THE YEAR THE WORLD CAUGHT FIRE
Nigel Dudley, Jean-Paul Jeanrenaud and Sue Stolton, with contributions from the WWF network

A report to WWF International

SUMMARY

- In 1997, vast forest fires in Indonesia, Papua New Guinea, Brazil, Colombia and Africa focused attention onto what is rapidly becoming a global crisis.

- Fires have important impacts on ecology, wildlife, human health, crops, property, air pollution, freshwater and marine life, soil erosions, global warming and economic development.

- Impacts depend on the forest type, and particularly on whether it is likely to burn under natural conditions. Fire is a natural component of many forest ecosystems, where it plays an important role in ecology. However, in other cases it is rare and ecologically destructive.

- Today, the balance between humans and fire is breaking down. This often means *too much* fire, so that the ecosystem can no longer cope. Conversely, fire *suppression* sometimes becomes so efficient that it causes ecological and management problems.

- Most natural fires are caused by lightning during hot periods or drought. Risks are sometimes increased by human activities such as selective logging, drainage and pollution-related climate change. Most accidental fires result from losing control over deliberate fires - used for land clearing, charcoal burning, cooking etc - while some begin from sparks from transport, dropped cigarettes etc. Deliberate fires are also increasing, and are used to clear land for farming, hunting or plantation establishment, for timber speculation, insurance crime, political protest or, occasionally, simply vandalism. WWF identifies the widespread *breakdown of the rule of law* as a critical factor in fire abuse.

- Forest fires occur through natural causes, accidents or fire setting. Outside boreal forests, most fires are deliberately started by humans. Fire is used, and misused, as a management tool, a weapon in criminal activity and a political statement.

Regional survey

- **INDONESIA:** For several months, an area of South-East Asia from the Philippines to Australia was enveloped in smog, caused by forest fires in Java, Borneo, Sulawesi, Irian Jaya and Sumatra. Over a million hectares were destroyed. More than 40,000 Indonesians became ill as a result and smog caused plane crashes and shipping accidents. Primary forest and at least 19 protected areas were damaged, along with endangered species such as the orang utan. Business, including tourism, suffered badly. Most fires were set deliberately - often illegally - by commercial interests including plantation owners. Impacts were exacerbated by the El Niño climatic effect, which was itself probably intensified by pollution-related climate change. The political fall-out is intense.

- **PAPUA NEW GUINEA**: Thousands of square kilometres of grassland and rainforest have burnt all over the country, mainly from careless land clearance fires. The worst drought for fifty years threatens famine and a massive relief effort is underway; fires add another problem to what, for many Papuans, is already a desperate situation. Although many fires started in secondary forest and bush, primary rainforest was also burnt along with protected areas. Commercial forestry ventures suffered, including extensive damage to the second largest state-owned plantation. Cases of respiratory disease are reported from the Western Highlands.

- **BRAZIL**: Fires raged in the Amazon, with an increase of 28 per cent compared with 1996. From August 1st, for example, 24,549 fires occurred in 41 days, affecting the Amazon over a distance of 10,000 miles as loggers, ranchers and peasants cleared land and renovated pasture. Around 88 per cent of this land is used for cattle grazing. Although most fires are on previously cleared land, natural forest is also destroyed; in south Para, a third of the burned area was pristine forest. Fires risk causing long-term vegetational and climatic changes and scientists believe that in southern and eastern Amazon trees are near the limit of their

ability to remain evergreen during the dry season, risking more serious fires in the future. Current fire use acts synergistically with logging to promote fires, even in forests that normally do not burn easily.

- **COLOMBIA**: Over 7,000 forest fires have occurred during the year, including 37 separate events within protected areas, and 17,000 hectares of national parks have been burnt. Amongst the areas affected was Los Farallones de Cali National Park in the Andes, a protected area for rare species such as the jaguar and spectacled bear, and included in the *WWF Global 200 Ecoregions*. Apart from damage to vegetation, the fires also cause soil erosion. Fire has affected the health of many people and has reached the outskirts of major cities such as Cali. More fires are expected during the December to March dry season because of the impacts of El Niño.

- **AFRICA**: Fires also affected forests in Africa, including key protected areas. In *Kenya*, parts of the unique Imenti Forest around Mount Kenya were burnt through the collusion of illegal settlers and corrupt forestry officials. The Kenya Wildlife Service said that this increased risks of clashes between elephant populations and villagers. Important medicinal trees were also destroyed. In *Rwanda*, fire affected part of the Nyungwe Forest Reserve, threatening relic cloud forests. Large fires were also reported from many other countries, including Tanzania, Congo and Senegal.

- Meanwhile, in North America, fire suppression has caused problems by altering ecology and creating a build-up of flammable material which risks occasional, more serious fires. Now, the US government is trying to use the *risk* of fire as an excuse for felling "overaged" forest, thus diverting government funds to help the logging industry and threatening some of the country's few remaining old-growth forest areas.

Responses

- Forest fires affect everybody in the world. An international response is therefore necessary. Below, we outline the steps needed to address forest fire disasters and the breakdown of the rule of law.

- The key points identified by WWF are:

    - changes in **management practice** to minimise risks;

    - wide-ranging **educational activities** to tell people about forest fire hazards;

    - development of realistic **management plans** that allow fire to play a beneficial role;

    - encouragement of **community forest management** to give local people a stake in protecting and managing forests;

    - strict enforcement of, and where necessary improvements to, existing **national laws**;

    - development of **compensation frameworks**, for countries suffering cross-border damage and countries setting aside resources for global benefits;

    - development and implementation of **independent monitoring** of natural resource management;

    - implementation of an international strategy to **control illegal activities** relating to resources;

    - development of a system of **global arbitration** regarding environmental protection and natural resource management, such as an International Court of the Environment;

    - establishment of an **international task force** to address environmental catastrophes;

    - development of a strategy for addressing some of the **underlying causes** behind fire mismanagement, such as insecurity of land tenure, poverty and indebtedness.

PREFACE

The continuing environmental catastrophes in Indonesia and the Amazon have, for the first time, focused global attention onto the enormous damage caused by fire in tropical forests.

Why have the fires made such headlines in 1997? Freak weather conditions - probably made worse by pollution - mean that this year's impacts have been so great that they have also affected the lives of urban dwellers throughout South East Asia. For the first time, the rich and powerful have suffered alongside the poor and the powerless.

But these fires were not an Act of God. They were deliberately set, as they have been for many years, to clear forest for other purposes and sometimes to cover up timber poaching and land theft. It is also increasingly clear that the guilty parties are not just small farmers as is often assumed, but that most of the damage is being done by plantation and timber companies.

Like many others, WWF has watched with growing horror as the fires raging out of control in Indonesia have spread a choking yellow smog that has blanketed the region. Simultaneously, on the other side of the world, fires in the Amazon have, yet again, increased dramatically in area and extent. Our film crews have documented this human and environmental tragedy and our national organisations have been working day and night to assist the international response. These disasters have also drawn attention to other fires - in Africa, Asia, the Americas, Europe and the Pacific - where the tragic events are being duplicated in many other forest ecosystems.

This is not just an emergency, it is a planetary disaster. As the guilty are identified and the blame is apportioned, we must ensure that national and international responses go further than identifying a few scapegoats. This must never be allowed to happen again.

1997 will be remembered as the year that the world woke up to the problem of uncontrolled forest burning. We are releasing this report to give some background to the fires, to document the impacts, to identify some of the immediate and underlying causes, and to outline a strategy that will ensure that forests are valued and managed sustainably in the future.

Political leaders, industrialists, ecologists and the many, many people around the world directly affected by the fires must now work *together* to seek a realistic and workable solution to this terrible tragedy.

Claude Martin, Director General, WWF

Gland, Switzerland,
December 1997

INTRODUCTION

Fire mismanagement is now one of the most serious problems facing forests in many parts of the world. The crisis in Indonesia, and the news of another increase in the rate of burning in the Amazon have served to focus attention on what is actually a global forest issue - and a global crisis.

Note that we say fire *mismanagement*. Fire is a natural, inevitable and often essential part of many ecosystems. People have for countless centuries managed to live with, and sometimes to benefit from, forest fires. Even in forests that rarely burn naturally, fire has sometimes been used as a management tool since prehistoric times.

Unfortunately, today the balance between humans and fire is increasingly breaking down. In many cases, this means that there is now *too much* fire, so that the ecosystem can no longer cope with the level of burning. Conversely, and confusingly, in some parts of the world fire *suppression* has now become so efficient that this is, in itself, causing ecological and management problems. For example, in parts of North America where fire has been effectively suppressed, fire frequency has declined precipitously but fire intensity has escalated - indeed there is an inverse relationship between frequency and intensity of fires. Therefore the issue of the type of fire occurring is sometimes more important than the number of fires. Different forest types have very different fire regimes, and the way that we manage fire in forests has to change accordingly.

In some northern boreal forests, where fire is a common element in ecological cycles, most fires start from natural causes, usually as a result of lightning strikes during dry periods. However in most of the world's forests - and particularly in tropical moist forests - most fires are now caused by humans. On a world scale, few of these fires are accidental or simply as a result of vandalism. Fire is used, and often misused, as a management tool, as a weapon in criminal activity and occasionally also as a political statement. Understanding *why* people set fires is a key factor in getting management back under control.

The following report started life as a WWF response to the widespread fires in Indonesia, that have continued to provide a grim backdrop to our work throughout its preparation. However, as we started writing, news began to trickle in from other areas, first from various countries in the Amazon region, then from parts of Africa, Papua New Guinea and North America. Patterns started to emerge. Rather than writing a report about a fire, we have written a more general text about forest fires, using the events of 1997 as a starting point - hence the title of this report.

As we put the final touches to the text, it appears that the delayed rains have, at last, begun to dampen the fires in South East Asia. But some will continue to burn for months to come, particularly in areas where peat has caught fire. And no-one expects this to be the last burning season.

The text has of necessity been written at some speed; nonetheless it draws on thinking within WWF that now goes back several years, particularly with respect to the conclusions and recommendations. The events in South East Asia and Latin America have confirmed and highlighted trends that had been apparent for some time.

Given the short production time, we are even more grateful than usual for information, advice, help and support from around the world. WWF Indonesia and WWF Malaysia have both played a key role in telling the world about the fires in Kalimantan and Sumatra, and WWF Malaysia's web site has proved a key reference for conservationists and journalists all over the world. In addition, we would like to thank: Mark Aldrich (UK), Garo Batmanian (Brazil), Bob Buschbacher (Brazil), Claudia D'Andrea (USA), Dominick DellaSala (USA), Vanessa Diago (Colombia), Andréa Finger (France), Don Gilmour (Australia), Roy Hagen (USA), Bill Jackson (Switzerland), Isabelle Louis (Malaysia), Richard Luxmore (UK); Alison Lucas (UK), Elizabeth Obel-Lanson (Kenya), Agus Purnomo (Indonesia), Devendra Rana (Switzerland), Michael Rae (Australia), Simon Rietbergen (Switzerland), Sue Stolton (UK), Francis Sullivan (UK), Rachel Thackray (UK), Sabri Zahn (Malaysia).

FIRE IN INDONESIA

For several months in summer and autumn 1997, an area of South-East Asia stretching from Thailand and the Philippines to Malaysia and Irian Jaya has been enveloped in a dense cloud of smog, caused by vast forest fires on the islands of Java, Borneo, Sulawesi, Irian Jaya and Sumatra. More recently, Sri Lanka and northern Australia have also been affected by haze. Up to a million hectares of forest have already been destroyed. Some primary forest and protected areas have been damaged, and wildlife has suffered catastrophic decline in places. For humans, the smog has caused deaths from respiratory diseases, along with hunger, plane crashes, shipping accidents and misery for the 70 million people living in the affected area. These have had a disastrous economic impact, contributing to dramatic stock market falls throughout the region, with knock-on effects in the rest of the world. Most of the fires were set deliberately, and often illegally, primarily by commercial interests in Indonesia. Their misuse has been exacerbated by the periodic El Niño climatic effect, which has itself probably been intensified by pollution-related climate change. The political fall-out for the Indonesian government is already intense and has threatened regional cooperation.

THE DISASTER

- Fires raged out of control for several months on a number of Indonesian islands;
- Up to a million hectares have been affected;
- Conditions were worsened by a long drought related to the El Niño climatic event which means that the rainy season was 3-4 months late;
- Peat deposits have also caught fire, and are likely to burn even after the rains come, creating high levels of carbon emissions;
- Fire and the resulting smoke has affected human health, wildlife and the economy.

Fires have been burning out of control on several Indonesian islands. The main centres of the conflagration were Kalimantan in Borneo, Sumatra and Irian Jaya, with other fires reported from Sulawesi and Java. Estimates of the area damaged by fire vary. An Indonesian government spokesman at the World Forestry Congress in October 1997 suggested that 219,000 hectares had burned while the country's leading environmental watchdog, Walhi, has estimated that roughly 1.7 million hectares (4.2 million acres) of forest and ground across the country have been affected by the fires. The *Christian Science Monitor* quoted figures varying from 10,000-1.85 million hectares. The WWF Indonesia Programme estimated that by the end of November 1997, 800,000 to 1 million hectares had already been burnt. Although most fires are in scrubland and secondary forest, the WWF Indonesian Programmes estimates that up to 100,000 ha of primary forest has also been burned.

Although the fires started in July, it took many weeks before serious efforts were made to control them. Since then, there has been a major international response; for example Malaysia sent a thousand fire-fighters to the region to swell the number of people fighting the fires to around 10,000, the World Bank donated money and France, Japan and other countries have donated expertise and equipment.

