EUROPEAN UNION
MINISTRY OF FORESTRY AND ESTATE CROPE

Forest Fire Prevention and Control Project

A Field-Level Approach to Coastal Peat and Coal-Seam Fires in South Sumatra Province Indonesia

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Kanwil Departemen Kehutanan dan Perkebunan
Propinsi Sumatera Selatan

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Cover photograph

Peat swamp forest burnt in a logging concession in OKI Regency, South Sumatra province, November 1997.

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This is one of a series of reports prepared during 1999 by the Forest Fire Prevention and Control Project. Together these reports 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. Imandar 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 Muhnadar.
- ***Vegetation fires in Sumatra, Indonesia: a first look at vegetation indices in relation to fire occurrence and fire risk.*** I.P. Anderson, I.D. Imanda and Muhnandar.
- ***A fire danger rating system for South Sumatra province, Indonesia.*** M.V.J. Nicolas, I.P. Anderson and H. Pansah.
- ***A field-level approach to coastal peat and coal-seam fires in South Sumatra province, Indonesia.*** M.V.J. Nicolas and M.R. Bowen.
- ***Fire management in the logging concessions and plantation forests of Indonesia.*** M.V.J. Nicolas and G.S. Beebe (Joint publication with GTZ).
- ***The training of forest firefighters in Indonesia.*** M.V.J. Nicolas and G.S. Beebe (Joint publication with GTZ).

FFPCP will also publish reports on;

- ***the policy, planning and implementation aspects of natural resource management in 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
The Councilor (Development), Representation of the European Commission, PO. Box 6465 JKPDS, Jakarta 10220, Indonesia
Fax number: +62 21 570 6075

FOREWORD

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 regions 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-emphasized. 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 Regencies 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

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 of South Sumatra

SUMMARY

The European Union funded Forest Fire Prevention and Control Project (FFPCP) has gained considerable practical experience in the management of peat and coal seam fires in the province of South Sumatra, Indonesia. The project works in co-operation with the Provincial Forestry and Estate Crops Office of South Sumatra.

The safety of firefighters is paramount. Full protective clothing, training, rigid discipline and a knowledge of first aid are essential prerequisites before fire control is attempted.

Numerous fires that burned in an extensive zone of coastal peat swamp in Pampangan to the east of the main town of Palembang, were a primary source of the trans-boundary smoke haze that blanketed the region from September to mid-November 1997.

The wetlands are extensively and heavily exploited. Widespread commercial land clearance, to eliminate undergrowth and so facilitate log extraction, started many of the larger fires that then escaped control. Deliberate firing to clear land for pulpwood and oil palm plantations also contributed to the damage. Burning by many individuals - intended to clear smaller patches for sonor rice cultivation and to simplify the netting of fish - also escaped in the drought and added greatly to the damage.

It is estimated that up to 500 000 ha. of the 3 000 000 ha. of coastal wetlands in South Sumatra were fire-affected in 1997.

FFPCP supervised the containment of several fires in these deep-peat swamp forests. Fire-lines were dug down for between two and three metres to mineral soil and the fires were prevented from spreading to adjacent expanses of unlogged primary forest. The fires were fought with the combined use of hand-tools, backpack sprayers, and pumps and hoses.

Although these zones are classified as swamps, water supply was always limited in the 1997 drought. In some places 2.5 x 2.5 x 2.5 m. pits dug as water collection points for firefighting, took 24 hours to replenish by seepage. In other areas water had to be brought to the site through a 10 km. specially laid main. On average it took 40 men three days to contain an individual fire.

Limited water supplies coupled with the deep-seated nature of the fires, meant that total suppression was impossible and the fires were only extinguished after two months by the onset of the rains and the rising watertable.

Fire prevention is essential if there is not to be a further reduction of the wetland ecosystem and future trans-boundary smoke haze. Government must prohibit conversion to plantations; a practice that leads both to direct loss of land and to major wildfires. And the draining of new zones must be forbidden.

Training and equipping of an adequate force of field-based firefighters is a priority. Once such a force is in place the limited use of helicopters to rapidly move man and machinery to prevent small fires becoming uncontrollable should be considered.

Surface coal seams are found in Muaraenim Regency in the centre of the Province. Coal seam fires are extremely laborious to extinguish but in South Sumatra the fire-fronts progress less than five metres per year. Thus only if expensive and essential infrastructure is threatened is there a need to consider digging out the seat of the fire or diverting streams to flood the area and extinguish the coal. In most instances isolation from flammable surroundings provides sufficient control

FFPCP oversaw the containment of four coal seam fires. All were of long-standing duration and were burning in pulpwood plantations where they were potential ignition sources. Wide firebreaks were scraped down to bare ground around the burning patches, and a system of fire-watchers arranged for the duration of the dry season. A much cheaper alternative than attempting to extinguish the fire.

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1. INTRODUCTION

Background

Although a considerable literature exists on the peat lands of Indonesia, they remain poorly understood in comparison with there temperate equivalents. There is, however, unanimous agreement on their great ecological importance and their fragility. Their role in carbon sequestration remains under debate. Danielsen and Verheugt (1990) and Rieley and Page (1995) between them provide a comprehensive overview of the geography, vegetation, forestry, land-use and wildlife of the coastal areas of South Sumatra.

The extreme susceptibility of Indonesia's peatlands to fire during drought years was brought home by their widespread destruction in late 1997 and early 1998.

The control of vegetation fires on forest land – a category that includes large tracts of grassland, scrub and heavily degraded forest - ultimately lies with the Ministry of Forestry and Estate Crops (MoFEC). A sizeable part of this estate lies on peat soils and, as noted above, has proved to be particularly vulnerable to fire. Within pulp and timber concessions, the Ministry is assisted by the license holder in its task of managing fires. Outside the concessions a number of other government agencies are involved.

