1997/1998 fires in Indonesia have been estimated to exceed 9 billion USD with carbon emissions high enough to elevate Indonesia to one of the largest polluters in the world (ADB and BAPPENAS, 1999; Barber and Schweithelm, 2000). The major causes of these fires are, however, still unclear. Many have blamed small-scale farmers and large-scale estates for causing fires, suggesting that these actors deliberately set fires to forest to open up land for plantations or agriculture. In 1994, the Indonesian government blamed slash-and-burn activities by smallholders as the major cause of fire, and they estimated that these people accounted for more than 90 % of the total area burned (Jakarta Post, 7 October 1994). Environmental NGOs, however, blamed activities by forest concessionaires and plantation owners as the major causes of fires. Taking advantage of data obtained from fire hot-spot information and satellite imagery, all institutions, including government agencies, believe that large-scale land clearing for plantations of fast growing trees for pulpwood and oil palm were the major causes of fire in 1997 and 1998. Yet, fires occurred at multiple scales and for many reasons, and impacts on local communities and forest had a variety of complex causes.

In this report, the Centre for International Forestry Research (CIFOR), the International Centre for Research in Agroforestry (ICRAF), and the United States Forest Service provide a study of the underlying causes and impacts of land and forest fires in Indonesia. The aim is to answer questions about the reasons (why), nature (what), perpetrators (who), and locations (where) that were associated with the fires. Several methods of information gathering were used, ranging from remote sensing imagery from satellites to in-depth field investigations at the landscape level. When used in combination, a more complete picture of the fires in general, and the 1997 fires in particular, can be developed. For example, images from satellites provide information on the location, extent, and the type of land cover burned. However, only through extensive interviews with local people combined with on-the-ground participatory mapping, can an answer be found to whom was

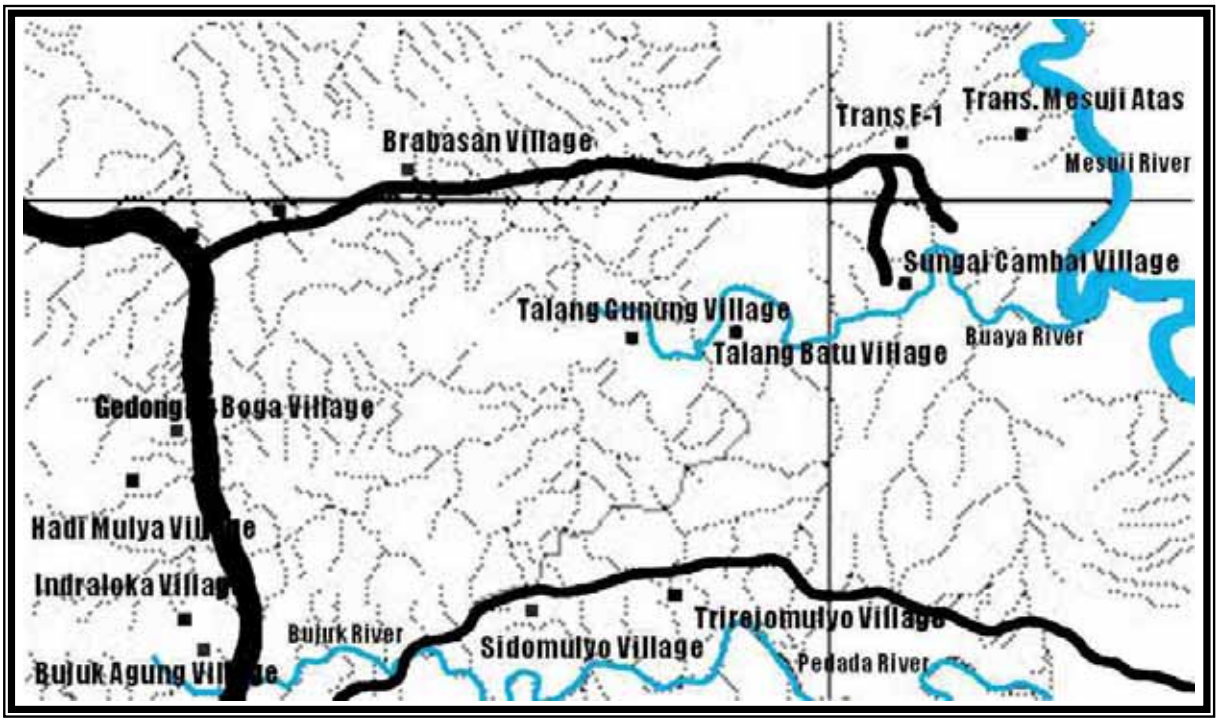
responsible for the fires and what were their underlying reasons. From the field investigations and the use of a Geographic Information System (GIS), a more accurate estimate of what burned can be determined at the landscape level. This study will apply three levels of spatial analysis: island-wide, province, and site. At the site-specific level, the study focuses on the relationship between fire, land tenure and land cover/use change. The Menggala site was chosen as it represents a coastal swamp forest and peneplains area that covers various land use/cover types including swamp forest, tree crop estates, smallholder agricultural land and transmigration settlement. The land tenure conflicts that arise here between farmers and forest/tree crop plantations provide an interesting case for the study of causes of land cover changes and fires.

2. SITE DESCRIPTION

For this study, the site of Menggala, located in the Tulang Bawang District, Lampung Province, was selected (Figure 2-1). The elevation of this site ranges from 0 to 50 m above sea level. Soils include alluvial, red/yellow podsols and swamp soils. Average monthly rainfall during the 1993-1995 dry seasons was 56 mm/month. However, average monthly rainfall between 1994 and 1997 was only 6 mm/month, as it included a very long drought (Agricultural Extension Office, Menggala, 1999).

Based on the ecological zones of Sumatra, our study site was divided into two parts: an eastern one, classified as the coastal swamps, and a western one classified as the peneplains area. The total area of the coastal swamps study site is 80,000 ha, and the dimensions are approximately 28 km by 28 km. In the coastal swamp area, along the Way Buaya River (see Figure 2-2, sub site 1), lives a local community of ethnic *Mesuji*. *Mesuji* people originally came from South Sumatra and have lived in this site since the early 1900s (Sevin, 1989). The major farming system is called *sonor*. *Sonor* is a system of traditional rice shifting cultivation, which is only practiced during drought periods, which would suggest that activities of the *sonor* system significantly contribute to fire problem in this area. Close to the *Mesuji* villages, in the eastern part of the coastal swamps, the government established around 15 villages in the swamp areas between 1993 and 1999 (sub-site 2) (see section 4.1.1.2).

Level I. Lampung/ TM Wide



Level 2. Menggala Site Landscape

Figure 2-1 Location of study site

The peneplains area totals 71,200 ha and is 27 km by 28 km in size. The peneplains lie in the western part of Menggala (sub-site 3) and contain the industrial timber plantation of PT Silva Inhutani Lampung (PT SIL) that was established in 1989. PT SIL controls 43,000 ha of land and has planted three main tree species: rubber (*Hevea brasiliensis*), acacia (*Acacia mangium*) and albizia (*Paraserianthes falcataria*). In the western and southern part of the PT SIL timber plantation, live the original people of the area, called the *Menggala* people. Like other local Lampung people, the *Menggala* people established early settlements along a river, and made a living from shifting cultivation and fishing. In the central part of our study site (sub-site 4), the tree crop (coconut hybrid and oil palm) plantations of PT Bangun Nusa Indah Lampung (PT BNIL) are the dominant land-use. In this area, land tenure conflicts have arisen due to the political and social turmoil resulting from the fall of Indonesia's long-term President Suharto in 1997.

Transmigration settlements have been established in the peneplain site since the 1970s, and large areas in the Menggala site are allocated for transmigration use. Most of the transmigrants in this site engage in cassava and upland rice farming. In the northern part of our site about 11 settlements are located, that were established between 1983 and 1986. In the southern part of the site, around 16 transmigration settlements were established during 1985-1988. These transmigrants initially engaged in cassava farming and rice cultivation, but starting in 1994, some farmers planted oil palm under the Nucleus Estate and Smallholder Scheme or NES[1] system associated with PT BNIL.

[1] NES is a tree plantation development program relying on partnerships between large companies and local smallholders.

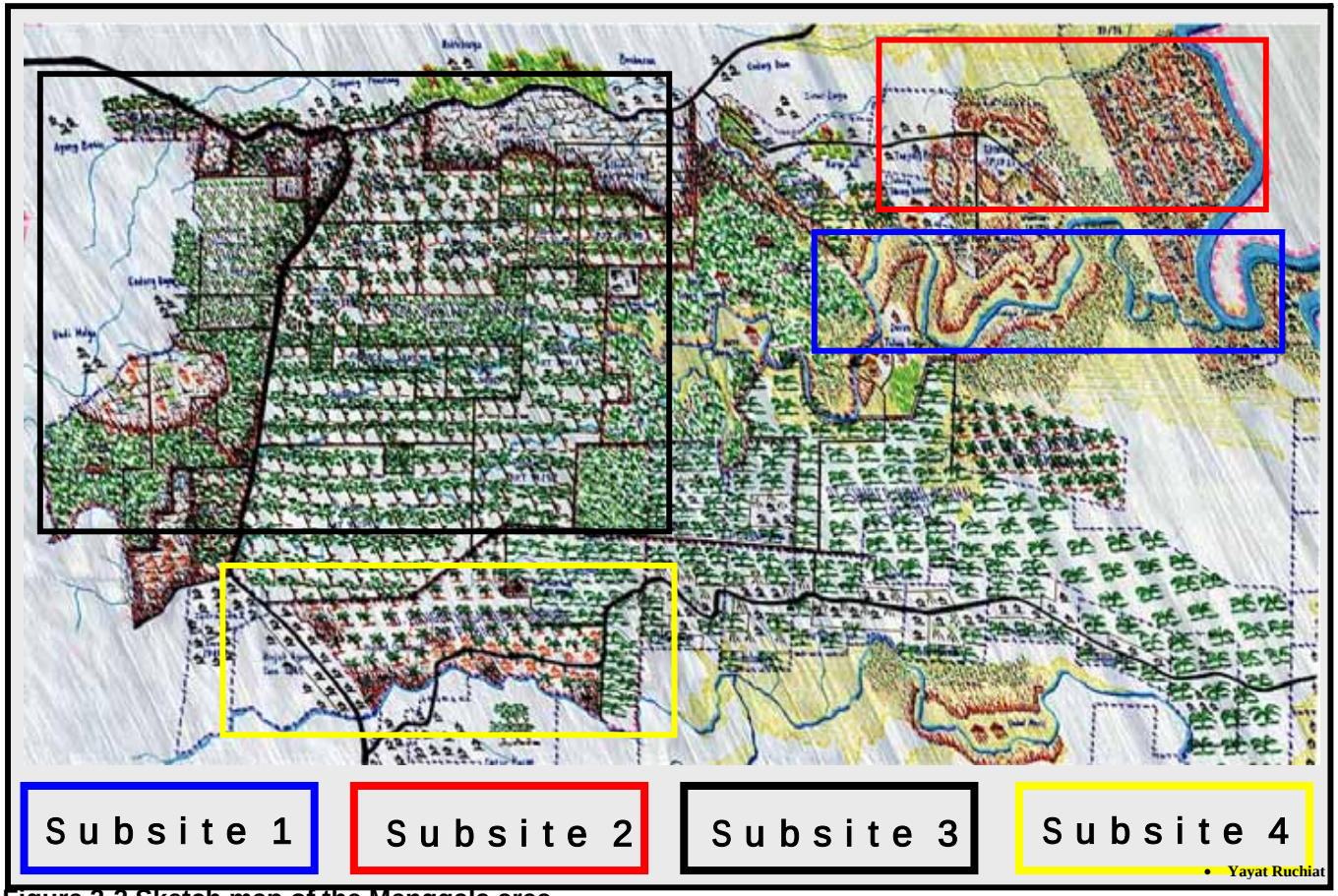


Figure 2-2 Sketch map of the Menggala area

3. METHODOLOGY

3.1 Socio-economic study methods

Sketch mapping at the landscape level and rapid rural appraisals were conducted between August and November 1999. As a basis for the sketch maps, existing administrative and land use maps were used. Subsequently, managers of timber and oil palm plantations, community leaders, and local government officers were interviewed, and several field visits for additional information were made. Information obtained through interviews included the history of the plantations and villages, the history of land clearing and planting, land clearing techniques, fire history, demography, land use, agricultural activities, and land tenure conflicts. The information provided through these interviews was added onto the existing base maps, and checked during the field visits.

3.2 Remote Sensing and GIS

3.2.1 Site-wide methodology

Through remote sensing and Geographic Information System (GIS) activities, the historic and current patterns of land cover and land use change were analyzed. The selection of satellite imagery for the Menggala site was somewhat complicated by the fact that it fell on the boundary between two Landsat image scenes. Therefore, to cover the site, two scenes were required both of which could be from different dates. It proved difficult to obtain similar dates for both scenes. The only complete coverage obtained was for 1984 and 1999, where the shift of scene boundaries enabled the study site to fall completely within one scene. For the western part of the peneplains area only, imagery was available for more dates, 1984, 1986, 1994 and 1999. Table 3-1 gives details of the imagery used.