Unfortunately, it seems unlikely that current fire-fighting operations will be able to extinguish many of the fires. The area was already suffering the worst drought in fifty years because of the periodic El Niño climatic event. Even cloud seeding by plane, in an attempt to start rain, was ineffective. Although rains have started in some areas, for example in parts of Sarawak and Sabah in northern Borneo, most of the area remains extremely dry and predictions suggest that some of the fires could burn until April 1998. Smogs was reported again from Singapore in early November, when 36 hot spots were again identified in Indonesia.

Worse still, in some areas peat and perhaps coal deposits have also caught fire, fuelled by tinder-dry conditions. Peat, which occurs in deposits up to 10-20 metres deep, is even more difficult to extinguish as fire can spread unnoticed underground and emerge several kilometres from its source. Peat fires contributed to the periodic re-emergence of fire during September and October 1997. They can kill tree roots and destroy seed banks, making future regeneration more difficult. Peat has been already identified as the major source of smoke in some affected areas, particularly in Riau province.

IMPACTS
The fire has had an enormous series of side effects on ecology, air quality, human health and the climate. In brief:

- Large areas of forest and peatland have been burnt;
- Wildlife has been damaged and destroyed including endangered species;
- Human respiratory diseases have increased dramatically in affected areas;
- The smog has caused accidents to transport systems;
- Rain has become dangerously acid;
- Tap water is too impure to drink in places.

Impacts on vegetation and habitat
Over-use of fire as a management tool has already causes massive changes to the vegetation of large areas of Indonesia, shortening the traditional slash and burn cycle to as little as five years, with resulting dramatic losses to biodiversity, non-timber forest products and soil fertility.

Threats to the peat swamps are particularly acute. The countries of South-East Asia, particularly Malaysia and Indonesia, contain over 20 million hectares of tropical peatland, amounting to over 60 per cent of the global resource. Initial estimates suggest that a million hectares of peat forest may already be on fire in Indonesia, amounting to 5 per cent of the regional total. Fires in these peatlands are particularly dangerous because they create many times more smoke per hectare than other forest types and they are almost impossible to extinguish without restoring the naturally high water levels in these swamps. The fires can go deep underground and can continue to burn - uncontrolled and unseen - for months.

Previous land-use changes have increased the risk of peat fires. The Center for International Forestry Research, based near Jakarta, now identifies the main fire problem in Indonesia as coming from a one million hectare area of peat being drained for a government rice-planting project; the peat is now much drier and thus easier to ignite. There are still said to be fires burning deep in peat from the 1983 fires. **Faizal Parish**, executive director of Wetlands International Asia Pacific, points out that:

> *Lowering water tables and opening up the forest canopy promotes the risk of fire in peat soils.*

Impacts on wildlife
Impacts on wildlife and ecology have yet to be studied systematically. It is known that many plants and animals have been killed directly by the fire or had their habitat destroyed. Although fires initially destroyed mostly scrub and degraded forests, with relatively low wildlife value, later satellite images showed that fire is now spreading into closed forests as well, and some protected areas have been damaged (see Table 1), with Tanjung Putting National Park being particularly badly affected. In addition, large areas of dried out peat swamps are also burning, damaging important seasonal wetlands.

Protected areas at risk
According to the **World Conservation Monitoring Centre**, fires have threatened or are currently threatening at least 19 protected areas, including a World Heritage site, Ramsar wetland and biosphere reserve.

Experience during the 1983 forest fire suggests that fruit-eating mammals and birds are likely to be particularly badly affected, because the trees they feed on take many years to mature and set fruit. Orang utans and hornbills, which occur in both Sumatra and Kalimantan, fall into this category and are already under pressure from habitat loss.

Table 1: Conservation Areas on Fire in Indonesia

Island	Protected area	Details
Sumatra	Bukit Barisan Selatan National Park	Location and size of fire unknown
	Bukit Tiga Puluh National Park	Location and size of fire unknown
	Berbak Sembilang National Park	Ramsar site. Location and size of fire unknown
	Kerinei Seblat National Park	One fire at Tangkil village already extinguished
Kalimantan	Muara Kencawangan Nature Reserve	Several fires blazing, fire troops (including one from Malaysia) sent to the area
	Maya Island, Karimata Islands Protected Forest	Several fires blazing, some endemic subspecies may be at risk.
	Tanjung Putting National Park	UNESCO biosphere reserve. Fire has badly affected the park and damaged orang utan populations.
	Pleihari Martapura Wildlife Reserve	Location and size of fire is unknown
	Kutai National Park	Location and size of fire is unknown
	Bukit Soeharto Protected Forest	Location and size of fire is unknown
Sulawesi	Tangkoko Nature Reserve	Fire has burned 20 Maleo
Irian Jaya	Lorentz National Park	Several fires have been extinguished.
	Wasur National Park	Fires throughout the area
Java	Gunung Halimun National Park	Fires started by local people in some places.
	Mount Tepong area	Reports of tigers and monkeys fleeing fires
	Mount Merubu area	Reports of tigers and monkeys fleeing fires
	Mount Malabar area	Reports of tigers and monkeys fleeing fires
	Gunung Arjuno-G Lawu Complex Protected Forest	500 ha on fire, fire troop in operation.
	Ujung Kulon National Park	World Heritage site. At least 3 fires have occurred, and were controlled by local villagers. Suspected causes include fishermens' fires and local people collecting honey.
Lombok Island	Mount Rinjani National Park	Fire reported at the end of October.

Data supplied by WWF Indonesia, using information from satellite imagery, reports from field programmes and press reports

Animals that live in the leaf litter of the forest floor, such as reptiles, amphibians and invertebrates, are also especially vulnerable, as are species that live in cavities in dead trees, including many bats, because the dead trees are particularly likely to catch fire. Insects suffer badly, often being unable to escape the effects of the fire, thus having impacts further up the food chain. Indonesia contains some of the world's most important and endangered species; several of these have been put at further risk by the fires, including the sun bear (*Helarctos malayanus*), Sumatran tiger (*Panthera tigris sumatrae*) and Asian elephant (*Elephas maximus*). Remnant individuals of the Sumatran rhinoceros (*Dicerorhinus sumatrensis*), classified as *critically endangered* by IUCN, are threatened by fire in Way Kambas although the main populations live outside major fire areas.

Fire has also put some threatened tree species further at risk. Sumatra contains 180, and Kalimantan 250, threatened tree species; in total approximately 5 per cent of trees recorded for Indonesia are already currently classified as

globally threatened. For example there are, respectively, 17 and 23 threatened peat swamp tree species in Sumatra and Kalimantan. Also of concern are heath forests in both island, which are characteristic of extremely nutrient-poor acidic soils and have distinctive floras including ant plants (eg *Myrmecodia*) and insectivorous plants such as *Nepenthes*, *Drosera* and *Utricularia*. The fires also threaten scattered remnants of semi-evergreen forests in Sumatra, which have already lost 90 per cent of their habitat to logging and development, while forests of ironwood (*Eusideroxylon zwageri*) were also at risk from fires in Sumatra.

There are also likely to be longer term impacts through ecological changes. Even if an individual animal survives the fire, it may face further problems from lack of food or habitat, or because it is driven into areas where it suffers competition from other animals or from humans. The haze is believed to be depressing plant growth, thus leading to an overall reduction in food availability, compounding the effects of droughts.

The fires also pose serous risks to marine life. When rains finally come, they are likely to create large-scale erosion due to the amount of ash deposited and the loss of vegetation to stabilise soil. Run-off has already had severe effects on riverine life including fish. It is likely to cause serious damage to offshore coral reefs, mangroves and marine ecology as a result of a sudden influx of freshwater and sediment. In the short-term, die-offs are expected in reef communities, with implications for both fisheries and tourism.

Orang utan (*Pongo pygmaeus*) at risk: Orang utans are amongst of the most threatened primates on earth, requiring undisturbed rainforest to live. They are already under threat from changes in Borneo and Sumatra and have declined from 30-50 per cent *in the last decade*, falling to a total population of less than 30,000. Dr **Barita Manullang**, WWF Indonesia's orang utan expert, warned that "these fires are likely to push orang utans to a more critical phase in their fight for survival". Even if they can escape a burning area, they usually have to cross open ground where they may be attacked by humans, or face territorial disputes with other orang utans in surrounding forests. Being unable to swim, they can also be trapped by rivers.

Reports are difficult to verify. According to **Willie Smits**, Advisor (for orang utan affairs) for the Ministry of Forestry, animal traders have been taking advantage of the fire to capture fleeing animals, including the orang utan, which are sold as pets. He reported that by the beginning of October, 31 animals had been rescued: 11 from central Kalimantan, 7 from the eastern region, 12 from the north and one from the south. He also had information that 30 adult females had already died. By early November, Smits was reporting at least 120 orang utans killed as a result of the fires and estimated that up to a thousand had been affected by the fires. Orang utans have been or are currently threatened by fires in several areas including in the area south of the Gunung Palung National Park in southwest Kalimantan, within and north and east of Tanjung Puting National Park also in Kalimantan.

Air quality

In addition to forest damage, the fires have caused dense smog over a vast area. According to information from Satellite Noah 14 on 26 October 1997, 41 cities were covered by haze including Palembang, Bengkulu, Jambi and Padang, with at least four airports shut due to poor visibility. Problems were most intense in Borneo and Sumatra. In Pekanburu in Riau province, central Sumatra, thick smoke had forced visibility down to only 20 metres. The entire state of Sarawak, with a population of 1.8 million people, was severely affected by smog with the air pollution index (API) reaching 849 (usually 100 is considered to be unhealthy and 300 is hazardous). In Malaysia as a whole, although heavy air pollution persisted since July 1997, air quality deteriorated dramatically in the last week of September. Penang recorded an API of 371, the highest ever for the peninsula. Even as far away as Singapore, air pollution index readings of over 200 were recorded. Serious haze from Indonesian fires was recorded for the first time from the Philippines.

When rain does fall, it is unnaturally acid as a result of the pollution, causing further damage to vegetation and corrosion to metals and concrete. Newspapers in Kuala Lumpur have reported that rain falling on Sabah state in Borneo has an acid content of pH 3.85, as compared with a usual value of pH 5.2.

The fires also resulted in a massive release of carbon into the atmosphere, which is likely to contribute to global warming. **Jack Rieley**, a peat bog specialist at the University of Nottingham, UK, estimates that peat bog fires in Indonesia over the next six months could release more carbon dioxide than the annual contribution from cars and power stations in western Europe.

Human health impacts

Human health impacts have already been enormous. The smoke contains high concentrations of particulate matter

and numerous chemicals that are harmful to health, especially when exposure continues over several months. By late October, it was estimated that over 40,000 people in Indonesia had suffered respiratory illness in the previous three months; this figure is likely to underestimate the actual effects because many of the rural people most immediately at risk must have been out of reach of hospital facilities and official statistics only record people using state hospitals and not private clinics. Several deaths occurred in Indonesia and Malaysia. The *Guardian* in the UK reported that authorities in Jakarta say that at least a million Indonesians have suffered eye, skin and respiratory problems. **Suryoputro**, deputy dean of the medical faculty of Diponegoro University said that some impacts will not be seen for up to ten years, citing increased risk of heart and asthma problems, while causing mental and brain disorders, inflammation and respiratory infections, skin and eye allergies.

Steve Tamplin of the World Health Organisation's Philippine office estimated that hospital visits for upper respiratory type problems were up 2-3 times usual levels when the smog was at its worst in Indonesia. In Padang, West Sumatra, the head of the local health office **Firdaus Bahauddin** reported that:

> *The haze in this region has not only caused over ten thousand cases of respiratory tract ailments but thousands of others have complained of eye irritation and infections due to sulphur dioxide.*

In Sarawak, Malaysia, 2800 people were treated over just two days for respiratory and eye diseases at the height of the haze and thousands of people have been admitted to hospitals. Around 70 per cent of victims experienced upper respiratory tract infections, with the remainder suffering from asthma, conjunctivitis and bronchitis. Schools and businesses have been closed. Face masks were distributed in Malaysia, particularly to children and to people with respiratory problems. Australia agreed to supply two million mouth and nose masks to help immediate health problems and the Caltex Indonesia oil firm offered to supply four million surgical masks from the USA. A day's exposure to levels of pollution in Kuala Lumpur was reported by environment officials as being equivalent to smoking 20 cigarettes.

Hunger is also likely to prove a critical - perhaps the critical - health impact in some areas. In parts of Sarawak, transport restrictions coupled with the impacts of the long drought have created conditions in which food and water shortages are now a serious problem. Such problems could prove critical in a year when El Niño has caused a severe drought that already threatens many people in Irian Jaya and Papua New Guinea with starvation.

The real health effects of the fire are likely to be experienced over the coming decades. Hong Kong University pollution specialist **Anthony Hedley** warned of "tens of thousands of illnesses" as a result of the smoke, including chronic bronchitis, emphysema and lung and cardiovascular diseases.

Transport and industrial disruption

The weather conditions have also caused a range of accidents. By mid-September, over 800 flights into and out of nine airports in Sumatra had been cancelled. Flights were also cancelled as far away as the southern Philippines islands of Palawan and Mindanao. Ships were warned to stay off the sea unless they had good navigational equipment and attempts were made to curb road transport. On 25 September, a Garuda airliner carrying 222 people crashed shortly before landing at a north Sumatran airport after the pilot got confused in dense smoke, resulting in Indonesia's worst ever air disaster. On 27 September, two ships collided in the Straits of Malacca, due to the smog, with 29 people lost. On 19 October, a further collision between a passenger boat and tug left four people dead and a reported 21 missing, and soon afterwards a collision in thick fog on the Barito River resulted in 29 people drowning when a ferry sank.