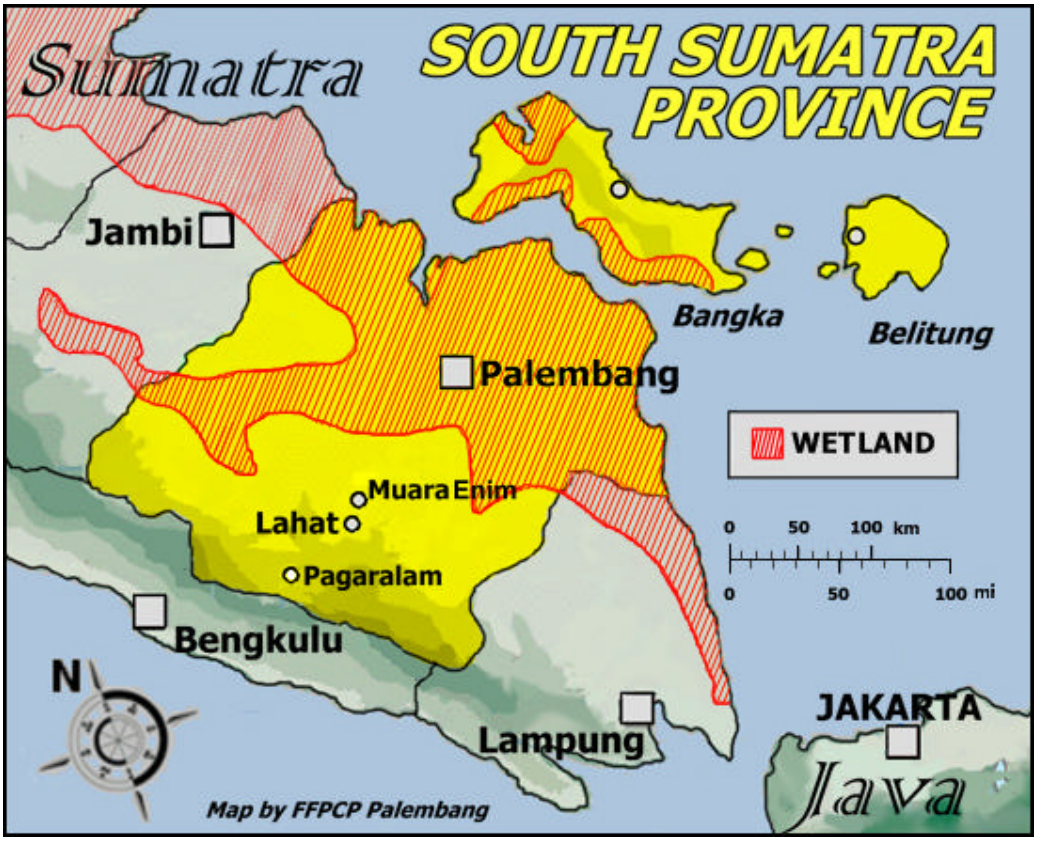
Four donor-funded projects supply fire management expertise. The EU-Forest Fire Prevention and Control Project (FFPCP) works with the Provincial Forestry and Estate Crops Office of South Sumatra (*Kanwil Kehutanan dan Perkebunan*) in Palembang. FFPCP has gained considerable practical experience in the management of vegetation fires - including coal seam and peat soil fires - within the province (Nicolas, 1998; Nicolas and Beebe, 1999).

In East Kalimantan, GTZ assists MoFEC in the control of fires on peat and inorganic soils (Schindler, 1998), while JICA has reported work on the satellite detection of peat fires in Kalimantan and Sumatra (Ueda *et al*., 1998). [Effendy (1998) gives a short, theoretical account of peat fire control in West Kalimantan]. Work supported by USAID on coal-seam fires is at an early stage.

The Locations of Peat Soils in South Sumatra

Within Sumatra large belts of peat-swamp forests lie along the eastern coastal regions in the provinces of Riau, Jambi and South Sumatra. A smaller expanse occurs further south in Lampung. Estimates of total area made by different authors vary considerably, although the RePPProt (1990) figure of some 8.3 million hectares seems to be generally accepted.

Within South Sumatra, these coastal wetlands are located in the Pampangan division, to the east of the main provincial town of Palembang, and extend northwards to the boundary with Jambi and southwards to Lampung. They cover approximately 3 million hectares (Sjarkowi, 1997). Smaller expanses of peat soils occur inland in the central district of OKI, and to the north in MUBA. (Map 1).



Map 1. The distribution of wetlands in South Sumatra Province and their continuation into Lampung and Jambi Provinces.

Types of Peat

All peats form in wet, often water-logged, areas and most are found in zones which still have a high watertable. Within South Sumatra the watertable typically varies from 1.0 m. above to 1.5 m. below ground surface. Under the United States Department of Agriculture classification, peat-land soils (organosols) are those that contain more than 66 percent organic material. They are sub-divided into three groups; *tropofibrist*, 'raw' peats; *tropohemist*, a transitional state with 33 to 66 percent decomposition, and; *troposaprist*, 'mature' peats.

Plate 1. The 2 m (± 1 m) thick peat in PT. SBA Wood Industries, March 1998.

Anderson (1983), as quoted by Rieley *et al*. (1997) notes that, "The lowland peats of South Sumatra consist of slightly or partially decomposed trunks, branches and roots of former forest trees within a matrix of almost structureless dark-brown amorphous, organic material"; largely a tropofibrist peat but with more mature fractions. They thus burn readily when dry. Ignition losses are almost always over 90 percent and can be as high as 99 percent. Little ash thus remains.

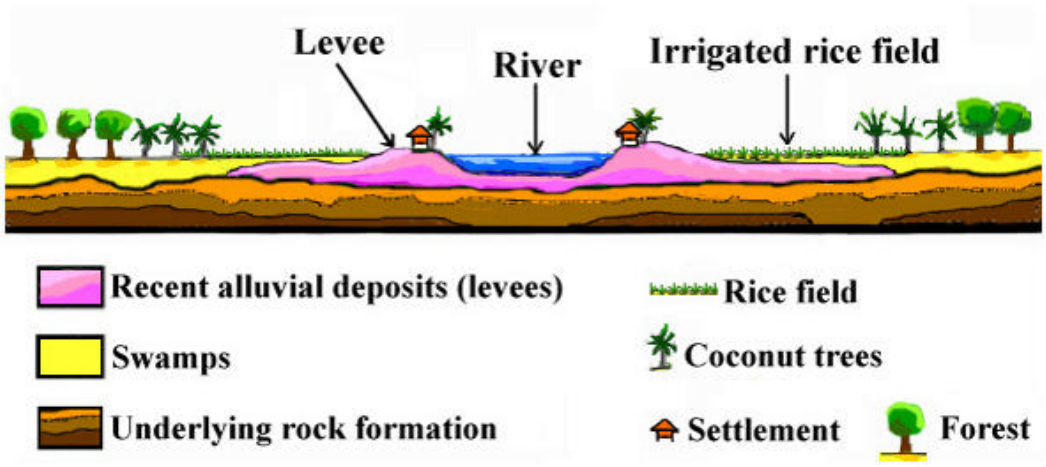


Figure 1. Cross-section of a river in the eastern lowlands of South Sumatra (after Scholz, 1983).

