PN-ACS-859
120087

AGENCY FOR INTERNATIONAL DEVELOPMENT
PPC/CDIE/DI REPORT PROCESSING FORM

ENTER INFORMATION ONLY IF NOT INCLUDED ON COVER OR TITLE PAGE OF DOCUMENT

1. Project/Subproject Number
498-024

2. Contract/Grant Number
IAA AAG-P-00-97-00003-00

3. Publication Date
February 2002

4. Document Title/Translated Title
Fires in Indonesia: An Assessment of the Causes. Summary of Research Findings 1997-1998 Fires

5. Author (s)
1. Center for International Forestry Research (CIFOR)
2. International Center for Research in Agroforestry (ICRAF)
3. USDA Forest Service

6. Contributing Organisation (s)
ASEAN, East Asia and Pacific Environmental Initiative (EAPEI)

7. Pagination
16

8. Report Number

9. Sponsoring A.I.D. Office
USAID Bureau for Asia and the Near East
East Asia and Pacific Environmental Initiative (EAPEI)

10. Abstract (optional - 250 word limit)

Large-scale fires and associated smoke is an increasing problem in Indonesia and surrounding countries as evidenced by large scale burning in 1982/1983, 1987, 1991, 1994, and 1997/1998. These fires devastated large areas of forest and caused significant economic losses, both in Indonesia where most fires occurred and in neighboring countries.

In 1998, the Center for International Forestry Research (CIFOR), the International Centre for Research in Agroforestry (ICRAF), and the United States Forest Service (USFS) commenced a multi-disciplinary study looking at the underlying causes and impacts of forest and forest land fires in Indonesia. In order to assess the relative roles of the different factors influencing the creation of fire-prone and fire-resistant landscapes, eight study sites with different historical land use patterns were chosen across Sumatra and Kalimantan.

Details at http://www.cifor.cgiar.org/fire-project/index.htm

11. Subject Keywords (optional)

1. R08.5
2. R11.53
3. R11.D5
4. R11.D5.2
5. R13
6. Indonesia

12. Supplementary Notes

13. Submitting Official
Tim Resch

14. Telephone Number
202 712 4453

15. Today's Date
April 5, 2002

.....DO NOT write below this line.....

16. DOCID

17. Document Disposition
DOCRD [ ] INV [ ] DUPLICATE [ ]

AID 590-7 (10/88)

Fires in Indonesia

SUMMARY OF RESEARCH FINDINGS: 1997-1998 FIRES

Fires in

Burnt swamp forest in the lakes area of Danau Sentarum located in West Kalimantan (Borneo). Although much of the area is a National Park, use of fire has increased due to intense competition for land. Agriculture, hunting and fishing, and oil palm development have increased in the region. The area is critical habitat for wildlife species including the orangutan and proboscis monkey.

Cover: Fire on an acacia plantation in Sumatra.

Indonesia

El Niño inspired fires raged across Indonesia from 1997 to 1998, polluting the air of much of Southeast Asia, intensifying cultural conflict within the area, and harming Indonesia's potential for viable participation in the global economy. The fires caused an estimated $9 billion (US) in damage, while carbon emissions elevated Indonesia to one of the largest polluters in the world (ADB 1999; Barber and Schweithelm 2000). The resulting smoke plume spread as far as southern Thailand and the Philippines, placing the health of over 75 million people at risk.

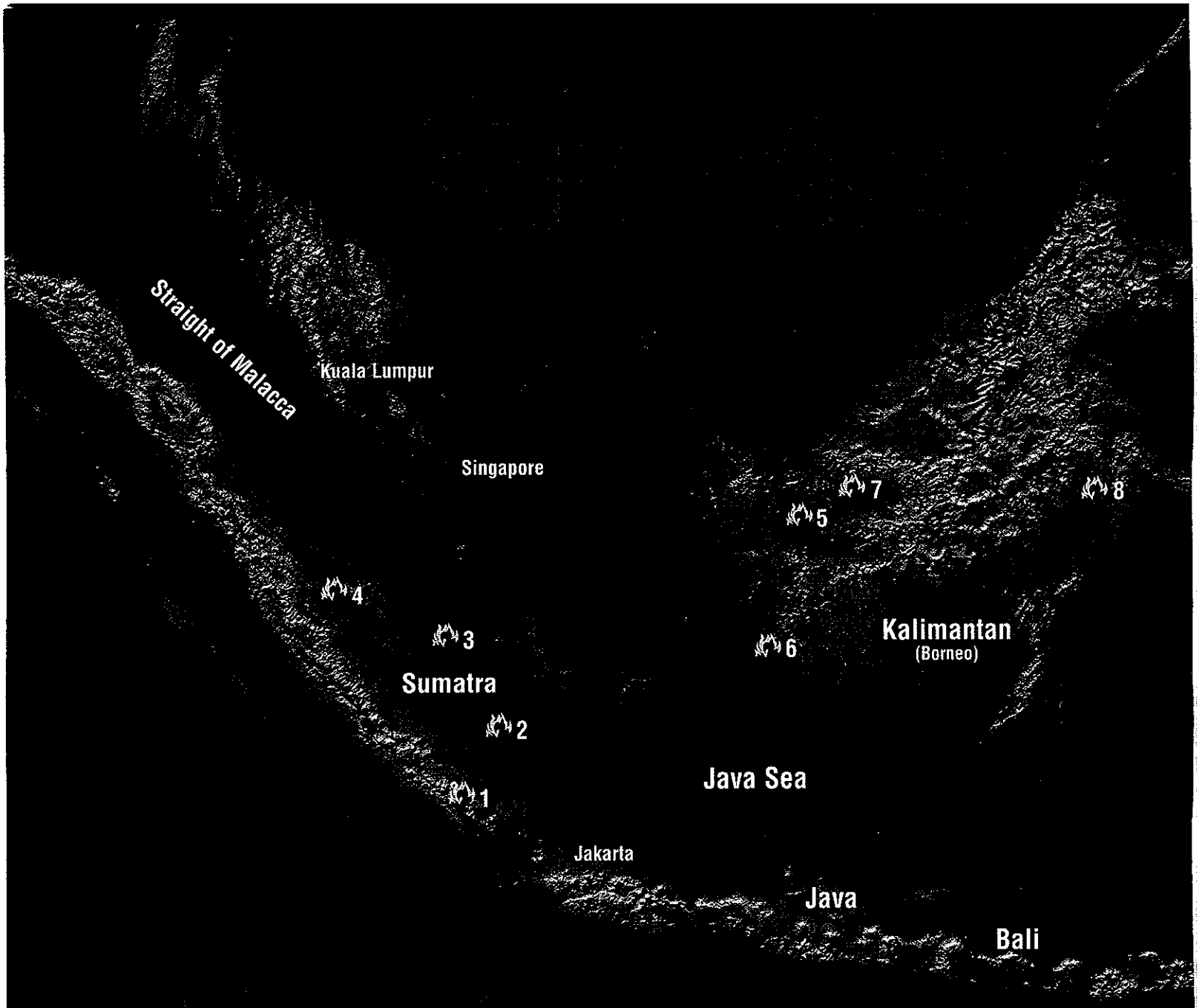
Fires in the region are not new; they have occurred throughout the archipelago in the past. For instance, major fires occurring during the El Niño years 1982-83, 1987, 1991, and 1994 (Dennis 1999) devastated large areas of forest and caused significant economic losses, both in Indonesia and in neighboring countries. Numerous factors perpetuate the problem to this day, promising to escalate the intensity of damage with every El Niño cycle.

