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A thematic study prepared in the framework of the Global Forest Resources Assessment 2005

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Foreword

In 2005, FAO held a Ministerial Meeting on Forests which called for a strategy to enhance international cooperation in fire management, to which this global assessment of fire management is an important contribution. This study complements the Global Forest Resources Assessment 2005 (FRA 2005) as an in-depth thematic study. The FAO-led Global Forest Resources Assessment has continued to respond to the needs of its users and has expanded its coverage to include new issues in sustainable forest management. The present study on fire management was developed from 12 regional working papers prepared within the framework of the Global Wildland Fire Network of the United Nations International Strategy for Disaster Reduction. 'Fire management' is defined as involving protection (early warning), preparedness, prevention, response and suppression, restoration/rehabilitation and monitoring.

This study presents information on fire in greater depth than was possible in FRA 2005, including its incidence, impact and management in different regions of the world. It recognizes that not all fires are destructive and that fire management is an essential part of sustainable forest management. Indeed, some ecosystems require fire to induce regeneration and to maintain or enhance biodiversity, agricultural productivity and the carrying capacity of pastoral systems. The study also finds that people are the overwhelming cause of fires in every region, for a wide range of reasons. Without political commitment and proactive campaigns, unplanned fires will continue to impact forests and livelihoods negatively around the world.

Fires in vegetation, including forests, woodlands, rangelands and the interfaces between agriculture and forestry and between wildland and residential/urban areas, are a major, continuing and probably increasing threat to human life, health and livelihoods, to economic development and to the environment. Much more must be done to help the general public and policy-makers understand the scale of this threat and take long-term preventive action, not simply emergency suppression measures when a fire disaster strikes. More must be done, as well, to improve the understanding of fire by urban people at the wildland/urban interface, especially the need to reduce fire threat through fuel management, including prescribed burning. Most important is to address the fire issue at its roots – educating those using fires in land-use systems or in land-use change and those setting wildfires, either through negligence or intentionally. Collection of information at the country level is urgent in order to quantify the impact and scale of the problem, detect trends and contribute to awareness-raising. This data can then be consolidated at the regional level. International collaboration is required, within and between regions, to set up such a data-collection system and to promote the exchange of information and even resources, while donor support is required for capacity-building and the establishment of advanced detection and monitoring systems.

The evidence suggests that a number of factors, but especially climate variability and change and the increasing spread of urban development and attitudes into rural areas, will greatly increase this threat and the scale of fires in vegetation.

The process of preparing this study has highlighted once again the challenges faced by those attempting to gather reliable and current information on fire in different types of vegetation. Feedback by readers is encouraged, including comments or new data, in order to contribute to the evolution of knowledge.

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Acronyms and abbreviations

ASEAN	Association of Southeast Asian Nations
CBD	Convention on Biological Diversity
CBFiM	community-based fire management
CIFOR	Center for International Forestry Research
CIS	Commonwealth of Independent States
COFO	Committee on Forestry (FAO)
CONAF	Corporación Nacional Forestal (Chile)
EFFIS	European Forest Fire Information System
F&RS	fire and rescue services
FDRS	fire danger rating system(s)
FRA	Global Forest Resources Assessment
GBA	Global Burnt Area
GFMC	Global Fire Monitoring Center
GIS	geographic information system
GOFC-GOLD	Global Observation of Forest and Land Cover Dynamics
GTZ	German Agency for Technical Cooperation
GWFN	Global Wildland Fire Network
IATF	Inter-Agency Task Force on Disaster Reduction (UN-ISDR)
ICS	Incident Command System
IFFM	Integrated Forest Fire Management Project
ILO	International Labour Organization
ITTO	International Tropical Timber Organization
IUCN	World Conservation Union
JFM	Joint Forest Management Programme
JRC-EU	Joint Research Centre of the European Commission
MODIS	Moderate Resolution Imaging Spectroradiometer
NAFC	North American Forest Commission
NASA	National Aeronautic and Space Administration (United States)
NEESPI	Northern Eurasian Earth Science Partnership Initiative
NGO	non-governmental organization
NOAA	National Oceanic & Atmospheric Administration (United States)
NWFP	non-wood forest product
PREVFOGO	National System for Wildfire Prevention and Suppression (Brazil)
PROARCO	Arc of Deforestation Programme (Brazil)
RECOFTC	Regional Community Forestry Training Centre (Asia and the Pacific)
SADC	Southern African Development Community
SCO	Shanghai Cooperation Organization
TCP	Technical Cooperation Programme
UNCCD	United Nations Convention to Combat Desertification
UNCED	United Nations Conference on Environment and Development

UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UN-ISDR	United Nations International Strategy for Disaster Reduction
UN-OCHA	United Nations Office for the Coordination of Humanitarian Affairs
UNU	United Nations University
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
WFAG	Wildland Fire Advisory Group (UN-ISDR)
WG-4	Working Group on Wildland Fire – Working Group 4 (IATF/UN-ISDR)
WHO	World Health Organization
WMO	World Meteorological Organization
WUI	wildland/urban interface
WWF	World Wide Fund for Nature

Executive summary

In the millennium year 2000, an evaluation of satellite data revealed that the land area affected by vegetation fires worldwide was 350 million hectares, much of which was forest and woodland. Most of the area burned was in sub-Saharan Africa, followed at some distance by Australasia. Due to a lack of long-term, consistent data on the occurrence and impact of vegetation fires, it is not possible to determine trends in the global number of fires or the area burned. However, there is evidence from some regions that the trend is towards more fires affecting a larger area and burning with greater severity, while the risk of fire may be increasing under the influence of climate change, in association with land-use changes and institutional constraints on sustainable forest and fire management.

In interpreting the statistics, however, it should be remembered that many ecosystems throughout the world have evolved under the influence of fire and require it for their regeneration.

This global overview of fires in vegetation is based on 12 regional working papers submitted mainly by representatives of the UN-ISDR Global Wildland Fire Network in late 2005. Although many of the countries concerned acknowledge that the reliability of the information may not be high, it is nevertheless the best estimate of the global fire situation to date and gives a good indication of the scale of the impact of vegetation fires on society, on the economy and on the environment.

People were reported by almost all regions to be the main cause of fires in vegetation and in agricultural areas. The estimated social and economic damages caused by fires are enormous, although largely unquantified. They include human and animal lives lost, short- and long-term effects on health, direct material losses and indirect costs such as time lost in evacuations, as well as effects on the environment, including the release of greenhouse gases.

Countries expend considerable resources in fire detection and suppression, primarily through human resources on the ground, but increasingly through satellite systems and aerial firefighting. However, the reaction of policy-makers to catastrophic fire outbreaks, using expensive suppression measures, may divert funds and staff from fire prevention – which could have averted the disaster in the first place. Given that people are by far the main cause of those fires that create problems or have negative impacts on the environment and society, public awareness programmes should be given higher priority. Awareness campaigns should include the increasingly urban populations that oppose all fire, even the prescribed burning that could reduce risk, but persist in building homes in attractive but hazardous locations at the wildland/urban interface.

Fire prevention and suppression are reportedly hampered by unclear lines of institutional responsibility, as well as by conflicting policies and legislation in some countries. Fire management involves early warning, preparedness, prevention (including fuel management, public awareness and training), suppression and

restoration. The importance of national fire management plans that cover all aspects and that reconcile intersectoral considerations cannot be overstressed.

The regional summaries in Part 2 report some collaboration between countries within regions, and even between countries in different regions. International awareness and the potential for collaboration have been increased through high-level regional and global consultations.

The report offers the following recommendations:

- At the political level, the positive as well as the negative effects of fire must be recognized and a strong commitment made to the concept of fire management by all national policy-makers.
- Reliable assessments of the extent and impact of vegetation fires are urgently needed, including:
  - harmonization of terminology and definitions;
  - development of internationally accepted standards and procedures for data collection;
  - development of regional fire databases.
- People must be made more aware of the economic, social and environmental damage caused by fires. Target groups should particularly include policy-makers, urban dwellers and rural populations, especially farmers and pastoralists. One of the main messages to policy-makers should be the need for fire planning and management.
- The role of community-based fire management as an adaptive and sustainable mechanism should be recognized.
- Institutional strengthening is needed in many countries, including clear definition of the responsibilities of each institution in the various aspects of fire management. Fire management plans should be prepared taking into account the plans of other sectors and should include provisions for conflict resolution. There is often a need for the training of fire personnel or for retraining in more sophisticated fire detection, communications or suppression techniques, and for training of others outside the forest sector, including training of farmers in secure methods of prescribed burning.
- National institutions require adequate budgets, and coordination between national institutions and agencies is necessary.
- International collaboration should be continued and expanded.
- Countries should continue to share knowledge and experiences, and should develop reporting frameworks and regional policies on fire management.
- Regional networks, particularly those organized under the UN-ISDR Global Wildland Fire Network, should be consolidated and strengthened and links developed with others – not only for the exchange of information but for training and regional fire planning as well.
- Bilateral agreements on mutual assistance (joint fire suppression) should be promoted, and compatible approaches developed.
- Technical workshops and occasional high-level meetings should be conducted to promote international and regional collaboration and demonstrate political recognition of the importance of fire control.

- Donor support is required in a number of fields, especially for:
  - equipment, training and research into advanced techniques for detection and prediction – in particular satellite systems;
  - training in community-based fire management and encouragement of communities of interest.

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Part 1

Introduction and global analysis

R. Meyers

1. Introduction

The role of fire in the world's vegetation is ambivalent. In some ecosystems, natural fires are essential to maintain ecosystem dynamics, biodiversity and productivity. Fire is also an important and widely used tool to meet land management goals and maintain the functioning of ecological processes. However, every year, wildfires destroy millions of hectares of forests, woodlands and other vegetation, causing the loss of many human and animal lives and immense economic damage, both in terms of resources destroyed and the costs of suppression. There are also impacts on society and the environment – for example, damage to human health and delays in transport from smoke, loss of biological diversity, release of carbon dioxide (CO_2) and other greenhouse gases, damage to recreational and amenity values and much more. Then there are the secondary effects: erosion, land- and mudslides, flooding – when high rainfall impacts steep slopes where the vegetation cover has been burned – and insect infestations following fires.

The positive and negative roles of fire must be recognized, as well as the need for holistic management, rather than just suppression.

Despite the severe social, economic and environmental impacts of fire, reliable, current information on extent, causes, impact and costs is insufficient. Yet such information is essential to the development of policies, legislation and plans for prevention and suppression.

TERMINOLOGY

There is some confusion over fire terminology. The scope of this paper might be presumed to be fires in forests and woodlands, yet relatively few countries can distinguish these categories in the information they collect on fires. Even if they were distinguished, there might be doubt as to whether the data refer to fires in the administratively defined forest (often called 'forest estate'), or in the forest as defined by the Global Forest Resources Assessment 2005 ('FRA 2005' – FAO, 2006a), which specifies canopy cover of more than 10 percent, area of more than 0.5 hectares (ha) and trees higher than 5 metres (m). Data on numbers and extent usually refer to fires in forests (FRA definition), other wooded land, rangelands, grasslands, bushlands, agricultural lands such as those used for shifting cultivation or grazing, or barren land – collectively known as 'wildland fires'.

This paper refers to fires in all types of vegetation. It does not use the term wildland fires, largely because of the difficulty of translating the term, while noting that it has been used by FAO in the past, specifically in *State of the World's Forests 2003* and *2005* (FAO, 2003 and 2005a).

SOURCES

The present study is presented in two parts: first, a global analysis, derived from 12 regional working papers submitted at the end of 2005, including global developments since submission of the papers (provided by the Global Fire Monitoring Center (GFMC – www.fire.uni-freiburg.de/)); and, second, summaries of the working papers themselves. The Bibliography lists cited references; Annex 1 suggests additional reading by region; Annex 2, a global table, documents the lack of reliable, current fire data; Annex 3 provides a glossary of selected fire terminology; and Annex 4 lists the FAO Fire Management Working Papers series, including the regional papers.

The regional working papers were prepared from country reports grouped according to the regions of the Global Wildland Fire Network (GWFN) of GFMC (see Part 2). Countries that contributed information to the working papers are listed in Table 1.

TABLE 1
Global Wildland Fire Network countries contributing to the regional working papers

Region	Countries[a]
Africa, sub-Saharan	Botswana, Côte d'Ivoire, Ethiopia, Kenya, Namibia, Senegal, South Africa, United Republic of Tanzania
Caribbean & Mesoamerica	Bahamas, Barbados, Cuba, Dominica, Dominican Republic, Grenada, Jamaica, Guadeloupe, Saint Lucia, Saint Vincent and the Grenadines, Trinidad and Tobago
	Belize, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama
North America	Canada, Mexico, United States
South America	Argentina, Bolivia, Brazil, Columbia, Chile, Ecuador, Paraguay, Peru, Uruguay, Bolivarian Republic of Venezuela
Central Asia	Afghanistan, Armenia, Azerbaijan, Belarus, China (northern territories), Georgia, Islamic Republic of Iran, Iraq, Kazakhstan, Kyrgyzstan, Mongolia, Pakistan, Russian Federation, Tajikistan, Turkmenistan, Ukraine, Uzbekistan
Northeast Asia	China, Democratic People's Republic of Korea, Japan, Republic of Korea, Russian Federation (Far East)
South Asia	Bhutan, India, Nepal, Sri Lanka
Southeast Asia	Brunei Cambodia, Darussalam, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Philippines, Singapore, Thailand, Viet Nam
Australasia	Australia, New Zealand
Balkans	Albania, Bulgaria, Croatia, Greece, Serbia and Montenegro,b Slovenia, The former Yugoslav Republic of Macedonia, Turkey
Baltic and adjacent countries	Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Luxembourg, Netherlands, Norway, Poland, Russian Federation (Republic of Karelia), Slovakia, Sweden, Switzerland, United Kingdom
Mediterranean	Algeria, Cyprus, Greece, Israel, Italy, Morocco, Portugal, Spain, Turkey

[a] A list of all member countries of each regional network is available at www.fire.uni-freiburg.de/GlobalNetworks.html. Note that the GWFN country composition does not correspond to the six FRA regions, and some countries, or parts of countries, are represented in more than one GWFN region, i.e. China (Central and Northeast Asia), Greece (Balkans and Mediterranean), Mexico (Mesoamerica and North America), the Russian Federation (Baltic area and Central and Northeast Asia) and Turkey (Balkans and Mediterranean).

[b] Before the independence of Montenegro in 2006.

As several of the regional summaries and this global synthesis note, availability of information may not be high, let alone its reliability. For example, the true environmental, social and economic costs of fires are almost entirely unavailable, while satellite information on the extent of fires appears to be much more reliable (and often several times greater) than land-based assessments.

2. Global analysis

EXTENT BURNED

The global estimate of land area affected by fire in 2000 was 350 million hectares. This estimate was made by the Joint Research Centre of the European Commission (JRC-EU), based on fire scars detected by the SPOT-VEGETATION satellite sensor (JRC-EU, 2005). A significant proportion of this area must have been forest and woodland, but how much is not known.

Given the lack of common fire terminology and consistent data collection at the regional level, the figures derived from the regional working papers for yearly average area burned can only be described as representing 'vegetation fires'. In many regions, it is not possible to distinguish wildfires (unplanned and uncontrolled fire – see definitions in Annex 3) from land-use fires (fires intentionally applied in land-use systems, e.g. prescribed burning or traditional slash-and-burn agriculture and rangeland burning).

- Africa, sub-Saharan – 168 million hectares (from national statistics over a variable number of years); 230 million hectares (2000, from JRC-EU, 2005);
- Caribbean and Mesoamerica – 446 000 ha (2000–2004, three Caribbean and nine Mesoamerican countries, including Mexico);
- North America – 4.1 million hectares (2000–2004, excluding Mexico);
- South America – 2.9 million hectares (1986–2004);
- Central Asia – 2.0 million hectares (nine countries, FAO, 2006a), but the Global Burnt Area 2000 Project (GBA2000) reported 42 million hectares;
- Northeast Asia – 1 million hectares (1990–2004);
- South Asia – 4.1 million hectares (2000, mainly in India – FAO, 2006a);
- Southeast Asia – 6.9 million hectares (FAO, 2006a);
- Australasia – 54.5 million hectares (which is the Australian seven-year average for 1997–2003);
- Balkans – 156 000 ha (1988–2004);
- Baltic and adjacent countries – 32 000 ha;
- Mediterranean – 700 000 to 1 million hectares.

Comparisons between regions are meaningless, due to differences in the base date, area, population density and vegetation type. Even adjusting the regional figures on a unitary basis of, say, fires per head of population or fires per hectare of surface area is impossible because of the duplication of figures of countries in more than one region.

In addition, the figures reported by countries for vegetation fires may be highly inaccurate (see Annex 2 – Global Table). A comparison of the national statistics on areas burned with the satellite-derived data from the GBA assessment of 2000 showed that the national statistics of seven countries in Africa grossly underestimated the actual area burned. In the Russian Federation, during the 2002 fire season, satellite imagery

showed that 12 million hectares of forest and non-forest land had been affected by fire, while official figures reported 1.2 million hectares of forest land and 500 000 ha of non-forest land had been burned. In these two cases, and possibly others, the reasons for this under-recording include the difficulty and cost of ground and aerial surveys of fire-affected areas, as well as the lack of monitoring and recording of fire occurrence and their impact on non-protected forest and other lands. In the recent past, the wish to conceal ineffectiveness in combating fires has also certainly contributed to under-reporting.

Some countries are already detecting fires by satellite remote sensing (e.g. Mexico with four of its neighbouring Central American countries), while Mesoamerica and some other regions are suggesting the use of satellite systems for fire monitoring, especially given the physical difficulty and cost of ground surveys of burned areas.

Only one region, the Baltic area, reported that "most countries in the region are not facing major problems of fires in forests ...." The Balkans indicated an increasing trend in the number of fires in recent years, and both Central and Northeast Asia showed an increase in both the number of fires and the area burned.

The South American region reported that 120 000 ha of plantations had burned in 30 years. The African working paper also mentioned fires in plantations, and with the rapid increase in plantation areas during the past decade, the risk of fires in forest plantations must be growing.

The African regional working paper drew attention to the evolution of many ecosystems through the human use of fire and the need for fire in maintaining these ecosystems. The North American paper noted the natural role of fire, particularly in boreal ecosystems, where tree species have adapted to fire to the point that it is essential to their regeneration. Fire adaptation is seen in several other natural ecosystems, such as the pine forests of Central America and Mexico.

Most regions drew attention to the lack of reliable, up-to-date information on fires, and they recommended:

- definition of a common terminology and format for reporting fires; as a prerequisite for ⟶
- development of a common database for fires; which would permit ⟶
- analysis at country and regional levels of the direct and indirect causes of fires and the exchange of experience on all aspects of fire management.

Such analyses would support research into a range of issues and into the use of satellite remote sensing for fire monitoring and reporting.

CAUSES

> *... a box of matches remains the simplest and least expensive tool available to fire users.*
>
> **– FAO Fire Management Working Paper FM/10/E**

Almost all regions reported that people are the overwhelming cause of fires. Several regions estimated the proportion:

- Mediterranean – 95 percent;
- South Asia – 90 percent;

- South America – 85 percent;
- Northeast Asia – 80 percent;
- Balkans – 59 percent.

Even where causes were given as 'unknown', it is believed that most fires are caused by people. The list of human-induced causes included land clearing – especially for shifting cultivation – and other agricultural activities, maintenance of grasslands for livestock management, extraction of non-wood forest products (NWFPs), industrial development, resettlement, hunting, negligence (such as the careless disposal of cigarettes) and arson. In countries in transition towards a market economy, there has been an increase in abandoned agricultural land and thus a build-up of fuel. The most commonly mentioned causes were land clearing and other agricultural activities, negligence and arson.

Only in the very remote areas of Canada and the Russian Federation is lightning a major cause of fires (50–70 percent reported in parts of Russia). The remoteness of these areas often means that fires develop into serious conflagrations: 35 percent of the number of fires in Canada, but 85 percent of the area burned. In other regions, rain extinguishes most fires started by lightning.

Arson was frequently mentioned in the reports. Fires may be deliberately set as a form of protest or vengeance against others or against the government, for spite, entertainment (Caribbean) or employment in firefighting. In some cases, it is a cause of half the fires in the country. But it is not easy to apprehend arsonists: Australia reported that in the 2002/2003 fire season, of 10 000 fires of actual or potential arson, there were only 43 convictions, while the South American working paper noted that the absence of specific procedures for enforcement under the law for vegetation fires makes the law difficult to impose.

A trend in recent decades, in almost all countries, has been the movement of people from rural areas to cities (e.g. Australasia, the Mediterranean). Fewer people living in the country means that fires set for agricultural clearing are more likely to run out of control. In some regions of Africa, HIV/AIDS is causing severe mortality in adults, and fires started for agricultural clearing have escaped because of these labour shortages and the lack of experience among the often-orphaned youths carrying out the task. All these factors, including pressure from a growing urban population, have resulted in worse fuel management and increased fuel levels, augmenting the risk and scale of fires.

Urban people may have a very poor understanding of the dangers of fires and their consequences. The working papers for Australasia and North America both mentioned the problem of houses being established in zones at risk for fire. Urban dwellers also tend to perceive all fires as bad for the environment, leading to public pressure against prescribed burning (Australia). Increased numbers of fires at the wildland/urban interface (WUI) were also mentioned in the paper for South America.

Many regions identified the need for better public awareness campaigns – particularly among urban people – of the need for more holistic approaches to fire management.

The paper for South America also recorded severe droughts, widespread burning activities and wildfires related to El Niño events in 1992, 1993, 1997 and 1998. The influence of El Niño in creating weather conditions favourable to wildfires was also mentioned in the paper for Africa.

Research on climate change, quoted in the North American paper, indicates that the incidence and severity of fires "will increase dramatically", while the Mediterranean paper noted that increased air temperatures and reduced summer rainfall are predicted, leading to an increased fire risk not only in that region but in other fire-prone regions as well. The Caribbean and other papers also commented on the increased fire hazards likely to arise from climate change.

EFFECTS – THE DAMAGE CAUSED BY FIRES

Regional damage reports were largely descriptive (i.e. qualitative) rather than quantitative. Most regions discussed the environmental damage caused by fires – forest degradation, soil erosion, secondary insect attacks (e.g. *Ips* bark beetles in southeastern Europe) – as well as the effect of fires crossing from fire-adapted to fire-sensitive ecosystems, with the consequent effect on biological diversity, especially species composition, regeneration and stand structure.

Most regions also reported the effect of fires on climate through the emission of greenhouse gases, mainly CO_2. The Northeast Asian paper stated that the region may account for more than 2 percent of global biomass burning and carbon emissions yearly. The African region drew attention to a recent FAO study (FAO, 2006b) that estimated the impact of vegetation fires in Africa on the global carbon cycle. The current estimate of the quantity of biomass burned globally each year, from all sources, is about 9 200 million tonnes (Andreae, 2004). Overall, global fires in vegetation consume 5 130 million tonnes, 42 percent of which is in Africa. This burning releases about 3 431 million tonnes of CO_2, as well as significant quantities of other emissions. However, only a fraction of the carbon released by vegetation fires remains in the atmosphere. The cyclic nature of fire disturbance in fire-adapted and fire-dependent ecosystems involves sequestration of atmospheric carbon for regrowth of plant biomass. Thus natural or anthropogenic fires in those ecosystems with sustainable, fire-adapted regimes are not contributing to a net release of carbon into the atmosphere or to an increase in the natural or anthropogenic 'greenhouse effect' and global warming.

The Northeast Asian region drew attention to the effect of fires on permafrost sites, which may lead to degradation of forests due to the long restoration process. Other regions, e.g. Central and Southeast Asia, mentioned the environmental impact of fires in deep organic layers such as peat, which are difficult or impossible to control, as well as the continuing effect on human health of smoke emissions from these fires.

Some regions cited the loss of human lives, both in the general population and among firefighters. Perhaps the worst was that in Brazil, where over 700 people were killed in 1998. Several regions described the effect of haze pollution on human health. The Southeast Asian region referred to recurrent land-use fires that generate emissions seriously affecting the environment, human health and security.

The African region emphasized the impact of fires on livelihoods, especially of the extremely poor, but this effect on livelihoods and on the food security of the poorest, the disadvantaged, minorities and women was severe in all developing economies.

A few countries and regions quoted figures on fire damage – for example, US$107 million in India in one year and US$4.2 billion in Russia in 1998. Mexico reported losses in 2003 of US$337 million in wood, US$6.6 million in firewood and US$39 million in reforestation costs. Northeast Asia recorded losses in timber from forest fires on the order of US$0.5–1 billion yearly. Both Canada and the United States referred to losses of homes and businesses, especially in the WUIs, where homeowners had little knowledge of the danger from fire, and communities lacked building codes adapted to fire or to the management of fuel adjacent to properties. In 2003, 334 homes and 10 buildings were destroyed by fire in Canada, while in the United States, in the same year, 3 640 homes, 33 businesses and 1 140 other structures were destroyed. Added to those losses were the costs of evacuating residents.

A few regions (e.g. Africa and the Balkans), where there are countries with important tourist industries, cited the negative visual impact of fires on the appearance of the landscape.

There are, however, no agreed standards for the collection of data on fire damage. The paper for Australasia mentioned the difficulty of calculating even yearly firefighting costs. It referred to the existence of sophisticated methods for assessing the environmental impact of economic developments, while no assessments are made of the environmental impact of fires. Thus there is no data to support or prioritize inputs for the restoration of landscapes or ecosystems – despite the existence of the technical skills and capacity to do so.

PREVENTION

Fire prevention in most countries is targeted at people – the main cause of fires – through awareness-raising, education and participation in communities of interest. Australia referred to the extension of urban development into rural lands and the consequent need for public education there. The Mediterranean region noted that the message for urban people may stress the risk of fire and its potential consequences, while the message for rural people is often aimed at their own self-interest – i.e. at not destroying their resources. India reported that various projects have raised awareness in communities and have increased participation in prevention and suppression, reducing fire outbreaks by up to 90 percent in some regions.

The Australasian paper quoted an Australian source:

> *Those creating the risk historically have no direct interaction with those dealing with the results, the fires. Worse perhaps is the absence of any useful engagement with those creating the future risk – the risk that fire and emergency services, insurers and society will be dealing with in the future* [i.e. factors such as climate change, urban expansion, changes in lifestyle, etc.]. *This may well be a characteristic that is experienced more widely even outside Australia in the future.*
>
> **– Handmer, 2003**

Most countries have laws to prevent the setting of fire or to control the period during which fire may be used. Many have developed fire prevention programmes or plans. But few countries have the ability to enforce these legal provisions or the capacity to administer the programmes. A zero-burning policy by the Association of Southeast Asian Nations (ASEAN) came into effect in 1999, but is proving ineffective in reducing fires in Southeast Asia, as it appears that fire is a more fundamental need in the livelihoods of rural people than had been appreciated. Some modified guidelines are now being developed for prescribed burning by small-scale landowners. The inclusion of the great number of shifting cultivators in the fire prevention programmes in developing economies presents considerable challenges. They frequently have no formal land tenure, are used to customary/traditional forms of land management and hence are reluctant to risk change.

Several countries – in the Mediterranean region, for example – aim to reduce the fuel load through preventive burning or other fuel reduction methods such as controlled grazing. Training courses in prescribed burning were described in the South American paper. But such preventive burning may be opposed by an increasingly urban population, and the education of these people was identified as important by several countries. The United States noted that prescribed burning is not only a tool for prevention, but can also be used to restore and maintain ecosystems. The use of green or bare strips of land to prevent the spread of fire is common in many regions. China, for example, reported that at the end of 2000 the total length of bare firebreaks was 490 000 km, and of greenbelt fuelbreaks, 172 100 km.

Early warning systems and fire danger rating systems are increasingly being used throughout the world to give advance notice of periods of high fire risk. The ASEAN Specialized Meteorological Centre and the Southeast Asian Fire Danger Rating System have provided regional fire danger and meteorology information via their websites since 2000 – although difficulty in accessing and interpreting the information remains in some rural and semi-rural locations. Viet Nam has developed a national fire danger rating system, which is disseminated widely by various means, while Russia and countries of the Commonwealth of Independent States (CIS) reported similar systems. The GFMC Wildland Fire Early Warning Portal (www.fire.uni-freiburg.de/fwf/fwf.htm) provides access to all global, regional and national early warning systems.

A special problem is the prevention of fires in areas contaminated with radionuclides. The Central Asian region reported that 6 million hectares of forest lands were polluted as a result of the failure of the Chernobyl nuclear power plant in 1986, with the most polluted forest area covering over 2 million hectares in Belarus, in the Kiev region of the Ukraine and in the Bryansk region of the Russian Federation. Despite best efforts, every year hundreds of fires occur in these contaminated forests, peatlands and former agricultural sites. A report published after the Central Asia regional working paper revealed that radioactive emissions from fires burning in Central Asia in 2003 were recorded in Canada (Wotawa *et al.*, 2006).

There is a similar situation in Kazakhstan, where more than 450 nuclear tests, including some 100 atmospheric tests, were conducted from 1949 to 1989. Radioactive contamination is highest in eastern Kazakhstan, including the fire-

prone pine forests along the Irtysh River. Since 2004, the World Bank has financed the Kazakhstan Forest Protection and Reforestation Project, in which radioactive contamination and fire management are key project issues.

The relative neglect of fire prevention activities was documented by reports from many countries that most of the fire management budget goes for suppression, with a much smaller proportion for prevention.

SUPPRESSION

The suppression of fires starts with detection. Most regions rely on the early detection of fires by watchtowers and patrols, but increasing numbers also reported the use of satellites and aerial surveillance. Industrialized countries tend to use sophisticated equipment and advanced technology. Canada and the United States reported prediction of the most likely locations of fires (from either lightning or human causes) and enhanced detection through lightning detection systems and aircraft patrols. The Southeast Asian region, however, reported that the use of satellite detection of active fires peaked following the 1997/98 fire season, with the recognition of limitations such as coarse resolution of fire detection maps, cloudiness, time delays in information relay to field sites, and inaccuracy.

Fires are extinguished primarily by ground-based suppression forces using hand tools and mechanized equipment, aided by indirect techniques such as backfiring and the use of fire traces. The Mediterranean region mobilizes approximately 30 000 workers for firefighting activities each summer, and in particularly serious seasons, the number may swell to 50 000. The Southeast and Northeast Asian regions reported that although fire suppression resources are available they are often insufficient.