The Causes of Peat Fires

There is consensus that all peat fires within Sumatra result from man's activities; and it should be borne in mind that the coastal swamp forests of South Sumatra are heavily used. An extensive system of small canals runs through the Pampangan wetlands. Canals vary from one to three metres in width and were around 1.3 m. in depth in the 1999 rainy season. It is likely that the majority were dug in anticipation of the arrival of transmigrants in 1985. However a rudimentary system seems to be of much earlier origin and may have served as the only source of access to what is still a more remote and difficult region.

Predictably, the transmigrant agriculture failed and many of the smaller canals are now weed choked. The larger are heavily used by the remaining transmigrants who make a poor living collecting wood. Living trees, almost all *Melaleuca cajuputi* ssp. *leucodendron* (known locally as gelam), are cut at 70 – 100 mm. diameter and 4 – 5 m. in length, for use as scaffolding in the building industry. Larger, dead wood, 150 – 200 mm. in diameter and probably killed in the 1997 fires, is also collected and cut at the major river and rare roadside into 1.0 m. lengths to be sold as fuel for the brick kilns around Palembang. The poles and wood are floated out over long distances, often with the aid of empty drums and cans to give additional buoyancy.

Plate 2. Wood floated out using small canals in the Pampangan area, OKI Regency, March 1999.

Subsistence fishing is ubiquitous both in the freshwater of the inland canals and in the brackish channels close to the coast. Fish rarely exceed 100 mm. and many are only fifty.

FFPCP (1997) noted the destructive practice of *sonor* rice cultivation. In droughts opportunistic farmers burn haphazard areas in search of a fertile plot into which they plant rice on the receding watertable: several hectares are burnt for each one cultivated. Fishermen also take advantage of the falling rivers and use fire to clear vegetation around newly isolated, heavily-stocked river pools to swing their nets. These pools tend to be nearer the banks of the larger rivers of the Musi delta where the forest has been heavily exploited, first for timber and later for building poles.

There is now major commercial exploitation of the forest and conversion of logged sections to oil palm and pulpwood crops. Private commercial companies maintain existing channels and within the last two years have cut at least 50 km. of new canals – 5m. in width – to float felled logs to the coast.

Plate 3. Canal used for commercial timber extraction in PT. SBA Wood Industries, Bina Hutan Base, March 1998.

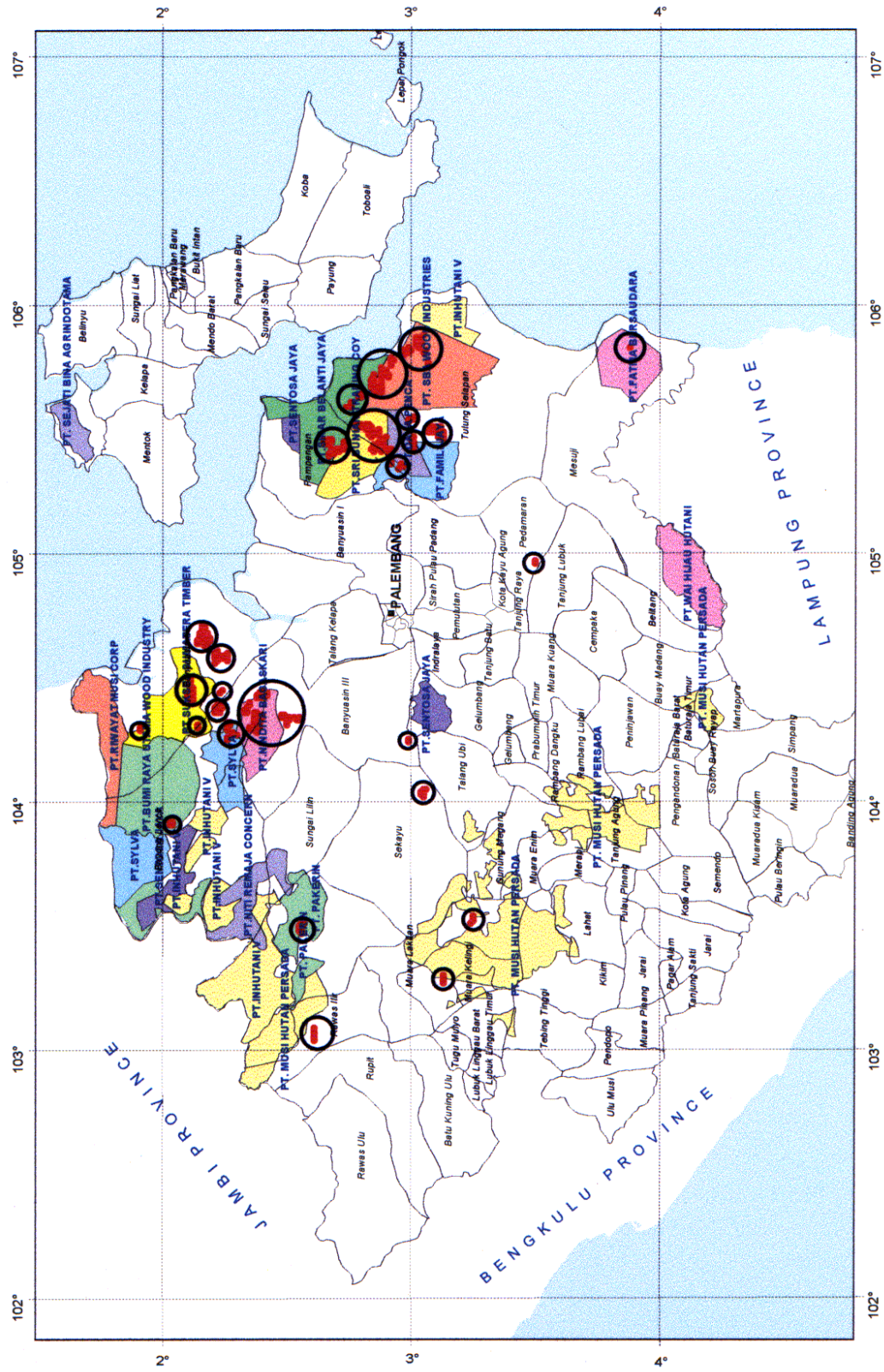
Our observations showed that in concessions some fires were set to clear undergrowth and make it easier to drag logs to a light, moveable railway system that aids log extraction. (Nicolas, 1998). In the case of one company that had applied to government for authorization to convert 40 000 ha to pulpwood plantations, the area was systematically burnt over a three month period in anticipation of approval. In all cases in 1997, fires that had been set deliberately spread out of control and it was difficult to assess what contribution each activity made to the over-all destruction.