Although the majority of fires were – and continue to be – deliberately set, the underlying causes were poorly understood. Numerous claims regarding the causes of fire in Indonesia have been made. In 1994, for example, the Indonesian government asserted that slash-and-burn activities by small holders accounted for more than 85 percent of the 5 million hectares burned (*Jakarta Post*, 7 October 1994), while environmental organizations blamed forest concessionaires and plantation owners (*Jakarta Post*, 3 October 1994). Data collected from satellite imagery in 1997-1998 indicated that large-scale land clearing for pulp and oil palm plantations were the major causes of the 1997-1998 fires. Fires occurred, however, at multiple scales and for many reasons.

The Center for International Forestry Research (CIFOR), the International Centre for Research in Agroforestry (ICRAF), and the USDA Forest Service, conducted research to assess the underlying causes of fires in Indonesia. To measure the relative roles of the different factors influencing the creation of fire-prone landscapes, eight study sites with different historical land-use patterns were identified across Sumatra and Kalimantan. A number of common land-use situations were encountered including large-scale plantations, transmigration projects, small-holder plantations, logging concessions, and agriculture. The sites also included areas with peat soils, the burning of which contributed substantially to smoke and haze during the 1997-1998 fires.

Data collected from the sites described the extent to which the fires were influenced by land-use policies and practices, from the village or landscape level to the national level. Combining spatial analysis (via satellite imagery, aerial surveys, and extensive field investigations) with social-science research provided information on the location, extent, and type of land cover burned. Through extensive interviews with local people, combined with on-the-ground participatory mapping, researchers answered questions about the causes (why), nature (what), and perpetrators (who) of the fires.

This paper highlights the key findings of the research and concludes that a diverse set of political and institutional changes are needed in Indonesia's management of its natural resources. Based on the analysis of underlying causes, possible policy implications are highlighted.



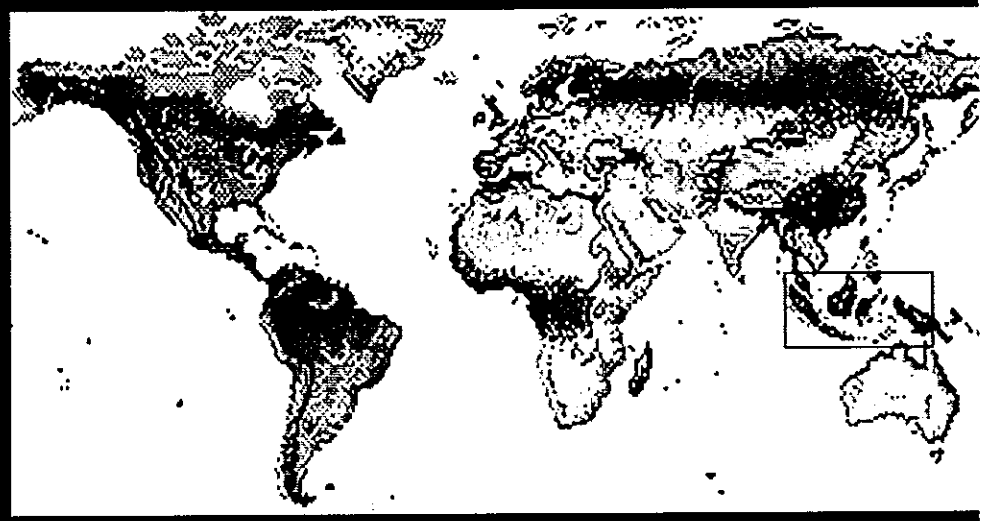
Eight study sites were identified across the islands of Sumatra and Borneo (Kalimantan) covering common land-use situations including large plantations, transmigration settlements, small-holder plantations, logging camps, natural forests, and agricultural areas. These two islands are economically important to Indonesia, consequently the rate of deforestation and conversion to other land uses is high. Fires were common in many of the study sites in the 1980s and early 1990s.

1. Sekincau, Lampung — This mountainous area is characterized by expanding coffee gardens, illegal logging, and weak law enforcement in and around a national park. These features contributed to the spread of deliberate and accidental fires.

2. Menggala, Lampung — With peneplains to the west and coastal swampland to the east, this region is marked by large forest plantations and small rice farms. Forests are burned to prepare land for farming and to settle disputes in land tenure.

3. Musi Banyu Asin (MUBA), South Sumatra — The peat soils and vegetation that burned beneath the swamp forest of this area contributed much of the smoke that drifted across Southeast Asia. Large-scale fires were ignited by illegal loggers, fishermen, and swamp-rice cultivators. Swamp forests transformed into scrublands exacerbate the problem.

4. Tanah Tumbu, Riau — Oil palm plantations have increased in this area dramatically over the past 30 years. Fire has been used to clear and prepare land for plantations. Arson attacks on plantations are also common.



Philippine Islands

Celebes

Irian-Jaya

Flores

Timor

5. Sanggau, West Kalimantan — Natural forests at this site have been replaced by fire-prone grasslands and scrub forests. This site was reportedly burned by plantation staff who wished to speed up the appropriation of land and by villagers who wished to reclaim property they believed was wrongly cleared by plantation companies.