Ground-based firefighters are often reinforced – in Mediterranean countries for example – by fixed-wing aircraft (including amphibious models) and helicopters; the latter are often used to transport firefighters. The working paper for Southeast Asia stated that the use of helicopters is increasing in the region, especially for rapid access by fire crews. In the South American region, Argentina, Brazil and Chile usually combine terrestrial and aerial resources in firefighting, as do Canada and the United States. China reported that air-jet extinguishers are used for surface and grass fires, and fire-extinguishing bombs have been developed. The Mediterranean paper emphasized that if the land-based forces are not sufficient, the introduction of additional airborne forces will not improve overall efficiency. It may even retard future development, as resources that could have been better invested in the formation of land-based brigades are diverted.

Australia reported that aerial support to fire suppression cost over US$80 million equivalent in the 2002–2003 fire season, and aircraft costs constituted a large part of overall fire management costs. Canada drew attention to the constantly rising costs of fire suppression owing to a number of factors, including the use of more costly equipment, expansion of fire protection zones northward to match shifting forest operations, and increased costs associated with protection of an expanding WUI zone. Changes in the weather patterns affecting fire mean that annual suppression costs, excluding public and industrial losses, are not only increasing, but are

highly variable, averaging US$450 million equivalent, but reaching US$900 million equivalent in an extreme fire season. Fire suppression as practised today may not be economically sustainable: Canada will not be able to meet current targets in terms of area burned and the control of escaped fires. This will have direct effects on wood supply and the competitiveness of the forest industry, and on the approximately 300 communities in Canada that are dependent on the forest industry.

INSTITUTIONS, RESPONSIBILITIES AND ROLES

Countries have many different institutional arrangements for organizing fire management. The national fire service is usually responsible for fires that pose a hazard to people, with priority given to urban areas, while the forestry authority, at the national or state/provincial level, is responsible for fires in the forested areas under its jurisdiction. Environmental and/or conservation agencies such as national parks authorities may be responsible for fire management in reserves or parks. The national defence force may provide support where the capacity of the other institutions is limited, while agencies concerned with meteorology, tourism, health, infrastructure, development, legislation, national emergency and ambulance services may also be involved in prediction, protection and support. At the forestry/agriculture interface, the private sector, non-governmental organizations (NGOs), civil society and research and education/training institutions are increasingly engaged in dialogue and action with respect to the prevention and suppression of fire and restoration and rehabilitation following it.

The countries of the Mediterranean reported two trends in institutional arrangements:

- a system in which the forest service is responsible for forest fire prevention and control;
- a 'mixed' system, in which the forest service is responsible for forest fire prevention and the fire service takes over suppression and presuppression activities.

In most Mediterranean countries, forest authorities have full responsibility for fighting fires in the forest. European Union countries, however, use the mixed system, with various agencies involved, supported by expensive, mostly aerial fire suppression tools. There is also a movement away from fire suppression by the forest service to professional firefighters, which represents a shift from a fire management approach to a more operational one. While this may be correct in principle, it reduces the participation of forest management authorities in fire protection, creating more of a crisis-response character. Another reason for this development may be the increasing urbanization of European Union country populations, which do not understand the fire management approach and consider fire 'bad' and to be totally excluded. The Baltic region also reports that fire management is no longer the responsibility of forestry staff, but has been assumed by the fire and rescue services – which in general lack appropriate training and equipment for vegetation fire management. This operational approach is evidently not proving effective in the face of the increasing fire hazard.

The involvement of so many institutions in fire management means that coordination of their inputs is essential. In 1997 Turkey instituted a Fire Command Centre, which is responsible for all fire management issues and has evidently improved coordination. South Africa has established a National Disaster Management Centre, and a number of African countries are following this example. Russia has maintained a centralized, national forest-fire management system, with two departments – the Federal Forestry Agency and the Aerial Forest Protection Service – while the Ministry of Emergency Situations is involved in extreme conditions. However, in the wake of the decentralization process in Russia, more responsibilities are being delegated to the regions. Mexico has established a Group for Interagency Coordination with the participation of the 12 Federal Secretaries of State. The group will support fire management activities and ensure coordination of resources for the prevention, detection and suppression of fires.

Nevertheless, lack of coordination among the various responsible organizations for fire management remains a constraint in many countries. The paper for South Asia referred to "a lack of feeling of responsibility [for fire management] on both sides – government and local population. Tackling the difficult issue of fire is postponed by national Parliaments as soon as … the danger recedes." Similarly, in South America, the political reaction to fires occurs after a catastrophic event. Lack of political will may be the reason not only for lack of institutional coordination in fire management, but for problems in other fire issues as well, ranging from adequate budgetary provision for prevention to enforcement of fire control and other laws.

COMMUNITY PARTICIPATION

Community-based fire management (CBFiM) exists and is increasing in some developing countries. 'Communities of interest' are emerging, in which groups contribute towards fire management motivated by self-interest in a landscape threatened by fire. In most developed economies, however, it appears that communities *per se* participate less and less. In these countries, there has been a move away from a local-level approach, in which fire protection measures are part of forest management, towards a more high-input, operational model, in which professional, specialized units are involved and supported by advanced equipment, but only after the outbreak of the fire.

A significant step in CBFiM occurred in Bangkok in 2000 at the first international workshop on this phenomenon. Very encouraging CBFiM programmes have been established in the sub-Saharan region, for example in Burkina Faso, Mozambique, Namibia and South Africa, and in Southeast Asia. The results of these projects have shown that, in Africa at least, the community approach is probably the only sustainable, long-term approach to improving the fire situation.

Other countries have also reported CBFiM initiatives. In China, India, Nepal and Turkey, the response of local people and communities to fires has improved considerably in recent years, owing to public awareness campaigns dealing with attitudes towards forest resources, supported by new community regulations. Bolivia, Brazil and Chile have also had encouraging experiences. FAO is providing strong support to CBFiM training and projects.

NATIONAL AND INTERAGENCY COLLABORATION

In addition to cooperative arrangements for communities and other stakeholders, there is a need for close cooperation and coordination by the national, provincial and local agencies involved in fire management (see *Institutions, responsibilities and roles*, below). In countries in which fire management is solely the responsibility of states or provinces, such as Australia, interstate cooperation agreements or federal regulations have been developed for border-crossing fire events or emergency situations. In some countries, support to states from national/federal authorities is provided regularly (the Russian Federation and Spain). National agencies responsible for fire management in territories distributed over various states or provinces have created interagency coordination mechanisms and centres (Canada and the United States).

Interagency cooperation is practiced, by definition, by all those having shared responsibility for fire management. However, there is often a critical gap in the availability of adequately trained and equipped human resources for the specific tasks of vegetation fire suppression. In many countries in Europe, fire services are using fire suppression hardware, including personnel protection equipment, designed for firefighting in buildings or for the suppression of fires of hazardous chemicals, and they are often not adequately trained in the fundamentals of vegetation fire behaviour and safety. This has repeatedly resulted in an inability to control fires or in fatal accidents.

INTERNATIONAL COLLABORATION

Bilateral and multilateral agreements on mutual assistance

The regional working papers indicated that there is increasing collaboration among countries and among regions, but that there is also variation in the amount and type of collaboration. In some regions, such as South Asia, there is little reported collaboration in fire management, but in others, such as North America, parts of the Mediterranean and Australasia, collaboration among countries is strong.

The regional analyses report a total of 22 international emergency response agreements, 16 international agreements on other matters and six national inland agreements dealing with forest fires globally. Bilateral and other agreements for joint fire suppression or the exchange of fire crews are in force in several places, especially in border areas, for example Canada with the United States; China with Russia; among some countries of Mesoamerica; Mexico with the United States; Mongolia with China and Russia; Russia with Finland; and Russia with the Islamic Republic of Iran. Moreover, ad hoc agreements have been formulated to respond to emergency situations, such as in Brazil and Colombia in 1998 (www.fire.uni-freiburg.de/emergency/int_agree.htm).

The three North American countries have jointly adopted the Incident Command System,[1] enabling them to work together using a unified command structure and terminology.

[1] The Incident Command System is a standardized on-scene emergency management concept, specifically designed to allow its user(s) to adopt an integrated organizational structure equal to the complexity and demands of single or multiple incidents, without being hindered by jurisdictional boundaries.

Bilateral and multilateral emergency assistance is in place, for example the assistance offered by Australia and Singapore to Indonesia in 2005, or by the United States to Mexico, or that among Australia, New Zealand and the United States in severe fire seasons.

In view of the extreme fire and smoke pollution episodes since the late 1990s, during which a number of countries throughout the world requested foreign assistance for disaster response, the Joint Environment Unit, Emergency Services Branch, of the United Nations Environment Programme (UNEP), the United Nations Office for the Coordination of Humanitarian Affairs (UN-OCHA) and GFMC recognized the need for improved cooperation in early warning, information dissemination and response to vegetation fire emergencies. In 2001, Joint Interface Procedures were signed by UNEP, UN-OCHA and GFMC that led to increased efficiency in the provision of information and in coordination of the response (GFMC, 2006a).

International fire response exercises have been conducted with multilateral cooperation in the Baltic region (BALTEX Fire 2000), the European Union (France 2004) and the Balkans ("Taming the Dragon" 2002, organized by the North Atlantic Treaty Organization (NATO) and the Euro-Atlantic Disaster Response Coordination Centre, and EASTEX Fire 2005) (www.fire.uni-freiburg.de/emergency/International%20Wildland%20Fire%20Exercises.htm).

While this development is encouraging, there would seem to be potential for further collaboration, considering the scale of the problem.

International mechanisms and networking to enhance cooperation

As a contribution to – and in accordance with – the framework for the implementation of the United Nations International Strategy for Disaster Reduction (UN-ISDR), in 2000 the World Conservation Union (IUCN) and GFMC suggested the creation of an interagency working group on wildland fire. This proposal was in line with several declarations made in international conferences during the second half of the 1990s. It intended to bring together technical members of the fire community and the authorities concerned with policy and national practices in vegetation fire management in order to realize their common interests on a global scale. The UN-ISDR Inter-Agency Task Force on Disaster Reduction (IATF) agreed to establish a Working Group on Wildland Fire (WG-4) in 2000. From 2001 to 2003, WG-4 provided an international, interagency and intersectoral forum in which United Nations agencies and programmes, international organizations and civil society worked together to formulate a vision and common goals to enhance interagency and international cooperation towards "reducing the negative impacts of fire on the environment and humanity".[2]

[2] By consensus of the parties involved, this overall goal included promotion of the concept of integrated fire management, i.e. the recognition of the role of natural fires in ecosystem dynamics and the sound application of prescribed fire in land-use systems.

One of the priority activities to be addressed by WG-4 was establishment of a "global network of regional- to national-level focal points for early warning of wildland fire, fire monitoring and impact assessment, aimed at enhancing existing global fire monitoring capabilities and facilitating the functioning of a global fire management working programme or network", consisting of a set of regional networks that were either in place or would be initiated during the process of formation.

The 3rd International Wildland Fire Conference and the International Wildland Fire Summit (both held in Sydney, Australia, in October 2003) were used as platforms to convene representatives of the regional networks. The strategy formulated by the summit ("A Strategy for Future Development of International Cooperation in Wildland Fire Management") included agreement that "… the Regional Wildland Fire Networks will be consolidated, developed and promoted through active networking in information sharing, capacity building, preparation of bilateral and multilateral agreements, etc. This process will be facilitated through regional wildland fire conferences and summits in cooperation with the International Liaison Committee and the UN-ISDR Working Group on Wildland Fire" (GFMC, 2004a). A side meeting of regional fire management groups[3] recommended the maintainance and strengthening of a unified approach under the auspices of the United Nations.

After its scheduled termination at the end of 2003, WG-4 became the Wildland Fire Advisory Group (WFAG) under the auspices of UN-ISDR. WFAG represents an advisory body to the United Nations system, providing technical, scientific and policy-supporting advice through UN-ISDR and IATF and acting as a liaison between the United Nations system and GWFN and its supporting partners (UN-ISDR, 2006).

Regional wildland fire networks cooperating within GWFN do not follow a standardized establishment or *modus operandi*. Some are networking arrangements that were in place before 2001, including the FAO/UNECE/ILO Team of Specialists on Forest Fire (Baltic region), the ASEAN Agreement on Transboundary Haze Pollution (Southeast Asia), the Working Group on Wildland Fire of the FAO North American Forestry Commission (North America), FAO *Silva Mediterranea* (Mediterranean) and the Australasian Fire Authorities Council (Australasia). Newly established regional wildland fire networks cover the following regions: Central America, the Caribbean, South America, sub-Saharan Africa, Southeast Europe/Caucasus (formerly Balkan), Northeast Asia and Central Asia. The South Asia network is still to be defined (its foundation is projected for early 2007) (see Figure 1 in Part 2).

Important activities of the regional networks include:

- regional agreements such as the ASEAN Agreement on Transboundary Haze Pollution in 2001, which entered into force in 2003, and the Congo Basin Conservation Treaty, signed at the Congo Basin Forest Summit in 2005;

[3] WG-4; FAO/United Nations Economic Commission for Europe (UNECE)/International Labour Organization (ILO) Team of Specialists on Forest Fire; Fire Management Working Group, FAO North American Forest Commission (NAFC); and the Forest Fire Group of FAO *Silva Mediterranea*.

- regional plans for cooperation in fire management, such as the fire management cooperation strategies in the Caribbean, and Central and South America (with an overall regional strategy for Latin America and the Caribbean);
- establishment of training centres such as the Wildland Fire Training Center Africa, set up by the Regional Subsahara Wildland Fire Network (AfriFireNet) in cooperation with local partners in South Africa;
- regional meetings and declarations, including:
  - meeting of the prime ministers of the six member countries of the Shanghai Cooperation Organization (SCO) in September 2001, which documented the need for member countries to work together in various fields, including forest fire prevention;
  - Helsinki Declaration on Cooperation in Wildland Fire Management in the Baltic region (Helsinki, Finland, May 2004);
  - Antalya Declaration on Cooperation in Wildland Fire Management in the Balkans, eastern Mediterranean, Near East and Central Asia (Antalya, Turkey, April 2004);
  - conclusions of the International Technical and Scientific Consultation "Forest Fire Management in the Balkan Region" (Ohrid, The former Yugoslav Republic of Macedonia, April 2005);
- regional assistance, especially within the context of the enlargement of the European Union, to harmonize legislation, reporting and prevention.

United Nations specialized agencies, programmes and conventions are addressing vegetation fire, both sectorally and in accordance with their mandates (GFMC, 2005a). Their contributions include:

- FAO – promotion of international cooperation in vegetation fire management; technical cooperation programmes (TCPs) in the field, and information dissemination through seven regional forest commissions; global forest fire assessments jointly with GFMC (e.g. FAO, 2001a; GFMC, 2004b); *Fire management guidelines for temperate and boreal forests* jointly with GFMC (FAO, 2002a); *FAO wildland fire management terminology*, updated jointly with GFMC (FAO and GFMC, 2003); promotion of CBFiM; and a database of international agreements on cooperation in vegetation fire management;
- World Health Organization (WHO) – development of *Health guidelines for vegetation fire events* (Schwela *et al.*, 1999);
- World Meteorological Organization (WMO) – forecasting/early warning of El Niño, fire weather and smoke transport phenomena involving the global network of hydrometeorological stations;
- UNEP/UN-OCHA – Joint Environment Unit; Advisory Group on Environmental Emergencies; and World Summit on Sustainable Development Type II Partnership on Environmental Emergencies;
- International Tropical Timber Organization (ITTO) – support to national fire management programmes and participation of producer countries in the 3rd International Wildland Fire Conference;
- United Nations University – vegetation fire research and training focus through establishment of the University of Freiburg as an associate institute of UNU;

- UN conventions – agreement by the secretariats of the three Rio conventions (Convention on Biological Diversity – CBD, United Nations Convention to Combat Desertification – UNCCD and United Nations Framework Convention on Climate Change – UNFCCC) to give priority to fire-related environmental degradation (Workshop on Forests and Forest Ecosystems: Promoting synergy in the implementation of the three Rio conventions, Viterbo, Italy, April 2004).

After the International Wildland Fire Summit, which led to better international appreciation of the scale of the challenge posed by fires and to an informal statement of consensus on international collaboration, GWFN and FAO worked jointly on a Fram ework for the Development of the International Wildland Fire Accord (GFMC, 2005a). The documentation outlined the global situation major stakeholder groups that supported an international alliance to address global vegetation fire problems (United Nations, non-United Nations international organizations, NGOs, the scientific community, civil society and governments) and recorded major international events manifesting the interest of the international community in development of an international agreement on fire. Recognizing the importance of enhancing the fire management capabilities of all actors globally, the FAO Ministerial Meeting on Forests (Rome, 14 March 2005) (FAO, 2005b):

> *… called on FAO, in collaboration with countries and other international partners, including the International Strategy for Disaster Reduction, to develop a strategy to enhance international cooperation on wildland fires that advances knowledge, increases access to information and resources and explores new approaches for cooperation at all levels.*

At the Seventeenth Session of the FAO Committee on Forestry (COFO) (Rome, 15–19 March 2005) (FAO, 2005c), an Action Programme for FAO in Forestry was agreed. It included Recommendation No. 53:

> *… that FAO continue its support for regional and national networks to combat fire as well as insects and disease, in collaboration with relevant organizations such as the United Nations International Strategy for Disaster Reduction and the Global Wildland Fire Network, and further requested that FAO work with partners to develop voluntary guidelines on the prevention, suppression and recovery from forest fire.*

FAO has been coordinating a multistakeholder process towards a framework of priority principles of fire management, within which to provide policy, legal, regulatory and other enabling conditions for and strategic actions towards more holistic approaches. The draft text is available at www.fao.org/forestry/site/35487/en. It will be a voluntary, non-binding instrument tailored primarily to land-use policy-makers, planners and managers in fire management, including target users such as governments, the private sector and NGOs. Its scope includes the positive

and negative social, cultural, environmental and economic impacts of natural and planned fires in forests, woodlands, rangelands, grasslands and agricultural and rural/urban landscapes.

The definition of fire management covers early warning, prevention, preparedness (international, national, subnational and community), safe and effective initial attack on fires and landscape restoration following them. This international framework discusses cross-sectoral issues and elaborates principles and attributes in order to balance social, cultural, environmental and economic dimensions of fire management and outline key actions for the planning and management of fires.

The fire management principles will also provide a framework for achieving the Millennium Development Goals: in particular Goal 1 to eradicate extreme poverty and hunger, Goal 7 to ensure environmental sustainability and Goal 8 to develop a global partnership for development.

Capacity-building in fire management

Another main area of collaboration regards capacity-building in fire management. A number of international training courses have been conducted in the Mediterranean, southern Africa and Central America under the auspices of the Government of Spain, GFMC/UNU, FAO and The Nature Conservancy.

Fire research

The need for international cooperation in fire research was noted in a number of reports, although they did not refer to international cooperative research projects conducted before and during the reporting period (1998–2003), mainly under the auspices of the International Geosphere-Biosphere Programme. The Central Asian paper mentioned that several interdisciplinary research campaigns had been initiated in the period 1993–2000. The need for research into the use of remote sensing for fire detection was one topic mentioned in the papers, while others were carbon pools and flows affected by fire and the impact of fire on permafrost. The Fire Paradox research programme was launched by the European Commission in 2005, within its 6th Framework Programme (2006–2010), for the European Union and associated countries in Africa, Asia and Latin America. It will investigate the use of prescribed fire and suppression of fire in forest fire management. Expected to begin in 2006, it will be operational for four years.

Development of technologies for fire research, monitoring and management

Satellite remote sensing. The use of space-borne instruments for the detection, monitoring and impact assessment of vegetation fires is being promoted by the Global Observation of Forest and Land Cover Dynamics (GOFC-GOLD – http://gofc-fire.umd.edu/). GOFC-GOLD is a panel of the Global Terrestrial Observing System programme, which is sponsored by the Integrated Global Observing Strategy. Its main goal is to provide a forum for international information exchange, observation and data coordination, as well as a framework for establishing long-term monitoring systems. The GOFC-GOLD Fire Mapping and Monitoring Theme aims

to refine and articulate international observation requirements and to make the best possible use of products from existing and future satellite observing systems for fire management, policy-making and global change research. Regional GOFC-GOLD fire networks have been developed in Africa, Eurasia, Latin America and Southeast Asia. Bilateral and multilateral agreements for the joint use of satellite assets have been developed, for example between Mexico and various Mesoamerican countries and within the Baltic region.

Progress has been made in using data from the following space-borne sensors in fire monitoring, assessment of areas burned and emissions:

- Advanced Very High Resolution Radiometer (AVHRR);
- Moderate Resolution Imaging Spectroradiometer (MODIS) on the Earth Observing System (EOS) Terra and Aqua satellites;
- Medium Resolution Imaging Spectrometer (MERIS);
- Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER);
- SPOT-Vegetation; and
- Measurements of Pollution in the Troposphere (MOPITT).

A new generation of dedicated space-borne sensors for fire characterization has been designed to provide more precise information on fire extent and characteristics, for example the Bi-spectral Infrared Detection (BIRD) mission of the German Aerospace Center (DLR).

Early warning. Fire danger rating is a mature science that in several countries has long been used to provide early warning of the potential for serious wildfires. Fire danger rating systems (FDRS) use basic daily weather data to calculate wildfire potential. FDRS early warning information is now often enhanced by satellite data, such as signals of high-temperature events for early fire detection and spectral data on land cover and fuel conditions. FDRS tools for early warning are highly adaptable and have demonstrated their application for a wide range of users, from independent remote field stations (local fire suppression and preparedness decisions) to global and regional fire information centres (large-scale decision-making, for example in multinational resource sharing). There are numerous examples of current operational systems that use geographic information system (GIS) technology and computer modelling of landscape-level fire danger, and which process and transfer early warning information very quickly via the Internet.

The European Commission DG Joint Research Centre set up, since 1999, a research group to work specifically on the development and implementation of advanced methods for the evaluation of forest fire risk and mapping of burnt areas at the European scale. These activities led to the development of the European Forest Fire Information System (EFFIS). Since the year 2003 EFFIS is part of the Regulation (EC) No 2152/2003 (Forest Focus) of the European Council and Parliament on monitoring of forests and environmental interactions. All the EFFIS activities are coordinated with DG Environment to reach the final users, Civil Protection and Forest Services, in the Member States. EFFIS is aimed to provide

relevant information for the protection of forests against fire in Europe addressing both pre-fire and post-fire conditions. (http://effis.jrc.it/Home/). On the pre-fire phase, EFFIS is focused both on the development of systems to provide forest fire risk forecast based on existing fire risk indices, and on the development of new integrated forest fire risk indicators (http://effis.jrc.it/Home/).

Historical knowledge of the conditions during wildfires and the utility of fire danger forecasts is important to the immediate development of early warning systems and to the planning and preparation associated with the impact of climate change. The UN Secretary General had requested development of a global vegetation fire information system, as laid out in the *Hyogo framework for action 2005–2015: building the resilience of nations and communities to disasters* (GFMC, 2006b). In 2005 an international consortium of institutions endorsed such an information system as a thematic component of the global multi-hazard early warning system.

The objectives of the global fire early warning system are to:

- develop a global early warning system for vegetation fire, based on existing and demonstrated science and technologies;
- develop an information network to quickly disseminate early warning of fire danger to global to local communities;
- develop a historical record of global fire danger information for early warning product enhancement, validation and strategic planning purposes; and
- design and implement a technology transfer programme to provide the following training for global, regional, national and local community applications:
  - early warning system operation;
  - methods for local to global calibration of the system;
  - use of the system for prevention, preparedness, detection and, where appropriate, fire response decision-making.

NEEDS AND LIMITATIONS

Each regional working paper included an assessment of the needs and limitations of member countries in fire management. However, the assessment was sometimes included in the section on analysis and recommendations, thus responses in the two have been combined in this overview of the main issues identified. In approximate order of frequency, the needs and limitations included:

- Harmonization of definitions and the development of a common system for data collection and reporting were seen as major needs, whose absence limits the development of common regional databases for analysis and for identification of topics for research.
- Awareness-raising among the public is a major need. This activity is a prerequisite for fire prevention, paying particular attention to the value of forests to rural people and promoting the positive as well as the negative roles of fire to urban people. Traditional knowledge may have a role in developing awareness-raising programmes.
- Information and data on the severe social, economic and environmental impact of fires were often lacking. However, this shortcoming was perceived

as unimportant by the general public, and this perception, itself, is a serious constraint on the development of effective fire management.

- Many regions noted the need for the public and policy-makers to understand fires as a continuing threat to livelihoods – especially of the poorest – and to development. Policy-makers must not react only when a fire disaster occurs.
- The shortage of consistent funding was seen as a major limitation in several regions, some of which mentioned that most of their limited resources were devoted to fire suppression rather than fire prevention.
- Arson was a widespread problem and a constraint on sustainable forest management, but effective action to charge arsonists was seen as difficult.
- Collaboration among agencies involved in fire management – and hence improved definition of responsibilities and country profiles – were needed by countries in many regions.
- Institutional development of the appropriate agencies, including decentralization of fire management and development of fire management plans, was seen as a need and a limitation.
- Capacity-building and training at all levels were seen as needs and limitations in several regions. Training of fire crews and others involved in fire management was seen as a need by some regions, although others recognized that the expertise exists and the need is for further training in more sophisticated techniques of fire detection and suppression. Several regions mentioned the need for training in the control of large fires, especially decision-support systems. Training may also include those outside the forest sector, particularly farmers, who in several regions were seen as benefiting from training in prescribed burning.
- Improved resources and equipment for predicting and detecting fires were referred to in several working papers as a need, with special reference to the use of satellite systems.
- Community-based approaches to fire management were seen as an important need. Meeting it will require addressing underlying social constraints and improving public confidence in the agencies responsible.
- Forest-sector policies and legislation related to fire can limit effective fire management in forests. They need to consider all related sectors, as well as implementation capacity.
- Fire-related policies and legislation of other sectors (especially agriculture and livestock) can limit fire management in forests. These are often perceived by countries as impacting the forest sector negatively, although it is recognized that they should be related to the actual needs of people in pursuing their livelihoods.
- Improved cooperation within and between regions was seen as a need by many regions, including development (or further development) of networking and the exchange of information. Development of compatible approaches to firefighting, such as the Incident Command System, was seen as a related need in regional collaboration.
- Regional plans for fire management were needed, including the identification of cooperation mechanisms.

- International and donor support in fire management was identified as a need by several regions, especially financial support to satellite warning systems and to the development of community-based fire management.
- Research was being done in some countries, but the results were not always shared. There is a need for regional research on fire management, including on the impact on ecosystems, the development of fire risk assessments/fire danger ratings, fire behaviour prediction and social studies linked to the causes of fire. Lack of adequate and continuing finance is a limitation to fire research.
- Looking to the future – risks may increase because of various environmental, social and economic trends, of which the most frequently mentioned was climate change. But other factors were also noted as important, such as more complex, natural vegetation systems with higher fuel loads due to land-use change, and increasing urbanization – especially at the wildland/urban interface.

CONCLUSIONS

Reports on fire were received from all 12 of the regions defined by UN-ISDR/GWFN. Additional inputs on international collaboration and initiatives were provided by GFMC.

Fires in various types of vegetation continue to cause widespread social, economic and environmental damage in every part of the world. Based on satellite-derived evidence in 2000, the global estimate of land area affected by fire was 350 million hectares. Neither the number of fires nor the area burned appear to be decreasing, and there is evidence from some regions that the number is increasing, the size of individual fires is getting larger and the severity worse.

It is not possible, at present, to assess the extent of fires occurring specifically in forests and woodlands, due not only to the lack of reliable, current and consistent data, but also to the absence of common terminology and definitions. In a number of countries, a comparison of the reported area burned with the area detected by satellite showed that the reported area grossly underestimated the area identified by satellite imagery. Nearly all of the regional working papers recommended development of:

- agreed terminology and definitions for fires in all vegetation types;[4]
- a common system for data collection; and
- regional and global databases to record and report data.

People are overwhelmingly reported to be the main cause of fires, and agricultural clearing is one of the most frequently mentioned reasons. Training in prescribed burning may help reduce this source of fires. Arson, however, is also common and currently one of the most difficult practices to prevent or punish. Social research

[4] The *FAO wildland fire management terminology* (FAO and GFMC, 2003) includes a complete set of English definitions and incomplete and outdated counterpart terms or translations in French, Spanish and German. All other languages are lacking. A Russian version is in preparation.

is needed here. Lightning causes fires in some regions, largely in remote areas of Canada and Russia, where storms are not accompanied by heavy rains.

With increasing urbanization and the abandonment of rural lands, environmental pressures to refrain from fuel management, under-resourcing of fire authorities, and the emphasis on fire suppression have resulted in an increased risk in the incidence, scale and impact of fires, particularly in extreme fire danger conditions.

Several reports drew attention to the positive as well as the negative effects of fire. For example, some vegetation types are adapted to fire and require it for regeneration. Fire may be used to reduce fuel loads and thus reduce the risk of a catastrophic event. But increased urbanization means that city-dwellers are often not aware of these features of fire management, and there is strong popular and political feeling against any preventive use of fire.

Reports from some developed countries (including Australia, Canada, Mediterranean countries and the United States) referred to the increased risks to life or property arising from increased urbanization. Urban people appreciate life at the WUI, but may build their houses in high risk locations due to poor understanding of the danger of fire. Most regional working papers recommended public awareness campaigns as part of fire prevention campaigns, with different messages targeted at different groups.

Looking ahead, most regional working papers drew attention to the increased risk of fire that climate change will bring.

The papers also indicated the need for a change in attitude towards the dangers and consequences of fire by people and policy-makers. They should not just react when severe fire events occur; planning and prevention are required always. Many countries not only reported inadequate budgets and staff allocations for fire management, but that most resources were allocated to fire suppression, while increased efforts in prevention could have greater impact. Besides public awareness campaigns and prescribed burning, many countries saw the need for further development of early warning systems and fire danger rating (which already existed in a number of countries) and development of satellite-derived products for operational use in fire management.

