Forestry Department
Food and Agriculture Organization of the United Nations

FRA 2000

GLOBAL FOREST FIRE ASSESSMENT 1990-2000

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The Forest Resources Assessment Programme

Forests are crucial for the well-being of humanity. They provide foundations for life on earth through ecological functions, by regulating the climate and water resources, and by serving as habitats for plants and animals. Forests also furnish a wide range of essential goods such as wood, food, fodder and medicines, in addition to opportunities for recreation, spiritual renewal and other services.

Today, forests are under pressure from expanding human populations, which frequently leads to the conversion or degradation of forests into unsustainable forms of land use. When forests are lost or severely degraded, their capacity to function as regulators of the environment is also lost, increasing flood and erosion hazards, reducing soil fertility, and contributing to the loss of plant and animal life. As a result, the sustainable provision of goods and services from forests is jeopardized.

FAO, at the request of the member nations and the world community, regularly monitors the world's forests through the Forest Resources Assessment Programme. The next report, the Global Forest Resources Assessment 2000 (FRA 2000), will review the forest situation by the end of the millennium. FRA 2000 will include country-level information based on existing forest inventory data, regional investigations of land-cover change processes, and a number of global studies focusing on the interaction between people and forests. The FRA 2000 report will be made public and distributed on the World Wide Web in the year 2000.

The Forest Resources Assessment Programme is organized under the Forest Resources Division (FOR) at FAO headquarters in Rome. Contact persons are:

Robert Davis	FRA Programme Coordinator	robert.davis@fao.org
Peter Holmgren	FRA Project Director	peter.holmgren@fao.org

or use the e-mail address: fra@fao.org

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The FRA Working Paper Series provides an important forum for the rapid release of preliminary FRA 2000 findings needed for validation and to facilitate the final development of an official quality-controlled FRA 2000 information set. Should users find any errors in the documents or have comments for improving their quality they should contact either Robert Davis or Peter Holmgren at fra@fao.org.

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Paper drafted by: Johann G. Goldammer, Fire Ecology Research Group, Max Planck Institute for Chemistry/The Global Fire Monitoring Center, GFMC, c/o Freiburg University, Germany

& by: Robert W. Mutch, Fire Management Applications, USA

Technical Coordinator: Robert W. Mutch

Editing & lay out: Patrizia Pugliese, FAO, FRA Programme

The photo on the cover page reproduces a painting by the artist Monte Dolack

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Contributors for the country fire profiles

Name of the contributor	Reported country
AFRICA	
Saket, M.	Mozambique
Trigg, S. & Le Roux, J.	Namibia
De Ronde, C. & Goldammer, J.G.	South Africa
Tandjiékpon, A.M.	Benin
Eva, H. & Grégoire, J-M.	Central African Republic
Bekele, M. & Mengesha, B.	Ethiopia
Ndambiri, J.K. & Kahuki, C.D.	Kenya
Drame, M.	Senegal
Bayoumi, A.A.M.S.	Sudan
ASIA	
Goldammer, J.G. & Hoffmann, A.A.	Indonesia
Wan Ahmad, W.M.S.	Malaysia
Pogeyed, M.L.	Philippines
Akaakara, S.	Thailand
Bahuguna, V.K. & Singh, S.	India
Bajracharya, K.M.	Nepal
Ariyadasa, K.P.	Sri Lanka
Shu, L. & Tian, X.	China
Allard, G.	Iran
Khaidara, K. & Arkhipov, V.	Kazakhstan
Lim, J-H.	Republic of Korea
GFMC	Mongolia
EUROPE	
Hadjikyriakou, G.	Cyprus
Xanthopoulos, G.	Greece
Scipioni, A., Gabellini, B., Caldari, F. & Cavalensi, R.	Italy
Bassil, M.	Lebanon
Vélez, R.	Spain
Bilgili, E.	Turkey
Mysleiko, I.G. & Shamal, V.	Belarus
Kütt, V.	Estonia
Vainio, T.	Finland
Lex, P. & Goldammer, J.G.	Germany
Gertners, A.	Latvia
Gaigalas, G.	Lithuania
Shvidenko, A. & Goldammer, J.G.	Russian Federation

Name of the contributor	Reported country

OCEANIA

Gill, M. & Moore, P.H.R.	Australia
King, T.	Fiji
Craig, A.	New Zealand

NORTH AMERICA , CENTRAL AMERICA & CARIBBEAN

Stocks, B.J.	Canada
Mutch, R.W.	USA
Cedeño, O.	Mexico
Román Cuesta, R.M.	Chiapas
De Dixmude, A.J.	Nicaragua
Ramos, M.	Cuba
Singh, K.	Trinidad & Tobago

SOUTH AMERICA

Dentoni, M.C.	Argentina
Martínez, I. & Cordero, W.	Bolivia
Mutch, R.	Brazil
Sanhueza, P.I.	Chile

Abbreviations

ADB	Asian Development Bank
ADIE	Association pour le Développement de l'Information Environnementale
AIFM	ASEAN Institute for Forest Management
ALIDES	Alianza Latinoamericana para el Desarrollo Sostenible
API	Air Pollutant Index
ASEAN	Association of South East Asian Nations
ATSR	Along Tracking Scanning Radiometer
AVHRR	Advanced Very High Resolution Radiometer
BALTEX	Baltic Exercise on Fire Information and Resources Exchange
BAPEDAL	Environmental Impact Management Agency
BIBEX	Biomass Burning Experiment
BIRD	Bi-spectral IR Detection
CCAD	Central America Commission for Environment and Development
CDF	Centre de Développement Forestier
CEOS	Committee of Earth Observation Satellites
CIFOR	Center for International Forestry Research
CONAF	Corporación Nacional Forestal (Chile)
DBH	Diameter at Breast Height
DMSP	Defense Meteorological Satellite Program
DNFFB	Direcçao Nacional de Florestas e Fauna Bravia
EDC	Eros Data Centre
ENSO	El Niño-Southern Oscillation
EOS	Earth Observation System
ERS-2 SAR	European Radar Satellite-2-Synthetic Aperture Radar
EXPRESSO	Experiment for Regional Sources and Sinks of Oxidants
EZ	Ecological Zone
FAA	Fire-Affected Areas
FAO	Food and Agricultural Organization of the United Nations
FDI	Fire Danger Index
FMUs	Fire Management Units
FORIS	Forest Resources Information System
FPAs	Fire Protection Associations

FRA	Forest Resources Assessment
FREG	Fire Ecology Research Group
FSTCU	Forestry Sector Technical Coordination Unit
GDP	Gross Domestic Product
GFMC	Global Fire Monitoring Center
GIS	Geographic Information System
GOFC	Global Observation of the Forest Cover
GTZ	German Agency for Technical Cooperation
GVFI	Global Vegetation Fire Information system
HTE	High-Temperature Events
IBAMA	Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renovaveis
ICS	Incident Command System
IDNDR	International Decade for Natural Disaster Reduction
IFFM	Integrated Forest Fire Management
IFFN	International Forest Fire News
IGAC	International Global Atmospheric Chemistry
IGBP	International Geosphere and Biosphere Programme
IGOS	International Global Observing Strategy
IIASA	International Institute for Applied Systems Analysis
ILO	International Labour Organization
INSARAG	International Search and Rescue Advisory Group
IR	Infra Red
ISDR	International Strategy on disaster Reduction
ITTO	International Tropical Timber Organization
IUCN	World Conservation Union
JFM	Joint Forest Management
JICA	Japan International Cooperation Agency
KBDI	Keetch/Byram Dryness Index (a metric fire danger index)
Landsat MSS	Landsat Multi-Spectral Scanner
NDVI	Normalized Difference Vegetation Index
NFPA	National Forest Priority Areas
NGO	Non-governmental Organization
NOAA	National Oceanic and Atmospheric Administration
NTFP	Non Timber Forest Products

OCHA	UN Office for the Coordination of Humanitarian Affairs
PREVFOGO	National system for Wildland Fire Prevention and Suppression (Brazil)
RECOFTC	Regional Community Forestry Training Center
SADC	Southern African Development Community
SAFARI	Southern Africa Fire-Atmosphere Research Initiative
SEAFIRE	South East Asian Fire Experiment
SODEFOR	State Reforestation Service
TACIS Project	Technical Assistance to the Commonwealth of Independent States
TOMS	Total Ozone Mapping Spectrometer
TREES	Tropical Ecosystem Environment observations by Satellites
TSP	Total Suspended Particulate matter
UNDAC	The United Nations Disaster Assessment and Coordination
UN-ECE	United Nations Economic Commission for Europe
UNESCO	United Nations Educational, Scientific and Cultural Organization
USDA	US Department of Agriculture
WMO	World Meteorological Organization
WWF	Worldwide Fund of Nature

Dedication

This assessment of the global fire situation is dedicated to the many men and women who lost their lives fighting wildfires during the drought-plagued 1990s. We all know that firefighting can be a dangerous business. The valiant efforts to protect people, property and natural resources from wildfires during 1990 to 2000 too often resulted in the death of brave people. Family, relatives, co-workers, friends and the world grieve these losses to this very day. No Region in the world was spared the grief associated with the tragic consequences that sometimes result from wildland firefighting.

We owe it to the memory of these fallen firefighters to apply the lessons learned from fatality fires, so that each and every fire crew member in the future always returns home following a fire assignment. Fire safety must be our number one priority.

We also dedicate this report to the villagers and citizens who found themselves in harm's way and died because of a wildfire. Safeguards need to be implemented to ensure that communities are better protected from fire.

Acknowledgements

We gratefully acknowledge the leadership provided by FAO in setting a high priority on the collection and reporting of wildfire data and the wildfire situation for Member countries. This is the first time that such an in-depth fire analysis has accompanied FAO's 10-year Forest Resource Assessment. Such fire information is essential in developing strategies to better protect the world's forest resources from the ravages of wildfires. FAO's initiation of a comprehensive process that accounts for the effects of fires on wildlands will return valuable dividends for years to come as additional countries contribute to the database. Also, this benchmark effort will further improve communications among countries regarding the diverse nature of wildfire problems; and help to strengthen international cooperation.

The direction, knowledge and guidance provided by Gillian Allard have been instrumental in reviewing and understanding the current state of fire data reporting. She provided an excellent perspective regarding information requirements that helped immeasurably in collecting country fire data for the Forest Resource Assessment 2000 (FRA 2000). We sincerely thank her for a job well done.

In addition, Robert Davis, Peter Holmgren and Magnus Grylle graciously provided valuable insights into the purpose and data structure of the FRA 2000 process. They encouraged the development of a fire data reporting form that would standardize the collection of important information from Member countries. They also ensured that country fire information would be displayed on an FAO webpage, so that many audiences could easily share country fire profiles.

Graciela Andrade-Cianfrini at FAO was especially helpful in answering questions and assisting with many aspects of report development. Her friendly support is greatly appreciated.

We owe a special debt of gratitude to the many country authors and correspondents who answered the call to help on this project with enthusiasm and dedication. This global assessment of forest fires is more thorough and complete than it might have been due to their diligence in documenting the fire situation within their respective countries. We cannot begin to thank them enough for their many excellent contributions.

Much of the fire information used in this report is from the ECE/FAO International Forest Fire News (IFFN) which is published on behalf of the UN-ECE Trade Division, Timber Section, Geneva. It is available on the Website of the Global Fire Monitoring Center (GFMC). The enthusiastic work of the GFMC staff in continuously updating global wildland fire data and maintaining contacts with correspondents all over the world is gratefully acknowledged. Many of the country reports will appear in issues of the International Forest Fire News.

We would like to thank Jim Space, an FAO Consultant, who edited many of the country reports in a thorough and careful manner. His timely assistance allowed us to maintain our production schedule for the overall report. Also, Dennis Simmerman, Fire Sciences Laboratory in Missoula, Montana, was especially helpful in providing graphics and illustrations.

Finally, a very special thank you is extended to artist Monte Dolack from Missoula, Montana, for granting permission to use his artwork "Northern Rockies Fires of 2000" on the cover of the report. The Monte Dolack Gallery (www.dolack.com) was commissioned by the Northern Rockies Coordinating Group to produce this poster dedicated to all those involved in fighting the fires of 2000. Thirty thousand copies of the poster were distributed to firefighters who worked in the Northern Rockies of the western U.S. during the 2000 fire season as a token of appreciation.

Executive Summary

The Expert Consultation on Global Forest Resources Assessment 2000 held in Kotka, Finland, during June of 1996 recommended that FAO provide annual statistics/estimates for the Forest Resources Assessment 2000 for each country on the number of forest fires and the area burned over the period 1990-2000.

Soon after the Kotka meeting, the El Niño drought conditions of 1997-1998 focused public, media and political attention on the worldwide outbreak of fires that were devastating forests. The size and damage caused by these fires was so widespread that one U.S. newspaper called 1998 "the year the earth caught fire." An "earth on fire" seemed literally true at times as huge smoke palls blanketed large regions, air and sea navigation were disrupted, many lives were lost, public health was adversely affected, homes were destroyed and natural resources were severely impacted.

Some ecosystems like the rain forests of Indonesia and Brazil and the cloud forests of Mexico, areas usually not seriously affected by forest fires, sustained considerable damage in 1998[1]. A world audience was hungry for detailed information about the extent of these fires, but such information was not available for some regions because many countries do not have a system in place for reporting even basic forest fire statistics.

Although FAO has provided forest fire management assistance for years, including data collection and dissemination, the organization recognized that current data on fires are still incomplete. Thus, it remains difficult to assess the annual degradation of forests caused by wildfires.

The Forest Resources Assessment process 2000 provided an opportunity for FAO to define the global effects of fires on forests as a part of the forest assessment that is undertaken every ten years. This global assessment of forest fires summarizes the results of questionnaires and contacts with countries to obtain wildfire data and narrative information regarding the fire situation. The report is organized according to FAO's six geographical regions: Africa, Asia, Europe, Oceania, North and Central America and South America. In-depth fire situation profiles are presented for 48 countries, with shorter reports highlighting fire conditions in several additional countries.

Through the FRA 2000 process, FAO was able to close out the 20th Century by instituting a system for collecting meaningful fire data for developing countries. Although the submission of wildfire data on fire numbers, area burned and causes fell short of expectations, the importance of regularly recording and evaluating such information has been established with Member countries.

This assessment of the global forest fire situation revealed strengths and weaknesses associated with sustaining the health and productivity of the world's forests when threatened by drought, wildfires and an increasing demand for natural resources:

[1] Public Policies Affecting Forest Fires in the Asia-Pacific Region, James Schweithelm; and Public Policies Affecting Forest Fires in the Americas and the Caribbean, Robert W. Mutch et al; In FAO Meeting on Public Policies Affecting Forest Fires, FAO Forestry Paper 138, Rome 1999.

- Wildfires during drought years continue to cause serious impacts to natural resources, public health, transportation, navigation and air quality over large areas. Tropical rain forests and cloud forests that typically do not burn on a large scale were devastated by wildfires during the 1990s.

- Many countries, and regions, have a well-developed system for documenting, reporting and evaluating wildfire statistics in a systematic manner. However, many fire statistics do not provide sufficient information on the damaging and beneficial effects of wildland fires.

- Satellite systems have been used effectively to map active fires and burned areas, especially in remote areas where other damage assessment capabilities are not available.

- Some countries still do not have a system in place to annually report number of fires and area burned in a well-maintained database, often because other issues like food security and poverty are more pressing.

- Even those countries supporting highly financed fire management organizations are not exempt from the ravages of wildfires in drought years. When wildland fuels have accumulated to high levels, no amount of firefighting resources can make much of a difference until the weather moderates (as observed in the United States in the 2000 fire season).

- Uncontrolled use of fire for forest conversion, agricultural and pastoral purposes continues to cause a serious loss of forest resources, especially in tropical areas.

- Some countries are beginning to realize that inter-sectoral coordination of land use policies and practices is an essential element in reducing wildfire losses.

- Examples exist where sustainable land use practices and the participation of local communities in integrated forest fire management systems are being employed to reduce resource losses from wildfires.

- In some countries, volunteer rural fire brigades are successful in responding quickly and efficiently to wildfires within their home range; and residents are taking more responsibility to ensure that homes will survive wildfires.

- Although prescribed burning is being used in many countries to reduce wildfire hazards and achieve resource benefits, other countries have prohibitions against the use of prescribed fire.

- Fire ecology principles and fire regime classification systems are being used effectively as an integral part of resource management and fire management planning.

- Fire research scientists have been conducting cooperative research projects on a global scale to improve understanding of fire behaviour, fire effects, fire emissions, climate change and public health.

- Numerous examples were present in the 1990s of unprecedented levels of inter-sectoral and international cooperation in helping to lessen the impact of wildfires on people, property and natural resources.

- Institutions like the Global Fire Monitoring Center have been instrumental in bringing the world's fire situation to the attention of a global audience via the Internet.

In reviewing the global fire situation, it is apparent that a continued emphasis on the emergency response side of the wildfire problem will only result in future large and damaging fires. The way out of the emergency response dilemma is to couple emergency preparedness and response programmes with more sustainable land use policies and practices. Only when sustainable land use practices and emergency preparedness measures complement each other do long-term natural resource benefits accrue for society.

1 Introduction

The mission of FAO's global forest resources assessment programme (FRA 2000) is to provide the world community reliable information to describe and understand the situation of the world's forests and related resources and how they change over time. The assessments are carried out jointly by FAO, Rome, and UN-ECE/FAO, Geneva, in cooperation with member countries and partners. FAO is directly responsible for information for developing countries, as well as a global synthesis, and UN-ECE/FAO, Geneva, is responsible for the industrialized countries.

The Expert Consultation on Global Forest Resources Assessment 2000 held in Kotka, Finland, during June of 1996 recommended that FAO should provide annual statistics/estimates for the FRA 2000 for each country on the number of forest fires and the area burned over the period 1990-2000.

Just after the Kotka meeting emphasized the importance of accounting for the annual occurrence of forest fires within countries, the El Niño drought conditions of 1997-1998 garnered public, media, and political attention to the world-wide outbreak of fires that were devastating forests. The size and damage being caused by these fires was so enormous that the Christian Science Monitor called 1998 "the year the earth caught fire." At times the earth did seem to be on fire as huge smoke palls blanketed large regions, air and sea navigation were disrupted, many lives were lost, public health was adversely affected, homes were destroyed, and natural resources were severely impacted. Some ecosystems like the rain forests of Indonesia and Brazil and the cloud forests of Mexico, areas usually not seriously affected by forest fires, sustained considerable damage in 1998[2]. A world audience was hungry for detailed information about the extent of these fires, but such information was not available for some regions because many countries do not have a system in place for reporting even basic forest fire statistics.

Although FAO has provided forest fire management assistance for years, including data collection and dissemination, the organization recognized that current data on fires are still incomplete. Thus, it remains difficult to assess the annual degradation of forests caused by wildfires. The global fire problems witnessed in 1997-1998 served as a catalyst for FAO to sponsor a meeting of "Public Policies Affecting Forest Fires" in Rome in October 1998 to review policies affecting fires, collect information about global fires, and produce recommendations to better protect the world's forests.[3]

Seventy-one participants from 33 countries and 13 international organizations concluded, among other things, that "there is a need for reliable and up-to-date systems for national, regional, and global fire reporting, analysis, and storage of data. Such data, and information on fire causes and socio-economic and environmental effects, are required as a sound basis for policy making." International organizations also were urged "to support the design and

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[2] Public Policies Affecting Forest Fires in the Asia-Pacific Region, James Schweithelm; and Public Policies Affecting Forest Fires in the Americas and the Caribbean, Robert W. Mutch et al; In FAO Meeting on Public Policies Affecting Forest Fires, FAO Forestry Paper 138, Rome 1999.
[3] FAO Meeting on Public Policies Affecting Forest Fires, FAO Forestry Paper 138, Food and Agriculture Organization of the United Nations, 28-30 October 1998, Rome, Italy, FAO Forestry Paper 138 369 pp.

implementation of a global fire inventory or reporting system, in close collaboration with the fire science community and end users."

FRA 2000 provided an opportunity for FAO to begin to define the global effects of fires on forests as a part of the forest assessment that is undertaken every ten years. This global assessment of forest fires summarizes the results of questionnaires and contacts with countries to obtain wildfire data and narrative information regarding the fire situation in FAO's six geographical regions: Africa, Asia, Oceania, Europe, North and Central America, and South America. See the Annex for a copy of the Fire Template used in soliciting information from Member countries.

1.1 Forest fires at a global level: an overview

Comparing the decades of the 1980s and 1990s. Comprehensive national, regional or global statistics on wildland fires are not available that would allow a reliable and precise comparison of the global fire occurrence in the 1980s and 1990s. However, some general observations can be made. Both decades experienced high inter-annual regional and national variability of fire occurrence and fire impacts. El Niño episodes such as in 1982-1983 and 1997-1998 were the most important climatic oscillations affecting area burned and fire impacts in both decades. In these years, most of tropical Asia, Africa, the Americas and Oceania regions experienced extremely extended wildfire situations. During 1997-1998, the amount of land-clearing fires and other escaped fire situations have increased in the equatorial forest regions of Southeast Asia and South America.

The northern temperate/boreal forest zone also experienced extremely dry years in both decades. Central-Eastern Asia was affected most severely in 1987, particularly Central-Eastern Siberia and the northeast of China. The Far East of Russia also was severely affected by wildfires during the 1998 drought.

Statistical evidence from Canada suggests that there is a trend of increasing area burned starting in the early eighties and continuing to increase in the 1990s. Wildland fire statistics for National Forests in the western United States also show an increase in area burned from the mid-1980s onward compared to the earlier part of the 20th Century (Figure 1-1). Differing fire response strategies in Canada today and unnatural fuel accumulations in the U.S. because of fire exclusion help to explain some of these increases in area burned.

It is not surprising in the aftermath of the extensive 1910 wildfires in the western United States that public policies were developed that emphasized fire suppression programmes over prescribed fire programmes. This programme emphasis on fire suppression was universally accepted by society and politicians. But since 1910, a large body of scientific knowledge has developed regarding fire history, fire regimes, and fire effects; the decline in the health of ecosystems has reached alarming proportions; and large, high intensity wildfires are increasing in size during the past two decades (Figure 1-1). Here is an example where the accurate recording of area burned on an annual basis has produced a wildfire database that is now highlighting an alarming trend in larger fires towards the end of the 20th Century.

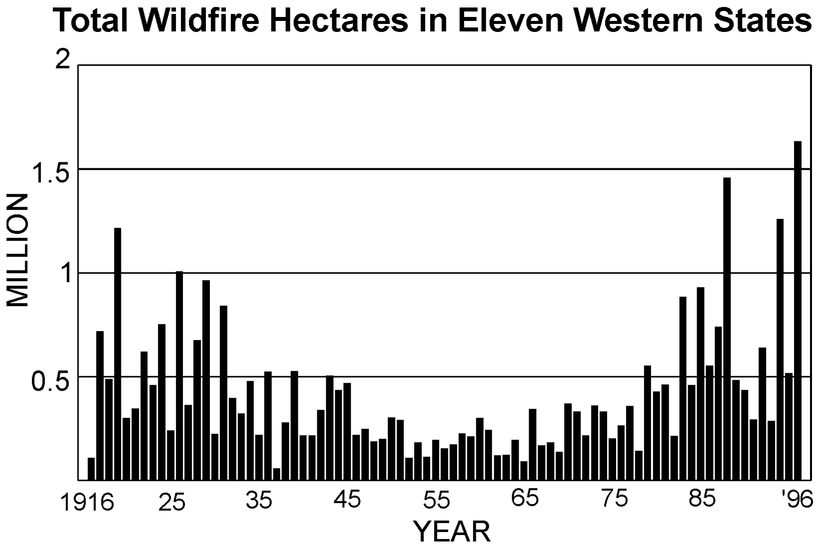

Figure 1-1 Total wildfire hectares burned in the 11 western states on all Federal lands between 1916 and 1996.