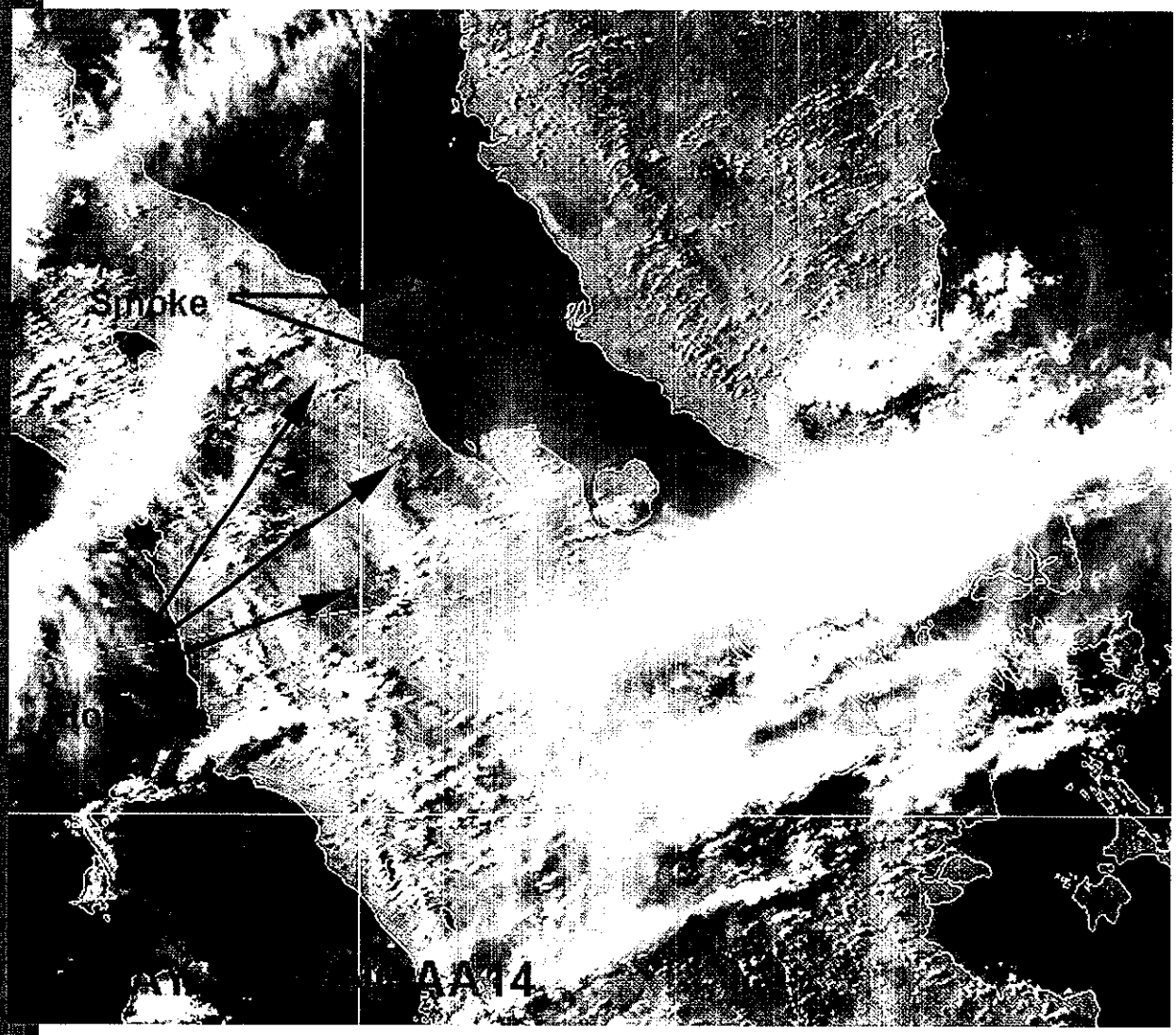
6. Tumbang Titi, West Kalimantan — This low-elevation site consists mostly of fire-prone grasslands, indicative of highly degraded and improperly managed land. One portion of the site, however, is hilly and still covered with natural forest. Villagers harvest honey on bee boards scattered throughout the forest. The forest provides a major source of income. The community is still ruled by *adat*, or local law, and people suppress unwanted fires and protect the land.

7. Danau Sentarum, West Kalimantan — This site is characterized by seasonal lakes, swamp-forest flooding, and low hills. Two groups inhabit the area: a fishing community near the river and farmers/hunters who live in the hills. Most fires have resulted from local resource extraction, increased population, and access. Fire has not been a factor in high swampland and temporary agricultural areas.

8. Long Segar, East Kalimantan — This area has been severely degraded by development and fire. Timber companies harvested the lowland forests and plantation companies supported by transmigration policies followed. Population has increased greatly and newcomers have no sense of identity with the land and thus do not protect the area from fires.

Methods

A multilevel approach was used to address the causes of fires. The research made use of satellite imagery, aerial surveys, and field assessments and interviews. Remote sensing and geographic information systems (GIS) were used for gathering spatial information on planning boundaries, fire scars, forested concession areas, land-use and land-cover changes. Through extensive interviews with local people and on-the-ground participatory mapping, information was derived regarding the underlying reasons for the fires. This combined approach provided an understanding of the historic and current patterns on the sites in terms of fires.

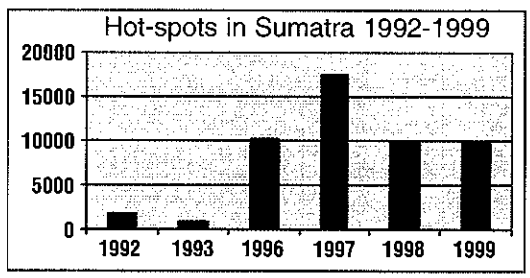


Smoke drifts from Sumatra across large portions of Southeast Asia including Singapore and Maylasia. This imagery, available daily from NOAA, provides information on the location of fires and drifting smoke.

Remote Sensing and Geographic Information Systems

Remote sensing and GIS were used to analyze changes in land cover and land use over time. Information on the frequency and location of fires was derived from "hot-spots" visible on NOAA-AVHRR (National Oceanic and Atmospheric Administration - Advanced Very High Resolution Radiometer) satellite imagery. Analyzing hot-spots from the 1997-1998 fires provided an indication of the location and the duration of fires. Hot-spots dating back to 1992 were compared to understand yearly patterns of burning (right). Sets of high-quality, remotely sensed imagery were also acquired for each of the study sites (opposite page). These included Landsat Thematic Mapper (TM), Multi-spectral Scanner (MSS), SPOT, and synthetic aperture radar (SAR) imagery. In general, these image sets spanned two decades from the mid-1980s to the late 1990s.

From these images, land cover and burn scars relating to the fires could be mapped. The multiple-date image sets were used to determine trajectories and area estimates of vegetation change. For example, the area of forest burned and converted into coffee or oil palm plantation was monitored.



Hot-spot histories from the NOAA-AVHRR satellite imagery were assembled to depict fire frequency over the past decade.