Fires have caused extensive damage in recent years, leading to loss of life of civilians and firefighters, affecting human health on a wide scale through smoke haze, burning property and businesses and causing extensive environmental damage to fire-sensitive systems. Most reports noted that fires contribute to global warming and climate change, notably through the emission of CO_2 – perhaps as much as 5 130 million tonnes of vegetation may be burned each year, of which 42 percent is in Africa. There were very few estimates of the true social, economic and environmental costs and impacts of the damage caused by fire, which would allow more informed decision-making and the setting of priorities. The absence of these estimates may largely be due to lack of political or public appreciation of the need for them and the difficulty of collecting the data.

Most fire suppression is done by land-based firefighters and workers, reinforced in some countries by the use of aircraft to drop water or retardant and of helicopters

to transport fire crews to the fire site. These sophisticated methods are used not only in developed economies, but in several developing ones. They are effective, but very expensive, and cannot be used in isolation from sufficient crews on the ground.

Countries reported a wide range of institutions responsible for fire management, ranging from the national forest department, alone, to a number of different authorities concerned with fires. Some countries have institutional arrangements for the coordination of different agencies in emergency situations. But lack of a clear definition of responsibilities and of coordination between the various national institutions were identified by many countries as severe constraints on effective fire management.

Countries recognized the important role that communities can play in fire prevention and suppression, and some had been taking steps to promote CBFiM. However, in some countries where CBFiM was implemented in the past, it now appears to be diminishing in favour of high-tech detection and centrally coordinated suppression.

Generally there is increasing collaboration between countries within regions and between regions. There are, for example, a number of bilateral agreements for joint fire suppression, arrangements for regional training courses, several regional networks for the exchange of information and experience and some regional fire management plans.

There have been two global meetings on fire in recent years: the International Wildland Fire Summit, Sydney, 2003, and the Ministerial Meeting held at FAO, Rome, 2005 (FAO, 2005a). Both meetings have enhanced international cooperation, as have a number of high-level regional meetings. There are several international organizations and countries involved in promoting cooperation and offering support, the main ones being FAO, GFMC, The Nature Conservancy, Australia and the United States. The forthcoming fire management framework and the assessment to enhance international cooperation in fire management – a study currently in progress that will complement the framework – will contribute further to fire management and to collaboration among countries, regions and donors.

RECOMMENDATIONS

On the basis of the needs and limitations and conclusions given above, the following recommendations have been developed.

Political commitment

Recognition of the positive as well as the negative effects of fire and a strong commitment to the concept of fire management are recommended to all national policy-makers. Political commitment is required for the implementation of all the recommendations that follow, but is noted in particular for: provision of adequate and continuing budgets; the need for proactive rather than reactive responses to fire catastrophes; amendment of conflicting policies and legislation; and the definition of clear responsibilities for fire management.

Assessments

The urgent need for the collection of reliable data on fires was the recommendation identified by most countries in the regional working papers. It has two closely linked components:

- harmonization of terminology and definitions; and
- development of a common format for regional databases on fire.

Agreement between countries on the terminology and definitions to be used in reporting fires in vegetation is fundamental to the development of regional fire databases. The data can then be used as a basis for the detection of regional trends and the development of regional policies and plans. It is recommended that FAO, with its neutral role and experience in developing definitions for use in the Global Forest Resource Assessment (FRA) process, should provide the forum for such discussions. Other international bodies should collaborate in such discussions and provide technical input.

Several countries report the use of information from space-borne sensors, which appears to provide a reliable and timely methodology for the collection of data on fires. The offer of the GOFC-GOLD network of scientific institutions to assist FAO in developing and applying standardized methods for national to global fire impact assessments should be taken into consideration.

Training of national staff in the collection of fire data (including the interpretation of satellite imagery) will be essential; this is discussed under *Institutional strengthening*.

Awareness-raising

One of the main messages recommended for all target groups of awareness-raising campaigns was that fire has positive as well as negative effects, and there is an urgent need to recognize the role of fire planning and management. Particular target groups recommended for awareness-raising campaigns included:

- Policymakers, who should move from an attitude of reaction after the outbreak of severe fires to a proactive approach of planning and prevention. This should include increased budgets for prediction and prevention, which should lead to a reduction in the need for funds for suppression.
- Urban dwellers, who must appreciate the dangers of fire risk in building homes at the WUI and must understand the preventive benefits of burning to reduce fuel loads.
- Farmers, especially those who employ fire for land clearing. Training in prescribed burning may help reduce this common cause of runaway wildfires in many countries.

A general recommendation on awareness-raising campaigns relates to the need to share experiences among countries with similar needs.

Community-based approaches

It is recommended that all countries recognize that CBFiM offers one of the most sustainable, adaptive approaches for managing fire, especially for prevention. It is noted, however, that in some countries the practice of CBFiM appears to be

diminishing, due to reliance on the use of technically advanced means of detection and dedicated, centrally coordinated, professional suppression teams.

Nevertheless, all countries should consider the role of CBFiM in harnessing the expertise and experience of communities of interest in fire management programmes. Donors and international agencies should continue to support CBFiM training courses and workshops, and countries should exchange experiences in this area.

Institutional strengthening

It is recommended that countries consider the need to strengthen the various institutions responsible for fire management, including clear definition of the responsibilities of each institution (see *Institutions, responsibilities and roles*, above). Countries should also assess:

- the validity of fire management plans or the need for preparation of such plans where they do not exist, including the potential for decentralization of responsibilities;
- the impact of plans of other sectors on fire management plans, and provision for the resolution of conflicts;
- the need for training of fire personnel, or for retraining in more sophisticated fire detection, communication or suppression techniques, noting the trend towards large fires in some regions;
- the training of others outside the forest sector, including training in prescribed burning for farmers.

National funding

It is recommended that all countries review national budgets for fire, noting that without adequate and continuing funds, fire management plans cannot be implemented. The allocation of funds within plans should also be reviewed, giving due weight to prevention as well as to suppression of fires.

Provision should be foreseen for the replacement or upgrading of equipment, the introduction of new techniques, such as remote sensing, and training. Provision should also be made for research (see *Research and development*, below).

National cooperation

It is recommended that the role of all institutions and agencies involved in national fire management be reviewed to:

- improve interagency and multistakeholder collaboration through the involvement of all in the preparation of the national fire management plan and establishment of mechanisms to promote cooperative approaches;
- define responsibilities clearly and without overlap;
- resolve overlapping or conflicting policies or legislation.

International collaboration

It is recommended that countries collaborate within and between regions, sharing knowledge and experiences and developing reporting frameworks and regional policies related to fires. Regional networks should be consolidated and strengthened

and links developed with others, not only for the exchange of information, but also for training and regional fire plans.

Bilateral agreements should be promoted for joint fire suppression. In the field of cross-border firefighting, or where fire crews or expertise are shared, it is recommended that compatible approaches, such as the Incident Command System, are accepted as common standards and collaboration procedures developed.

International and regional collaboration should be continued at technical workshops and at high-level meetings of decision-makers and/or policy-makers to promote collaboration and to demonstrate political recognition of the importance of fire management.

Donor support

It is recommended that donor governments and agencies consider their potential to support fire management in a number of areas:

- equipment, training and research into advanced technologies for detection and prediction, especially satellite systems;
- training in community-based fire management;
- strengthening of regional fire networks and of the international dialogue facilitated by GWFN and WFAG;
- other aspects of fire research, noted in Research and development.

Research and development

A number of recommendations were made by countries and international institutions on directions for fire-related research. They included:

- development of a new generation of polar-orbiting and geostationary satellites with dedicated sensors for fire applications;
- investigation into the operational use of satellite systems for fire prediction, detection and assessment of the extent of burned areas;
- development of fire danger rating and people-centred early warning systems for different vegetation types and global to local application;
- studies of assessment methods of the social, economic and environmental costs and impacts of fires, including proposals for standardized procedures of data collection;
- social research into the motivation for arson;
- forecasts of the effects of global change (the coupled effects of climate change and demographic and socio-economic changes) on vegetation fires in different localities.

Part 2

Regional summaries

P. Vuorinen

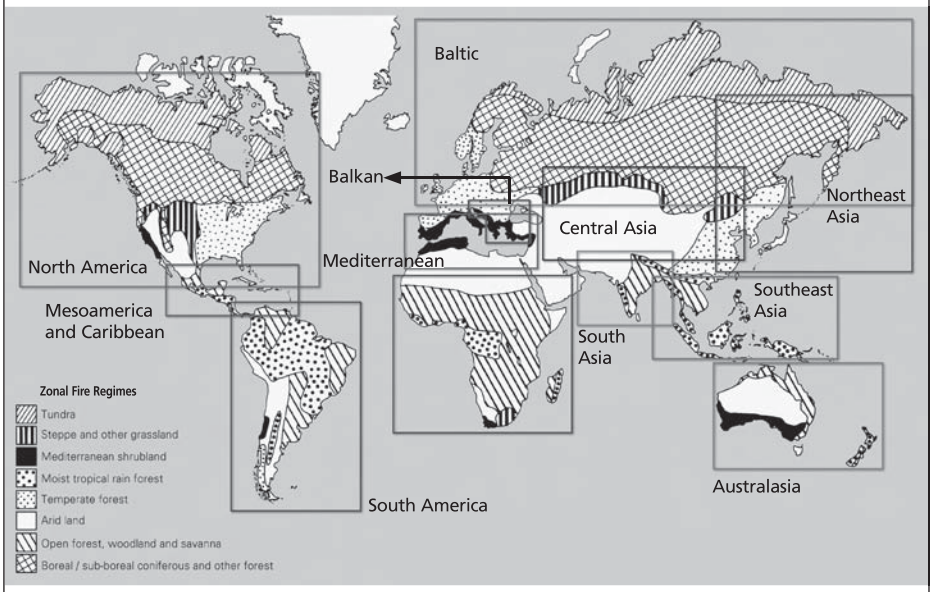
3. Background

Following release of the report *Global Forest Resources Assessment 2000* (FAO, 2001b), the FRA process entered its next reporting cycle. In July 2002 the Kotka IV expert consultation made recommendations on the direction of global FRAs, which were confirmed by COFO 2003. The recommendations included an update of global FRA data in 2005 and increased, direct involvement of countries in assessment and reporting, in particular the submission of national reports on the status and trends of a range of forestry parameters.

One recommendation for Global Forest Resources Assessment 2005 was the preparation of thematic studies, including the present study on fire, which is built on regional reviews of forest fire management in GWFN (Figure 1).

The purpose of this study is to provide data and information – to a greater depth than was possible in FRA 2005 – on the incidence, impact, management and issues relating to vegetation fires in unique regions around the globe. The data and information were prepared by specialists from each of the 12 GFMC regional wildland fire networks, which are also supported by FAO and UN-ISDR. In

FIGURE 1
UN-ISDR/GFMC Global Wildland Fire Network



Source: UN-ISDR/GFMC.

March 2006 FAO published the regional working papers individually under the Fire Management Working Papers series.[5]

This thematic study assesses the fire situation in each region, including area extents, number and types of fires and their causes. The positive and negative social, economic and environmental impacts are outlined. An integrated approach to vegetation fire management is taken, including prediction, preparedness and prevention as key elements in reducing the negative impacts of fire, rapid response to extinguish fire incidents and restoration following fires.

The study also addresses key issues of institutional aspects of fire management, including the roles and responsibilities of stakeholders and their capacities for prevention and suppression, particularly the role of CBFiM.

[5] Since 2005 the Mesoamerica region delineated on the map has consisted of two networks (Central America and the Caribbean). A thirteenth network covering South Asia was not yet established at the time of reporting for and compiling of the thematic summary report. The regional report was compiled by FAO and GFMC based on reports from the region – mainly in the UNECE/FAO *International Forest Fire News* – and from GFMC correspondents.

4. Sub-Saharan Africa

Historically, the use of fire in sub-Saharan Africa was controlled by traditional authorities, who restricted its use to certain planned occasions and events such as hunting. New fire legislation and no-burn policies were introduced during colonial times. Local practices and control mechanisms were revoked or became invalid and, although traditional authorities no longer controlled fires, the colonial officers implementing the fire bans were seldom present due to the remoteness of many areas.

Given this lack of supervision, fire was increasingly used by the local population at the beginning of the last century. The history of controlled burnings was forgotten, and people began believing that the indiscriminate use of fire was part of the inherited traditions. By 1970, almost all forest and woodlands in southern Africa were fully or partially burned every year.

Information for the regional working paper was obtained from 22 countries of sub-Saharan Africa (details are provided in FAO Fire Management Working Paper FM/9/E).

EXTENT AND TYPES OF FIRE

Africa sparkles with more routine fire than any other landmass.

– Pyne et al., 2004

The overwhelming part of sub-Saharan Africa has distinctive wet and dry seasons, which favour regular vegetation fires. The wet season stimulates growth, while the dry season provides ideal conditions for burning. However, drought may lead either to increased fire danger, due to extreme fire weather conditions, or to a decrease in fire danger, as there is not enough fuel to sustain a fire. In addition, every few years the El Niño weather pattern provides climatic conditions that favour extended wildfire episodes.

Most fires, wanted and unwanted, occur in the savannah biome due to slash-and-burn practices or to the burning of agricultural residues. Large-scale burning of slash after forest harvesting is also a common practice in the forest plantations of southern Africa.

There are huge discrepancies in information between satellite-derived data and data collected on the ground, as well as discrepancies among the different satellite systems. The collection of reliable ground data is presently not feasible in the vast territories of the African continent, with the exception of a few countries. Remote sensing is presently the only reliable way to collect statistical fire data.

A review of the most recent satellite-derived assessments of the land area affected by fire in Africa was provided by an FAO study prepared for the 24th FAO Regional

Conference for Africa (FAO, 2006b). The study quotes the first global survey of burned areas, carried out by the Joint Research Centre of the European Commission, based on the detection of fire scars for 2000 by the SPOT-VEGETATION sensor. The survey showed that Africa is the most fire-prone continent. An estimated 2.3 million km^2 – or 7.7 percent of the continent – burned in 2000, i.e. 64 percent of the global total of just over 3.5 million km^2 (JRC-EU, 2005). Africa also had the highest number of fires (54 percent), as indexed by the number of fire scars. Burning in 2000 was most extensive in East Africa (873 840 km^2 or 15 percent of the area), Central Africa (539 225 km^2, 13.5 percent) and Southern Africa (677 123 km^2, 11.5 percent).

In 2004, the MODIS instrument on board the Terra and Aqua satellites of the US National Aeronautic and Space Administration detected active fires on the equivalent of 7.8 percent of Africa's land area, the same percentage as in 2000.

It must be remembered that most ecosystems of sub-Saharan Africa have evolved through the human use of fire. Thus these ecosystems, including their biodiversity, need fire to be maintained. However, too much fire, or the wrong kind of fire, is as detrimental as lack of fire, especially around the basins of the Sahara, Kalahari or Namib. Following uncontrolled burning, for example, water and wind erosion degrade former forest land into desert.

CAUSES

> [In Africa,] *anthropogenic fire originated and has resided longer than anywhere else.*
>
> **– Pyne et al., 2004**

Lightning can be a significant ignition source, for example in western Namibia, where 60 percent of all fires stem from electrical storms. However, most fires in Africa are started by people. Considering the fact that fire and early human beings played important roles in shaping the environment in Africa for hundreds of thousands of years, one could come to the conclusion that people are also, in a way, a 'natural' cause of fire in Africa.

The slash-and-burn method is widely used in African agriculture to clear agricultural sites or remove agricultural residues. However, planned fires are often left unattended and can spread; thus negligence is the most common cause of fire throughout Africa. The list of agents is long – honey hunters, poachers, children at play, abandoned campfires, cooking and warming fires or escaped prescribed fire.

Arson may be caused by cultural or religious beliefs, misunderstanding of an 'African burning tradition', civil unrest and personal anger or fear (burning the bush to open it up). Arson fires are also commonly lit by marginal community members for the thrill or to feel empowered.

One of the underlying causes of frequent arson is the problem of 'ownership' or tenure. Very often the land belongs to the state or to an anonymous company, and most profits never reach the local population. Thus no sense of responsibility is created for the sustainable use of natural resources and the environment.

In forest plantations, large-scale prescribed burning is a standard practice to prepare sites for planting after harvesting. Firebreaks around and within the compartments are also prepared through burning. More than 10 percent of all plantation fires originate from these activities, due to lack of training of personnel (Goldammer and de Ronde, 2004).

EFFECTS

Although estimates of the total economic damage caused by African fires are not available, ecologically and economically important resources are increasingly being destroyed by fires crossing borders from a fire-adapted to a fire-sensitive environment (Goldammer and de Ronde, 2004).

In general terms, unwanted fires change the species composition, vegetation structure and composition. As a result, soil properties are degraded and the soil productivity, both commercial and natural, decreases. In some biomes, the frequency of wildfires is widespread and alarming, such as in the forests and savannahs of West and East African countries (Pyne *et al.*, 2004).

The impact of wildfires on the extremely poor cannot be overstated. These people live at the margins of daily survival and are always the most vulnerable. Rural settlements (and also some urban ones) in the interface between densely settled land and lands carrying high fuel loads – and eking out marginal livelihoods – are also among the most vulnerable.

The occurrence of uncontrolled wildfires has a negative influence on the tourism industry of sub-Saharan Africa – a burned landscape hardly appeals to the tourist's eye. Tourists may also feel insecure if nearby fires are raging and destroying the environment.

FAO (2006b) provides a statement that summarizes the main impacts of vegetation fires in Africa on the atmosphere, and in particular on the global carbon cycle:

> *The current estimates of the quantity of biomass burned globally each year from all sources is about 9 200 million tonnes. Overall, global wildfires consume 5 130 million tonnes, 42 percent of which is burned in Africa (including fires associated with deforestation). This burning releases about 3 431 million tonnes of CO_2, as well as significant quantities of other emissions.*

PREVENTION

Most African countries have established a national fire prevention programme, but implementation is a different story. As a preventive measure, fuel reduction is carried out primarily through prescribed burning between and around commercial forest plantations and nature conservation areas. Countries such as Botswana, Namibia and South Africa prepare quite extensive networks of firebreaks annually. But a problem in most countries of sub-Saharan Africa is the lack of even basic burning equipment, basic knowledge of fire behaviour and skills in the safe use of fire as a tool.

Knowledge of fire behaviour is a key factor in a successful prevention programme. The more that efforts are put into education and training of local farmers, the less

uncontrolled fires will occur. Apart from South Africa, most countries in sub-Saharan Africa do not have sufficient capacities, resources or skills in wildfire detection and suppression.

SUPPRESSION

Most fire suppression resources in sub-Saharan Africa are urban or municipal, are located in capitals or bigger cities and do not respond to wildfires occurring in rural areas; sometimes they even lack the mandate to deal with fires in rural areas. There is little capacity within the private sector for fire suppression, with the exception of South Africa and a few other countries.

Government priorities change with time, but food-security issues usually remain at the top of the rural livelihood agenda. If a fire management budget is available, in most cases 95 percent of these funds are invested in improving fire suppression and monitoring capabilities, instead of in prevention and capacity-building.

INSTITUTIONS, RESPONSIBILITIES AND ROLES

Traditionally, in the Southern African Development Community (SADC) and neighbouring sub-Saharan countries, the responsibility for fires lies with the Ministries of Environment/Agriculture and Rural Development. However, an increasing number of countries are following the South African example and giving national disaster management centres a share in this mandate. In the United Republic of Tanzania, joint involvement of forestry staff and staff of the Fire and Rescue Service Force has been suggested.

However, an important issue remains to be resolved, i.e. the leadership and authority of the fire chief conducting fire suppression activities. The role and authority of the chief have to be clearly defined, especially in commercial farming areas, in relation to regional authorities such as governors.

COLLABORATION

Collaboration in fire management has been instituted in many African countries, given that they have few resources. In this way, win-win situations can often occur for the partners involved, as in South Africa, where local to national cooperation was developed.

The success and experience gained in handling a major fire emergency in Ethiopia, from February to April 2000, was the initial point for international cooperation in fire emergency management in sub-Saharan Africa (Goldammer, 2000). Subsequently, systematic, regional cooperative measures were initiated in 2002 through the creation of AfriFireNet. This network encourages countries to establish or expand cooperative and networking activities, and one of its first activities, the Wildland Fire Training Center Africa, was founded in cooperation with local partners in South Africa. GFMC and the former coordinator of AfriFireNet prepared the *Wildland Fire Management Handbook for sub-Saharan Africa* (Goldammer and de Ronde, 2004). In cooperation with the governments of Germany, Finland, Mozambique, Norway and South Africa, and with FAO

and UN-ISDR, a number of international training courses were successfully conducted over the last two years.

Another encouraging example of international cooperation in sub-Saharan Africa comes from West and Central Africa, where the first region-wide conservation treaty was signed on 7 February 2005 at the Congo Basin Forest Summit. The signing of the treaty and an agreement to protect over 7 percent of the Congo Basin forests are historic milestones for the future of the world's second largest moist tropical forest. "Central Africa is a model for the entire world on how to reach across borders to tackle the tough issues that are threatening wildlife, forests and the livelihoods of local communities" (Carroll, 2005).

COMMUNITY PARTICIPATION

Since nearly all fires in the region are caused by human activity, the reasons for these fires must be addressed, rather than simply increasing suppression capacity or tightening fire legislation. Data on the underlying causes of fires are required, and only then will it be possible to develop national strategies for the appropriate use of fire as a management tool.

Some forestry and wildlife management agencies within the region have the basic infrastructure with which to detect, prevent and suppress fires, but this capability is rapidly breaking down and becoming obsolete. Traditional controls on burning in customary lands are now largely ineffective. Fire control is also greatly complicated by the fact that the hundreds of thousands fires in Africa occur as widely dispersed, small events, primarily related to agricultural seasons.

There is a need to raise awareness among local people and provide training to stakeholders at all levels in the proper use of fire as a management tool at the landscape level. By managing fires at the local level, resources, including forests, can be managed sustainably.

Very encouraging CBFiM programmes have been established in Burkina Faso, Mozambique, Namibia and South Africa (Goldammer *et al.*, 2002). The positive and promising results of these projects show that, in Africa, the community approach is probably the only sustainable, long-term solution to improving the fire situation at the grassroots level.

A major national South African fire management programme, Working on Fire (WoF), has created a remarkable people-centred approach to fire management – a labour-intensive initiative that provides training and empowerment for socially marginalized people (www.fire.uni-freiburg.de/WoF/welcome.html). Since conclusion of the process to develop the regional fire working paper, WoF has assumed the leadership and coordination of AfriFireNet, with the support of GFMC. The programme is currently negotiating with neighbouring countries to make its experience available.

NEEDS AND LIMITATIONS

The prevailing lack of financial, infrastructural and equipment resources for fire management in the SADC region and neighbouring sub-Saharan Africa is aggravated

by the lack of adequately trained human resources. The gap between decreasing preparedness capabilities in fire management and the increasing fire problems in the area requires an immediate response through capacity-building (Goldammer and de Ronde, 2004).

The expertise, motivation and technical means for the development of integrated fire management systems are already available in Africa. The major limitations are inadequate budgets, absent infrastructure, weak capacity and social and political environments that do not sufficiently enable or empower the affected population to deal with the fire problem itself. The challenge is to convince policy-makers to provide this support to communities.

These needs must also be considered within the context of the myriad other problems that face governments and communities in Africa, including wars, poverty, exploding populations, migration and health (and, in particular, HIV/AIDS). While unwarranted and uncontrolled burning may greatly affect sustainable resource management on a local scale, it may not yet appear sufficiently important to warrant the concern of policy-makers. That perception must be challenged as a first step towards more deliberate, controlled and responsible use of fire in Africa (Goldammer and de Ronde, 2004).

ANALYSIS AND RECOMMENDATIONS

Integrated fire management approaches in sub-Saharan Africa face an incredible number of difficulties and obstacles. The lack of funding and of sound, sustainable fire management strategies are the most prominent ones.

Since fire management in sub-Saharan Africa is almost exclusively an agricultural issue, the key is to involve the agriculture sector in the controlled use of fire.

Each country should analyse its fire situation and specific causes and develop a strategy for fire management. In some countries, more effective action against arsonists is an important part of the solution, while in others, awareness of fire prevention and control need to be increased. Improved monitoring appears to be a general requirement, and fire reporting mechanisms should be established.

Given the lack of budgetary support, governments wishing to improve their fire situation should allocate a sustainable budget and create a position that deals exclusively with fire management. A clear mandate for all aspects of fire management would help coordinate efforts – be it a community approach, development of progressive and enabling legislation, capacity-building, danger rating or fire suppression.

International exchange of experiences, ideas, resources and sometimes even funding is important. The regional collaboration that was started through AfriFireNet should be built on. An additional option would be the establishment of one or more regional vegetation fire management centres – as centres of excellence – to assist and support countries in each region. There is already a huge reservoir of expertise available within the different regions of Africa.

There is a need, as well, to improve regional monitoring and increase scientific understanding of fires. Research is needed on the ecological dynamics, desired long-term ecosystem conditions and underlying causes of fire.

The adverse economic, social and environmental impacts of HIV/AIDS have reached catastrophic dimensions in many regions. HIV/AIDS education could be combined with local education in fire management in the countries worst hit by the pandemic. This educational activity would help lessen the occurrence of wildfires started in connection with land-clearing activities, which, over the past years, have increased due to labour shortages and the lack of experience of the often-orphaned youth now carrying out these tasks.

5. Caribbean

The Caribbean region includes some 20 island states ranging in size from 110 to 110 000 km². Information was available from seven of these (Table 2). Although they are usually small in comparison with Mesoamerican mainland states, forest resources play an important role in their economies and the effect of fires can be significant (details are provided in FAO Fire Management Working Paper FM/12/E).

In common with the mainland, the island climate is determined by movement of the intertropical convergence zone, the prevailing trade winds and topography. Most islands tend to have drier western areas under the rain shadow of the central land mass. Mountainous areas are wetter than lowlands, owing to orographic effects. As rainfall diminishes, the dry season becomes more severe and fire hazard increases. The prevalence of hurricanes further raises fire hazard by building up fuel loads.

TABLE 2
Land areas and available data on wildfire occurrence in the Caribbean

Country	No. of wildfires *(annual average for period or for specified year)*	Area affected *(ha/yr)*	Source
Antigua and Barbuda	No data	No data	
Bahamas	No data	No data	
Barbados	1 338 (2003)	No data	Jones (2004)
British Virgin Islands	No data	No data	
Cayman Islands	No data	No data	
Cuba	325 (1984–1998)	4 878 (1984–1998)	Rodríguez (2000)
Dominica	Range: from 50 (1986) to 222 (2001)	No data	James and Dupuis (2004)
Dominican Republic	141 (2000–2003)	4 660 (2000–2003)	González and Sierra (2004)
Grenada	100	No data	Thomas (2004)
Guadeloupe	No data	No data	
Haiti	No data	No data	
Jamaica	No data	No data	
Martinique	No data	No data	
Montserrat	No data	No data	
Netherlands Antilles	No data	No data	
Puerto Rico	No data	No data	
Saint Kitts and Nevis	No data	No data	
Saint Lucia	Range: from 22 (2004) to 200 (2001)	No data	Isaac (2004)
Saint Vincent and the Grenadines	No data	No data	
Trinidad and Tobago	315 (1987–2003)	4 082 (1987–2003)	Singh and Adam (2004)

EXTENT AND TYPES OF FIRES

Vegetation types in the islands respond differently to wildfires; they can be grouped as follows:

- vegetation maintained by wildfires: pine forests in the Bahamas and the Dominican Republic; non-native grasslands and bamboo forests (mainly on the Windward and Leeward Islands);
- vegetation sensitive to wildfires and prone to fire damage: forest plantations of introduced species, e.g. Caribbean pine (*Pinus caribaea*) and teak (*Tectona grandis*); dry evergreen coppice forests in the Bahamas; flooded forests in Guadeloupe under exceptional, dry-weather conditions; lowland evergreen and semi-evergreen forests; dry deciduous forests; mangrove forests in transition to inland forest; and disturbed montane forests;
- fire-independent vegetation: undisturbed montane forests; humid montane forests at higher elevations; and mangrove forests in tidal zones.

Forest fires occur mainly within the dry forest types (1 000–1 500 mm mean annual rainfall), where most human settlements are located. Moist tropical forests and montane forests with higher rainfall (1 500–2 000 mm) are less susceptible to fires, but can burn in exceptionally dry years.

CAUSES

As mentioned, forest fires occur mainly in dry forests. The risk of fire increases with logging, since reduction of the upper canopy triggers development of scrub and bush undergrowth, which dries up more quickly and is easier to ignite than the original understorey. Almost all fires in broadleaf forests seem to be caused by people. In common with other regions, increasing population pressure in the Caribbean has led to the reduction of forest area, associated with fires as a tool to aid clearance.

The main causes of fires are as follows:

- In rural areas, fires are used to clear land for agriculture and settlement, to improve pasture for livestock grazing and to facilitate hunting by clearing the area and driving animals out. When such fires get out of control, adjacent forest is burned. There is little motivation to control such fires if the neighbouring lands are state-owned or ownership is uncertain.
- Deliberate burning occurs as a form of protest against people or governments. Fires may be used to force settlement of disputes between neighbours, family members or interest groups over land use or ownership.
- Negligence is sometimes a cause, for example discarded cigarettes and, in areas close to urban settlements, campfires and children at play.
- There seems to be a widespread culture of starting fires for entertainment or some unspecified reason. In most cases affected forests are on public land, often in remote areas. Lack of supervision, low probability of being caught and lack of understanding of the damage caused increase the likelihood of fire. These fires are often described as malicious acts or antisocial behaviour, but appear to have a cultural or social dimension that requires research.

- Lightning is associated with heavy rainfall and thus unlikely to cause fires, although this does occur in native pine forests.
- Volcanic action can be a rare but catastrophic cause of fires, and may result in complete incineration of large areas.

Particular concerns in the region are the lack of awareness of the damage caused by fires and the prevalence of deliberate burning for unknown motives.

EFFECTS

Damage can be extensive on some islands, but some effects are also beneficial – fire is a natural component of pine ecosystems and serves as a management tool.

As in the Mesoamerican mainland region, fire damages island ecosystems by debilitation, selective mortality and incineration of plant life, as well as by degradation of the soil. This leads to many effects, including changes in ecosystems (often with impoverishment of biodiversity and productivity), predisposition to disease and reduction of environmental services.

Many islands depend on tourism for their economy. Wildfires can have a particularly adverse effect on this by degrading – directly or indirectly – the landscape, air quality and the marine environment.