Date	Sensor	Scene (path/row)	Used for
17 March 1984	Landsat MSS	124/63	Peneplains/Swamps
26 June 1986	Landsat MSS	124/63	Peneplains (west)
26 June 1992	Landsat TM	124/63	Peneplains (west)
31 May 1994	Landsat TM	124/63	Peneplains (west)
3 September 1999	Landsat TM7	123/63	Peneplains/Swamps

Table 3-1. Imagery used for the Menggala site

The imagery was of variable quality (see Figure 3-1). The Landsat MSS image for 1984, which covered both the peneplains and coastal swamp areas, was covered in places by patchy cloud making interpretation difficult. The June 1986 Landsat MSS was of good quality but only covered the western part of the peneplains area. The next image in the time sequence, Landsat TM June 1992, was also of good quality and showed a large active fire, unfortunately this image only covered the western portion of the peneplains area. The May 1994 Landsat TM was also of good quality with some scattered cloud, but again, only covered the western peneplains. The most recent image in the sequence is dated 3 September 1999, and came from the new Landsat 7 satellite. This image covered the entire site but was cloudy in the coastal swamps area.

Once the imagery was selected for classification it was geo-referenced using 1:50,000 topographic base maps. The 1999 Landsat TM was used as the base for geo-referencing and the remaining images were co-registered to it. Prior to classification, all images were spectrally enhanced and various band combinations were assessed. For Landsat MSS a 4,3,1-band combination was preferred and for Landsat TM, bands 4,5,7 were preferred as it highlighted vegetation as well as recent burn scars.

The next stage in the process was classification of the imagery in land cover classes. On-screen digitizing was the selected digitizing method. The 1999 image was the first to be classified and the result was then used as a template for identifying the changes in the 1984 image. For the western part of the peneplains area, the 1986 and 1994 images were also classified.

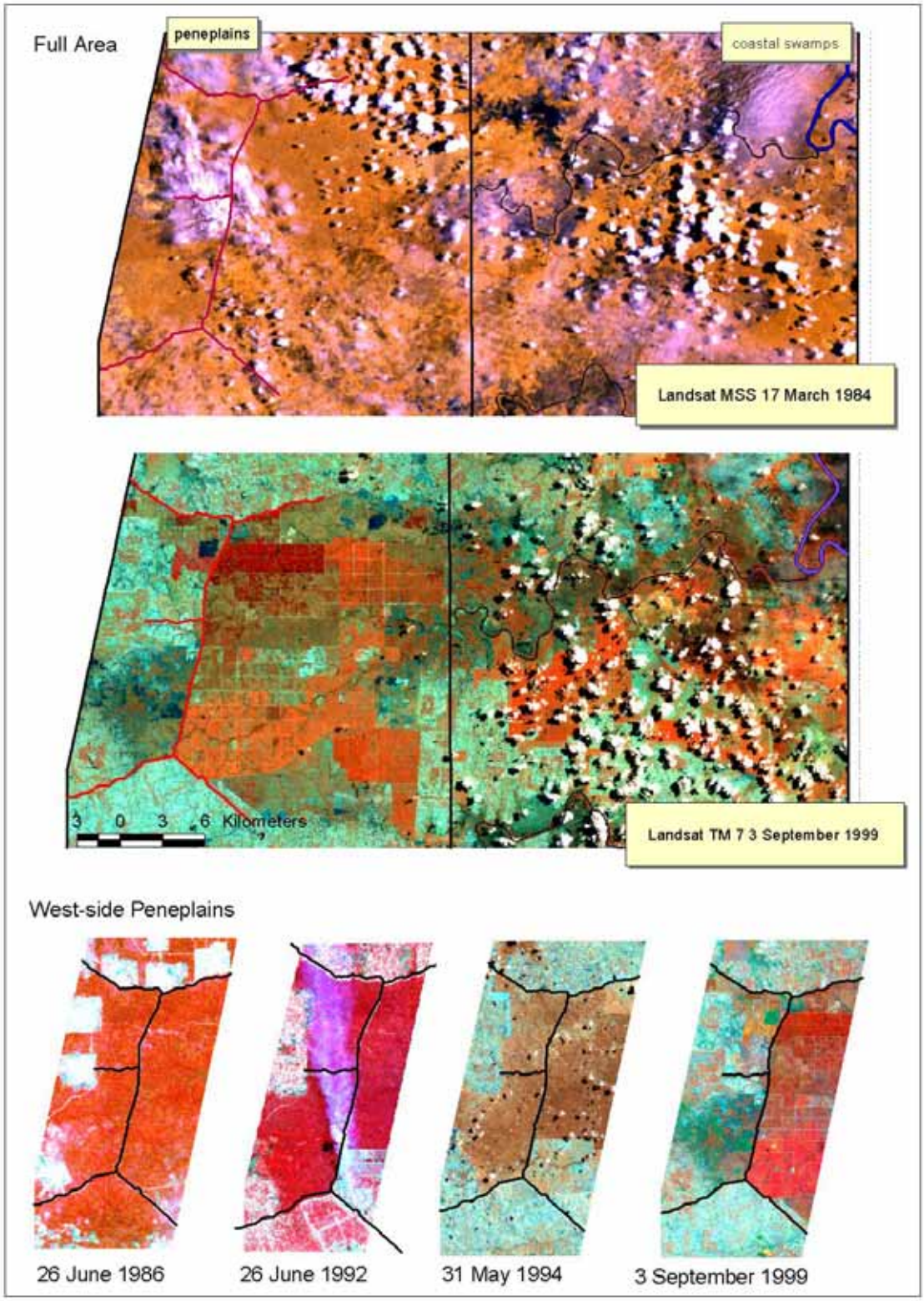


Figure 3-1 Satellite imagery used in the Menggala study site

3.2.2 Derivation of fire hot spots

Hot-spots data from NOAA-AVHRR imagery were available from various sources and covered 13 periods between 1992 to 1999 (for more detail refer to Appendix I). Hot-spots in the Menggala area were overlaid onto 1999 Landsat TM imagery to establish the relationship between land-use and fire.

3.3 Integration of Social Science and Remote Sensing

In order to improve the analysis of underlying causes of fire, a methodology was developed that integrates some of the results of the socio-economic research with the results of the remote sensing-based change analysis. A GIS was used for this integration. Not all outputs from the socio-economic research are compatible with a GIS and from site to site, the types of outputs are likely to vary slightly. For the Menggala site, the focus was on integrating local people's narratives and sketch maps with land cover change maps and burn scar maps. Using the functionality of the GIS, it was possible to calculate the types and size of land cover changes. In addition, local people's narrative could be added to the land cover change results to provide an insight into how and why these changes occurred. For the 1997 fires, sketch maps were overlaid with the burn scar maps and compared to provide both a quantitative and qualitative assessment of the fires.

4. RESULTS

4.1 Fires

Information from the socio-economic survey suggested the following three causes of burning in the Menggala study site:

1. Activities associated with traditional rice cultivation by local *Mesuji* people,
2. Agricultural activities by transmigrants
3. Land tenure conflicts between local people and large companies
4. Land clearing activities by plantations

The backgrounds to these three causes are described in detail below.

4.1.1 Coastal Swamps

4.1.1.1 Fire as a tool in 'traditional' land management

A large fire occurred in the swamp area near the *Mesuji* community in 1997/1998, and during the socio-economic survey in 1999, an attempt was made to understand the relationship between these fires and the local land management techniques. The *Mesuji* people live along the river, where they mainly practice traditional rice cultivation called *sonor*. Furthermore, they extract *gelam* trees (*Melaleuca* sp.) from the swamp forest for house construction. Under the *sonor* system, farmers only plant rice during after a considerable drought, usually associated with an El Niño event. A 5 to 6 months dry period is required to be able to burn swamp forest for planting rice. Usually, *Mesuji* people burn the swamp in September or October. They burn as much swamp forest as they can, and make no effort to control escaping fires. The desirable characteristic of such *sonor* systems is their extremely low labor demand. Farmers just leave the fields after planting rice and return to them after 6 months for harvesting. Then, they fallow the field for 3 to 4 years (depending on the dry season cycles). During the fallow period, the swamp forests regenerate and *gelam* trees become the dominant species again (see Figure 4-1).

Figure 4-1 Regeneration of swamp forest after rice cultivation (*sonor*)

Mesuji people came from South Sumatra to Lampung in the early 1900s, where they already practiced *sonor* cultivation. Over the last 10 years, farmers practiced the *sonor* system in the very dry years of 1987, 1991, 1994 and 1997. These years coincided with the El Niño phenomenon. According to the chief of the *Mesuji* people, thousands of hectares of swamp forest were burned and cultivated under the *sonor* system in 1997, with most households cultivating more than 5 ha.

Except for Umbul Talang Gunung, more than 70 % of the *Mesuji* village areas in sub site 1 is dominated by swamp soils (see Table 4-1). Farmers in Umbul Talang Gunung, which consists for 85 % of dry land (as opposed to swamp), claim around 5,700 ha land under traditional law. However, since 1990, an industrial timber concession (PT SIL) has claimed Umbul Talang Gunung's customary land. We will discuss the problem arising from these overlapping claims in section 4.3.1.

Sub-village/village	Total area	Percentages of land type [a)]	
	(ha)	Non-Swamp	Swamp
Umbul Talang Batu	600	25	75
Umbul Talang Gunung	5,700	85	15
Tebing Tinggi	2,600	30	70
Stajim	400	10	80
Sungai Cambai	3,000	4	96
Total	**12,300**	**48**	**51**

[a)] Information from farmers.

Table 4-1 Total land area of Mesuji sub-villages in 1999

The total swamp area of the five villages mentioned in Table 4-2 is around 6,300 ha. Not all swamp areas can be cultivated, however, as in some areas water levels remain too high even in drought years.

Sub-village/village	Total swamp	Estimation of sonor in 1997	
	areas (ha)	ha	%
Umbul Talang Batu	459	428	93
Umbul Talang Gunung	855	285	33
Tebing Tinggi	1,820	1,690	93
Stajim	320	300	94
Sungai Cambai	2,880	2,736	95
Total	**6,334**	**5,439**	**86**

Table 4-2 Estimation of *sonor* area in 1997

Community leaders were asked to estimate the percentage of swamp areas that could be planted by rice under the *sonor* system. Based on their estimation, and excepting Talang Gunung, more than 93 % of swamp can be cultivated. Therefore, it was estimated that in 1997, around 5,400 ha of swamp land was burned for rice cultivation under the *sonor* system (Table 4-2). On the average, in 1997, *Mesuji* people cultivated five ha of land per households, while recent immigrants cultivated two ha of land per households under the *sonor* system. Using these data, it was estimated that the *sonor* area in 1997 was 5,500 ha (Table 4-3). The result is consistent with the previous estimation.

Type of population	Number of households (HH)	Average sonor per HH (ha)	Total sonor area (ha)
Mesuji people	892	5	**4,460**
Recent Migrant	524	2	**1,048**
Total	**1,416**	**3.9**	**5,508**

Table 4-3 Average *sonor* area per household

One farmer who was interviewed said that he had cultivated 20 ha of *sonor* rice field in 1997. He only used labor of three family members for land preparation and it took them one month to prepare the fields. He said that land preparation is very easy and simple, and that they just burned the swamp, cut down the remaining vegetation and burned again to clean up the fields. Although land preparation required relatively little manpower, lack of labor for harvesting has been a problem. Therefore, many seasonal labor migrants from transmigration areas were asked to assist in the harvest, using a contract labor system. Landowners and laborer equally shared the harvest. This high reward for harvesting indicated a lack of labor supply in the area, and farmers said that in 1997, some rice field areas could not be harvested because of a lack of labor. Average yield per hectare under the *sonor* system is 4 metric tons of unhulled rice, which is almost double the yield of the non-*sonor* system farming.

4.1.1.2 Transmigration in coastal swamp areas

Close to the *Mesuji* villages, there are three transmigration settlements (F-SP1, F-SP2 and F-SP3) (see Figure 2-2, sub-site 2), which were established in 1993. Transmigrants are mostly Javanese who already lived in other parts of Lampung. These three settlements included 1,500 households and 6,297 people in 1993. In 1997, the population grew to 1,790 households (7,880 people). Each household received two ha of land, consisting of 0.25 ha for housing and home garden, 0.75 ha *Lahan Satu*[2] for upland food crops and one ha *Lahan Dua*[3] for multi-purpose crops. The Government carried out land clearing for *Lahan Satu*. However, farmers are responsible for clearing the *Lahan Dua* land.

[2] Lahan satu is the land first cultivated to produce subsistence food and income for the family
[3] Lahan dua is the secondary land to provide an income beyond subsistence

Table 4-4 shows the transmigration village area by type of land use. Each village has between 1,150 to 1,400 ha of land with the allocation for housing, home gardens and public services (around 16-17 %), *Lahan Satu* (around 26-33 %) and *Lahan Dua* (around 51-57 %).