Summarizing the wildfire trends of the 1980s and 1990s, it can be concluded that there is no unidirectional tendency. Some areas suffered more fires due to increasing land-use intensity. Other forest regions have become more susceptible to larger and more damaging fires as a result of long-term fire exclusion. An important consideration is the fact that large areas of degraded forests and other wooded lands have been converted to grasslands and shrublands with repeated fires. These grasslands and shrublands are prone to burn much more frequently, inhibiting the succession back to tree cover.

1.2 Forest fire issues and opportunities

The participants of 33 countries attending FAO "Meeting on Public Policies Affecting Forest Fires" held in Rome, Italy, in October 1998 identified numerous global fire issues:

- Declining forest health
- Wildland/urban interface: loss of many homes
- Fire damage to tropical forests
- Forest damage from unregulated burning for agricultural and forest clearing purposes
- Global health impacts from wildfire smoke
- Numerous fatalities to firefighters and others as a result of wildfires
- Wildfire disruption of air and sea transportation due to reduced visibility
- Escalating costs of fire suppression and resource damage
- Increased contribution of combustion gases to global climate change
- Need to link sustainable land use policies and practices with emergency preparedness measures to reduce negative impacts of wildfires
- Need for community involvement and private sector involvement in developing sustainable land use practices and fire management programmes

- Need for a quantitative fire database in fire-prone countries
- Role of fire in managing fire-adapted ecosystems

It was clear at the Rome meeting that most of these issues and opportunities could be resolved through the development of public policies that provided concise guidance and direction. Actions to be taken were considered by Ministers responsible for forestry at their meeting in Rome in March 1999.

It was also recognized at the Rome meeting that a fire statistics database was essential in providing managers with a system of comparing fire season severity over time as a means of projecting future trends. Simard (1997) listed numerous ways that fire statistics can serve many purposes, organizations, and communities:

- international commitments (global biomass burning inventories, carbon budget, biodiversity conventions);
- national interests (criteria and indicators, sustainable forest management, the national forest strategy, public health and safety, biodiversity, atmospheric emissions);
- land management agencies (fire and sustainable forestry, landscape management, ecosystem management, wildlife management, watershed management);
- fire management agencies (fire planning, operations, suppression, prevention, prescribed fire, budgeting, audit and evaluation);
- fire science (fire history, the fire environment, fire management, fire ecology, fire economics, global climate change, and fire);
- political leaders (fire management policies, appropriate levels of fire management);
- general public (health and safety, management of forests);
- media.

1.3 Fire exclusion and fire use in the management of forests

Recurring fires are part of the natural environment--as natural as rain, snow, or wind (Heinselman 1978). Evidence of past fires and their periodicity is found in charcoal layers in lakes and bogs; and in the fire-scarred cross sections of trees. Heinselman indicated that fire-adapted ecosystems in North America are termed fire-dependent, if disturbances by fire are essential to the functioning of these systems (1978). Fire affects the functioning of ecosystems in numerous ways:

- Regulating plant succession

- Regulating fuel accumulations.

- Controlling age, structure and species composition of vegetation.

- Affecting insect and disease populations.

- Influencing nutrient cycles and energy flows.

- Regulating biotic productivity, diversity and stability.

- Determining habitats for wildlife.

Lightning, volcanoes and people have been igniting fires in wildland ecosystems for millennia. The current emphasis on ecosystem management calls for the maintenance of interactions between such disturbance processes and ecosystem functions. It is incumbent, therefore, on resource managers and fire managers to understand the historic frequency, intensity and areal extent of past fires. Such knowledge provides a frame of reference for prescribing appropriate management practices on a landscape scale. Many studies have described the historical occurrence of fires. Swetnam (1993), for example, reported on 2000 years of fire history in giant sequoia groves in California. He found that frequent small fires occurred during a warm period from about A.D. 1000 to 1300, and less frequent but more widespread fires occurred during cooler periods from about A.D. 500-1000 and after 1300. Swain (1973) determined from lake sediment analysis in the Boundary Waters Canoe Area in Minnesota that tree species and fire had interacted in complex ways over a 10 000 year period.

An even larger body of science details the numerous effects of wildland fires on ecosystems. It is this knowledge of fire history, fire regimes and fire effects that allows managers to develop strategies for the management of fire in various ecosystems. For those ecosystems that are fire-adapted, fire prescriptions and prescribed fire programs are developed to achieve a variety of resource management objectives. Other ecosystems in the world that are fire sensitive are better served by excluding wildland fires through well organized and staffed fire protection programmes.

1.4 Ecosystem management: use of fire regimes as indicators

The understanding of fire effects is becoming increasingly important to land managers because wildland fire is a disturbance process closely associated with the concept of ecosystem management. Although governmental and private organizations differ on an exact definition of ecosystem management, the goal of sustainability is basic to most approaches (Christensen et al. 1996). This goal focuses on the delivery of goods and services. Christensen et al. (1996) defined ecosystem management as *management driven by explicit goals, executed by policies, protocols, and practices, and made adaptable by monitoring and research based on our best understanding of the ecological interactions and processes necessary to sustain ecosystem structure and function.* This definition places primary emphasis on the sustainability of ecosystem structures and processes necessary to deliver goods and services. Ecosystem management also includes other concepts such as the conservation of biodiversity, sustained yield of multiple resources, and ecosystem health (Salwasser 1994).

Managing fire to achieve beneficial effects and avoid unwanted results poses a complex challenge for natural resource managers (Brown and Smith 2000). Even attempts to eliminate harmful fire can cause long term undesirable consequences, such as increased risk of damaging fire and declining ecosystem health (Covington et al. 1994; Mutch et al. 1993). Fire regimes can be used as indicators to help determine appropriate strategies for wildfire protection and prescribed fire use.

A fire regime refers to the character of fire occurring over long time periods and the immediate effects of fire that generally characterize ecosystems. Descriptions of fire regimes

are general and broad because of the enormous variability of fire in time and space. The fire regime concept brings a degree of order to a complicated body of fire behaviour and fire ecology knowledge; and provides a simplifying means of communicating about the role of fire among technical and non-technical audiences (Brown and Smith 2000).

There have been several different systems used in classifying fire regimes (Heinselman 1978; Agee 1993; Morgan et al. 1998; and Frost 1998). Brown and Smith (2000) classified fire regimes based on fire severity. Use of fire severity as the key component in describing fire regimes is appealing because it relates directly to the effects of disturbance, especially on survival and structure of the dominant vegetation. Brown and Smith (2000) described fire regimes as follows:

- Understorey fire (applies to forests and woodlands)--fires are generally non-lethal to the dominant vegetation and do not substantially change the structure of the dominant vegetation.
- Stand replacement fire (applies to forests, woodlands, shrublands, and grasslands)--fires kill aboveground parts of the dominant vegetation, changing the aboveground structure substantially. Approximately 80 percent or more of the aboveground dominant vegetation is either consumed or dies as a result of fires.
- Mixed severity fire (applies to forests and woodlands)--severity of fire either causes selective mortality in dominant vegetation, depending on different tree species' susceptibility to fire, or varies between understorey and stand replacement.
- Non-fire regime--little or no occurrence of natural fire.

Generally, the severity and intensity of fires are inversely related to fire frequency (Swetnam 1993). For example, stand replacement fires tend to occur in forests with low fire frequency, and understorey to mixed severity fires tend to occur in forests with high fire frequency (Brown and Smith 2000). Considerable variability exists within this generalization. The role of fire can be understood and communicated through the use of fire regimes. Significant changes in the role of fire due to management actions or possible shifts in climate can be described by shifts in fire regimes. Thus, fire regimes can be used to understand the past role of fire, current changes in fire regimes due to management actions, and as indicators to guide future management through more sustainable practices and policies.

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2 Africa Region Fire Assessment

2.1 Introduction

The Africa region report is divided into a regional introduction and summary and three sub-regional sections: 1) tropical and non-tropical southern Africa, 2) west moist and central Africa, and 3) west and east Sahelian Africa. A number of selected country reports provide examples and insight into fire conditions. For other countries, brief descriptions are provided as well as bibliographic or Internet references. The north African countries are included in the Mediterranean fire report (Europe region).

In this introductory section various manuscripts authored by Winston S. W. Trollope (Department Livestock and Pasture Science, Faculty of Agriculture, University Fort Hare, Alice, South Africa) have been used, notably Trollope (2000). The introduction to southern Africa is from the regional analysis of vegetation and fire regimes by Brian van Wilgen and Robert J. Scholes (1997).

2.1.1 The fire environment, fire regimes and the ecological role of fire in the region

Africa is often referred to as the "fire continent" due to the regular and widespread occurrence of vegetation fires. This description is equally pertinent to southern, west and east Africa where the savannah biome is a major plant community. The capacity of Africa to support fire stems from the fact that climatic factors are the driving force of fire ecology and the main requirement for fire to occur anywhere on earth is to have lightning as the primary ignition source and climatic conditions that permit the ignition of vegetation and the spread of fires caused by lightning strikes. Africa is a continent that is highly prone to lightning storms and has a fire climate with both dry and wet periods, during which fires can burn the plant fuels produced and accumulated during the wet, rainy period. Although in the past lightning was the primary ignition source of fires in the Africa savannahs, the stage has now been reached that humans have become more important than lightning as a source of ignition (Goldammer and Crutzen 1993). Africa also has the most extensive area of tropical savannah in the world, characterised by a grassy understorey that becomes extremely flammable during the dry season.

As a result, burning is recognised as an important ecological factor in the savannah ecosystems of Africa. Research on the effects of fire on the biotic and abiotic components of the ecosystem has been conducted since the early twentieth century. This has given a general understanding of the effects of the type and intensity of fire as well as the season and frequency of burning on the grass and tree components of the vegetation. This in turn has clarified the use of fire as a range management practice and viable burning programs have been developed for savannah areas used for livestock production, game farming and nature conservation.

Areas that can be classified as "Forest and Other Wooded Land" and are regularly subjected to fire are much smaller than the area of the savannah biome.

2.1.2 Summary of major wildfire impacts on people, property and natural resources during the 1990s

During the 1980s and 1990s, several extended drought periods affected regional fire occurrence in Africa. The years 1982-1983 were greatly influenced by the El Niño-Southern Oscillation (ENSO) event highlighted in the Asia regional report. The ENSO caused an extended drought in western Africa leading to extreme fire occurrence. A report from Côte d'Ivoire reveals that more than 60 000 ha of forests and 108 000 ha of coffee and cacao plantations were destroyed by wildfires. Between 1983 and 1994 wildfires destroyed more than 70 000 homes and killed 77 people (Anonymous 1996).

The impact of extended droughts on savannah and open woodland ecosystems of southern Africa (including other wooded land), however, often results in decreased fire activity. The extended drought that affected southern Africa in 1991-1992 reportedly led to a decrease in the productivity of grasses that constitute the fuels that carry fire through the grass savannas and open woodlands (van Wilgen et al. 1997a). Scarcity of grazing resources for wildlife and domestic animals further reduced fuel loads below critical thresholds (a minimum of 0.5 to 1 t/ha of grass fuel is needed to carry a fire) so that the overall amount of fuels available for wildland fires decreased.

The consequences of extreme droughts on afro-montane forests are described in the Ethiopia country report that is part of this regional analysis. Increasing land-use pressure, especially in the context of food shortages and famine associated with drought, led to an increase of fire use and escaped wildfires in these highly fire-vulnerable ecosystems.

The impacts of wildfires in Benin, Ethiopia, Kenya, Mozambique, Namibia, Senegal, South Africa and the Sudan are described in the country reports of this regional study. For emissions from vegetation fires in Africa, see under Fire Research.

2.1.3 Fire management organizations in the region

<u>National</u>

The Organizational arrangements and procedures of national and local fire management systems vary from country to country.

In the years after 1983, forest and bush fire control became an important priority of the environmental protection policy of the government of Côte d'Ivoire (Anonymous 1996). In 1986 a National Committee of Forest Protection and Bush Fire Control was formed. Personnel of the Forest Service fill the positions of the General Secretariat and the Presidency of the National Committee. These bodies coordinate the participation of 14 ministries involved in national programs. The task of this committee is to raise the awareness of the population of the damage caused by fires, the need for fire prevention and techniques for extinguishing fires. On the administrative level, 1 500 Village Committees, 57 Local Committees and 32 Regional Committees were created to decentralize the task of fire control during the last ten years. These committees consist of elected members, a secretary and a president. The committees work to raise consciousness of fire threats and inform the public about fire prevention. The office of the Secretary General and the regional

divisions support them in an advisory role and also play an important role in monitoring the current forest fire situation at the national level. The contracts with the committees are paid monthly (during the four months of the dry season). The remuneration is inversely proportional to the size of the area affected by fire (Oura 1999). The basis of payment is:

- F CFA 500 000 (US$1000) per month per committee for 0 ha burned
- F CFA 400 000 (US$800) per month for less than 5 ha burned
- F CFA 200 000 (US$500) per month for less than 10 ha burned
- F CFA 50 000 (US$100) per month for less than 20 ha burned

The average cost of surveillance is about F CFA 3 000 (US$7) per ha per year for forest plantations and F CFA 1 000 (US$2) per ha per year for natural vegetation.

In Bénin, Local Fire Committees have been created in the villages for fire prevention, detection, and suppression in collaboration with forest rangers and local agricultural officers (see Bénin country report). After disastrous fires in 1983, Ghana also established a National Anti-Bush Fire Committee in 1984.

For other national fire management systems see the country reports of this regional study. FAO (1996) and Goldammer and de Ronde (2001) give general recommendations for fire management in Africa.

Regional

Attempts to organize regional fire management efforts in the Southern African Development Community (SADC) zone were made in the 1990s. The member states of SADC include Angola, Lesotho, Mauritius, Namibia, Swaziland, Zambia, Botswana, Malawi, Mozambique, Republic of the Congo and Seychelles. In 1992, during discussions between representatives of the Forestry Sector Technical Coordination Unit (FSTCU) of SADC and the USDA Forest Service, the possibility of a SADC-wide regional forest fire management system was raised. This led to terms of reference in 1994 for an investigation or review of the situation in each country. A project team, consisting of experts from the United States and Canada, conducted the review and prepared a report on the findings and recommendations. These were discussed at a meeting in Lusaka in November 1995 attended by representatives of 11 of the then 12 SADC countries and by the project team. A follow-up report was produced in February 1996. FSTCU is still seeking assistance in implementing the projects that have been identified. For details see Kromhout (1999). The SADC concept was supported by the recommendations of the Namibia Round Table on Fire in 1998.

2.1.4 Fire databases

The average extent of vegetation affected by wildfires in sub-Saharan Africa, including inter-annual variability of area burned, is not exactly known. However, an increasing number of national and regional studies using remote sensing data have been completed. The country reports of the Central African Republic, Namibia and Sénégal, as well as the introduction to the report on southern Africa (van Wilgen and Scholes 1997, Kendall et al. 1997) and other studies reveal the magnitude of fire activity as assessed by satellite remote

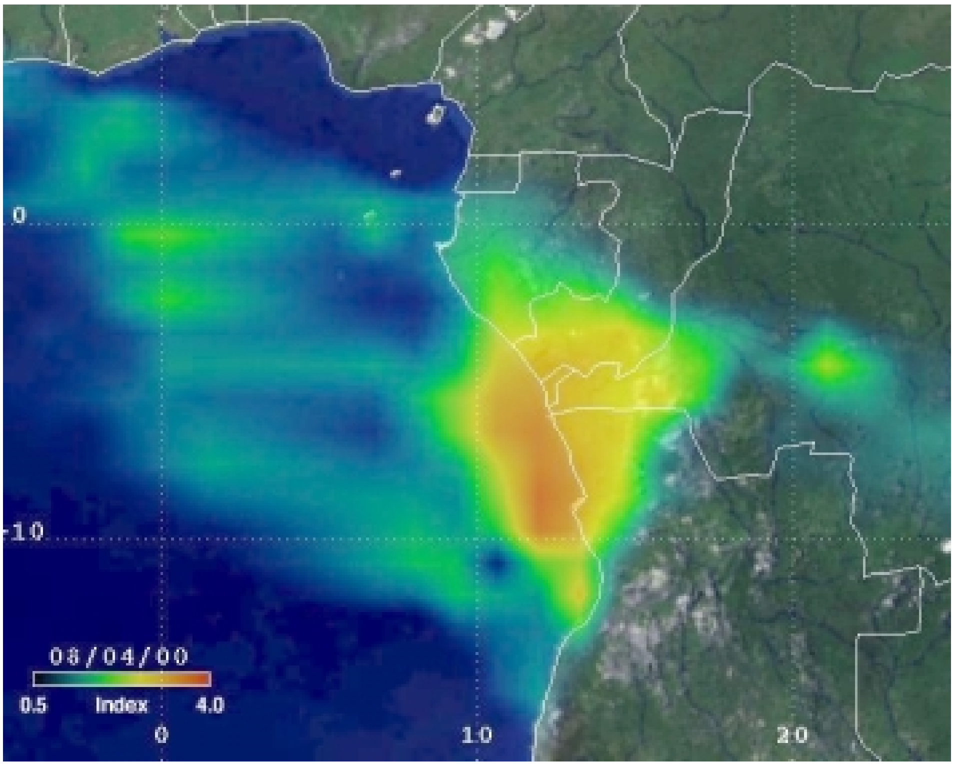
sensing. The following case studies using remote sensing or modelling illustrate the magnitude of wildfires that affect forest and non-forest ecosystems:

- Benin: 7.5 million ha of forests exposed to fire annually (see country report)
- Botswana, 1996 and 1998: 6.2 and 3 million ha of vegetated land burned (source: Botswana Department of Meteorological Services)
- Namibia, 1997: 3 million ha of vegetated land burned (Trigg 2000)
- Sénégal, 1995-1996: >0.5 million ha of vegetated land burned (see country report)
- Sudan: 60 million ha of vegetated land exposed to fire annually (see country report)
- Sub-equatorial Africa: ca. 170 million ha of vegetated land burned (Scholes et al. 1996)

However, these remote sensing products, obtained from country or regional studies, do not provide any information on the impact of wildfires in the degradation of forests, other wooded lands and other lands.

Several regional and global satellite remote sensing studies have generated useful products that show the distribution of pan-African fire activities in time and space. The evaluation of DMSP data (NOAA-NESDIS 2000), the ESRIN ATSR Fire Atlas (ESRIN 2000a) and the ESRIN AVHRR Fire Atlas (ESRIN 2000b) as well as the ongoing work of the regional African nodes of the World Fire Web are the most prominent examples (WFW 2000). Regional African and global burned area assessments using NOAA AVHRR and ATSR data are currently in preparation.

Total Ozone Mapping Spectrometer (TOMS) products depict emissions from forest and other vegetation fires. Earth Probe TOMS, launched on 2 July 1996, shows aerosols emitted from vegetation fires, desert dust storms and other sources. Figure 2-1 shows a smoke plume generated by fires in northern Angola, Zaire and the Republic of Congo on 4 August 2000.



Source: NASA.

Figure 2-1 Smoke from vegetation fires burning in northern Angola, Zaire and the Republic of Congo on 4 August 2000, depicted by the Total Ozone Mapping Spectrometer (TOMS).

2.1.5 *Use of prescribed fire*

The following remarks are based on Trollope and Trollope (1999), de Ronde et al. (1990), de Ronde (1999, 2000) and van Wilgen et al. (1990).

Forestry

In Namibia specific guidelines have been formulated for the management of forested areas where fire occurs as a natural factor of the environment. The primary reason for prescribed burning in these areas is to reduce fuel loads in order to reduce fire intensity, thereby reducing the negative effect of fires on the recruitment and development of valuable timber species like *Baikiaea plurijuga* (teak) and *Pterocarpus angolensis* (kiaat).

The use of prescribed fire for fuel reduction in forest plantations has been promoted in Africa for many years. The main candidates for prescribed burning are pine (*Pinus* spp.) plantations.

Nature Conservation

Prescribed fire is commonly used in South Africa to maintain biodiversity in sclerophyllous shrubland (fynbos) ecosystems, including the prevention of tree invasion.

The usual reasons for burning rangeland in nature conservation areas are:

- to remove moribund and/or unacceptable grass material;
- to control and/or prevent the encroachment of undesirable plants; and
- to encourage wildlife to move to less preferred areas in order to minimise the overgrazing of preferred areas. Such burns are normally coordinated with the two preceding reasons if possible

Livestock farming

The reasons for burning rangeland for livestock farming are:

- to remove moribund and/or unacceptable grass material; and
- to control and/or prevent the encroachment of undesirable plants.

An often-quoted reason for burning rangeland is to stimulate out-of-season green growth. This is often done during the late growing season or late dry season to provide grazing for livestock. This practice is completely unacceptable because:

- it reduces the vigour of the grass sward;
- it reduces the canopy and basal cover of the grass sward;
- it increases the runoff of rain water; and
- it can result in increased soil erosion.

Production of grass thatching material

Prescribed burning for the production of grass thatching material is apparently unique to Namibia where it is widely practised in the northeastern regions in areas receiving higher rainfall (700 mm per annum) or that are subject to annual flooding. The primary reason for controlled burning is to remove old dead thatching material that has accumulated after harvesting so as to ensure the production of new, high quality material.

2.1.6 Public policies affecting wildfire impacts

Most countries in Africa have adopted national policies that give priority to wildfire prevention through public education and raising awareness. Laws in many countries impose restrictions on the use of fire for shifting cultivation or other land clearing activities and the use of prescribed fire (e.g., prescriptions for early burning). However, the effective enforcement of these regulations varies from country to country.

Three African nations recently initiated major steps toward improved legislation and/or strategic planning of national fire management programmes (see country reports). In 1998, South Africa released the National Veld and Forest Fire Act (von Krosigk 1999). Namibia initiated a national fire management strategy by calling for a Round Table on Fire Management in 1998 (Goldammer 1998, 1999) and preparing national guidelines on fire management (Jurvélius 2000) in accordance with the international ITTO Guidelines on Fire Management in Tropical Forests (ITTO 1997). After disastrous forest fires in early 2000, Ethiopia also convened a National Round Table on Fire Management and drafted a long-term perspective for the establishment of fire management capability in the country.

A general remark by W.S.W. Trollope concerning the state of fire management in Kenya and Namibia is applicable to most African nations:

"Insights into the ecology and use of fire in these countries are very poorly developed at practitioner, scientific and government levels. A possible exception to this in both countries is the conventional wisdom on fire ecology that still exists in the older members of tribal communities. However, virtually no effort is being made to capture this conventional wisdom about fire ecology and it is bound to disappear with time with the demise of these senior members of society. The only viable solution to the problem is for the scientific communities in Namibia and Kenya to develop management orientated research programs on fire. These must be aimed at providing information on the effects of the different components of the fire regime on the biotic and abiotic components of the ecosystem. This will enable the formulation of ecologically viable controlled burning programs involving recommendations on the type and intensity of fire and season and frequency of burning required for the different valid reasons for burning. Finally these research programs must include the development of simplified techniques for assessing range condition that can be used for assessing whether rangelands need to be burnt or not. Such simplified techniques are required by members of both the advisory services and the land users living in regions where controlled burning is an ecological necessity for different systems of land use."