PREVENTION AND SUPPRESSION

The smaller islands rely on basic methods of prevention, detection and control. On the larger islands (Cuba, Jamaica and Hispaniola), techniques are being developed that parallel those in Mesoamerica. Ignition sources are being reduced through campaigns to build awareness and enforce legislation. Techniques to control fire are improving. In some cases, early detection is supported by satellite and aerial surveillance. Most countries have ground patrols and some have a system of watchtowers. Fires are mostly extinguished by ground crews, aided by techniques such as backfiring and the use of fire traces.

INSTITUTIONS, RESPONSIBILITIES AND ROLES

Several institutions are responsible for fighting fires. The national fire service is usually responsible for fires posing a hazard to people, with priority given to urban areas. The forestry authority is responsible for fires in forested areas under its jurisdiction. Additionally, environmental and/or conservation agencies may be responsible for special reserves or parks. The national defence force may also provide support where the capacity of the other institutions is limited.

Initiatives to increase cooperation and synergies among the countries of the Caribbean region have been underway since 2004:

- Participants in the Foundation Meeting of the Regional South America Wildland Fire Network, held in Curitiba, Brazil, in June 2004, proposed establishment of a Caribbean fire network within GWFN.
- A meeting of the Regional Caribbean Wildland Fire Network was held in October 2004, followed by the Pan-American Wildland Fire Conference.

A Caribbean fire management cooperation strategy was developed in 2005,

with the assistance and support of FAO project TCP/RLA/3010(C) and GFMC, to be integrated into the Regional Fire Management Cooperation Strategy for Latin America and the Caribbean. A regional report (Ramos Rodríguez, 2004) foresaw approval of a fire management working group within the Caribbean Subregional Group for the FAO Latin American and Caribbean Forestry Commission (LACFC). The Caribbean strategy aims to strengthen fire management networking with other regions sharing similar characteristics. The final strategy was presented during the commission's June 2006 session.[6]

COLLABORATION AND COMMUNITY PARTICIPATION

The extent of collaboration and community involvement in firefighting depends on the size of the island and the number of institutions involved. On many of the smaller islands there can be close collaboration, and local community groups are enlisted to help fight fires. On the larger islands, there appears to be less integration.

NEEDS AND LIMITATIONS

Needs and limitations are quite variable, due to the scattered nature of the islands and their differing sizes and economies. The 12th Caribbean Foresters Meeting, held in Puerto Rico in 2004, sought to identify the main issues and make recommendations (Eckelmann, 2004).

ANALYSIS AND RECOMMENDATIONS

The Caribbean foresters offered the following analyses and recommendations:

- Deliberate arson, including setting fires for entertainment, is one of the major causes of fires.
- All states have indicated that awareness-raising may be one of the solutions. It should be a priority in fire prevention and control, and use educational programmes in schools and the media. There are already some excellent programmes to promote conservation awareness. School activities in particular should be given high priority.
- Tourism is important in island economies, and fire can have a negative impact. This underlines the need for interagency collaboration to increase the effectiveness of fire prevention and control. To facilitate such cooperation, standard protocols and operational procedures should be developed where these do not exist.
- Initiatives to promote community involvement in fire detection are closely linked to awareness and interagency collaboration. Such initiatives will become more effective as the role of fire is better understood, public confidence is placed in collaborating agencies and underlying socio-economic constraints are addressed.

[6] The subregional strategies for the Caribbean, Central America and South America, as well as the Regional Fire Management Cooperation Strategy for Latin America and the Caribbean, are available on the websites of the regional wildland fire networks at www.fire.uni-freiburg.de/GlobalNetworks/globalNet.html.

- Many states have legislation that governs the use of fire, mainly in agriculture. However, the level of enforcement is generally low because of limited capacity, or because some laws are controversial. Responsibility for firefighting is divided among various agencies. Some legislation needs to be revised, as well, as it was originally laid down to regulate slash-and-burn agriculture.
- Many states indicate that there is a need to improve documentation of fires. This would ensure that the extent, causes and effects of fires can be better understood. Research strategies for fire management should be developed as well.
- Regional networking and exchange of ideas, such as those already carried out under the auspices of the Caribbean Foresters Network or the GWFN should be encouraged. The Caribbean Community (CARICOM) secretariat could be involved in implementing certain regional mechanisms.

6. Mesoamerica

There are eight countries in the region, covering a total land area of approximately 2.4 million km², with a wide variety of climate, topographic and forest types, including desert scrub, subtropical montane forest and lowland, moist tropical forest. Reports were received from seven of the countries participating in the regional working paper process (Table 3) (details are provided in FAO Fire Management Working Paper FM/12/E).[7]

EXTENT AND TYPES OF FIRES

There are extensive areas of fire-climax coniferous forests (i.e. the pine forests and savannahs) in which fire is an integral part of the ecosystem. The main environmental problems in the region are deforestation, which is estimated at 1.3 million hectares per year (equivalent to 1.8 percent annually), forest degradation and wildfires. Fires are many and serious, with the peak season in April and May.

CAUSES

Mesoamerican countries reported many varied causes of vegetation fires, including: social inequity, devalued natural resources, a culture that does not respect forests,

TABLE 3
Land area of countries and area affected by fire in Mesoamerica 1998–2004

Country	Land area (km²)	Area affected by fires (ha)						
		1998	1999	2000	2001	2002	2003	2004
Mexico	1 908 690	849 632	231 062	235 915	136 879	208 297	322 448	81 322
Belize	22 800	No data						
El Salvador	20 720	2 041	359	1 700	1 613	1 261	3 661	3 497
Guatemala	108 430	679 000	10 600	53 400	22 150	22 387	425 000	6 703
Honduras	111 890	96 623	54 986	63 593	82 356	63 442	56 655	8 409
Nicaragua	121 400	161 684	25 227	92 355	24 318	26 148	27 448	33 252
Costa Rica	51 060	64 893	11 192	36 896	57 511	50 337	32 372	35 228
Panama	74 430	77 586	3 397	2 204	4 247	3 739	17 765	1 723[a]
TOTAL AREA	**2 419 420**							

Source: López, 2004.
[a] For Panama, in 2004, 1 723 ha corresponded to forest fires, with agricultural fires totalling 6 293 ha (2004).

[7] A detailed analysis of the fire situation in Mexico is included in the report for North America (Mexico is a member of the FAO North American Forestry Commission's Fire Management Working Group, which constitutes the UN-ISDR Regional North America Wildland Fire Network).

inadequate policies and lack of forest resource management by communities. Almost all fires are set by people, and the immediate causes are clearance for agriculture, arson, abandoned campfires, discarded cigarettes and hunting.

EFFECTS

Damage resulting from wildfires can be very extensive. In pine forests, however, fire is beneficial, since it is an integral part of the ecosystem. It is also used as a tool in land husbandry.

In fire-sensitive ecosystems, fire causes immediate damage to ecosystems by debilitation, selective mortality and incineration of plant life, as well as degradation of the soil. This leads to many effects, including changes in ecosystems (often with impoverishment of biodiversity and productivity), predisposition to pests and diseases (e.g. infestation by *Dendroctonus* bark beetles) and reduction in environmental services.

Global climate change and local phenomena such as El Niño are leading to both drier spells, which increase fire risk, and to more intense storms, which build up fuel from debris. Smoke pollution from the resulting fires can be widespread, causing health problems and disruption of transport. Many lives have been lost due to the effects of smoke and fire, and there can be considerable damage to property. Overall, the influence of fire on national economies can be severe.

PREVENTION

Countries in the region vary in the extent to which they have been able to manage fire. Many have now had several decades of experience. With regard to prevention, ignition sources are being reduced through campaigns to improve awareness and enforce legislation. Techniques to control fire are improving. Fire calendars are being used to improve prediction. Early detection is carried out via satellite and aerial surveillance, watchtowers and ground patrols. Access to fires and control of spread are being improved by road and firebreak construction. Fuel loads are being reduced through the increasing use of prescribed burning, or adoption of practices that reduce fire risk, such as agroforestry.

SUPPRESSION

Most fires are extinguished by ground crews, with the aid of backfiring and fire traces. Where severe damage has occurred, steps may be taken to rehabilitate land through promoting natural regeneration or planting.

INSTITUTIONS, RESPONSIBILITIES AND ROLES

A wide variety of institutions are involved in fire management. The main government agencies include those responsible for forestry, agriculture and livestock. Additionally, institutions concerned with the environment, protected areas and individual crops (e.g. coffee) may have a role. Agencies concerned with meteorology, tourism, health, infrastructure, development, legislation, national emergency, defence and fire and ambulance services are also involved in prediction, protection and general support.

Over the past few years, there have been various initiatives to address the issue of wildfires from a regional perspective and to build up institutional capacity:

- The first Mesoamerican Meeting on Cooperation Regarding Protection against Forest Fires was held in Guatemala in 2002. It aimed to identify specific activities for regional cooperation between Mexico and Central American countries.
- A workshop to develop a regional strategic plan for forest fires and pests was held later in 2002 in Honduras. On this occasion, the Regional Working Group on Fire Management was established under the Technical Committee on Forests of the Central American Commission on Environment and Development (CTB/CCAD).
- To begin implementation of the strategic plan, two more workshops were held in 2004 in El Salvador and Guatemala, focusing on developing an action plan for Central America and Mexico.
- The Central American and Mexican Regional Network on Forest Fires and Pests was officially established in 2004, in El Salvador, during a meeting of the Central American Council of Forests and Protected Areas. Council members are the directors of the national forest service of each country in the region.
- A meeting of the Regional Network of Central America and Mexico was held in October 2004, followed by the Pan-American Wildland Fire Conference.
- A fire management strategy for Central America was being developed in 2005 by the CTB/CCAD Regional Working Group on Fire Management, with the assistance and support of FAO project TCP/RLA/3010(C), to be integrated into the Regional Fire Management Cooperation Strategy for Latin America and the Caribbean. This strategy aims to unify technical criteria and establish dynamic interactions among the countries of the region (Scholz, 2005). For additional information, see Casaza (2005a, 2005b).

COLLABORATION

As a result of the initiatives noted above, a number of collaborative actions are being carried out:

- Satellite detection of forest fires is being implemented through bilateral agreements by Mexico (National Commission for the Knowledge and Use of Biodiversity – CONABIO) with Costa Rica, El Salvador, Guatemala and Honduras.
- Honduras and Nicaragua are also collaborating on satellite detection of forest fires.
- Under the bilateral agreement between Mexico and Guatemala and the agreement between the Commission on Forest Pests and Fires in Central America and Mexico, two international Mesoamerican courses in forest fire protection have been given (in 2002 and 2003).
- A regional strategic plan for forest fires and pests, elaborated in Honduras in 2002, was executed with the assistance of the United States Agency for International Development (USAID).

- In the Trifinio forest area in the frontier zone between El Salvador, Guatemala and Honduras, collaborative forest fire prevention and control are being developed.
- In other frontier areas, forest fire prevention and control are being carried out in countries belonging to the Central America and Mexico Regional Network on Forest Fires and Pests.
- In Central America, two training processes have taken place: one supported by the Office for Disaster Assistance of USAID and the other supported by Mexico – the Mesoamerican Course on Forest Fires.
- Coordinated management of emergencies has been established in the frontier area between Guatemala and Mexico.
- An emergency coordination agreement was established for Costa Rica, Nicaragua and Panama.

COMMUNITY PARTICIPATION

The involvement of communities in fire management is increasing as there is more awareness of local forest benefits and more trust is placed in the organizing institutions.

NEEDS AND LIMITATIONS

Governments in the region increasingly recognize that prevention of forest fires is important – as well as control – but because of political constraints, many initiatives have not achieved concrete results. In recent years, however, both fire control and the strengthening of local fire prevention capabilities have been emphasized.

From the technical point of view, it is necessary to increase and adapt training to the required level in each country, improve planning, organization and detection so as to reduce response time; and implement formal systems for predicting forest fires at the regional level. As part of this process, the priorities are: decentralization of fire prevention and control activities to the level of communities, municipalities and civil organizations; and strategic planning and action to strengthen technical capacity, resources and equipment, in order to increase technical capability to predict, detect and monitor forest fires.

ANALYSIS AND RECOMMENDATIONS

The incidence of wildfires in the region has a significant and deleterious effect on national economies and society. The causes of fire include land clearance for agriculture, arson, abandoned campfires, discarded cigarettes and hunting. The El Niño weather pattern has an effect on the fire hazard. Early detection is carried out via satellite and aerial surveillance, but fire control is still conducted largely by ground crews.

The region has trained human resources, as well as detection systems and basic equipment and tools for control. Recently fire control and the strengthening of local fire prevention strategies have been emphasized, but training must be increased and adapted to the required level in each country. Priorities are the decentralization of fire prevention and control activities, and strategic planning and action.

Political, social and environmental constraints have often limited efforts to introduce effective prevention and control. Various initiatives are being undertaken to address the issue of wildfires from a regional perspective, build up institutional capacity and promote collaboration. Bilateral initiatives are promoting such collaboration in cross-border areas.

In a brief presented at the Pan-American Wildland Fire Conference (López, 2004), it was suggested that the following activities should be carried out to strengthen regional cooperation:

- improve satellite systems for detecting and monitoring fires in the region and develop processes for predicting forest fires;
- revise the regional strategic plan for forest fires for Central America and Mexico and establish a regional forest fire management policy, taking into account the Central American Regional Forest Strategy, which is considered a strategic framework for the forest sector for the next 25 years;
- give priority to the problem of forest fires and provide resources through the countries of the Central America and Mexico Regional Network on Forest Fires and Pests;
- develop bilateral and regional cooperation mechanisms and projects in support of forest fire management, presenting such proposals for international financial and technical assistance;
- define objectives, procedures, cooperation formats, work mechanisms and protocols;
- create channels and procedures for communications that are easily implemented by the networks in Central America and Mexico in coordination with those in South America, the Caribbean and North America;
- develop a short-term work plan at the level of the regional networks, with clear roles and responsibilities and dates for presenting results.

7. North America

The North American region, constituting the Regional North America Wildland Fire Network, includes Canada, Mexico and the United States. Mexico is also a member of the Mesoamerican region and actively participates in both networks.

Forests cover a significant part of this region, from the boreal forests in northern Canada and Alaska to the moist tropical forests in southern Mexico. They pose a vast array of fire management challenges (details are provided in FAO Fire Management Working Paper FM/15/E).

EXTENT AND TYPES OF FIRES

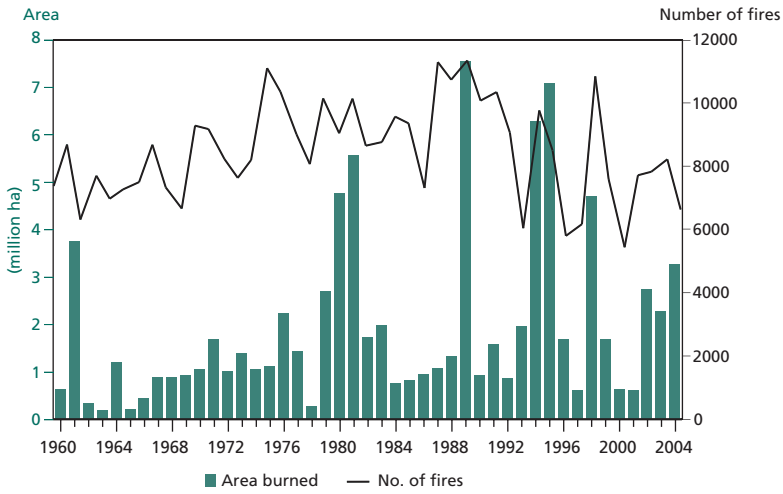
Forest fires have been a dominant disturbance regime in Canadian forests since the last Ice Age some 10 000 years ago. Fire is natural and essential across much of Canada's forested landscape, and along with insects, disease, wind and natural regeneration, it helped shape the character of Canadian forests before the country was settled. Fire is particularly significant in Canada's vast boreal forest region, where primary boreal species such as pine, spruce, birch and aspen have adapted to fire to the point that it is essential to their existence, and adequate regeneration requires the high-intensity crown fires natural to this region. Periodic lower-intensity fires are also required to maintain surface fire regimes in other forest regions of Canada. Canadian forests are thus strongly connected to the fire regime, and maintenance of natural forests is crucial.

However, Canada is a forest nation, and the industrial use of forests is intimately linked to the country's cultural, economic and social development. The forest sector has become the largest contributor to Canada's positive trade balance. Forest recreation is also an expanding Canadian activity. Such extensive use of the forest requires adequate protection from fire. Reconciling the natural role of fire in ecosystem maintenance with the need to protect life, property and valuable products derived from the forest is a complex challenge.

The area burned by Canadian forest fires fluctuates greatly from year to year, from under 500 000 ha to more than 7 million hectares in extreme years. In comparison with the 1950s and 1960s, the average annual area burned has been increasing over the past three decades. During the 2000–2004 period, unofficial statistics indicate 7 321 fires and 1 689 424 ha of forest burned annually (Figure 2).

In Mexico, the average annual burned area over 2000–2004 was 197 000 ha on all lands. An analysis of fire occurrence from 1970 to 2005 indicates that the number of fires has tended to increase over time. This is widely assumed to be the result of population increases in forested areas, together with a change in climatic conditions. At the same time, the trend in burned area is decreasing (Table 4), most likely the result of more-effective suppression efforts.

FIGURE 2
Annual number of fires and area burned in Canada 1960–2004[a]



[a] Post-2000 statistics are not yet official.

TABLE 4
Annual number of fires and area burned in Mexico 1988–2004

Year	Total number of fires on all lands	Total area burned on all lands *(ha)*	Area of forest burned *(ha)*	Area of other wooded land burned *(ha)*	Area of other land burned *(ha)*	Human causes *(%)*	Natural causes *(%)*	Unknown causes *(%)*
1988	10 942	518 265	188 622	55 164	274 479	84	1	13
1989	9 946	507 471	214 418	119 364	173 689	84	2	14
1990	3 443	80 400	23 143	20 772	36 485	85	2	13
1991	8 621	269 266	113 790	58 427	97 049	84	1	13
1992	2 829	44 401	12 440	9 100	22 861	84	2	14
1993	10 251	235 020	54 773	66 923	113 324	85	2	13
1994	7 830	141 502	32 703	48 740	60 059	84	1	13
1995	7 860	309 087	115 117	105 014	88 956	85	2	13
1996	9 256	248 765	57 139	102 202	89 424	84	1	13
1997	5 163	107 845	23 444	37 924	46 477	84	2	14
1998	14 445	849 632	198 487	298 903	352 242	85	2	13
1999	7 979	231 062	41 365	101 857	87 840	84	2	14
2000	8 557	235 915	40 475	94 285	101 155	85	2	13
2001	6 340	136 879	18 805	53 441	64 633	84	1	13
2002	8 256	208 297	31 988	88 507	87 802	85	2	13
2003	8 211	322 448	88 261	130 287	103 900	84	1	13
2004	6 300	81 322	10 514	32 861	37 947	85	2	13
Av./yr	8 013	266 328	74 440	83 751	108 137	84	2	13

In the United States, the last five-year period saw one of the most severe series of fire seasons since statistics have been recorded. Over 2.8 million hectares were burned in 2000, 2002 and 2004 (Table 5). The initial figures for 2005 indicate that over 3.48 million hectares burned, a figure more than twice the ten-year average. In 2002, the National Interagency Fire Centre reported that 2 381 structures were destroyed in fires.

The severity and impact of fires have been increasing for several years. There is significant year-to-year variability in both the number of fires and total area burned, but the overall trend is an increase in area burned.

CAUSES

Canada and the United States are among the few countries to report significant numbers of fires caused by lightning. In Canada, it is responsible for an average of 35 percent of the number of fires, but 85 percent of the total area burned. Lightning fires occur randomly, often in significant numbers, over large areas, presenting access problems not usually associated with human-caused fires. Thus they often spread because detection and initial attack are delayed. Recreational activities, forest industry operations and homeowners living in or near the forest are primarily responsible for the accidental, human-caused fires that dominate in the protected forest regions of Canada.

In Mexico, population increases have generated an increasing demand for farmland. With more agriculture, the use of fire in farming activities is more frequent and fire risk has increased. There are more fires than in the past and the natural fire cycle has changed.

Most fires in the United States are also caused by people. However, the causes vary by region, with lightning being a major cause of fires on federal lands in the west and human-caused fires being more common in the east, where lightning storms are commonly accompanied by heavy rains. The summer storms in the

TABLE 5
Annual number of fires and area burned in the United States 2000–2004

Reporting agency	2000		2001		2002		2003		2004	
	No.	Area *(ha)*	No.	Area *(ha)*	No.	Area *(ha)*	No.	Area *(ha)*	No.	Area *(ha)*
Bureau of Land Management	3 288	538 791	3 312	305 724	2 402	403 527	2 919	136 483	2 721	510 818
Bureau of Indian Affairs	5 964	186 717	4 958	79 012	6 260	438 875	5 826	176 983	5 267	30 235
Fish and Wildlife Service	548	157 772	397	26 127	481	201 354	494	64 838	520	745 931
National Park Service	771	91 427	841	85 322	680	86 563	738	150 209	685	209 367
USDA Forest Service	9 788	853 399	9 236	217 947	7 485	635 960	8 902	69 317	7 120	182 875
State/private	103 971	1 497 948	84 362	693 466	74 812	1 093 875	64 318	1 074 514	65 973	1 249 635
Total	**124 330**	**3 326 053**	**103 106**	**1 407 597**	**92 120**	**2 860 154**	**83 197**	**1 672 346**	**82 286**	**2 928 861**

west tend to be 'dry', meaning that the precipitation evaporates before reaching the ground, or the amount of precipitation is not adequate to extinguish the fires started by the lightning strikes.

EFFECTS

In Canada, in recent years, there has been a large increase in the number of homes and communities built adjacent to and among forest and other flammable vegetation. Living close to a forest is attractive to many former city dwellers, and expensive communities are growing up in the WUI. These homeowners have little knowledge of wildfires or of the need to protect their homes, and very few of these communities have building codes that require residents to build homes resistant to vegetation fires and/or to manage fuels on their property. The threat of WUI wildfires became common knowledge to all Canadians in the summer of 2003, when extreme fire danger conditions and multiple ignitions in the interior of British Columbia overwhelmed suppression capabilities. A total of 334 homes and 10 businesses were destroyed and over 45 000 people evacuated. The total economic impact to the province was measured in hundreds of millions of Canadian dollars.

In Mexico, losses to buildings and other infrastructure have not become a serious problem. While there are population centres within forest areas that could be affected by fires, they are usually surrounded by farming zones, or the fuel loads have been reduced so that fires do not burn intensely, if at all. The principal negative impacts from fires are to natural resources and the forest industry.

Damage to many ecosystems is very significant in terms of alteration of the fire regimes across Mexico. According to older members of the rural population, the natural fire frequency used to be from 50 to 200 years, but fire frequency in the last decades has increased to from five to eight years. This situation is particularly significant to the tropical forest ecosystems, where fires were almost unknown.

Economically, the 2003 fires resulted in losses of US$337.03 million in wood, US$6.57 million in firewood and US$39.17 million in reforestation costs in the affected forest areas. This does not consider losses of biodiversity, the effects on erosion, the hydrologic cycle, scenic beauty and recreation, or the production of greenhouse gases.

In the 2003 fire season, the United States had an average area burned and a below-average number of fires. Nevertheless, the most critical period occurred later in the year, when approximately 304 000 ha burned in southern California, in and around Los Angeles and San Diego. The fires destroyed 3 640 homes, 33 commercial buildings and 1 140 other structures.

PREVENTION

Public awareness of forest issues in Canada, including fire management practices, has been growing quickly in recent years, partly due to the success of public awareness programmes and expanded media coverage. This is particularly true with First Nations peoples[8], forest landowners and former city dwellers moving to a WUI.

[8] 'First Nations' peoples refers to any of the indigenous groups formally recognized by the Canadian government under the federal Indian Act of 1876. The term does not include non-Indian peoples such as the Inuit or the Métis.

In Mexico, within forest areas, prescribed burning is a preventive tool for fuel reduction. In areas of commercial forest production, prescribed burning is used for forest management as well as fuel reduction, reducing the damage from fires. Other preventive and silvicultural practices are used in conjunction with prescribed burning, such as the opening and maintenance of firebreaks, pruning and thinning, the use of debris as firewood and others. In some protected natural areas, firebreaks are constructed, but prescribed burning is not allowed.

Fuel management activities are a critical component of fire protection in the United States. Prescribed burning can be a very effective measure for reducing the risk of fire to communities and protected areas. However, fuel management activities, including the use of prescribed fire, are much more than just a prevention tool. They are used to restore and sustain ecosystems and enhance resources.

In the area of public relations, Smokey the Bear has been the symbol of US fire prevention activities since 1944. The purpose of the Smokey Program is to create and maintain public awareness of the need to prevent unplanned, human-caused fires.

SUPPRESSION

Fire suppression costs are constantly increasing in Canada due to a number of factors, including the use of more costly equipment, expansion of fire protection zones northward to match shifting forest operations and increased costs associated with the protection of an expanding WUI zone. Changes in fire weather patterns mean that annual suppression costs, not including public and industrial losses, are not only increasing but are highly variable, averaging Can$500 million (US$382 254 million) and reaching Can$1 billion (US$765 million) in an extreme fire season. It appears that fire suppression as practised today will not be economically sustainable in the future, and Canada will not be able to meet current targets in terms of area burned and the control of escaped fires. This will affect wood supply and the competitiveness of the forest industry, along with some 300 forest-industry-dependent communities.

In the United States and Canada, two key objectives in controlling fires are early detection and initial attack when fires are small. This involves prediction of the most likely locations in which fires will start (both lightning- and human-caused fires) and the implementation of enhanced detection in those areas (primarily aircraft patrols). When fires are detected, initial attack forces are deployed by land or helicopter and are often supported by aircraft dropping water, foam or fire-retardant chemicals.

In Mexico, agencies and organizations at all levels of government assist in the fire suppression effort. They employ a range of resources, including ground crews or brigades, engines and helicopters. These resources respond to fires for the initial attack and then extend the attack using both direct and indirect suppression techniques. The Secretariat of the National Defense uses elements of the Mexican Army and Armed Forces for fire suppression. In 2005, they were used for 23 004 person-days.

In the United States, the total number of resources fluctuates every year and is based on budgets, fire-season severity and other variables. Resources used by federal agencies in 2002, a typical year, included over 15 000 firefighters, 277 ‘smokejumpers’,

over 1 700 management staff, 152 helicopters and 74 airtankers, as well as 92 other aircraft. The states and local jurisdictions provide additional resources for their areas of responsibility. While many state resources are available for national mobilization, most state and local resources are needed for local initial attacks.

Fire suppression in all three countries is managed through the Incident Command System (ICS), a management system used to plan and organize the strategic and tactical response to fires.

INSTITUTIONS, RESPONSIBILITIES AND ROLES

In Canada, the bulk of forested land is public and is owned by the provinces/territories. Thus responsibility for forest management, and therefore fire management, rests with each of the 13 autonomous provinces and territories. The emphasis in national parks is on maintaining ecological integrity through prescribed landscape-scale burning and wildfire monitoring. In addition, 80 percent of aboriginal communities are located in forested areas, and these communities negotiate agreements for protection. A number of federal agencies are also involved in some aspect of fire management.

In Mexico, the Group for Interagency Coordination supports the National Programme of Protection against Forest Fires. The 12 secretaries of state in the Federal Government participate. The group provides support for fire management activities and ensures that resources for the prevention, detection and suppression of fires are coordinated. The National Forest Commission (CONAFOR) leads this interministerial working group for forest fire suppression and coordinates all efforts in protection at national, regional and state levels.

Current legislation in Mexico assigns responsibility for the prevention, detection and suppression of forest fires to the landowner, as well as to the authorities of the three levels of government (local, state and federal) based on their jurisdictions and the complexity of the problem. This new legislation has not yet been applied completely throughout the country.

Fire protection responsibilities in the United States depend on ownership patterns and on any protection agreements between agencies or owners. Federal, state, municipal, county and local fire districts all play a role in managing and suppressing fire. Each state has fire protection responsibility, with the jurisdiction defined by individual state statutes and regulations. Many have state forests and other state-owned land and some states have statutory responsibility to protect private lands as well.

COLLABORATION

The three countries are members of the FAO North American Forest Commission. NAFC established a Fire Management Working Group over 40 years ago. It is still active and meets annually to plan exchanges, training, study tours and other cooperative activities.

The borders between Canada and the United States and between Mexico and the United States are covered by international agreements that authorize the exchange

of firefighters and provide for assistance on fires that cross international boundaries. There are national-level agreements and also local agreements between adjoining jurisdictions to address local needs. As a result, fire suppression resources in any of the three countries are available to respond to neighbouring jurisdictions as long as the terms of the agreements are met. Moreover, the countries are able to work together on fire suppression because they have all adopted the ICS.

During severe fire seasons, the United States has provided Mexico with technical assistance and equipment, and with specialized resources for infrared photography and photo interpretation.

Mexico is also an active participant with its southern neighbours in the Regional Mesoamerica Wildland Fire Network. It provides technical support to Guatemala for initial attacks in the common border zone and occasionally dispatches its armed forces or private helicopters for these attacks.

In 2000, federal agencies of the United States signed an agreement with Australia and New Zealand for the exchange of firefighters. While this arrangement is relatively new, Australia, New Zealand and the United States have engaged in a long-standing series of exchanges and joint technical and training programmes.

COMMUNITY PARTICIPATION

There appears to be little formal community involvement in the region – or at least little was reported. In the United States, the FIREWISE programme provides information to homeowners and community leaders. The programme is a cooperative effort by federal agencies, the National Association of State Foresters, the US Fire Administration and the National Fire Protection Association.

ANALYSIS AND RECOMMENDATIONS

All countries of the region recognize the positive role that fire can play in sustainable forest management, but in no country does an increasingly urban public appreciate this. Public awareness campaigns are needed not only for fire prevention, but also for information on the positive aspects of fire.

It appears that in all countries the number of fires and area burned are highly variable, but that the trend in damage is increasing. In response to this, there is increasing collaboration in firefighting. This collaboration could be extended to agreement on common terminology and the regional collection of data.

Mexico has many issues that complicate its fire management programme. There is a lack of public understanding of the complexities of the fire problem. Many communities use fire for forestry, farming or livestock management purposes, but others see fire as a problem to be totally excluded from forests. This translates into a lack of understanding by the public of the full range of issues of forest and fire management.