The haze has also had an important economic impact on transport companies. For example, Malaysian Airlines Systems staff claim to have lost US$1.95 million worth of business due to cancelled flights.

Economic impacts

The economic impacts of the fires have not yet been calculated. The *Jakarta Post* reported that the costs of the fires in East Kalimantan had exceeded US$21 million by October, from the burning of 25,000 ha. True costs are likely to be orders of magnitude greater, both because the total area affected is to date around 40 times as large, and because of additional costs from pollution, legal compensation, health effects etc. Analysts suggest that the fire could cause additional serious economic problems to the whole region and already estimate the costs in terms of billions of dollars.

WWF is currently working with the Indonesian government on a US$32,000 project to calculate the economic costs

of this year's fires, in cooperation with the World Resources Institute in Washington DC. Preliminary estimates put the costs in terms of tourism, health effects, legal costs and lost productivity at some *US$20 billion*.

Oil palm and rubber are both likely to be depressed with price rises likely next year. Many industries have suffered from temporary closure due to the smog, particularly if they rely on clean conditions such as electronic industries, and some transnational companies are apparently considering pulling out of the area. Dust particles in the air in Palangkaraya, Kalimantan, have also been reported as causing problems with electricity generators, through clogging air filters, leading to the overheating of generators and reducing their output by around 50 percent.

Non-timber forest products are also affected by the fires. The chairman of the Association of Medicinal Plant Exporters, **Hartano Chandra**, pointed out that about a hundred medicinal plants lived in the forests affected by fire, including many that were endemic and not cultivated.

The US$26 billion Indonesian tourist industry is likely to be particularly hard hit and local tour operators report that there are many cancellations, with the number of foreign tourists down 26 per cent. In London, British travel agent Thomas Cook said that it was refusing to take new bookings for holidays in affected parts of Southeast Asia and the US State Department issued a warning against travelling in the region. Although the main tourist centres on Bali were not particularly affected by the haze, a growing number of people are cancelling holidays in the region. Recent fires in Lombok Island have increased fears of the overall tourism impact.

Tourism is also being negatively affected in surrounding countries. Tourism is currently Malaysia's second biggest industry, earning US$45 billion per year and hotel owners on the popular tourist destination of Penang report bookings down from 30-80 per cent due to the haze. Singapore tourist hotels also report booking down by as much as a third. The Penang International Hotels Association intends to spend about RM100,000 during the rest of 1997 to counter the bad press surrounding the haze, using the money mainly to fly foreign journalists and travel agents to Penang to see conditions for themselves. Association chairman **Francois Sigrist** claimed that: *The situation has cleared up but the foreign tourists still do not know that.*

Fearing long-term damage to its tourism industry, on November 5 the Malaysian government ordered scientists and environmentalists at state-run universities to refrain from making public statements about regional air quality problems exacerbated by the smoke from forest fires. Education Minister **Najib Tun Razak** said that the gag order was to prevent researchers from releasing "speculative" reports and that "*in sensitive matters such as the haze ... only higher authorities are allowed to make statements*". He went on to say that negative publicity has been "manipulated" by the foreign media "to mar the country's image."

John Koldowski, of the Pacific Asia Tourist Association, pointed out the dangers of the fires becoming a regular feature:

> *If it is a constant thing, the whole area at that time of the year will be a no-go zone.*

Health costs will also be enormous. The World Bank estimates that Jakarta already spends about US$250 million a year in health services to fight air pollution from cars and industry according to **David Kuper**, director of the Jakarta Clean Air Project.

There are rumours that insurance companies of plantation and timber companies are considering not paying for any fire damage claims from these fires, due to the alleged gross negligence by the plantation owners and timber owners.

> ***FLASHBACK* - The Great Fire of Borneo**: What was at the time thought to be the biggest forest fire in history took place on the island of Borneo, burning for several months during 1983. Combined effects of fire and drought destroyed 25,500 km^2 of primary and secondary forest and a further 7,500 km^2 of shifting cultivation and settlements. Kutai National Park was virtually destroyed by the fire, and in some dipterocarp forest areas left unburnt by the fire, 70 per cent of the bigger trees died of drought. Since then, the cycle of forest fires in Borneo appears to be increasing and fires were reported to be larger than ever before during 1994, creating such a smoke haze that flights out of Kalimantan had to be cancelled for long periods.

CAUSES

- Immediate causes include deliberately started fires, set mainly by plantation concessionaires and other land-owners;

- Secondary causes include selective logging and other human activities, which increase the likelihood of fire, coupled with a severe El Niño climatic effect, which may itself be intensified as a result of global climate change

- Underlying causes include the desire to clear land cheaply, to increase (often illegally) the size of holdings and to cover up evidence of timber poaching, coupled with high consumption patterns throughout the rich countries;

- It appears that the fires may have increased as a deliberate act of defiance against government attempts to crack down on illegal activity.

Immediate causes
Most of the fires have been caused deliberately. Although slash and burn agriculture pastoralists have used fire as a means of land clearance for hundreds of years, the majority of these fires are small and controlled. **In the current spate of burning, the Indonesian government believes that about 80 per cent of the fires were started by plantation owners, industrial estates and transmigration land-clearing projects.** Comparing the logging companies with small-scale, traditional farmers, Emy Hafild, director of the Indonesia environmental group Walhi, said: "They burn a thousands hectares at a time, while shifting cultivators burn only a hectare at a time".

Use of GIS systems - donated as emergency assistance by WWF Netherlands - has allowed sources of fires to be identified and their extent measured more accurately than in the past. Volunteers from WWF and other NGOs worked with government officials to create a temporary control centre, where computer-generated images can immediately match the location of fires with land ownership. Close analysis shows that an unusual number of the fires broke out in the morning, when land clearance work began, and were often concentrated in areas that have been approved for commercial land use. It also seems likely that many of the fires had been set by smaller companies, in part because many of these are facing credit problems with banks that larger plantation owners are better able to withstand.

Fires are often used as a quick and cheap way of clearing away secondary forest to establish plantations. They are also sometimes used to deliberately blur the boundary of concessions, to acquire more land, or to cover up the evidence of timber poaching. The impact does not come so much from a handful of huge fires, but from an enormous number of smaller fires; for example in the second half of September over a thousand new hot spots were identified on satellite images, each responsible for fire over an average of 200 hectares.

Indonesia has, for the first time, publicly identified suspected the culprits. So far, 176 plantation, timber and construction companies and transmigration schemes have been named as possible users of fire to clear land, despite the unusually long dry season. These include a reported 43 Malaysian companies.

Secondary causes
Fire risk is increased dramatically by the conversion of natural forests to rubber and oil palm plantations, and by the selective logging of natural forests which open the canopy and dry out the ground cover. Plantations are drier and more evenly spaced than natural tropical moist forest, thus increasing the opportunities for fire to spread. Evidence also suggests that fires burned most easily and fiercely in secondary forest that had already been disturbed through (frequently illegal) timber operations. Selective logging destroys much of the moist undergrowth and the closed canopy that reduces the likelihood and impact of forest fires in natural forests. Drainage for agriculture also increases risks of fire.

The spread and intensity of fires have both been increased this year as a result of unusually dry conditions, caused by the climate fluctuation known as El Niño. The drought is supposed to have been the most severe for 50 years and the onset of the monsoon is delayed.

Although El Niño arrives every 3-8 years, it has recently been increasing in intensity and some climatologists link this to overall destabilisation related to pollution-related global warming and climate change. Biomass burning may

itself be helping create the conditions in which future burnings are more likely, creating a spiral of increasing destruction, although it should be noted that the majority of greenhouse gases come from fossil fuel burning in the rich countries.

Underlying causes
The hidden causes behind the fire range from the set of conditions that have allowed illegal burning to gain such a foothold in Indonesia to, the expectations produced by a high consumption society at the end of the twentieth century. Issues such as lack of secure land tenure, poverty and enforced changes in society can all help crete the conditions in which fires flourish.

Illegal practices have become widespread in the Indonesian timber and plantation industry. These have been allowed to flourish as a result of lack of infrastructure and because of widespread corruption. During the fire, this problem has been highlighted by the Indonesian government. For example, Environment Minister **Sarwono Kusumaatmadja** has said that collusion between local-area government officials and companies is one reason for open violation of laws by forest companies.

Fires are set partly because it is easier and cheaper than clearing away secondary vegetation, old plantations and sometimes also primary forest. However, they are also used to cover up illegal logging activities and to blur the lines of concession boundaries, allowing concessionaires and plantation owners increased access to land. Protected land burnt in the 1983 Borneo fire, previously unavailable for commercial purposes, was later reclassified from "protected" to "degraded" and so made available to timber and plantation companies. Such illegal practices have come under increasing criticism both inside and outside the country. Recently, the Indonesian government introduced some tough new laws against malpractice and it is being widely speculated that the increase in burning was directly in response to a perceived threat of government action - either to cover up past illegality and/or to clear as much land as possible before the new laws bite home.

For example, in August 1997 the government cancelled three forestry concessions in northern Sumatra, and reclassified them as "protected forests" where industrial development is banned and human activity is "strictly controlled". The decision, which affects 734,000 acres, came after the Indonesian Forestry Minister **Djamaluddin Suryohadikusumo** surveyed the concessions in the Aceh province by helicopter, and saw clearcut areas, illegal sawmills and the encroachment of the concessions onto adjacent protected or conservation forests. The Minister also discussed, with the head of the National Police and the Supreme Court, the possibility of applying the law on "special criminal acts" in the case of illegal logging. The Director General for Forest Protection **Soemarsono** reminded the public of the increasing forest fire risk and told concessionaires to avoid the use of fire during land clearing. Even before the onset of the dry season, 90 ha of forest had already burnt in Kalimantan and Sulawesi.
There are few signs that illegal activity ceased. Even since the full scale of the disaster became generally known, reports have been coming in continually of new fires being lit on plantation sites. On 25 September, the Indonesian government announced that it had proof that 14 companies had been illegally burning off *since* a ban on land-clearing by fire was announced ten days earlier.

Perhaps the most worrying aspect of the fires is that they appear to be a deliberate act of defiance against the Indonesian government by an industry that is increasingly operating outside the law.

Of course, the companies involved in the fires did not act in a vacuum. The *underlying conditions* that encouraged the fire reflect on people all over the world. A society based on high consumption, the desire for cheap goods and the readiness of governments, industry and consumers to buy goods that have been made in environmentally and socially damaging practices all contribute to the fires.

POLITICAL REPERCUSSIONS

Large forest fires have been a repeated occurrence in Indonesia since 1982, and the average scale and intensity have been steadily increasing. Countries such as Singapore have become used to suffering intense fogs during the burning season, which have often closed airports and disrupted economic and social life. Indonesia has, for more than a decade, been promising its neighbours to curb transboundary pollution by stopping the fires at their source. The ASEAN group of countries agreed to collaborate in preventing forest fires in Indonesia as long ago as 1994. However, current events show that in spite of the promises, very little has been achieved in practice.

The Indonesian government has been open about the problems. Although at the beginning of September a government spokesman was quoted as saying that most of the fires had been started by slash and burn farmers, a few days later the Minister of Agriculture, **Sjarifudin Baharsjaf** was publicly estimating that 80 per cent of the fires were started by plantation companies. He also condemned those companies guilty of setting fires. The Indonesian government declared the event a national disaster. In addition, **President Suharto** took the unusual step of twice publicly apologising to neighbouring countries and in early September demanded that illegal burning must stop immediately. In a statement by the Department of Foreign Affairs of the Republic of Indonesia, on September 26, the government stated bluntly that:

> *These fires are not only destroying valuable natural resources but also imposing serious health and economic consequences for Indonesians and citizens of neighbouring countries. The Government of Indonesia wishes to assure everyone affected by this situation that every possible effort is being made to end these fires as rapidly as possible. We do not underestimate the seriousness of this disaster.*

The Indonesia Minister of the Environment, **Sarwano Kusumaatmadja**, said:

> *We have done them [our neighbours] great harm but we are doing ourselves even greater harm. This is not a business-as-usual scenario, this is a disaster scenario.*

Mr Sarwano, an advocate of political and bureaucratic reform, has apparently often been outmanoevered by political opponents in the government, working hand-in-hand with powerful and influential business interests. In September, he publicly blamed the large companies for allowing small farmers to take the blame for the problem.

The Minister of Forestry, **Djamaluddin Suryohadikusumo** has announced his intention to resign over the fires, although he has generally been regarded as a good minister.

The government's position was in sharp contrast with that of the timber baron **Mohammed "Bob" Hasan**, who defended major forest concerns and put the blame on small farmers, saying that the fault lay with "people's plantations, shifting cultivation farmers and wood thieves". he also charged that environmental groups blaming the timber industry "have links to communists".

By October, the government had named 133 plantation owners, 28 industrial estates and 15 transmigration land-clearing projects, who had been told that they may have their license to use timber products frozen if they cannot prove that they were not responsible for the fires. The companies were given two weeks to prove that they were not involved in the burning, or have their licences revoked. However, in early September, the Association of Indonesian Forest Concessionaires suggested that companies should be given the chance to improve their performance before losing their licences.

By October 4, it was reported that 29 companies had had their permits revoked, out of 66 which failed to submit reports rebutting accusations that they had started fires. The Ministry said that 37 other companies were not licensed to start with. However, at the same time, a protest march about the fires, organised by the Indonesian Environmental Forum, was banned. Near the end of October, the government was threatening to revoke the licenses of at least 50 companies in Riau, East Kalimantan and West Kalimantan. In early November, it was reported that 48 people had been arrested for setting fires, including four company workers.