Name of villages	**Total area (Ha)**	***Lahan Satu* (%)**	***Lahan Dua* (%)**	**Others (%)**
SP1-Ekamulya	1,300	29	55	16
SP2-Dwi Karya Mustika	1,150	33	51	16
SP3-Wonosari	1,400	26	57	17
Total	**3,850**	**29**	**54**	**17**

Table 4-4 Transmigration area by type of land

In 1994, along with the rice cultivation under the *sonor* system, transmigrants started to plant rice in *Lahan Satu*. Transmigrants used fire to burn small shrubs. At that time, it was easy to burn swamp because of very dry conditions. In 1994, the total burnt areas for *sonor* in these three villages was 1,118 ha in 1994 (See Table 4-5). They planted a high yielding rice variety (IR64) and applied fertilizer. They harvested rice before the water level rose. Since most areas of *Lahan Satu* were located in drier land, farmers could continue to plant upland rice in the following years.

Lahan Dua areas contain wetter and more swampy soils than *Lahan Satu* areas. Thus, it was more difficult to clear and to cultivate this land. The only opportunity to cultivate this land was to follow a *sonor* system (see section 4.1.1.1). In 1997, along with the rice cultivation under the *sonor* system, transmigrants began to cultivate *Lahan Dua* land. They did not, however, completely follow the steps of a traditional *sonor* system. They preferred to apply a non-tillage system using a high yielding rice variety (IR 64) rather than a traditional variety. Transmigrants do not like the traditional varieties because these do not taste as good according to them.

Names of villages	1994				1997			
	Total *sonor* (ha)	**Cult. Lahan Satu (L1) (%)**	**Cult. Lahan Dua (L2) (%)**	**Total cultivated land (L1+L2) (%)**	**Total *sonor* (ha)**	**Cult. Lahan Satu (L1) (%)**	**Cult. Lahan Dua (L2) (%)**	**Total cultivated land (L1+L2) (%)**
SP1-Eka Mulya	375	100	0	35	588	100	30	54
SP2-Dwi Karya Mustika	375	100	0	39	934	100	95	97
SP3-Wonosari	368	100	0	32	559	100	24	48
Total	**1,118**	**100**	**0**	**35**	**2,081**	**100**	**48**	**64**

Source: interview with community leaders.

Table 4-5 Areas under cultivation in 1994 and 1997 in three transmigration settlements

In 1997, the total burnt area for cultivating rice (*sonor*) in these three transmigration settlement was 2,081 ha. Farmers only cultivated 48 % of *Lahan Dua*, and especially in the SP1-Ekamulya and SP3-Wonosari settlements, the percentage of opened *Lahan Dua* was very small. In SP-1 Ekamulya, most swamp areas are very deep and wet, and thus it is more difficult to clear the land. In contrast, the reason for the low proportion of opened-up *Lahan Dua* in SP-3-Wonosari was because of a land tenure conflict between the indigenous *Mesuji* people and transmigrants. The *Mesuji* people continue to claim the *Lahan Dua* area that was allocated to transmigrants, and because no solution has yet been found, the land remains uncultivated. To the east of these three transmigration villages, another 12 transmigration villages were established between 1993 and 1997. These settlements were located in swamp areas with elevations below 10 m a.s.l. The characteristics of these 12 transmigration settlements are similar to the three already described. If the number of households per village is assumed to be constant, the estimate of the total number of households in these 12 transmigration villages would be 6,000 in 1997. The average land per household that can be cultivated during the *sonor* period is one ha per household. Therefore, we estimate that, in 1997, about 6,000 ha of swamp forest were burned for rice cultivation by transmigrants from these 12 transmigration settlements. The establishment of transmigration settlements in swamp areas increased the burning of swamp forest areas especially during the drought season.

4.1.2 Peneplain area

4.1.2.1 Fires arising from land tenure conflicts

During 1997 to 1999, fires destroyed around 8,450 ha of the PT SIL area (Table 4-6). Land tenure conflict was found to be the major underlying cause of fire in this area, although in some cases accidents may have caused fires as well. Farmers reported that fires were accidental in this area, but it is suspected that land tenure conflicts were the actual cause. Thus, in general, causes of fires were distinguished as follows: 1. Land clearing; 2. Land tenure conflicts; 3. Land tenure conflicts mixed with accidents; and 4. Accidents.

Year	Land clearing	Land Tenure Conflict		Accident	Total
		Land tenure	Mix with accident		
1997	2,000	0	2,796	235	**5,031**
1998	0	400	363	10	**773**
1999	0	2,100	546	0	**2646**
Total	**2,000**	**2,500**	**3,705**	**245**	**8,450**

Table 4-6 Burnt areas and their underlying causes in PT SIL in 1997-1999

In 1997, fire occurred in 5,031 ha of the PT SIL area. Around 40 % of the burning was for land clearing activities by the plantation, while 56 % of the burning was caused by uncontrolled fire in land clearing activities by smallholders. These smallholders are, firstly, *Mesuji* people whose land claims overlap with those of the industrial timber plantation, and, secondly, transmigration farmers who opened land in the border areas with PT SIL. Farmers did not control fire in land clearing activities, and took no care to prevent fire from escaping to the tree plantations. The incentive to control a fire was weak, because they considered that PT SIL had taken their customary land. In addition, even if fires from the smallholder activities escaped to the tree plantation, there would not be a rule to oblige farmers to pay compensation. With this situation, it is easy to see how fires could burn out of control during droughts like the one in the 1997 El Niño year.

The burnt area, in 1998, was 773 ha, and, in 1999, 2,646 ha. As opposed to the 1997 fires, in 1998 to 1999, the effect of land tenure conflicts on burning areas was much clearer. In these years, farmers directly burned the areas of PT SIL, including trees that had been planted by PT SIL, for the establishment of settlements and agricultural land (Figure 4-2).

Figure 4-2 Conflict burning in the PT SIL plantation

These cases may be considered as arson. Table 4-7 shows the distribution of burned areas by vegetation types and by causes of fires. The data show that the initial land cover of areas burned for land clearing was secondary forest. On the other hand, the vegetation of burned areas where fires were caused by land tenure conflicts was not only secondary forest and primary forest (39 %), but also included trees planted by PT SIL (61 %). Between 1997 and 1999, fires caused by land tenure conflicts destroyed 2,405 ha of albizia and 1,370 ha of acacia plantation.

Vegetation		Land clearing	Land tenure conflict (%)		Accident	Total
		(%)	Land tenure	Mix with accident	(%)	(ha)
Albizia		0	0	64	0	2,385
Acasia		0	18	25	51	1,495
Rubber		0	0	0	45	110
Primary forest		0	4	5	0	300
Secondary forest		100	78	5	4	4,160
Total	**(ha)**	**2,000**	**2,500**	**3,705**	**245**	**8,450**
	(%)	**24**	**30**	**44**	**3**	**100**

Table 4-7 Burnt areas, causes of fires, and their relationship to land cover/land use in PT SIL (1997-1999)

From June to September 1999, in sub-site 4, fire destroyed almost 400 ha of hybrid

coconut belonging to PT BNIL, as a result of a land tenure conflict between PT BNIL and a local community. Since the end of 1998, around 700 households have claimed 7,000 ha of PT BNIL's areas. They rebuilt houses in between hybrid coconut in the former areas of seven villages. They also cultivated crops such as cassava, corn, and other crops (see Figure 4-3). Farmers used fire in clearing land for cultivation. With no incentive to control fires, fire from land clearing spread to the company's hybrid coconut. This accidental spread of fire destroyed about 55 % of the total burned areas in this sub-site. Another 45 % of the total burned area was intentionally burned, probably by a community that lives on the border with PT BNIL.

Figure 4-3 Illegally planted crops in the PT BNIL plantation

4.1.3 Burn scars

Recent burn scars were mapped from the September 1999 Landsat TM imagery. Through ground checking of the imagery, it was found that recent (within a few months of the date of the imagery) burn scars showed a distinctive spectral reflectance. In some cases older burn scars could be identified but in general, the older the burn the more likely it was that vegetation would have grown up. Field experience gained through this project has shown

that the distinctive spectral reflectance of burn scars was due to a combination of charred woody vegetation and a young vigorous growth of pioneer species such as grasses.

4.1.3.1 Burn scar patterns in the peneplains site

Visual analysis of the imagery, dated 3 September 1999, identified 6 main burning zones characterized by a distinctive pattern; these six zones are highlighted in Figure 4-4. Characteristics of each of the burn scar zones are shown in Table 4-8.

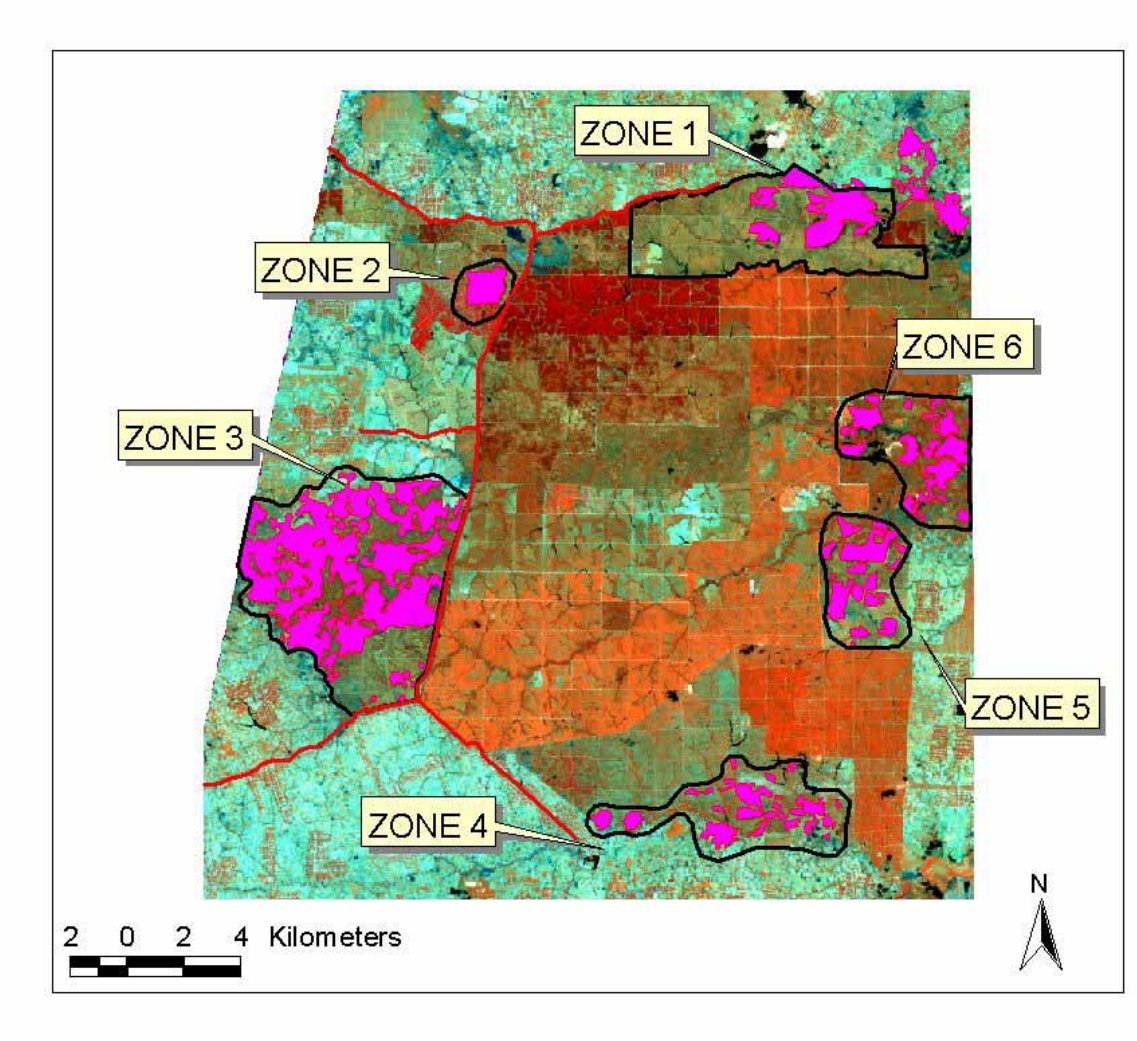


Figure 4-4 The study area and the 6 burn zones that were investigated for burn scars

Burn scar zone 1 lies close to the swamp area on the edge of the PT SIL plantation. The

zone is also part of sub-site 3 in the social research analysis (see section 4.1.2.1). In 1997, when vast areas of *sonor* were burning, fire escaped into the plantation causing great damage. Almost 2,385 ha of young albizia and acacia trees burned. By 1999, much of the area was covered by *Imperata* grassland and no re-planting had taken place. Some parts of this area burned again during the dry season of 1999. Field research in 1999, showed that most of these fires were accidental. *Imperata* grassland is particularly prone to fire and small accidental fires can easily get out of control and with no incentive to stop them, the fires burned large areas of grassland. The total area of burn scars in this zone is 650 ha, which equates to 23 % of the total area of the zone. There are 4 distinct burn scars, the largest being 422 ha.