Plate 4. Light railway system used to extract logs in PT. SBA Wood Industries, March 1998.

The Detection of Fires

The incidence of vegetation fires in Sumatra has been monitored by FFPCP since January 1996 using NOAA-AVHRR derived data (Anderson, Bowen, Imanda and Muhnadar, 1999; Anderson, Imanda and Muhnandar, 1999). Sizeable fires with a flaming front can be placed to an accuracy of around 2 km. within an hour of a satellite pass. Fire presence is monitored twice a day in routine periods, up to four times in severe droughts. Siegert and Hoffmann (1998) record similar satellite monitoring of fire occurrence in Kalimantan. Despite this intensive monitoring many small surface fires and somewhat larger underground fires go undetected as the heat they generate is insufficient to register on the NOAA sensors.

As an example of NOAA fire detection, the distribution of fires in South Sumatra province as recorded by FFPCP in the early hours of 23 October 1997 is shown in Map 2. Three major and five smaller ‘clusters’ of fires were recorded in the Pampangan coastal wetlands east of Palembang, and one major and nine smaller clusters in similar zones to the north. Each fire cluster is indicative of serious, persistent burning. (A full description of the types and interpretation of fire clusters is given by Anderson, Imanda and Muhnandar, 1999a.) The fire clusters are predominantly in HPH / HPHTI territories. And it is known that further licenses have been allocated since the base map was prepared. It is thus probable that the clusters to the north of Palembang that appear to be outside concessions, in fact fall within such newly licensed areas.



Map 2. The distribution of fires in South Sumatra province on 23 October 1997.

The sparse population, the absence of telecommunications and few roads make the prompt reporting of fires found by field observation almost impossible. The use of lookout towers has been suggested (Chandrasekharan, 1998). However, they are expensive - $ 24 000 for a well constructed 25 m. tower on mineral soil in 1997 (FFPCP, 1997a). Construction in wetlands would be even more difficult and expensive and such towers become pointless in the smoke haze that goes with even small peat fires.

Nor is the solution to the, incorrectly presumed, slow fire reporting in the peatland belts to be found in the proposal (BAPPENAS, 1999) for the early purchase of light surveillance aircraft. Operational costs are high, maintenance difficulties formidable and the craft are unable to fly if the smoke haze reaches 1997 levels. And any limited improvement in reporting would be negated by the absence of an anywhere near sufficient force of field equipment and firefighters. Satellite detection with an elapsed time of some seven hours from the start of a serious fire to a report reaching a fire crew is adequate for the foreseeable future.

Characteristics of Peat Fires

Fully saturated peats are, as may be expected, not prone to burn. However as the watertable falls during droughts the organic layers dry-out and become flammable. This is particularly the case with raw peats that have many air-filled spaces between the fibres and therefore burn fairly readily when completely dry. Half-decomposed peats still contain sizeable air spaces - although they often also contain more moisture - and fires thus tend to ‘tunnel’ slowly into deeper areas rather than burn freely. Fully mature peats have a relatively solid composition with few air spaces and are appreciably wetter. Thus any fires that do occur, burn more slowly, often as a ring or crater.

The spread of the surface fire-front in burning peat soils is, in itself, not particularly rapid. However with a wind, burning particles fly many metres, cause numerous spot-fires and thus spread the fire very quickly. And, if the land is covered in dry grass or shrubs, these burn freely and also carry the fire swiftly to new domains.

Deep burning peat fires spread slowly but consume many cubic metres of organic matter. Grasses and standing scrub burn above the ground, and under the ground roots weaken as the fire spreads and cause cavities. Undermined trees topple and can themselves burn. Smoldering organic fires in Kalimantan have been known to persist throughout the subsequent rainfall period, to be reactivated as an ignition source in the next dry spell (Goldammer and Seibert, 1990)

Plate 5. Underground peat fire covering 800 ha. in swamp forest within PT. Sribunian, OKI District in October 1997.

All ground fires produce copious smoke as the peat contains some residual moisture and they smolder over many weeks. Seven large groups of peat fires are identified by Legg (1998) as the source of the smoke haze that blanketed many of Indonesia's provinces, Singapore and large parts of Malaysia in 1997. Three of these fire groups were in Sumatra, in the coastal peats of Riau, Jambi and South Sumatra provinces.

Even small damp vegetation fires set to clear gardens close to fully settlements are smoky, although on a very much smaller scale. FFPCP has observed smoke plumes from commercial flights departing Palembang over the swamps, from fires no larger than 5 x 5 m., that were visible for seven minutes on still evenings (a conservatively estimated distance of 40 km.) but indicative of persistence of such smoke.

Smoke from smoldering peat fires is high in fine particulates and higher organic fractions (Levine, 1998), both of which are especially hazardous to health. Dieterle and Heil (1998) reviewed the extent, composition and the direct and indirect impact of the trans-boundary pollution on the health and general economy of the region that resulted from the 1997 fires.