Social Surveys

Assessments were done on a local level through contacts with community leaders, logging companies, local officials, and others. Based on information learned at each site, landscape-level maps were created, depicting land cover, fire scars, and land use. The verbal narrative developed from this process is perhaps the most important element in defining the true causes of the fires. Fire and land-use history, land-clearing customs and techniques, and institutions and people involved were also recorded. Information collected locally was used in the broader area analysis completed from satellite imagery and aerial survey.

Participatory Mapping

26 June 1986

26 June 1992

26 January 1998

Most of the swamp forests have disappeared in the Musi Banyu Asin study site located in South Sumatra. Landsat images document the disappearance of forest and increase in fire since the 1980s. In 1997, fires started by illegal loggers, fishermen, and swamp rice cultivators, burned 45 percent of the land area. Since this is a transmigration area, the draining of swamps and poor logging practices (both legal and illegal) left the area susceptible to devastating fires.

Drainage canals

Land cover

- high density swamp forest
- low density swamp forest
- high density estuarine forest
- low density estuarine forest
- mangrove forest
- riverine vegetation
- scrub and grassland
- swamp scrub
- dry swamp scrub
- mixed agriculture (transmigration)
- wet land cultivation
- burn scars
- settlement
- water

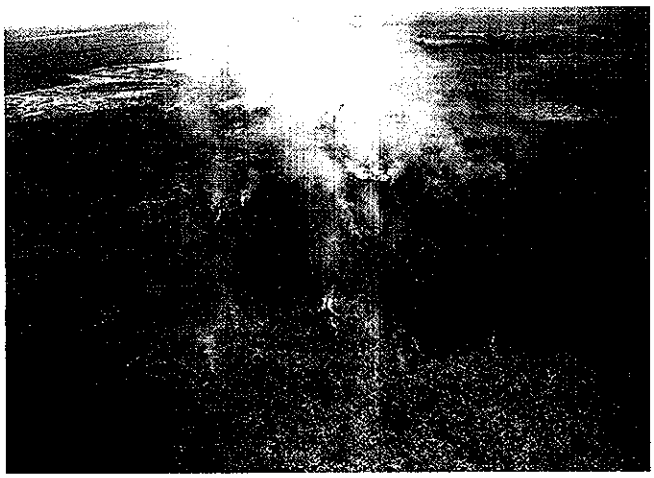
N

10 0 10 20

Kilometers

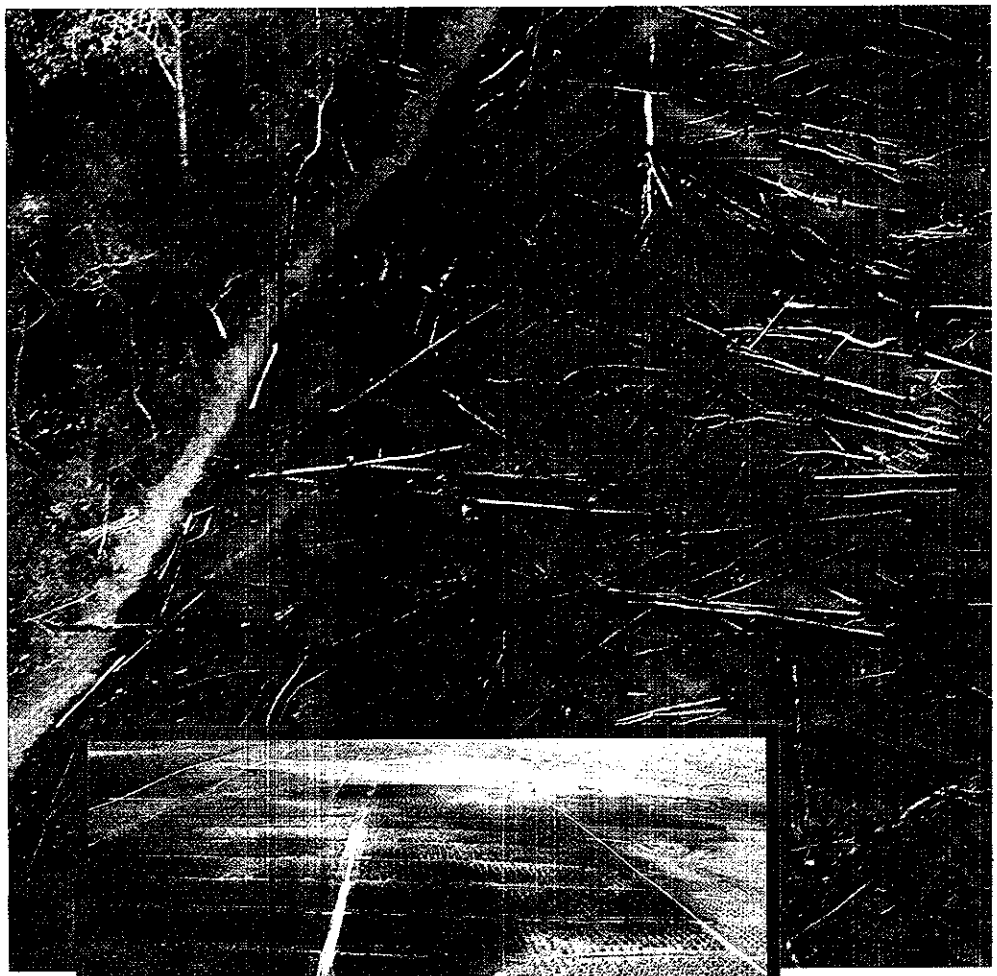
Causes of Indonesia's Fires

The Indonesian dry season of 1997 was unusually severe. The global weather pattern El Niño created drought conditions throughout the area. The fires in Indonesia were exacerbated by these conditions, but the fires were also the product of a larger socioeconomic situation. Those who argue that the 1997 fires were mostly due to weather conditions point out that the social issues behind those fires were not necessarily worse that year than any other year. The issues existed before 1997 and also exist today. The study clearly revealed, however, that increasingly problematic social conflicts instigated many fires. Thus, to accurately assess the causes and effects of the fires, the socioeconomic situation of the country, the land ownership patterns, the government's priorities, and the needs of the common people must all be examined.



Indonesia has the third-largest tract of tropical forests in the world. Indonesia's growing population along with the worldwide demand for raw products, such as wood fiber, latex, and palm oil, places persistent pressure on these natural forests. As few as 30 years ago, many of the areas surrounding the study sites were dense tropical forests. Since the early 1970s, however, the government has promoted two development-oriented programs for these areas: logging concessions for private companies and transmigration of people from densely populated regions to less densely populated regions in Sumatran and Kalimantan. These programs have served to open remote areas, clear dense forest, and provide easy access.