Reactions from other countries, initially muted, have increased in both volume and intensity. In Malaysia, for example, NGOs mounted rare public demonstrations demanding immediate action to address the problems caused by the haze. It is also reported that the neighbouring countries of Malaysia, Brunei and Singapore have all filed complaints with Indonesia's Agency for Environment Control, because the deliberately started fires have disrupted their transportation industries and resulted in financial losses. Malaysia has said that it will not be claiming compensation, but Thailand has said that it will be suing the Indonesian government for loss of revenue from tourism.

Malaysia, Singapore and Indonesia have agreed to cooperate at ministerial level on a regional action plan which will include early detection systems and fast response deployment of technical personnel and equipment to fight fires. An initial meeting of the Asean Haze Technical Task Force was held in Kuala Lumpur on November 18 1997.

CONCLUSIONS

It seems that 1997 has seen a sharp escalation in both the scale of fires and the degree of public concern, and this concern is spread throughout the ASEAN region and more generally around the world. The 1983 Great Fire of Borneo was scarcely even reported in the world's press, and for a decade events in Sumatra and Kalimantan have been overshadowed by concerns about forest loss in Sarawak (which ironically is now once again increasing).

This is no longer the case. It is clear that from now on, the eyes of the world will be focused on what is happening in the tropical rainforests of Indonesia.

SOURCES

The information used to write the Indonesian case study has been drawn from personal observations by WWF and IUCN staff and consultants, press reports, government statements, papers from UN bodies, satellite images of the fire, and from several Web sites which have been compiling information about the emergency. In particular, information has been provided by the WWF Indonesia Programme, the WWF Malaysia *Haze Alert* Web site and a forest fire Web site run by the World Conservation Monitoring Centre.

PAPUA NEW GUINEA CASE STUDY

Thousands of square kilometres of grassland and rainforest have also been burning in Papua New Guinea, mainly as a result of carelessly lit fires used for land clearance. The worst drought for fifty years is already threatening the country with mass starvation and a massive humanitarian relief effort is now getting underway. Fires add another grim problem to what, for many Papuans, is already a desperate fight for survival. Yet these events have scarcely been reported outside the region.

Enormous areas of grassland and rainforest are being destroyed by fire in the island of Papua New Guinea. Many parts of the Highlands have been burning since at least September, and witnesses speak of a pall of smoke covering much of the island. On November 11, the capital Port Moresby was itself reported to be covered by dense smoke. By late November, some rain had fallen in the Highlands Region, leading to hopes that the rainy season was beginning. However, it will be some time before either the fires go out or the effects of the drought recede.

Most of the fires are apparently the result of carelessness during routine slash and burn agriculture, and the authorities appear relatively powerless to stop the problem. In one case, a fire brigade's water supply had been cut off because of non-payment of water bills.

Fires were not confined to a single region. In the Tambul area of the Western Highlands, a massive fire destroyed forest along the Mount Giluwe Range, while another bush fire is reported to have devastated the Anglimp/South Waghi area along the Kubor Range. All along the Highlands (Oku) highway, fire has been destroying bush, gardens and even houses. Water sources were also damaged as a result.

Although many of the fires started in secondary forest and bush, primary rainforest is also being affected. In the Chimbu province, the Mount Wilhelm Wildlife Protected Area was reported to be ablaze in early September, threatening several bird of paradise species, possums, tree kangaroos and other rare wildlife. The peak, which is the highest in Papua New Guinea, was at risk of being burnt bare after fire started on the Madang side of the mountain and spread upwards. Bush fires are also reported to have destroyed most of East Kambia and thick rainforest at Mount Digini in Gumine, and to have burnt rainforests in the Western Highlands, parts of the Southern Highland, Enga and the Eastern Highlands.

Mount Hagen city was virtually cut off as haze threatened to close the international airport at Kagamuga; pilots were reported to be circling the airport for several hours while they waited for a "hole" in the smoke haze. Local officials described the city as "sitting on a time bomb". Forests have also been on fire on Mount Hagen itself.

Commercial forestry ventures were also affected. Papua New Guinea's second biggest state-owned forest plantation, at Lepugu near Goroka, burned sporadically for at least four months, destroying a reported 300 hectares with other areas still at risk. Project Supervisor **Peter Lafana** stated in September that: "We have been having fires at Lapegu on a weekly basis". Fires have also affected the Norikori Forest Plantation at Kainantu. Palm oil producers, already facing huge losses as a result of the drought, have also lost trees to fire.

The fires had a direct impact on relief efforts, as low visibility caused by the thick smoke haze hindered the delivery of drought relief supplies. In mid November, the Australian Defence Force had to abandon deliveries of urgently-needed rice, flour and oil in several places because aircraft were unable to land due to smoke.

Samuel Maiha, acting chief climatologist at the National Weather Service, claimed that the haze could last as long as the drought:

> *The drought and random burning of bush and grasslands, either naturally or otherwise, is providing dust for haze formation, especially during the daytime in inland areas.*

Cases of respiratory disease are already being reported from the Western Highlands and typhoid is increasing.

Sources: Reports from *The National* and *Post Courier*. Personal communication from Michael Rae of WWF Australia.

BRAZIL

On the other side of the world, fires have also been raging again in the Brazilian Amazon, with a reported increase in burning of 28 per cent this year compared with 1996. Thousands of fires are burning across 10,000 miles of the Amazon rainforest, as loggers, cattle farmers and peasants take advantage of the region's dry season to clear land for farming. Fires have also threatened Brazil's remnant Atlantic rainforest. The fires are on as great a scale as those in Indonesia but have received far less attention from the media.

Extent of the fire

Although virtually ignored by the world's media, a similar level of burning is again taking place in the Amazon. There is evidence that this year's burning season will have affected the largest area of forest in the last decade. The fires are being monitored by the US National Space Research Institute satellite. A reported 24,549 fires appeared over a sample of 41 consecutive days from the beginning of August, an average of 599 fires a day as compared with 466 in 1996. Similarly, in September 1997 some 20,469 fires were reported from the Amazon, as compared with 16,371 in 1996. Burning has increased by 28 per cent over 1996 figures according to the government's National Institute for Spatial Research.

Even these figures may be an underestimate. According to the US Environmental Defense Fund, the satellite being used in 1997 passes over at night when many of the fires have been extinguished, so that this figure may be up to an order of magnitude too low.

Furthermore, the actual increase in damage may be even greater because of the dry summer. In early October, twenty new fires a day were being reported around the outskirts of Manaus, Brazil alone. In Peru, fire almost reached the ancient city of Machu Pichu. In Brazil, burning was concentrated in the states of Mato Grosso and Para, followed by Tocantins, Rondonia and Maranhao. Despite a $205 million dollar World Bank loan to Mato Grosso to combat deforestation, the logging capital of Manaus has been covered by a smog similar to that enveloping much of Southeast Asia.

In addition to the problems in the Amazon, fires are also reported from the critically-endangered Atlantic forest, a temperate forest which is the world's second most endangered vegetation type after the forests of Madagascar. Reports suggest that 1000 hectares burnt, making up 20 per cent of a critically important reserve, which amongst other things is the main refuge of the golden lion tamarin (*Leontopithecus rosalina*) may have been destroyed. This fire began on August 18th and lasted seven days, destroying fringe forest areas, grassland and trees.

Impacts

The annual burning leads to a rapid increase in deforestation and forest degradation. Although most of the area being burned is on previously cleared land, where fire is used to renovate pasture or for slash and burn agriculture, natural forest is also being destroyed. In one study in south Para, Brazil, one out of three hectares burned was pristine forest.

The fires are creating the risk of long term vegetational and climatic changes. Researchers at the Woods Hole Institute and the Institute of Environmental Research in the Amazon believe that in large areas of southern and eastern Amazon, where logging and burning have been most intense, trees are near the limit of their ability to remain evergreen during the dry season, risking far more serious conflagrations in the future.

Daniel Nepstad and **Paulo Moutinho** are funded by the World Bank to investigate the fires. They have found satellite data on fires may underestimate the real extent of the problem, suggesting that for every acre of burning forest detected by satellite sensors, there is another acre burning out of sight. Nepstad commented that:

> *We are facing a very dangerous scenario. Virgin forest that always acted as a firebreak because it did not burn is losing that ability and becoming flammable.*

Fires directly threaten species such as the golden lion tamarin, which has been the subject of intensive conservation efforts after the wild population fell to an estimated few hundred individuals. The Atlantic forests contain a wealth of other wildlife, including three more lion tamarin species (one of which was only discovered in 1990), the maned sloth and the woolly spider monkey, along with 680 birds species, including 199 that are found no-where else in the world. The Brazilian press has been full of reports of health problems and transport interruptions. In a month, the airport of Rio Branco, State of Acre, was closed 20 times and the airport of Porto Velho, State of Rondonia, closed 30 times. Respiratory problems in Manaus health care centres increased by 40 per cent over the same period.

Control
Effective control of illegal fire is almost impossible with current resources. In Brazil, 400 poorly paid inspectors are trying to cover an area the size of France and Spain combined. Between 1996 and 1997, the Brazilian government's budget for tropical forest protection decreased by 64 per cent. Most logging in Brazil is illegal, but goes unchecked because the Brazil Environment Agency (IBAMA) has no statutory authority to enforce environmental legislation, and is powerless to levy fines, apprehend timber stolen from public lands or otherwise carry out its mandate. The government introduced draft legislation that would allow IBAMA to operate effectively in 1991; however this only passed the Senate in 1997 and is currently blocked in the House of Representatives.

A recent government study found that nearly 80 per cent of the timber harvested from the Amazon was being taken illegally. As in many other parts of the world, it is also clear that there is a certain amount of government complicity in the fires, both at local and national level. Lack of commitment to controls, and sometimes outright support of the continued clearance by senior politicians, contributes to the overall breakdown in the legal framework.

Causes of the fires
Most fires are started deliberately. Researchers at the Institute of People and the Environment have shown that current fire use practices act synergistically with selective logging in the region to promote more serious fires, even in forests that normally do not burn easily. Amazon forest fires sometimes take place below the canopy and are therefore difficult to detect with satellite images. In an ecosystem unadapted to fire, damage is far greater than it would be in, say, a boreal forest. Even a light fire can kill almost half the trees. Once burned, the forest is far more likely to burn in subsequent years, leading to a gradual spiral of degradation and decline.

Although some of the land burned is cattle pasture being repeated set alight each year, areas of primary forest have also been destroyed. The extent of fire-related forest loss is a matter of controversy. **Eduardo Martins**, president of IBAMA, Brazil's environmental protection agency, claims that 94 per cent of burnings are on land that has been burnt before and that: "It's just not true that an increase in the number of burnings means increased deforestation". Slightly more conservatively, Brazil's Institute for Environmental Research in the Amazon (IPAM), estimates that about 70 percent of the fires this year occurred on previously deforested lands, but notes that the last time there was a rapid increase in burning in the Amazon, the deforestation rate also increased. "It's true there's no one-to-one link of burned to deforested area", says **Garo Batmanian**, executive director of WWF in Brasilia, "but historically speaking, we know there has always been an increase in deforestation when the number of fires has increased."

As in Indonesia, blame tends to be apportioned to small farmers, but this is a distortion. Only 12 per recent of the forest cleared in the Amazon is actually used for farming. The remaining 88 per cent of land cleared so far is used for cattle pasture, and most new clearance is used for ranching. New areas are typically first made accessible for ranching and agriculture through the construction of logging roads to extract mahogany. Small farmers complain of death threats from land-owners intent on starting fires. A farmer interviewed in a WWF video complained:

> *We small producers, we want to work always without destroying the forest, but the big farmers responsible for cutting down trees, start uncontrollable fires, burning our property and when we denounce them to the government, there is no punishment, and we are threatened with death by the big farmers in the area.*

Fires are easier to start because illegal logging has reduced the crown cover and dried out forests. A similar pattern of degradation, burning and deforestation as occurs in Indonesia is being used for quick profits by business interests. According to IPAM, 1997 was the first year in which accidental burning exceeded the area intentionally burnt, suggesting that conditions are changing and people setting fires are increasingly unable to control the fires that they unleash.

Previous trends in deforestation have been closely linked to economic cycles, and as Brazil's economic stabilisation plan takes hold many observers expect an increase in deforestation. Meanwhile, Brazil is opening 5.4 million acres of the Amazon to commercial logging. The government says that it wants to demonstrate logging practices that can sustain nearby communities and the environment.

SOURCES
Information for this case study was drawn from information supplied by WWF Brazil, a report by the Environmental Defense Fund and from press reports.

CASE STUDY: COLOMBIA

Forest burning has become an almost annual event in parts of Colombia, threatening some of the richest forest ecosystems in the world. Fires are burning up to the edges of urban areas and degrading protected areas and primary forest as well as secondary forest and scrub. Although an action plan has been introduced to control the fires, there are currently insufficient resources for it to be implemented adequately.

National overview

According to the Ministry of the Environment of Colombia, there have been 7,009 forest fires all over the country during 1997, from January to mid November. During the first dry season of the year, which as usual took place from January to May, Colombian authorities detected 1,891 forest fires. From July to mid November (the second dry season of the year), 5118 forest fires were detected, The vegetation burnt in 1997 due to forest fires rose to 130,862 hectares. Of the total number of forest fires detected this year, 37 occurred within protected areas and approximately 17,000 hectares of National Parks burnt during 1997 due to forests fires.