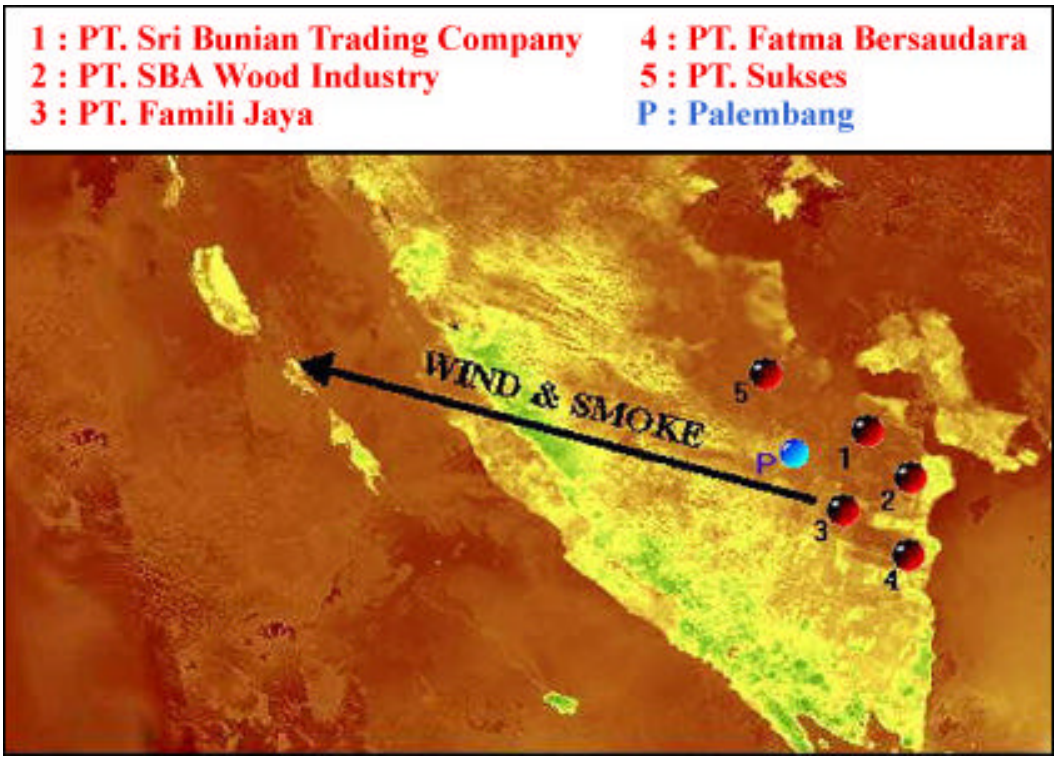


Plate 6. Smoke over Palembang generated by peat fires in logging concessions; NOAA NDVI composite, October 1997.

The Extent of the 1997 Fires

There have been numerous estimates of the total area in Indonesia affected by fires in 1997 – 1998. Of those made for fire-affected peat and swamp forests in Sumatra, the figure of 300 000 ha. given by Sukrismanto, Ratomo and Hansen (1999) for the island as a whole, is ‘average’.

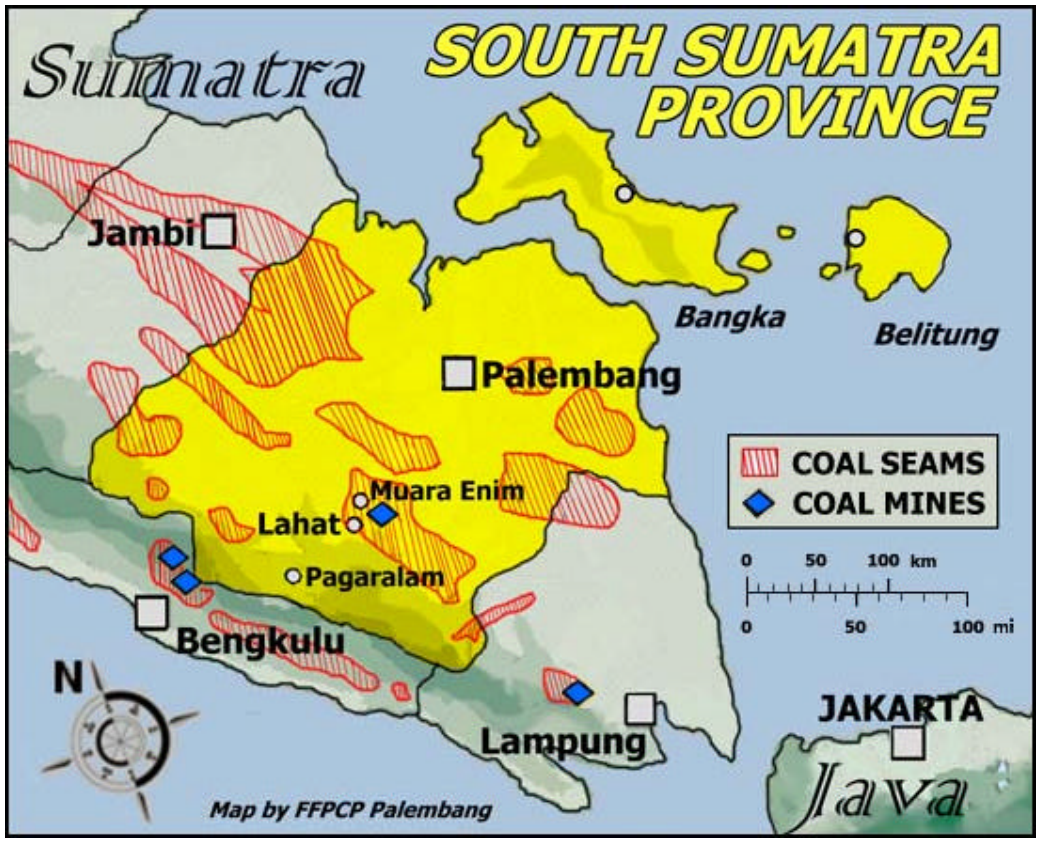
However field observations – by foot, boat, road and helicopter – suggest that this figure is a considerable underestimate. In 1997 some 40 000 ha. of the 134 000 ha. in the logging concession of SBA Wood Industries burnt over a two month period from mid-September to mid-November. And we estimate that the total area of coastal wetlands damaged within the province of South Sumatra alone was close to 500 000 ha.

Plate 7. Peat swamp forest burnt in PT. SBA Wood Industries, OKI Regency, November 1997.

No figures are available for the area of *inland* peats burnt in South Sumatra in 1997, although observations suggest that fires were less numerous and severe than in the coastal wetlands (see Map 2). They certainly produced less smoke haze. It is stressed that, like all previous figure, the areas given here are 'best estimates' rather than fully mapped results.

The Coal Seams in South Sumatra

South Sumatra has considerable coal resources that make a substantial contribution to the provincial economy. Seams are numerous, particularly in Muaraenim Regency in the centre of the province and, to a lesser extent, in MUBA Regency in the north. The major mining company, PT. Bukit Asam, is located at Tanjung Enim, close to the town of Muaraenim (Map 4.), and has a target production of 10 $Mt.y^{-1}$. The coal, which is open-cast mined, is described as, "High in volatiles, sulphur and moisture." (Rod, pers.comm.).



Map 3. The distribution of coal seams and coal mines within southern Sumatra.

2. FIGHTING PEAT FIRES

Safety When Firefighting

Burning particles from surface peat fires fly up to 100 m. and spread the fire with extreme rapidity. The numerous new 'spot-fires', in turn, quickly become sizeable fires. A two metre wide water ditch will check the original fire but is not a barrier to its propagation. The greatest care must be taken not to isolate firefighters from a way of retreat. (Nicolas and Beebe, 1999a).

Underground peat fires produce copious heavy smoke with a high concentration of carbon monoxide. They are thus a danger to firefighters. These sub-surface fires also burn hidden holes in the peat and the over-lying crust is liable to collapse without warning under the weight of a man. Consequently, firefighters must move carefully and wear safety equipment of adapted clothes, boots, gloves, and a helmet and hood for breathing protection. (Nicolas and Puri Indonesian Language Plus, 1998).