A Working Group on Africa, which was set up at the FAO expert meeting "Public Policies Affecting Forest Fires" (October 1998), concluded that it was not in a position to make specific policy recommendations but that it was possible to identify key principles that should guide policy making in fire management (FAO 1999):

- Fire management practises should take into account ecological differences/variations, recognising that in some ecosystems, e.g. the Sahelian annual grasslands, fire should be completely excluded, whereas in others, e.g. moist savannahs, it is an essential management tool.
- Fire management must be an integral part of overall land-use policies and practises.
- Fire is a legitimate management tool in a number of African ecosystems.
- Greater regional cooperation is needed in sharing information and resources and taking joint action in relation to fire and its adverse effects.
- Cultural values and socio-economic realities need to be taken into account in formulating policies for different areas, particularly in communicating information and instructions about fire use and management.
- Community-based natural resource management programs require not only the devolution of responsibility from central government to local communities but also increased support for local decision making, including provision of technical information on the effective management of fire.

2.1.7 Sustainable land-use practices to reduce wildfire hazards and wildfire risks

A system of agricultural activities integrated into a wildfire prevention system is an economically efficient participatory approach. The concept of fuelbreaks follows the principle of creating fire barriers (or buffer zones) in which the combustible materials (fuels) are modified in such a way that the intensity and rate of spread of a wildfire will be reduced to such an extent that the fire can be suppressed by the means available. Fuelbreaks also provide easier and safer access to a closed forested area for fire fighting.

While firebreaks are constructed in such a way that all plant material is removed and the mineral soil is exposed completely, the concept of fuelbreaks provides for continuation of plant production (or vegetation cover), either by growing trees and/or agricultural crops or by maintaining strips of grazing land. The labour invested in planting and cultivating crops is simultaneously utilized for wildfire hazard reduction.

The social and ecological conditions of Jebel Marra, Sudan, were considered favourable for the use of this system (Goldammer 1991). Restrictions were determined (1) by the site condition (suitability of the sites for agricultural production) and (2) by the distance to the villages from which farmers are to be recruited.

Permanent agro-silvopastoral fuelbreaks offer the advantage of having local farmers actively engaged in fuelbreak maintenance on a permanent basis. Certain crops, such as groundnuts and legumes, are especially suitable because they have little aboveground biomass (fuel) and are harvested completely. In the case of millet, the most important agricultural crop in the area, the contract with the farmer should be written so that all the aboveground plant biomass must be removed immediately after harvest, generally around the beginning of the dry season. Usually the stems of millet are removed only at the end of the dry season. This highly combustible material, if left on site, constitutes a considerable risk that fire would be carried into the adjoining forest plantation). Farmers can be motivated to use the assigned land by providing it on a cost-free base and also by doing the initial ploughing by tractor.

Fuelbreaks that are stocked with wide-spaced trees ("shaded fuelbreaks") are designed as agroforestry or silvopastoral systems. The spacing of trees depends (1) on the demand for light and water by the trees or by the grass grown under them and (2) on the topography of the terrain. The open tree overstorey needs to be carefully thinned and pruned (removing ladder fuels) and the slash and any encroaching brush and tree vegetation must either be disposed of by prescribed fire or cleared mechanically. Shaded fuelbreaks in general are designed to produce high-quality timber (via pruning) in rotation periods that are determined by the timber market (critical diameters).

2.1.8 Community involvement in fire management activities

An Integrated Forest Fire Management (IFFM) program was begun in the northeastern region (Caprivi) of Namibia in 1995 as part of the Namibian-Finland Forestry Programme (Jurvélius and Kawana 1998, 1999). The program consisted of two parts. The first was a very successful large-scale public awareness campaign via roadside billboards, local radio bulletins, pamphlets, village meetings and drama presentations. The campaign focused on school children because experience has shown that they are very successful in transmitting fire awareness to their parents and other members of the community. A particularly powerful extension tool has been fire-related open-air dramas presented at schools and in rural communities by the Caprivi Theatre Group. These plays met with an enthusiastic response because of the professionalism of the actors and participation by the school children. The second component of the program was the construction of cutlines (firebreaks) in the different rural communities. This involved constructing 10- to 15-m-wide cutlines (two cleared strips with a burnt central portion) that have a dual role as a means of applying backfires when controlling wildfires and in the application of controlled burns. The progress made in the construction of cutlines has been most impressive, having increased from 100 km in 1995 to 1 832 km in 1998. This also appears to have contributed to the public awareness campaign as well because both the local community leaders and members of the contract teams constructing the cutlines became very well informed about the necessity for controlling fires and the role cutlines play in achieving this objective.

Finally, an important addition was made to the IFFM program in Namibia in 1999 when the need for controlled burning was recognised as a means of maintaining the ecological well-being of savannah ecosystems. This has resulted in a research program in the Caprivi region to develop simplified techniques to assess whether or not an area of rangeland needs to be burned. The results of this research are currently being analysed. They will enable the IFFM program to develop controlled burning programs based on the ecological requirements of the vegetation for different systems of land use.

Frost (1999) describes the concept and history of another such community-based fire management programme in the Western Province (formerly the Kingdom of Barotseland), Zambia, and the initial steps taken to implement the programme.

2.1.9 Fire research

Extensive research on the impact of wildland fires has been accomplished in the 1990s. The largest international fire research initiative was the Southern Africa Fire-Atmosphere Research Initiative (SAFARI), which was operational in the field and laboratory between 1991 and 1996. The scientific results (JGR 1996) were synoptically published by van Wilgen

et al. (1997) and show the ecological and atmospheric significance of wildland fires in the southern African subcontinent. At the time of writing this report a Southern African Regional Science Initiative (SAFARI-2000) is operational that includes a fire research component (SAFARI 2000). Numerous other fire research projects have been conducted in other parts of Africa.

Gas and aerosol emissions from vegetation fires in Africa have been assessed by numerous research groups and have recently been re-evaluated (Scholes and Andreae 2000). This report indicates that fires in African savannah ecosystems account for about 22 percent of the phytomass burned globally. In Africa more phytomass is apparently burned in shifting cultivation than in deforestation (permanent conversion of forest to other land-use systems). However, reliable data on emissions from forest conversion burning are not available.

The prevailing dry conditions during the fire season and the dryness of fuels exposed to fire results in high fire intensities and the export of smoke, which is lifted into the troposphere. Thus, unlike the near-ground pollution of smoke from of forest conversion burning and peat fires in Southeast Asia, smoke from the majority of wildland fires in Africa does not pose a critical threat to human health. However, the consequences to atmospheric chemistry are very significant, e.g. the seasonal increase of tropospheric ozone concentration in the southern hemisphere. Vegetation burning in Africa contributes to the emission of radiatively active trace gases. An increase in the anthropogenic greenhouse effect depends on the fate of carbon and the regeneration potential of forest and other vegetation after fire. Cyclic and sustainable burning of African savannahs and woodlands does not lead to a net increase of atmospheric carbon. However, forests that are degraded or destroyed by fire contribute to a net increase of carbon. Increased deforestation and associated fire in the Guineo-Congolian rainforests or the afro-montane and coastal forests will certainly contribute to a net release of carbon into the atmosphere.

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SAFARI 2000. www.safari2000.org ; http://safari.gecp.virginia.edu

2.2 Tropical and non-tropical southern Africa

The state of knowledge of fire regimes in African forest and non-forest ecosystems is best developed in tropical and non-tropical southern Africa. Thus, special emphasis is given to this region. The editor is greatly indebted to Brian van Wilgen, Robert Scholes and the University of Witwatersrand Press, Johannesburg, South Africa, for permission to partially reproduce the book chapter cited (Van Wilgen and Scholes 1997). Country reports of Mozambique, Namibia and South Africa are provided in full.

Determinants of fire in Southern Hemisphere Africa

The occurrence of fire in the different vegetation types of Southern Africa is dependent on several factors. The vegetation providing the fuel available for fires is a product of both the soil and the prevailing climate. Climatic conditions conducive to fire must also be present, as must a source of ignition. Herbivory competes with fires for the available grass fuels, and may prevent fires in some areas as fuels are eaten before they can burn. Finally, human intervention through active management can materially affect the occurrence of fires.

Climatic conditions as a determinant of fire

The climates of southern hemisphere Africa range from continuously very wet in the equatorial regions of the western side of the continent and at high altitudes on some of the mountains of the eastern side, to very arid in the southwest and northeast. Associated with this aridity gradient is increasing seasonality of rainfall. The rainfall over most of the range is concentrated into one or two rainy seasons (the latter in the monsoonal climates of East Africa). The rainy season is generally in the summer. In the extreme southwest there is a winter rainfall region dominated by evergreen, sclerophyllous shrublands (*fynbos*). Although the hot, dry summers of this area provide ideal fire conditions, the slower rates of fuel accumulation and the coarser nature of the fuels results in much longer intervals between fires (between ten to twenty years).

The largest portion of southern hemisphere Africa therefore experiences a climate in which there is a prolonged dry period every year during winter. The atmosphere is warm and dry due to the high radiation, and fine fuels readily dry out sufficiently to ignite. These climates coincide with the distribution of savannahs (in the broad sense), shrublands and grasslands. We will argue that this coincidence is not accidental: the existence of this fire climate is one of the main factors determining the distribution of these vegetation types.

Climate also has an indirect influence on fire frequency and intensity through its control on the rate of fuel accumulation. The most important factor controlling aboveground primary production is the water balance of the site, followed by the fertility of the soil. At the regional scale, plant water availability is positively related to mean annual rainfall, whereas site fertility is negatively related to rainfall. The arid areas of southern hemisphere Africa burn infrequently because there is rarely enough fuel present to carry a fire across the landscape (a minimum of about 0.5-1 t/ha is needed). Several years of fuel accumulation or an exceptionally wet growing season, especially in the presence of herbivory, are required to generate this minimum fuel load in arid areas.

Most of the rainfall in southern Africa occurs as convective storms associated with lightning. In areas where there are few human ignition sources, lightning may be the dominant form of ignition, but currently it accounts for only 1-10 percent of the observed ignitions. Lightning is rare during the dry months. It has generally been inferred that the pre-human fire season was therefore concentrated in the early part of the wet season, when lightning occurs but the fuel is still dry enough to ignite.

The meteorological conditions at the time of the fire have a profound influence on fire behaviour. Fire managers make skilful use of the knowledge that high humidity, low air temperature and low wind speed reduce the rate of spread of fires. High fire risk is associated with dry, hot and windy conditions, the coincidence of which is related to the regional macroclimate and very intense fires can result. For example, when air masses spill off the interior plateau they create hot, dry winds (known in South Africa as bergwinds). These bergwind-driven fires are responsible for the confinement of forest patches in the southern Cape to fire-protected locations such as the leeward side of steep slopes and rivers.

Soils and fuel accumulation

The second major factor controlling the rate of fuel accumulation in southern hemisphere Africa is the soil type. In arid environments, an equal amount of rain falling on a clayey soil is less available to plants than if it had fallen on a sandy soil. The reverse can be true in wet environments. More grass grows per unit plant-available water on fertile than infertile soils, but the grass is more nutritious and thus more likely to be eaten by herbivores. Infertile soils are less productive, but the fuel accumulates because it is unpalatable.

Ground fires are rare in southern Africa, with the exception of some organic (peat) soils associated with montane wetlands and low-nutrient tropical wetlands such as the Okavango swamps. When the dynamics of channel formation in the swamps causes the peat to dry out, these soils can ignite and smoulder, sometimes for months on end. In the process, a thick layer of peat is consumed, lowering the land surface and preparing the way for future reflooding.

Herbivory and fuel depletion

Fires and herbivores can be thought of as competitors for grass, since only the grass that is not eaten is available as fuel. To ignore herbivory could therefore lead to serious overestimates of the rate of grass fuel accumulation. Grasses growing in moist, infertile soils are fibrous and have low nutrient content except when they are young (for instance, after a fire). There is insufficient protein in the dry grass to sustain the digestive symbionts of large mammalian herbivores, and little of this grass is eaten. Decomposition rates of the dry, standing grass are low, so fuel accumulates and is burned. If it remains unburned it reduces the primary productivity of the grass sward in subsequent years by shading the new growth, and reduces the secondary productivity by restricting access by herbivores to the more nutritious new leaves. Pastoralists burn off the old growth for these reasons.

On fertile soils (and infertile soils in arid regions, since the nutrient characteristics of a grass depends on its growth rate) the grass is digestible even when dead, and so it is usually eaten rather than burned. Fires only occur in years when abnormally high rainfall causes more grass to grow than the herbivores can consume, or where herbivory is abnormally low.

Effects of management on fire regimes

Traditional practice

Historically, both African pastoralists and hunter-gatherers set fires, especially during the dry season, to create patches of green grass, to supplement the nutrition of domestic stock in the case of pastoralists or to attract game in the case of hunters. Burning begins early in the dry season and continues until the spring rains. The vegetation pattern in landscapes ignited this way is distinctive: it consists of a patchwork of irregularly-shaped overlapping scars of different ages, some large but most quite small.

The first European settlers in southern Africa copied the fire management practices of the Khoi and Bantu people. Despite early attempts to regulate the use of fire, effective legal control on burning practices only began in the twentieth century. The use of fire was officially discouraged in all of the southern African colonies, so the mean fire frequency may have decreased during the colonial period in some areas. Since the 1950s the regulated, periodic use of fire has been promoted as a tool for grazing management. The fires set for grassland management on commercial ranches in South Africa and Zimbabwe are clustered in the late dry season and first few weeks of the wet season, and the aerial impression is of regularly spaced polygons, each a few hundred hectares in extent.

In the miombo woodlands, especially in Zambia, a traditional ash-fertilisation agriculture called chitimene is practised. In one form, the trees over a radius of about 200 m are pollarded and the branches dragged into a central area of about 50 m radius, where they are dried and burned. Crops are planted in the ash bed. After a few years, the patch is abandoned for another.

Policy and laws

Most of the countries of the region have laws regulating vegetation burning. The vigour with which these laws are applied varies greatly among countries and between districts within countries. In general the laws are anti-burning. Examples of fire policies and laws in southern Africa are given in the country reports of South Africa and Namibia.

Ecological considerations

There is much evidence that fire has an important and usually beneficial role in maintaining the diversity, structure and function of southern hemisphere African ecosystems. In nutrient-poor ecosystems the primary production in the seasons following a fire is slightly enhanced relative to unburned areas due to the release of nutrients from the ash. The enhanced nutrients in the new growth are attractive to grazers, which in some environments would not be able to survive without the patchwork of burns. Fire is also one of the key factors in maintaining the competitive balance between trees and grasses in savannahs. Many plant species have growth and reproduction attributes directly linked to the fire cycle, for instance germination, flowering or seed dispersal only after burning. Similar examples can be found for birds and animals, all of which suggest that fire has a long evolutionary history in Africa.

In general, ecologists would like to see the maintenance of a historical fire regime, including its natural variability in time and space. The details of the historical fire regime are unknown.

In most areas it probably peaked in the late dry season, but was unlikely to have been as limited to that period as it is now. The widespread increase in woody biomass in savannahs under commercial management suggests that the current fire frequency and intensity are lower than the historical levels, favouring trees over grass. In intensively managed landscapes, such as parts of South Africa and Zimbabwe, the size of the areas burned is typically a few hundred hectares (the size of a grazing paddock or the area which can be conveniently burned in a morning). Historically the patch sizes would have been much more variable and not repeatedly confined to the same areas.

Major vegetation types and their fuel properties

The vegetation types of southern hemisphere Africa have traditionally been mapped and described on the basis of the species that they contain (a floristic classification) rather than on the basis of their physical structure. The floristic approach results in a large number of classes with no clear association to their fire-related properties. The variation in fire regime within each floristic class can be largely due to structural variations. National-scale maps usually contain more structural information than the continental-scale maps. We therefore used the best-available national vegetation maps for southern Africa to define functional vegetation type units on the basis of their fire ecology (Figure 2-2). The fuel characteristics of the classes are summarised in Table 2-1 and some additional notes are provided below.

Ecologists usually distinguish between total fuel (the maximum amount of vegetation that could burn under the most extreme conditions) and available fuel (the amount of vegetation that actually burns under a given set of conditions). The aboveground biomass of vegetation represents total fuel in some cases, but usually certain categories (for example, the live trunks of large trees) are not included, as they do not burn even under extreme conditions. In order to assess the amount of aboveground biomass consumed in fires, we provide estimates of consumption from the literature where these are available, or from local experience. The most important fuel properties of these vegetation types are summarised in the sections below.

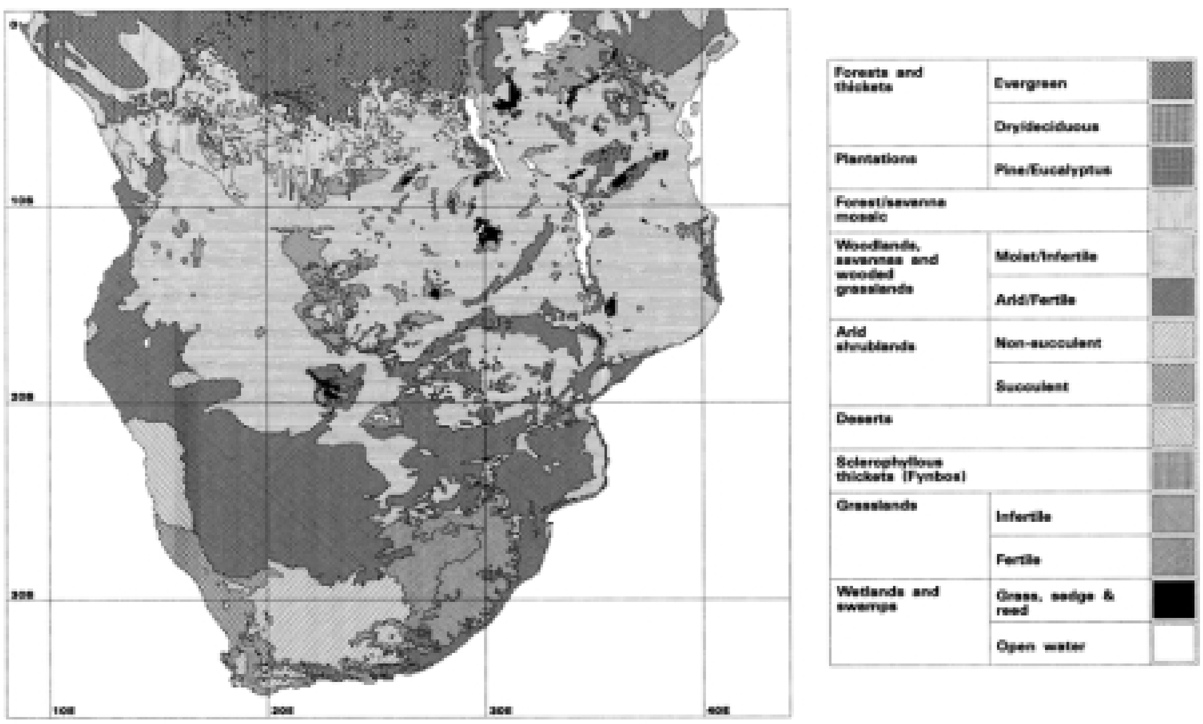

Figure 2-2 Map of southern hemisphere Africa showing the distribution of the most important vegetation types. See Table 2-1 for a description of the vegetation types

Evergreen forest

Most forests (stands of trees ranging in height from 10 to 50 m or more with a continuous multi-layered canopy) in Africa are evergreen or semi-evergreen. These forests have a complex structure, with the many co-dominant species reaching different sizes when mature. The most widespread type is the Guineo-Congolian rainforests of Zaire and neighbouring countries. Swamp and riparian forests are widespread in the Zambezian region but of limited areal extent, while in the eastern half of Africa, afro-montane and coastal forests have a localised and fragmented distribution.

The fuel properties of evergreen forests are poorly studied. In afro-montane forests in the Western Cape province of South Africa, dead fuels were restricted to densely packed litter layers and the canopies of trees were sparse and consisted of live material. Fires in these vegetation types are rare and restricted to occasional extreme fire weather conditions.

Dry/deciduous forests

These forests have a canopy that is near-continuous and multi-layered, dominated by deciduous trees. They occur in areas where there is a two to three month dry period in the year. Areas where the dry season is three to six months in duration support woodlands and savannahs, so the dry forests can be considered as transitional between evergreen forests and woodlands. They also occupy the ridge tops in some areas where the valleys are filled with evergreen forests due to the ridgetop soils being shallower and better drained and therefore having a lower water storage capacity. Dry forests would be more prone to fire than evergreen forests and would therefore burn periodically because of the accumulation of fuel in the form of dry leaf and twig litter.

Plantations

Plantations of non-indigenous trees, predominantly species of *Pinus* and *Eucalyptus,* supply most of the timber needs of countries outside the tropical forest region. The plantations are actively defended against fire, with varying degrees of success. In South Africa, for instance, an average of 6 430 ha (0.5 percent of the planted area of 1.3 million hectares) per annum was burned during 1986-1993. In some plantations, slash resulting from pruning or felling operations is intentionally burned (see initial remarks and country report of South Africa).

Forest/savannah mosaics

Forest/savannah mosaics can be edaphic (determined by soil conditions) or anthropogenic (created by human land use). In the former case, the forests usually occupy either the moist places in the landscape (for example, the valley floors and the southern slopes of steep ridges) or the places that are topographically protected from fire, such as the leeward side of rocky outcrops. Anthropogenic mosaics are created in areas that were formerly forested, particularly through the process of slash-and-burn agriculture. Once the forest cover has been fragmented it is prevented from regeneration by frequent fires or by continuous harvesting of woody regrowth.

Moist/infertile savannahs

Savannahs are vegetation types in which the biomass is shared by trees and grass. Savannahs are the dominant vegetation of the seasonally wet tropics, and are the location of the greatest area of vegetation burned in the world. There are conflicting views regarding the necessity of fire in the creation and maintenance of savannahs. Many studies have shown that the exclusion of fire from savannahs leads to an increase in woody biomass, and this has been interpreted as evidence that fire is essential for the persistence of savannahs. However, in dry environments fire exclusion does not eventually lead to a forest or even woodland, but rather to a denser form of savannah. Clearly competition for water, nutrients and light is also important in determining savannah structure.

The savannahs of Southern Africa can be classified into two broad groups, with a minority of outliers and intermediate cases. The two groups are associated with the broad soil fertility classes described above as well as with the rainfall gradient. The moist/infertile savannahs are identifiable by the predominance of broad-leafed, thornless trees in the families Ceasalpinaceae and Combretaceae. The most extensive example of this vegetation is the miombo woodlands, dominated by *Brachystegia* and *Julbernardia* species, that occupy a broad belt from Angola to Tanzania. A very large fraction of all the biomass burnt in southern Africa occurs in this type. Many miombo ecosystems burn every one to three years, although the area-weighted average is closer to three years. As in all savannahs, the grass fuel load varies inversely with the tree cover. Grass growth is suppressed except where the tree canopy has been opened up, for instance, by ash-fertilisation agriculture. Fallen leaves and twigs can make up a large part of the fuel, especially where the tree cover is high.

Arid/fertile savannahs

Thorny, fine-leafed trees of the families Mimosaceae (predominantly *Acacia* species) and Burseraceae (*Commiphora* spp.) dominate the arid/fertile savannahs. These savannahs are more widespread in the countries south of the Zambezi. The frequency with which they burn varies greatly, depending on rainfall, herbivory and local management practice, but it is seldom more often than once every three years, and probably averages around once every eight to ten years. The fuel is predominantly fine dry grass. Dead tree trunks and dung are a minor part of the available fuel load, but their contribution to emissions is disproportionate to their mass.