Zones 2 and 5 are areas where PT SIL carried out deliberate land clearing in 1999. Zone 2 contains only one burn scar that covers an area of 149 ha and is quite rectangular in shape. Prior to the fire in 1999, this was an area of secondary forest with the status of Protection Forest. From field observation it is likely that PT SIL deliberately cleared this area in 1999 for cassava planting as it lies adjacent to an area of cassava. Zone 5 is also an area where cassava will be planted by the company, these burn scars are smaller and more scattered. Prior to the burn of 1999, this area was under dispute between PT SIL and PT BNIL; cassava had already been planted but had gone to fallow. In 1999, the companies had come to an agreement to plant cassava again and they used fire to clear the fallow cassava.

Land tenure conflicts and land claims are the main underlying causes of fires in zones 3 and 4. Zone 3 covers 4,772 ha and lies within an area that was planted with acacia in 1994. Zone 4 lies on the southern boundary of the plantation and is equivalent in the social science research to sub-site 4. In 1998 and 1999, local farmers used fire to claim back land that was owned by the plantation. Burn scars account for 50 % of zone 3 and the average size of a burn scar is 131 ha with the largest continuous burn scar being 1,562 ha. The burn scar areas are composed of burns from a number of different dates and possibly years, showing that the area has been very actively cleared in 1998 and 1999. The burn scars also show an irregular pattern, which could suggest that these are uncontrolled fires that were allowed to burn.

Zone 6 lies close to the swamps. Although this area falls within the boundary of the plantation it is not planted. The burn scars in this zone are irregular in shape and lie close

to the river. Knowledge of this area suggests that local fishermen may have caused these fires. At the time of this image, the conditions were quite dry and activities associated with fishing could have caused these fires.

Burn Scar Zone	1	2	3	4	5	6
Size of zone (ha)	2,861	356	4,772	1,820	1,207	1,588
Total area of burn scars (ha)	650	149	2,369	406	421	488
% area of burn scars in zone	23 %	42 %	50 %	22 %	35 %	31 %
Number of burn scars	4	1	18	16	15	12
Average size of burn scar (ha)	162	149	131	25	28	41
Maximum size of burn scar (ha)	422	149	1,562	72	126	194
Minimum size of burn scar (ha)	4.4	149	1.3	3	2	4
Cause of burning	1997: fires escape from swamp. 1999: grassland fire, accident	1999: clearing for cassava planting	1998/1999: land tenure conflicts/ land claim between local people and PT SIL	1998/1999 land tenure conflicts/ land claim	1999: Overlap between PT SIL and PT BNIL. now: clearing for cassava planting	Swamp fires

Table 4-8 Burn scar characteristics in 6 main burning zones

A few tentative conclusions can be drawn about burn scar patterns in this site. Controlled burns in plantations tend to have a regular shape and can be large with few small burns in close association. Fires associated with land tenure conflicts are usually in the periphery of

the plantation. The burn scars have a very irregular shape and can be large. However, accidental burns, as seen in zone 1 and 6, also have a similar pattern but are not usually quite so extensive.

4.1.3.2 Burn scar zones in the coastal swamps

The coastal swamps site exhibits some interesting burning patterns. Along the rivers *sonor* dominates the fire regime, as described in Section 4.1.1.1. Outside the *sonor* areas burn scars are seen in scrubland/grassland, mixed agricultural areas and also within the oil palm plantations.

On the 1999 Landsat imagery the *sonor* areas are thought to be synonymous with the low-density swamp forest located along the rivers. The last time these areas burned was in 1997 and in the intervening period the swamp forest has started to regenerate. The total area of low-density swamp forest that appears to be regenerating is about 12,000 ha, although this entire area has not been validated in the field. Figure 4-5 shows the location of the possible *sonor* areas. Analysis of the 1984 imagery shows that possibly 20,917 ha of low-density swamp existed. Further research needs to be conducted on identifying *sonor* areas from satellite imagery, especially from Landsat MSS.

On the 1999 Landsat imagery, recent burn scars account for 2,170 ha. These burn scars are confined to areas of scrub/grassland and agricultural areas. Older burn scars are possibly seen in the oil palm plantation south of the Buaya River, but fieldwork was not conducted in the area so it is not known whether fire was used to clear this land for oil palm or not.

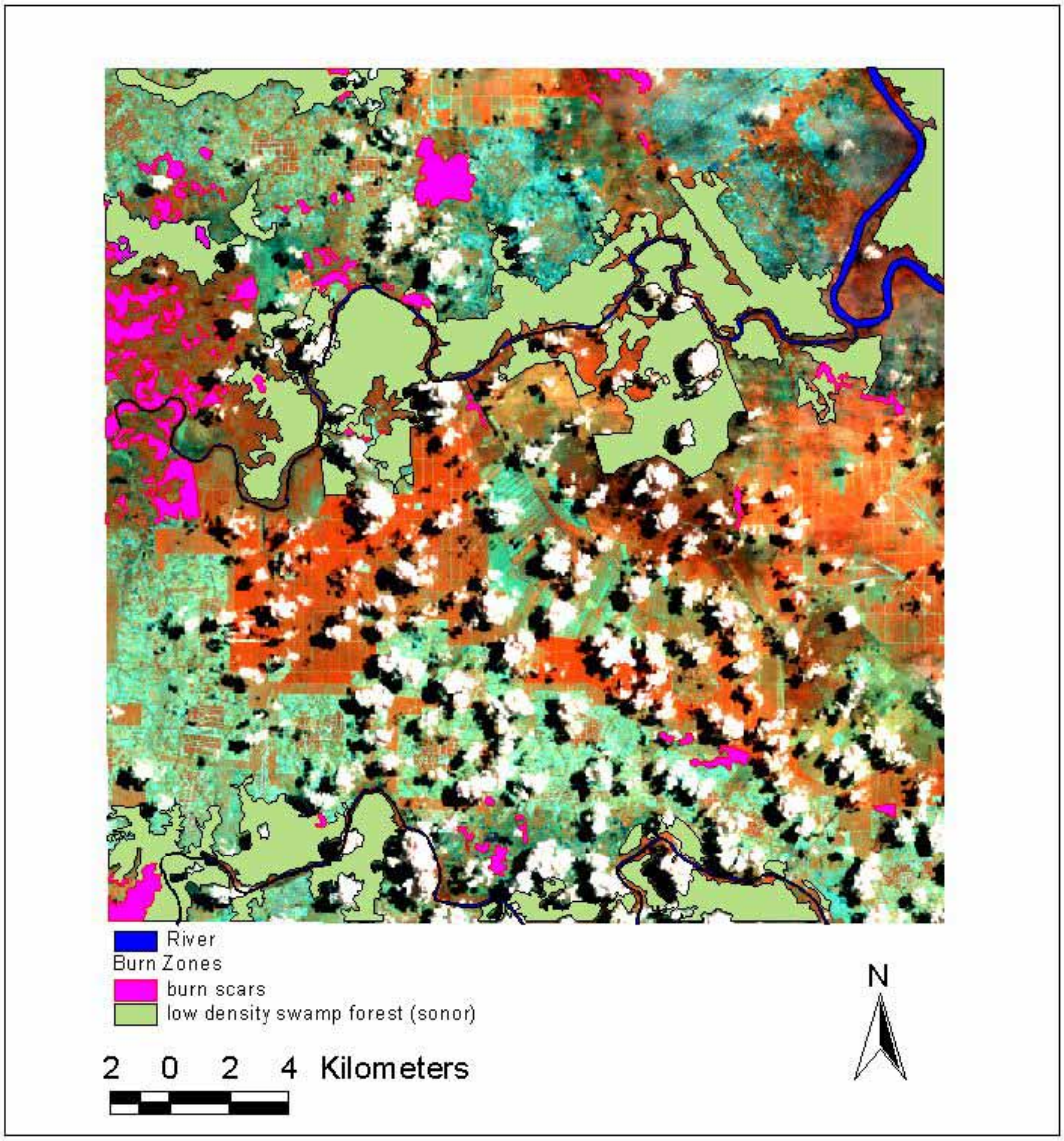


Figure 4-5 Burn scars in coastal swamps area

4.1.4 Hot-spots

Between 1992 and 1999, but excepting 1994 and 1995, the total amount of hot spots in Lampung province was 2,875, with a total hot-spot density of 8.5 per 100 km^2. During the same period, in the Menggala study area, 334 hot spots were detected, leading to a fire density of 23 per 100 km^2. 203 of these 334 hot-spots were located in the peneplains and

131 in the coastal swamps. Around 60 % of the hot spots in the peneplains were detected in 1997, while for the coastal swamps this is 77 %. Therefore, the 1997 fire event was exceptionally intense compared to other years. Table 4-9 shows the variation in hot-spots density between the whole Menggala study site, the two sub areas (peneplains and coastal swamps), the whole of Lampung Province, the whole of Sumatra, and all Sumatran swamps.

Year	Density total study site[a]	Density peneplains	Density coastal swamps	Density Lampung	Density Sumatra	Density Sumatra swamp
1992	0.35	0.34	0.36	0.15	0.33	1.31
1993	1.88	2.60	0.73	0.56	0.18	0.45
1996	2.72	2.15	3.64	0.59	2.17	4.59
1997	15.41	13.44	18.57	5.49	3.68	11.46
1998	0.07	0.11	0.00	0.11	2.04	7.72
1999	2.86	4.29	0.55	1.69	2.01	5.75
Total Hot-spot Density	**23.29**	**22.93**	**23.85**	**8.59**	**10.41**	**31.28**
Average: Normal years [b)]	**1.58**	**1.90**	**1.06**	**0.62**	**1.35**	**3.96**
El Niño year [c)]	**15.41**	**13.44**	**18.57**	**.49**	**3.68**	**11.46**

a) All densities are in number of hot spots per 100 km^2 per year, apart from the total hot-spot density, which was calculated over a period of 7 years
b) 1992, 1993, 1996, 1998 and 1999
c) 1997

Table 4-9 Hot-spot distribution in different areas

Both in the normal years and the El Niño year, the average hot-spot density in the peneplains and coastal swamps is higher than both the average density of Sumatra and the average density of Lampung province. This indicated that the incidence of fire in our study site is high. Table 4-9 also shows different patterns of hot-spot densities in the peneplains and coastal swamps, while there is also variation between normal years and the one El Niño year. During the El Niño year, average hot-spot density in the coastal swamps is higher than in the peneplains, but it is lower during the normal years. This suggests differences in land management, related to the use of fire in the two ecologically different

zones. As described in section 4.1.1.1, the main farming system in this coastal swamp area is traditional rice cultivation, in which land preparation is only practiced during long droughts. This would explain the differences in hot-spot density between a normal year and an El Niño year. Compared to the total Sumatra swamp area, average hotspots density in the Menggala coastal swamps is higher in the El Niño year and lower in normal years. One way to explain this may be that the coastal swamp area in this study site is dryer during the El Niño year and wetter during the normal year.

Land use in the Menggala peneplains (1999)	**Area in km^2 (% of total)**	**1992**	**1993**	**1996**	**1997**	**1998**	**1999**	**Total (% of total)**
forest	4 (1)	0	0	0	0	0	0	**0 (0)**
logged over area	43 (6)	0	0	0	2	0	2	**4 (2)**
plantations	388 (54)	3	15	14	57	0	27	**116 (71)**
mixed agriculture	150 (21)	1	3	1	13	0	2	**20 (12)**
burn scars	34 (5)	0	0	1	6	0	6	**13 (8)**
savanna and grassland	45 (6)	0	0	2	4	0	1	**7 (4)**
others	53 (7)	0	0	1	3	0	0	**4 (2)**
Total	**716**	**4**	**18**	**19**	**85**	**0**	**38**	**164**

Table 4-10 Fire hot-spot occurrence in relation to land-use in the Menggala peneplains area

Table 4-10 corroborates the data from the socio-economic analysis and the study of satellite imagery, i.e. most fires occur in the plantations, with other significant contributions from agricultural fires. Clearly, the hot-spot data cannot tell who set fire to the vegetation. For this see sections 4.1.2.1 and 4.3. Table 4-10 further shows that, although fires were most intense and frequent in the 1997 El Niño year, there were also many fires in less dry years such as 1993, 1996, and 1999.

Table 4-11 shows the hot-spot distribution between 1992 and 1999 (except 1994 and 1995) in the coastal swamps region. It is very striking how much more fires there were in the 1997 El Niño year, compared with other wetter years. In the peneplains area, the 1997 hot-spots accounted for 52 % of the total in those years, whereas in the coastal swamps 74 % of all hot-spots were found in 1997. A possible reason for this may be that either land

clearing and/or planting of crops is more dependent on dry conditions in the coastal swamps than it is in the peneplains.

Another interesting result from the hot-spot analysis is that fires in plantations accounted for much of the total number of hot-spots in the coastal swamps region. This is a result that was not found during the socio-economic surveys. It is clear, however, that fires on what was qualified as plantation land in 1999 are frequent, certainly in very dry years. A question that cannot be answered is who set fire to the vegetation in the plantations, and what were the underlying causes? It could be that fires for the establishment of *sonor* escaped into the plantations, or that there was conflict burning, or that the plantation used fire themselves to clear more land. More detailed research is required to establish the causes of plantation fire in this area. Figure 4-6 shows on overlay of the hot-spots on the land cover classification.