Plate 8. Firefighter training in South Sumatra province; firefighters are correctly equipped with safety clothing and handtools.

General Recommendations

The suggestion by BAPPENAS (1999) that more attention be paid to fire control in wetlands is welcome. But their contention that effective techniques and equipment to suppress peat fires are insufficiently researched is incorrect. Both are well known. What is lacking is the equipment itself and staff trained in firefighting methods and fire control tactics. Difficulties arise as fire numbers rise rapidly to levels that would overwhelm the capacity of even well equipped and trained firefighters.

Fire prevention is essential if there is not to be an additional reduction of the fragile peat swamp forest ecosystem as well as further occurrence of trans-boundary smoke haze. Prevention must be given at least equal attention to control. There is an urgent need for government to prohibit additional conversion of coastal wetlands to plantation – a major cause of fires. Logging companies need to be tightly regulated and closely supervised: the construction of further channels to float out logs must stop. Consideration needs to be given to the disablement of existing channels to retain higher watertables and thus the re-flooding of some areas. As pointed out by Hadisuparto (1999), ground fires destroy not only the surface vegetation but also buried seeds, and thus rehabilitation of burnt areas is slow and uncertain.

Surface peat fires may progress quickly but, if water is available, can be extinguished with relative ease using pumps or backpack water-sprayers. Hand-tools are sufficient to control the fires if there is no water source.

Figure 2. Construction of a fire-trench using a locally made fire rake adapted to South Sumatra conditions.

Underground peat fires spread slowly. A deep trench dug around the fire isolates them and they can often be safely left to burn out. If there is a danger that these underground fires will flare-up as surface fires and spread to new areas, they can be extinguished by

water using pumps, hoses and nozzles adjusted to give a high pressure and a straight stream. Deep fire spots need to be dug up and doused. If backpack pumps or buckets are used, a wetting agent should be added to the water. Liquid soap is an effective and cheap mixer to break the surface tension of the water and let it sink easily through the peat fuel.

The novel idea - reprinted by MoE/UNDP (1998) as an example of community initiative - to limit the spread of peat fires by placing water-filled plastic bags as a barrier and then lobbing further bags into the fire to quench it, shows enterprise but is doomed to fail.

Plate 9. Firebreak and trench to stop a ground fire in peat swamp forest, PT. Sribunian, October 1997.

Fighting the Fires in South Sumatra

In late October 1997 two large peat fires were fought in Pampangan. The first was in swampland within the logging concession area of PT. Sribunian. Hand-tools and pumps with hoses were used. Holes (2 x 2 x 2 m.) were dug to obtain water.

Plate 10. Hole dug to obtain a water supply for fire fighting in PT. Sribunian, October 1997.

The second fire was located in peat swamp forest. Water had to be brought from reservoirs - through a specially laid 10 km. metallic main running alongside a light railway used to extract timber – to fight the fires with pumps and hoses. A long, wide firebreak was made with hand tools; the trench ‘fire line’ was dug to a depth greater than the 1.5 m. peat layer.

In both cases it took 35 men, working during daylight hours, three days to contain the fire. Final extinguishing - ‘mop-up’ - was not possible because of water shortage and the depth of the peat that was burning. Fire-watchers were retained to ensure that blowing embers did not spread the fire to new sections.

Plate 11. Use of 10 000 l. tank, pump and hoses to fight a peat fire in the swamp forest, PT. Sribunian, October 1997.

Also in October, fires were fought in the PT. SBA Wood Industries HPH concession, again in the Pampangan zone, and the site of many large and persistent NOAA-detected hot-spots in October and November. Up to 40 000 ha. burnt within the HPH and parts of the adjacent Protection Forest were also severely damaged.

Fires were so numerous and on so large a scale that fighting was possible only in selected locations close to, and designed to protect, the unlogged forest growing on 2 - 3 m. deep peat. Firebreaks were constructed with hand tools and fire lines were dug through to mineral soil.

Twenty permanent firemen with basic training and equipped with 19 motor pumps, hoses and hand tools were brought to the critical locations each day from the secondary base-camp at Bina Hutan - at least 10 km. and on occasion, 20 km. away - using the light-railway system. The firefighters had then to walk for up to a kilometer to the fires, often cutting their way through heavy bush. On occasion the permanent firefighters were supplemented by members of local communities paid at between Rp 5000 and Rp 10 000 per day.

Wind direction was always east southeast and wind speed low at less than 20 $km.h^{-1}$. The absence of wind reduced the ferocity of the fires and the danger of flying sparks igniting new fires; it thus aided firefighting. However visibility, because of the slowly moving smoke, was always below 100 m. Reduced visibility in itself, was not a problem, although it caused chronic eye infections and respiratory difficulties.

Afternoon shade temperatures reached 33^{o}C – although there was no shade – and a relative humidity of 60 percent despite the drought, added to the difficulties of the firefighters. The company supplied food and drinking water three times during each working day.

Water supply was again limited and the 2 x 2 x 2 m. holes that were dug were quickly pumped dry and took 24 hours to refill. Fighting, on 12 hour shifts, continued daily for two months and succeeded in preventing fires entering the unlogged forests. But fires were not extinguished until the arrival of heavy rain at the end of November.

The absence of monkeys, birds, or indeed any wildlife, was notable while fighting the fires; neither were dead animals found.

Plate 12. Digging a hole to obtain a water supply in PT. SBA Wood Industries, October 1997.

Plate 13. Transporting motor pumps by railway in PT. SBA Wood Industries, October 1997.

The Future

The remoteness of the peat forests and the difficulties of access will continue to prevent the effective suppression of fires in the coastal wetlands to the east of Palembang for many years to come. A permanent trained reserve and the deployment of the thousands of firefighters needed to extinguish well-established fires in years of severe drought is not feasible.

We have consistently advocated a field-level, low-technology approach to the detection and control of vegetation fires. Our views are based on the reality of the shortage of firefighters and equipment at Regency level and the totally inadequate budget available to remedy the deficiencies. Money must not be diverted to national level state-of-the-art detection and surveillance systems at the expense of immediate and direct support to the Regencies.

However we see no contradiction in looking five to ten years ahead and suggesting that the use of helicopters may be the best way to fight fires in the coastal wetlands. In peat areas the prompt suppression of small fires in El-Nino years is essential. Unchecked, fires rapidly grow uncontrollable; the land is severely degraded and the smoke haze, hazardous. Preliminary studies (FFPCP, 1997b) indicate that in such cases the use of helicopters to quickly move a task force of men and equipment to the site of small fires is appropriate. Thereafter the machine can re-supply the ground crew. If suitably equipped the helicopter can also act as a water-bomber, re-filling at those canals and rivers that are still flowing (Figure 3).