Colombian environmental authorities have pointed out that - along with Brazil, Congo and Indonesia - Colombia is one of the tropical countries with the most severe air pollution due to forest fires. Colombia also has the world's fifth highest rate of deforestation, according to local experts. According to research by the Defensoria del Pueblo (a government organization in charge of the defense of Colombians' rights and interests), this year the forest fires caused hundreds of human health problems; in addition it left more than a hundred people either dead or badly injured.

In the Colombian department of Valle del Cauca, located in the southern part of the biogeographic Chocó, the authorities had by September detected approximately 40 forests fires within forest reserves - an average of 5 fires per month, As a result, 380 hectares of vegetation were burnt.

Forest fires and wildlife

One of the National Parks affected by this year's fires is Los Farallones de Cali, located in the department of Valle del Cauca, which in turn is inside one of the WWF Global 200 ecoregions: the biogeographic Chocó. This vitally important region extends north to south from Panama to Ecuador, through the western part of Colombia and from the western Andean slopes right through to the Pacific Ocean. It is one of the world's richest areas in terms of biodiversity.

The Los Farallones de Cali National Park is located in the southwestern Andes. It has an area of 150,000 hectares, varying in height from 200 meters up to 4,100 meters above sea level. From the beginning of the year through the month of September, Colombian authorities detected 10 forests fires within this national park, with more than 17 hectares burnt as a result. The effects of the forests fires on wildlife have not been studied in detail, in part due to lack of resources. However, the high levels of biodiversity and endemism present in Los Farallones mean that the fires are likely to have been extremely damaging. The area is a refuge for threatened species such as the jaguar (*Panthera onca*) the spectacled bear (*Tremarctos ornatus*) and the American lion or puma (*Felis concolor*), among others. There are also threatened plant species in the Farallones, some of which are unique to Colombia; for example a species of oak called *Quercus humboldtii*. The biodiversity of the Farallones includes 600 bird species (some of them endemic and some important migratory species) and poisonous frogs such as *Dendrobates lehmanii*. Such diversity of life can be partially explained by the variety of ecosystems within the protected area, which includes such different ecosystems as tropical rainforests and paramo vegetation.

In the whole department of Valle del Cauca, 7000 hectares of land have been affected by the fires, including forests, pasture, underbrush and stubble. There were also fires in areas where large-scale reforestation efforts were taking place, such as the hill Las Tres Cruoes (in English, "The Three Crosses"). During 1997, an environmental foundation planted 10,000 native trees in the area; there is as yet no information on the effect that the fires have had on the young trees.

Effects on environmental services and people

Although there has not yet been detailed research into the effects of this year's fires on people, the authorities detected numerous fires - some of them taking place simultaneously - over of the hills surrounding the Cali, the capital of Valle del Cauca where the WWF Colombia Programme Office is based. The ashes blew over the city and

into buildings. On several occasions fires even threatened to enter the houses in some city districts.
Approximately 360 families live in and near the Farallones National Park, subsisting mainly on farming and domestic agriculture. The Farallones is also visited by many tourists. It has three well known environmental education centres and a centre for biological research. Several of the rivers that provide water to important Colombian municipalities rise in the Farallones, including the Cali River (which provides water to 400,000 homes) and the Meléndez River. Rivers from the Farallones provide 40 per cent of the potable water for Cali. Some of the rivers rising in the park also eventually flow into one of the main Colombian rivers, the River Cauca. Among the wider consequences of forest fires in Colombia are impacts on soil including erosion, loss of soil and vegetation, avalanches, landslides and river floods.

Causes

According to the Ministry of the Environment of Colombia, 95 per cent of the forest fires are caused by human interference. Among the main causes are: agricultural practices such as the burning of stubble and vegetable remnants; the expansion of agricultural frontiers; and the use of fire to clear land (including forest) for agricultural and other uses. Although these practices are commonly used throughout the year, they represent serious risks in the dry seasons. Other causes are garbage burning, irresponsible tourism, promotion of illegal settlement and vandalism.

Lack of resources and other problems in controlling fires

Even though 1997 was a critical year for forest fires in Colombia, these phenomena are not rare in the country. According to **Ferney Cobo**, of the Special Administrative Department of the System of National Parks of Colombia, some areas of Colombian territory burn every year during the dry seasons (from December through May and from July through November). This is partly due to there being insufficient technical and financial resources available for an effective prevention and control strategy. According to the environmental authorities, another confusing factor is the large number of different government and local government departments charged with solving the problem. The chief executive of the Defensoria del Pueblo, **José Fernando Castro**, pointed to failures in governmental prevention and control activities as one reason for the particularly bad fire season in 1997.

In order to prevent and control forest fires, the Ministry of the Environment designed a *National Plan for the Prevention and Control of Forest Fires*. The city of Cali is charged with implementing a pilot project, which is currently in progress. The plan relies upon setting up high observation towers at strategic points in rural areas surrounding cities. In the case of Cali, there are three observation points, each fairly near a fire station. There are also local squads paid to attend emergencies, made up of 8 to 10 people, each of whom have at least basic training and rudimentary fire-control equipment. Whenever a fire is detected, the nearest squad and fire officers are mobilised. However, the equipment used and the number of squads and observation points are insufficient to control the very large number of forest fires currently occurring, particulary as several can be ablaze at the same time. In the case of the area around Cali for example, there are only three observation points and three squads of 10 people each to prevent and control the fires in approximately 37,442 hectares. Additional help, from army helicopters with water sprays, is only available in the case of the most serious fires.

According to Ferney Cobo, finding enough financial resources is at the heart of the problem of implementing the plan, because this depends upon political decisions and in most cases the prevention and control of forest fires are not considered vote-catching activities. The National Plan for the Prevention and Control of Forest Fires received approximately US$ 286,000 this year and it is expected to receive approximately US$ 359,000 in 1998.

Further trouble expected

Ferney Cobo went on to explain that more forest fires are expected during the dry season, from December 1997 to March or May 1998, since the forecasts predict that the phenomena of El Niño - which is expected to last until mid 1998 - will bring severe droughts to Colombian territory.

SOURCES

This case study was written by **Vanessa Diago** of the WWF Colombia Programme Office, drawing on information from the Ministry of the Environment of Colombia, the Special Administrative Department of the System Of National Parks of the Ministry of Environment of Colombia, *Farallones de Cali Estancia del Agua* - a publication of the System of National Parks of Colombia and Defensoría del Pueblo of Colombia.

CASE STUDY: AFRICA

Fires also affected forests in Africa, including Kenya, Tanzania, Senegal and the Congo. Damage included forest loss in key protected areas. the fires were mainly caused by the combination of increased pressure for land and the unusually dry conditions created by El Niño. Some examples are summarised below.

Kenya

Unique forests around Mount Kenya have been burnt during the 1997 drought, through the collusion of illegal settlers and corrupt forestry officials.

The 2400 hectare Imenti Forest is home to many tree species, including endemics such as the Meru Oak, and to a wide range of animal species including 300-400 elephants. However, this unique area is rapidly being destroyed, through illegal logging, land clearance and arson according to reports from the Kenyan press.

Illegal settlers from the Meru and Nyambene districts have been clearing forests and setting fire, often working at night. In some cases, forestry officials have unlawfully "sold" parts of the forest for land clearance, sometimes even giving receipts. Attempts to remove the settlers have been unsuccessful and large farmers are reported to be extending their fields by clearing indigenous forest.

So far, at least 800 hectares have been burnt, although some reports suggest that larger areas have been set alight. The Kenya Wildlife Service has condemned the situation and pointed out that the actions increase the risks of clashes between elephant populations and villagers. Important medicinal trees, including the *Mushambi* tree, whose bark is used as a treatment for malaria, are being destroyed. In addition, the Imenti Forest is an important watershed, and its degradation and loss threatens a nearby drinking water reservoir which is already reported to be drying up.

Humphrey Kifio of IUCN The World Conservation Union, points out that wild grassland fires often encourage regeneration of important species, forest fires of this type tend to have the opposite effect, and disrupt the natural vegetation cycle.

Rwanda

During autumn 1997, fire affected part of the Nyungwe Montane Forest Reserve in southwestern Rwanda, threatening relic cloud forests and adding further complications to the already complex set of problems facing the country's protected areas system. The fires affected several square kilometres and burned for several weeks during autumn 1997. There were apparently few organised attempts to put them out.

Part of the problems were caused by a severe drought linked to El Niño. The rainy season should normally start in early to mid-September, but Kigali only received its first rains by mid-October. While fire in the forest has not been totally unheard of during previous droughts, the size and extent of this fire is apparently unprecedented.

Common factors

Most fires appear to have been started deliberately, either as part of a regular management cycle or to extend farmland. In the former case, this year's particular problems stem from lack of knowledge about likely fire impacts during the unusually dry conditions associated with global weather conditions, which may in part be linked to human pollution - here information and training may be able to reduce the problem. Where fire is being used to clear land, often illegally, the problem is more intractable - here the problem appears to be at least partly one of breakdown of the rule of law. However, other underlying causes almost certainly contribute to the problems, including lack of access to land, poverty and indebtedness.

SOURCES

Information on Kenya supplied by Elizabeth Obel-Lanson of the East Africa Regional Office of WWF and reports from *The Nation* and *The Sunday Nation*, October 1997. Information on Rwanda supplied by Roy Hagen.

IMPACTS OF FOREST FIRES

Fires have important impacts on ecology, wildlife, human health, crops, property, air pollution, global warming and on economic development. The nature and extent of the impacts depend on the forest type, and in particularly on whether it is or is not likely to burn under natural conditions. Fire is a natural component of many forest ecosystems, where it plays an important role in ecology. However, in other cases fire is rare and ecologically destructive. Today, most of the problems associated with forest fires arise from unnaturally high levels of fire, although conversely in other cases fire suppression has been so effective that this is also causing difficulties.

All forest fires have important ecological, social and economic impacts, but the nature and extent of these vary according to forest type and condition. The natural fire frequency usually determines the degree to which forests adapt to the influence of fire. At the risk of presenting an oversimplified picture, three broad classes of forest can be distinguished:

- **Fire dependent forests**: forests that can be expected to burn relatively frequently in ecological terms - for example many boreal forests, some dry tropical forests etc - where fire is an expected and necessary part of the ecosystem;

- **Fire-free forests**: forests that seldom if ever burn naturally - including tropical moist forests and fire refugia in other forests such as wetlands and ridges - where fire is likely to prove more damaging;

- **Fragmented forest**: fire dependent forests which are now so small and fragmented that they are unable to absorb further fires - such as many Mediterranean forests and some woodlands in arid parts of Africa - where although fire is theoretically a necessary part of the ecosystem, it has now become a damaging factor, or at least requires very careful management.

There are also differences in the intensity of fires, with three main types being recognised:

- **Surface fires**: relatively cool and fast moving fires which may kill a few saplings but are unlikely to damage mature trees. In the least serious fires, trees will be singed but not seriously damaged, flowering plants will recover within a single season, and the fire will have negligible effects on the larger vegetation pattern.

- **Crown fires**: occur in upper parts of trees due to lightning, or from surface fires fed by heavy accumulations of litter and woody debris. They can destroy stands of trees but are often a necessary part of forest ecology through their actions in opening the canopy for regrowth. Slightly less severe fires kill only susceptible trees, changing the mosaic of vegetation but not removing forest cover.

- **Ground fires**: the hottest fires of all, which consume soil down to the mineral substrate causing destruction not just to trees and surface vegetation but also to seeds, roots and many nutrients. The intense conflagrations that kill most or all trees over a wide area are rare in almost all forest types.

Even in fire dominant areas, most fires will be localised, short lived and relatively unimportant from an ecological perspective.

Beneficial effects of fires

Fires play an important role in the ecology of some forests, including providing the following services.

- **Opening up the canopy**: a thick canopy can stifle the growth of young tree seedlings, for example because there is insufficient light or because they are disproportionately affected by pests from adult trees. A fire creates breaks in the canopy, thus allowing the emergence of pioneer species, often starting with herbaceous plants and progressing through fast growing tree species, such as willow (*Salix*) and birch (*Betula*) in boreal regions, through to mature forest species again.

- **Germination and dispersal of seeds**: some plant seeds only germinate after they have become heated in the soil by a forest fire, thus ensuring that they only start growing when there is space for them to develop. Some conifer cones need to be heated in order to release their seeds. These relationships are only likely to be found in forests where fire is common. For example, Knobcone pine (*Pinus attenuata*) is a Californian

closed cone conifer which is typically found in single aged stands that date back to catastrophic fires. Successful reproduction is apparently dependent on fire melting a resin that otherwise seals cones shut and prevents seed dispersal. Reproduction in several other Californian trees is enhanced by fire of a certain intensity, including giant sequoia (*Sequoiadendron giganteum*), jack pine (*Pinus banksiana*), Bishop pine (*Pinus muricata*) and various species of Californian lilac (*Ceanothus*)

- **Influencing forest succession**: fire can either initiate an almost entirely new forest succession by destroying everything in its path or, more usually, selectively start succession in some species or areas in the case of less catastrophic fires. This influences both tree species and other species dependent upon them; for example in Alaska it appears that lichens need periodic fires to continue a healthy growth, although the precise relationships remain uncertain. The result is to increase the forest mosaic on a landscape scale, even if fire sometimes results in small scale monocultures.

- **Changing the mixture of tree species**: some trees will be better able to withstand fire than others; for example older Douglas fir has thick bark which allows it to survive fires that kill other species. Other forest ecosystems rely on fire to maintain a balance between species. For example, forests of the Cascade and Sierra Nevada mountains in the western United States are undergoing a major shift in the balance between tree species due to the fire suppression policy of the last seventy years, with white fir (*Abies concolor*) gradually outcompeting other species in some areas.