Land use in the Menggala coastal swamps (1999)	**Area in km^2 (% of total)**	**1992**	**1993**	**1996**	**1997**	**1998**	**1999**	**total (% of total)**
forest	227 (28)	0	2	4	29	0	0	**35 (22)**
logged over area	32 (4)	0	1	0	2	0	1	**4 (3)**
plantations	179 (22)	2	5	7	31		1	**46 (29)**
mixed agriculture	105 (13)	0	3	0	8	1	0	**12 (8)**
wet land rice	38 (5)	0	0	3	9	0	0	**12 (8)**
burn scars	10 (1)	0	0	0	0	0	0	**0 (0)**
savanna and grassland	39 (5)	0	0	0	13	0	0	**13 (8)**
others	171 (21)	0	3	6	24	0	1	**34 (22)**
Total	**801**	**2**	**14**	**20**	**116**	**1**	**3**	**156**

Table 4-11 Fire hot-spot occurrence in relation to land-use in the Menggala coastal swamps area

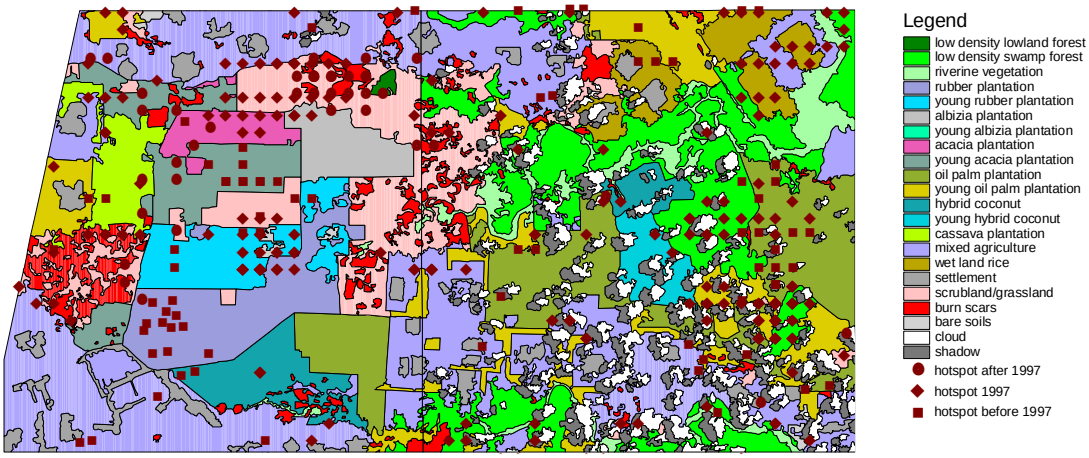


Figure 4-6 Hot-spots overlaid on 1999 land cover

4.2 Land Cover/Use Changes

4.2.1 Landscape level changes

Until the early 1970s, natural forest (including swamp forest) in the Menggala site was still abundant and belonged to the community under the customary (*adat*) law. Generally, groups of farmers that consisted of up to 10 people cleared forest for cultivating upland rice under shifting cultivation. In the areas of shifting cultivation, they built houses, where they usually stayed for 1 to 5 years. When the fertility of the soil decreased, they would move to open new forest areas. Some of these temporary settlements would develop into villages. However, in the early 1970s, a logging company, PT BG Dasaad (PT BGD) started to log forests. Along with the logging activity by the timber concession, local communities had also started to log the forest in their communal forest, and they illegally logged in concession areas. Some rich local communities operated a small-scale sawmill and sold the logs to the nearby island of Java. During the period from the 1970s to the 1990s, the logs produced from this site were known for their high quality. After 1990, illegal logging activities decreased, since most of the areas in this site had been used for transmigration settlement, industrial forest concession and tree crop plantation, and little or

no natural forest remained. The industrial forest concession PT SIL was established in 1989, starting with a concession area of 32,600 ha. In 1994, PT SIL obtained another 10,500 ha. The area of PT SIL was located in the expired PT BGD logging concession. From 1989/1990 to 1997/1998, PT SIL planted around 22,666 ha, or about 75 % of the total concession area.

Table 4-12 shows the distribution of planting areas by planting year. In the first two years of the operation, PT SIL was able to plant 2,600 ha of plantation. In the next four years, the annual planting area increased to up to 4,520 ha. In the last three years, the annual planting area was between 1,800 ha to 2,800 ha. PT SIL planted three major tree species: rubber (43 %), acacia (35 %) and albizia (22 %). During the first 4 years, albizia was a major tree in this industrial forest concession because the Government recommended industrial forest concession to plant albizia, a fast-growing species, to fulfill a supply of raw material for pulp industries. Albizia, however, did not grow well in this area. Therefore, after 1993/1994, PT SIL stopped planting albizia, and substituted it with acacia and rubber.

Planting Year	Type of Trees			Total
	albizia	acacia	rubber	
1989/1990	1,100	0	0	**1,100**
1990/1991	1,600	0	0	**1,600**
1991/1992	500	0	2,800	**3,300**
1992/1993	1,865	0	0	**1,865**
1993/1994	0	0	3,550	**3,550**
1994/1995	0	2,320	2,200	**4,520**
1995/1996	0	1,620	500	**2,120**
1996/1997	0	2,200	600	**2,800**
1997/1998	0	1,810	0	**1,810**
Total	**5,065**	**7,950**	**9,650**	**22,665**

Source: PT SIL

Table 4-12 Planting areas by planting year and type of trees (ha)

PT SIL planted cassava in the first two to three years before planting trees. Thus, during our survey period, we found that on around 2,000 ha of land in the industrial concession-PT SIL cassava was grown.

Tree crops plantations are also developed in our site. PT Sumber Indah Permai (PT SIP) established an oil palm plantation between 1991 and 1993. Starting in 1994, PT SIP established more than 4,000 ha of oil palm plantation for transmigrants under the NES system. Another firm, PT BNIL, also started in the 1990s with the establishment of 3,500 ha of coconut hybrid and 2,700 ha of oil palm plantation.

4.2.2 Quantitative landscape level changes

Quantitative assessment of land cover/land use change at the landscape level was carried out for three areas for different dates; the peneplains: 1984 and 1999, the western part of the peneplains: 1984, 1986, 1994, and 1999, and the coastal swamps: 1984 and 1999. The following sections describe and discuss the results for each of the three areas.

4.2.2.1 The peneplains 1984 – 1999

The level of detail and quality of the image dictated the classes chosen for the classification. As can be seen in Figure 4-7, the number of classes in 1984 is less than in 1999. This is partly due to the difference is spectral and spatial resolution of the Landsat MSS as compared to the Landsat TM and partly due to a much more heterogeneous land cover in 1999. For each year, particularly 1984, cloud cover (haze) and shadow are present and affect the overall totals. Discrimination of land cover classes on the 1984 Landsat MSS imagery was difficult due to the quality of the image and high degree of cloud cover. In contrast, the excellent quality of the 1999 image and the wealth of field knowledge produced a highly accurate classification.

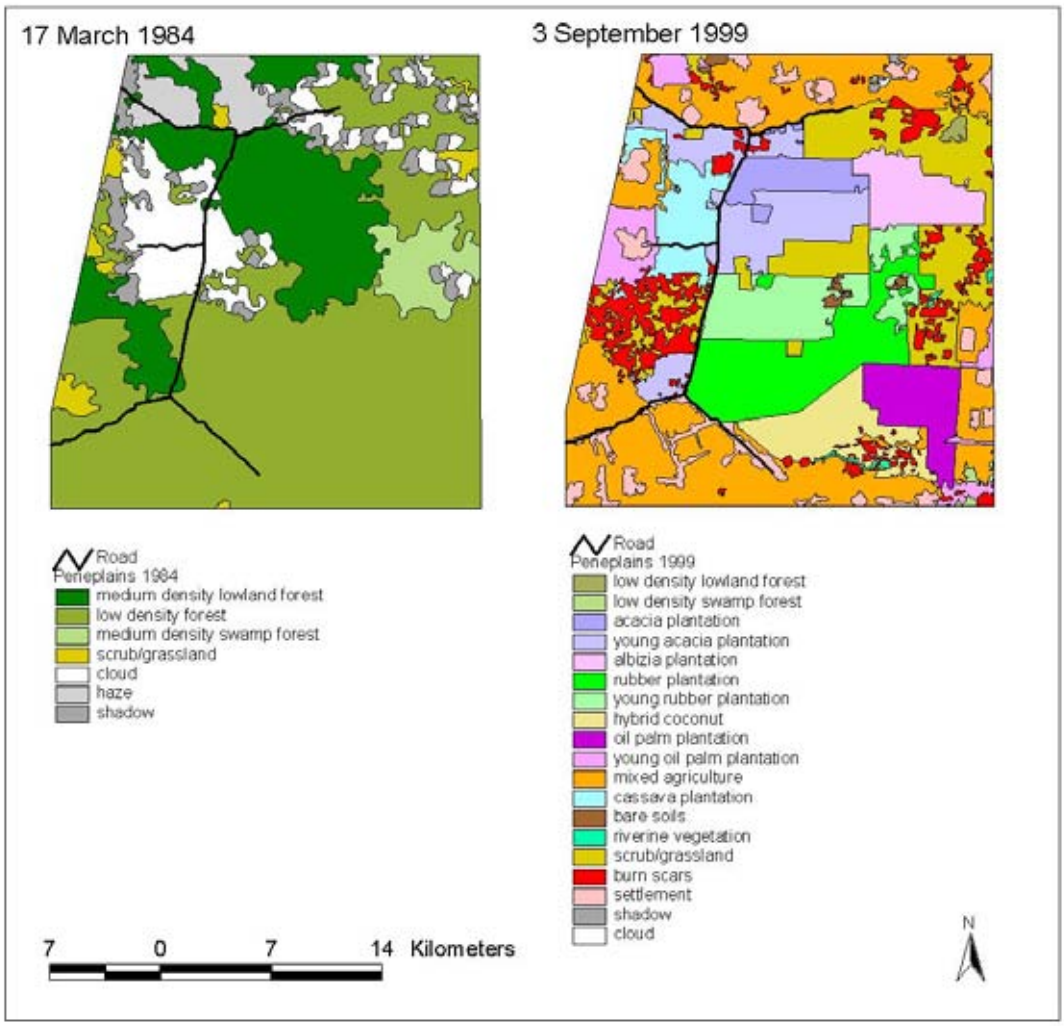


Figure 4-7 Land cover changes between 1984 and 1999

A number of different types of analyses were carried out on the land cover/land use classifications. The most basic analysis was to compare cumulative figures and percentages between years, thus giving a general picture of changes. This type of analysis gives an insight into the predominant land cover change processes. Change trajectory matrices were also calculated. These matrices can be consulted in Appendix II.

The most striking change in the peneplains site between 1984 and 1999 is the almost complete removal of natural forest shown by a 99 % reduction from 55,593 ha to 331 ha (see Table 4-13). Most of the natural forest area in 1984 was already within a timber concession and much of it had already been logged. The total area of natural forest in 1984 is actually higher than shown in Table 4-13 but cloud obscures about 14,000 ha, most of

which is likely to be natural forest at that time. In this 15 year period, much of the natural forest has become plantations (31,541 ha), agriculture (21,647 ha) or scrub and grassland (7,056 ha) (see Table 4-13). Although Table 4-13 shows no agriculture in 1984 it is likely there was agriculture but it was not possible to discriminate this class on the imagery. The low density forest class may contain areas of mixed agriculture. Settlement has also increased and now covers at least 3,000 ha, much of which is associated with transmigration schemes.

A new feature of this landscape is large-scale fires, seen as burn scars in the classification. No large-scale burn scars were identified on the imagery in 1984 but in 1999 as much as 4,000 ha (5.5 % of the total area) of recent burn scars are identified. From field observations, it is also known that scrub and grassland in this area are associated with previous fires.

Analysis of the change matrix in Appendix II gives an insight into the types of changes occurring at the peneplains. From the change matrix it can be seen that 27,455 ha (52 %) of the medium and low density lowland forest in 1984 has become industrial plantations (predominantly acacia, rubber and oil palm) by 1999. 18 % of this forest type has been burned and remains as burn scars or scrub/grassland by 1999 and 26 % has become mixed agriculture. Medium density swamp forest only accounts for 13.8 % of the area in 1984. By 1999, 34 % had become industrial plantations, predominantly rubber, coconut and oil palm. The remainder had become burn scars or scrub/grassland (60 %), and mixed agriculture (1.3 %).