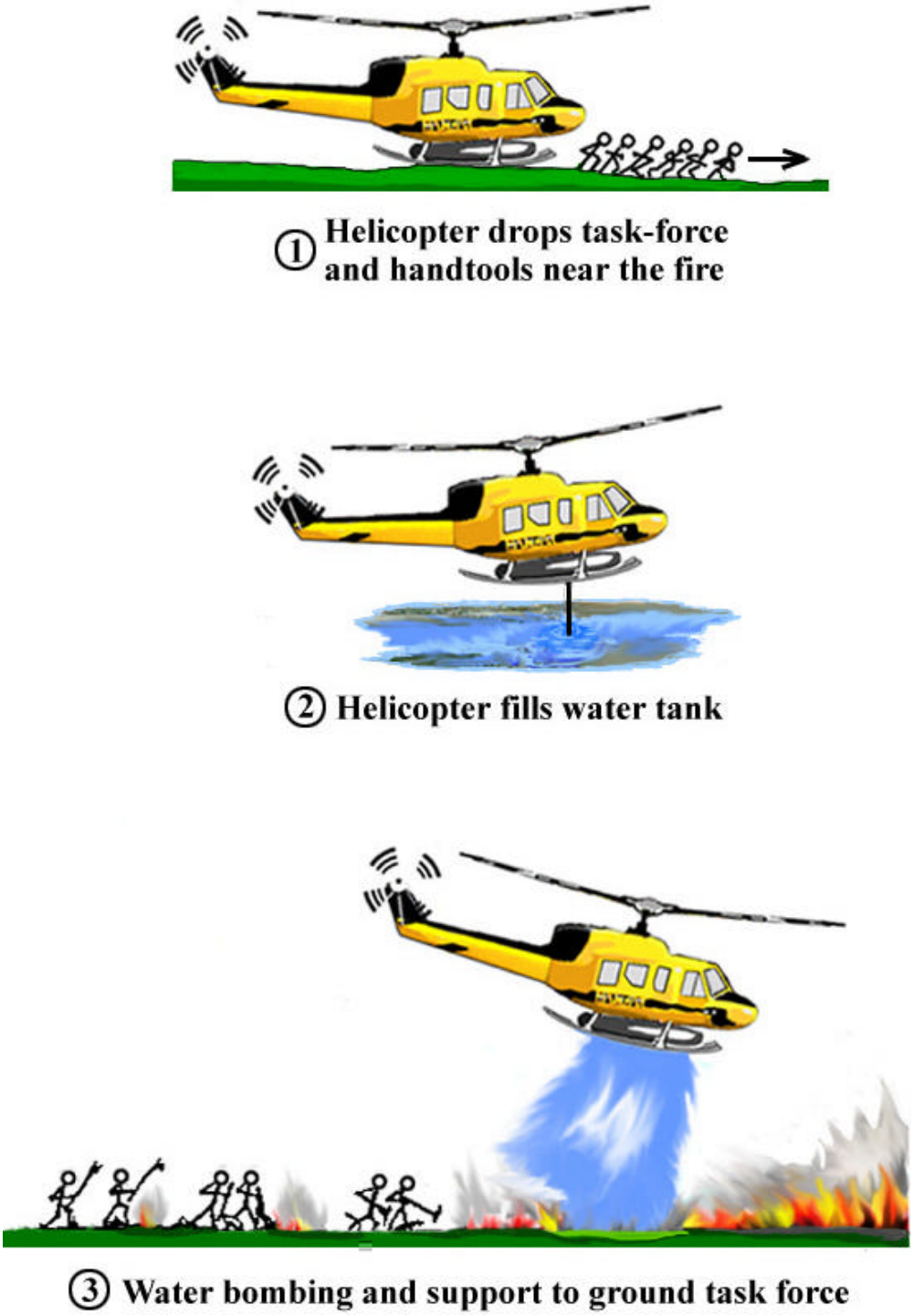


Figure 3. The three action phases of a water-bomber helicopter; Bell 205 or similar fixed tank machine.

3. COAL SEAM FIRES

Background

Responsibility for the control of coal seam fires lies with the Ministry of Mines and Energy. Work on the suppression of surface seam fires is being assisted by FFPCP and three other projects sponsored by JICA (Makihara, 1998), GTZ (Anon. undated), and USAID (Anon. 1999). FFPCP, and the GTZ and JICA projects are attached to MoFEC, the USAID to the Ministry of Mines and Energy.

JICA, GTZ and USAID work in the province of East Kalimantan and have directed their main efforts to extinguishing seam fires – some ten to date - that threaten the Balikpapan to Samarinda road. USAID has sent four Ministry of Mines staff on a 'train the trainers' course in the USA.

Coal Seam Fires

Coal fires, caused by spontaneous combustion that ignites gases produced in seams exposed by erosion, geology and mining, are well known in Indonesia. The process is favoured by periodically dry, warm climates (Rosema, Gendersen and Schalke, 1989). Thermo-luminescent analysis of burnt clay lying over an extinguished coal seam near active coal fires in East Kalimantan, showed that the seam fires are not new and some date back 15 200 to 17 300 years (Goldammer and Seibert, 1990). Surface coal seams can also be ignited by wildfires caused by lightening or planned burns that have escaped control. As the seams continue to burn they, in turn, may cause further wildfires. However, observations by FFPCP suggest that in South Sumatra, burning coal seams only spread vegetation fires in drought years.

The edges of the burning coal seams progress slowly through the ground within the forest. Makihara (1998) reports rates of 4 – 5 m. per year for coal-seam fires started by the 1982 - 1983 forest fires in Bukit Soerhato National Park, East Kalimantan. Similar rates of progression for the South Sumatra fires are suggested by FFPCP visits and interviews; and this speed of burning is in accord with the experience of Rod (pers. comm.) for seams in Muaraenim Regency. There is therefore no call for immediate action.

Plate 14. Sub-surface coal seam fire under primary forest on the bank of the Musi River bank near Muaraenim in July 1997.

Safety Considerations

Fighting coal-seam fires brings added dangers to those faced during the suppression of vegetation fires. The soil is liable to collapse under foot as the coal burns holes beneath the surface. Hot steam and smoke are both annoying and toxic: the combustion process itself produces significant quantities of carbon dioxide and noxious carbon monoxide, sulphur dioxide and mixtures of oxides of nitrogen. If water is forced into the seam under pressure in an attempt to extinguish it, chemical reactions lead to the production of further volumes of carbon monoxide.