Though the direct causes of fire ignition stand out as obvious factors, indirect causes, which include underlying motivations that lead individuals and groups to light the fires, are equally important. The causes of fire are not mutually exclusive and are often interrelated. Understanding direct and underlying causes is important for recommending appropriate policies that may limit the detrimental effects of fire.



Direct Causes

The research done by CIFOR, ICRAF, and the USDA Forest Service found that there are generally four direct causes of fire in Indonesia. The most important direct causes of fire resulted from land clearing fires and accidental fires. It should be noted, however, that in most cases the accidental fires arose from the lack of incentives for people to manage fire not on their land.

1. Fire as a Land Clearance Tool

Large and smallholders alike have found that mechanical removal of low-quality woody material from an area is expensive, while clearing the land with fire is cost-effective. Both small farmers and large commodity producers use fire for agricultural site preparation – clearing land for gardens, rice fields, or oil palm and pulp plantations. In most cases the fires are deliberately set. One example is the increase of oil palm plantations in Indonesia from 120,000 hectares in 1989 to almost 3 million hectares by 1999. Fire was used as a land clearance tool by many companies. In the Tanah Tumbah study site in Sumatra's Jambi province, concentrations of fire identified from satellite in 1997 were found within the boundaries of the PT SMA and PT Tebora oil palm plantations.

Fire is used as a tool for land clearing. Land holders deliberately set fires as part of land preparation for production of agricultural or plantation crops and establishment of transmigration settlements.

2. Accidental Fires

The greater the population in formerly remote, forested areas, the greater the chance for mistakes that start fires, especially by temporary residents who have come for resource extraction and care little for the long-term health of the local forest. Loggers, for example, may start fires for cooking and leave them to burn and spread to the surrounding forest. In the Musi Banyu Asin study site in South Sumatra province, the majority of large fires in 1997 began as small, deliberately set fires which subsequently got out of control. Most of these fires were started by illegal loggers, fishermen, and transmigrants.

3. Fire as a Weapon

The lack of an equitable system for allocating land and resources between indigenous peoples, migrants, and corporations often leads to conflict. Arson, a means of asserting rights and driving competition away, was a major cause of fire in many of the resource-rich areas where these conflicts are especially fierce. Farmers and local communities who feel that they were unfairly deprived of their land by plantation companies and others are using fire to reclaim land and destroy property. For example, in the Menggala study site located in Lampung province, 700 households have laid claim to 7,000 hectares of oil palm and coconut plantation. They have used fire to destroy over 400 hectares of coconut and considerable areas of oil palm. This pattern is being repeated in many parts of the country.

4. Fire as a Means to Improve Access

Hunters, beekeepers, fishermen, and farmers set fires to clear underbrush and improve access to forest areas for resource extraction. Sometimes these fires escape and burn out of control into forests that are already susceptible to burning. In the Danau Sentarum area in West Kalimantan – a remote region of lakes and seasonally flooded peat and swamp forest – many of the fires in the 1990s were set by fishermen searching for the valuable arowana fish in swamp forests.

Underlying Causes

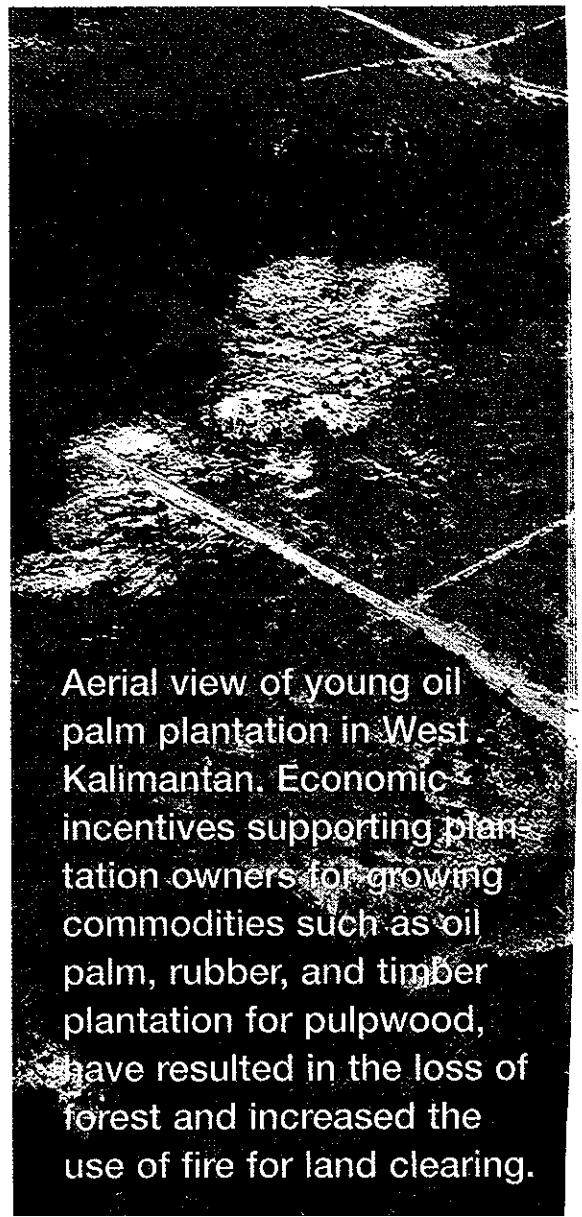
While the four direct causes of fires stand out as major contributors to the ignition of fires, six underlying conflicts and unresolved social problems in Indonesia act as indirect, but equally significant, causes of fire. An understanding of these underlying causes is a crucial step in developing effective, appropriate, long-term policy.

1. Land Tenure – A Confused Issue

A lack of formal rules governing who owns and uses land has led to an increase in the scale, severity, and frequency of fires in Indonesia. In some parts, smallholders have sought to establish *de facto* rights over public lands, or over land where ownership is disputed, by using fire to clear vegetation prior to occupying the land and planting crops. The frequency and severity of fire is increased in at least two ways. First, as mentioned previously, when the conflict becomes particularly bitter, the parties may resort to arson, creating fires that can quickly spread out of control. Second, if ownership is in doubt, as when fire is used to clear natural forest, communal lands, or existing plantations to make room for new crops, there is little incentive for people to use care in their handling of fire or to expend effort extinguishing fires once they have begun. In such a way transmigrants, mainly from Java, have appropriated over 30,000 hectares of land in Bukit Barisan Selatan National Park (Sekincau, Lampung study site) and transformed what used to be pristine forest into coffee gardens. Admittedly, the smallholders followed in the wake of illegal loggers, but their actions have effectively claimed a considerable area of national park for agriculture. Further north, in the Menggala study site, smallholders have used fire to take over plantations on land where the rights of ownership and use are contested.