There is also a need to develop an effective programme of fuel management and prescribed burning for fire prevention. This might include legislative changes to ensure the protection and conservation of protected areas and to recognize that fire is an important tool in the sustainable management of forests.

In the United States and Canada, there has been a great increase in recent years in the number of homes and communities constructed adjacent to and within forests or among other flammable vegetation. Living close to a forest has become attractive to many ex-urbanites, and upscale communities are springing up in the WUIs. These homeowners have little knowledge of wildfires or the need to protect their homes.

A number of provincial/territorial fire management agencies and municipal governments are attempting to institute hazard mitigation programmes within and around these communities, but this is a formidable task, given the rate of WUI expansion and the increasing wildfire threat. These programmes should consider the biophysical aspects of hazard mitigation (e.g. fuel reduction/modification) together with the social aspects (e.g. public awareness/involvement).

In addition, communities in northern Canada, which are primarily indigenous or associated with resource-extraction industries, require better protection against the impact of fire through hazard mitigation. These communities depend on the forest around them for their livelihoods; thus even fires that do not impact a townsite directly can significantly affect the future of that community.

It is a generally accepted conclusion among scientists and a growing percentage of the public that climate change is a reality, and that impacts across the region will be profound – and largely unavoidable – over the next century. Research to date indicates that both the incidence and severity of forest fires will increase dramatically.

8. South America

The regional working paper on forest fires in the South American region covered the vegetation fire situation in the ten most affected countries (Argentina, Bolivia, Brazil, Colombia, Chile, Ecuador, Paraguay, Peru and Uruguay). There was some limited information available for French Guiana, Guyana, and Suriname (details are provided in FAO Fire Management Working Paper FM/5/E).

EXTENT AND TYPES OF FIRES

Wildfires are present in all ecosystems of South American countries, extending from 12°N to 56°S. The frequency, intensity and time distribution of wildfires during the year are variable in response to different human factors such as cultural practices, population density, tourism affluence and the characteristics of fire suppression activities. In addition to the human factors, wildfires are affected by environmental factors such as the El Niño effect, droughts and, in some instances, lightning.

Figures are not complete, because data are often unavailable, non-existent or inaccurate. Moreover, most countries do not distinguish the different forest types in the affected areas. Thus it is difficult to elaborate the national and regional wildfire statistics accurately.

The number of fires and the area burned annually vary widely. Most of the area corresponds to other wooded lands (26 percent), followed by other lands (20 percent) and forests (17 percent). During the 1990s, an average 25 000 wildfires burned 4.3 million hectares on average each year (Table 6).

The main areas affected were grasslands and protected natural areas in Argentina, Bolivia, Chile and Uruguay (20 percent) and not the intensively managed savannahs, shrublands and wildlands of Brazil (*cerrados*), Bolivia, Colombia and the Bolivarian Republic of Venezuela (13 percent). Twelve percent of the burned areas were native, moist tropical forests that are not intensively managed, mainly in the Amazonian watershed.

The Darien gap zone in Colombia (Silva, 2003) and peat in the highlands of Peru were also affected by fires. Several countries, especially in 1998, reported fires from forests throughout the southern, central, and eastern Amazonian watersheds (Nepstad, Moreira and Alencar, 1999; Nepsted *et al.*, 2001). Unfortunately, there is no quantitative data on the numerous fires that occurred across the Guyana Shield in Suriname and Guyana. Fires in moist tropical forests, which traditionally had not been affected by fire, have increased due to deforestation and land-use changes.

Fires occurring near WUIs have become a significant problem over the last decade, disturbing normal life in the main cities of Argentina, Chile, Ecuador and Uruguay (Viegas, 1997; Lopes, Sousa and Viegas, 2002).

TABLE 6
Annual number of fires and area burned in South America 1990–2004

Year	Number	Area burned *(ha)*
1990	5 201	45 698
1991	11 279	9 759 804
1992	11 280	654 224
1993	7 533	1 861 720
1994	2 339	1 688 040
1995	11 490	979 165
1996	11 572	564 674
1997	66 807	5 585 369
1998	15 877	1 137 305
1999	43 016	13 592 352
2000	16 401	2 891 800
2001	17 966	4 888 276
2002	23 519	2 607 460
2003	29 158	3 667 640
2004	9 191	430 418

The fire season varies according to the onset of the rainy season. In the north of Argentina, Chile and Colombia, and in Bolivia, Brazil, Ecuador and Peru, fires occur mainly in autumn and winter, associated with the dry seasons. In the territories where the dry season occurs in late spring and early summer, wildfires occur mainly from January to May, as well as in November and December (the south of Argentina, Chile and Colombia, and in Uruguay and the Bolivarian Republic of Venezuela.

CAUSES

Eighty-five percent of the vegetation fires in the region are caused by human activities. Most result from fires that escape from pasture and agricultural land maintenance activities, as a result of forest clearance, logging and hunting, cooking, rubbish- or waste-burning activities, as well as arson and accidents.

Nepstad, Moreira and Alencar (1999) stated that the combination of slash-and-burn cultivation with drought is causing an increase in moist tropical forest flammability. Areas farmed by slash-and-burn methods are not commonly included in the national statistics for fires, but this type of coltivation could be the cause of 60 percent of the recent increase in the area burned in Amazon basin countries.

Agrarian policies to promote expansion of the agriculture and livestock sectors lack adequate planning and control mechanisms. They are thus causing large-scale transformation of moist tropical forests to rangeland and to agriculture for soya, especially in Brazil, Bolivia, Colombia, Ecuador, Paraguay, Peru and the Bolivarian Republic of Venezuela.

Policies favouring the construction of oil and gas pipelines and highways in Brazil, Colombia, Ecuador, Peru and the Bolivarian Republic of Venezuela are also

leading to vegetation fires. These activities affect even protected areas. A report from UNEP (2002) indicated that agro-industrial, mining and transport policies prevail over forest policies and are indirectly promoting fire outbreaks.

Lightning or other natural causes account for 5.5 percent of fires. These occur in central and southern Patagonia (Rodríguez, 2000), the *cerrado* of Brazil (Mutch, 2003), the savannah biome of Colombia (Silva, 2003) and the eastern Bolivarian Republic of Venezuela. Heavy rains commonly accompany tropical thunderstorms and usually preclude the ignition of fires by lightning. Unknown causes account on average for 9 percent of the total number of fires.

EFFECTS

During the 1990s, increasing numbers of fires were reported in most countries. They have caused serious environmental damage, killed and injured people, burned hundreds of homes and destroyed several villages and towns.

At least 742 people lost their lives and 429 were injured as a consequence of these wildfires. The highest loss of life was in Brazil, in the Roraima wildfires, in which 700 people died (UNEP, 2002). In addition, the smoke produced by wildfires has caused widespread respiratory and cardiovascular problems, in particular constrictive and obstructive lung disorders, while the number of cases of asthma, pneumonia, bronchitis, acute laryngitis, bronchiectasis and conjunctivitis have increased dramatically. Respiratory diseases have caused the death of children and old people in Sucre (Bolivia, 2004).

The greatest impact of vegetation fires in the region may be on moist tropical forests, where widespread fires have had grave consequences. The situation has become acute in Brazil, Bolivia, Colombia, Ecuador, Paraguay, Peru and the Bolivarian Republic of Venezuela. In French Guiana, Guyana and Suriname, the changes are less visible. The effect of fires on temperate forests and savannah are serious, but these ecosystems are fire-adapted to different degrees and the interrelationship of fire and vegetation within them is reasonably well understood.

Regarding greenhouse gas emissions, Barbosa and Fearnside (1999) estimated that about 3.5–4.0 tonnes of carbon were released as CO_2 for each hectare burned in Brazil. Thus about 4.4 million and 800 000 tonnes of CO_2 were released in 1998 and 2003 respectively. For Bolivia, Martínez and Cordero (2001) indicated that 82.6 million tonnes of CO_2 were released from savannah forest fires, followed by grassland fires. In Colombia, savannah fires were also recognized as a major contributor to the release of greenhouse gases (Silva, 2003).

An additional negative environmental impact of wildfires is soil erosion, which has occurred in the Andean mountains, in tropical and temperate forests and on the coast. Erosion processes caused floods and landslides in Bolivia, Brazil, Colombia, Chile, Ecuador, Peru and the Bolivarian Republic of Venezuela (UNEP, 2002).

Fires have a range of economic and environmental costs, from medical costs, timber losses and damage caused by floods, landslides or erosion to airport closures due to atmospheric haze. However, the real costs of wildfires in the region are unknown, mainly due to a lack of data.

PREVENTION

Extension and training activities at the municipal level are the main preventive activities in some South American countries. Public and private campaigns were launched in Bolivia, Brazil, Chile and Ecuador after the occurrence of major fires. These campaigns included public meetings and targeted seminars addressed to rancher associations, farmers, municipal forestry units, local social groups, indigenous communities and the general public. The mass media were also used in these campaigns, including radio, television, posters and bulletins.

A second main topic in wildfire education is training in prescribed burning, which has been undertaken by a number of institutions and organizations (full details can be found in the regional working paper). In Bolivia, public meetings and seminars have been organized since 2000. In Brazil, training courses were run for farmers, dealing with prescribed burning and regulations regarding the use of fire in land management. In Ecuador, several organizations have run courses for farmers since 1996. In Colombia, workshops on prescribed burning were organized and a national booklet was published on wildfire prevention through prescribed burning. In Argentina, the Secretariat of Agriculture, Livestock, Fisheries and Food is conducting prescribed burning in forest plantations through research and extension projects.

In Brazil, Chile and Ecuador, the importance of providing information on fire to primary and secondary schools has been emphasized by both the regional Secretariat of Education and the Ministries of Education. NGOs are also carrying out capacity-building activities for primary school teachers in rural areas. In Argentina and the Bolivarian Republic of Venezuela, these activities include public meetings, courses and seminars, and a preschool programme is being arranged by the US National Fire Protection Association in Bahía Blanca, Argentina. However, fires and prescribed burning are not taken into account in the primary education curricula in Bolivia, Paraguay, Peru or Uruguay.

At higher levels of education, most universities include fire management in the curriculum for forestry training, either as a mandatory or voluntary subject. It is significant that universities in the region do not have master or doctorate degrees in fire prevention or firefighting.

Early warning systems of high fire risk conditions have been used in some countries since the 1990s, while other countries have just recently had access to the technology required. Satellite-based sensors that produce maps and written reports on fire danger rating and fire weather forecasts at national and state levels are common in many countries.

Wildfire detection and monitoring activities in the region are carried out by both traditional and modern technologies. In Chile, Colombia and the Bolivarian Republic of Venezuela, fire detection is done by spotting towers, aircraft and ground patrols, which require substantial infrastructure and coordination. In the Amazonian watershed, in particular, fire detection from planes is expensive and, given that it is limited by clouds and smoke, is feasible only in specific circumstances. The National Brazilian Space Research Institute (INPE) provides daily maps, with fire locations detected by the currently available space instruments. It also provides daily maps for

Bolivia, Paraguay, Peru and the Bolivarian Republic of Venezuela (www.cptec.inpe.br/queimadas/).

Regarding fire statistics, the Native Forests Resources Direction in Argentina is responsible for national wildfire statistics management. In Brazil, federal conservation units summarize the stored information. The Corporación Nacional Forestal (CONAF) in Chile and the National Directorate of the Fire Service in Uruguay are in charge of national wildfire statistics. In Uruguay, the directorate also carries out investigations into the causes of wildfire (Tamburi, 2004), while in Chile the national police investigate these.

Institutions in Colombia (Antioquía Autonomous Corporation – CORANTIOQUIA), Ecuador (Loja Municipality) and Peru (Universidad Nacional Agraria La Molina) intend to gather statistics at state, municipal and national levels, but they do not have official responsibility for them (Polanco and Javier, 2002; Manta and León, 2004). Bolivia and Paraguay have no databases of wildfire statistics, which makes it impossible to determine trends in fires or analyse causes.

The building up and improvement of wildfire statistics databases are essential activities in fire prevention. With them, one can study wildfire causes and allocate suitable resources to trouble spots.

References to 'sustainable land use' to reduce fire hazard in the region often intend forest management practices, maintenance of reserved areas for protecting biodiversity and the use of these areas by indigenous peoples. All countries have approved laws and established strategies and plans for forestry management practices, but only some of them have reached an adequate level of practice in sustainable forest management.

SUPPRESSION

Argentina, Brazil and Chile usually combine their terrestrial and aerial resources for firefighting.

In Chile, CONAF has extensive experience in terrestrial and aerial fighting against wildfires at the national level. Argentina is divided into federal provinces, which all have the legal obligation to fight fires. However, when complex fires threaten to overrun the provincial firefighting systems, the law stipulates that assistance can be requested from the Fire Management Programme. In Brazil, the Arc of Deforestation Programme (PROARCO) and the National System for Wildfire Prevention and Suppression (PREVFOGO) combat wildfires and inappropriate prescribed burnings. They provide full coordination, establish strategic task forces and distribute resources to priority areas.

One factor contributing to large fires in the Amazonian watershed is the ineffectiveness of air attacks. Smoke from the tropical forest canopy makes it difficult to locate the source of the fire, and the canopy intercepts much of the water and the fire suppression agent.

Colombia, Uruguay and the Bolivarian Republic of Venezuela do not have adequate aerial suppression capability and mainly use ground suppression techniques. In Uruguay, firefighting is primarily concentrated in forest plantations.

Bolivia, Ecuador, Paraguay and Peru do not have professional ground crews. They use voluntary brigades from local communities, some brigades at protected natural areas and intermediate corps of voluntary firefighters with basic training and equipment.

In order to improve firefighting activities, training courses have been implemented by governments and NGOs in several countries. In particular, Brazil, Chile and Ecuador have undertaken such initiatives. Training is only partially implemented in Bolivia and is very limited in Paraguay and Peru.

INSTITUTIONS, RESPONSIBILITIES AND ROLES

In most South American countries, natural resource policy is oriented towards the agriculture, mining and transport sectors. Because of the low contribution of the forestry sector to gross domestic product (with the exception of Bolivia, Brazil and Chile), the forestry administration has little economic or political power and a low position in the administrative agrarian hierarchy – and in the case of Colombia and Ecuador is virtually non-existent.

The political agenda for fires is mainly a reaction after the occurrence of a catastrophic event – or is connected with the vested interests of the political parties. It is not generally part of the development process, nor is it in line with national needs. There is also instability due to changes in governments and the problem of corruption, which facilitates the transformation of wooded lands into other land uses.

The institutionalization of wildfire management varies according to the responsibilities and roles of the organizations in charge, the hierarchy within the public structure, management capacity, available technology and economic resources. For example, the total yearly budget in Chile for fire prevention and firefighting to protect 3 million hectares of plantations was US$22 million in 2004. Ninety-five percent of the budget is devoted to detection and firefighting, while just 5 percent is devoted to prevention. One-third of the total investment is covered by the state and the remaining two-thirds by private forestry enterprises.

Brazil obtained a loan of US$15 million from the World Bank in 1998 to support the PROARCO programme for preventing and suppressing large-scale wildfires in the southern part of the Brazilian Amazon (Mutch, 2003). However, other countries, such as Bolivia, Ecuador, Paraguay and Peru, have very limited resources.

Argentina, Bolivia, Brazil, Chile and Uruguay each have one national government organization responsible for fire management, whereas Colombia, Ecuador, Peru and the Bolivarian Republic of Venezuela have several organizations. In Paraguay, there is no national government organization for fire management.

In mid-2002, the institutional group Prevention, Control and Mitigation of Wildfires was created in Ecuador to set up a new plan to fight forest fires and improve the management capabilities of state and municipal organizations. In Peru, the national system for wildfire suppression and prevention has not yet been established, despite the approval in 2001 of the law for its creation.

LEGISLATION

The governments of the region use different legal tools for fires and prescribed burning. These are not integrated into a specialized law for wildfires, but correspond to regulations promulgated by different institutions in each country.

At least 153 national legal texts exist in the South American region, 57 of them devoted specifically to fires and prescribed burning, and the rest dealing generally with forestry issues and, to some extent, forest cover. However, most national government organizations related to fire management are not able to apply them for a variety of reasons: incompleteness of the regulations, lack of rules by which to develop the specific procedures for implementation and, finally, the fact that the provisions do not clearly give a mandate or legal responsibility to the relevant body.

In many countries, the absence of specific procedures for enforcement under the penal code for vegetation fires makes it difficult to punish people for illegal burning, even in the case of state-protected areas.

COLLABORATION

Chile has the highest number of agreements in the region (six) on collaboration for fire management. It also has a standard annual operating plan, which details procedures to obtain emergency assistance within the country and at the international level. In Bolivia, Ecuador, Paraguay, Peru, Uruguay and the Bolivarian Republic of Venezuela, clear agreements have not yet been established.

Although widespread emergencies in recent years in all regions of the world have underscored the importance of establishing international agreements in advance of fire occurrences, Argentina and Chile are the only nations with operative bilateral emergency agreements in the South American region. However, even though countries did not have prior agreements, many national and international agencies and organizations successfully integrated their activities to fight the Roraima fires in Brazil and Colombia's fires in 1998, as well as the fires that occurred at the beginning of 2005 in Paraguay and Uruguay.

There is also international collaboration in joint research programmes on wildfires. International research organizations with regional counterparts are developing advanced research into the causes, effects and behaviour of tropical wildfires (for example, the Latin-American Tele-detection and Wildfires Network, the Regional South America Wildland Fire Network and the Latin America and the Caribbean Fire Learning Network). The use of remote sensing data is another priority research field. However, the critical problem remains of the effectiveness of detection and suppression activities in the moist tropical forests of the Amazon – a problem that has not yet been solved by international collaborative research.

COMMUNITY PARTICIPATION

Local populations, particularly those that live in rural areas and suffer the negative impacts of wildfires most directly, have begun promoting campaigns of sensitivity against them.

Communal activities in fire management include the formation of local, volunteer firefighter brigades. Bolivia offers the model of registering and monitoring information on slash-and-burn authorizations at the municipal level. In Brazil, the Amazon Working Group has a network of more than 300 organizations. In 1998 it conducted a large-scale programme of field courses, with the goal of encouraging farm community leaders to form wildfire brigades in their own communities. The government is also preparing local brigades through PREVFOGO to prevent and fight wildfires in the conservation units.

In Chile, every fire season, local communities create their own firebreaks in high risk interface areas, making use of the national network programmes against fire (Sanhueza, 2003). In Ecuador, remarkable success was obtained in a project to train and equip volunteer firefighter brigades in all forestry districts of the country from 1985 to 1996 (Galindo, 2005).

In many countries, the private sector is contributing to strengthening firefighting groups. In Chile, the private forest industry is a good example of this participation, as well as in Argentina, where an increasing number of private consortia exist. Owners of small forest plantations in Ecuador have established local volunteer fire brigades during the dry season. In Argentina and Bolivia, local communities are involved in safety activities in interface areas to protect homes and in some forestry and protection clubs to protect fauna and flora.

NEEDS AND LIMITATIONS

After assessing the different aspects of wildfire management issues in the member countries of the South American region, the following needs and limitations have been identified:

- In most countries, the wildfire issue is not a high priority in policy agendas.
- Most countries in the region are not able to provide the necessary funds to establish wildfire protection programmes.
- Laws, regulations and rules on wildfires and agricultural burning should be created or reviewed and modified.
- A low level of integration of the different actors, mainly related to fire prevention tasks, results in inefficiency and increased costs.
- There is a lack of highly qualified human resources to set the requirements at different decision-making levels of fire management, as well as of a national system for capacity-building and accreditation.
- Although the topic of wildfires has been incorporated into school programmes and training curricula in some countries, the handling of the topic is varied, both within and among countries.
- Fire terminology must be defined and used more consistently.
- There is a need to create and maintain a common, high-quality database, which allows a quantitative determination of forest types and other ecosystems affected by forest and land-use fires, and to determine the causes of inefficiency in fire management, as well as the economic losses due to fire.
- A common early warning system for the whole region is lacking, one that

aims to achieve harmonization of the different scales used to rank wildfire risk values.
- Appropriate equipment and tools for firefighters are necessary, both for their personal security and their work efficiency.
- Several administrations take the position that planes represent the answer to combating wildfires in tropical forests. However, the effects of aerial attacks are very limited in many forest types of the region, owing to clouds and the thick foliage.

ANALYSIS AND RECOMMENDATIONS

- Common objectives, projects and programmes should be developed at both national and regional levels. This would strengthen the integration of various actors in fire management at the national level and contribute to the definition of regional positions. It would allow implementation of regional strategies for wildfires, help develop policies for the coherent, shared use of resources, and improve access to international financing.
- Coordination should be strengthened among the different actors and institutions within countries in order to improve the use of resources and raise efficiency and effectiveness in fire management.
- Greater participation of the various stakeholders in decision-making should be facilitated, assigning responsibilities for the reduction and restoration of areas affected by fires, sharing budgets and giving access to information sources.
- In order to improve prevention of fires, it is recommended that the topic be incorporated at all levels of education, exploring new forms of publicity and taking traditional knowledge into consideration.
- Since agricultural burning in South American countries can degrade forest resources rapidly, it is recommended that prescribed burning techniques be taught to farmers.
- Countries with limited capacity for fire management, such as Bolivia, Ecuador, Paraguay, Peru and Uruguay, could improve their institutions through collaboration among themselves and with countries such as Argentina, Brazil, Chile and Colombia, and could adapt some of the policies and programmes that have given good results.
- The collection, storage and analysis of data on vegetation fires should be improved at national and regional levels.
- Training and specialization of firefighter crews and training in the use of ground equipment must be emphasized before undertaking aerial suppression programmes. Programmes for professional instructors should be established and experiences exchanged, both within and outside the region.
- Links for international cooperation within the Andean-Amazonian region must be improved.

9. Central Asia

This regional summary covers the countries of geographical Central Asia (Armenia, Azerbaijan, Belarus, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan), as well as those parts of the Russian Federation not covered in the regional working papers on the Baltic region and Northeast Asia (Karelia and the Russian Far East). It also covers the neighbouring states of Afghanistan, the Islamic Republic of Iran, Iraq, Mongolia and the northern territories of China, although no information was in fact obtained for Afghanistan, the Islamic Republic of Iran and Iraq (details are provided in FAO Fire Management Working Paper FM/16/E).

Extent and types of fires

In most countries of the region, the data collected by agencies on the ground or by aerial monitoring do not reflect the full extent of vegetation fires. Forestry agencies or aerial forest protection services may collect data only for protected forests and other protected vegetation under their jurisdiction. In none of the countries are data for grassland, steppe or peat fires entering the databases, even if figures on such fires are recorded by other services, e.g. civil protection or fire services. Unfortunately, these different databases are not merged or published jointly.

There are extremely large discrepancies between the burned forest areas reported by ground or aerial observations in FRA 2005 and the satellite-derived data from GBA2000, which included all burned areas (Table 7). The differences were particularly marked in the case of the Russian Federation and were confirmed by data from an independent remote sensing institution of the Russian Academy of Sciences, the Sukachev Institute of Forest, Krasnoyarsk.

On the other hand, new capabilities in remote sensing have generated datasets of fire information based on various space-borne sensors such as the Advanced Very High Resolution Radiometer (AVHRR) of the US National Oceanic & Atmospheric Administration (NOAA), Moderate Resolution Imaging Spectroradiometer (MODIS), Medium Resolution Imaging Spectrometer (MERIS), Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) and SPOT-Vegetation instruments. These datasets include all vegetation types affected by fire, but satellite-derived data cannot be compared directly with the conventionally collected data of forest services unless validated or embedded in a fire information system that includes GIS layers with ecosystem sensitivity and potential fire behaviour and effects.

The Central Asian region constitutes the largest area in the world with a high contamination by radionuclides and it is located in a fire-prone forest environment. A total of 6 million hectares of forest lands were polluted by radionuclides as a result of the failure of the Chernobyl nuclear power plant in 1986. The most polluted forest

TABLE 7
2005 forest fire data derived from FRA 2005 and satellite-derived information from GBA2000

Country	FRA 2005 Total forest areaaffected by fire *(ha)*	GBA2000 Total area affected by fire *(ha)*
Azerbaijan		53 100
Kazakhstan	180 000	8 162 200
Kyrgyzstan		106 700
Tajikistan	4 000	44 900
Turkmenistan		23 300
Uzbekistan		50 600
China	51 000	6 238 800
Mongolia	418 000	2 655 600
Russian Federation	1 268 000	22 380 000
Georgia		18 100
Armenia		7 900
Belarus	6 000	43 500
Ukraine	4 000	2 193 800
Islamic Republic of Iran	6 000	104 200
Iraq		6 500
Afghanistan		
Pakistan	41 000	44 900

area covers over 2 million hectares in Belarus, in the Kiev region of the Ukraine and in the Bryansk region of the Russian Federation. Every year hundreds of wildfires occur in these contaminated forests, peatlands and former agricultural sites. From 1993 to 2001, a total of 770 fires in the closed zone of the Ukraine affected 2 482 ha, while in 2002 a total area of 98 000 ha of wildland burned. In the period 1993–2000, 186 wildfires occurred in the closed zone of Belarus and affected an area of 3 136 ha, including 1 458 ha of forest.

There is a similar situation in Kazakhstan, where more than 450 nuclear tests, including some 100 atmospheric tests, were conducted from 1949 to 1989 at the Semipalatinsk Nuclear Weapons Test Site. Radioactive contamination is highest in eastern Kazakhstan, including the fire-prone pine-strip forests along the Irtysh River on the border with the Russian Federation. Since 2004, the World Bank has financed the Kazakhstan Forest Protection and Reforestation Project, in which radioactive contamination and fire management are key project issues.

CAUSES

As in most regions of the world, the current fire regimes in Central Asian ecosystems are primarily determined by people. On the other hand, successful suppression of lightning-caused fires in some territories – such as the former Soviet Union, where a complete fire protection policy was practiced for many decades – may have resulted in changes in ecosystem properties. Fuel accumulation and the changed species composition and structure of fire-protected stands may have increased the risk of

more intense fires. In addition, extreme droughts in Central Asia have aggravated the risk of extremely large and severe wildfire episodes.

The country report from Russia for FRA 2005 stated that up to 72 percent of forest fires over the past ten years were caused by people, about 7 percent result from agricultural burning, 7 percent from lightning and 14 percent from other causes. However, in some regions – especially the northern areas of European Russia, Siberia and the Far East, where population is sparse and forest fires are not suppressed – the share of lightning-caused fires was considerably higher (up to 50–70 percent).

The amount of lightning ignition in Kazakhstan is comparatively high, owing to the continental climate and the regular occurrence of thunderstorms during the fire season (April–September). A recent analysis of fire data revealed that, in some years, up to 60 percent of the fires were caused by lightning. Recently, however, an increase in human-caused forest fires was recorded (about 50 percent), often associated with illegal activities.

In Mongolia, one of the most sparsely populated countries in the world, it is difficult to obtain accurate information on causes. During the main fire seasons (spring and late fall), there are almost no lightning fires. The recent increase in the number of fires was related to the opening of markets once highly controlled or restricted. The vast majority of fires were not deliberately set to clear land, but were more a reflection of negligence.

According to the fire reports submitted by China to GFMC, more than 98 percent of forest fires there were caused by people. In Pakistan and the Islamic Republic of Iran, most fires were caused by arson and were primarily pasture fires. Some were caused by land mines triggered by cattle and by artillery fire – a side effect of the smuggling of opium and oil through the Islamic Republic of Iran and of refugee activity.

EFFECTS

Information on the damage caused by fire comes mainly from the Russian Federation and Mongolia. The consequences of large, intense fires in Central Asia and its adjoining regions are quite diverse, depending on the specific site conditions and regional climate. The Far East of Russia is an example of fire regimes having changed dramatically over the last decades.

According to information provided by the Russia/USAID Forest Resources and Technology (FOREST) Project, the economic losses from wildfires in Sakhalin from 1998 to 2004 exceeded US$833 million. In Belarus, in 2004, a damage assessment based on long-term statistics concluded that average annual direct vegetation fire damage amounted to US$700 000, while indirect (ecological) wildfire damage amounted to about US$340 000.

A report on the situation in Mongolia in 2005 summarized the damage over the last five years (2000–2004), particularly in the autumn and spring seasons. A total of 853 wildfires affected 5.1 million hectares of forest and 9 million hectares of steppe vegetation. Environmental damage in the country amounted to the equivalent of US$8.5 million and damage to infrastructure to the equivalent of US$150 000. The cost of fire suppression amounted to the equivalent of US$600 000.

A major source of extended smoke pollution in the Russian Federation comes from fires burning in drained or desiccated peatlands.

Measurements of carbon monoxide (CO) from ground-based stations in the Arctic and Europe by Yurganov *et al.* (2004) revealed increased CO concentrations in the summer and autumn of 2002 and 2003 in comparison with the previous two years. The study concludes that the wildfires occurring in Northern Asia are most likely responsible for the hemispheric CO build-up.

PREVENTION

Since most vegetation fires in the Russian Federation and adjoining Central Asian countries are human-caused, the prevention of forest fires is considered a priority. But a recent publication pointed out that the Russian Federation has deficits in public education, as well as insufficient law enforcement. Thus public education and awareness-building are now considered among the primary tasks. Activities include public lectures and reports, articles in the local, regional and national press, and mass distribution of public relations materials.

In Kazakhstan, fire prevention measures consist of awareness campaigns to educate the population on ways to handle fire in a forest and on simple methods of extinguishing a fire. Technical and silvicultural measures for the prevention of fires are implemented by forest enterprises and the mechanized subdivisions of the aviation groups. These measures include the creation of forest edges composed of less flammable and fire-resistant species, firebreaks and fuel breaks, and mineralized strips and removal of debris along roads.

In China, construction of firebreaks by mechanical means, the use of herbicides and prescribed burning are priorities. The total length of firebreaks in China is 490 000 km, and the total length of green-belt fuelbreaks is 172 100 km. In the Far East and Baikal regions of the Russian Federation, prescribed burning of the grass layer has been used extensively in the spring to reduce highly flammable surface fuels.

In Belarus, Kazakhstan and the Russian Federation, aerial patrolling is implemented on a regular basis for detection of forest fires and for reconnaissance/monitoring of ongoing ones.

In CIS countries, fire danger rating systems have traditionally been used to provide early warning of the potential for serious wildfires. FDRS use basic daily weather data to calculate wildfire potential. This early warning information is often enhanced by satellite data, which detect fires early on, and spectral data on land cover and fuel conditions. In Russia, the daily fire danger index is used to determine the preparedness of the fire management organization, including the number of daily patrol flights.