- **Pest reduction**: a moderate fire can have a beneficial impact on forest health if it is intense enough to kill pests and pathogens whilst leaving the trees relatively unharmed. Suppression of fire in forests in Alaska has been linked to increase in pests such as the spruce budworm (*Chloristoneura occidentalis*).

- **Releasing nutrients from the soil:** fire releases some nutrients, especially in cold conditions where decomposition is slow, but may destroy others. It also alters water holding capacity and the make-up of microbial populations. In the Mediterranean region, it is hypothesised that fire may be important to release nutrients from sclerophyllous (hard leaved) plants, which will otherwise only decompose very slowly. Plants have evolved several adaptations to fire, including: fire-induced flowering; bud protection and sprouting after fire; fire stimulated germination of seeds stored in the soil; and fire-stimulated dispersal of seeds still on plants.

- **Providing fresh food sources**: vigorous growth following fires can result in increased food supply for key animal species. For example, vigorous growth of aspen, willow and birch following forest fires in Alaska result in an increase in moose populations, typically from five to twenty years after a fire.

- **Increasing the amount of dead timber**: standing dead timber (snags) and down logs are key microhabitats in most forests. Fires increase the amount of dead timber in forest systems, which may continue to provide habitats for fungi, invertebrates, nesting birds and other species for many decades following the fire.

- **Maintaining prairie**: in a balanced ecosystem, some forest fires also have the function of reducing the total area of forest and allowing prairie and steppe to develop. Fire suppression in the United States has resulted in substantial encroachment of prairie areas by trees.

The net result of these effects is to increase the variety of the forest in terms of species composition, size and age. This in turn has influences beyond the trees themselves, by multiplying the range of habitats within the forest and thus increasing the net biodiversity of the ecosystem. Although animals and plants are inevitably killed in forest fires, the overall forest community benefits from limited and naturally-occurring fires. Indeed, the increased mosaic of size, shape, age and species caused by minor forest fires is believed to help prevent the spread of more catastrophic fires in some areas. It should be noted that even after a fairly severe fire, standing dead trees (snags) provide a measure of protection against the wind and perhaps some other climatic factors, thus helping young trees to establish themselves. By the time the snags have toppled to the ground, young trees are likely to be strong enough to survive unprotected.

Damaging effects of fires

Unfortunately, today many fires are occurring in the wrong forests, at the wrong times of year and at the wrong intensity. Any ecological benefits are being more than outweighed by a range of damaging effects. Some important problems are outlined overleaf:

- **Disruption of ecological balance**: the most important overall impact of forest fires in non fire-dependent forests is the risk of permanently upsetting the forest ecology. Impacts can include: alterations to the forest vegetation mosaic; changes in groundwater levels and hydrological systems; serious soil erosion (particularly when heavy rains follow fire); alterations to trees' ability to remain evergreen during the dry season; and - in a positive feedback that can lead to spiralling destructio - increased susceptibility to further fire.

- **Alterations to vegetation**: burning in a fire-dependent forest will have little permanent impact on vegetation (although it can change the species found for dozens or even hundreds of years by starting off a new succession). However, burning in forest not adapted to fire can result in long-term or permanent changes, because some species will be poorly adapted to recover and therefore outcompeted. At worst, forests can be lost altogether and replaced by other vegetation. For example, repeated burnings in Kalimantan have created large areas of unproductive *alang alang* grassland (*Imperata cylindrica*) in place of the original dipterocarp forest.

- **Loss of wildlife**: as illustrated by the case studies described above, forest fires can have disastrous impacts on many species of wildlife. Although larger animals, such as elephants and primates, tend to receive the most attention, even greater losses are likely to be experienced amongst smaller species such as small mammals and invertebrates.

- **Human health impacts**: humans are directly at risk from fires and can also suffer both long and short term health impacts from smoke and particles. For example, large-scale fires in Australia killed over a hundred people on Black Wednesday in 1982. In 1997, immediate respiratory health problems have been experienced by at least 40,000 people so far in Indonesia, although medical experts believe that more serious side effects may only come to light some years in the future.

- **Air pollution**: fires release a wide range of chemicals and also particulate matter, causing haze, smog and acid rain. This causes a range of direct and indirect impacts, through loss of visibility, reduction in solar gain (which can depress crop and other vegetation growth) and long term damage to trees and other species.

- **Contribution to greenhouse gases**: although carbon emissions from large-scale forest fires are still dwarfed by emissions from vehicles and industry in the rich countries, they now form a significant contribution to global greenhouse gases. For example, six month emissions from the 1997 forest fires in Indonesia are thought to be equal to a year's emissions from all sources in western Europe. While natural forest fires are an inevitable source of carbon dioxide, the deliberate burning of large areas of non fire-dependent forests is now being increasingly questioned.

- **Disruption of transport**: the most immediate impact of forest fires on human communities is often the disruption of transport systems, particularly air traffic. Flight cancellations as a result of deliberately set forest fires are now costing millions of dollars a year.

- **Economic impacts**: fires have a wide range of other economic impacts, from depletion of forest resources, lost human productivity through sickness, loss of tourist revenue and damage to sensitive industries such as computer and other microelectronic manufacture which require pristine conditions.

One urgent requirement in the wake of the 1997 fire disaster is that a full assessment of the environmental, social and economic costs of the fires is urgently required. Quite apart from the long-term environmental consequences of the fires, hundreds of thousands of people around the world are suffering severe financial losses because of fires set, often illegally, by a relatively small number of people.

Fire suppression as an ecological problem

A less common problem is caused by *over-suppression* of fire in areas where it plays a regular and important part of the ecological system. This phenomenon is best known in parts of North America and Scandinavia, but also occurs in other areas.

Lack of fire in fire-dependent forests can result in substantial changes in the balance of ecosystems. For example, the success of fire suppression in parts of Alaska, where three government and state departments combine to provide a unique integrated approach to fire-fighting, is now thought to be having noticeable effects on the forest. This situation is now leading to a change in policy, where different zones are designated, for complete protection, partial protection and no protection at all, depending on proximity to settlements, managed forests and agriculture. The policy will ensure that natural fire continues to affect large wilderness areas of the state, and will also save considerable public money in reduced fire fighting expenses.

More contentious problems arise when potentially catastrophic fire threatens areas set aside as wilderness or recreational parks. Following a serious fire in the Yellowstone National Park in the United States some years ago, there has been an active debate about future policy towards a much more serious fire that is statistically likely to affect the forest within the next several decades. The forest ecosystem is thought to need a very strong fire to revitalise trees and other forms of life, and some conservation biologists are arguing that the fire should be allowed to rage relatively unchecked. However, this will cause serious problems from the perspective both of people visiting the park and because changes in the area around mean that there is not the same pool for the renewal of biodiversity that would exist in natural conditions.

CAUSES OF FOREST FIRES

*Forest fires occur both as a result of natural causes and because of accidental or deliberate human interference. In some cases humans also **increase** the risk of what are at first sight natural fires. Causes differ in importance around the world, however one general conclusion can be that most deliberate fires are started for a specific reason rather than as a result of pointless vandalism.*

Although individual countries and regions have carried out detailed surveys of causes of forest fires - such as the annual assessment by the UN Economic Commission for Europe - no global analysis is available. Generally speaking, five broad categories of causes can be identified:

- natural causes;
- indirect human impacts - ie more-or-less natural fires where the risk is increased or exacerbated as a result of human activity;
- accidental fires caused by humans;
- deliberate fires caused by humans;
- underlying causes that contribute to the three human-related causes listed above.

Many of these factors have already been seen in the case studies outlined above. Each is now briefly described, with examples where appropriate.

Natural causes

Almost all natural fires are caused by lightning or other electrical discharges, usually linked to hot periods or drought conditions.

- **Lightning strikes**: are possible anywhere and are the main natural cause of forest fires. It has been calculated that there are, on average, a hundred lightning strikes to earth every second. Lightning is particularly common in some areas, where ecology has adapted to fire; for example in Alaska it is estimated that there are up to 30-35,000 lightning and fireball strikes a day at some times of year and fires are an important element of the forest ecology.
- **Drought**: not a direct cause, but can increase the impacts of all others. Forest fire frequency peaks in drought years, particularly in arid or semi-arid countries. For example drought has been implicated in major fires in Australia in 1994 and Cyprus in 1995.
- **El Niño**: or the Southern Oscillation is a periodic climatic phenomenon which can lead to particularly severe droughts, thus increasing both the risk of natural fires and the likely extent and impact of human fires. 1997 has seen the most severe El Niño incident for at least fifty years.

Indirect human causes

Apparently "natural" fires can be increased by human impacts such as forest management and pollution.

- **Selective logging**: can open up the canopy and create artificially dry forests that are more susceptible to fire, particularly in tropical moist forests. Impacts of logging, including illegal logging, have been identified as an important contributing factor to forest in both Indonesia and the Amazon.
- **Forest management and selection of species**: creation of artificial plantations, of well-spaced trees arranged in straight rows, can increase fire risk, particularly if the trees are of species that catch fire easily - so-called *pyrophitic species*. Even-aged monocultures lack the "baffling" effect that a natural forest mosaic has which slows forest fires, and uniform plantations create wind tunnels which can further spread fire. Exotic plantations have been associated with increased fire risk in parts of Spain and Portugal.
- **Artificial fire suppression**: paradoxically, fire suppression can increase the risk of occasional intense fires in high risk areas, because cutting out minor fires allows build-up of flammable material. Increased intensity

of fires has been observed in parts of Sweden and Finland as a result of fire suppression and, famously, in the Yellowstone National Park in the USA.

- **Drainage and changes to hydrological systems**: drainage of wetlands, including peat, introduces fire risk to areas that would naturally be fire refugia. Drainage of natural wetlands to establish rice plantations has increased the incidence of fire in parts of Borneo.

- **Climate change**: increased frequency and intensity of drought has led to a dramatic rise in the number of forest fires in some areas, and climate models suggest that this trend is likely to continue. Whilst the extent to which air pollution is creating climate changes remains uncertain, the evidence for human activity having some impact on climate is growing stronger all the time. **Many climate models suggest that this year's particularly severe El Niño event has been exacerbated by greenhouses gas emissions.**

Accidents

Although many causes of fires remain uncertain, in cases where the cause is known, human interference is often more important than natural causes, even when fires are in high natural risk areas. For example, analysis of fires in the Russian Federation in 1993 found 84 per cent of known causes to be due to human interference and only 16 per cent to be natural. A range of direct and contributory factors exist:

Direct factors

Most accidental forest fires start as a result of losing control over deliberate fires, while a minority begin from accidental sparks from transport, power generation etc. Sources include:

- **Land clearing**: fire has been used to alter vegetation for at least half a million years, both as a means of clearing land for agriculture or settlement, or to stimulate particular growth patterns. Farmers and indigenous groups use fire as a means of clearing land for farming either on a temporary or permanent basis. Traditional "slash and burn" agriculture creates a high risk of fire in dry or windy conditions, and has been a major cause of hot spots in Indonesia during the 1990s. Fires also sometimes spread to woodlands in temperate regions as a result of heather burning to encourage game birds.

- **Cooking fires**: can be particularly dangerous, particularly if they are set by amateur campers and others who have little experience of fire management. Lighting fires in wilderness areas is now completely banned in parts of Norway because of the risk of fire, and cooking fires set by fisherfolk have caused fires in some parts of Kalimantan.

- **Cigarettes**: dropped cigarette stubs are an important cause of fire in some regions, particularly along roadsides when burning cigarettes are thrown from vehicles.

- **Infrastructure and communications**: electricity cable sparks, railways, roads etc all increase fire risk.

- **Charcoal burning**: itinerant burners sometimes fire whole standing trees as a crude charcoal-making technology in for example the Himalayan regions of India and Nepal, thus risking spread of fire to other areas.

Contributory factors

Over the past few years, changes in rural and urban populations, culture and expectations have all contributed to increased risks of accidental fire in many areas. A selection of factors are outlined below.

- **Depopulation**: can result in loss of traditional management skills and changes of attitudes to forests, thus creating the conditions in which forest fires are more likely to occur. Loss of skills have for example been identified as important contributory causes in inland and mountainous parts of the Mediterranean region.

- **Overpopulation**: also creates risks of forest fires through intensive use, often because of an influx of outsiders who do not understand fire ecology. Population pressure has created additional fire hazards in for example many Asian countries, popular parts of southern France and coastal California and in the Mombassa region of Kenya.

- **Settlement patterns**: settlement in high fire risk forest carries obvious risks. For example, construction of wooden dwellings in forest areas has led to an increase in forest fires in parts of California, such as the Bay area near San Francisco.

- **Recreation**: increased visitor numbers create important additional risks from picnic fires, camps etc.

Deliberate causes
Deliberate fire-raising is the largest cause of forest fires in many countries, although the proportion varies. However, there are many types of, and motivations for, arson, including:

- **Vandalism**: most arson fires are probably started for some reason (see below) although motiveless fire-raising is important in some countries.

- **Clearance for hunting**: burning areas of forest to improve shooting access.

- **Clearance for farming**: especially to create increased pastureland. This can be an important cause of forest fires where ranching or farming is being extended or where land tenure issues are causing conflict, including for example in parts of the Amazon, around Mount Kenya in Africa and in Kalimantan and Sumatra in Indonesia.

- **Reclassifying land**: some fires are started to free land for building development, for example to reclassify land in coastal areas of Spain and in Italy for development.

- **Timber speculation**: for example to overcome laws about clearing timber for sale or to create a source of damaged, and thus cheap, timber.

- **Insurance crime**: difficult to quantify but thought to be important in some areas.