The most widespread non-conforming savannah types belong to the *Colophospermum mopane* woodlands. Mopane, a broad-leafed tree belonging to the Ceasalpinaceae, almost completely dominates the tree layer in a broad belt from Northern Namibia to Mozambique. It occurs on base-rich, arid sites, often where the soil profile includes a compacted layer within half a metre of the surface. Mopane woodlands should be treated as arid/fertile savannahs, despite their broad leaves and absence of thorns. The resinous live and dead mopane leaves provide a large part of the fuel, especially in the low-growing scrub form of this vegetation.

Other ecosystems

Fire characteristics of ecosystems other than forest, other wooded lands and arid and moist savannahs include:

- Arid shrublands (e.g. *karoo* in South Africa);
- Succulent arid shrublands;
- Deserts;
- *Fynbos* (sclerophyllous shrubland vegetation of the western and eastern Cape Provinces in South Africa);
- Infertile grasslands;
- Fertile grasslands;
- Wetlands (e.g., the Okavango swamps in Botswana and Lake Bangweulu in Northern Zambia);
- Crop agriculture.

Conclusions

The climate and soils of southern hemisphere Africa are conducive to vegetation types that support fires of moderate intensity. The bulk of these fires occur in savannahs between the latitudes of 5° and 20° S, with other vegetation types, such as grasslands, fynbos and wetlands supporting the balance of fires in the subcontinent. Moist evergreen forests and arid areas that account for 18 percent of the land surface of southern hemisphere Africa are less important in terms of fire.

There can be little doubt that fires are a permanent, inevitable and necessary process that drives the ecology of the savannah, grassland and fynbos areas in southern hemisphere Africa. Other areas (such as fertile areas) may escape fires for longer periods as fuel loads are removed through herbivory, but even these areas burn from time to time. All plants in fire-prone areas have evolved adaptations to cope with fire, and many are even dependent on fire to the degree that they can become locally extinct in areas protected from fire.

The colonisation of Africa by European peoples, many of whom brought an abhorrence of fire with them, was marked by attempts to prevent fires. Such attempts were made for various reasons – to protect forest resources, to prevent the putative destruction of grazing, to protect infrastructure or crops, or in often misguided attempts at the conservation of indigenous plants. As an understanding of the role of fire in the ecology of African vegetation developed, these strategies were replaced by others that recognised and utilised fire as an integral process in the ecology and management of vegetation.

The importance and inevitability of fires in southern hemisphere Africa needs to be recognised in the development of global policies for the management of the atmosphere. While fires in Africa are no doubt an important contributing factor to global emissions, a factor that needs to be understood and quantified, they are not necessarily in the same category as the felling and burning of non-fire-prone tropical forests, or fossil fuels. Calls for the elimination of fire are neither feasible nor even desirable.

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Table 2-1 Fuel properties of major vegetation types in southern hemisphere Africa.

Vegetation type	Fuel structure	Typical fuel loads (g m^{-2}) and consumption in fires (% of biomass)	Sources
Evergreen forests	Evergreen trees with relatively high moisture content and relatively moist, compact litter layers.	The fuel component of aboveground biomass (finer twigs, leaves, and litter) is around 3 500 g m^{-2}. Consumption is poor in most fires (0-10 %), but can be much higher in rare conflagrations (80%?).	van Wilgen *et al*. (1990b)
Dry/deciduous forests	Dry leaves, twigs and fallen dead trees	No data available	No fire related literature exists
Plantations	Evergreen trees with moderate moisture content and compact, often substantial, litter layers, especially under pine stands.	Aboveground biomass is substantial (for example 18 000-25 000 g m^{-2} in mature pine stands) but fuel loads vary. On some sites, needle litter under pines can exceed 15 000 g m^{-2}. Eucalyptus plantations reach 39 400 g m^{-2} at 27 yrs; litter layers below such stands are 3 000 g m^{-2}.	van Laar and van Lill (1978); Bradstock (1981); De Ronde (1984); Morris (1992)
Forest/savannah mosaic	See entries on evergreen forests and savannas; the proportion of forest in these mosaics varies from 5 to 95%.		
Moist infertile Savannas	Erect grass swards with continuous distribution provide fine fuel to support fires. Trees unimportant in carrying fire, but provide woody material for smouldering combustion.	Grass fuel loads of greater than 200 gm^{-2} are needed to support a fire. Total aboveground biomass varies from 500 to 6 000 gm^{-2}, of which up to 4 000 g m^{-2} can be woody vegetation. Fuel consumption of the grass component is efficient (70-80%).	Huntley (1984); Rutherford and Westfall (1986)

Table 2-1. Cont.

Vegetation type	Fuel structure	Typical fuel loads (g m^{-2}) and consumption in fires (% of biomass)	Sources
Arid fertile savannas	Erect grass swards with patchy distribution provide fine fuel to support fires. Trees unimportant in carrying fire, but provide woody material for smouldering combustion. Dung is also common and adds fuel for smouldering combustion.	Fuel consumption of the grass component is slightly less efficient than in infertile savannas, due to the greater patchiness. Within a burned patch, over 90% of the fuel is consumed, but the burned patches may only make up 50% of the landscape.	Trollope and Potgieter (1985)
Non-succulent arid shrublands	Includes sparse grasslands where fuels are not sufficient or continuous enough to support fires.	Fuel loads are insufficient to carry fire except after exceptionally wet years.	No fire-related literature exists
Succulent arid shrublands	Includes or open karroid shrublands where fuels are not sufficient or continuous enough to support fires.	Fuel loads are insufficient to carry fire.	No fire-related literature exists
Deserts	Characterized by an almost complete absence of plant material.	Fuel loads are insufficient to carry fire.	No fire-related literature exists
Fynbos	Complex fuels comprising mixtures of restioid (coarse reed-like plants) and ericoid (fine leaved shrubs) elements, forming a continuous fuel bed below a stratum of broad-leaved sclerophyllous proteoid shrubs.	Largely dependent on post-fire age. Can support fires four years post-fire when fuel loads reach 500 g m^{-2}. Typical fuels range from 1 000 to 3 000 g m^{-2} at 15 yrs post-fire. Maximum fuel loads of > 7 000 g m^{-2} in 40 yr post-fire stands. About 70% of the aboveground biomass is consumed in fires.	Kruger (1977); van Wilgen *et al*. (1985); van Wilgen and van Hensbergen (1992)
Infertile grasslands	Erect grass swards with continuous distribution providing fine fuel to support fires.	Around 600 g m^{-2} for Natal Drakensberg fuels. Fuel consumption component is efficient (70-80%).	Everson *et al*. (1985); Everson *et al*. (1988)

Table 2-1. Cont.

Vegetation type	**Fuel structure**	**Typical fuel loads (g m^{-2}) and consumption in fires (% of biomass)**	**Sources**
Fertile grasslands	Erect grass swards with patchy distribution providing fine fuel to support fires.	Fuel loads of 400-1 450 g m^{-2} recorded in the Serengeti, Tanzania. Combustion efficiencies ranged from 49-86%	Stronach and McNaughton 1989
Wetlands	Reeds and sedges form the aboveground fuels. In places, peaty layers several metres thick develop and can support ground fires.	No data available.	Ellery *et al*. (1989)
Crop agriculture	Only sugar-cane fields burn on a regular basis	Total aboveground (wet) biomass of sugarcane fields averages 5 000 gm^{-2}. Of this, 9% is consumed in fires.	Scholes and van der Merwe (1993)

Table 2-2 Dominant fire regimes of the major vegetation types in southern hemisphere Africa.

Vegetation type	Fire frequency	Fire season	Fire intensity	Fire type	Sources
Evergreen forests	Not usually subject to fire, but can burn at intervals of 100-300 years under extreme weather conditions.	Fires restricted to rare extreme weather conditions, usually in very dry periods.	Crown fires would be rare but intensities high (> 100 000 kW m^{-1}).	Canopy fires under extreme conditions.	van Wilgen *et al*. (1990b)
Dry/deciduous forests	Intervals of 20-100 years	Dry season; generally June to September	Variable; typically low if only litter is consumed, can be very high if stemwood ignites.	Surface or crown fires	No fire-related literature exists
Plantations	Once in 200 years	Fires are accidental; typically in the dry season	250-700 kW m^{-1} for prescribed burns. No data available for wildfires.	Surface fires for prescribed burns or crown fires for wildfires.	De Ronde *et al*. (1990)
Forest/savannah mosaic	See entries on forests and savannas; the components behave independently				
Moist infertile savannas	1-6 years, with a mean frequency of once in 3 years in the Kruger National Park.	Fires are restricted to dry winter periods where grasses are cured or relatively dormant.	Intensities range from <100 to 6 000 kW m^{-1}.	Surface fires in grass layers. Canopies of trees scorched but do not usually contribute to combustion.	van Wilgen and Wills (1988); van Wilgen, Everson and Trollope (1990a); Trollope (1993)

Table 2-2. Cont.

Vegetation type	Fire frequency	Fire season	Fire intensity	Fire type	Sources
Arid fertile savannas	2-11 years, with a mean frequency of once in 8 years in the Kruger National Park; 3-10 years in the Etosha National Park.	Fires are restricted to dry winter periods where grasses are cured or relatively dormant.	Intensities range from < 100 to 4 000 kW m^{-1}.	Surface fires in grass layers. Canopies of trees scorched but do not usually contribute to combustion.	Siegfried (1981); Trollope (1993)
Non-succulent arid shrublands	For practical purposes, fires do not occur here.	For practical purposes, fires do not occur here.	For practical purposes, fires do not occur here.	For practical purposes, fires do not occur here.	Booysen and Tainton (1984)
Succulent arid shrublands	For practical purposes, fires do not occur here.	For practical purposes, fires do not occur here.	For practical purposes, fires do not occur here.	For practical purposes, fires do not occur here.	Booysen and Tainton (1984)
Deserts	For practical purposes, fires do not occur here.	For practical purposes, fires do not occur here.	For practical purposes, fires do not occur here.	For practical purposes, fires do not occur here.	Booysen and Tainton (1984)
Fynbos	Fires occur at intervals of between four and 40 years, with a mean around 15 years.	Fires occur mainly in the dry summer periods, but can occur at other times under suitable weather conditions.	Intensities range from < 500 to > 20 000 kW m^{-1}	Fires in these shrublands can be regarded as canopy fires.	van Wilgen (1984); van Wilgen *et al*. (1985)

Table 2-2. Cont.

Vegetation type	Fire frequency	Fire season	Fire intensity	Fire type	Sources
Infertile grasslands	2-4 years. Annual fires are possible. (Fire frequency averages once in three years in the Natal Drakensberg.)	Fires are restricted to dry winter periods where grasses are cured or relatively dormant.	1 000-3 000 kW m^{-1}	Surface fires only.	Everson *et al*. (1985); van Wilgen, Everson and Trollope (1990a);
Fertile grasslands	4-10 years, with the lower frequencies in the more arid areas.	Fires mainly in the dry winter periods where grasses are cured or relatively dormant.	No data, but would be similar or lower than for montane sour grassland.	Surface fires only.	No fire related literature exists
Wetlands	2-100 years	Fires are restricted to dry winter periods.	No data	Surface fires and ground fires.	Ellery *et al*. (1989)
Crop agriculture	Annual where residue burning is practiced.	May to September	Low	Surface fires	No fire-related literature exists

Table 2-3 Estimates of the quantity of biomass burned in vegetation fires in southern Africa.[1]

Vegetation type	Area in southern hemisphere Africa	Fuel load in June by type			Fraction of area burned annually	Biomass consumed
		Leaf litter	Twigs	Herbaceous		(Tg)
	m^2 x 10^9	gm^{-2}				
Evergreen forest	1036	67	14	0	0.038	9.5
Dry deciduous forest	113	96	47	0	0.181	6.8
Forest/savannah mosaic	716	16	0	91	0.270	21.4
Moist infertile savannah	4177	23	0	88	0.250	88.4
Arid fertile savannah	2140	44	54	60	0.089	29.6
Non-succulent arid shrubland	370	0	0	4	0.011	0.4
Succulent arid shrublands	164	0	0	0	0.000	0
Desert	131	0	0	8	0.001	0.0
Fynbos	74	109	167	235	0.050	2.2
Infertile grassland	371	0	0	137	0.317	10.6
Fertile grassland	267	0	0	147	0.180	3.8
Wetland	42	0	0	252	0.528	4.3
Other (plantations, water etc)	37					
Total	**9638**					**177**

[1] The values are for an average year (nominally 1989) and exclude biomass burned during land clearing (for instance, tropical deforestation) and biomass fuels burned for domestic or industrial energy. The fuel loads are simulated using an empirical plant production, herbivory and decomposition model, driven by rainfall and calibrated for each vegetation type. The fraction of the area burned is determined using a calibrated fire detection algorithm applied to daily NOAA satellite data. The biomass burned column is not simply the product of the preceding columns, since it is an annualised sum, while the fuel load is only reported for a single month. The combustion completeness, not reported here, also varies month by month. Tg = teragrams; 1 teragram = 10^2 grams. Source: Scholes et al. (1996).

2.2.1 Fire Situation in Mozambique

By
Mohamed Saket
ETC UK Ltd.

Fire environment, fire regimes and the ecological role of fire

The natural vegetation cover, which accounts for 78 percent of the country's area, varies from evergreen to deciduous, from mountainous to lowland, gallery and mangrove and from forest to edaphic grasslands.

In a comprehensive description of fire effects on the major vegetation types in Mozambique (de Campos Andrada 1951), six eco-types are recognised:

- Moist (hygrophile) forests in Milange, Gurué, Tacuane, etc. The forest in this moist environment used to be thick and well developed but now openings promote fire events.
- Mesophile forest at medium altitude characterised by a habitat, which is neither very moist nor very dry. Vegetation is composed principally of *Brachystegia* and *Julbernardia globiflora* and it is commonly open with frequent meadows where grass grows tall and thick. Fires in these openings can be very destructive, particularly to young regeneration when frequent burning occurs in late dry season. Older trees are frequently partially burnt and sometimes entirely.
- Low altitude dry (xerophile) vegetation is found relatively close to the littoral zone where the habitat is characterised by intense droughts. The timber rich forest in places such as Derre and Buzi is deciduous. Fire is very destructive to the forest due to the amount of grass.
- Dry to arid forest of *Colophospermum mopane* and/or *Acacia* spp. is associated with low and scarce to non-existing annual grass. Forest fires there are less frequent and less damaging.
- Plateau of Angonia with little or no forest.
- Edaphic grass in Marromeu and Chinde districts of Sofala and Zambezia.

Mozambique is dominated by two main seasons. The hot and wet season lasts from November to April and is followed by the cool and relatively dry period between May and October. Forest fires are linked to the seasons and sporadic fires start in April each year at the beginning of the dry season. Fires increase in intensity by late August to October when the vegetation is completely dry, until the first rains in November or December. The size of burning also follows a similar trend. The average size of early fires from April to June is relatively small compared to that of late dry season due to the high water content of the still green vegetation. As grass layers and leaf litter become drier, burning intensifies and spreads.

According to satellite interpretation in November 1996 (Taquidir 1996) 39.6 percent of the country is affected by fire every year. The northwestern and central parts of the country are the

most affected as 73.6 percent of these areas are burnt annually. The coastal strip with its evergreen to semi-evergreen coastal vegetation has the lowest burning intensity in the country (4.6 percent).

The study shows also that fires have been affecting the low and open woody vegetation such as shrub (57.4 percent), wooded grassland (44.5 percent), thicket (41.2 percent), agriculture lands (49.7 percent). Burning in the forestry formations classified as LF1, LF2 and LF3 oscillates between 27.5 and 37.6 percent annually.

The data on forest burning quoted above is comparable to that of 40 percent reported in the "Manual de Legislação Florestal". The latter information was gathered from a sample of aerial photographs taken at different dates in Mozambique, while the recent data were measured by coverage of Landsat TM images recorded between 1989 and 1992.

Both data sets possibly under-estimated the real size of annual burning, since the early fires are not easy to detect by remote sensing.

The countryside in Mozambique is poorly managed due to resource constraints and has a very low road density. The natural forest has never been put under any sort of management. The road network is insignificant and firebreaks do not exist. Between rivers and streams, the forest is often composed of single blocks ranging from a few hundred to many thousands of hectares. When a fire is set in a forest area, it sweeps the whole area until a river opening halts it. The extent of a fire in any area depends, therefore, on the month of burning, the extent of a single block of vegetation, the wind speed and direction and on other weather conditions such as rain and temperature. Depending on these conditions, a single fire can burn from a few hectares to many thousands of hectares.

With the increase of populations in Mozambique, the requirement for agriculture land as well as for forestry and wildlife products has drastically increased thus increasing pressure on limited resources. Fires have became one of the main tools for land clearing, cultivation and house construction, hunting and timber exploitation. Also, the acquisition of other goods and services from the forest, including charcoal production and honey collection, and protecting resources from wild animals are achieved through the use of fire. These activities, as well as accidents with cigarettes, may lead to uncontrollable wildfires.

Narrative summary of major wildfire impacts on people, property, and natural resources

The scarcity of natural regeneration and the rapid population growth in the rural areas associated with an increased intensity of agriculture activities in the field are indications of a mounting trend of forest fires.

Fires have an unmistakable destructive role on natural vegetation and on bio-diversity. They affect a wide range of aspects of environment as well as peoples' welfare.

Loss in standing timber, very much needed by the national economy, is significant (no figures available).

Natural regeneration is affected by fires, which occur yearly and at increasing rates. If natural regeneration is not sufficient due to increasing fire intensity and logging, a number of species will be threatened e.g. *Pterocarpus angolensis, Millettia stuhlmannii, Milicia excelsa,*

Androstachys jonsonii, Erythrephleum suaveolens, Burkea africana, Dalbergia melanoxylon, etc.
Indications are that forests are becoming less rich in species diversity, more fragmented and poorer in species associations. The remnants of forests are also in the process of losing their characteristics, as various sites are now fragmented forests intermingled with other forms of vegetation. The forests may be shrinking due to the loss of trees by burning incursions. Climbers are disappearing and grass and other herbs are invading the ground. The openings created in the forest canopies exposes shade demanding plants and trees to more light and consequently to physiological disturbances and death. Pioneer trees, which germinate under intensive sunlight, invade the space created after elimination of shade demanding trees by fire.

Impoverished soils produce less biomass and render natural regeneration less successful. Less grass cover exposes the soil surface to torrential runoff and the erosion of upper layers. Less water infiltration keeps the water table deeper, which makes the growth period shorter and eliminates drought susceptible vegetation. Impoverished vegetation cover also degrades wildlife habitat.

Vegetation species in Miombo woodland have developed survival strategies against forest fires but there is a threshold of tolerance. Intensive and frequent fires exceed the defensive capacity of any vegetation. Perennial plants can have their root system alive for years while above ground parts are constantly burnt.

In Cheringoma area for instance, the forest vegetation exhibits different physiognomies including: (a) forests with multi-layers, climbers and lack of grass layer; (b) woodland with open canopy having less than three layers and abundant grass layer and; (c) all appearances in between. The succession from forest to woodland in this area is widespread and apparently a result of fires. For edaphic reasons, woodlands may also occur in the area independently of fire effects.

Fire management organization

Although fire has been recognised as a serious problem affecting social, economic and environmental levels, the Government institutions, especially those specialised in forestry research, have not yet acted to study and contain this problem. While the forestry administration has been strengthening itself over the last two decades, forest fires continue to ravage the resources and contribute to significant changes in the ecosystems.

Wildfire database

Table 2-4 provides a summary of the land area affected by wildland fires. The data are based on the aforementioned case studies and assessments.

Table 2-4 Wildfire database for Mozambique, 1990-1999.

Year	Total No. of Fires on Forest, Other Wooded Land, & Other Land No.	Total Area Burned on Forest, Other Wooded Land, & Other Land ha	Area of Forest Burned ha	Area of Other Wooded Land and Other Land Burned ha	Human Causes No.	Natural Causes No.	Unknown Causes No.
1990		38-40%	28-38%	41-57%	~90%	~5%	~5%
1991		"	"	"	"	"	"
1992		"	"	"	"	"	"
1993		"	"	"	"	"	"
1994		"	"	"	"	"	"
1995		"	"	"	"	"	"
1996		"	"	"	"	"	"
1997		"	"	"	"	"	"
1998		"	"	"	"	"	"
1999		"	"	"	"	"	"
Total		38-40%	28-38%	41-57%	~90%	~5%	~5%

Source: Saket (1999)

Trends of forest fires

Data collected on forest fires using aerial photographs taken during the period of 1950 to 1970 are comparable to that from Landsat images recorded in 1989-92. Both studies were carried out to determine the extent of annual fires. The two periods were characterised by similar political events. The first period covers the liberation war when a large proportion of the local population had left their areas of origin. The second was marked by the civil war, which affected all the country and disrupted population distribution, with displacement of the rural population to refugee camps along security safe corridors and to neighbouring countries. In spite of the exodus of the local people from their areas of origin during the eighties, wildfires continued to sweep over 40 percent of the country. The question now is what will be the trend of forest fires after the return of the local people has been completed to their areas of origin?

Information on forest fires from the previous decades is not available or is scarce and poor. A few sporadic publications are available in DNFFB from colonial times but these only served to create public awareness.

Fire Management and use of prescribed fire to achieve resource management objectives

In a recent report on the fire situation in Mozambique, Saket (1999) stresses that fire management is the most important component in any technical proposal for forest management planning in Mozambique, owing to the degree to which fire affects the flora and to the damage it causes annually. The role of the local people in fire management is also central to any Government fire control strategy or plan. Local support is needed for sustainable timber exploitation and for the forest to continue to provide the people's needs with various forestry products and services.

Complete exclusion of fires from the forest is very unlikely. In the fire-conditioned forest ecology, complete exclusion of fire will probably lead to different species mixes, especially in the littoral and more particularly in the Cheringoma area, where forest physiognomy will likely regain ground.

Controlled fires in the Cheringoma, by reducing fire frequencies and limiting their occurrences in the early dry season (May-June), are also likely to produce new compositions and new vegetation associations within the natural flora. It will save large proportion of the new regeneration from destruction.

Thus, the following fire management directives are recommended:

- The forestry services at national, provincial, district and local levels should campaign for control of fires every year before the end of the wet season. Meetings with local community leaders and farmers should be held every year in February-March to highlight the fire consequences affecting the people's well being. This would also be an opportunity to describe the Government strategy for the combat of fire, introduce fire control techniques and inform people about the legislative implications.

- Legislation should encompass fire control measures as well as punitive measures in case of infractions and recidivism.

- Use of fire around households and cultivation fields within or near forests should be limited to wet seasons and to early dry seasons (January-June).

- Areas set on fire should be separated from the forest by firebreaks not less than 5m wide and should be monitored by the person who set it until its full extinction. Fires that spread to the forest should be reported to the local authorities for action. Any fire that reaches the forest and spreads there and is not reported to the relevant authorities should be investigated. Those who set the fire should maintain responsibility for it according to the legislation in force.

- Starting fires in the forest during the period extending from July to December should be completely forbidden. Fires in that period expose those responsible for ignition to judiciary measures in accordance with the legislation in force.