SUPPRESSION

In most CIS countries, the reduction of the financial resources of government agencies as a consequence of the transition to national economies has substantially weakened fire management capabilities. The organizations responsible for fire suppression face severe financial and logistics constraints, resulting in reduced availability of modern

equipment and flight hours to detect and monitor fires quickly and to respond efficiently by aerial and ground means. The number of firefighters employed has also decreased sharply. Despite technological developments in fire management, forestry enterprises of some CIS countries are not provided with adequate technical and financial means for fire management. In the Russian Federation, many forestry enterprises (*leskhozes*) have outdated and generally inadequate equipment for fire suppression, and do not have sufficient financial resources for silvicultural and technical fire prevention measures.

In Belarus and China, unique types of fire suppression equipment are used. Chinese firefighters employ air-jet extinguishers for fighting surface and grass fires (92 000 units are in use), as well as fire-extinguishing bombs. In Belarus, motorized sand blowers are used for fighting wildfires in the forest belt on sandy soils.

In the remote regions of Mongolia, firefighters typically use traditional tools and means of transport. The 2002 fire report of Mongolia revealed that wildfires were fought by 11 464 people using 2 737 horses, among other forms of transportation.

INSTITUTIONS, RESPONSIBILITIES AND ROLES

Despite the transition from centrally planned to market-based economies by most Central Asian countries and the attempt in some countries to decentralize the formerly strong and highly centralized system of forest management, the responsibility for forest fire management is still mainly centralized and predominantly under the forest services.

In the Russian Federation, responsibility for fire suppression is under the overall auspices of the Federal Forestry Agency. Repeated discussions have been held regarding a transfer of overall forest fire suppression responsibility to the Ministry of Emergency Situations. The Aerial Forest Protection Service, Avialesookhrana, is the main institution for forest fire suppression over a total protected area of 690 million hectares, including 12.9 million hectares of reserved forests.

In Kazakhstan, forest protection, including fire protection, remains under the control of the State Forestry Committee at the national level, and of provincial administrations for forest reserves and nature parks under provincial jurisdiction. The Aerial Forest Protection Service is under the State Forestry Committee.

In Mongolia, the National Disaster Management Agency and its subordinate bodies at provincial and local levels are responsible for forest fire suppression.

COLLABORATION

The international dialogue between most countries in the region has a long tradition. With the establishment of the FAO/UNECE/ILO Team of Specialists on Forest Fire in 1981, now operating under the auspices of the UNECE Timber Committee and the FAO European Forestry Commission, a platform for exchange and dialogue in forest fire management was created in the UNECE region. The most recent developments brought the team and their home countries into the new regional wildland fire networks that joined, became recognized or were established under the UN-ISDR.

A number of bilateral agreements in forest fire management are in place between China and Mongolia, China and Russia, the Islamic Republic of Iran and Russia, Russia and Finland, and Russia and Mongolia.

A number of regional conferences and consultations held since 2000 have brought some countries of the region together. One important activity was a meeting of the prime ministers of the six member countries of SCO: China, Kazakhstan, Kyrgyzstan, Russia, Tajikistan and Uzbekistan. The first SCO summit, held in September 2001, concluded that member countries needed to work together in a variety of fields, including forest fire prevention.

Numerous scientific initiatives have been undertaken in recent years to clarify the role and importance of natural and anthropogenic fires in forests and other vegetation. The main research issues addressed in Central Asia/Eurasia included:

- recent changes in fire regimes due to anthropogenic and climatic influences;
- carbon pools and carbon fluxes affected by changing fire regimes;
- improvement of monitoring tools;
- the role of fire on permafrost ecosystems.

Several interdisciplinary research campaigns were initiated from 1993 to 2000 (Goldammer, Sukhinin and Csiszar, 2004). The most recent initiatives include establishment of the Northern Eurasian Regional Information Network, the Siberian/Far Eastern Regional Network, the Western Russian/Fennoscandian Regional Network of GOFC-GOLD, the Siberia II project and the Northern Eurasian Earth Science Partnership Initiative (NEESPI). The Siberia II project contributed to improving assessment of emissions of radioactive trace gases from fires in the Russian Federation. NEESPI is an active, strategically evolving programme of internationally supported earth systems science research. It focuses on issues in northern Eurasia regarding regional and global scientific and decision-making communities. By establishing a large-scale, multidisciplinary programme of funded research, NEESPI aims to develop an enhanced understanding of the interactions between the ecosystem, the atmosphere and human dynamics in northern Eurasia. It is expected that forest-fire research will continue to play an increasing role in the overall NEESPI programme.

COMMUNITY PARTICIPATION

In the Russian Federation, increasing attention to fire prevention indicates the overall involvement of the general public in reducing human-caused wildfires. In Kazakhstan, Civil Defence, Department of Home Affairs, Emergency Office and the Rayon Home Affairs Department stipulate the participation of human resources and equipment for fire management not only from enterprises and agencies, but also from family farms adjacent to forests.

In Pakistan, a community-based forest firefighting system is being established with the assistance of the United Nations Development Programme (UNDP), which is providing firefighting training and equipment to communities living in the forest.

From 1997 to 2000, the Integrated Fire Management Project – supported by Germany – was operational in Mongolia in the Khan Khentii Strictly Protected Area

and its buffer zones. However, the project did not leave any institutional structures that could be regarded as substantial or sustainable.

NEEDS AND LIMITATIONS

The main limitations to fire management in the region are institutional weaknesses and economic constraints (which, in some countries, are a consequence of economic transition) and a lack of awareness, adequate policies and commitment and involvement by civil society.

These limitations translate into the following needs:

- institution-building, especially improved capacities of government institutions, research entities, businesses and NGOs with regard to the planning and implementation of sustainable development programmes;
- improved technological capacity, including the provision of modern fire-extinguishing equipment, use of satellite information and information technologies;
- improved public awareness and increased sense of responsibility of civil society in issues related to fires;
- training and educational programmes;
- a clear legal and institutional basis for forest protection;
- increased and continuing funds for fire management;
- implementation of international cooperation, including compliance with Agenda 21 of the United Nations Conference on Environment and Development (UNCED) and the conventions related to fire issues in Central Asia – notably the CBD, UNCCD, UNFCCC and Ramsar Convention on Endangered Species;
- links to and interaction with the Europe and North Asia Forest Law Enforcement and Governance process, related to the increase in intentionally set fires in conjunction with illegal logging or to obtain salvage logging permits.

ANALYSIS AND RECOMMENDATIONS

Over the past decade, many countries of Central Asia have witnessed a growing number and size of wildfires in forest and non-forest ecosystems, usually caused by people, but also by lightning in sparsely populated areas. These fires have caused considerable ecological and economic damage and some have had transnational impacts, for example through smoke pollution, loss of biodiversity or forest degradation at the landscape level. The depletion of terrestrial carbon by fires burning under extreme conditions in some vegetation types, especially in temperate, hemiboreal and boreal peatlands, is an important factor in disturbance of the global carbon cycle. The increasing vulnerability of human populations living in or around forest environments has been noted throughout the region. Projected trends in the impact of climate change on vegetation cover and fire regimes, as well as observed demographic and socio-economic trends, suggest that fire may continue to play a major role in the destruction of vegetation cover in Central Asia, resulting in the

accelerated formation of steppe conditions, among other effects. Based on this analysis, the following recommendations are made.

Given the significance of Eurasia/Central Asia's boreal forest in the functioning of the Earth's climate, and the continuing and predicted loss of forest cover and terrestrial carbon storage potential, the increasing destruction of these forests should be addressed vigorously at national and international levels.

Forest and fire management are the responsibility and in the interests of all countries. However, currently and for the near future, some countries of Central Asia do not seem to be in a position to ensure sustainable forest fire management practices. Weak institutional capacities in fire management and law enforcement are limiting the ability to halt forest destruction by illegal logging and/or wildfires and these must be addressed.

The international community has a vital interest in preserving the multifunctional role of forests and other vegetation – including wetlands – through efficient fire management in Central Asia. International conventions, other international negotiations and recent international ministerial meetings have confirmed the interest of the international community in cooperating in sustainable forest management, which includes fire management.

Such international cooperation and targeted projects and programmes must rely on accurate and meaningful fire data and information in assessing the current fire situation and trends. Fire statistics from individual countries are often incomplete and are not comparable owing to different methodologies and lack of coverage. Satellite remote sensing is not yet used systematically to assess the extent and impact of fire, and there is no agreed system in place for economic and environmental fire damage assessment.

International cooperation will be important in developing internationally or regionally accepted standards and protocols, and in sharing knowledge, expertise and resources in joint projects and programmes in fire management. Most fire-prone forests and other vegetation in Central Asia are located in countries in which Russian is the official or prevailing language. Thus investments in training materials, guidelines, terminologies, etc. could be easily shared.

The Regional Central Asia Wildland Fire Network, together with its neighbouring networks (the Baltic area and Northeast Asia) may offer a suitable vehicle for developing cooperative efforts and synergies. The recommendations of governments represented at the regional forest congress, Forest Policy: Problems and Solutions, held in Bishkek, Kyrgyzstan, in November 2004, revealed a positive atmosphere for enhancing cooperative efforts in the region.

Existing joint activities in fire management research should be continued and strengthened.

10. Northeast Asia

The Northeast Asian region, covered by the UN-ISDR Regional Northeast Asia Wildland Fire Network, includes China, the Democratic People's Republic of Korea, Japan, the Republic of Korea and the Far East area of the Russian Federation. This part of the world is highly diverse in socio-economic, environmental management systems and their trends, and each country faces different driving forces of development, as well as different, but always major, challenges (details are provided in FAO Fire Management Working Paper FM/6/E).

In considering the Russian Federation, it should be appreciated that while much is typical of Northeast Asia, other, western parts of Russia are more typical of Europe. The Russian Far East has closer economic and trade connections with Northeast Asian countries than with most western parts of Russia.

EXTENT AND TYPES OF FIRES

A comparison of national statistics for the Northeast Asian countries shows an average of about 1 million hectares of forests burned each year during the period 1990–2004. The occurrence of forest fires varies with climate variability and the accumulation of combustible materials between years. However, the trend in areas affected by vegetation fires and estimates of the damage show an increase in recent decades.

The average annual number of forest fires in Japan is about 3 000, of which about 150 were larger than 1 ha. During the last 20 years, the largest area affected by forest fires was about 1 000 ha.

The average annual number of forest fires in China during 1990–2004 was 5 337, covering an average of 135 050 ha. The latest peak of fires was in 2004 with 13 401 fires, covering 345 585 ha of forests.

In Russia in recent years, with the advent of international satellite coverage and in collaboration with Russian fire scientists, more realistic burned-area estimates have been made than in the past. For example, during the 2002 fire season, satellite imagery revealed that about 12 million hectares of forest and non-forest land (wildland) had been affected by fire in Russia, while official sources reported only 1.2 million hectares of forest land and 500 000 ha of non-forest land burned in the protected areas of 690 million hectares (Goldammer, Sukhinin and Csiszar, 2003). During the early summer of 2003, remote sensing data indicated that the total area affected by fire in Russia exceeded 22 million hectares (GFMC, 2003). Based on recent remote sensing data, it appears that the annual burned area in Russia can vary from 2 to 15 million hectares per year. In addition, agricultural prescribed burning (e.g. pasture management) in Russia is estimated to affect 30 million hectares annually. Estimates for the Far East are about 1 million hectares per year.

There are two reasons for the official under-recording: insufficient monitoring of fires in the extensive territories of northern Russia, Siberia and the Far East, and an attempt by local authorities to hide their inefficiency in combating fires. This inefficiency is often not technical, however, but rather related to lack of funds.

CAUSES

In Northeast Asian states, human activities in the forest are expanding because of demographic and socio-economic changes in the developing countries of the region, and for mainly cultural/aesthetic reasons in the developed ones. The origins of fires are invariably linked with human activities such as commerce (wood production), cultural-aesthetic spheres (hunting with a camera, tourism, etc.) and arson. Fires are intensified by current non-burn policies in fire-adapted ecologies, and are caused by accidental burning; land conversion (agriculture, pasture lands, industry and construction, forestry practice and plantations); harvesters of non-wood products; cattle herders; tourists; road and rail workers; traditional uses of fire such as hunting; and infrastructure development.

Vegetation fires overwhelmingly originate from human actions: 95 percent in China, 71 percent in the 1990s in Japan, and 79 percent in the Republic of Korea. The present harsh economic realities force the North Korean population to clear forests in order to collect wood for heating and cooking. According to government statistics in Russia, the share of human-caused forest fires in the Far East during the last two decades was 60–80 percent (84 percent in 2004).

EFFECTS

Uncontrolled vegetation fires were the principal causes of deforestation and forest degradation in the Northeast Asia region (Shu Lifu *et al.*, 2004). There have also been estimates that timber losses in the region, due to forest fires alone, are on the order of US$0.5–1 billion per year.

The temperate and boreal forests of the Northeast Asia region may account for more than 2 percent of both global biomass burning and carbon emissions. Furthermore, there is growing concern that fires on permafrost sites in the region will lead to the degradation or disappearance of forests on these sites, due to the long restoration process. Increased numbers of fires in the boreal forests of Russia are a major threat to the global carbon budget.

The scale of the negative impact of fire on nature and society during the last decades (environmental damage, economic losses, resources spent on fire suppression) seems to be increasing. The impact on human health is also estimated to be growing. The outbreak of large-scale forest fires in October 2004 in two areas of the Russian Far East caused atmospheric pollution, felt also in neighbouring countries.

During the period 1959–1998, China's losses in firefighting were about 100 human lives and 500 injured. Significant human losses were also recorded in 1998 and 2003 in neighbouring Russia. In the Republic of Korea, huge property losses of US$83 million were recorded in April 2000, with associated severe effects on forests.

It is doubtful that existing methods of data collection provide a true picture of the economic losses to society caused by vegetation fires. There is great variation in the estimation of annual regional forest fire damage. For example, the Russian methodology of post-fire assessment is not able to give a detailed figure. During the spring, summer and autumn of 1998, fires ravaged 2.2 million hectares of forests in the Russian Far East. At the time the damage was estimated at US$200 million. However, a recalculation of lost resources using world market prices amounts to US$4.2 billion and provides a more accurate picture (Kondrashov, 1999).

PREVENTION

Northeast Asian countries employ a wide range of preventive and fire awareness measures. Advanced fire management systems, including the use of remote sensing for detecting and monitoring fires, are in place in China, Japan, the Republic of Korea and Russia. The Republic of Korea is introducing a new ground-based system equipped with automatic cameras for detecting forest fires, capable of covering 93 percent of total forest area (6.4 million hectares). No other country in the region has a similar system.

The creation of green fire belts and mineralized strips of soil in China and Russia, air patrolling, fire watchtowers, satellite monitoring and radio communication are all common fire prevention methods in the countries of the region, except in the Democratic People's Republic of Korea (Shu Lifu, 1998; Telitsyn, 1988; Ostroshenko, 2000).

In Japan, the Republic of Korea, the forest region of Daxinganling (China) and the Khabarovsk Territory (Russia), a lightning detection and monitoring system has been established to identify and locate fires ignited by lightning.

In Northeast Asian countries, fire is used for clearing land to plant crops, develop pastures or establish forest plantations. It is appreciated that fire, when properly prescribed and skilfully managed, can be less destructive to site quality than mechanical clearing methods, since soil disturbance is minimized and there is no soil compaction by heavy equipment. Prescribed fires are used to prevent forest fires of high intensity and to improve conditions for the growth of forest trees.

Most countries in the region have adopted a policy of fire prevention through awareness-raising programmes and training for local populations.

SUPPRESSION

Fire suppression practice is advancing in the region, despite often insufficient financing and technical support. There are few differences in the fire suppression techniques of the Northeast Asian countries, but management systems and the level of equipment use are quite varied. For example, in Japan, which is a densely populated country where it is possible to reach forest sites in a relatively short time, fires are eliminated by the urban fire and rescue services, but in the Republic of Korea, firefighters use helicopters to reach fire spots in any part of the country within half an hour.

Russia is currently changing its policy of total suppression of all forest fires, taking into account experience from other parts of the world. The application of a new forest

fire management policy has been delayed due to ongoing changes in state forestry management, earlier problems with adoption of the new forest code, uncertainty regarding the allocation of authority, shortage of financing, and technical problems.

INSTITUTIONS, RESPONSIBILITIES AND ROLES

Forest protection is generally an important component of the national policy of all countries, providing ecological sustainability and preserving 'green' potential. But in the Northeast Asian region, legislation and the ability to implement it differ from country to country.

Major achievements have been made in several countries of the region with regard to their institutional framework. In China, Japan, the Republic of Korea and Russia, national and local versions of Agenda 21 have been formulated, directly relating to their national forests. In addition, environmental plans or strategies have been developed, such as Japan's Basic Environment Plan, the Republic of Korea's Green Vision 21, the Democratic People's Republic of Korea's National Strategy for Conservation and Sustainable Use of Natural Resources, and Russia's Concept on Forestry Development.

Progress has been achieved in virtually all areas of environmental protection in all countries, but expenses have increased and thus the extent of progress differs. Recent initiatives, such as the creation of the Presidential Commission on Sustainable Development in the Republic of Korea, which involves people from the business sector, academia and NGOs, seem to provide the potential for an effective multistakeholder voice in policy implementation.

China's Forest Action Plan for its Agenda 21 of 1995 laid the foundation for a comprehensive range of sustainably managed forest ecosystems together with a fully developed forest industry by 2010. In Japan, the nationwide Forest Plan (1996) was developed, together with policy directions and guidelines for forest management. The 4th Forest Development Plan of the Republic of Korea (1998) created the basis for sustainable forest management by improving forest resources, fostering competitive industries and maintaining a healthy forest environment.

Russia has well-defined laws on forest protection, but law enforcement is quite weak. There were not many supporters of the recently prepared forest code, which will radically change the property and management system in Russian forestry and is now set to begin implementation from January 2007. The Russian Far East is a part of the all-Russia forest fire management system, with two lead departments: the Federal Forestry Agency and the Aerial Forest Protection Service. Both departments have subdivisions in the various regions of the country. The Ministry of Emergency Situations becomes involved in extreme circumstances.

The importance of forestry research and education is widely recognized through Northeast Asia as a prerequisite for effective management of natural resources. Research, education and information systems vary across the region, depending mainly on the availability of funding, other resources and facilities. But, without exception, countries invest less in forestry research than in related sectors such as agriculture.

Understanding the need for partnerships in managing forest-fire events, the countries in the region have ratified, accessed to or accepted most multilateral environmental agreements and conventions adopted prior to or after the 1992 UNCED. Despite this, there is still no international forest fire cooperation programme in the region.

Further, the control of fires is a national issue that must be addressed in a coordinated manner on the basis of the resources and expertise of individual nations. Technical assistance may have a key role to play here, together with the development of partnerships. There are fewer federal (central) resources available and many issues have been devolved to local governments, NGOs and partners. New models for partnership, cooperation and, in some cases, trilateral agreements by the private sector, NGOs and national and local governments may be expected in the near future.

COLLABORATION

Unacceptable losses of resources and transboundary pollution have had a positive impact on collaboration between nations, especially between neighbouring countries such as China and Russia. A number of Northeast Asian countries have participated actively in the international dialogue on forests. This includes discussions in the Intergovernmental Panel on Forests, the Intergovernmental Forum on Forests, and subsequently in the United Nations Forum on Forests. A number of countries from the region have sponsored or hosted initiatives and meetings, directly contributing to this international dialogue.

A variety of other regional forestry agreements, institutions and ad hoc meetings promote international cooperation on forestry within the region. FAO, the International Network for Bamboo and Rattan (INBAR), the International Plant Genetic Resources Institute (IPGRI), ITTO, IUCN, UNDP, the World Bank and the World Wide Fund for Nature (WWF), among others, have a range of forestry programmes or involvement in forestry.

A wide variety of forestry-related NGOs also operate in the region, implementing bilateral and multilateral development projects, and they play important roles in facilitating dialogue and exchange. Japan is one of the main donor countries, both in the region and on a global scale, contributing substantially to forestry projects in the Asia and the Pacific region, while the Global Environment Facility is supporting Forest Fire Management in Biologically Valuable Forests of the Amur-Sikhote-Aline Ecoregion. This Russian Far East project involves all components of civil society in its implementation.

In 2004 the Regional Northeast Asia Wildland Fire Network was established under the UN-ISDR GWFN. This regional network is coordinated by the Korean Forest Research Institute and facilitated by the Pacific Forest Forum. It is currently providing a platform for fire information dissemination and exchange, which could, through increased cooperation, lead to effective work on fire management.

COMMUNITY PARTICIPATION

The region is undergoing a positive change with regard to society's perception of the problem of fires. However, people are still not fully aware of the consequences of forest fires.

The countries of the region have recognized the immense pressures on forests in densely populated areas, and also that authoritarian styles of centralized forest management are neither appropriate nor effective in meeting the broader forest management objectives of today. Forest departments have increasingly found their management objectives unattainable, or seriously compromised, unless they empower communities and stakeholders to participate in decision-making.

Many villages in China and some other countries have developed community regulations and agreements and have successfully strengthened forest fire management at the local level. But this is not widespread, nor has technology transfer gone far. The main measures for managing fires are to raise public awareness through publicity and educational activities, legislate for fire management, build firefighting teams, develop an enabling framework for society's involvement in fire prevention and reinforce the development of infrastructure and fire preparedness in key danger zones.

Local people may have extensive knowledge on fire management that is well adapted to the local environment and thus may be in a position to manage or prevent fires without outside assistance. However, in the case of very large fires, communities often cannot manage the situation because of inadequate training, experience and professional expertise.

In the Russian Far East, USAID established the Forest Resources and Technology (FOREST) Project, devoted to forest fire prevention through changing people's behaviour in the forest. The project has been working in Khabarovsk, Krasnoyarsk and Primorski territories and Sakhalin and Irkutsk regions. It introduced an integrated approach to forest fire prevention awareness activities among local citizens. The approach involved three interdependent components: development of educational campaigns and general awareness for targeted groups; development of the Fire Prevention Awareness Program for Preschool and School Age Children; and strengthening of foresters' skills in communication/community participation.

Although changes in people's behaviour and attitudes usually take place gradually over decades, checks showed that, in one year, about 90 percent of the people had become familiar with and remembered some elements of the campaigns and 18 percent declared that they had changed at least one aspect of their behaviour in the forest. As the FOREST Project shows, regular fire prevention awareness activities among citizens cannot be implemented without laws, stable finance and established institutions. Moreover, financing systems and institutional structures must also be in place (Kuzmichev, Kolomytsev and Chekurdaev, 2004).

NEEDS AND LIMITATIONS

Major constraints on forest fire management face Northeast Asian countries:

- limited institutional and technological capacities;
- organizational and financial problems in implementing international cooperation;
- the challenge of full implementation of Agenda 21 measures and actions at national and regional levels;
- lack of public awareness of fire issues;

- lack of technical cooperation, training capacity, educational programmes and the ability to combine the efforts of all components of civil society;
- absence of a clear legal, institutional and financial base, including new measures for taxation;
- absence of measures to increase the responsibility of civil society for the condition of forests;
- the need to enhance the capacity of government institutions, research entities, business and NGOs with regard to planning and implementation of sustainable development programmes;
- the need to develop institutional mechanisms that integrate both the developed and developing countries in the region;
- shortage of modern fire control equipment, insufficient use of satellite data and information technologies.

ANALYSIS AND RECOMMENDATIONS

Comparing the periods 1988–1992 and 1998–2004, an increase can be observed in: scale and frequency of forest fires, area burned, economic damage (albeit with great differences among countries), costs of fire suppression, efforts to regroup forces and attract voluntary firefighters, and awareness among the general public and national/local politicians of the necessity for fire management.

In summary, the goals of sustainable forest fire management are most likely to be achieved through:

- adopting enabling approaches, forming partnerships and activating participatory mechanisms;
- building capacity of partners;
- monitoring and evaluating progress, and learning from each other's successful practices through networking and the use of modern information technologies;
- developing international cooperation to facilitate active participation at all levels of government and by all relevant partners in decision-making, policy formulation, implementation, evaluation and resource allocation.

Vegetation fires and their negative impact continue to be a major issue in Northeast Asia: fires cause deforestation and influence the quality of life, land, air and water. Unacceptable resource losses and the spread of transboundary pollutants need immediate attention by the nations of the region and their international partners.

Integrated programmes and strategies must be developed to address the wildfire problem at its roots, while at the same time creating an enabling environment in which appropriate tools are developed to enable policy-makers to deal with wildfire proactively. The traditional approach of dealing with fires exclusively through fire exclusion schemes must be replaced by an intersectoral and interdisciplinary approach.

Fire management experts from Northeast Asia have a good picture of how to improve methods and incorporate modern technologies of forest fire prevention and suppression. There is also a clear perception of the need to take into account

post-fire ecological consequences and their role in global processes. Fire impact on forest ecosystems is now perceived as many-sided, useful as well as harmful, and a necessary element in fire management. Large forest fires are still the main threat, since they have been increasing proportionally over the last 30–40 years.

However, there is still no regional database on forest fires. Due to different approaches, information is not always compatible among countries. Efforts are underway to further such compatibility, but political will and government support are needed to realize this concept.

Institutional capacities are among the weakest points in forest fire management in the region and need to be improved.

Emergency preparedness and response programmes must be coupled with better land-use policies and practices. Fire prevention should become a priority in the forest protection system, while the application of prescribed fires and preventive controlled burnings as a measure of fuel management should be increased.

The quality of training for fire risk assessment (fire danger index) must be improved, and there is a need to unify approaches to regional zoning according to forest fire risk.

Advanced technologies for forecast and detection of fires should be introduced, and other information technologies as well. There is a need for development and provision of free access to a global early-warning system for fire occurrence and fire risk. The establishment of fire management networks can be a very effective tool to support local communities in fire preparedness.

The interrelationship of fires with climate change and the global carbon cycle, the expected long-term socio-economic consequences and the change in forest resources should be studied.

International cooperation in suppressing forest fires should include not only information exchange, but also the transfer of fire suppression resources such as airplanes, ground forces and equipment from country to country. The main problems facing the use of aerial means are the operational and maintenance costs, but comparing suppression costs with the possible ecological and economic damage, a balanced solution must be found.

There is a need to improve capabilities in local, national, regional and global early warning and risk assessment and in the detection, monitoring and regular assessment of fires.

11. South Asia

This region includes Bhutan, India, Nepal and Sri Lanka. It stretches from the mountain forests of the Himalayas in the north, to tropical evergreen forests in south India and Sri Lanka. The range of landforms and climates in South Asia has resulted in a high diversity of ecosystems and forest types, and consequently diverse fire regimes and vulnerabilities (details are provided in FAO Fire Management Working Paper FM/14/E).

EXTENT AND TYPES OF FIRES

The latest and only data on forest fires in South Asia that are compatible with other regions are provided by the FRA 2005 country profiles (FAO, 2005d). In 1990 the average area in South Asia affected annually by fire was 1.43 million hectares, excluding the Kingdom of Bhutan, where no data were reported before 1992. In 2000 the approximate annual fire-affected area was 4.11 million hectares, of which 90 percent was in India. However, no information is available on fires in other wooded lands.

Moist deciduous forest is the most vulnerable to fire in India. Nearly 15 percent of this ecosystem is frequently disturbed by fire and 60 percent is occasionally affected. Nine percent of the wet/semi-evergreen forests burn frequently and an additional 40 percent burn occasionally. In the northeastern region of India, recurrent fires annually affect up to 50 percent of the forests.

The coniferous forests in the Himalayan region, notably *Pinus roxburghii* stands, are also very fire prone. Many wildfires occur during the winter drought. The 2005/06 winter was a typical example: numerous fires burned in the high-altitude forests and shrublands of Bhutan, Nepal and Sikkim (India). In neighbouring Tibet, a major wildfire burned for almost two weeks at the foot of Mount Qomolangma (Mount Everest) and destroyed valuable bushland in the county of Tingri.

CAUSES

In all countries in the region, fire is used by the rural population as a common tool to clear agricultural land. It is also used to facilitate the gathering of NWFPs and in hunting and herding. Uncontrolled fires are common in regions with a long, intense dry season. All of these fires have the potential to cause major damage.

Over 90 percent of fires are due to human causes. There are very few cases of fires ignited by lightning.

Bhutan's climate conditions during winter (freezing temperatures, lack of rainfall and high wind velocities) strongly favour fires. Moreover, at the end of the dry winter season the fields are prepared, and these fires often escape and cause damage.

In Nepal, analysis revealed that 58 percent of the fires were deliberate, followed by those caused by negligence (22 percent) and accident (20 percent). With human

populations moving into WUIs, an increasing number of fires were human-induced, caused, for example, by discarded cigarette butts and by the collectors of NWFPs and fuelwood. Fires were started deliberately by livestock owners, shepherds and herders, who ignited grasslands to promote a new flush of growth for their animals. These fires often spread to forests – and this was a key threat in the Terai area.

India gave an example of a case study area (the Nilgiri Biosphere Reserve in Coimbatore) in which successful fire management had been practised for a long time, but where it suddenly started to fail (Srivastava, 1999a). The reasons were a reduction in the means and funds for fire prevention and control, continuous encroachment by herders and NWFP collectors, and a decreasing sense of responsibility for fire control among local people.

EFFECTS

The consequences of uncontrolled fires in South Asia are serious degradation of forests, ecological changes and deterioration of social and economic conditions.

According to reports from the region, the main environmental damages to forests included destruction of biodiversity, extinction of plants and animals, soil degradation with erosion and loss of fertility, loss of wildlife habitats and depletion of wildlife, degradation of watersheds and halting or slowing of natural regeneration.

Microclimates were affected, with changes in soil moisture balance and increased evaporation. Important carbon sinks were lost or degraded, leading to an increase of carbon in the atmosphere. Smoke haze polluted the atmosphere and endangered people's health (Srivastava and Singh, 2003).

Economic and social losses due to fire included losses of valuable timber resources, NWFPs, fuel wood and fodder. Loss of employment was seen, as well as destruction of property and loss of lives.

According to the FRA 2005 country profile of India, 3.7 million hectares of forest were affected annually by fire, creating damage of US$107 million equivalent (Bahuguna and Singh, 2002). In Bhutan from 1981–1985, 232 fires were reported, affecting an area of 29 516 ha and causing damage of US$19.2 million equivalent (Chhetri, 1994).