Class Name	1984 (ha)	1984 (%)	1999 (ha)	1999 (%)	Change (%) (amount of cloud 1984)	Change (%)
Natural Forest	***56,779***	***(78.3)***	***331***	***(0.4)***	***-56,448***	***-99.4***
medium density lowland forest	14,182	(19.6)	0	(0.0)	-14,182	-100
low density lowland forest	0	(0.0)	179	(0.2)	+179 (39)	-
low density forest	39,091	(55.2)	0	(0.0)	-39,901	-100
medium density swamp forest	2,595	(3.6)	0	(0.0)	-2,595	-100
low density swamp forest	0	(0.0)	152	(0.2)	+152	-
Plantation	***0***	***(0.0)***	***31,541***	***(43.5)***	***+31,541***	**-**
acacia plantation	0	(0.0)	2,025	(2.8)	+2,025 (62)	-
young acacia plantation	0	(0.0)	5,984	(8.2)	+5,984 (1,445)	-
albizia plantation	0	(0.0)	2,747	(3.8)	+2,747 (132)	-
young albizia plantation	0	(0.0)	1,308	(1.8)	+1,308	-
rubber plantation	0	(0.0)	6,477	(8.9)	+6,477 (4)	-
young rubber plantation	0	(0.0)	4,406	(6.0)	+4,406 (495)	-
hybrid coconut	0	(0.0)	3,465	(4.8)	+3,465	-
oil palm plantation	0	(0.0)	2,778	(3.8)	+2,778	-
young oil palm plantation	0	(0.0)	2,351	(3.2)	+2,351 (723)	-
Agriculture	***0***	***(0.0)***	***21,647***	***(29.8)***	***+21,647***	-
mixed agriculture	0	(0.0)	18,426	(25.4)	+18,426 (4,008)	-
cassava plantation	0	(0.0)	2,897	(3.9)	+2,897 (2,470)	-
bare soil	0	(0.0)	324	(0.4)	+324 (70)	-
Other Vegetation	***1,553***	***(2.1)***	***9,853***	***(13.5)***	***+8,300***	***+534***
riverine vegetation	0	(0.0)	189	(0.3)	189	-
scrub/grassland	1,553	(2.1)	9,664	(13.3)	+8,111 (2,608)	+522
burn scars	***0***	***(0.0)***	***4,981***	***(6.8)***	***+4981 (987)***	**-**
settlement	***0***	***(0.0)***	***4,036***	***(5.6)***	***+4,036 (1,019)***	**-**
cloud/shadow/haze	***14,192***	***(19.8)***	***135***	***(0.1)***	***0***	***0***
TOTAL AREA	***72,524***	***(100.0)***	***72,524***	***(100.0)***		

Table 4-13 Land cover changes between 1984 and 1999

4.2.2.2 The western peneplains

For the western part (38,913 ha) of the peneplains, site imagery was available for the periods 1984-1986-1994-1999. Analysis of this time sequence allowed a gradual view of the changes taking place over the period 1984 - 1999. The complete peneplains site was only covered by two dates 1984 - 1999 and showed an abrupt change between the two years. Figure 4-8 shows the land cover maps for each of the years and Table 4-14 shows the cumulative change per year.

The change in natural forest shows a decline in the forest cover density from medium to low. From Table 4-14 it would appear that there is an increase in forest cover but this is not the case because some forest areas covered by cloud in 1984 are not covered in 1986. The reduced change, accounting for cloud cover, is from 26,767 ha in 1984 to 24,619 ha in 1986, all of which is low-density lowland forest.

Other changes that can be seen between 1984 and 1986 are an increase in agriculture and the establishment of transmigration schemes. In 1986, plantations had not yet become established and burn scars were not detected. By 1994, some major changes become apparent in the area. There has been a constant decline in natural forest cover, and plantations are beginning to appear in the areas previously forested. Plantations now total 3,461 ha and are composed of albizia, rubber and oil palm. For the first time burn scars are identified in the imagery.

Finally, between 1994 and 1999, the total removal of all natural forest cover occurs, with a loss of 18,525 ha in 5 years. The area of industrial plantations has increased by over 300 % from 3,461 ha in 1994 to 14,592 ha in 1999. The area of agriculture has not increased markedly but the cassava within the areas of agriculture has increased. Areas associated with fires, such as burn scars and scrub/grassland, have increased markedly in the years 1994 - 1999. Burn scars increased to 2,907 ha from 515 ha in 1994. These burn scars are mainly in areas of land tenure conflict. The areas of increased scrub/grassland are mainly located in areas where fires were a problem in 1997 (see Section 4.1.3.1). The changes described above correlate well with the historical data collected in the field.

Class Name	1984	1986	1994	1999

	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)
Natural Forest	26,767.0	(68.8)	31,928.0	(82.0)	18,525.0	(47.6)	0.0	(0.0)
medium density lowland forest	9,876.0	(25.4)	0.0	(0.0)	0.0	(0.0)	0.0	(0.0)
low density lowland forest	0.0	(0.0)	31,928.0	(82.2)	18,525.0	(47.6)	0.0	(0.0)
low density forest	16,891.0	(43.4)	0.0	(0.0)	0.0	(0.0)	0.0	(0.0)
Plantation	0.0	(0.0)	0.0	(0.0)	3,461.0	(8.9)	14,592.0	(37.4)
acacia plantation	0.0	(0.0)	0.0	(0.0)	0.0	(0.0)	1,696.0	(4.4)
young acacia plantation	0.0	(0.0)	0.0	(0.0)	0.0	(0.0)	5,247.0	(13.5)
albizia plantation	0.0	(0.0)	0.0	(0.0)	0.0	(0.0)	0.0	(0.0)
young albizia plantation	0.0	(0.0)	0.0	(0.0)	7.4	(1.9)	0.0	(0.0)
rubber plantation	0.0	(0.0)	0.0	(0.0)	0.0	(0.0)	3,077.0	(7.9)
young rubber plantation	0.0	(0.0)	0.0	(0.0)	2,617.0	(6.7)	2,381.0	(6.1)
hybrid coconut	0.0	(0.0)	0.0	(0.0)	0.0	(0.0)	435.0	(1.1)
young hybrid coconut	0.0	(0.0)	0.0	(0.0)	108.0	(0.3)	0.0	(0.0)
oil palm plantation	0.0	(0.0)	0.0	(0.0)	0.0	(0.0)	0.0	(0.0)
young oil palm plantation	0.0	(0.0)	0.0	(0.0)	3,461.0	(8.9)	1,756.0	(4.5)
Agriculture	0.0	(0.0)	4,478.0	(11.5)	14,556.0	(37.4)	15,050.0	(38.6)
mixed agriculture	0.0	(0.0)	560.0	(1.4)	13,639.0	(35.0)	12,041.0	(30.9)
mixed agriculture/settlement	0.0	(0.0)	862.0	(2.2)	0.0	(0.0)	0.0	(0.0)
new establishment								
of transmigration	0.0	(0.0)	3,056.0	(7.9)	0.0	(0.0)	0.0	(0.0)
cassava plantation	0.0	(0.0)	0.0	(0.0)	0.0	(0.0)	2,898.0	(7.4)
bare soil	0.0	(0.0)	0.0	(0.0)	918.0	(2.4)	111.0	(0.3)
Other Vegetation	1,178.0	(3.0)	2,508.0	(6.4)	154.0	(0.4)	3,248.0	(8.3)
riverine vegetation	0.0	(0.0)	0.0	(0.0)	0.0	(0.0)	0.0	(0.0)
scrubland/grassland	1,178.0	(3.0)	2,508.0	(6.4)	154.0	(0.4)	3,248.0	(8.3)
burn scars	0.0	(0.0)	0.0	(0.0)	515.0	(1.3)	2,907.0	(7.5)
settlement	0.0	(0.0)	0.0	(0.0)	1,602.0	(4.1)	3,077.0	(7.9)
cloud/shadow/haze	10,968.0	(28.2)	100.0	(0.3)	100.0	(0.3)	100.0	(0.3)
TOTAL AREA	**38,913.0**	**(100.0)**	**38,913.0**	**(100.0)**	**38,913.0**	**(100.0)**	**38,913.0**	**(100.0)**

Table 4-14 Land cover changes in the western peneplains

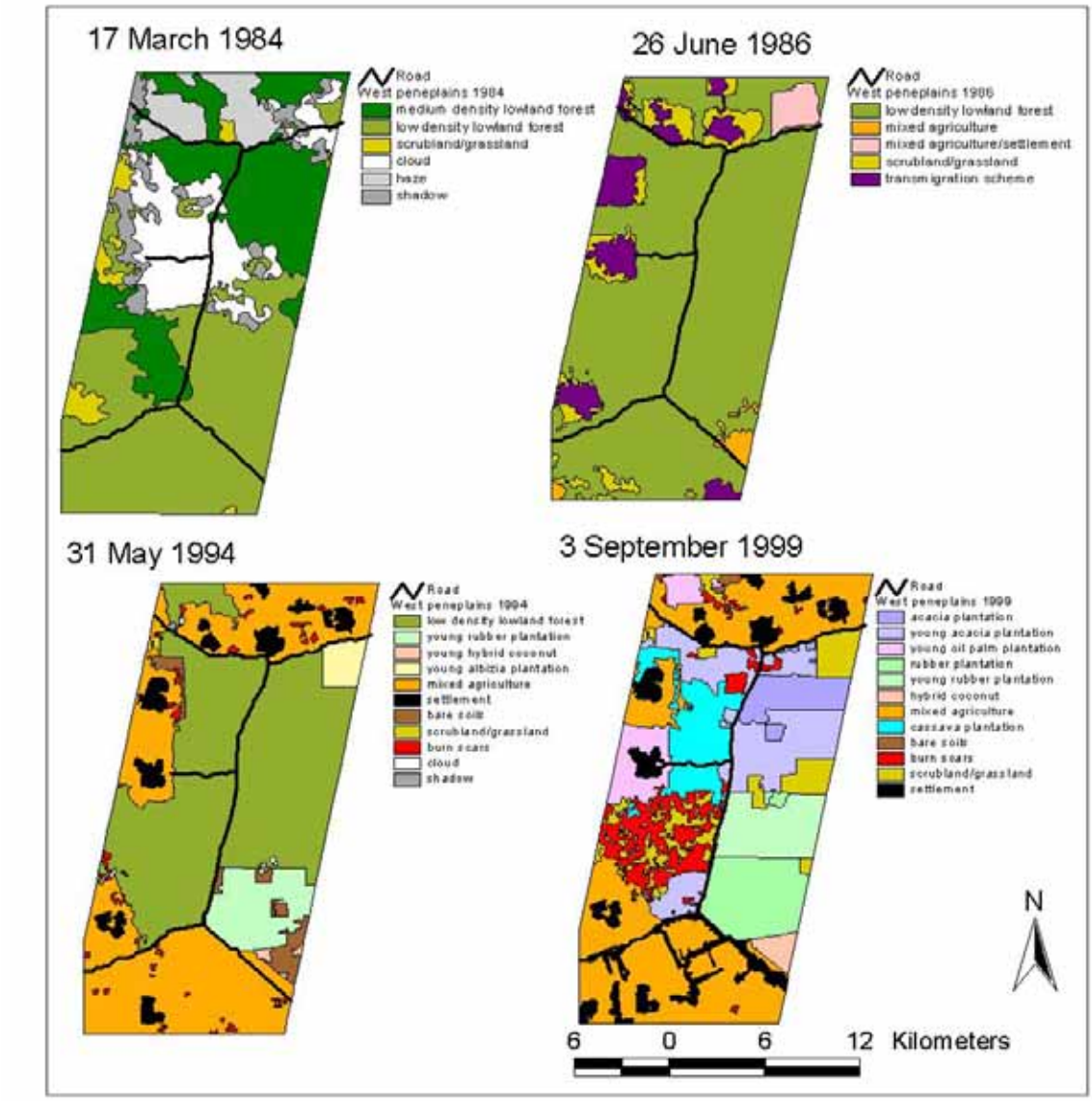


Figure 4-8 Land cover changes in the western peneplains

4.2.2.3 The coastal swamps

The coastal swamps have seen changes as dramatic as those seen in the peneplains (see Figure 4-8 and Table 4-15). The reduction in natural forest cover between 1984 and 1999 was 77 %, a loss of 48,713 ha. All of the medium density forest, both lowland and swamp has disappeared or become low-density swamp forest. The only natural forest type remaining in 1999 is low-density swamp forest, which coincides to some extent with the

'*sonor*' areas. The low-density swamp forest is mainly located along the rivers (see Figure 4-8). From the change matrix in Appendix III, it can be seen that 17,047 ha of natural forest has become plantations, 13,499 ha has become agricultural land, and 5,532 ha has become scrub/grassland or burn scars.

class name	1984		1999		change	change
	(ha)	(%)	(ha)	(%)	(%)	(%)
Natural Forest	***63,623***	***(80)***	***14,910***	***(18.7)***	***-48,713***	***77.4***
medium density lowland forest	6,605	(8)	0	(0.0)	-7,227	-100
low density lowland forest	2,169	(3)	0	(0.0)	-2,208	-100
medium density swamp forest	1,038	(1)	0	(0.0)	-1,038	-100
low density swamp forest	21,969	(28)	14,910	(18.7)	-7,059	-32
low density forest	31,841	(40)	0	(0.0)	-31,236	-100
Plantation	***0***	***(0.0)***	***19,686***	***(24.6)***	***19,686***	-
hybrid coconut	0	(0.0)	1,022	(1.3)	1,022	-
young hybrid coconut	0	(0.0)	1,522	(1.9)	1,522	-
oil palm plantation	0	(0.0)	10,025	(12.6)	10,025	-
young oil palm plantation	0	(0.0)	7,117	(8.9)	7,117	-
Agriculture	***0***	***(0.0)***	***17,954***	***(22.5)***	***17,954***	-
mixed agriculture	0	(0.0)	13,648	(17.1)	13,648	-
wet land rice	0	(0.0)	4,177	(5.2)	4,177	-
bare soil	0	(0.0)	129	(0.2)	129	-
Other Vegetation	***4,116***	***(5)***	***8,319***	***(10.4)***	***4,203***	***102***
riverine vegetation	3,216	(4)	4,625	(5.8)	1,409	43
scrubland/grassland	900	(1)	3,694	(4.6)	2,794	310
burn scars	***0***	***(0.0)***	***2,170***	***(2.7)***	***2,170***	-
settlement	***0***	***(0.0)***	***2,181***	***(2.7)***	***2,181***	-
cloud/shadow/haze	***11,928***	***(15)***	***14,442***	***(18.2)***	-	-
TOTAL AREA	***79,732***	***(100.0)***	***79,732***	***(100.0)***		

Table 4-15 Land cover changes in the coastal swamps

Industrial plantations, transmigration schemes and mixed agriculture are the main land uses

in the area by 1999 (see Figure 4-9). By 1999, approximately 19,686 ha, 25 % of the site, consisted of mainly oil palm (17,142 ha) and some hybrid coconut (2,544 ha) plantations. Agriculture accounts for 17,594 ha, or 22.5 %, of the site, and these areas are located near to the transmigration areas in the north and south of the site. The area of settlement has increase to 2,181 ha.