- Starting fires out of the fire period for any reason (timber exploitation, stimulate germination of fire demanding seeds, etc.) should be authorised by the forestry and wildlife authorities. Intervals between two successive fires on the same area should not occur below a minimum of 8 years. Fire should be restricted to the area of interest.

- All forest roads should be graded in May-June every year to serve as fire breaks.

- Limits of timber as well as wildlife concession areas should follow natural boundaries (rivers, streams, water divide, etc). Concessions not separated by natural openings, such as rivers, should be delimited by 10 metre firebreaks that are graded or weeded annually.

- Fire Control Units should be set up with the mandate to campaign for forest fire control, apply legislation when is necessary and implement fire prevention techniques.

- Natural forests should be put under a management system. Management plans should include fire management direction subdividing the area into compartments separated by firebreaks. The participatory and integrated management plans will alleviate the state responsibilities in fire control by involving the private sector and local communities.

The need to integrate the use of prescribed fir in forest and other vegetation management is underscored by Saket (1999) who recommends prescribed burning at the levels of a concession area (Table 2-5).

Table 2-5 Recommendations for fire management (fire control and prescribed burning) at the levels of a concession area.

Forest types	Fire management
Closed forest	No fire. In case it happens extinguish as soon as possible
Open forest	Periodic burning is desirable
- Natural regeneration	Burn every 8 years in early dry season
- Late sapling and thicket height	Burn every 4 years in early dry season
- Fire declared in shorter period in open forest should be extinguished as soon as possible	
Grassland	Burn annually in early dry season. Elimination of grass reduces the fire hazards in the surrounding forests

Source: Saket (1999)

Public policies affecting wildfires and fire management

From the early forties, the foresters in Mozambique have joined their colleagues in other parts of Africa in the long debate on social and environmental roles of the bush fires. They have expressed concern on the trends of fires and put forward ideas for their regulation and control. It has been suggested that:

- Fires should only be started when there is urgent need for it.
- Fires should be only started with permission from the relevant authorities.
- Farmers and local people should take appropriate measures to avoid fires from encroaching into the forest areas.

The 1921 forestry legislation prohibited making fires and clearing forestry vegetation under the shifting cultivation system. In a decree of 1928, the Governor of Mozambique underlined the prohibition of use of fire in the forests, but with apparently less emphasis. Article13 of the decree stipulated that the local authorities should avoid, whenever possible, big fires and itinerant agriculture.

However, forest fires are not properly featured in the Government policy for the sector. The forestry legislation fell short of expectations with respect to concrete measures for the nation-wide combat of fires and setting up a widely accepted and effective fire control system.

Acknowledgements

The country brief is based on a report by Saket (1999). Additional bibliographic sources are provided.

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Source

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2.2.2 Fire Situation in Namibia

By
Simon Trigg
Oshakati, Namibia & Natural Resources Institute, University of Greenwich, United Kingdom
&
Johan le Roux
Etosha Ecological Institute Okaukuejo, Namibia

Fire Environment, Fire Regime & Ecological Role

Introduction

Namibia lies in the west of Southern Africa, bordering Botswana and South Africa to the east and the Atlantic Ocean to the west, and covers an area of approximately 824 000 km.

Large areas burn each year, with more than 3 million hectares estimated to have burned in 1997 alone. Excessive, indiscriminate burning is having highly negative effects on some ecosystems, while in other areas fire frequencies are more in equilibrium with requirements for long-term stability of existing vegetation communities (Goldammer 1998).

Fires burn during Namibia's severe dry season from April to October. The vast majority occurs as surface fires that spread in the grass and shrub layer. Crown fires and ground fires occur over only limited geographical areas. The amount and connectivity of the predominant grass and shrub fuel is highly variable spatially and temporally, controlled by a severe rainfall gradient oriented in an approximately SW to NE direction. This means that the most frequent, intense and extensive fires occur in the north and particularly in the northeast, while in the south and west fires rarely occur. Figure 2-3 shows a burned area map of the fire-prone areas of Namibia (derived from remote sensing) and demonstrates how the size and extent of burned areas increases from SW to NE.

Lightning fire is the most significant natural cause, but accounts for a small percentage of all fires. The majority of fires are ignited by people, either deliberately or accidentally.

Table 2-6 describes the broad fire environment and fire regimes for six different zones (Figure 2-4). The zoning into different fire regime areas in Figure 2-4 is based on the GIS-based analysis of different maps of land use, rainfall, vegetation and maps of burned areas (e.g. Figure 2-3).

Ecological Roles of fire in the six zones

In Zone 1, the desert fringe of western Namibia, fire is so infrequent that its ecological role can be discounted.

In Zone 2, the fuel load is so low and fires are so infrequent that fire plays a limited but positive role in removing material.

In Zone 3, fires are generally not desired as the resulting loss of fodder may constrain pastoralism. Therefore, in cases where fires occur, coordinated efforts are made to put them out quickly. This means fires rarely spread over very large areas. However, decades of fire exclusion have contributed to severe bush encroachment over extensive areas.

In Zone 4, the Etosha National Park, fire is managed according to a block burning strategy designed to promote the maintenance and, in special cases, to increase the biotic diversity. Fires prescribed by management result in reduction of moribund material, regeneration of palatable grasses, control of bush encroachment and prevention of severe fire hazard by reducing the fuel load (Du Plessis 1997).

In Zone 5, fires are perceived negatively, although few coordinated efforts are made to put them out. In years with sufficient fuel load and continuity, fires can spread over very large areas. High livestock density and grazing pressure maintain the fuel load at relatively low levels that limit fire intensity. Ecological impacts are therefore small and tend to do little more than prevent moribund material from accumulating in the herbaceous layer. Fire does not pose a serious threat to forested or wooded areas within this zone.

In Zone 6, high fire frequency and high shrub/grass biomass pose a serious threat to the large areas of wooded land and forest present by converting important areas of forest and wooded land into shrubland with very few mature trees. Succession of the shrubland to mature wooded land and the survival of many seedlings is prevented by subsequent high frequency fire. In Mopane/Terminalia woodland, fire tends to prevent bush encroachment. In areas of Other Land, fire plays an important role in the regeneration of grasslands.

Wildfire impacts

Important impacts occur mainly in zones three to six. In Zone 6, large areas of wooded and forested land have been damaged by high frequency fire, with a significant reduction in areas of commercial and non-commercial timber resources, loss of habitat, reduction in woodland biodiversity, and losses of wood resources for domestic use. The high fire frequencies also promote the establishment of fire-resistant, but often less useful woody species, such as *Dichrostachys cinerea*. Fires have also killed large mammals, with peat ground fires in the Malangalenga area of Caprivi killing 170 buffalo in 1996 alone. (Mendelsohn and Roberts 1997). During the height of the dry season, large smoke plumes and high levels of background smoke are present, although any effects of reduced air quality upon public health are yet to be quantified. In Zones 3 and 5, the removal of pasture by fire is a highly undesired impact that can threaten survival of livestock. This situation is compounded during years when rains fail after burning. In Zone 4, the active management of fire aims to promote beneficial impacts, and adverse impacts are rare.

In exceptional cases, people are trapped and receive fatal burns. Centralised figures on the different impacts are unavailable.

Fire Database

Fire statistics are not yet compiled or aggregated to the national level, and resources for obtaining fire statistics in the field are limited. By far the most comprehensive surveys of active fires and areas burned have been made using image data from the Advanced Very High Resolution Radiometer (AVHRR) sensor onboard the U.S. NOAA (National Oceanic and

Atmospheric Administration) satellite series (Cracknell 1997). Maps and statistics have been compiled for north-central and northeast Namibia (primarily Zones 4, 5 and much of Zone 6), with the whole of Namibia mapped for just 1997 (Trigg 1997, 1998; Le Roux *pers. com.*). Based on AVHRR data, fire frequency maps have been prepared for much of Zones 5 and 6 and all of Zone 4.

Fire numbers

Due to difficulties in determining independent ignitions from active fires detected using AVHRR, there are no reliable statistics on fire numbers.

Area burned

AVHRR-based burned area maps are available for five consecutive burning seasons (1994-1998 inclusive) for all of Zone 4 area and for the majority of the most fire prone area of Zone 5. They are also available for the most fire-prone part of Zone 6, for four consecutive burning seasons (1996-1999 inclusive). Figure 2-5 to Figure 2-8 are all based on these remotely sensed data.

Figure 2-5 shows the areas that burned each year in the different zones. Zones 4 and 5 are characterised by high variability between years. In zone 6, fire is much less variable, with large areas burned every year.

Figure 2-6 shows that in zones four and five, only a small percentage of the land burned during the years under consideration, whereas in zone six, some 40 to 60 percent of the land has burned every year.

Examination of an image showing how many times Zone 6 burned during the four year period 1996-1999 (Figure 2-7), reveals that some 10 percent of the land area burns every year, and that most of the area burned between two and four times. The small unburned areas are coincident with areas of high population pressures and high livestock numbers, and consequently little combustible biomass. As mentioned, the high return period of fire poses a serious threat to the survival of the large areas of wooded land and forest remaining in Caprivi.

It is evident from Figure 2-8 that the vast majority of Zones 4 and 5 did not burn in the five year period under consideration, with a distribution skewed towards relatively low fire frequency. The more normal distributions in the two sub-areas of zone 6 illustrate that fires occur much more frequently, with more than 10 percent of the area to the east of 21°E having burned every year (Figure 2-8D).

Causes of fire

In Zone 6, people light the majority of fires for many reasons. Those reasons include: to stimulate the growth of fresh grass for cattle, to attract game, to flush out game that can then be hunted, to clear vegetation around waterholes and honey-gathering areas, to clear land for cultivation, or to promote the regeneration of grasses used for thatching. Arson also occurs. As most fires occur at times with no convective thunderstorm activity, it is clear that lightning plays a relatively minor role (Mendelsohn and Roberts 1997).

In Zones 3 and 5, fires originate either as a result of lightning strikes during convective storms at the beginning or the end of the burning season, or are started accidentally during charcoal making or from inadequately supervised camp fires, or careless use of cigarettes. In zone five,

large areas are sometimes burned accidentally as the uncontrolled extension of fires deliberately lit to clear new fields.
In Zone 4, fires are ignited mainly by lightning and park management and occasionally by accident.
In Zones 1 and 2, the rare fires that occur are started mainly by accidental ignition and lightning.

Operational fire management systems and/or Organizations

Fire is managed over the full extent of Zone 4 (Etosha National Park) by the Directorate of Resource Management of the Ministry of Environment and Tourism. Part of East Caprivi within Zone 6 is managed by local communities mobilised by the Directorate of Forestry. In Zones 2 and 3, farmers' associations are concerned with fire suppression, although their links to central government is yet to be formalised.

Fire prevention

Large scale fire prevention occurs only in Zones 4 and 6. In Zone 4, Park management actively prevents fires from entering the Park from neighbouring areas. The Park itself is divided into fire management blocks separated by well-maintained fire breaks. Fires naturally occurring within any block are actively contained within that block. In Zone 6, communities mobilised by the Directorate of Forestry, with support from the Finnish government, make a network of fire lines to prevent the spread of fire into important forest reserves. This contribution has resulted in a reduction in areas burned.

Fire early warning, detection and monitoring

Staff at the Etosha Ecological Institute (within Zone 4) collect NOAA AVHRR satellite data at approximately 12 hour intervals every day. These data are used operationally to provide early warning of approaching fires, to detect and monitor the progress of active fires within the zone and to map burned areas. AVHRR data are also used to map fires operationally in Zone 5 and in part of Zone 6.

Suppression

Undesired wildfires are suppressed where possible in most of zone 2, all of zone 3 and 4 and in some areas of Zones 5 and 6. In Zones 2 and 3, fires are suppressed by members of the farmers' association. In Zone 4, Park management staff from the Directorate of Resource management suppresses wildfires. In parts of Zone 5, local officials from the Ministry of Agriculture assist community members in combating certain fires. In part of East Caprivi in Zone 6, the communities mobilised by Directorate of Forestry have also been equipped and trained to suppress wildfires. Table 2-7 summarises the main Organizations involved in the different fire-related activities.

Main research issues

In eastern Caprivi (Zone 6), research has developed simplified techniques for assessing range condition for controlling burning. This will provide a practical means of applying ecologically acceptable controlled burning for different systems of land use in East Caprivi. It is intended that the simple criteria developed can be used by non-rangeland specialists as an objective basis for deciding whether rangeland needs to be burned or not (Trollope et al. 2000).

Research is also being conducted with the primary aim of improving the accuracy with which burned areas can be mapped using remote sensing. This involves consideration of potential improvements from new satellite sensors such as MODIS (Moderate Resolution Imaging Spectroradiometer), launched December 1999 (Trigg and Flasse 2000), as well as the development of techniques to improve the accuracy assessment of resultant burned area maps. The latter step is seen as an important step in improving the reliability and accuracy of techniques for the remote sensing of burned areas.

Use of prescribed fire in the region to achieve management objectives

Trollope and Trollope (1999) state that the main land-use types relevant to prescribed burning in East Caprivi (within Zone 6) are:

- Livestock farming
- Nature Conservation
- Forestry in the State Forest
- Production of thatching material in communal lands

By considering the reasons for burning within each land use type and by understanding the effects of different fire regimes, they have formulated guidelines for prescribed burning in each land use category. The techniques for range condition assessment (described briefly above) are a more detailed extension of this work. The guidelines also reflect the need to continue measures to prevent and exclude fires from the forest and wooded land that is currently under threat from excessively frequent fire. These studies will form the basis for fire management that is adapted to and specifically focused on the promotion or maintenance of land for specific uses.

Prescribed fire is used to achieve management objectives in the Etosha National Park (Zone 4) as described above. In Zone 6, small fires are prescribed to prepare land for agriculture.

Sustainable land-use practices employed to reduce wildfire hazards and wildfire risks

In Zone 6, communities mobilised by the Directorate of Forestry, with support from the Finnish government, have been trained and equipped to cut firebreaks to prevent the spread of fire in important forest reserves. This contribution has resulted in a reduction in areas burned.

Public policies concerning fire

The formulation of policy and regulations concerning fire is an ongoing process. The Directorate of Forestry has prepared a document on the Development of a National Fire Policy and Guidelines on Fire Management in Namibia (Goldammer 1998). This builds on the Namibia Forestry Strategic Plan, which provided the basis for fire policy and management planning. The Strategic plan recognises many of the complexities of fire, including; the need to reduce the occurrence and severity of uncontrolled and accidental forest fire, while still allowing controlled fire under specific circumstances; that community participation is desirable in the protection of forest resources; and that different policies could, in theory, be adopted in different parts of Namibia as necessary.

A Round Table Meeting on Fire was held in Windhoek on 10-11 October 1999 (Goldammer 1999) towards further definition of fire policy and the coordination of responsibility for fire management (Goldammer 1999). Draft proposals for regulations on bush fire management have been prepared recently (Piepmeyer 2000).

Namibia has ratified the UN convention on Climate Change, and is consequently required to provide quantitative assessments of free-burning vegetation fires (Goldammer 1998).

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Source

Trigg, S. & le Roux, J. 2001. The fire situation in Namibia. *Int. Forest Fire News* 25.

Table 2-6 Fire environment and fire regimes for six major zones of Namibia.

	Fire Environment				Fire Regime		
Area	**Land use**	**Vegetation**	**Rainfall**	**Biomass**	**Return period**	**Season**	**Intensity**
1.	State land, tourism, mining	Sparse grass and shrubs, trees confined to water courses, occasional succulents	Extremely arid below 100 mm rainfall	Very low	Ten years or more	March to December	low
2.	Commercial and communal farmland	Karoo shrub, grass, trees	100 to 300 mm	low	Five to ten years	July to December	low
3.	Commercial and communal farmland	Mixed tree and shrub savanna, wooded land	150 to 550	Medium to high	Two to ten years	July to December	Low to high
4.	National Park, wildlife and Tourism	Mixed tree and shrub savanna	250-500 mm, increasing from west to east	Low to medium, increasing along the rainfall gradient	One to five years	July to December	Low to medium
5.	Communal farmland	Mixed grassland, savanna and wooded land.	250-500 mm, increasing from west to east	Low to high, increasing along the rainfall gradient	Two to five years	July to December	Low to medium
6.	Communal farmland, National Parks, State forest	Mixed grassland, savanna, wooded land and forest	500-750 mm, increasing from west to east	Medium to very high	One to three years over majority of area.	May to November	Medium to very high

Table 2-7 Main Organizations involved in fire suppression activities.

Zone	Fire Prevention	Early warning, detection and monitoring	Suppression
1	None	None	None
2	None	None	Farmer's associations
3	None	Directorate of Resource Management, on ad hoc basis.	Farmer's associations
4	Directorate of Resource Management.	Directorate of Resource Management.	Directorate of Resource Management.
5	None	Directorate of Resource Management	Ministry of Agriculture
6	Directorate of Forestry	Directorate of Resource Management, Directorate of Forestry (National Remote Sensing Centre)	Directorate of Forestry

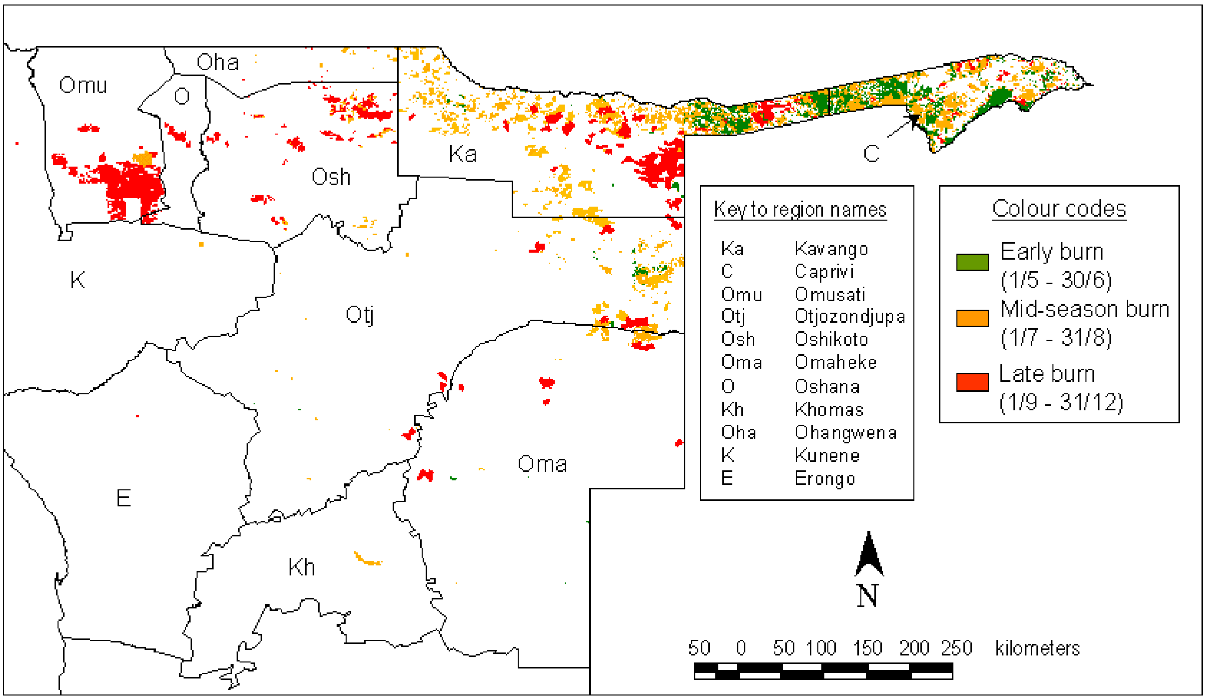

Figure 2-3 Fires in Northern Namibia for the 1997 burning season, colour coded according to approximate date of burn.

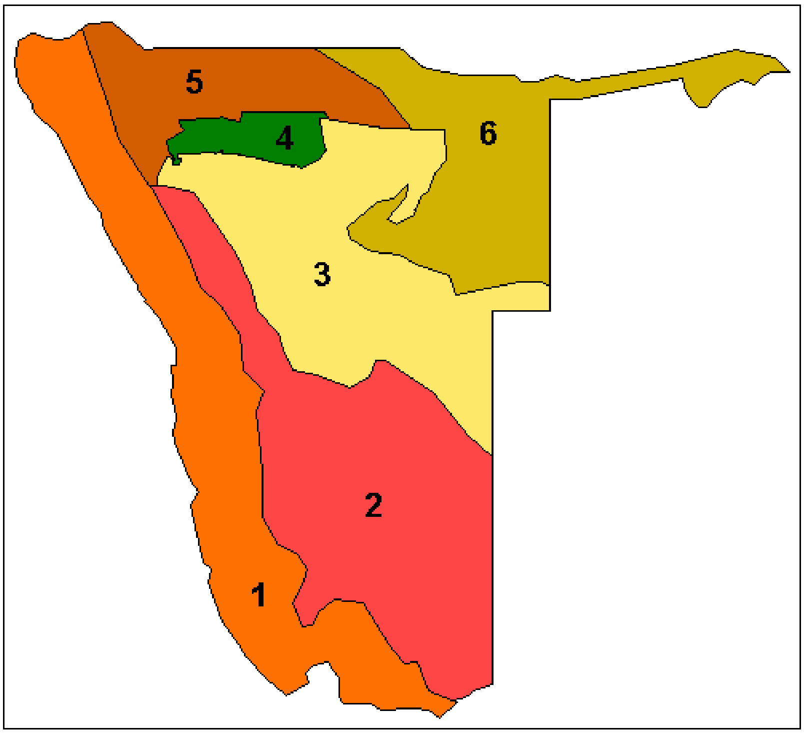

Figure 2-4 The six Zones used to describe the different fire regimes of Namibia.