Firefighters must move carefully. Adapted clothes, strong boots, gloves, a helmet, goggles and breathing protection hood are essentials (Nicolas and Beebe, 1999a).

Plate 15. Individual protective equipment used by firefighters from the Provincial Forestry and Estate Crops Office of South Sumatra.

General Recommendations

Accepted methods to suppress surface seam fires are by covering with soil, by blasting burning coal outcrops, or by injecting water under pressure into the sub-surface fire pockets. It is not worth trying to fight the exposed parts of the fire with high-pressure pumps; as found by PT. Musi Hutan Persada, success is rare – see below.

It is also possible to quench coal seam fires where streams can be dammed or diverted to act directly and continuously on the seat of the fire (Makihara, 1998). But such exercises can only be justified if valuable infrastructure such as major roads or buildings are threatened. In most cases the only economical way of control is to limit the potential damage by preventing fire spread into surrounding fuels.

On flat ground a fire trench at least 1.5 m wide is dug down to mineral soil to isolate seam fires. Where access allows, a track-hoe or bulldozer makes construction easier and more effective.

Figure 4. Undercut fire trench dug down to mineral soil to isolate a coal-seam fire.

Burning seams that runs horizontally across slopes must have an undercut-line put in place below. Burning materials up to log size, roll downhill as the fire burns around them and scatter ignited matter down the slope. The undercut fire trench must be deep enough to catch and hold all the material that may roll into it. A width of 1.0 m. and a depth of 300 mm. is usually sufficient; the excavated earth is banked-up along the lower edge to increase the holding capacity. The trench must be periodically emptied and strengthened. Potential fuels above the fire trench - rotting stumps and logs - are covered with sufficient mineral soil to insulate them.

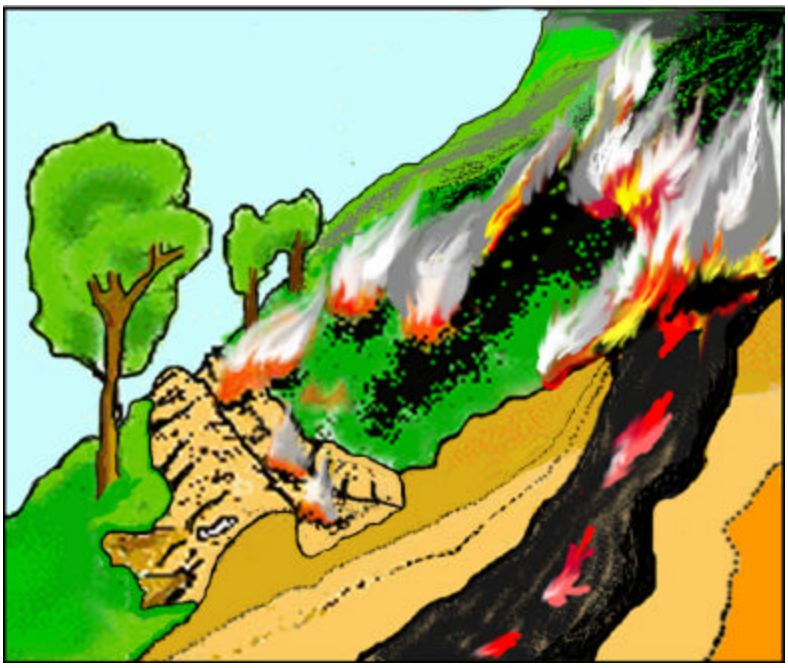


Figure 5. Undercut fire trench built below the line of a burning coal-seam that runs horizontally across a slope.

Containing Coal Seam Fires in South Sumatra

Five seam fires in Muaraenim Regency were studied by FFPCP in mid-1997. A deep-seam fire had burnt for four years without incident outside PT. PLM Solar – a petroleum storage company - in Tanjung Enim and was used by villagers as a rubbish disposal system. The extinction of such a deep-seated fire is impossible - water is ineffective - and as the fire was of no direct danger and no infrastructure was threatened, action was limited to clearance of the sparse vegetation in the immediate vicinity. The fire was then left to burn.

Two coal-seam fires that had suddenly appeared and ignited nearby vegetation were visited inside the concession of PT. Musi Hutan Persada near Suban Jeriji, in Muaraenim Regency. The original ignition source is not known with certainty but was most likely itself a vegetation fire of which no trace remained. The seam had probably burnt underground and undetected for over two years.

The first seam was in an inaccessible, rugged terrain *Acacia mangium* plantation. A bare-ground firebreak with a minimum width of 1.5 m. was made around the burning seam using hand tools. A low chance of spread - and thus value at risk - difficult access, and a lack of a stream that could be easily diverted made suppression both unnecessary and infeasible. A permanent system of fire-watchers was started to ensure prompt control of any further spark-induced fires in the plantations. The watchers remained in place for the duration of the drought.

Two further coal-seam fires – also in *Acacia mangium* plantation – had burnt since 1995 close to a wide track. Musi Hutan Persada had unsuccessfully attempted to extinguish the fires in 1996 using high-pressure hoses to surface spray the fire for a number of days. The ground was flat and there was little risk that spark-induced fires would spread either within the plantations or to adjacent logging areas. A bulldozer was used to make a firebreak around the seam fire and permanent watchers organized. Further attempts to extinguish the fire were not justified.

Plate 16. Construction of a bare-ground firebreak with hand tools; Suban Jeriji, August 1997.

Plate 17. Bulldozer construction of a large firebreak; Suban Jeriji, August 1997.

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ABBREVIATIONS AND ACRONYMS

AVHRR	Advanced Very High Resolution Radiometer
BAPPENAS	National Development Planning Agency
EU	European Union
FFPCP	Forest Fire Prevention and Control Project (EU)
GTZ	Deutsche Gesellschaft fur Technische Zusammenarbeit (German Agency for Technical Cooperation)
HPH	Hak Pengusahaan Hutan (Forest Concession)
HPHTI	Hak Pengusahaan Hutan Tanaman Industri (Industrial Plantation)
IFFM	Integrated Forest Fire Management Project (GTZ)
JICA	Japan International Cooperation Agency
MoFEC	Ministry of Forestry and Estate Crops
MUBA	Musi Banyu Asin (name of a Regency in South Sumatra)
NOAA	National Oceanic and Atmospheric Administration
OKI	Ogan Komering Ilir (name of a Regency in South Sumatra)
PT.	Perseroan Terbatas (Limited Liability Company)
RePPProt	Regional Physical Planning Programme for Transmigration
UNDP	United Nations Development Programme
USAID	United States Agency for International Development