Increased knowledge of the profitability of coffee production combined with increased access to land in the National Park brings new migrants to the area.

Deforestation in a national park located in the Sekincau, (Lampung Province) Sumatra study site. Fire was used to clear land for coffee cultivation or set accidentally by individuals engaged in illegal logging. Lack of incentives or will on the part of local communities or authorities led to uncontrolled spread of fire into nearby forests.



Aerial view of young oil palm plantation in West Kalimantan. Economic incentives supporting plantation owners for growing commodities such as oil palm, rubber, and timber plantation for pulpwood, have resulted in the loss of forest and increased the use of fire for land clearing.

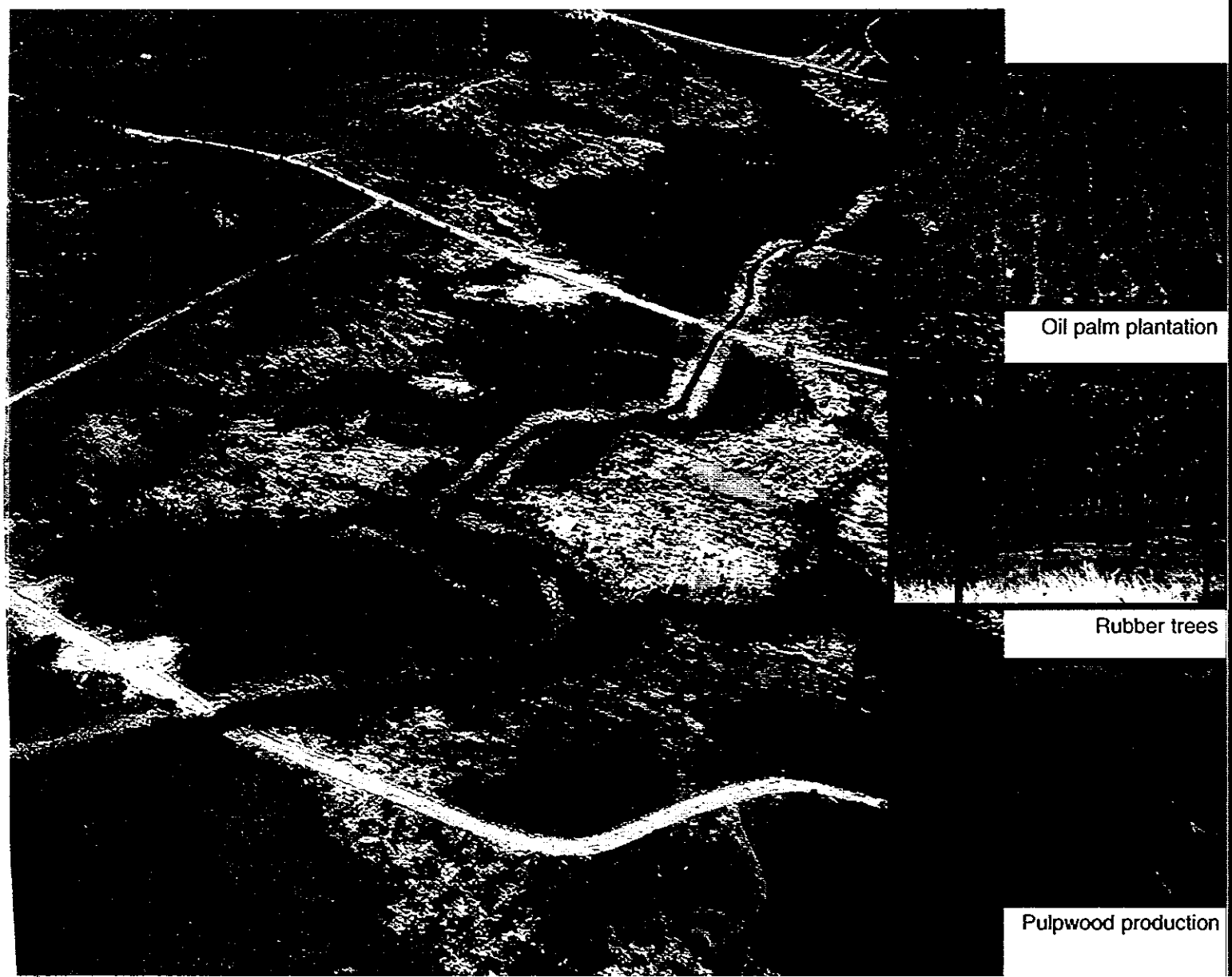
2. Land Use Allocation

In Indonesia we are witnessing a clash between traditional law and the law of the state. Often, the overlap between two fundamentally different systems of social structure causes conflict that results in the use of fire. On one hand, many of the small, resource-dependent communities made up of either indigenous people or rural migrants operate under a traditional form of local law called *adat*. The important features of this system include community ownership of a certain claimed territory surrounding the village and dispute arbitration by the local headman. On the other hand, the nation of Indonesia is centrally governed from Jakarta with regional or territorial governors and their staffs. Under this system, land is often granted in large swaths to corporate concessionaires for development. These land grants acquire the veneer of legality and have been enforced by the military, but may directly overlay large areas claimed by villages as communal territory. Often, these allocations may be inappropriate for the intended purpose, such as in areas covered by lowland swamp forest. One example of inappropriate use is the one million hectares of largely peat land that was allocated by the central government for rice production in Kalimantan. The area which was cleared, drained, and burned, has been abandoned for large scale rice production, leaving a social and environmental disaster.

Coffee production started around the charred remains of what was natural forest prior to burning in the 1997 fires.

3. Economic Incentives and Disincentives

Natural forest in Indonesia is often perceived of as having little value. Thus, the profitability of clearing the forest through inexpensive means – fire – to meet global demands for coffee, rubber, and other commodities encourages its use. Perverse incentives, such as those rewarding companies that transform production forests into plantations, encourage the clearing of natural forests. In addition, corrupt land acquisition practices allow a politically powerful elite to dismiss international business ethics. These perverted development incentives and mechanisms promoted the clearing of forests by fire.