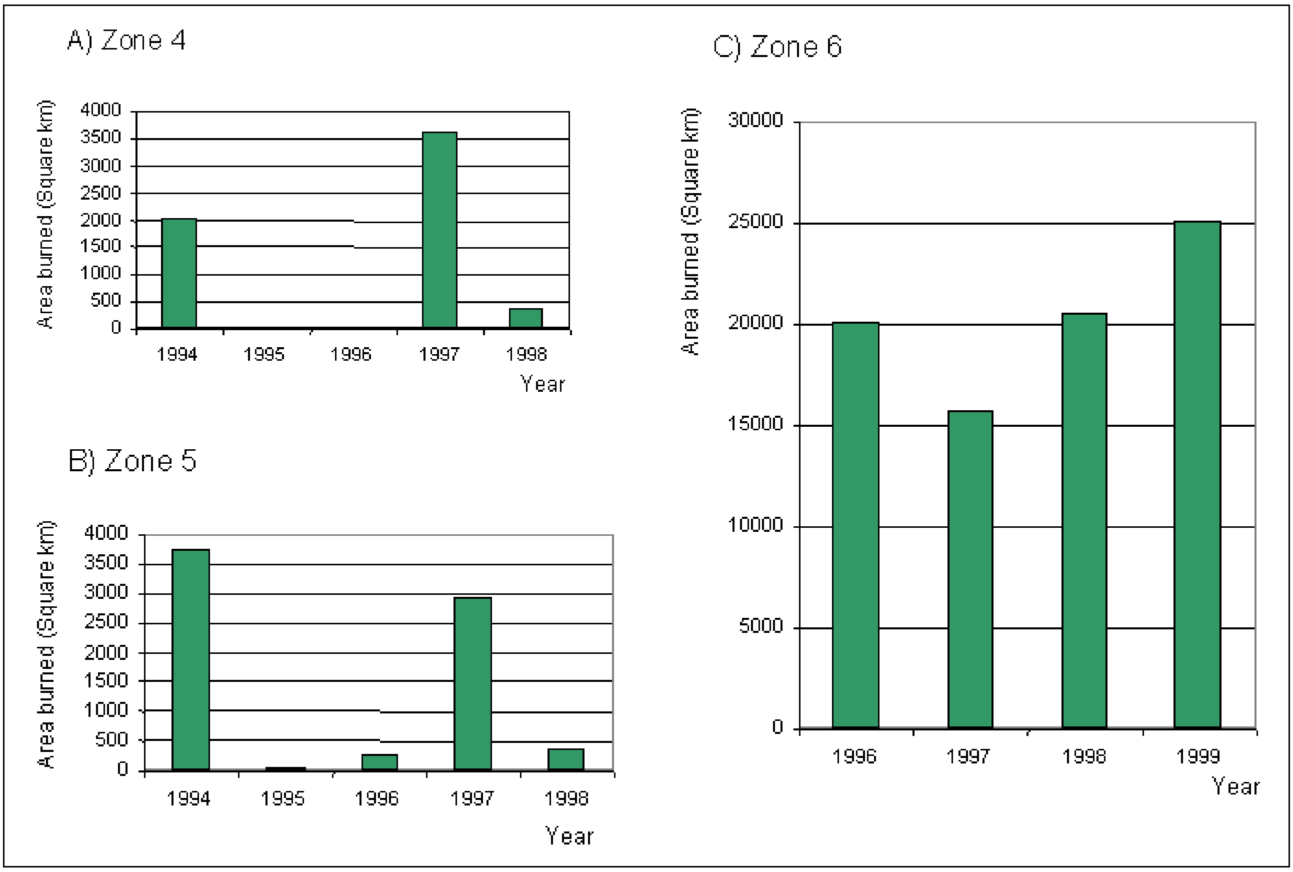

Figure 2-5 Areas burned in Etosha National Park (Zone 4), and the areas of Zones 5 and 6 for which burned area maps are already available.

Note that A and B are for the years 1994 to 1998, whereas C is for 1996-1999 (note the very different scale of A and B compared to C).

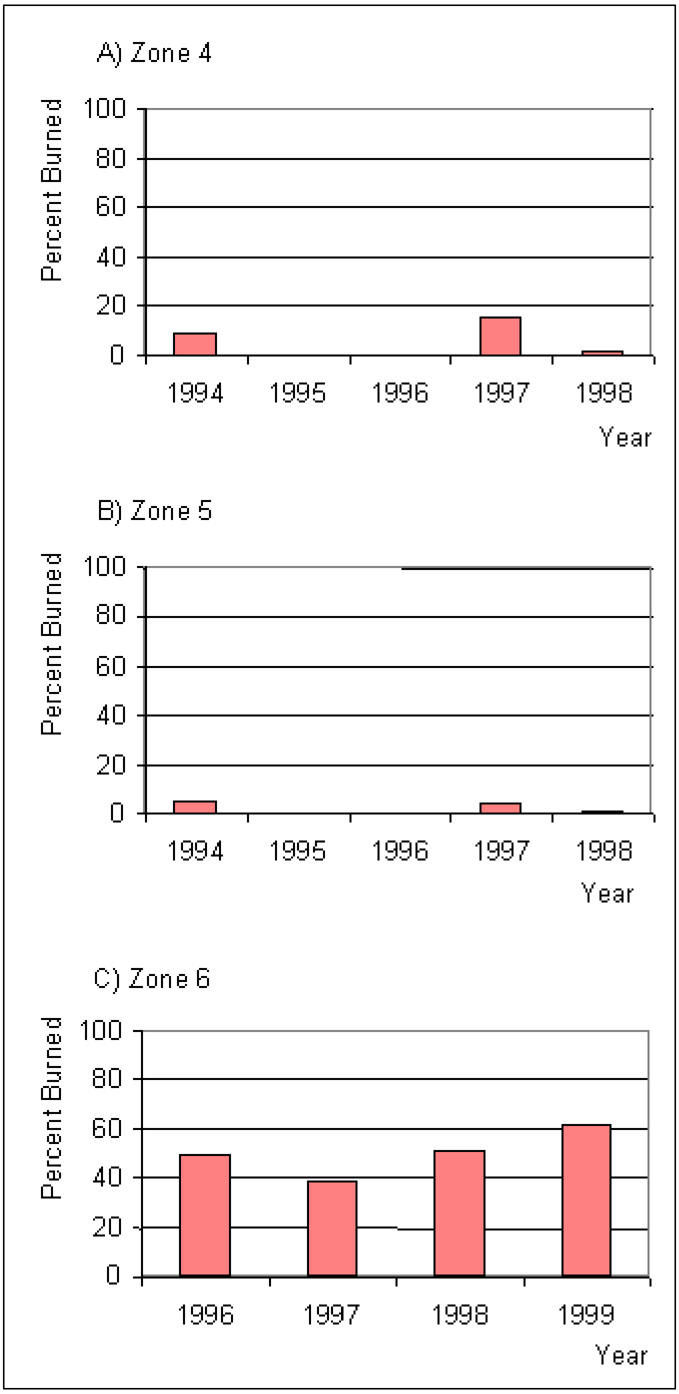

Figure 2-6 Percentage area burned in Etosha National Park (Zone 4), and the areas of Zones 5 and 6 for which burned area maps are already available.

Note that A and B are for the years 1994 to 1998, whereas C is for 1996-1999.

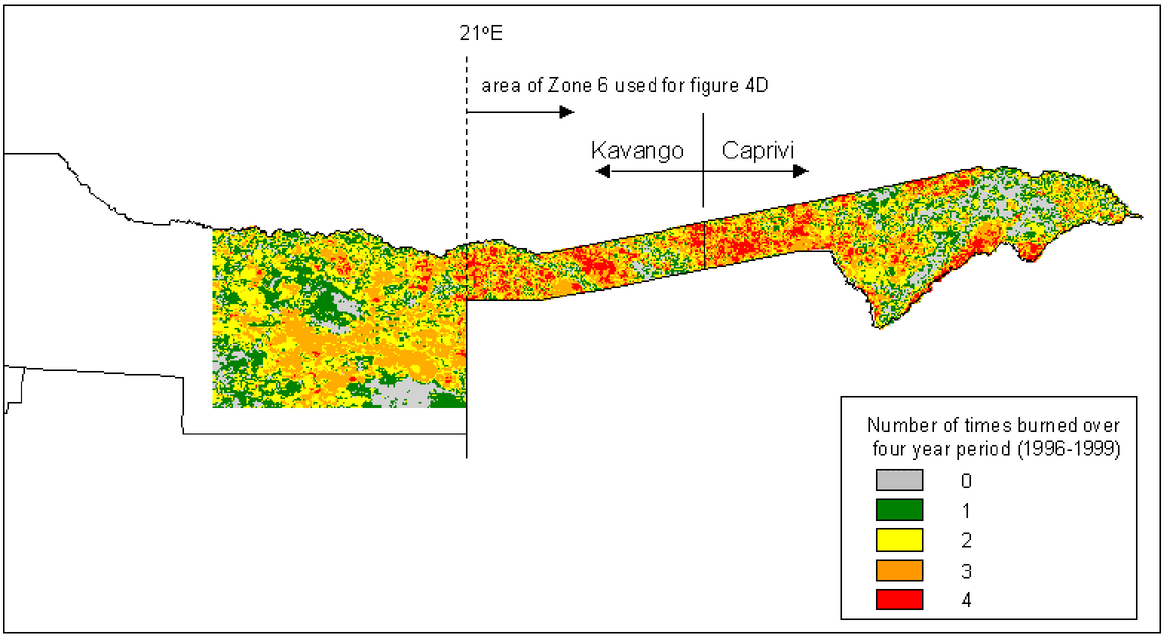

Figure 2-7 The number of times the areas of Zone 6 (routinely monitored by AVHRR) burned over a four year period (1996-1999).

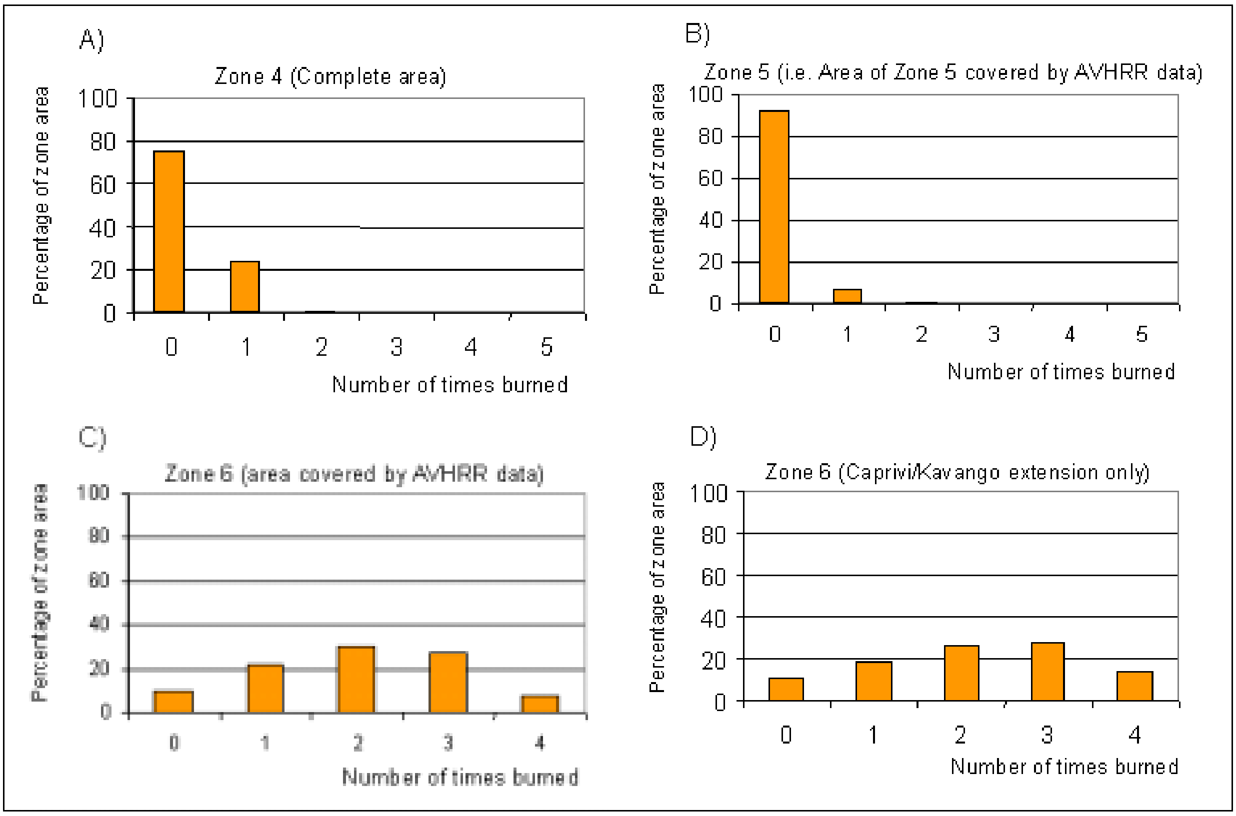

Figure 2-8 Percentage of land having burned different numbers of times within a set number of years.

A and B show the percentage of Zones 4 and 5 that burned between 0 and five times during a five year period (1994-1998). C and D show the percentage of Zone 6 and the Caprivi-Kavango extension of Zone 6 (see Figure 2-7) that burned between 0 and four times within a four year period (1996-1999).

2.2.3 Fire Situation in South Africa

By
Cornelius de Ronde
SILVA Forest Service, Bredasdorp, South Africa
&
Johann G. Goldammer
Global Fire Monitoring Center, Freiburg, Germany

Fire environment, fire regimes, ecological role of fire

Forest

Natural forests in South Africa cover less than 1 percent of the total area, and fire plays an important role on the edges of these forest communities. However, wildfires seldom penetrate the larger patches of mature forest, although charcoal within the soil profiles of some forests indicates that fires may occur in natural forests at intervals of several hundreds of years (Huntley 1984).

Industrial forests, such as even-aged *Acacia*, *Eucalyptus* and *Pinus* plantation stands, cover an area of approximately 1.5 percent of South Africa, and have mostly been established in the higher rainfall areas of the Grassland Biome of the Summer Rainfall Region. These forests are regularly exposed to wildfire damage, because of the fire history of the host vegetation, and the fire history of the countries of tree origin. Until 1990 fire was mostly excluded from these forests. More recently slash burning after clearfelling and prescribed burning under trees for fuel reduction purposes are now established management tools. These prescribed fires are being applied at a limited, but increasing, scale.

Other wooded land

The Fynbos Biome falls under this category, where trees are rare, but the vegetation is dominated by evergreen sclerophyllous heathlands and shrublands (Huntley 1984). This Biome covers approximately five percent of the land area of the country. Fynbos communities generally require four to six years to accumulate sufficient fuel to burn and fires occur at random within 6 to 40 year rotations (Kruger 1979). Prescribed burning is applied in most fynbos communities, but during the 1990's prescribed burning programmes have been reduced for various reasons, such as to allow more natural fire occurrence. Another reason for fewer prescribed fires is the reduction in the availability of experienced fire managers who can apply block-burning correctly (own observations).

Other land

The remaining vegetated land of South Africa includes these categories: Grassland (24 percent), Arid Savannah Biome (24 percent) and Moist Savannah Biome (9 percent). These estimations have been rounded off to make provision for plantation forests. As yearly biomass production differs significantly within these biomes, fire rotations vary likewise (from 1 to 15 years), and these rotations are also exposed to seasonal variation. Winter burns normally occur after moisture stress and frost sets in during autumn.

Fire is an infrequent, but significant phenomenon in the Arid Savannah Biome, normally occurring after above-average rainfall has been recorded, and subsequently a higher biomass production was experienced. In the Moist Savannah Biome fire occurs more frequently at approximately five-year intervals, but as common as annually in places during some seasons (Huntley 1984).

A recent paper by van Wilgen et al. (2000) analyses the fire history of the Kruger National Park (1.9 million ha) for different periods in the park's history, where fire protection was followed by prescribed burning and then a "natural" (lightning) fire policy. Fires covering 16.79 million ha occurred between 1941 and 1996 (16 percent of the area burning each year on average). Of this area, 5.15 million ha burnt between 1941 and 1957, when limited prescribed burning and protection from fire took place (16 percent burning each year on average). Between 1957 and 1991, 2213 prescribed burns covering 5.1 million ha (46.3 percent of the 10.98 million ha burnt during that period) were carried out.

Lightning fires burnt 2.5 million ha between 1957 and 1996, or 21.6 percent of the area. The mean fire return period was 4.5 years, with intervals between fires from 1 to 34 years. The distribution around the mean was not symmetrical and the median fire interval was 3.1 years. Some areas burnt more often than others, and mean fire return periods ranged from 2.7 to 7.1 years in the 11 major land systems of the park. Fires occurred in all months, but 59 percent of all fires took place from September to November. Prescribed burns were concentrated late in the dry season (September to November). Lightning fires were later, with 84.7 percent of the area burning between September and January (see also van Wilgen et al. 1998, Brocket et al. 2000).

Major wildfires experienced during 1990 - 2000, and their impacts

<u>1990/91</u>

Compared to the year 1989 - which was a year that saw some serious wildfires in Industrial Forests - 1990 and 1991 saw a steady increase in the number of fires experienced in Kwazulu-Natal, from 210 during 1989, to 350 during 1990 and to 510 during 1991. The Fire Danger Index (FDI) only reached one day of extreme fire danger (a red day) during 1990 and one day during 1991. Large forest fires were not recorded during these years.

<u>1992/93</u>

In 1992, a serious drought occurred in most of the Summer Rainfall Regions in the North and East of South Africa. Subsequently, the number of fires reported in the forest regions of these provinces increased to 792, but surprisingly losses from wildfires were less than during 1991, and only 9 333 ha of industrial forests were lost (Meikle et al. 1993). In 1993, no major fire events were recorded.

<u>1994</u>

A few serious wildfires occurred in industrial forests and in surrounding grassland in the Mpumalanga and Kwazulu-Natal Provinces. Towards October 1994, three major plantation wildfires raged in the Sabie District, destroying more than 1 000 ha in each case. During one fire in a SAFCOL plantation in the area, ten firefighters lost their lives when the fire spotted around the team inside *Pinus* and *Eucalyptus* stands. Two firefighting vehicles were also

burned out in the process, and combined losses for the district in terms of timber losses exceeded US$1 million.

1995

During the dry winter season, some serious grassland wildfires were experienced in the Eastern Free State, while in one fire 5 500 ha of timber plantations were destroyed in the Melmoth District of the Kwazulu-Natal Province. Surprisingly no lives were lost.

During December 1995 a bushfire spotted into a heap of 15 000 tons of sulphur belonging to an explosives and chemical company near Cape Town, and a local community was overwhelmed by the toxic fumes. Two thousand five hundred people had to be evacuated, and 500 patients had to be treated in the trauma unit of the nearby hospital. Two persons died. The fumes also affected nearby agricultural crops through direct scorching of leaves.

1996/97

Numerous grassland fires were reported in the Summer Rainfall Region of SA, but higher than average rainfall prevented serious moisture deficiencies from occurring, and subsequently area burned remained relatively small. During both years rainfall days extended well into the June/July period, and long seasonal drought was avoided.

1998

A dry summer prevailed in the Cape Regions. An early start of hot *Bergwind* conditions during March/April caused extreme fire weather conditions in these areas in the Fynbos Biome, and in some adjoining Industrial Forests. Two serious fires occurred in the Tsitsikamma Region. In one of them 60 000 ha of fynbos were burned and 4 000 ha of industrial forests were destroyed. Six people lost their lives in this fire and 250 were left homeless. Damage to standing timber alone exceeded US$1 million. The ecological impact of this fire on the fire-adapted fynbos was not that serious, although some of the older fynbos sub-communities experienced excessive fire temperatures that may have led to some localised erosion problems on steep slopes.

In the Summer Rainfall area the fire season started extremely early in April. By May 30 000 ha of grassland grazing areas were lost in wildfires in the Eastern Free State, and one fire blackened 20 000 ha of a nature reserve in the region. Another wildfire burned most of the grassland in a Nature Reserve in Mpumalanga. A tragic loss of life occurred indirectly as a result of a grassland fire in the Gauteng Province during June. Twenty people lost there lives in a traffic pile up caused by thick smoke on a highway from a nearby grassland fire.

Also in the Summer Rainfall area, four people lost there lives in one of the numerous grassland wildfires in Mpumalanga, while wildfires in industrial forests caused losses exceeding 1 000 ha of standing timber in the Northern Cape and Mpumalanga Provinces, and in Swaziland. In the NW Province, where wildfires are seldom experienced, a grassland fire burned down some farms and homesteads and killed two policemen.

1999

In the Southern Cape and Tsitsikamma regions, more wildfires burned through thousands of ha of fynbos vegetation, burning down homesteads in the Plettenberg Bay area, as well as a

few thousand ha of timber plantations and farmland. These fires occurred during extremely dry *Bergwind* conditions. In the Summer Rainfall area, most wildfire damage - in the form of grazing area lost and timber plantations damaged - were experienced in Swaziland.

2000

During January 2000, the Cape Peninsula was devastated by a serious fynbos wildfire, which burned 8 000 ha of fynbos vegetation in that area. Elsewhere in the Western Cape Province an additional 10 000 ha of fynbos burned. In the Cape Metropolitan area 70 houses were damaged or destroyed by the fire and 200 shacks of an informal settlement were also razed in the process. Total fire suppression costs exceeded US$3 million, while insurance claims are expected to exceed US$0.5 billion. No lives were lost.

Fire database

Additional databases are not available. For fire data in the grassland and savannah biomes the reader is kindly referred to the overview summary on fire in sub-Saharan Africa.

Operational fire management organization

The Department of Water Affairs and Forestry (DWAF) is responsible for the provision, management and administration of the 1998 *National Veld and Forest Fire Act,* and the support of Fire Protection Associations (FPAs). DWAF will not play a direct firefighting role or duplicate the work of fire management agencies.

Fire prevention is normally regarded to be the responsibility of the landowners, guided by DWAF and the new National Veld and Forest Fire Act. However, there is still a lack of regional co-ordination in this field. Certain exceptions exist where integrated regional fire protection plans have been implemented: the Mpumalanga Highveld, in the Melmoth District of the Kwazulu-Natal Region, and in the NE Cape. Local (private and state) fire management bodies in Industrial Forests, Agricultural Regions and Nature Reserves are normally responsible for their own fire prevention measures.

Early warning, fire detection and monitoring systems are extensively used in Forestry regions, and these are mostly managed by private forestry concerns. Elsewhere in South Africa detection systems, such as fire towers and other early warning systems, are seldom used.

In most provinces the firefighting role is conducted and controlled by Regional Services Fire Brigades in rural areas, assisted by Municipal Firefighting Units in Metropolitan districts. In some areas these efforts are being assisted by certain Central Government bodies, such as the Defence Forces, particularly when wildfires expand to disastrous sizes. Local forestry Organizations and agricultural bodies also assist in fighting fires in certain regions, depending on the dominant land-use of these regions.

The most important forestry firefighting Organizations in South Africa are the Forest Fire Association (FFA) based in Nelspruit, the Zululand Fire Protection Association (ZFPA) and the Natal Fire Protection Association (NFPA).

Although spontaneous firefighting support from local communities has been recorded during some wildfires, no major voluntary firefighting Organizations exist in South Africa.

Fire research

Some fire research in South African Natural Biomes is being maintained under the umbrella of universities, nature conservation bodies and forestry companies. However, during the 1990s there was a marked decrease in these activities, compared to fire research conducted during the 1980s. It was particularly in the formal Agricultural and Forestry Sectors that there has been a marked decline in fire research funding and this has had a particularly negative effect on some longer-term research venues, which were in many cases shelved or terminated.

During 1999, however, there is a more positive approach to fire management in general in South Africa, with some training institutions now in the process of restructuring their fire management/ecology curricula (such as at the Forestry Training Centre of the PE Technicon at Saasveld). Some fire research programmes are also re-considered.

Use of prescribed fire

Forestry (industrial forests)

Slash burning after clearfelling even-aged stands is a common practice, particularly where heavy slash from tree crowns make re-establishment of trees a costly operation. However, where slash is not forming serious obstacles, *e.g.* steep slopes occur or where nutritional problems occur (such as on poor sandy soils), slash burning is avoided.

Prescribed burning inside *Pinus* plantations is being used more as a fuel reduction measure, particularly within strategic buffer zone (fire belt) systems in some forest regions (de Ronde et al. 1990).

Natural Biomes

Prescribed burning is used extensively in grassland management throughout the area, particularly in areas with a high biomass production where grassland curing causes a regular wildfire threat. Grassland is burned in fire protection systems outside and within plantation areas, and, also, in the form of fire belts elsewhere in the Summer Rainfall Region. Grassland is also burned regularly by farmers and by nature conservators to provide grazing, where this type of burning is classified as maintenance burning. In certain nature reserves, such as in the Kruger National Park, there was also a major shift in policy towards more natural (lighting) fire areas (so-called *Laissez Faire* approach) and less prescribed block-burning (*Structural Burning*). However, the debate regarding these issues is continuing, and some form of combination of both regimes is probably the answer.