- **Political action**: fires started as protest or an act of war. Palestinians sometimes start fires in Israel in protest against settlement policies in disputed territories.

Small-scale farmers and settlers have used fire as a cheap and often effective management tool for centuries. However, in a sharp escalation of the fire problem, over the last few years an increasing proportion of fires are started at the behest of richer and more powerful figures - ranchers, plantation owners, land speculators and criminals. Underpinning this is another related phenomenon; a wider breakdown in the implementations of rules and laws regarding forest protection and management. WWF believes that this is a critical - perhaps *the* critical - factor in the current global crisis, and as such examine it in more detail in the section below.

Breakdown of the rule of law
A fundamental problem underlying events in both Indonesia and the Amazon is a ***breakdown in the rule of law****. Many of the current efforts to address global forest problems rely upon developing complex frameworks of codes of practice, legislation and agreements that, together, will ensure sustainable forest management and protection of key habitats. Such negotiations are worthless if a significant number of people, corporations and governments - both rich and developing countries - are unwilling or unable to implement them. The breakdown of the rule of law is one of the most serious of all underlying causes of environmental degradation.*

Illegal activities play a critical role in determining long-term sustainability, in part because they are outside standard democratic controls. In the following section, we deliberately step back from the events described and look at these issues in a global context.

Information on the extent of illegal logging, plantation establishment and burning has increased considerably, due to work by official institutions such as the European Commission, and by NGOs such as TRAFFIC, Friends of the Earth and WWF. It appears that the problem is increasing on a global scale, due to increased criminality in the former USSR and because regional timber shortages and/or high profits are encouraging illegal exploitation; for example around Thailand, in the Amazon and in central African countries such as Liberia and the Republic of Congo. Many illegal timber traders are located in the North. Although control policies exist these are implemented with varying success.

A major problem is that in a number of cases public bodies, officials, and even whole public institutions, are involved in illegal activities, although this is politically difficult to state openly. In others, concerned governments have enormous difficulty in controlling powerful business interests, who act above the law, with or without the collusion of key politicians (this for example appears to have been the case in Indonesia, where government attempts to reduce illegality were met with defiance). The control at entry point in importing countries is also often poor and sometimes the purchase of illegally traded timber is clearly visible (sometimes even appearing in official statistics). Some importing countries also semi-openly flout international conventions regarding for example trade in endangered species.

Addressing such problems poses severe challenges for governments and intergovernmental organisations. Different responses are needed for different situations. For example, different *levels* of illegal action require different responses. Illegal felling for community use, local trade and international trade are three very different aspects of the same problem, and cannot all be addressed in the same way. (In practice, governments often target the small illegal operation and tacitly ignore the larger problem.)

The degree and extent of local corruption makes it particularly difficult for some governments to act to control illegal operations. In this case, some *transgovernmental* process is essential to ensure that all countries are pulled towards the same general and agreed legal and regulatory framework. International agreements are also implemented with only varying success. For example, if some countries recognise a ban on trade in an endangered species while others do not, this undermines the conservation efforts and provides additional opportunities for illegal operations.

Underlying causes

The factors listed above could be described as "immediate" causes of fire. Behind these are deeper, often more intractable, causes which help create the *conditions* in which fire management is undermined. These include:

- **land tenure**: pressures on forests are increased in many countries because most of the good farmland is owned by a few people, thus forcing the poor and landless to try farming in forested areas. In addition, where people are uncertain of their land tenure, they have little incentive to manage for the long term. Disputes about land entitlement have been at the root cause of many fires in Asia.

- **current consumption levels**: current expectations for a standard of living that involves high consumption of many renewable and non-renewable resources increases pressure on land and can lead to conditions in which fire is misused as a management tool, for example to clear forest for cattle pasture.

- **poverty**: lack of money is a critical factor driving many people to use forests unsustainably. Recent trends have indicated a widening gap between rich and poor in many countries, as highlighted at the World Summit on Social Development in 1995. Many of the fires in Africa and Papua New Guinea, for example, have apparently been started by people with few other options in terms of access to resources.

Other underlying causes include the levels of international debt and structural adjustment, pressure for trade and development and factors such as human migration and population growth. In the rush to identify "guilty parties" for the 1997 fires, care must be taken to look at the underlying, as well as the immediate, causes of the problem.

Conclusions

The world is currently suffering the events of a major breakdown in the rule of law as applied to the environment. The result has serious implications for us all. The failure of individual governments to enforce the rule of law means that responsibility for addressing problems of this magnitude rely on the international community.

The following section outlines some steps that must be taken to address this urgent and fundamental problem.

RESPONSES TO THE CRISIS IN FOREST FIRE MANAGEMENT

Disasters of the scale outlined in this report affect everybody in the world. An international response is therefore both appropriate and necessary. In the following section, we suggest several key steps that should be taken to address environmental disasters and the breakdown of the rule of law regarding the environment.

The 1997 fire disasters must not be allowed to become just a temporary media event. They should, instead, be the final motivation for developing and implementing a package of policies to ensure that such catastrophes never occur again. The final section of this report presents some preliminary ideas about what this might mean in practice.

The key points identified by WWF are:

- changes in **management practice** to minimise environmental risks;
- a wide-ranging series of **educational activities** to tell people about forest fire hazards;
- development of realistic **management plans** that allow fire to play a beneficial role within the forest ecosystem;
- encouragement of personal involvement in forest management through **community forestry**;
- strict enforcement of, and where necessary improvements to, existing **national laws**;
- development of **compensation frameworks**, both for countries suffering cross-border damage and for countries setting aside resources for their global benefits;
- development and implementation of **independent monitoring** of natural resource management;
- implementation of an international cooperative strategy to **control illegal activities** relating to natural resources and pollution;
- development of a system of **global arbitration** regarding environmental protection and natural resource management;
- establishment of an **international task force** to address environmental catastrophes;
- addressing **underlying causes** of forest loss.

These are discussed in more detail in the following pages.

Management practice
In many cases, a few critical changes in management practice could help reduce environmental problems. For example, with respect to fire, there are many standard fire prevention techniques - creating fuel breaks, prevention of gaps in forest canopy, exploration of controlled burning options in susceptible areas, fire watching and fire prediction techniques - although of course these will be of far less use if fires are set deliberately. Management also sometimes requires introduction of fuel reduction techniques, such as thinning from below and prescribed burning.

An integrated approach to education about fires
Many of the 1997 fires started or spread by accident, particularly through poor management of slash and burn systems at a time of severe drought. Research suggests that carefully managed educational promotions, financed by government, industry or NGOs, can help reduce the impact of fires through providing simple instruction about particularly dangerous periods for starting fires, fire management techniques etc. Suitable media include local newspapers, radio and TV channels, schools and through extension services. For example, satellite monitoring of fires in Guinea appears to confirm that use of local radio to promote the safest time for slash and burn helped reduce wildfires.

Development of management plans for forest fires on a landscape level
Forest fires are a natural element in many forests, while in others they are a cultural component of forest management stretching back hundreds or thousands of years. In both cases, eliminating fires entirely is not a realistic option. Balanced fire management needs to reduce the detrimental impacts of fire without necessarily attempting to eliminate it completely; indeed over-suppression of fire can result in build-up of flammable material and more intense fires in the future. Increasingly, countries such as Canada, Sweden and Finland are *managing* fires, to minimise damage to property and wildlife, which in some cases means allowing fires to burn freely.

Management must necessarily change depending on forest type, location, resources and others related factors such as climate, degree of forest fragmentation, etc. Management certainly does not, in all cases, equal prevention: in many temperate and boreal countries a "right to burn" policy encouraging landowners to use prescribed fire where ecologically appropriate, may be a necessary component of a broader fire management policy. For example, in the southeastern USA, there is a policy that encourages landowners to burn understorey vegetation as a way of reducing fire intensity in fire-adapted forests. Periodic low intensity burns in the understorey can reduce the magnitude of fire events when applied using the historic fire frequency and intensity patterns.

It should be remembered that although most of the examples discussed in this report are of forests experiencing too much fire, in other ecosystems fire suppression is also a problem. Overall management is therefore of critical importance.

Community forestry initiatives
Experience shows that management, including fire management, tends to be better organised and implemented if people living in or near the forest have some measure of control over the forest. Systems of *co-management* or *collaborative management* help to encourage and reinforce positive commitment to maintaining a high quality forest estate, particularly if local people have security of land tenure and therefore confidence that they will be able to benefit from good forest management in the long term. Conversely, in situations where there is no feeling of ownership and no land security, the quality of forest management starts to decline and unsustainable or deliberately destructive policies become more common.

Strict enforcement of existing laws
Most countries now have at least the basis of environmental legislation, and many countries have an increasingly good set of environmental and forestry laws. In other cases, further development is required. However, *legislation is useless if it is not implemented*. Implementation requires both determination by the government and legal officers and the existence of sufficient capacity in terms of trained personnel, equipment and techniques. Capacity building for regulators - police, courts etc - to help ensure that the agreed regulations are effectively applied, is a key requirement. While richer countries can aid developing countries in terms of capacity building, political determination eventually relies on national governments and on the population as a whole.

Compensation frameworks
It is becoming increasingly clear that environmental damage carries social and economic costs alongside ecological costs. Options for compensation linked to environmental costs and benefits need to be improved and standardised within and between countries. Four main elements need to be explored:

- compensation mechanisms for people, businesses and governments within a country for claiming damages as a result of environmental mismanagement - for example people suffering from health effects of fire or pesticides, landslips caused by deforestation, damage to hydrological systems or salmon spawning grounds due to logging or pollution etc;

- similar compensation mechanisms for people, businesses or governments in other countries to claim compensation for cross-border damage - for example countries around Indonesia to claim compensation for the fires;

- ways of rewarding local communities within a country for maintaining hydrological systems, forests etc for the common good - for example through the ecological VAT systems being used in some Brazilian states;

- ways of rewarding governments of countries that maintain a disproportionate amount of the world's ecological services - such as forests like the Amazon, high biodiversity hotspots, etc.

The difficulty of agreeing and enforcing such mechanisms should not be underestimated. However, a recent upsurge in legal cases relating to environmental costs suggests that these mechanisms will become increasingly important in the future.

Development and implementation of effective monitoring of natural resource use, including independent monitoring

One reason that illegal activity is currently allowed to flourish is because in many cases law breaking goes undetected. It is significant that NGOs and independent researchers have for many years been the main source of information on issues such as the illegal timber trade; and indeed NGOs have been supplying the Indonesian government with information about the location of the current fires.

Recent developments in GIS systems, criteria and indicators of good forest management, independent certification of forest management, computer-based monitoring systems and other survey techniques offer an important opportunity for governments and others to discover and monitor illegal activities. Three elements are important:

- improved official **national monitoring** of natural resources, legal and illegal resource management and trends in vegetation cover, air quality etc;

- agreed systems of **international monitoring**, through instruments such as the Convention on Biological Diversity, UN Forest Resources Assessment, World Conservation Monitoring Centre, etc;

- effective **independent systems of monitoring**, such as those developed by the Forest Stewardship Council, organic agriculture certification systems, environmental and fair trade labels.

These three together could guarantee both the independence needed to ensure that monitoring was accurate and, in the last case, clear incentives for welcoming and implementing such inspections, to gain a market advantage from having a recognised certificate of good environmental practice.

A global framework for controlling environmentally-damaging activities

At the moment, countries are frequently demonstrating complicity in illegal activities such as logging and the animal trade because there is no framework for addressing the problems - for example many countries have no legal way of blocking the import of timber even if they know that it has been felled and exported illegally. Recent changes in trade rules under the World Trade Organisation have, if anything, made development of such mechanisms even more difficult. However, many opportunities still remain and examples of practical cooperation exist, for example in the field of illegal wildlife trade where customs services and police in several countries frequently cooperate. Introduction of well-planned bans on trade in the most highly endangered products, through a modified CITES or some new body, could for example help reduce some kinds of illegal logging, which often modify forests and thus create an unnatural fire regime.

A system of global arbitration

All of the suggestions above are both sensible and possible. However, they will not be implemented effectively so long as large areas and large sections of industry are - in effect - operating beyond legal control. As stressed several times before in this report, addressing the critical issue of the breakdown of the rule of law must be at the centre of attempts to prevent tragedies such as the one that has overtaken Southeast Asia. WWF believes that the international community has a responsibility to help individual nations in addressing these deep-seated problems.

The suggestion of some worldwide system of arbitration over environmental issues is resisted by some countries. Yet it is far from unprecedented. Nations have, in the last few years, willingly ceded an enormous amount of authority to a global system with respect to trade - with, incidentally, some compelling evidence of environmental degradation as a result. The role of the International Court of Human Rights is also increasingly respected.

An **International Court for the Environment** - perhaps modelled on the International Court of Justice - could provide a means for the global community to address global environmental issues which take place within the borders of a particular country. Such a court should, at the very least, have the mandate to help in the consideration of compensation when cross-border issues affect neighbouring states or the international community. It might also in theory have the power to extract direct penalties - trade bans or fines for example - for persistent failure to meet international agreements.

The vehicle for such an initiative would need to be selected only after careful consideration - options might include one or more of the environmental conventions, or an expanded version of UNEP. It may, for example, be more politically acceptable, and more efficient, to aim for a system of regional governance with global monitoring and assessment.

The political difficulties of introducing such a system should not be underestimated. However, the need is becoming increasingly apparent, and concerned institutions, governments and NGOs should plan now to ensure that it becomes reality in the future.

Establishment of an international task force

The plethora of conventions, initiatives and conferences relating to the environment, which have increased in number since the Earth Summit, will all fail if nations and, increasingly, industries feel powerful enough to flout agreed standards of behaviour.