In Nepal the average annual loss of saw logs and fuelwood in Bara district in 2004, at market price, was some US$370 000 (Kafle and Sharma, 2005).

Sri Lanka lost 26 ha due to forest fires in 2000 (FAO, 2005d). In the years from 1994–1998, 641 fires were reported, burning an area of 1 648 ha and causing estimated damage of US$75 000 equivalent.

ECONOMIC AND SOCIAL BENEFITS

In Nepal firewood collectors evidently prefer *dola daura* (round fuelwood of saplings killed by fire and dried) to freshly cut wood because it burns slowly and produces higher heat yield.

Farmers welcome the first post-monsoon flash floods from burned forest to their lands because they carry organic matter, available phosphorus, potash and nitrogen.

Fires boost the formation of fresh, palatable shoots as cattle fodder. The collection of minor NWFPs, such as seeds of sal (*Shorea robusta*), *niguro* (edible ferns), mushroom and *kurilo* (*Asparagus racemosus*), is facilitated by fire because they are more easily seen, and the forest is more accessible.

PREVENTION AND SUPPRESSION

Among the South Asian countries, only India and Sri Lanka have information on forest fire prevention. Bhutan and Nepal seem to have no preventive methods at all, due to lack of capacity, including human resources.

Preventive measures in India and Sri Lanka consist mainly of traditional practices such as fire lines and tracks, prescribed burning and hiring fire spotters during the fire season. Villagers in the vicinity of forest areas often have permission to gather dead wood free of charge in order to reduce the fuel load. They are also expected, even if not legally required, to assist the forest authorities in fire suppression.

In Sri Lanka forest management plans do not include activities to prevent forest fires. They consist mainly of training programmes for local officers and villagers in firefighting, and few projects have been launched to develop community involvement.

The Indian Ministry provides financial assistance to state governments within the Modern Forest Fire Control Methods plan. Financial support is used to buy hand tools, fire-resistant clothing, firefighting tools and radios, build fire watchtowers and pay spotters. The funds are also applied to the creation of fire lines, as well as for research, training and awareness-raising. This plan has been implemented in more than 70 percent of the forested area.

The Joint Forest Management (JFM) Programme, a UNDP project (1985–1990) and a project in Western Ghats in 1994 served to raise awareness among communities and increase their participation in fire prevention and forest conservation. The programmes were quite successful: fire outbreaks decreased by up to 90 percent in some regions (Srivastava, 1999a).

INSTITUTIONS, RESPONSIBILITIES AND ROLES

In most South Asian countries, the destruction caused by forest fires is well known and acknowledged by governmental authorities. Most politicians are aware of the necessity to practice fire prevention and to have a functioning fire control system. But this awareness and acceptance are often forgotten as soon as the monsoon season starts. Nevertheless, most countries have a forest law, which contains at least a clause prohibiting the setting of fire under certain conditions. This is often the only legal provision for fire control and prevention and its enforcement is often difficult.

The Social Forestry Division of the Bhutan Government recently took the first steps to prevent and fight fires through awareness campaigns and building capacity for prevention and control.

Activities of the Nepalese Government towards fire prevention are confined to television and radio broadcasts, since the Nepalese Department of Fire has neither the capacity nor the capability to prevent forest fires. However, the involvement of

volunteer firefighters is increasing and is promoted by the Firefighters volunteer Association of Nepal (www.fan.org.np/).

In Sri Lanka the Forest Department is in charge of all forest fire prevention and suppression activities, which are carried out by provincial district officers. Government support is provided through programmes promoting community involvement, for which fire management plans have been created. A new forest policy was introduced in 1995, but was not implemented until 1999.

In 1988 India had a quite visionary National Forest Policy, which focused on the protection of forests against fire and called for improved and modern management practices to deal with forest fires. The Ministry of Environment and Forests developed a National Master Plan for Forest Fire Control, which introduced a fire management plan focusing on education, research and development.

The Indian Government also set up guidelines for national forest fire prevention and control. The main features are: identification of vulnerable areas on maps, creation of a data bank on forest fires, fire danger and forecasting systems, provision for a crisis management group, involvement of JFM committees and efficient enforcement of legal provisions.

In the future, India intends to create a National Institute of Forest Fire Management, equipped with the latest firefighting technology using satellites. It will carry out research, training and technology transfer on a long-term basis to obtain sound information in order to improve fire management planning in forests.

In South Asia the local people and the administrative authorities are aware of the damage caused by forest fires, but the environmental and socio-economic consequences of these fires are usually underestimated. The governmental environmental/forest institutions of all countries play a key role in any activity related to forest fires. The local forest authorities are responsible for suppression, as well as for detection. Responsibilities are only shared in areas where local people are actively participating in fire management programmes, such as in India, or where the forest is community property and managed by the community, as in Nepal (Kunwar and Khaling, 2005; Sharma, 2005).

In general, there seems to be a lack of feeling of responsibility on both sides – government and local populations. Tackling the difficult issue of fire is postponed by national parliaments as soon as the season changes and the danger recedes. Since law enforcement is rarely practised, nobody feels guilty and therefore nobody feels responsible.

COLLABORATION

Most international cooperation is implemented through organizations such as the Center for International Forestry Research (CIFOR), FAO, ITTO, IUCN, UNDP, UNEP, the World Bank and WWF. Some regional institutions and programmes support collaboration and assist in the dialogue between partners, for example the Asian Development Bank, South Asian Association for Regional Cooperation, South Asia Co-operative Environment Programme and FAO's Asia-Pacific Forestry Commission.

Organizations that have launched programmes explicitly concerning forest fires are few. The Asia Forest Partnership is addressing the problem of forest fires and in the future is planning to assign some projects to forest fire prevention. Furthermore, the Asia-Pacific Regional Workshop on Scientific Dimensions of Forest Fires, held in India in 2000 and initiated by the Committee for Science and Technology in Developing Countries, was organized to discuss how science and technology can be used to improve fire prevention, management and mitigation.

Specific cooperation agreements among the South Asian countries pertaining to forest fire management, as proposed by Sharma (2005) and the GWFN, is not yet in place.[9]

COMMUNITY PARTICIPATION

Community involvement in forest fire management in South Asia is receiving increasing attention.

In India community involvement is actively promoted through the creation of JFM committees, which have been founded throughout an area of over 10 million hectares. They are now an essential component of the Modern Forest Fire Control Plan and have been given responsibility to protect forests from fire.

As a result, forest fires were reduced significantly. Moreover, the forestry authorities accepted the control plan willingly and dialogue with the villagers improved, with the result that people were much more willing to cooperate in fire prevention and control.

Other attempts of the Indian Government to apply a fire management system have been more negative, since they replaced traditional, community-based fire management systems, for example in the Mizoram region. The governmental management systems deprive people of responsibilities and tasks, so they no longer feel in charge of fire prevention (Darlong, 2002).

In Nepal there is increasing interest in community involvement and participatory approaches (CBFiM) (Kunwar and Khaling, 2005; Sharma, 2005).

In Sri Lanka community involvement in forest fire management has been voluntary, but few programmes have been developed to attract villagers' interest. A new management plan was created containing a "participatory management working circle". The government intends to launch another participatory forestry management programme to enhance fire prevention and communication between communities and the forest authority.

NEEDS AND LIMITATIONS

Most countries of the South Asian region lack a national focus and the technical resources required to sustain a systematic forest fire management programme. Facing such a situation, it is clear that the needs and limitations are considerable.

[9] In September 2006 representatives of the fire research community in India and Nepal agreed to begin establishment of the UN-ISDR Regional South Asia Wildland Fire Network by early 2007.

They include:

- establishment of a fire division within the Forestry Departments, which would be in charge of all fire issues;
- provision of a legal and financial base for fire management;
- enforcement of existing or revised laws;
- absence of a specific forest fire management plan, or of fire management provisions within the forest management plan;
- launching of forest fire management programmes;
- introduction of community-based fire management;
- improvement of the present limited institutional and technological capacities;
- capacity-building within the forestry department as well as among local populations;
- provision of basic tools and materials for fire prevention and fighting;
- education of the population, including awareness-raising campaigns;
- lack of cooperation among South Asian countries, especially for knowledge and data exchanges;
- improvement of cooperation with international organizations, NGOs, etc.

Additional research is needed on fire outbreaks, suppression and fire ecology for better forest fire management. Modern technologies, such as remote sensing and satellite imagery, should be used for fire detection. India has already undertaken some initiatives in the use of these technologies (Srivastava, 1999a).

ANALYSIS AND RECOMMENDATIONS

Many of the South Asian countries have a long way to go to achieve sound forest fire management, as in the case of Bhutan, Nepal and Sri Lanka. India, on the other hand, seems to be realizing some improvements.

The destruction caused by forest fires is recognized to a limited extent by the people and by decision-makers in all countries, and some knowledge exists on how to address the problem of fires. The question is how countries decide to tackle these issues and what support and incentives may be available from outside.

The following recommendations aim to establish a sound, basic forest fire management system:

- In most South Asian countries, governments should first be more aware of and committed to fire prevention and fire suppression. As long as governments refuse to take into account the negative effects of fires, it is very unlikely that changes will be accomplished.
- The definition of responsibilities and the creation of internal structures in charge of fire-related matters within Forestry Departments are still lacking in several South Asian countries. These bodies should be responsible for, *inter alia*, developing fire management concepts, building up capacities at all levels and initiating awareness-raising campaigns.
- A legal framework is essential to fire prevention and control, since it can remove incentives that encourage people to start harmful fires.

- Development of fire management plans and programmes is an important parallel step.
- Awareness-raising and the creation of a sense of responsibility among rural people can be pursued by campaigns using the media, meetings and the enrolment of villagers in forestry programmes.
- Community-based approaches should be given priority in forest fire management by empowering local people and institutions and engaging them actively in management issues, including giving them user rights.
- Fire management capacities should be built at local and national levels.
- Basic tools must be provided for preventing and combating fires.
- National science bodies should be involved in data collection on forest fires and in collaboration with forest departments to support fire prevention, suppression, and mitigation.
- Stronger collaboration among South Asian countries is advisable for the purpose of information exchange.
- Cooperation with international organizations and NGOs should be intensified.

Once the basic needs for a working fire management system are met, other technologies, such as remote sensing and satellite imageries for fire detection, should be introduced to improve the efficiency of fire management.

12. Southeast Asia

The regional paper for Southeast Asia reviewed the countries of insular and continental Southeast Asia – members of ASEAN. Through the ASEAN Agreement on Transboundary Haze Pollution, member states are forming a network that will serve as the UN-ISDR Regional South East Asia Wildland Fire Network (details are given in FAO Fire Management Working Paper FM/10/E).

EXTENT AND TYPES OF FIRE

There has been almost no data on fire occurrence for the region since 1997/98. Thailand offered the only source of fire-related data for this study, including fire numbers and extent. Data for the post 1997/98 period were difficult to obtain, other than the limited data reported for FRA 2005 for six countries, or extracted from publications, such as Ganz (2003). Most available statistics dealt only with area burned and frequently there were no data at all relating to numbers of fires or causes.

In the past two decades, severe fire events in the region have been notable for the level of intraregional and global concern, but between these occurrences, there was little data collated to enable monitoring or evaluation at national or regional levels. Despite the level of inputs, including donor projects, almost no data were routinely collected and thus there were no time series against which routine performance and progress might be measured, other than the series of spikes at irregular intervals at the upper end of the spectrum.

CAUSES

Past analysis of the underlying causes of wildfires – by groups such as Project Firefight South East Asia (Ganz, 2003) and CIFOR (Murdiyaso and Lebel, 2006) – is still relevant and valid. Some reasons for fire use included:

- land-use change/conflict;
- increasing land-use pressure;
- inconsistent land-tenure policies;
- perverse economic incentives;
- direct economic incentives.

The most direct reason for fire use in the region was the search for subsistence and income, i.e. using fire as part of an agricultural cycle for either food or plantation crops.

The Integrated Forest Fire Management (IFFM) Project of the German Agency for Technical Cooperation (GTZ) drew together the elements of fire management and coherently structured them into a tropical fire management framework. IFFM included a clear basis for the underpinning information required (e.g. cause, impact,

behavior) to create an understanding of fire at management levels and to define the linkage between understanding the causes of fire and achieving effective fire prevention (Shields, 2004). Prevention campaigns were often aimed at sections of the community that did not cause a significant number of fires, e.g. school-aged children, while those that use and cause the most fires, the farming and plantation management communities, were ignored.

EFFECTS

Forest and other land fires in 1997/98 caused significant ecological and human impacts that focused world attention on the underlying nature of fire problems and their causes within the region. International attention had been directed to this region following severe drought and fire in 1982/83, 1991 and 1994. As might be expected, with the increasing ability to remotely monitor fire occurrence and extent, albeit very coarsely, the 1997/98 episode drew far more global attention than prior events, and future events will attract at least similar levels of scrutiny, driven heavily by neighbours that cause little fire but are impacted by the outputs from it.

Since 2000, there has been no new reported country-level information on specific social, economic and environmental impacts. Smoke haze episodes generated by wildfires and land-use fires have occurred repeatedly, such as in August 2000 and August 2005.

The fires in peat soils were burning in deep strata and thus it was not possible to suppress them by conventional techniques. Numerous slash-and-burn agricultural or land-clearing fires burned out of control as well, because of very dry weather conditions.

PREVENTION

The use of satellites for detection of active fires peaked following the 1997/98 fires, following recognition of the technology's limitations. 'Hotspot' identification using NOAA's AVHRR is increasingly recognized as offering no practical value for strategic and tactical suppression purposes. The use of fire location maps generated by AVHRR is limited owing to coarse resolution, cloudiness, time delays in information relay to field sites, and accuracy. Given the general development status of fire management capabilities and systems in Southeast Asia, the application of spaceborne information other than for monitoring purposes is difficult to justify at this stage.

The availability of fire-related weather information has improved in the period 2000–2004. The ASEAN Specialized Meteorological Center and the Southeast Asian Fire Danger Rating System now provide relevant fire danger and meteorological information via their websites. These tools are valuable to the fire manager, although difficulty in accessing and interpreting the information remains in some rural and semi-rural locations.

Viet Nam is operating a National Fire Danger Rating system. Fire-related weather data are collected in the field, analysed centrally and distributed as a fire danger warning across the country. The fire danger rating is made available in rural areas via various media, including facsimile, radio and roadside signboards.

An ASEAN zero-burning policy was ratified in 1999. It is apparent that the prohibition on burning is proving ineffective in reducing fire in the region. It is now more widely recognized that fire has a deeper role in society and in livelihood creation than a policy can prohibit. Some potential modification of this policy is now beginning to affect national fire considerations, including recently developed guidelines for prescribed burning aimed at small landholders, farmers and shifting cultivators.

SUPPRESSION

Fire suppression resources are available but are insufficient in most countries. Thailand, for example, has a nationally organized fire suppression capability, but it recognized in 2000 that it could offer coverage of only 20–30 percent of forested lands. No other national coverage estimates are presently available. Indonesia has begun a programme to develop fire brigades with trained and equipped staff in localities considered highly fire-prone.

The equipment and resources available in the region comprise a range of locally developed and imported technologies. Fire suppression field crews, equipped with standardized levels of manual and mechanized equipment, are being developed. Crew sizes vary from 3 to 15 people and have designated leaders and specialists capable of operating and repairing firefighting equipment. These suppression crews are the backbone of firefighting operations, and their continued development and increasing numbers across the region will mark significant changes in fire suppression in the future, provided they are supported by effective management systems.

Vehicles fitted with water tanks and pumps of varying capacities continue to be used. Their utility is limited by road access. Heavy equipment (bulldozers and excavators) is utilized more widely by plantation owners, particularly in peat soil fires.

The use of aircraft for fire suppression is just beginning in the region. One of the most successful aircraft uses in recent times is of light and medium helicopters for remote and rapid access to fires, with self-contained and well-equipped field crews, and for their support. Fixed-wing aircraft have not yet been widely engaged for rapid fire detection or work such as infrared scanning.

COMMUNITY PARTICIPATION

Significant evolution in understanding of CBFiM has taken place in the region since 2000. The first international workshop on this topic took place in 2001 in Bangkok, Thailand, and was jointly managed by the Regional Community Forestry Training Centre for Asia and the Pacific (RECOFTC) and Project FireFight South East Asia (operated by WWF and IUCN). The workshop was followed by an international conference in Balikpapan, Indonesia. Concurrently, several higher order reports and collations of case studies on CBFiM have been published, placing CBFiM firmly in a field of study and understanding that is now increasingly appreciated as a more socially adaptive and capable management method. For further information, see the regional paper.

Continued attention to CBFiM as a practical and suitable form of fire management in the region will increasingly enhance the overall fire management outcomes.

COLLABORATION

A significant policy development over the period 2000–2004 was the ASEAN Agreement on Transboundary Haze Pollution, which was signed by all ASEAN member countries in June 2002 and entered into force on 25 November 2003. This was the culmination of concerted and intensive regional efforts over several years to address transboundary haze pollution since the 1994 and 1997/98 severe haze episodes. The agreement is the first legally binding ASEAN regional environmental accord, although not all ASEAN member countries have yet ratified it, and until this occurs, questions about its potential effectiveness will remain.

NEEDS AND LIMITATIONS

First, while international action and input are seen as necessary to assist the region in guiding fire management along a path that will achieve a level of self-sufficiency, the ultimate goal is to achieve a state in which effective and practicable fire management can be sustained within the region, indeed within individual countries, without significant external input. In essence, the solution is for individual countries to develop their own or collective fire management solutions matched to their specific cultural, physical and financial constraints, rather than adopting fire management solutions developed for different circumstances. To achieve this, however, the region needs support and assistance from the wider global fire management community.

Second, there is apparently an increasing willingness for governments to cooperate on regional action on fire management issues. This willingness needs to be harnessed through the development of appropriate fire management capabilities at national, provincial and local levels.

Third, the routine collection and collation of fire information at local, provincial and national levels is essential to sound fire management decisions, policies and plans. Each country needs to direct efforts towards the collection of fire-related data such as the number of fires, area burned, vegetation types within which they occurred and, if possible, measures of impact. This will assist in identifying fire management needs and suitable programmes of management appropriately targeted and scaled to the circumstances.

Fourth, fire in the region is an annual event, not something that occurs without warning or understanding. The management of fire is a balance between livelihood creation and health and environmental concerns. The adverse livelihood, economic, health and environment impacts are all appreciated. For example, the heightened international awareness and pressure that result from haze events must be directed into longer-term management efforts, not simply immediate suppression and restoration. The majority of fire management efforts must be directed to long-term prevention.

ANALYSIS AND RECOMMENDATIONS

The management and impact of fire within the Southeast Asian region is a matter that requires a combined multinational and regional approach. The ASEAN Agreement on Transboundary Haze Pollution was one of the events of greatest significance in the region. Although this agreement has been accepted in principle and serves as a model for other regions to follow, not all member countries have yet ratified it or given it their full endorsement. Until all member countries have ratified the agreement, it will not become legally binding and its effectiveness will remain open to question. The August 2005 fires, although brief in nature, could serve as a trigger to ensure that this agreement is fully adopted and implemented.

CBFiM has emerged as a new and increasingly adaptive mechanism for working with and managing fire. The region has embraced the early development of CBFiM through donor projects, international workshops and the hosting of international conferences. The future of CBFiM and the benefits it can bring to communities will only be ensured if regional and international efforts for its development continue.

Although the underlying motivations for the use of fire are increasingly understood, whenever adverse fire weather conditions persist, it is almost a foregone conclusion that a severe air pollution/haze event will ensue, induced by fire-associated smoke. The lack of baseline annual fire data will continue to hamper well-structured fire management efforts in the region.

Without identifying action to sever the linkages between fire causes and fire prevention actions, and more particularly, to identify who sets fires and why, the effective targeting of sound fire management practices, particularly fire prevention, will remain a difficult task.

There is a strong need for fundamental analyses of fire situations on an ongoing basis – and not only when disaster strikes. If it is to be effective, fire management must be a daily, weekly and monthly programme of systematic management in any region of the globe. The attention to and effort in fire management in this region must achieve such time regimes if it is to have any effect in the long term.

Fire is an inescapable part of the environment in this region. As is the case elsewhere on the globe, a box of matches remains the simplest and least expensive tool available to fire users. Put simply, fire will remain a crucial part of the ASEAN environment for the foreseeable future.

13. Australasia

The regional paper for Australasia covered Australia and New Zealand (details are provided in FAO Fire Management Working Paper FM/13/E).

EXTENT AND TYPES OF FIRE

In the period from 2000 to 2005, the 2003 fire season in Australia was one of the most dramatic since European settlement in terms of its impact on people and homes, although the most extensive area was burned in 2001 (Table 8). Very large areas of southeastern Australia experienced fires under severe weather conditions, following a long and harsh drought. The damage to assets and the nature of the fire season led to a number of inquiries and reviews of fire management for Australian states and the nation as a whole.

In northern Australia, tropical savannah and grasslands are 'easy' to burn. Many living on the land, and relying on it for their livelihood, do not fear fire – they use it. In southern Australia, where settlement is denser, the landscape is highly fragmented and there are high-value fire-vulnerable assets. In addition, coastal communities are overwhelmingly urbanized and the majority of civil society and those that influence it see fire as 'bad'.

The area subject to yearly fires has declined significantly since European settlement, due to changed land-use patterns, fire suppression and the cessation of burning by aboriginal populations. These changes are leading to altered forest structures, emerging forest health problems such as dieback, and an increase in landscape-scale, high-intensity fires. Prescribed burning in southeastern Australia has been under pressure from public opinion, and the area undergoing such burning has been shrinking.

In New Zealand the average number of fires per season and the average area burned per fire, while indicative rather than definitive, suggest that the fire management

TABLE 8
Approximate fire-affected areas across Australia 1997–2003

Calendar year	Area *(million ha)*	% of total land area fire affected	% of fire-affected area consisting of tropical savannah
1997	48.3	6.3	86
1998	26.3	3.4	92
1999	60.0	7.8	86
2000	71.5	9.3	65
2001	80.1	10.4	84
2002	63.8	8.3	63
2003	31.6	4.1	85

Source: Western Australian Department of Land Information, cited in Ellis, Kanowski and Whelan, 2004.

system is working well. An average fire size of 2.4 ha is small for an annual average of 2 669 fires. While small fires can be significant in losses for plantations or natural ecosystems, particularly small-scale or localized habitats, the figures reflect effective arrangements for preventing, preparing for and responding to fires.

CAUSES

In addition to lightning, people cause the overwhelming number of fires in Australia. Human-caused ignitions are generally unintentional, although there has been an increase in arson. This recent increase is not reflected in the number of people convicted of offences following the 2002/03 fire season, where, out of a national total of over 10 000 fires identified as deliberately lit or as potentially arson, there were 43 convictions.

In New Zealand, also, fires are mainly caused by people. Lightning fires occur, but represent a very small percentage of ignitions.

EFFECTS

In Australia, generally, all fires are assumed by the public and the media to be bad. Research, experience and history generally demonstrate that this is not the case, but, except in the north, this overriding impression is widely held. As a result, questions are not asked about which fires, or parts of fires, were detrimental and which were beneficial.

There is generally very little information available on the economic impact of unwanted fires. Historically, the recording of losses has been limited nor are the details of the type of loss considered. Possible types of loss might include: reduced productivity, impact on tourism, infrastructure damage, loss of sales and loss of employment.

It is possible to extract indications of firefighting costs from annual reports and other sources. These are not necessarily clear or simple to calculate. In the recent past, the strong impression has been of increasing budgets for fire agencies and perhaps decreasing budgets for the management of land, including fire prevention.

There have been no assessments of ecological or environmental impacts. This information is essential to explain changes in land management practice and to support the evolution of policy, a need emphasized by persistent media descriptions of large and damaging fires as “environmental disasters”.

Development controls require the assessment of significant environmental impacts, for which there are sophisticated and highly regulated schemes and systems. Major wildfire events, on the other hand, attract no such assessment or evaluation of their environmental impact or the chances for recovery. Consequently, there is no information to support or prioritize efforts for restoration of landscapes and ecosystems, despite the availability of the skills and technical capacity to undertake restoration.

As in many countries, the costs of combating fires and the value of losses are not comprehensively measured in New Zealand.

PREVENTION

The three elements of prevention are prevention of ignition, of the movement of fires across landscapes and of damage. The measures and management needed to address these elements are most easily applied to preventing ignition and damage. Ignition-reduction strategies are quite well developed in Australia and are evolving as civil society evolves. The places where people choose to live are changing, shifting the rural/urban interface into natural areas, including protected areas and rural lands. At this interface, education about fire and systems to reduce fire damage (engineering and managing human behaviour) are applied in all Australian states.

The prevention of fires moving across the landscape involves managing or reducing fuels, and there have been increasing efforts in this area as well.

The difference between the tropical and non-tropical areas of Australia highlights the variation across the nation with respect to fire. In tropical areas, there is no real fire prevention focus at all. The emphasis is more on education as to when the community should use fire, rather than on not using fire at all; the issue is timing, not prohibition. There are also differences in land use, in some cases historically based, which influence the role fire plays. Some landscapes have a strong prevention culture and there are no random fires. In other landscapes, rural landowners use fire in a very unstructured way, "throwing around matches" as they move across their properties.

SUPPRESSION

There is a high level of fire suppression taking place. The majority of fires are contained and controlled, with the uncontained 5 percent of fires responsible for 95 percent of the damage suffered. Fires are put out mainly by ground firefighting techniques, but the use of aerial firefighting resources is increasing.

Air support to fire suppression operations was significant during the 2002/03 fire season. States and territories incurred a total cost of over $A 110 million. On the busiest day, over 100 aircraft were used. Helicopters and fixed-wing aircraft have consistently gained extensive public exposure, especially through the media, but the costs of aircraft are considerable and weigh heavily in overall fire management costs.

The International Wildland Fire Summit was held following the 3rd International Wildland Fire Conference in Sydney, Australia, in October 2003. One of its outcomes was an international agreement for the exchange of fire management personnel among Australia, New Zealand and the United States that is a model for other international agreements on cooperation in fire management.

COMMUNITY PARTICIPATION

Fire management in Australia has largely shifted from the community to government agencies. There is little input expected from communities and few significant opportunities for them to have substantial involvement in decision-making. The volunteer bushfire movement, which does not strictly meet the accepted definition of CBFiM, is, however, still heavily relied on for fire suppression.

NEEDS AND LIMITATIONS

In vegetation-fire risk assessment in Australia – also called bushfire and wildfire – Handmer (2003) identified three categories of actors and stakeholders to consider:

1. *those that create the risk* – these are the formal planning and land development systems and the informal attitudes and actions of people at risk;
2. *those dealing with the results of the activities that create the risk* – the key groups are the fire and emergency services, insurers and groups that work with them, such as forest and land managers. In an informal way, the media and the behaviour of volunteers, individuals and groups are all part of dealing with the risk;
3. *those that create the future risk* – these are factors such as urban expansion, governance, changes in lifestyle or values, possibly emergency management trends and climate change. Except for the last, these influences arise both from institutions and from individual choices and behaviour.

One aspect that is clear from Handmer's discussion is that these three groups of actors and stakeholders operate separately from each other: "Those creating the risk historically have no direct interaction with those dealing with the results, the fires. Worse perhaps is the absence of any useful engagement with those creating the future risk – the risk that fire and emergency services, insurers and society, will be dealing with in the future." This may well be a characteristic that is experienced more widely even outside Australia in the future.

In New Zealand there may be another future change. There is a trend towards an increase in biomass and the quantity of available fuels. Native forest, tussock land, wetland and scrubland areas that had been converted to pasture are becoming uneconomical or non-viable. They are reverting to scrubland or being converted to plantations, which contribute to a dynamic export industry. There have also been attempts to stabilize and vegetate steep landscapes hosting introduced exotic animals, in particular deer.

Thus some parts of the New Zealand landscape are moving from less complex systems with low fuel loads to increasingly complex systems with higher loads. Fuels are also physically more continuous, meaning that fires have a greater chance to spread across the landscape once they start. Fires will become more difficult to control, may occur in more remote areas and are likely to be much larger in size when fire weather conditions are severe. Severe conditions in New Zealand may recur every 15 to 25 years. The expansion of the plantation estate also suggests that losses will be higher.

ANALYSIS AND RECOMMENDATIONS

In Australia, fire management has largely shifted away from the community to government agencies. The country needs to develop an agreed, consistent data-collection process on all aspects of fires. The lack of such data will hinder research, operational planning and evidence-based funding of bushfire response capability. The legal framework may also require review because of the declining use of prescribed fire (because of inadequate recognition of the role and benefits of deliberate fire

use), and failure to support individuals and agencies engaged in applying fire to landscapes.

In New Zealand, changes in the composition and complexity of the vegetation in rural areas, and the implications of these changes for fuel loads in particular, will require adjustments to the way fire management is practised. The National Rural Fire Authority has recognized this and has started to identify changing needs and altered circumstances.

The first important step in both Australia and New Zealand is the development of research projects: to support and enhance fire danger rating; increase the understanding of fuel characteristics and dynamics; predict fire behaviour; and create a decision-support tool or system to assist rural fire managers in their planning and decision-making. In parallel, the management of resources, people and information is evolving to meet the expected needs of fire prevention, suppression and incident management.

Australia has noted the historic absence of interaction and engagement between those creating the risk of fire and those dealing with the results. It is an increasing threat in Australia, and one that is likely to be experienced elsewhere in the future.

14. Southeast Europe/Caucasus

This region comprises the Balkans and includes Greece and Turkey, which are also part of the Mediterranean region (details are given in FAO Fire Management Working Paper FM/11/E).

EXTENT AND TYPES OF FIRES

The number of forest fires per year in the Balkan region varied greatly from 1988 to 2004. Over this period, the smallest number of forest fires was recorded in 1991 (2 765) and the largest in 2000 (16 922). With the exception of 2000, the trend in forest fire occurrence increased steadily.

Over this period, the total burned forest area was 1 250 892 ha, and the annual average area burned amounted to 156 361 ha.

The countries most threatened were Bulgaria, Croatia, Greece, The former Yugoslav Republic of Macedonia and Turkey.