In the Fynbos Biome, prescribed burning has been used extensively in the past until the 1980s, but there was a marked decrease in prescribed burning activities in the Cape Regions during the 1990s. More natural fynbos vegetation was regarded as *Natural Burning Areas*, becoming dependent on the rare lighting occasion. This was mainly caused by a drain of experienced fire managers - and subsequent increase in fire hazard - as a result of fuel accumulation. Therefore, there was a marked increase in fynbos wildfires during the 1998 - 2000 period, in the Western Cape, Southern Cape and Tsitsikamma Regions.

Sustainable land-use practices used in South Africa

Integrated fire protection, at a regional scale, has been inplemented in areas such as the Mpumalanga Highveld, the Melmoth District of Kwazulu-Natal and in the NE Cape Region. However, these areas only form a small percentage of the total South Africa area (less than one percent).Further implementation of the system, using integrated fire hazard evaluation and fire break zoning, will be required in regions with a known high fire hazard. Implementation is at present being considered in the Western Cape (Boland District) and Kwazulu-Natal Midlands.

Fuel reduction programmes, such as the application of prescribed burning of natural and activity fuels on a selective scale, form the basis of this fire protection integration. This approach combines the use of fire for agricultural and silvicultural goals with fire application for ecological requirements and riparian zone maintenance.

Legislation and policies concerning fire

As a consequence of the severe fires in the Western Cape Province, the Minister of Water Affairs and Forestry, Pretoria, supported by the Premier of the Western Cape, established a *Task Team to Review the Western Cape Fires of January 2000*. The Task Team reviewed the course of events of several fires, analysed fire weather, interviewed role-players, and analysed the legislative framework. The report of the Task Team came up with a list of recommendations to improve fire management and fire disaster management in the country (Task Team 2000). The geographical scope of the study was the Cape Peninsula and the areas within the Berg and Breede River Water Management Areas.

The legislation pertaining to fires that occurred in the Western Cape fall under the categories:

(a) *Legislation Directing Regulating Fires and Fire Management (Within a mostly emergency management context):*

- Forest Act
- Fire Brigade Services Act
- National Environmental Management Act
- Mountain Catchment Areas Act

(b) *Towards Integrated Disaster Management Regulation:*

- Disaster Management Bill (in prep.)
- Veld and Forest Fires Act

(c) *Resource Management Regulation:*

- National Parks Act
- Cape Nature Conservation Ordinance
- Conservation of Agricultural Resources Act

(d) *Land Use Planning Legislation:*

- Physical Planning

- Development Facilitation Act
- Local Government Transition Act 209 of 1993
- Environment Conservation Act 73 of 1989
- National Environmental Management Act

(e) *Air Quality Control Legislation:*

- Atmospheric Pollution Prevent Act
- Local Authority Legislation

(f) *General Environmental Management:*

- National Environmental Management Act

The objective of the review was to use the lessons from these fires to identify the strengths of current fire management systems, and to propose necessary improvements. From an analysis of all relevant information, the study was to derive the lessons relevant to the Western Cape itself, as well as for the fire management systems in South Africa generally, including the relevant elements of the National Disaster Management System as a whole.

The key questions to be addressed in the review included:

- What ecological conditions (e.g. weather, natural and alien vegetation) prompted the fires to occur and contributed to their intensity and spread?
- What institutional arrangements were in place for fire management and firefighting, which of these proved effective, and what improvements may be needed?
- What strategies for fire management and firefighting were adopted during the fires and how were resources (personnel and equipment) used; what proved effective, and what needs to be improved?
- How effective were the extant provisions of the Forest Act of 1984, the provisions of the Veld and Forest Fires Act of 1998 that were in force at the time, and any other statutes that determine fire management?

The study was to generate a report that would include findings, the inferences from these findings, and recommendations for improvements in the legislative, institutional, and ecosystem management regime that determine the fire management system.

Specifically, recommendations were to include:

- Proposals for improvement to and guidelines for the effective implementation of the National Veld and Forest Fires Act, as well as recommendations for improved linkages between this Act and other relevant statutes.
- Recommendations for improvements in the organising and resourcing of and co-ordination and co-operative governance arrangements between spheres of government responsible for and otherwise influencing management for the prevention of veld fires, the control of fires that do break out, and the mitigation of the consequences of fires that do occur.
- Improvements in the management for fire control of ecosystems as well as of the built and settled environments adjacent to natural or semi-natural ecosystems.

The final output would be feasible proposals for improvements in fire management in South Africa, including legislation, especially the National Veld and Forest Fires Act, institutions and their co-operative governance arrangements, supporting systems, and ecosystem management.

The draft report has been submitted to the Minister in the second half of 2000. It contains a list of more than 60 recommendations addressing the major gaps and fields of activities that have been identified by the Task Team.

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Source

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2.3 West Moist and Central Africa Sub-Region

The fire situation in west moist and central Africa during the 1990s has been publicised in several cases. A unique research opportunity was provided by the Experiment for Regional Sources and Sinks of Oxidants (EXPRESSO) (Delmas et al., 1999) during which a satellite receiving station, capable of receiving NOAA-AVHRR data and detecting fires, was installed at Bangui, République Centrafricaine (Central African Republic). Data were collected for the 1993-1994 and 1995-1996 dry seasons. For the 1994-1995 dry season, a study by Eva and Lambin (1998) using satellite data estimated that just over 43 percent of the Sudanian savannahs and 58 percent of Guineo-Congolian Sudanian savannahs burned in the Central African Republic. This corresponds to an area affected by fire of 8.6 million ha and 19.1 million ha, respectively. The 1994-1995 dry season was considered to represent an average fire season (see country report on the Central African Republic).

2.3.1 Ghana

The following information covers only events that were recorded in the 1980s (Nsiah-Gyabaah 1996). There are few records on bushfires, especially fires ignited by lightning. Data on anthropogenically caused fires dating back to the pre-independence era are also lacking. However, occurrence of bushfires in Ghana is closely linked to drought periods. Droughts are naturally occurring events, but it was only after 1970 that the problem of drought and associated bushfires came to the forefront of concern for the environment. Available records show that during the 1982-1983 harmattan season about 35 per cent of the country’s crops were destroyed by bushfire. In 1984-1985, about 145 bushfires were reported in the northern savannah zone alone. The crops most affected were rice and maize. The average size of farms affected was ca. 50 ha, with the largest covering about 10 ha. Ghana experienced serious bushfires during the catastrophic Sahelian drought of 1973-1974 and again in the period 1984-1985. Available data on the 1984-1985 bushfires for all the country's ecological zones show clearly that the Guinea and Sudan savannah areas suffered the most impact with loss of vegetation, standing crops, farms, wildlife, habitat, human lives and property.

2.3.2 Cote d'Ivoire

In 1991 the country hosted a major fire research programme. "Fire of Savannas" (FOS/DECAFE) was part of the project DECAFE (Dynamique et Chimie Atmosphérique en Forêt Equatoriale). The overall aim of FOS/DECAFE was to investigate the contribution of gaseous and particle emissions from savannah fires to the regional and global emission budgets and to clarify the role of fire emissions on tropospheric ozone formation (Lacaux et al. 1993, 1995). Information on fires in forest ecosystems is given by two IFFN contributions (Anonymous 1996, Oura 1999). During the 1982-1983 drought Côte d'Ivoire suffered wildfires of a magnitude similar to Ghana. Vast forest fires occurred in closed forests (evergreen and semi-deciduous forests) and other areas:

- About 1.7 million ha of forest, bush fallow and tree crops were affected by wildfires;
- 45 000 ha of forests were destroyed;
- More than 100 000 ha of cash crops (coffee, cocoa, rubber tree, palm oil. etc.) burned;
- 4 000 ha of subsistence crops were destroyed;
- 21 people were killed.

The fires burned through 12 000 ha of industrial forest plantations and about 3 000 ha were partially or completely destroyed. From 1983 to 1998, 32 624 ha of forests were affected by wildfires and 4 836 ha were completely destroyed in the 20 gazetted forests managed by the State Reforestation Service (SODEFOR).

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2.3.3 Fire Situation in Bénin

By
André M. Tandjiékpon
Forest Research Unit, Cotonou, Bénin

Introduction

Located between 6°30'-12°30'N and 1°00'-3°40' E, Bénin is a small country situated in West Africa with an area of 112 622 km². It has a total population of about 5.5 million inhabitants. Sixty-five percent of the country is covered by vegetation dominated by savannah woodland (9 percent) and tree savannah and shrub (56 percent). The country straddles three main climate zones: a tropical coastal Guinean climate in the south part (6°30'-8°00'N) with two rainy seasons. The northern part is tropical Sudano-Guinean (8°00'-9°00'N) climate and Sudanian (9°00'-12°00'N) climate with one rainy season. These last two zones represent more than 70 percent of the total area of the country. This percentage is more or less the same for most countries in West Africa and constitutes the ideal environment for wildfires.

Fire environment, fire regimes, ecological role of fire common to country

In Bénin, and particularly in the northern part of the country, burning represents a cultural tradition, which is not easy to overcome. Used as a work tool generally by rural populations, fires serve for land clearing for agricultural purposes, pasture management for breeding, and animal tracking for hunters. These practices are common to most countries in West Africa covered by dry forests, or savannah from Guinea to Nigeria. Concerning Bénin, it has been noted that 95 percent of wildfires in forestland are human-caused. The habitual period for lighting fires is between November and May. The majority of damaging fires are observed from January onwards, due to the high temperatures during this period (30 to 35 °C) and also to the influence of the hot and dry *Harmattan* winds flowing from North to South between December and March. However, the importance of fire varies from one zone to another. Therefore, the area situated above the latitude 8°15' N in Bénin is more exposed to wildfires, mainly because of cotton and yam production. These two crops require high soil fertility and more space, so farmers clear new forestland each year.

Narrative summary of major wildfire impacts on people, property, and natural resources during the 1990s

The most important impacts of wildfire are ecological. In fact, for a long time, and particularly in the latest decade, increasing occurrence of wildfires has devastated and reduced the area of forest lands and caused the disappearance of sensitive species, exposure of soils to wind and water erosion, and destruction of wildlife habitats. In Bénin, because of the high proportion of dry forest lands, about 75 000 km² of forestlands are exposed to fires each year. In 1991-1998, there has been an increase of agricultural land and reduction of forest and woodlands area as shown in Table 2-8. In the same time, there has been an increase of about

30.96 percent of fuel-wood and charcoal production (FAO 2000). These situations are mainly favoured by fires used for clearing and shifting cultivation.

Table 2-8 Change of forest area between 1990 and 1998.

Land use	Years Area (in 1000 ha)		Increment (%)	Main annual increment (%)
	1990	1998		
Agricultural area	2270	2400	5.72	0.64
Forest and wooded lands	3470	3400 *	-2.02	-0.40

* Available data for 1994
Source: FAO (2000)

The economic and social impacts of wildfire concern the destruction of living conditions and harvests (cotton, yam, maize, sorghum, etc.) in rural land. Also, the perturbation of fruit production of spontaneous and planted species occurs which represents an important income. Such food sources include *Vitellaria paradoxa, Parkia biglobosa, Anacardium occidentale*, and *Adansonia digitata*. Besides these impacts, the annual loss of wood products, medicinal plants, wildlife, nuts, wild fruits, and honey is high but could not be quantified.

Operational fire management Organizations and fire database

Since bush fires are one of the main causes of land desertification and the degradation of natural resources, several governments in Bénin have supported fire control projects. At present four major government Organizations take an interest in wildfire problems:

- Direction of Forests and Natural Resources (DFRN). This institution is decentralised at province (or department) and commune (district) level. The main tasks of this Organization, through forest projects, concern the monitoring of fires events, organising local populations, and development of tools for fire prevention and suppression, mainly in the state forests (natural forests and plantations).

- Regional Centre of Action for Rural Development (CARDER). This agency is the equivalent of the Ministry of Rural Development at the province level. It is decentralised at the commune and village levels and has the same mission as DFRN. The main difference is that this Organization is connected to the local level and takes into account all forestlands (state forests and other ownerships). It directs the activities of *Local Fire Committees* and provides information to rural populations through networks at the local level.

- Forest Research Unit (URF) of the National Institute for Agricultural Research of Bénin (INRAB). The main activity of this Organization concerns the development of strategies and tools for sustainable management of forestlands by providing scientific information to the users concerned.

- Bénin Environment Agency (ABE). Its wildfire activity is focused on the dissemination of information.

Outside these Organizations, some Non-Governmental Organizations (NGOs) are also focused on the fire problems. However, their activities are very marginal compared to the importance and frequency of wildfires.
All these Organizations are facing common problems: lack of coordination of efforts and actions, low resources and reliability for monitoring and evaluation, and insufficient resources (financial, materiel, and human) for wildfire and forest fire projects. A statistical database of the country is not available.

Very few fire research projects are present in Bénin today. There is one project concerned with diagnosing the impacts of fires on natural regeneration; and developing a reliable schedule by agro-ecological zones for the use of early burning for forest management.

Use of prescribed fire in the region to achieve management objectives

Taking into account the socio-economic situation of Bénin, it has been apparent for some time that absolute forest protection against bush fires in dry forests, although possible, will eventually cause an undesirable accumulation of combustible material; and may increase the risk of diseases and insects. Therefore, early burning is prescribed in order to reduce the combustible material with least damage to tree growth and natural regeneration. The philosophy of this practice is that the early burning (burning at the end of rainy season) is the best tool to prevent destructive wildfires during the critical dry season. The practice of early burning is widely used in Bénin as well as in many countries in West Africa.

The recent research result from Côte d'Ivoire, Burkina Faso, and Bénin suggest that early burning in dry forestlands has positive impacts on natural regeneration, tree growth, and the regulation of the density of harmful insects and parasites.

Sustainable land-use practices to reduce wildfire hazards and wildfire risks

The construction of firebreaks and fuelbreaks is an important practice. However, due to the high costs involved, this practice is mainly used to protect plantation forests and agricultural lands. Breaks are produced by roads, paths, or planting vegetation strips, e.g. two or three lines of *Gmelina arborea* around *Tectona grandis* plantations in South Bénin, or the use of *Mucuna altilis* as cover vegetation in *Anacardium occidentale* orchards in North Bénin.

Also, agro-forestry practices are promoted in which crop production, forestry objectives, and the creation of pasture zones for breeders and nomadic herders are combined.

In addition to these practices, *Local Fire Committees* have been created in the villages for fire prevention, detection, and suppression in collaboration with forest rangers and local agricultural officers.

Public policies concerning fire

For a long time, wildfires in Bénin have been considered a major problem for environmental stability. Since the colonial period, many laws have been initiated to regulate fire use by populations. The most recent legislative acts are Law N° 93-009 of 2 July 1993 (Articles N° 56 and 57) and Decree N° 96-271 of 2 July 1996 (Articles N° 76 to 79) which stipulate that

the setting of bush fires is forbidden in the whole country except for the use of early burning to prevent wildfires. Modalities for early burning, particularly the time period, have to be defined each year by a joint decision of responsible ministries.

The problem with this legislation is that the laws concern populations that are largely illiterate and poor. The second difficulty concerns the lack of materials and human resources for informing populations about the law and training them on the prescribed methods to manage fires. These are the major constraints of implementing policies that address wildland fires in Bénin.

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2.3.4 Fire Situation in Central African Republic

By
Hugh Eva & **Jean-Marie Grégoire**
Space Applications Institute, Joint Research Centre of the European Commission, Ispra, Italy

Vegetation and fire environment

In the Central African Republic (RCA), there are three major vegetation formations as defined by UNESCO (White 1983): *Sudanian*, *Guineo-congolia/sudania,* and *Guineo-congolia*. These three formations form lateral bands covering the dry savannahs in the north, the wet savannahs in the centre and the humid forests in the south. The Sudanian region is predominantly open woodland savannahs.

The transition zone of the Guineo-congolia/sudania consists of secondary savannahs and woodlands with some open forest. These savannahs are deemed to be fire-maintained. In areas where there has been a decline in population, a regrowth of woody biomass has occurred. In the southern part of this transition zone, mosaics of dense forest and secondary savannahs are found.

The Guineo-congolia region is predominantly dense humid semi-evergreen forests (both *terre firme* and flooded), which are rarely subjected to fire, and of included savannahs. These included savannahs are very important in terms of biodiversity. Running north-south, the central Plateau of Ouadda is dominated by remnant forest. A more detailed partition of the vegetation types has been undertaken by Boulvert (1986). Fire activity starts in the northeast of the country around November, and moves southwest following the Harmattan winds, reaching a peak in late December, or early January. The onset of rains in March terminates the fire season.

Major fire impacts

While there are no official data available, there is a perception at government levels that vegetation fires have various detrimental impacts. Since the economy relies heavily on small-scale agricultural production, the accidental destruction of cultures is of major concern. The intensive use of fire throughout the region for agricultural practices, hunting and pastoralism threatens the sustainability of natural resources. Soil erosion on the hills around the capital, Bangui, has been linked to cultivation and intensive burning. Visitors to Bangui will note the poor air quality due to smoke particles in the dry season. The deposition of acid rain over the forests downwind of RCA's savannahs has been linked to the burning of savannahs.

Fire database

Little or no data exist to document the impact of fire over the last 20 years. A suite of scientific experiments was carried out in the mid-1990s on the sources of atmospheric pollutants in the regions. Under this initiative, EXPRESSO (Experiment for Regional Sources

and Sinks of Oxidants), a satellite receiving station capable of receiving the NOAA-AVHRR data and detecting fires, was installed at Bangui. Data were collected for the 1993-94 and 1995-96 dry seasons. For the 1994-95 dry season, a study by Eva and Lambin (1998) using satellite data estimated that just over 43 percent of *Sudanian* savannahs burned and 58 percent of *Guineo-congolia sudanian* savannahs burned. This corresponds to an area affected by fire of 86 000 km² and 191 000 km², respectively. The 1994-95 dry season is considered to represent an average fire season.

The area of forest affected by fires is difficult to assess in the absence of a suitable forest database. The work done by Eva and Lambin (1998) detected 2 486 cases of fires in "forested" areas. However, a close inspection of the data revealed that all these fires were on the edge of the forest domain. Some were likely for the purposes of establishing coffee cultures. It is not, however, possible to quantify these in terms of area of forest burned.

Operational fire management

Fire management is undertaken at the local level, where the decision to burn certain areas is decided at the village level. This usually covers areas within five kilometres of the road network. The government has tried to encourage a conservative approach to burning by the use of radio campaigns. Realising that lack of knowledge was one of the main obstacles to effective fire management, the RCA government, with the help of the ADIE (Association pour le Développement de l'Information Environmementale) and the EU Joint Research Centre, has installed a permanent satellite receiving station at Bangui. The objective is to work with the CNLIFBAC (Comite National de Lutte contre les Incendies, Feux de Brousse et Autres Calamités) to document the occurrence of fires in different vegetation strata, and to predict regions at risk of fires.

The data will be used to sensitise public opinion to the problems of fire using TV and radio campaigns and to organize prescribed burning. At the same time, the data can be used to better organize the campaign against illegal hunting. Under the same initiative, a study will be carried out on the economic effects of fire on the country.

Use of prescribed fire

Fire is used extensively across RCA. There are three main activities.

- **Large scale poaching**: This has its greatest impact in the north and north east of the country. The open savannahs of the Northeast, on the Sudan border, see large fire fronts (50 km) every year, moving southwest as the season progresses. The fires start on the frontier with Sudan in November and move southwest, arriving at Bakouma in February. These are thought to be due to large scale poaching activities. A similar process occurs in the north of the country on the frontier with Chad. Fires of several km's size advance down towards the Massif des Bongo during November, December, and January. This area is comprised of several national parks. The fires are smaller than those found in the Northwest as the landscape is more fragmented with rivers and woodlands. The Plateau of Ouadda, south of the Massif, sees many large hunting fires later in the season (January to March). This remnant forest area is a home to bush game.

- **Pasture management**: Fires are used to stimulate re-growth for cattle in the dry season. This occurs around the town of Bambari (central RCA) and on the routes from Northwest RCA (a livestock breeding area) to the markets in the south. The herdsmen light fires along the route both to stimulate regrowth and to facilitate passage. These fires tend to be at least five km from the road network. The fires are small in size and start in December and continue until March.

- **Agricultural fires**: These small fires occur across the country in December and January, but are predominantly close to the road network, being lit to prepare the fields for agriculture. At the same time, farmers burn the area around their crops and villages earlier in the season to avoid accidental fires caused by the passage of pastoralists. The conflict between the two groups, pastoralists and villagers, is a well-known one.

The CNLIFBAC intends to propose a “fire calendar” to the population to manage the spread of fire across the country.

Sustainable land-use practices employed in the country to reduce wildfire

Burning around villages before the migration of cattle through the areas is carried out to reduce the threat of wildfires.

Public policies concerning fire

The government’s policies are persuasion rather than enforcement, making use of television and radio campaigns. At present, the lack of information on the presence and impact of fires is the major obstacle to an effective national policy. The current initiative to develop an information system to document the occurrence of fires is a first step. At the same time, the receiving station is one of a network of sites contributing to the World Fire Web, organized by the GVM unit of the European Commission’s Space Application Institute. This will enable the country’s fire activity to be documented in the regional and global perspective.

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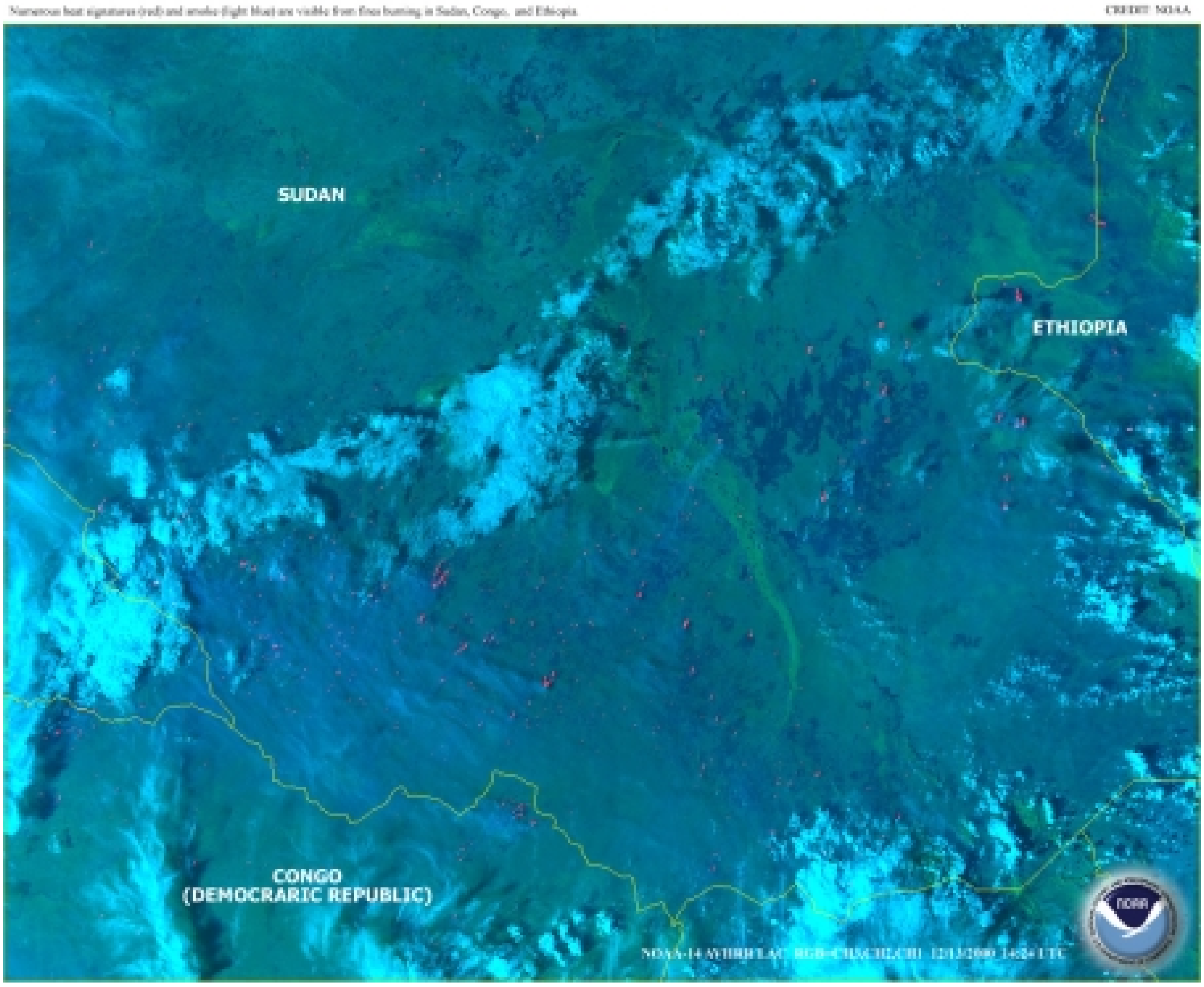
2.4 West and East Sahelian Africa Sub-Region

The lowlands of the west and east Sahelian region are dominated by fire-adapted savannah ecosystems. The country reports of Sudan and Sénégal show that large areas of savannah and open forest are affected by wildfires every year. A recent satellite image shows the extent of fire scars in Sudan and neighbouring countries (Figure 2-9).