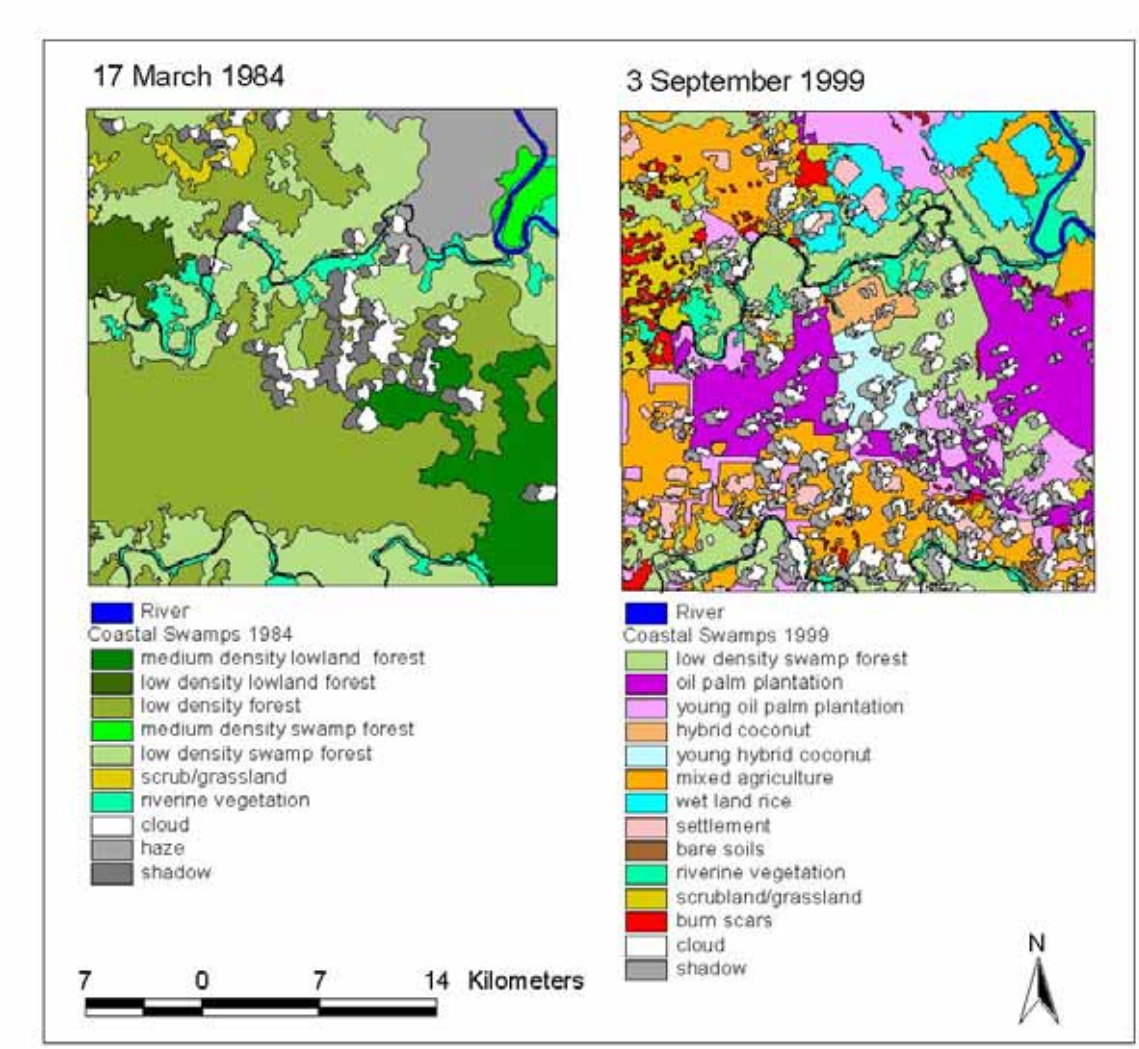


Figure 4-9 Land cover changes in the coastal swamps

As discussed in Section 4.1.3.2. there is an increase in burning in the coastal swamps site.

Most of the non-*sonor* burn scars are seen in areas of scrub/grassland, mixed agriculture and young plantation areas. Burn scars accounts for 2,170 ha of the non-'*sonor*' areas and no burn scars were detected in 1984. The estimation of burn scars in plantations is thought to be underestimated, as it was not possible to visit these areas and validate the image classification. Analysis of hot spots for 1997 indicated high hot-spot densities in the oil palm plantations.

4.3 Land Tenure Conflict

As reported in section 4.1.2, the major underlying cause of fires in the Menggala peneplains area is land tenure conflicts between local communities and large plantations. In this section, we describe different types of land tenure conflict, their causes and their effects on the occurrence of fire. These will be addressed individually in the following sections: 1. Decreased incentive to control fire; 2. Illegal land occupation; 3. Land speculation; and 4. Clashes between local communities and a large company.

4.3.1 Decreased incentive to control fire

Under the traditional *Mesuji* law, members of the community jointly own the swamp forest, and each member has a right to cultivate this land. If the land has not been cultivated in two succeeding *sonor* periods, then by customary law, other people can cultivate that land. When land is abundant and population densities are low, shifting cultivation can function efficiently and private land rights are not very important. Therefore, in the past, land tenure conflict rarely occurred. At present, however, there is evidence that land conflicts are on the rise. Members of the community try to keep the rights to land that they opened. Once they have cleared swamp forest for *sonor* cultivation, they maintain rights to cultivate this same land for every *sonor* period. The effort to obtain official recognition of these new land rights has increased since the establishment of oil palm plantations, transmigration settlements and spontaneous migrant settlement.

With the expansion of individual land rights and declining land availability, communities who live on the border of the large-scale plantations have tried to get back their customary

land. Since 1990, PT SIL has claimed 5,700 ha of land that is already used by Talang Gunung people (indigenous *Mesuji* people), after which they prohibited further agricultural activities. Talang Gunung people, however, have been holding out in that area and they have continued to cultivate the land illegally. Around 350 ha in this conflict zone consists of swamps. In 1997, Talang Gunung people and transmigrants from the Muara Tenang village cleared the swamp area for rice cultivation. Fires used in land clearing spread to trees belonging to PT SIL, who reported the loss of 2,112 ha of albizia and 384 ha of acacia (see Figure 4-10). In 1998, PT SIL asked the Indonesian military to remove the Talang Gunung people from that area. This effort, however, did not succeed, and in fact, Talang Gunung people kidnapped 12 soldiers. These soldiers were released after their commander apologised to the Talang Gunung people. Since that time, PT SIL has allowed Talang Gunung people to cultivate in the conflict area. PT SIL, however, requested farmers to inform them, when they wanted to cultivate the land. During land clearing, PT SIL also wished to make inspections and they requested that farmers establish fire breaks.

Figure 4-10 Accidental burning and land tenure conflicts on acacia and albizia plantations

4.3.2 Illegal land occupation

Indigenous *Menggala* people in Desa Labuan Batin are claiming about 4,000 ha of land

that currently belongs to PT SIL. In 1997/98, PT SIL had already planted around 1,000 ha of acacia in this area. In 1998 and 1999, however, *Menggala* people and migrants burned around 1,560 ha of land within the plantation for the establishment of a new village and new agricultural land. Some 450 ha of the burnt area had been planted with acacia only one year ago (Figure 4-11), while the remaining 1,110 ha of the burned areas consisted of logged-over forest. Subsequent to these events, villagers from Desa Labuan Batin requested formal Government recognition of the status of their new village. One condition for formal recognition of the village is that it contains more than 500 households. Therefore, *Menggala* people encouraged outside people to move to this area, by inviting migrants to cultivate the land without levying any charges. Ownership of the land, however, remains with the original *Menggala* people, and migrants only have a temporary right to cultivate. By November 1999, the population had increased to 650 households. The majority was ethnic Javanese (50 %), Balinese (20 %) and *Menggala* people (30 %).

The village leaders of Labuan Batin are now organizing a committee to draft a master plan for this new settlement. They plan to sell parcels of land that consist of 0.25 ha for housing and home gardens and one hectare land for upland food crops. In 1999, there were rumors that the District Head had proposed to take out 10,500 ha of the PT SIL area (the second phase of additional land for PT SIL) for community housing and smallholder agricultural land. This rumor encouraged *Menggala* people to claim more land. In the future, one may expect increased conversion of logged-over and secondary forest, as well as planted acacia areas in PT SIL's plantation, into smallholder agricultural land.

Figure 4-11 Illegal land occupation and accompanying illegal burning of plantation tree crops

4.3.3 Land speculation

In the northern part of the Labuan Indah areas, around 3,000 ha of land has not yet been planted by PT SIL. Since the end of 1998, farmers in two transmigration villages (Desa Gedong Boga and Desa Buko Poso) that are located within the border of PT SIL have burned and cleared these areas. By the end of 1999, this conversion of secondary forest to agricultural land had occurred on ca 940 ha (Figure 4-12). By the end of 1999, 390 households occupied this area, the majority of which were Javanese (80 %) with minorities of Balinese (10 %), and others. Most of them come from the transmigration villages. The major motivation for clearing this land is for land speculation. They do not know or pretend not to know that this land is within PT SIL's concession, and they consider it State land. The people reasoned that if the land belongs to the State, they could borrow it for planting cassava and rice, under the assumption that if many people cultivate this land, the Government would recognize their rights to it. Although, nobody has yet recognized their rights, they still benefit from cultivating cassava on this free land. There is a potential conflict with *Mesuji* people over this land, as they also claim it according to their customary laws.

Figure 4-12 Conversion of secondary forest to agricultural land by transmigrants speculating on land

4.3.4 Clashes between local communities and a large company

Learning from the official transmigration settlement program, Menggala communities adopted similar schemes to develop their villages and to establish a new settlement. People of Umbul Bujuk specifically invited Javanese who already lived in others part of Lampung to move to their areas. In 1982, migrants could receive 2 ha of land by paying Rp. 300,000 (US$ 454; 1982 conversion rate) to the Menggala community. Although these land transactions were informal (without any formal letter or land title), they did attract migrants. By 1984, the population had reached around 300 households. Following a similar process to the establishment of Umbul Bujuk Agung village, Umbulan Sutan Jimat had also become a formal village (named Desa Indraloka) in 1986. Around 810 households from mixed ethnic groups lived in this village at that time.

As a result of obtaining money from selling the land and learning from the release of their

communal land for tree crop plantation and transmigration settlement, *Menggala* people tend to sell more communal land before the land can be allocated to tree crop plantations or transmigration settlements. When *Menggala* people learned that the area of 7,000 ha located next to their village would be used for tree crop planting, the village leader sold the total area to migrants, before the companies had had a chance to plant the area. The price of the land was Rp. 600,000 (US$ 365; 1992 conversion rate) per 2 ha parcels of land. In a very short time, seven informal (illegal) villages were established, and in early 1992, 3,547 households lived in these seven villages.