CAUSES

The changing land uses and rural exodus in some parts of the region are resulting in increased wildfire hazards and vulnerability of ecosystems. Conversely, urban encroachment into wildlands means increased vulnerability of human populations to fire, particularly at WUIs. During the last 15 years, wars and economic and political disorders have had a significant role in forest fire occurrence, behaviour and suppression.

TABLE 9
Causes of forest fires in the Balkan region

Country	Causes (%)		
	Human	Natural	Unknown
Albania	63.7	0.8	35.5
Bulgaria	30.4	1.7	67.9
Croatia	75.3	0.8	23.9
Greece	55.5	3.0	41.5
Serbia and Montenegro (Serbia)[a]	66.0	3.0	31.0
Slovenia	45.9	8.3	45.8
The former Yugoslav Republic of Macedonia	72.5	2.0	25.5
Turkey	60.9	6.7	32.4
Average	58.8	3.3	37.9

Source:. Macedonia, 2005.

[a] Now Serbia, but the statistics for Serbia and Montenegro refer to the Serbian Republic of the commonwealth (State Union) before the independence of Montenegro in 2006.

On average, 58.8 percent of total forest fires have a human origin, 3.3 percent a natural one and 37.9 percent arise from unknown causes (Table 9). The human causes are often arson and negligence (including the negligence of tourists). Even those fires of 'unknown' origin are often caused by people.

EFFECTS

There are no international standards to define economic and ecological damages caused by fire, but according to available evidence, there is no significant social impact of forest fires in the region. The economic and environmental damages are much more important.

The environmental damages include soil erosion, which is observed in all countries with large burned areas. The mass outbreaks of bark beetles (*Ips* spp.) are a very significant problem in the pine forests of The former Yugoslav Republic of Macedonia. The effect of forest degradation on tourism in the region is significant, especially in Albania, Croatia, Greece, The former Yugoslav Republic of Macedonia and Turkey.

PREVENTION AND SUPPRESSION

Legal regulations regarding fire prevention exist in each country in the region. Other measures, such as awareness-raising and education, have also been used in most countries. Their quantity and quality depend on the economic situation and organizational potential of each country and they are usually carried out by the Ministries of Interior or Forestry, voluntary protection unions or some NGOs.

Human intervention is the most important means of extinguishing fires, given that the number of naturally extinguished forest fires is very low (no more than 3 percent) – usually when the cause of forest fire is lightning accompanied by rainfall. Regional exercises in the suppression of forest fires have been held in the interests of increased efficiency.

INSTITUTIONS, ROLES AND RESPONSIBILITIES, AND COMMUNITY PARTICIPATION

Institutional roles and responsibilities for wildfire management are different in each country in the region, but there are also similarities. In several countries, the forest services at federal or regional levels are responsible. In others, all fires are the responsibility of a fire department. Serious fires may require the assistance of other bodies through an interagency agreement.

Turkey reported that, since 1997, there have been substantial improvements in handling forest fires through the Fire Command Center, which is responsible for all fire management issues. A more comprehensive national database on forest fires is being created.

The Pact on Stability for South Europe developed an initiative to form the Regional Disaster Management Center in Croatia. It covers Albania, Bosnia and Herzegovina, Greece, Italy, Montenegro, Serbia, Slovenia and The former Yugoslav Republic of Macedonia. The aim of the centre, which is in the organizational phase,

is to facilitate cooperation in planning, preparation, prevention and reaction, and in reducing disaster consequences, including forest fire suppression in the area of southeastern Europe.

Turkey reported that local people are required by law to respond to a fire situation if and when requested. The positive response of local people and communities in combating fires has increased considerably in recent years – mostly as a result of public awareness campaigns and a change in attitudes towards forest resources.

Croatia has signed agreements on multilateral assistance with a number of countries. Bulgaria has received targeted support to improve forest fire management capabilities from Germany, Switzerland, the United States, FAO, UNDP and the World Bank. In 2006 a European Union Twinning Project is supporting the country in harmonizing legislative, reporting and preventive measures with European Union standards. GFMC has supported the Bulgarian-Swiss Forestry Programme in developing a national fire management strategy and the European Union in implementing the Twinning Project. The former Yugoslav Republic of Macedonia has international agreements with Bulgaria and Greece. Turkey reported that the Fire Command Center participates in interregional cooperation – firefighting assistance was provided to Georgia and Syria in 2005.

Universities have a role in fire ecology and management research in The former Yugoslav Republic of Macedonia and Turkey.

NEEDS AND LIMITATIONS

In April 2005, The former Yugoslav Republic of Macedonia hosted the International Technical and Scientific Consultation "Forest Fire Management in the Balkan Region" under the auspices of the Regional Balkan [now Southeast Europe/ Caucasus] Wildland Fire Network of GWFN (Macedonia, 2005; GFMC, 2005b). The following gaps in fire management were noted during the consultation:

- consistent information and statistics on fires, their causes and their effects;
- applied research in social sciences and humanities, including financing of research;
- integration of social, economic, environmental considerations and institutions in developing tangible policies and practices related to fire;
- integration of fire as a component of land, resource and forest management;
- community-based approaches to fire management;
- training in the appropriate use of fire (prescribed burning for fuel reduction and nature conservation);
- training in the safe and efficient use of resources for fire suppression (and appropriate equipment);
- compatible approaches, e.g. global implementation of the Incident Command System and the International Wildland Fire Agreements template.

The consultation was followed by the "Eastern European, Near East and Central Asian States Exercise on Wildland Fire Information and Resources Exchange – EASTEX FIRE 2004", a regional forest fire exercise organized by the host country, Bulgaria, the UN-ISDR regional network and GFMC. Fire and forest services from

Albania, Bosnia and Herzegovina, Bulgaria, Greece, Romania, Serbia and Montenegro, The former Yugoslav Republic of Macedonia and Turkey participated in the exercise (www.fire.uni-freiburg.de/GlobalNetworks/SEEurope/SEEurope_4.html).

ANALYSIS AND RECOMMENDATIONS

The consultation recommended the following plan of action to governments, international organizations and NGOs for cooperation on vegetation fire research and management in the Southeast European/Caucasus region:

- secure financing of a regional fire research programme;
- strengthen fire research cooperation between neighbouring countries;
- develop standardization of terminology and procedures;
- develop standardized data collection, including further development of global fire data collection;
- encourage increased involvement of the science community in fire-related, interdisciplinary research programmes;
- support the establishment of national or regional fire research centres;
- establish a regional fire weather network;
- approach the Erasmus/Sokrates programme of the European Union about developing a dedicated programme for fire information exchange.

It is evident that the majority of countries in the region are ready to establish and strengthen a regional dialogue on cooperation, exchange of information, research and fire management as a contribution to forest and environmental protection, stability and peace.

In May 2006, the Regional Southeast Europe/Caucasus (formerly Balkan) Wildland Fire Network presented a proposal for "Development of a Strategy for International Cooperation in Wildland Fire Management in Southeast Europe" to the 33rd Session of the FAO European Forestry Commission (Zvolen, Slovakia, 25 May 2006). The proposal aimed to enhance international cooperation in the region, including the development of standards and bilateral and multilateral agreements.

15. Baltic and adjacent countries

The working paper for this region covered Austria, Belgium, the Czech Republic, Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Luxembourg, the Netherlands, Poland, the Russian Federation (Karelia), Slovakia, Sweden, Switzerland and the United Kingdom (details are provided in FAO Fire Management Working Paper FM/7/E).

The Central European countries, the Alps and non-Mediterranean southeastern Europe belong to the temperate vegetation zone, where mesic and more fertile forests are generally dominated by broadleaved trees. The most fire-prone forest ecosystems in this area are often dominated by pine (predominantly *Pinus sylvestris* L.) in dry and dryish site types, primarily plantations.

The Nordic countries largely belong to the boreal and hemi-boreal vegetation zones. In this region, also, the most fire-prone ecosystems are pine-dominated forests (predominantly *P. sylvestris*) in dry and dryish site types. In the United Kingdom, especially in Scotland, the most fire-prone ecosystems are the heathlands, dominated by *Calluna vulgaris*.

Fires have always had social, economic and environmental effects that have generally been regarded as negative – especially in fire-prone ecosystems. But in Europe, especially in boreal ecosystems, fire has been reintroduced to forest ecosystems after a long period of no-burn policies. It is now used as a restoration and management tool for forest regeneration and biodiversity management.

EXTENT AND TYPES OF FIRES

In the southern part of the region, most fires occur in the spring, from February to April. Towards the north, where spring starts later, the highest fire frequency is in May and June. Another peak in the number of fires and area burned occurs in most countries in August.

In this region, the number of fires and the area burned annually vary mostly with the weather conditions. In general, the average size of a fire in the region is very small, often below 1 ha and not above 5 ha. Exceptions can be found in some countries, such as Poland, where a clear increase in the number of fires and area burned has been observed.

CAUSES

Arson is an important and increasing cause of forest fires; in Poland it is the reported cause in 44 percent of fires. The reason seems to be the high unemployment rate, which has led to fires being deliberately set to produce at least temporary jobs in firefighting and forestry. Arson has also been reported as a rather common cause of fires in Lithuania (16 percent) and Estonia (13 percent).

In both the southern part of the region and the Baltic countries, burning of grass in the context of agriculture is often carried out in the spring and is a common factor in the spread of fires. This seems to be a particular problem in many eastern countries of the region. The practice has ceased in Fennoscandia.

Changes in land tenure and ownership have led to omission of the necessary precautionary measures, especially in the Baltic countries, where a high number of new, small-scale forest owners have emerged. In addition, migration from the country and abandonment of rural lands have resulted in increased fuel loads and changes in vegetation composition and succession, leading to a higher fire hazard. Abandoned agricultural land has significantly increased in many countries of the region since the transition towards a market economy began. This has resulted in an enormous increase in the number of fires observed on such land. In Poland, for example, the number of fires increased from approximately 5 000 in 1994 to 53 000 in 2003. The extent of burned area in Poland has also increased – from about 13 000 ha in 1995 to 95 000 ha in 2003.

Regionally, large plantations of exotic species, particularly those of coniferous trees such as *Pinus contorta*, have led to an increased fire risk. Preventive actions to reduce fire risk, such as changing tree species composition from coniferous to deciduous species, are being carried out in some countries, for example Poland.

Uncontrolled fire use, especially in agriculture, and, infrequently, prescribed burning in forestry have been a cause of fires escaping into wildlands and occasionally into forests. But the use of fire for prescribed burning depends on the level of local public awareness and knowledge of the principles of fire ecology and management. In some countries, for example in Estonia, the attitude of the public and the national authorities is opposed to prescribed burning, This opposition, together with an effective fire suppression policy, has led to fuel accumulation, especially in conservation areas, and thus to an increased fire risk.

The use of prescribed fire in nature conservation and landscape management is increasing, including the use of fire in forestry and forest certification. The European Fire in Nature Conservation Network, an initiative of GFMC and the FAO/UNECE/ILO Team of Specialists on Forest Fire, reflects the broad variety of prescribed burning objectives and the increasing number of projects throughout the region (www.fire.uni-freiburg.de/programmes/natcon/natcon.htm).

EFFECTS

The economic costs of fire vary greatly within the region and among countries. However, the economic losses are generally quite low compared with other regions in which fires are more common and have more drastic consequences. Ecological damage is rare, but avalanches occasionally occur after fires, especially in the Alps. Health effects of fire are also rare, as the average size of fires in the region is small. However, the impact of smoke pollution from wildfires and land-use fires burning in neighbouring Russia has severely affected the Baltic region, notably in 2001 and 2006.[10]

[10] Results for 2002 are available at www.fire.unifreiburg.de/iffn/country/rus/IFFN%20Russia%202002%20Fire%20Report.pdf, and for 2006 at www.fire.uni-freiburg.de/media/2006/GFMC-Bulletin-01-2006.doc and www.fire.uni-freiburg.de/media/2006/05/news_20060518_uk.htm.

PREVENTION

Financial support for fire management varies within the region, and lack of resources causes difficulties in fire management, especially in the Baltic countries. Aerial control may not be available due to competing demands.

SUPPRESSION

Training in wildland and forest fire management and suppression and even in the use of prescribed burning is inadequate in most countries of the region, especially concerning the ability to respond to large and lengthy forest fires. Decision-support systems need further development for these situations, as well as for specialized training in fire management.

Bilateral and multilateral agreements on cooperation in fire management are also needed. The ICS, as an international standard for all incident management, should be introduced into interested countries.

INSTITUTIONS, RESPONSIBILITIES AND ROLES

Increasingly, fire management is no longer the responsibility of forestry staff, but of national fire and rescue services (F&RS). More often than not, these F&RS lack training in fire management and specifically in aspects of fire behaviour, including techniques in backfiring. Responsibilities shared between the authorities and organizations, as in Germany, can occasionally cause problems as well.

There appears to be no community involvement in fire management. Some regional bilateral and multilateral fire emergency exercises have been carried out, e.g. among Baltic countries, but more need to be arranged. Exchange visits and programmes should be promoted regionally. Specific attention should be paid to developing online information systems through Web sites.

During the last five-year period, fire research in the region has increased and northern countries have begun participating in European Union-funded fire research projects. Regional cooperation in the field of fire research has been initiated between the Baltic and Nordic countries. Finland, Germany, Poland and the United Kingdom are participating in the research programme Fire Paradox (www.fireparadox.org/). The emphasis is on the use of prescribed burning and fire suppression.

COLLABORATION

In May 2004, a Regional Baltic Wildland Fire Meeting was held in Helsinki, Finland, followed by a side meeting to promote Baltic cooperation in fire research.

At the meeting, trends in fire management in the Baltic region were studied and the *Helsinki Declaration on Cooperation in Wildland Fire Management in the Baltic Region* was issued. It included proposals to harmonize and strengthen efforts by UN-ISDR, WFAG and United Nations agencies and programmes to reduce the negative impacts of fires on the environment, but also to support and promote the knowledge and techniques to utilize the beneficial role of fire in ecosystem management, including the application of prescribed burning for the benefit of ecosystem stability and sustainability, with special emphasis on biodiversity.

The Helsinki Declaration aimed to promote international cooperation in fire management, strengthen multilateral and bilateral agreements for such cooperation and follow and support the recommendations made in a number of international fora (details can be found in the regional paper).

Those countries that are members of the European Union participate in the informal Forest Fire Expert Group, which meets twice a year. Most of the work on cooperation is based on Regulation (EC) No. 2152/2003, Forest Focus (http://europa.eu/scadplus/leg/en/lvb/l28125.htm), a European Community plan for harmonized, broadbased, long-term monitoring of European forest ecosystems. The plan focuses on protecting forests against air pollution and fire. To supplement the monitoring system, new instruments are to be developed for soil monitoring, carbon sequestration, biodiversity, climate change and protective functions of forests. The European Commission serves member states through the European Forest Fire Information System (EFFIS – http://effis.jrc.it/Home/), which provides information for the protection of forests against fire in Europe, addressing both pre-fire and post-fire conditions.

ANALYSIS AND RECOMMENDATIONS

Most countries in the region are not facing major problems with fires in forests and are able to establish and strengthen regional dialogue on cooperation in vegetation fire management. Preventive measures can clearly be improved, as in the case of grass burning in the spring. Financial restrictions, especially in the Baltic region, are one of the main problems.

Within the region, the following fields need to be strengthened:

- collection and standardization of data on fire occurrences;
- fire prevention measures, including improved public awareness;
- fire management, including training and fire research; and
- international cooperation.

Collection of fire statistics and reporting vary among the countries of the region, making comparisons over time and space difficult. There are clear differences in classification, for example of fire causes such as arson, which can lead to misleading conclusions. A common database on forest fires is required.

Fire management could be improved in many countries by preparing strategic fire-suppression plans at local and regional levels, while recognizing that the role of fire varies among the countries in the region. Increased public awareness of fire risks and benefits and a more careful attitude towards fire use should be promoted. Regional mobile, airborne fire-response units should be created.

Training for fire management, which is done mainly by the F&RS, is inadequate in most countries, especially regarding aspects of fire behaviour and the ability to respond to large, prolonged fires. Thus exchanges in training programmes and international training courses should be promoted. Decision-support systems need further development for situations involving large fires.

Current research projects are developing fuel-type maps covering the whole of Europe. This could help estimate fire risk in various European regions, in relation

to diverse vegetation types in diverse climatic conditions, and thus help develop fire management methods and prevention strategies. Further development is also needed in fire danger rating systems and in the fire weather index. Research at the European level in this region is continuing in the Fire Paradox programme.

Efforts towards international collaboration should build on the start made by the Baltic countries.

16. Mediterranean

The working paper for this region covered ten countries: Algeria, Cyprus, France, Greece, Israel, Italy, Morocco, Portugal, Spain and Turkey (details are provided in FAO Fire Management Working Paper FM/8/E). Greece and Turkey are also part of the South-East European/Caucasus region.

EXTENT AND TYPES OF FIRES

Fire is the main cause of forest destruction in the countries of the Mediterranean basin. About 50 000 fires sweep through 700 000 to 1 million hectares of Mediterranean forest, other wooded land and other land each year, causing enormous economic and ecological damage as well as loss of human life. For detailed information in addition to that of the working paper, see the annual regional European forest fire analyses published by EFFIS and the Joint Research Centre of the European Commission (http://effis.jrc.it/Home/).

Reflecting the prevailing climate, with its long summer droughts, Mediterranean forests are frequently characterized by fire climax species, i.e. those dependent on the presence of fire in the reproductive cycle. Pines form the largest forest stands on both the northern and the southern shores of the Mediterranean. These species also tend to have a particularly high content of resin or essential oils, making them extremely inflammable.

Socio-economic development in the region has led to a general decrease in grazing and in the collection of fuelwood and fodder. As a result, there has been a build-up of highly inflammable forest litter.

Another cause of increases in forest fuels, especially on the European side of the Mediterranean, has been the migration of populations from rural areas to cities. This population shift does not imply the total elimination of activities in the forest area. The remaining, often elderly, rural population continues to use fire to eliminate stubble and renew pastures and fields. However, the accumulation of fuel often allows fires set for agricultural purposes to spread out of control. Moreover, the sparse rural population makes fire suppression more difficult.

CAUSES AND EFFECTS

The forest fire situation in the Mediterranean basin is largely determined by climatic conditions. Prolonged summers with virtually no rain and average daytime temperatures well in excess of 30°C reduce the moisture content of forest litter to below 5 percent. Under these conditions, even a small addition of heat (lightning, a spark, a match, a cigarette) can be enough to start a violent conflagration.

Wind is another climatic factor influencing fire hazard. The inland summer winds are highly desiccating, characterized by high speeds and low humidity. The dry, cold winds of Mediterranean winters can also increase fire danger.

Statistics on the causes of forest fire in the Mediterranean region are far from complete, but it is evident that people set most fires. Natural agents such as lightning also cause forest fires, but the number of naturally occurring fires is small in comparison with those caused by people.

An important source of fires is shepherds, who ignite forest and grassland to promote new flushes of growth for grazing animals. Farmers also use fire to eliminate crop stubble and invasive thorn plants and to push back the forest to make room for agricultural expansion.

Urban populations in the Mediterranean region show a particularly poor understanding of the danger of fires and of their potentially negative consequences. Despite continuous, preventive propaganda campaigns, many city dwellers do not consider a forest fire to be a threat, even in the middle of summer. An increasingly important cause of fires is the burning of large quantities of solid waste by tourists and other recreational users of forest areas.

Finally, there are a growing number of fires ignited not for utilitarian purposes but with destruction as their sole aim, especially in the western Mediterranean. These fires may be lit for a variety of reasons, including private vengeance and conflicts related to ownership or hunting rights. Another important motivation for destructive fires, particularly in the European part of the Mediterranean, is an attempt to change land-use classification.

Ironically, there also seem to be a growing number of fires set by the auxiliary workers retained by national forest fire services, to generate employment during the critical summer months.

Land-use change and climate change are the main factors expected to play the most significant part in fire regimes of the Mediterranean basin during the twenty-first century.

PREVENTION

Prevention activities can be divided into two broad areas: those directed at the primary cause of fire, i.e. people, and those aimed at mitigating the flammability of forest resources.

Public information campaigns are carried out in most Mediterranean countries, with the intensive use of mass communications media, mainly television, radio and the press. In most cases, these campaigns are aimed almost exclusively at urban dwellers during the summer and stress the risk of fire caused by negligence and its potential consequences.

The situation regarding the rural population, however, requires a different approach. It is apparent that the rural population needs to be aware of the cost. Sociological studies to determine the behaviour and knowledge of rural people may be one key to developing effective information campaigns aimed at this population.

Information campaigns must be complemented by preventive silviculture, i.e. forest management techniques designed to minimize the risk of and damage resulting from fire. Fuel management involves such highly diverse techniques as tree thinning, brushwood crushing, prescribed burning, controlled grazing and species selection.

Protective techniques need to be integrated into overall silvicultural practices, which have generally concentrated on regeneration and production. The major problems in applying efficient preventive silviculture are the large area to be treated and the cost of the labour required.

National detection and monitoring networks based on fixed and mobile stations have been established in all Mediterranean countries. Aerial monitoring has also been experimented, primarily in Italy and Spain. But hi-tech systems cannot replace ground-based personnel with a good working knowledge of the terrain.

Danger rating systems are another essential element of fire control. Some countries, e.g. Greece, Portugal and Spain, are operating national fire danger rating systems. The pan-European EFFIS provides a daily fire danger forecast for member countries of the European Union and adjoining regions.

SUPPRESSION

Approximately 30 000 workers are mobilized for firefighting activities each summer in the Mediterranean region; in particularly hazardous years, the number may swell to 50 000, including the participation of members of the armed forces.

Having trained personnel available in sufficient numbers is a basic condition for successful suppression work. The organizational scheme providing the best level of protection is one consisting of a general, permanent fire service, which is reinforced with additional resources and personnel during critical periods. The dimensions of the basic service will be determined by the overall risk of fire.

The efforts of land-based suppression forces are reinforced in many Mediterranean countries by fleets of aircraft (mostly amphibious) and helicopters. Approximately 300 government-owned and contracted aircraft are used each summer for firefighting operations in the Mediterranean basin. The use of helicopters is assuming increasing importance, particularly in the transport of fire crews to difficult locations.

However, airborne suppression activities must not be viewed as a substitute for land-based efforts, particularly in view of the high costs involved. If land-based forces are not sufficient, the introduction of additional airborne forces will not improve overall efficiency, and may even retard future development as resources that could have been better invested in the formation of land-based brigades are diverted. Apart from their direct costs, airborne forces require an additional infrastructure of personnel and facilities.

INSTITUTIONS, RESPONSIBILITIES AND ROLES

Different countries have different ways of organizing their fight against forest fires. There is no up-to-date comparative information for the countries of the study. Most descriptions given to FAO or the European Union are lists of suppression means, especially airplanes, vehicles and firefighters. There is no critical description of the weaknesses and advantages of the systems applied.

The philosophy of forest fire prevention is similar throughout the Mediterranean basin. It is based on the creation of tracks, firebreaks and water reserves. This work is often designed within the framework of traditional management projects (e.g. in

Algeria and Tunisia). Maintenance of these networks is an important issue, especially as the authorities responsible for creating the systems are often not the same as those who are responsible for maintaining them.

Two general trends can be described within the countries of the Mediterranean, as far as protection from forest fires is concerned:

- a system in which the forest service is responsible for forest fire prevention and control;
- a mixed system, in which the forest service is responsible for forest fire prevention and the fire brigade takes over presuppression and suppression activities.

In some countries, the mixed system is more complex and local and national authorities are involved as well.

European Union countries apply the mixed fire protection system, with various players involved, strengthened through expensive fire suppression tools (mostly aerial). In the other Mediterranean countries, forest authorities have full responsibility for fighting fires in the forest. There are three main trends observed in relation to forest fire protection, moving from south to north of the Mediterranean:

- from a central agency towards a more peripheral system;
- towards increased participation of private bodies in fire protection; and
- from fire suppression by the forest services towards professional firefighters.

The third trend is actually a shift from a managerial approach to a more operational one. As the means for spending on firefighting increase, governments decide to invest their resources in a more complex system, where diverse groups of professionals work together. While this is, in principle, correct, it involves a reduction of the participation of forest management authorities in the fire protection scheme, giving it more of a crisis-response character.

Another reason for this development is that most people in European Union countries live in urban environments and do not understand the managerial approach. For them, fire is a bad thing and should be eliminated by all the means a modern society may have at its disposal.

As the problem of forest fires becomes more and more severe in the countries with the mixed system, a change in the policies and decision mechanisms is necessary. The players involved in fire management are not the crucial question. What is important is the policy under which these players operate and their coordination. The data so far show that the current policy is not efficient.

COLLABORATION

Various Mediterranean countries have established cooperative relationships to address specific forestry issues in the region.

The problem of forest fire is too large to be controlled at a single government level. It is a Mediterranean problem, but most international associations include forest fires as a small part of their activities, as a geographical or thematic subunit. There is a lack of a common perception of forest fires in the Mediterranean.

Since 2002, the Forest Fire Network of *Silva Mediterranea* – chaired by Spain – has become increasingly active in promoting and developing international

cooperation in forest fire emergencies. Two workshops on Multilateral Assistance against Forest Fires in the Mediterranean Basin (held in Zaragoza, Spain, in 2003 and 2004) addressed procedures for coordinating existing mutual assistance agreements and common legal and logistical tools. The ultimate aim is to share resources and improve multilateral assistance in extreme forest fire situations within the Mediterranean basin. The Forest Fire Network constitutes the Regional Mediterranean Wildland Fire Network within the UN-ISDR GWFN.

Data availability is a major problem in the countries of the region. Even where available, it is not comparable, due to different methodologies, definitions, perception and mentalities. Analysis of the causes of forest fires is also problematic. In many countries, there are too many fires attributed to unknown causes, due to lack of investigation after the fire or political and social reasons. Another phenomenon observed is an intense discussion on arson, especially in countries where the state tries to cover its own ineffectiveness in firefighting.

Lack of data on forest fires and their causes is a major obstacle in understanding the nature of forest fires and in designing strategies and measures at national and international levels. The differences in definitions concerning forest fires are also a major obstacle to the implementation of any international strategy.

The European Union policies related directly or indirectly to forest fires do not appear to be suitable to addressing the issue in the Mediterranean, additionally because they are strongly influenced by the timber-producing northern countries of the continent. As a result, forest fire management has often become a low priority and receives little attention and financial assistance.

However, the activities of *Silva Mediterranea* may be instrumental in facilitating intra- and interregional cooperation in forest fire management.

COMMUNITY PARTICIPATION

In non-European Union countries, the forest has lost value in comparison with other land uses, and people depend on those other land uses for primary production. This has led to overexploitation and degradation of the forest resource, both in terms of quality and quantity.

A major element emerging from the analysis is that local communities have become less involved in forest fire management over the years, in all countries. This lack of local involvement has caused fuel accumulation, making forest fires uncontrollable when they are not suppressed at the start. It has also changed forest fire management dramatically.

There is a clear trend away from a low-profile management approach (at subnational and local levels), in which fire protection measures are part of forest management, towards a high-profile operational model, in which high-technology equipment and professional, specialized units are involved after the fire breaks out. In the latter case, prevention and suppression are assigned to different players and coordination is often very poor.

Local populations are not very aware of the need for forest fire protection. They often burn forests by mistake, using fire as a tool at the wrong time and in the wrong

place. People also burn forests deliberately in order to replace them with other land uses that may bring short-term profits. A major factor that contributes to lack of awareness is the inability of Mediterranean countries to estimate and describe the impacts of forest fires on society and on people.

Government policies do not seem to contribute to the control of forest fires. Many have not established and applied simple management regulations for agriculture and pasture to prevent accidental fires (such as the season for burning or the method). In areas in which a central forestry body is responsible for the whole range of forest activities (mainly North Africa and Turkey), the state often fails to control and coordinate prevention and suppression measures. During years of extreme drought, with many fire outbreaks daily, the state mechanism is unable to respond successfully to all cases and the local populations are not part of the firefighting mechanism. In cases where the mixed system is applied, coordination before and during fires is a major problem. More importantly, different actors perform different tasks, usually following different mentalities and implementing different policies.

Governments, apparently, also fail to recognize and report problems. Almost all official reports present a very flattering picture of the organization of fire management in the country, although the numbers show that the problem has deteriorated. By employing a purely operational approach, governments may fail to recognize the nature of the phenomenon and may consider the accumulation of aerial suppression means the equivalent of the expected success of the mechanism.

NEEDS AND LIMITATIONS

From an analysis of forest fires in the Mediterranean basin, the following needs and limitations can be identified:

- Mediterranean countries share common characteristics concerning forest fires and their ecological and socio-economic features. An integrated approach is needed, both in forest planning and management of forest fires.
- Unfortunately, collaboration among Mediterranean countries on forest fire issues is very limited.
- Although the Joint Research Centre of the European Union maintains a standardized forest database for member countries, a common database for all Mediterranean countries is still lacking. Data from outside the Union are scattered, inconsistent and difficult to process.
- As a result, analysis of the direct and indirect effects of forest fires is at a very preliminary level, failing to identify and estimate the real burden posed to the economy and society from forest fires.
- Research on forest fires is carried out in some countries, but the results are not communicated through expert meetings and the exchange of information.
- Forests are not viewed as a common good having vital links with local economies. Communities do not feel part of forest management.
- Public awareness of the values of forests, other than direct timber production, is not adequately promoted.

- A management approach on forest fire issues is lacking. Fighting forest fires is in most cases seen as a reaction to a natural catastrophe, independent of the actual root causes and of forest management policies and practice.
- The policies of others sectors (e.g. agriculture, tourism development, urban development) often contribute to fires and may increase the sense of disconnection of communities towards forests.
- Forest policy at a national or European Union level is in most cases focused on production, and forest fires constitute only a minor part, despite their importance for the forests of the region. In most countries, forests and forestry are the lesser part of broader agricultural policy.

Mediterranean landscapes have been shaped through intensive human intervention over millennia, due to burning, cutting and grazing on non-arable lands, and the clearing, terracing, cultivating – and later abandonment – of arable land. Human intervention is still making a significant impact on current vegetation patterns and is expected to do so in the foreseeable future.

Although the main reason for the increase in fires in recent decades is most likely changes in land use, climatic factors should also be considered as a contributing factor. Predictions of climate change in the Mediterranean basin indicate an increase in air temperature and a reduction in summer rainfall. These changes, predicted for the near future, are likely to lead to increased fire risk not only in the Mediterranean area, but also in the other fire-prone regions of the world.

United States Forest Service

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