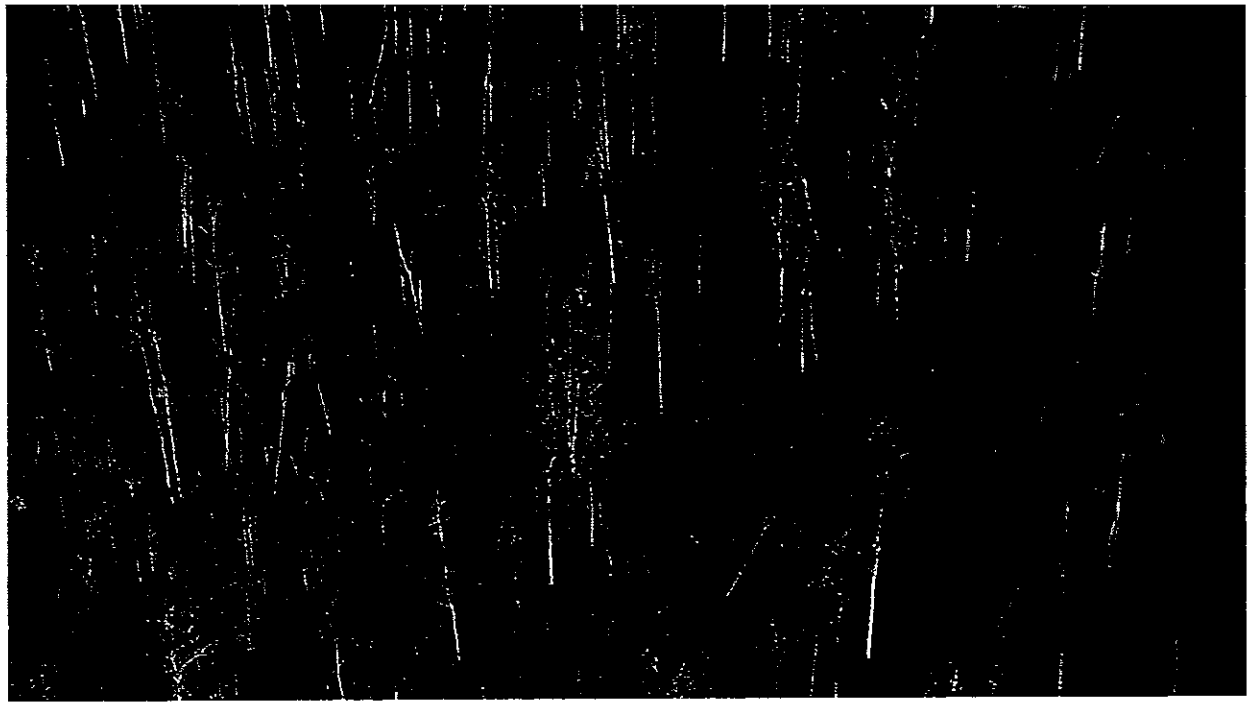
Oil palm plantation

Rubber trees

Pulpwood production

An area of natural forest in South Sumatra with trees in the upper canopy rising to greater than 50 meters. Natural forests in Indonesia are becoming rare as destructive forestry practices have altered the environment and created forests prone to fire.

Illegal log landing site (above) and covert logging trail (left) hidden in the swamp forests of South Sumatra. Extraction of the largest trees results in accumulation of slash and woody debris on the forest floor, reduction in humidity, and creation of a favorable environment for frequent, large fires.



Illegal loggers have removed the largest trees, leaving the remaining forest more vulnerable to fire. When fires start they are left to burn because the remaining forest is seen as having little or no value.

4. Poor Forestry Practices

Much of Indonesia's natural forest has been logged over the past 30 years. Slash and woody debris left on the ground at the conclusion of logging dries and provides fuel for subsequent fires. Logging is often accompanied by drainage and channeling of swamps for transportation. The effect that these forestry practices have on the fire regime is considerable. Many areas do not regenerate quickly or naturally and are thus converted to grasslands, shrub forests, and plantations, which are more susceptible to frequent, large fires. Moreover, the transition from healthy tropical forest to grassland or plantation also reduces the humidity of these areas. If land-management techniques are not improved and disturbed forests are not protected from fire, much of the logged-over forest will be reduced to shrubland or grassland (*imperata*) by fire. Chronic fires severely limit options and possibilities for rehabilitation.

Imperata

5. Shifting Populations

Since the early 1970s, the Indonesian government has promoted large-scale migration as a way to mitigate population pressure in some of its more densely settled regions. The transmigration settlements are often populated by farmers not familiar with safety measures associated with responsible fire use. Fires set by these newcomers may escape and quickly spread out of control. In addition, these relocation programs increase the potential for conflict between traditional and migrant resource user groups. In the Menggala study site in Sumatra, vast areas of swamp forest were cleared to make way for transmigration schemes. At the same time the area burnt for swamp rice cultivation (sonor) continues. This is a significant problem since much of the smoke and carbon dioxide emitted during the annual fires comes from the burning of swamp-land peat. On the other hand, during the 1997/98 drought, the Dayak forest dwellers in Kalimantan, who traditionally use fire to clear plots of land for shifting cultivation, refrained from burning forests: They knew that drought made it too dangerous. However, many transmigrants, who lacked the Dayak's knowledge of how to use fire judiciously, set fires which swiftly burned out of control.

6. Inadequate Fire-Suppression Infrastructure

Many formerly rural areas of Indonesia lack the leadership, planning, and equipment to suppress fires, even when the entire community desires it. Often, no competent organization is in place to coordinate and manage fires. Land-management institutions, such as national parks, are woefully understaffed and underfunded, leaving them unable to engage in suppression activities.

Policy Issues, Implications and Recommendations

With support from the international community, the Indonesian government must formulate and implement policies to mitigate the direct and underlying causes of the destructive annual fires. Policies that reduce fire used as a tool in land clearing and resolve land-use allocation and tenure problems are of particular importance. Additional policy changes should reduce forest-degrading practices and alleviate shifting demographics that result in increased burning. Economic incentives and disincentives, as well as expansion of institutional land-management support, should establish sustainable land and fire use. The recommendations must be implemented in a coherent manner if the region is not to experience, once again, the sort of devastation inflicted by fire during the previous El Niño drought. The research conducted by CIFOR, ICRAF, and the USDA Forest Service yielded the recommendations highlighted below:

1. Reduce the Use of Fire as a Land Clearance Tool

In 1994 the Indonesian government, under pressure from neighboring countries, issued a zero burning policy. The policy has been largely ignored: Each dry season tens of thousands of fires are deliberately set, and authorities do little to stop the practice. A policy such as this is clearly difficult to enforce in a nation as diverse as Indonesia. A better solution might be a system of more targeted regulations allowing burning where appropriate and banning fire use only during extremely dry years. Where burning is practical, such as areas where peat soils are not present, methods that generate less smoke are needed. For example, reductions in the quantity of fiber burned could be accomplished by abolishing export levies placed on low-quality wood. This would provide incentive for logging companies to utilize less valuable trees or portions of trees. These low-value trees could be marketed and removed mechanically rather than left on the forest floor to burn. At the same time, alternate methods of land clearing and land management, such as large scale mulching using heavy machines, two stage harvesting (pulp logs and then plywood logs), and gap planting, should be encouraged. These methods would reduce the area cleared using slash-and-burn techniques.