This issue crosses the borders of biomes, nations and interest groups. To address it, WWF suggests that we need an international task force, operating at a number of levels:

- at **intergovernmental level**, to provide a forum for discussion and policy development relating to law and the environment;

- at **international, regional and national levels** in terms of providing rapid expertise, funding and other resources to provide emergency assistance during times of environmental disaster.

Whether such as body should be official, presumably through an organ of the United Nations in the pattern of the Red Cross or the UN High Commission on Refugees, or unofficial in the pattern of relief agencies such as Oxfam and Medicins Sans Frontiers, would also have to be determined.

Addressing underlying causes

Although beyond the scope of the current report, the crisis in fire management will only really be addressed once some of the underlying causes are also alleviated. Poverty, lack of land tenure, inequity and indebtedness on the one hand and the driving forces of a high consumption society on the other are together creating the pressures that result in conditions in which fires are misused. Tackling these more fundamental issues has been identified as a critical requirement for restoration of a high quality global forest estate by the Intergovernmental Forum on Forests and by numerous other international initiatives, national governments and non-governmental organisations.

It is also increasingly clear that the El Niño event was the factor that turned what might have been a fairly serious situation in some areas into a disaster or near disaster. Indeed, weather patterns are often a critical - sometimes *the* critical - factor determining the nature, frequency and intensity of forest fires. There is a growing consensus that climate is being altered by human activity, often in ways that are not conducive to balanced fire regimes. Policies addressing climate change are therefore critical to the success of strategies to control the misuse of fire; for example discussions at the December 1997 meeting of the Climate Change Convention will play a critical role in determining the nature of forest fires in the next century.

Conclusions

Some of these proposals are obvious and, at least in theory, not contentious; few states are going to argue that they should not implement their own laws, even if they fail to do so in practice. Others are more controversial. However, we believe that the more fundamental and deep-seated changes are essential if the world is to develop an adequate response to the type of environmental disaster that is currently being demonstrated, all too graphically, in forest ecosystems around the world.

SOURCES OF INFORMATION

This report has been written against unusual time pressures, and while the events it describes continue to unfold. Information has, of necessity, come from press reports, eyewitness reports by WWF staff and others, satellite imagery and a series of excellent web sites - particularly drawing on the WWF Malaysia *Haze Alert* site and those of the World Conservation Monitoring Centre, Ramsar, the NOAA satellite images, the Gaia *Forest Conservation Archives*, WWF US, WWF Netherlands and the WWF Indonesia Programme Office, and the *Christian Science Monitor*.

Where information is scanty, uncertain or contradictory, we have tried to maintain transparency and present a range of views and opinions. The report is therefore not referenced in the standard format; instead footnotes identify major sources for each section and the following list provides a partial bibliography to both the events in 1997 and to the wider questions of fire and ecology.

Arden-Clarke, Charles (1991); *Mediterranean Forest Fires*, a briefing paper from the World Wide Fund for Nature, Gland, Switzerland

Barbour, Michael G, Jack H Burk and **Wanna D Pitts** (1980); *Terrestrial Plant Ecology*, The Banjamin Cummings Publishing Company, Menlo Park California

Berenstain, L (1986); Responses of long-tailed macaques to drought and fire in eastern Borneo, Indonesia: a preliminary report, *Biotropica* **18**(3): 257-262

Bradt, M A (1989); A note on the Sumatra, Indonesia peat swamp forest fires of 1987, *Journal of Tropical Forest Science* **1**(3): 295-296

Gill, A M (1977); Plant traits adaptive to fires in Mediterranean land ecosystems, in *Proceedings of the Symposium on Environmental Conservation, Fire and Fuel Management in the Mediterranean Ecosystem*, USDA Forest Service, Washington DC

Groome, Helen (1992); *Reforestation, Afforestation and Forest Fires: Case Study, Spain*, Paper from EHNE, Bilbao prepared for the WWF European Forests Workshop, Gland, Switzerland, April 1992

Guarrera, L (1991); *Forest Fires in Italy*, WWF Italy, Rome

Holdsworth, A R and **C Uhl** (1997); Fire in Amazonian selectively logged rain forest and the potential for fire reduction, *Ecological Applications* **7**(2), 713-725

Kirkpatrick, J B [editor] (1981); *Fire and Forest Management in Tasmania: Papers given at a seminar organised by the Tasmanian Conservation Trust, May 2nd 1981*, Hobart, Tasmania

Komareck, E V Snr (1964); The natural history of lightning, in *Proceedings of the Tall Timber Fire Ecology Conference* **3**, 139-184, Tall Timbers Research Station, Tallahassee, Florida

Koslowski, T T and **C E Ahlgren** [editors] (1974); *Fire and Ecosystems*, Academic Press, New York

Leighton, M and **N Wirawan** (1986); Catastrophic drought and fire in Borneo tropical rain forest associated with the 1982-1983 El Niño Southern Oscillation Event, in *Tropical Rain Forests and the World Atmosphere*, Westbury Press, Boulder, Colorado: 75-102

Peck, Dwight and others (1997); *Wetlands on Fire: Statement Issued by the Standing Committee of the Ramsar Convention on Wetlands: 2 October 1997, Gland, Switzerland*, Ramsar Archives

Republic of Indonesia (1997); *Statement by the Department of Foreign Affairs of the Republic of Indonesia on efforts to address the challenge of forest fires on several Indonesian islands*, September 26 1997, issued by the embassy in Washington DC

Revkin, Andrew (1990); *The Burning Season: The murder of Chico Mendes and the fight for the Amazon rain forest*, Collins, London

Salisbury, Harrison E (1989); *The Great Dragon Fire*, Little, Brown and Company, Boston and London

Setzer, A W and **M C Pereira** (1991); Amazonia biomass burnings in 1987 and an estimate of their tropospheric emissions, *Ambio* **20**(1): 19-22

Uhl, C J, **J B Kauffman**, and **D L Cummings** (1988); Fire in the Venezuelan Amazon 2: Environmental conditions necessary for forest fires in the evergreen rainforest of Venezuela, *Oikos* **53**(2): 176-184

United Nations Department of Humanitarian Affairs (1997); *South-East Asia - Environmental Emergency: DHA-Geneva Situation Report No. 7*, 30 October 1997

Wildfire Magazine, November 1997

Woods, P (1989); Effects of logging, drought and fire on structure and composition of tropical forests in Sabah, Malaysia, *Biotropica* **21**(4): 290-298

FORECAST FIRES UPDATE - MID DECEMBER 1997

The Year the World Caught Fire was finally sent to the printers towards the end of November. In the two weeks since, the situation has continued to evolve rapidly, with new outbreaks, fresh information coming to light and new perspectives on the causes and impacts of forest fires. This briefing document brings the story up to date.

Thomas Lovejoy, ecological consultant at the Smithsonian Institute, pointed out that: "If you put Indonesian burning and Amazon burning together, you'd see more of the world was on fire in 1997 than ever in recorded history".

BRAZIL
The latest research suggests that 1997 burning increased by over 50 per cent from 1996 and that fires now rank with logging and land clearance as the major threats to biological integrity in the Amazon.

Estimates for the area of the Brazilian Amazon burnt during 1997 have increased dramatically over the past few days. The latest estimates, based on NOAA-12 satellite data, suggest that ***fires increased by over 50 per cent between 1996 and 1997***, with 44,734 fires recorded in the 118 days between July 1 and November 22 1997. The average number of fires per day increased 75 per cent, from 217 in 1996 to 379 in 1997. It appears that rate of burning, particularly of cattle pasture, has been *increasing* during the burning season; for example during October 1997 there was tripling in fire frequency compared with 1996.

The actual number of fires are still larger than the NOAA-12 measurements, because its trajectory and the position of receiving stations means that the northern and western Amazon receive relatively poor cover. NOAA-12 also passes at night, when fewer fires are burning. Many ground fires are not detected in satellite images - the Environmental Defense Fund estimates that 15,000 square kilometres a year may be degraded by ground fires not recorded by satellites.

New research suggests that fires are becoming at least as great a threat to the biological integrity of the Amazon as deforestation. In addition, the results suggest that carbon dioxide emissions from the Amazon may have been underestimated by up to 30 per cent.

Source: Environmental Defense Fund, Washington DC

AUSTRALIA
Hundreds of fires have broken out in many parts of Australia as a result of severe drought following El Niño and fire-fighters have already been killed as a result.

As predicted in *The Year the World Caught Fire*, serious fires have broken out in Australia, at the start of the summer season and following a severe drought linked to the El Niño climatic event.

By December 3, over 400 bushfires were raging across Australia's eastern seaboard. Homes were burnt and the fires forced people to evacuate suburban areas of Sydney. Fires were being whipped up by high temperatures and winds, and fire officials were predicting that conditions could deteriorate so that fires become worse than those that ringed Sydney in 1994. Around 200 fires started in Victoria and South Australia, and a further 400 in New South Wales. At least 200 fires were considered to be out of control.

Huge fires burned across a 150 km front covering 250,000 hectares of forest and farmland in the Coonabarabran-Narrabri area of western New South Wales. Wildlife has already suffered. Koala bears and rare species such as the rufous bettong wallaby and the black-striped wallaby are believed to have been wiped out by a fire which destroyed half of the 500,000 hectare Pilliga forest and 80 per cent of the associated nature reserve. A spokesman said that: "This fire is an environmental catastrophe for the animals, especially the endangered species".

Gary Morgan, chief fire officer with the Department of Natural Resources and Environment in Melbourne said that this year's fires posed a greater threat to water quality than any since 1939, because of high threats to forests around the city's four main reservoirs.

Fires in much of Australia can pose a serious threat to both life and property, but generally have fewer long-

term ecological impacts than those in wet tropical regions. The dry sclerophyllous forests are well-adapted to burning and generally recover quickly, although human impact is probably increasing the intensity of fires above natural levels in some places. Fires are linked to either lightning strikes or human intervention during hot days with high winds, when the situation becomes literally explosive. Fires are not generally used for land clearing or forestry and there is a national ethos which tries to minimise fire risk, particularly as fires tend to threaten areas where people live.

Sources: *The Straits Times* and David Butcher of WWF Australia

NORTH AMERICA
Conversely, in North America poorly managed fire ***suppression*** *is often a more important problem - changing ecology and risking larger, uncontrolled fires in the future.*

Fire suppression in the US has been very effective in preventing fires, but with major ecological consequences. Although fire regimes vary considerably with local edaphic conditions, weather and forest types, dry forest types have been particularly severely affected by current fire management. Fire events have shifted from periodic ground burning fires that used to burn at regular intervals (for example every 5-30 years) to less frequent but catastrophic stand-replacement fires that consume large areas and have a far greater ecological and economic impact.

The changes have been created by the build-up of fuel through fire suppression activities and because of logging slash following clearcut and salvage logging. The shift has also had an enormous impact on plant communities dependent on periodic ground-burning fires. This has caused reduction in biodiversity in several forest types, including ponderosa pine forests in the eastern Cascades of Oregon and Washington, dry forests of the Sierra Nevada in northern California and long-leaf pine/wiregrass communities in the south-east, the last being one of the most endangered temperate forest ecosystems in the world.

Source: Dominick DellaSala of WWF US

MEDITERRANEAN
Fires have burnt again throughout the Mediterranean, threatening already badly fragmented forest habitats.

Over the last three years (1994 to 1996) more than one and a quarter million hectares of forests have been destroyed by fire in Portugal, Spain, France, Italy and Greece. In Italy, winter fires have been particularly severe in Liguria, with several thousand hectares of forest burnt. Despite the fact that fire can occur naturally in these forest types, current incidence is far higher than expected under normal ecological conditions and most of the fires are set deliberately. Reasons for fire raising include illegal land conversion for development or agriculture, to improve hunting conditions, insurance crime, creating cheap sources of timber and sometimes simply vandalism.

Source: Paolo Lombardi of WWF Italy

EUROPEAN UNION
The European Parliament has passed an important resolution on forest fires in SE Asia, calling for a portfolio of measures to address the problem.

The European Parliament agreed a resolution about the "crisis that has erupted in South-East Asia". The resolution points out that "many of the fires have been started by large companies in order to clear land for the establishment of oil-palm plantations, and expansion of wood pulp and rubber industries, whilst governments are deflecting blame on the age-old system of slash-and-burn agriculture".

The Parliament calls for a range of responses, including (i) that the Indonesian government enforce its newly-announced measures against companies violating environmental laws; (ii) stronger implementation of laws against land-clearance by burning; (iii) reorientation of European Commission aid programmes in tropical forests towards sustainable forest management, fire prevention and education; research into possible long-term effects of the pollution crisis; (iv) proposals for a global strategy for the prevention of natural catastrophes of this magnitude; (v) that the European Commission relaunch the initiative to establish a European Green Beret force, comprising a specialist intervention force for action in the event of natural and environmental disasters.

MALAYSIA

The Malaysian government is planning to use Russian technology to create artificial cyclones to combat future haze events. A local company - Biocure Sdn Bhd - has signed a memorandum of understanding with a Russian government-owned company to import the technology, the details of which will only be disclosed after it has been tested. However, leading meteorologists around the world have not heard of the technology and specialists warned against possible risks from untried methods of climate manipulation.

Source: *The Straits Times*, Singapore, December 5 1997

INDONESIA

Indonesia has reinstated 45 of the 146 timber exploitation permits revoked in the wake of widespread forest fires. The permits, held by 21 companies, were restored after the companies agreed not to clear land by burning.

Source: WWF Malaysia

Nigel Dudley
Jean-Paul Jeanrenaud