At the end of 1989, the regional land title offices and estate crops services of the Agricultural and Forestry Departments stated that on the western part of the main road two villages (Indraloka and Bujuk Agung) were located on 3,000 ha of land that had been designated for the establishment of tree crop plantations. A further eight villages, on the east side of the main road, were placed on 7,000 ha of land earmarked for tree crop plantations. The ten villages defended their land by protesting against the Government and demanding a guarantee for strong tenure of their land. In June 1990, the military arrested a leader of these communities. The military forced him to sign a letter of agreement. In this agreement, the area of 3,000 ha on the western side of the main road was allocated to local communities and the area of 7,000 ha on eastern side of the main road was allocated to the tree crop company. All residents who occupied the 7,000 ha on the eastern side of the main road had to move to Bujuk Agung or Indraloka. Each household would obtain one ha of land. However, almost all communities rejected that agreement, and they remained on the land designated for the commercial plantations.

On October 28, 1991, the Governor of Lampung released a decree (No.300/5342/G.Sospol/91) containing guidelines for solving tenure conflicts between tree crop plantations and communities. According to that decree, each household that already lived in the 10,000 ha of land allocated for the tree crop plantation would receive 2 ha of land. The land would consist of 0.25 ha for housing and home gardens, 0.75 ha for upland food crops and one ha for tree crops under a nucleus-estate system. During the first four months, PT BNIL would provide 40 kg of rice per month per household and for the next 3 months the Transmigration Department would give another monthly 50 kg of rice. The government would establish public infrastructure such as markets, clinics, mosques, and

other public facilities. The resettlement area was to be located on 3,000 ha of land on the western part of the main road. However, if farmers already lived on the 3,000 ha of land and already 'owned' more than 2 ha of land then they should release their extra land. For this they would receive a compensation of Rp. 100,000 (US$ 52; 1991 conversion rate) per ha.

In 1992, 1,570 households from the seven villages were relocated to Bujuk Agung (621 households) and to Indraloka (949 households). Note that the original number of households in Bujuk Agung was 690 and in Indraloka 810. On January 6, 1993, the Governor of Lampung formally recognized the villages and granted 6,717 ha of land to the PT BNIL tree plantation. In 1992/1993, PT BNIL started to clear the land and planted hybrid coconut and oil palm. Until now, PT BNIL has established 3,500 ha of coconut hybrid and 2,700 ha of oil palm.

In fact, the problem of land tenure conflict has not yet been solved. Not all households who lived in the seven villages got land. The tenure conflict committee categorized about 1,970 households as not eligible to receive compensation of 2 ha of land. Most of them went back to the original home places. Farmers, who should have received 2 ha of land, in fact only received 1 ha. PT BNIL refused to give 1 ha of land under the nucleus-estate system because they argued that the company had already paid Rp. 100,000 per ha to 1,500 farmers. However, farmers denied that they sold the land. They admitted that they received Rp. 100,000, and signed a blank receipt for this, believing that the money that they received was a substitute for the rice grant.

The farmers now feel treated unfairly and loath the tree crop-company, also because during the process of resettlement, the company used military assistance to intimidate them. The political changes that started in Indonesia in mid-1998, provided the communities with a chance to reclaim their land and to seek revenge for perceived injustice. In September 1998, local communities claimed the land of the tree crop plantation. About 200 people built houses in areas between hybrid coconut, and they pronounced a ban on further activities by the tree crop company. Within a short period, the population within the tree crop company increased to 500 people. Beside the former residents of the 10 villages, there are also other people (about 55 %) who moved from our areas in Lampung.

In response, the plantation company used the military and private guards to burn the illegal houses built by local communities and to protect the areas of tree crop plantation. On April 14, 1999, around 7,000 people attacked and burned the office of this tree crop plantation. The battle between local communities and military and guards resulted in seven deaths. Local communities again rebuilt houses in areas between coconut hybrid, and even more people claimed land and rebuilt houses. The land tenure conflict still continues.

5. UNDERLYING CAUSES

This study revealed that the causes of fires differed depending on the location within the site. The cause analysis will therefore differentiate between the drier peneplain and the wetter coastal swamps.

On the peneplain, there are four main underlying causes of fire on this site. Firstly, fires resulted from land tenure conflicts between local communities and large plantations. The incidence of fire due to land tenure conflicts has increased since mid-1998, following the political reformation in Indonesia. The study found evidence for smallholders not only having weak incentives to control fire from spreading out into tree plantation, but they also use fire as a weapon. Thus land tenure conflicts lead to an increased incidence of fires in two ways: 1. Smallholders burn plantations to reclaim land for agriculture, and 2. Smallholders feel little or no responsibility for fire control and fires set on their land can easily spread to neighboring plantations. Secondly, the large-scale clearing required for plantation development was found to be a major cause of fire in the area. Thirdly, the lack of a transparent legal system to address land claims, land 'ownership', and communal rights (*adat*) has lead to many conflicts. In the Suharto era, these conflicts were easily suppressed by force, but since 1997, after President Suharto's fall, the communities have seized opportunities offered by the present power vacuum to reclaim land that they once owned. Finally, a lack of fire management facilities in plantations, and a lack of a proper fire management plan, prevents the efficient prevention and suppression of fires in tree plantations.

In the coastal swamp area, fire is used as a tool in "traditional" swamp rice cultivation. The establishment of transmigration settlements in the swamp areas has increased the area used for swamp rice cultivation, and as fire is the main tool in land preparation, there has been a significant increase in fires in this area. Hot-spot data and burn scar analysis indicate that fires also occur in plantations in this area, especially during very dry years, but the underlying causes of these fires could not be established.

6. POLICY IMPLICATIONS

Developing policy suggestions based on a single site can often lead to misleading recommendations. In the study, some implications for both the national and provincial level are outlined.

Some of these implications are as follows:

PENEPLAINS

1. Plantation development must take into account the existing land claims of local communities. This may require the development of a special program looking into such matters.

2. Land use rationalization is needed, both at national and provincial levels

3. There is a need to improve and invest in fire management by companies. This will protect the companies' resources from accidents or escaped fires. Both the technical and social aspects of fire management need to be addressed.

COASTAL SWAMPS

4. There is a need to reduce swamp transmigration as too many people are now causing too much damage to the area's ecosystem. This leads to invasion by *Melaleuca* sp., which prevents the regrowth of other species. There is a need to prevent further fires in secondary swamp forests.

5. Consider fire management for *Melaleuca* sp. production.

6. Work with the communities to find more efficient ways of swamp use, including the control of swamp fires, and the development of mixed cropping of rice and *Melaleuca* sp. There is a need for technical inputs looking into substitute crops or improved rice varieties.

7. Investigate fires occurring in plantations, and consider improved fire management.

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APPENDICES

APPENDIX I : Sources for hot-spot data

Source	Dates	Analytic technique
EU-Palembang station	1997: 11 Sep – 31 Dec 1998: 18 Jan – 20 Oct 1999: 26 Mar – 26 Oct	see below [1.]
EU-JRC	1996: 19 Jan – 28 Dec 1997: 2 Feb – 15 Oct	processed by a contextual algorithm
ESRIN	1993: 3 Jan – 3 Dec	processed by a contextual algorithm; day time images
CNRM	1992: 26 Apr – 31 Dec 1993: 1 Jan – 28 Mar	processed with same contextual algorithm as EU-JRC data
ATSR	1996: 1 Nov – 31 Dec 1997: 1 Jan – 31 Dec 1998: 1 Jan – 31 Dec 1999: 1 Jan – 31 Dec	background value of 308 Kelvin used; night time data
DMSP	1997: 1 Jun – 31 Dec	various extraction methods

[1.] These hot-spot data were hand processed. Both night and daytime images were used. Initially, several objects that might be fire were calibrated to establish background temperatures, after which fire locations were extracted. Subsequently, limited tests were carried out to check data and consistency.

APPENDIX II: Land Cover Change in the peneplains

in hectare	1999																			
1984	low density lowland forest		low density swamp forest		riverine vegetation		acacia plantation		young acacia plantation		albizia plantation		young albizia plantation		rubber plantation		young rubber plantation		hybrid coconut	
medium density lowland forest	0	0.0	0	0.0	0	0.0	1,963	13.8	4,146	29.2	696	4.9	280	2.0	277	2.0	1,065	7.5	0	0.0
low density forest	140	0.3	152	0.4	121	0.3	0	0.0	394	1.0	1,825	4.6	971	2.4	5,835	14.6	2,420	6.0	3,466	8.7
medium density swamp forest	0	0.0	0	0.0	68	2.6	0	0.0	0	0.0	95	3.7	0	0.0	361	13.9	427	16.4	0	0.0
scrub/grassland	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	57	3.7	0	0.0	0	0.0	0	0.0
cloud/shadow	39	0.3	0	0.0	0	0.0	62	0.4	1,445	10.2	132	0.9	0	0.0	4	0.0	495	3.5	0	0.0
Grand Total	**179**	**0.2**	**152**	**0.2**	**189**	**0.3**	**2,025**	**2.8**	**5,985**	**8.3**	**2,748**	**3.8**	**1,308**	**1.8**	**6,477**	**8.9**	**4,407**	**6.1**	**3,466**	**4.8**

in hectare	1999																			
1984	oil palm plantation		young oil palm plantation		scrub/ grassland		settlement		mixed agriculture		cassava plantation		burn scars		bare soils		cloud/ shadow		**Grand Total**	
medium density lowland forest	0	0.0	473	3.3	2,052	14.5	140	1.0	1,304	9.2	223	1.6	1,380	9.7	183	1.3	5	0.0	**14,188**	**19.6**
low density forest	2,778	6.9	866	2.2	3,614	9.0	2,516	6.3	12,548	31.3	137	0.4	2,203	5.5	14	0.0	62	0.2	**40,063**	**55.2**
medium density swamp forest	0	0.0	0	0.0	1,165	44.9	0	0.0	34	1.3	0	0.0	389	15.0	57	2.2	0	0.0	**2,596**	**3.6**
scrub/grassland	0	0.0	290	18.7	224	14.4	360	23.2	533	34.3	67	4.3	21	1.4	0	0.0	0	0.0	**1,553**	**2.1**
cloud/shadow	0	0.0	723	5.1	2,608	18.5	1,019	7.2	4,008	28.4	2,470	17.5	987	7.0	70	0.5	63	0.4	**14,125**	**19.5**
Grand Total	**2,778**	**3.8**	**2,351**	**3.2**	**9,664**	**13.3**	**4,036**	**5.6**	**18,427**	**25.4**	**2,898**	**4.0**	**4,981**	**6.9**	**324**	**0.4**	**130**	**0.2**	**72,524**	**100.0**

APPENDIX III: Land Cover Change in the coastal swamps

in hectare	1999													
1984	low density swamp forest		hybrid coconut		young hybrid coconut		oil palm plantation		young oil palm plantation		riverine vegetation		scrubland/ grassland	
medium density lowland forest	0	0.0	0	0.0	93	1.4	1,882	28.5	1,515	22.9	0	0.0	88	1.3
low density lowland forest	0	0.0	0	0.0	0	0.0	0	0.0	2	0.1	0	0.0	1,448	66.7
low density forest	1,961	6.2	153	0.5	604	1.9	5,866	18.4	2,856	9.0	195	0.6	1,085	3.4
medium density swamp forest	377	36.3	0	0.0	0	0.0	0	0.0	0	0.0	503	48.4	0	0.0
low density swamp forest	9,282	42.2	334	1.5	18	0.1	1,430	6.5	2,256	10.3	936	4.3	870	4.0
riverine vegetation	0	0.0	80	2.5	0	0.0	33	1.0	56	1.7	2,358	73.3	23	0.7
scrubland/scrubland	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	23	2.6
unknown	3,290	27.6	456	3.8	808	6.8	816	6.8	432	3.6	634	5.3	157	1.3
Grand Total	**14,910**	**18.7**	**1,023**	**1.3**	**1,523**	**1.9**	**10,025**	**12.6**	**7,117**	**8.9**	**4,625**	**5.8**	**3,694**	**4.6**

in hectare	1999													
1984	settlement		mixed agriculture		wet land rice		burn scars		bare soils		unknown		**Grand Total**	
medium density lowland forest	151	2.3	646	9.8	0	0.0	36	0.5	128	1.9	2,067	31.3	**6,605**	**8.3**
low density lowland forest	0	0.0	0	0.0	0	0.0	473	21.8	0	0.0	246	11.3	**2,169**	**2.7**
low density forest	1,792	5.6	8,892	27.9	752	2.4	739	2.3	0	0.0	6,944	21.8	**31,841**	**40.0**
medium density swamp forest	0	0.0	106	10.2	53	5.1	0	0.0	0	0.0	0	0.0	**1,038**	**1.3**
low density swamp forest	111	0.5	1,646	7.5	1,276	5.8	793	3.6	0	0.0	3,017	13.7	**21,969**	**27.6**
riverine vegetation	0	0.0	224	7.0	2	0.1	22	0.7	1	0.0	418	13.0	**3,216**	**4.0**
scrubland/scrubland	108	12.0	592	65.8	0	0.0	35	3.8	0	0.0	143	15.9	**900**	**1.1**
unknown	19	0.2	1,542	12.9	2,095	17.6	72	0.6	0	0.0	1,608	13.5	**11,928**	**15.0**
Grand Total	**2,182**	**2.7**	**13,648**	**17.1**	**4,178**	**5.2**	**2,170**	**2.7**	**129**	**0.2**	**14,442**	**18.1**	**79,667**	**100.0**