2. Reform Land-Use Allocation and Tenure

This is an issue of major importance. Dramatic improvements in the mechanisms of land allocation and in the institutions that protect land ownership are necessary for Indonesia to solve many of the underlying conflicts leading to the use of fire as a weapon. Corrupt, secret, and unfair allocation of large land areas to politically connected corporations at the expense of local communities and indigenous people must be curtailed. This is one of the key motivators for arsonists. Moreover, a fair and transparent legal system for resolving issues of land ownership and land use is critical. Explicit procedures for the resolution of conflict must be in place before fires will cease to be used as a weapon. In addition, coordination among government agencies must be strengthened to avoid conflicts over land allocation. Finally, local community institutions that can serve to improve forest and fire management need to be encouraged and funded. Mechanisms and incentives need to be developed to ensure such involvement.

3. Reduce the Impact of Migration

Increased population pressure through migration and development leads to unsustainable resource management and conflict. To mitigate these impacts, the environmental and sociological implications of large developments should be considered prior to implementation. Where transmigration schemes are deemed to be environmentally damaging – as they have been on the peat swamps of northern Sumatra and southern Kalimantan – they should be avoided altogether. Additionally, input from local residents and recognition of their land claims during development planning is crucial for local acceptance and support. Finally, migrating populations need to be educated on the negative impacts of fire and land degradation in their new homes.

4. Reduce Poor Forest Practices

Policies to improve forest management and rehabilitation are necessary to reduce the occurrence of fires. It is critical to educate local communities regarding methods of timber harvest and agriculture that do not create conditions amenable to extreme fire behavior. These include reduction of logging slash and avoidance of practices that encourage conversion of natural forest to more fire-prone cover types. Research and extension services should promote sustainable land use practices among small-holders and the necessary technical assistance should be provided for transmigration schemes in swamp areas. Serious consideration should be given to incentives and policies promoting the rehabilitation of *imperata* grasslands. Promotion of community involvement in such rehabilitation efforts or management plans is essential for success.

5. Provide Economic Incentives and Disincentives

Economic policies that encourage sustainable land use and discourage forest destruction must be implemented. These could include trade restrictions on products like coffee grown in cleared forest areas such as national parks, and the promotion of products made from low-value tree species. Additionally, enforceable fines and other penalties need to be in place for inappropriate uses of fire and for fires that are allowed to escape from large-scale plantations to small holders as well as from small holders to large-scale plantations.

6. Improve Institutional Capacity

Institutional capacity for dealing with fires must be increased before the next major drought cycle. Indonesia should encourage investment in fire-suppression equipment by large private land-holders and commodity-production companies. Furthermore, the government of Indonesia needs to strengthen existing land-management institutions, such as national parks, with improved funding and training targeted at protecting those areas from uncontrolled burning. Finally, Indonesia should provide training programs for local communities in forest management and fire suppression.

Conclusion

The last two decades have brought increasing pressure on Indonesia's forests from timber concessionaires, plantation owners, migrants, and local residents. The population density has risen steadily with in-migration while policies relating to land tenure and use rights have been contradictory and unclear. As a result, regional conflict has increased dramatically and is a significant underlying cause of fire. Significantly, the study revealed in rare instances where social structures and property ownerships were stable, the forests have been protected from large destructive fires. The perceived value of these forests for economic reasons played a role in their protection. In most instances, these communities had customary laws intact that provided accountability for carelessness or arson and fostered a sense of ownership, responsibility, and care. While it is evident that the traditional community values and laws that support forest protection are unlikely to be duplicated in areas impacted by transience, population pressure, or boundary conflicts, they serve to highlight the probable utility of several of the policy changes proposed by the authors. The policy recommendations listed in this report could help extend such stability to the rest of the region.

Indonesia has the third-largest tract of tropical forests in the world. In areas where social structures and property ownerships are stable, forests have been protected from large, destructive fires.

...ATORS

Center for International Forestry Research (CIFOR)
International Centre for Research in Agroforestry (ICRAF)
United States Department of Agriculture – Forest Service

SPONSORED BY US Agency for International Development (USAID)
and East Asia and Pacific Environmental Initiative

The CIFOR/ICRAF team: Grahame Applegate, Team Coordinator; Suyanto, Economist; Tom Tomich, Economist; Rona Dennis, GIS/Remote Sensing Specialist; Fred Stolle, Remote Sensing Specialist; Yayat Ruchiat, Field Research Assistant; Iwan Kurniawan, Remote Sensing Analyst; Andi Erman, Field Assistant; Judith Mayer, Sociologist; Carol Colfer, Sociologist; Ann Casson, Sociologist.

The USDA Forest Service team: Gary Man, Team Coordinator; Henry Lachowski, Program Manager; Paul Maus, Remote Sensing Specialist.

References

Asian Development Bank (1999). Causes, extent, impact and costs of 1997-98 fires and drought. Final report, Annex 1 and 2. Planning for fire prevention and drought management project. Asian Development Bank TA 2999-INO. Fortech, Pusat Pengembangan Agribisnis, Margules P^yry, Jakarta, Indonesia.

Anshari, G., Kershaw, A.P. & Vander Kaars, S. (2000). A late Pleistocene and Holocene pollen and charcoal record from peat swamp forest, Lake Sentarum Wildlife Reserve, West Kalimantan, Indonesia. Palaeogeography, Palaeoclimatology, Palaeoecology.

Barber, C.V. & Schweithelm, J. (2000). Trial by Fire. Forest fires and forestry policy in Indonesia's era of crisis and reform. World Resources Institute (WRI), Forest Frontiers Initiative. In collaboration with WWF-Indonesia and Telapak Indonesia Foundation, Washington D.C, USA.

Dennis, R.A. (1999). A review of fire projects in Indonesia 1982-1998. Centre for International Forestry Research, Bogor, Indonesia.

Tomich, T. P., A. M. Fagi, et al. (1998). "Indonesia's Fires: Smoke as a Problem, Smoke as a Symptom." *Agroforestry Today* 10 (1): 4-7.