Source: NESDIS/OSEI NOAA-14 POES AVHRR LAC, displayed with image interpretation at the Global Fire Monitoring Center (GFMC) website (GFMC 2000a).

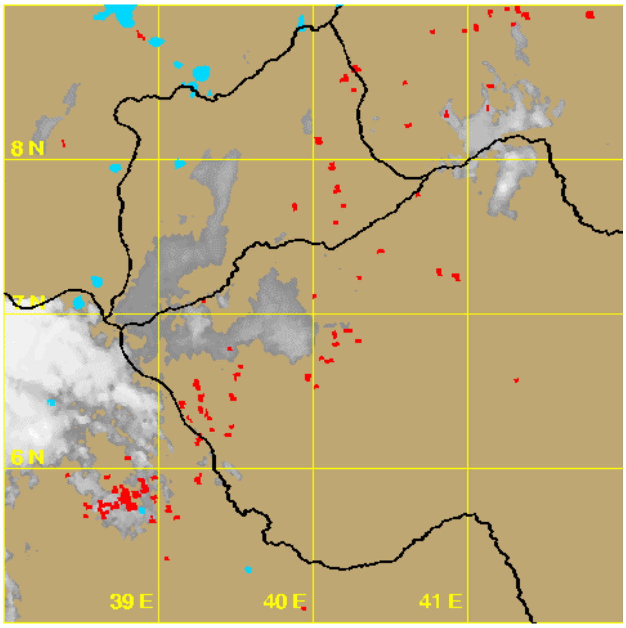
Figure 2-9 Satellite image showing numerous heat signatures (red) and smoke (light blue) generated by savannah and agricultural fires in southern Sudan, Ethiopia and Congo Democratic Republic on 13 December 2000**.**

The mountain regions seem to be experiencing increasing fire pressure. Between 1997 and 1999, several reports from Tanzania and Kenya revealed increasing fire problems in the high-elevation mountain forests of Mt. Kilimanjaro and Mt. Kenya. In 1997 more than 5 000 ha of forest and peatland between 2 800 and 4 000 m elevation burned. Since then a total of 21 000 ha of mountain forests were damaged by fire, according to reports as of March 1999. At that time Tanzania's Ministry for Tourism and Environment called for international assistance to overcome the problem of increasing wildfires that are devastating the biodiversity resources of the mountains.

Extensive wildfires affected Ethiopia in early 1984 and burned a considerable forest area. The area affected by forest type is summarized as follows (see also country report):

- High forest: 209 913 ha.
- Bush land: 41 785 ha.
- Plantation forests: 2 600 ha.
- Bamboo forest: 33 316 ha.
- Woodlands: 20 584 ha.

In early 2000 the countries of the Horn of Africa suffered a severe drought and numerous large fires. In late February Ethiopia called for international assistance that was channelled to the country through the assistance of the Global Fire Monitoring Center (GFMC). With the help of German and South African fire specialists and the recruitment of nearly 170 000 local personnel from the Armed Forces and villages the situation was brought under control more than six weeks later (Goldammer 2000, Bekele and Mengesha 2001). For the first time in Africa satellite images were used to facilitate the planning of fire suppression actions (Figure 2-10).



Courtesy: NOAA.

Figure 2-10 DMSP scene of the Bale region and Borana, Ethiopia, 10 March 2000

(upper left corner 9°N, 38°E; lower right corner 5°N, 42°E) made available for fire suppression planning during the fire emergency 2000 in Ethiopia (Goldammer 2000).

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2.4.1 Fire Situation in Ethiopia

By
M. Bekele & **B. Mengesha**
Ministry for Agriculture, Addis Ababa, Ethiopia

Introduction

Agriculture is the dominant sector of the Ethiopian economy, accounting for about 45 percent of GDP and 76 percent of export revenue. It is estimated to provide livelihood for 85 percent of the total population. There are more than seven million predominantly subsistence farm families who, on average, have a holding of 1.5 ha or less per family to cultivate. These farmers produce about 90 percent of the agricultural output, including most food crops (cereals, pulses and oilseeds), coffee, and virtually all livestock.

The primary task of economic development in Ethiopia is to reduce poverty. Substantial progress in poverty reduction can only be achieved through economic growth, and that will depend on growth in the agricultural sector, which in turn is closely related to how land and other natural resources are used (EFAP 1994). Over the last two decades the Ethiopian economy has performed poorly, with agriculture showing declining rates of growth. Both agricultural and economic growth were constrained by the deteriorating natural resource base of the country, especially in the Ethiopian highlands where 80 percent of the population lives. Agricultural productivity in the highlands is severely threatened by land degradation involving both soil erosion and declining soil fertility. This threat stems from the depletion and degradation of the vegetation cover of the country, especially forests, and exploitative farming practices. The clearing of forests is driven by the demand for crop and grazing land and for fuelwood, both spurred by a high rate of population growth. With a decline in fuelwood availability, animal dung and crop residues are increasingly used as household fuel instead of serving as natural fertilizers for the soil, thereby further depressing agricultural yields.

Arresting deforestation and expanding forest resources are, therefore, vital elements of a development strategy addressing poverty in Ethiopia. The new economic policy of the Federal Government of Ethiopia (FGE) identifies, among other things, deforestation, land degradation and diminishing agricultural productivity as key problems.

At present, however, deforestation has accelerated to the extent that only about two percent (2.4 million ha) of the closed natural high forest remains from the 40 percent of a century ago (EFAP 1994). Deforestation is estimated to take place at the rate of 200 000 ha/year. These closed forests are an important timber source and are confined to inaccessible areas in the southern and southwestern parts of the country. These forests are comprised of broad-leaved rain forests, with an estimated area of 2.3 million ha, and 0.1 million ha of coniferous forests that dominate the highlands (WBISPP 1995).

The woodland/savannah type of vegetation, which originally covered about 30 percent of the country in the semi-arid and sub-humid regions, has now been reduced to 7.5 percent of the

total area. This vegetation formation had a biomass stock of 30 m^3 per hectare, which has now been reduced to 10 m^3/per hectare as a result of continuous cutting of trees for fuelwood, construction purposes and frequent forest fires. Some of the plants have adaptive mechanisms that allow them either to survive fire or to regenerate after a fire.

Fire environment and fire regimes in Ethiopia

Ethiopia has a total land area of about 1.1 million km^2. There is a strong correlation between temperature and altitude. The rainfall pattern is strongly influenced by two moist air streams: the southwest monsoon originating in the Atlantic, and the southeast monsoon originating in the Indian Ocean. There are three rainfall patterns identified. A bimodal pattern with short duration rains in March-April and long duration rains from June-September is found in northeastern and central eastern Ethiopia. A bimodal pattern with seasons of equal length, or with long duration rains in March-May and short duration rains in October-November, is found in southeastern and southern Ethiopia. A unimodal pattern with rains between April and October is found in southwestern and western Ethiopia. Rainfall is generally higher in the unimodal rainfall area and increases with altitude up to about 3 500 m above sea level.

Temperature is inversely related to altitude, with mean annual temperatures of 22^o C to 27^o C in the lowlands and between 10^o C to 22^o C in the highlands up to about 3 000 m a.s.l. This information is very important for planning forest fire control operations.

There are no forest fire statistics permitting an analysis of the causes, risks and extent of damage. However, general information on the causes and season are available that could reveal information concerning the timing of forest fires, which depends on the climate.

Every year, just before the short rainy season starts, very large areas of lowland woodland and grassland formations are affected by fires, particularly in the drier parts of the country.

The effects of forest fires differ depending on environmental factors and the type of vegetation. People start most fires. In the eastern and northeastern parts of the country, the natural vegetation ranges from desert to grassland and woodland formations. Grazing is the dominant form of land use. The vegetation is deliberately burned in order to induce sprouting of fresh vegetation for cattle grazing. Sixty-five percent of the land area is subjected to this practice. Use of fire as an aid to hunting, to control tsetse fly and manage tick populations are among the other major causes of forest fires in the lowland areas.

In the highlands, where there is rapid population growth, fires are used as the major tool to clear forest land and convert it to agricultural use. Smoking out wild bees in order to gather honey is also another cause of forest fires. The traditional practice of using fire as a means to prepare land for agriculture and the enormous demographic growth exacerbate the impact of forest fires.

In general, the causes of forest deterioration by fire are rooted in (1) poverty caused by a high rate of population growth and economic depression, (2) low agricultural productivity, (3) the insufficient attention of government policies to the long-term implications of a deteriorating natural resource base, and (4) the use of many of the forest areas as a common property resource regardless of their suitability to sustain agriculture.

Major wildfire impacts on people, property and natural resources that occurred historically

Fire is mainly used to clear land for cultivation, and the timing is synchronized with the dry season before the onset of rains in March-April. Fire is used at least once a year in January and February so that the land is ready for planting in April. Honey collection takes place in April/May and October/November. Fire is used in the lowland areas, where livestock raising is an important part of the economy, to control tsetse fly or ticks, or to induce sprouting of fresh grazing or browsing vegetation and grasses. Fire is also used to smoke bees out of the hives in the process of harvesting honey.

In Ethiopia, accumulation of fuel load and flammability attain peak values in January and February of each year.

The timing of forest fires and the extent of effects depend on the type of economic activity of the area and the type of forest formation. Pastoralists usually set fires in their rangeland in order to produce fresh grazing and browsing material for their livestock. Thus, fire is used as a management system in the lowland areas where the woodlands and bushlands are located. It is used for the protection of animals from ticks and tsetse fly.

There were forest fires in early 1984 that affected a considerable forest area. The forest area affected by type is summarized as follows:

- High forest: 209 913 ha
- Bush land: 41 785 ha
- Plantation forests: 2 600 ha
- Bamboo forest: 33 316 ha
- Woodlands: 20 584 ha

Major wildfire impacts in the 1990s

There were no major wildfire reports for the 1990s (Table 2-9). A major wildfire episode affected the afro-montane forests in 2000, mainly in Oromiya Regional State. The total forest area affected by fire was ca. 95 000 ha. The firefighting operations in March-April 2000 involved more than 169 589 people (villagers, army, volunteers from Addis Ababa) and a group of foreign experts (Goldammer 2000, Goldammer and Habte 2000).

The Borana and Bale Administrative Zones reported the following losses of non-forest resources:

- 1 226 hectares of wild coffee
- 112 houses of the farming community who live in the natural forest
- 12 quintals of coffee
- 12 storage facilities of farmers for grain
- 8 029 bee hives
- 352 domestic animals (300 sheep, 32 hens, 9 cattle, 10 camels, etc.)
- 335 wild animals (antelope, lion, colobus monkeys, etc)

Fire management organization

At the federal level, forest protection, including fire issues, falls within the responsibilities of the Forestry and Wildlife Conservation Team of the Natural Resources Management and Regulatory Department of the Ministry of Agriculture. The federal responsibilities are not to supervise the regions' actions, but rather to develop policies that will give the framework under which regions can develop their own regional policies. Consequently, policies could vary between regions. The federal government can give help upon request (technical assistance).

At the regional level, the regional Bureau of Agricultural Development is responsible for forest fire protection. However, there are no special arrangements for fire management. It is at the regional level that actual operations for forest protection are undertaken. The regions manage their own budget, but there is federal funding for emergencies.

A recent initiative at the regional level is to prepare draft acts that that will include fire management issues.

There are no people trained and equipped for firefighting. Fire prevention is mainly through education of farming communities about the usefulness of the forests and the damage resulting from forest fires. Monitoring of forested areas and implementation of preventive measures has had limited effect due to weak institutional arrangements. However, for a few of the forestry projects, forest management practices such as timely pruning and weeding operations, controlled grazing, reduction of combustible materials in plantation forests before the fire season, ground patrol and construction of fire breaks are employed. There are 58 National Forest Priority Areas (NFPA) identified as potential areas for conservation and development, but only two of these are organized for fire protection. There are forest protection committees established in each administrative zone, but these are not functional and effective. There is no budget allocated for fire prevention.

From the wildfire incidence in 2000, a National Committee for Fire Management was established at the federal level and a similar committee was also established at different levels in all zones where wildfires were reported. The committees are responsible for organizing and mobilizing local and international fire suppression resources that are indispensable for firefighting.

Wildfire data base

Table 2-9 Forest fire statistics of Ethiopia for the period 1990-2000.

Year	Total no. of fires on forest and other wooded lands	Total area burned (ha)	Area of forest burned (ha)	Human causes	Natural causes
1990	4		1 072		
1991	2		153		
1992	1		32		
1993	20		3 159		
1994	1		1 550		
1995					
1996					
1997					
1998					
1999					
2000	> 120		95 000		

Source: paper records of the Ministry for Agriculture, Addis Ababa.

Average annual number of fires: There is usually one incidence of fire in Ethiopia, which is mainly in January, February and March before the onset of the rainy season.

Average annual fire size: There is no accurate information on annual fire extent available. However, from selected studies it is known that woodland and bushlands are burned annually to a large extent. Hence, the area burned annually amounts to millions of hectares.

Fire causes: Fires started by people account for 100 percent of the total fires. Of the human-caused fires, 20 percent are classified as arson and negligence and carelessness cause 80 percent. However, there is no research conducted on fire causes. These observations are based on personal experience in the field for the last 20 years.

Use of prescribed fire to achieve resource management objectives

In the lowland pastoral areas, which cover 60 percent of the total land area, controlled bush clearing for improved community based range management is practised. In addition, control of ticks and tsetse flies, which pose a serious problem to the livestock herds, is another positive effect of prescribed burning. Some of the traditional practices of the local people regarding prescribed burning are selective bush clearing, which is used to stimulate vegetative re-growth of grasses and many shrubs and trees during the dry season. They also use prescribed burning for increasing plant biomass and to control bush encroachment and favour the growth of the herbaceous layer, which is important for the nutrition of cattle, goats and sheep. They also use prescribed fire for the control of vectors of animal diseases.

Public policies

The lack of established ownership and open access has contributed to uncontrolled, illegal encroachment and clearing of forest land by frequent fires. Institutional arrangements are weak for monitoring forested areas and implementing preventive measures. There is a lack of clear land ownership rights to help insure local cooperation in such critical matters as forest fire prevention and control.

A general federal law gives responsibilities to the regions, including protection of the forest against insects, disease, fire, etc. There is a draft forest policy currently being reviewed by the Ministry of Agriculture (first draft in 1997). This policy document does not make special reference to fire issues.

After the large wildfires in early 2000 the Government of Ethiopia, supported by the German Agency for Technical Cooperation (*Deutsche Gesellschaft für Technische Zusammenarbeit* – GTZ) and the Global Fire Monitoring Center (GFMC) organized the Ethiopia Round Table Workshop on Forest Fire Management, which was held in Addis Ababa, 19-20 September 2000. The results of the workshop point toward the development of a national intersectoral strategic programme for fire management.

Sustainable land use practices used in Ethiopia to reduce wildfire hazards and wildfire risks

The major cause of forest fire is poverty, which is constantly fueled by a high rate of population growth in relation to low agricultural productivity. People usually look for new productive land and clearing of forests by setting fire is a means of land preparation. In order to alleviate this, the government, through the Ministry of Agriculture, has introduced an extension package programme in different agro-ecological zones to help boost agricultural production. The programme focuses on an integrated land management strategy.

There is a need to focus on increasing productivity on agricultural lands by providing better education and information to farmers and improving their performance.

The public needs to be educated to view forest fires as a threat to the national economy, since no forest fire prevention campaign can be successful without the general support of the local communities.

Community involvement in fire management activities

The development agents of the Ministry of Agriculture provide information to farmers on the impacts of wildfire on forest resources and its relation to the production system. They are informed and updated on the possible causes of fire and on precautions to be taken during the dry season.

The government and private radio channels, which disseminate agriculture-related programmes, provide educational messages to make the local farmers aware of possible fire impacts. They are also involved in firefighting through mobilization as legislation clearly states that all citizens have the obligation to cooperate in firefighting if fires occur in their surrounding area.

Local communities participate in firefighting activities. The number of people involved in firefighting in 2000 was estimated to be over 169 589.

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2.4.2 Fire Situation in Kenya

By
J. K. Ndambiri & **C.D. Kahuki**
Forest Department, Nairobi, Kenya

Fire Environment and Fire Regimes in Kenya

Kenya has a total land area of 582 646 km^2. Highlands form most of the south-west and central parts and are well watered and fertile. More than 70 percent of Kenya is a climate condition classified as both arid and semi-arid; and characterised by low biological activity.

The country's forests are concentrated in the moist central highlands where the human population and agricultural production are also found. In the extensive semi-arid region, forests are situated on isolated hills and in discontinuous narrow bands along river beds.

Kenya gazetted forests comprise some 1.64 million hectares of land (about 3 percent of the land area). Outside the gazetted forests, there are other large tracks of forests in trustlands, i.e. national parks, national reserves and privately owned land covering about 0.5 million hectares in the following regions:

- Coastal forest region
- Dry zone forest region
- Mountain forest region
- Western Mau forest region

Because of extended degradation of the closed forests, a programme of plantation establishment was started in 1946. Cutting of the valuable natural hardwood is considered non-sustainable and has been banned. The wood industry relies on softwoods from government forests.

Forest Fire Management

Most of the forests, especially the highly productive ones, including both indigenous and plantations, are located in the relatively high fire-prone areas. Wildland fires continue to be one of the biggest threats to forests. A forest fire protection unit exists with the Forest Department. A conservator of forests is appointed at the Headquarters who:

- Plans, organizes, equips, trains and provides a follow up supervision of a cost effective fire pre-suppression and suppression organization at all levels with the Forest Department.

- Develops a comprehensive nation-wide program designed to create awareness of the need for fire protection and control.

- Plans the implementation of risk and hazard reduction programmes.

In the field, District and Station Forest Officers organize and supervise forest fire prevention and suppression activities within their areas.

Available firefighting equipment includes, vehicles, tractors, pump units with hoses, knapsack sprayers and hand tools.

Firebreaks and forest boundaries are established and maintained on a regular basis to keep fires from spreading between plantations and from neighbouring settled reserves.

Fire detection is carried out by ground patrols and permanent stations (fire towers). A few of them have radio systems, vehicles, motorcycles and bicycles. When a fire occurs a comprehensive fire report is compiled detailing the location, area burnt, suppression cost and the actual damage to the forest.

Forest Fires Statistical Data

Table 2-10 Number of fires and area burned in Kenya for the period 1990 – 1999.

	Area burned (ha)			Number of fires
Year	**Plantations**	**Indigenous Forests**	**Bush/grass**	
1990	85	331	12 183	36
1991	1 705	236	6 697	64
1992	6 170	5 494	13 302	180
1993	1 731	515	1 718	48
1994	690	69	1 913	40
1997	4 726	2 961	7 729	121
1999	1 449	317	2 041	59

All fires in Kenya are started by people. Of these fires, 40 percent are classified as arson, 20 percent are caused by negligence and carelessness and 40 percent are due to unknown causes.

Community Involvement in Fire Management Activities

Campaigns through public meetings are organized before the declaration of the fire danger season to create awareness for the need to prevent any forest fires and action to be taken in case a fire is detected.

Fire Ecology and Management Research

A fire research programme conducted on the *Lewa Wildlife Conservancy* since 1992 increased understanding about the effects of type and intensity of fire on savannah vegetation in the central highlands of Kenya. Techniques for assessing range condition were developed to assess the condition of the vegetation and these were used to monitor and assess the effect of the controlled burns applied on the *Conservancy* during 1997 and 1998. The vegetation in this area is in the range type called Scattered Tree-Grassland (*Acacia-Themeda*) rangeland. The study during 1998 tested the fire intensity model developed for southern African savannahs (Trollope 1998). The study also determined the effect of type and intensity of fire on the mortality and topkill of stems and branches of different tree and shrub species occurring in the aforementioned range type.

The results of the research on the fire ecology of the savannah vegetation on the *Lewa Wildlife Conservancy* led to the following general conclusions regarding the effect of type and intensity of fires on the tree and shrub vegetation:

- Generally the mortality of trees and shrubs is very low irrespective of type or intensity of fire, i.e. 4.4 percent;

- Generally all the bush species were highly resistant to fire and the only woody species that consistently suffered a high mortality with burning was *Acacia nilotica*;

- Head fires burning with the wind caused a greater topkill of stems and branches of trees and shrubs than back fires burning against the wind. This difference increased significantly for bush greater than three metres in height;

- Increases in fire intensity caused a greater topkill of bush while increases in the height of trees and shrubs resulted in a lower topkill of bush;

- Cool fires that will cause a significantly lower topkill of bush can be obtained by burning in the late afternoon/early evening when the air temperature is <20°C and the relative humidity >50 percent;

- High intensity fires that will cause a significant topkill of bush can be obtained by burning during the heat of the day from noon onwards when the air temperature is >20°C and the relative humidity <30 percent.

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2.4.3 Fire situation in Sénégal

By
Mussa Drame
Centre de Suivi Écologique, Dakar, Sénégal

Introduction

In Sénégal, fire occurrence contributes to increased pressure on agricultural and rangeland systems through the destruction of natural pasture and the degradation of agricultural land, particularly in the Sahel. Fire activity in the forests in southern Sénégal decreases forest productivity and is a threat to regeneration.

The Government of Sénégal has put in place the means to fight bush fires in the principal eco-geographic zones of the country. These include active firefighting, prevention activities such as awareness campaigns, and the establishment of a network of fire breaks. One of the most important strategies, introduced in 1965, is the use of prescribed fires early in the season in order to reduce fuel loads and prevent late fires, which are often much larger, more difficult to control and more destructive.

These strategies are complemented by the appropriate use of fire information by the public services as well as the general public. Traditionally, fire information consisted of field reports of observed or fought fires. However, the estimation of burned areas and fire frequency are fundamental to the management of natural resources with respect to fire activity.

Remote sensing of active fires and area burned

To complement traditional fire information, the *Centre de Suivi Écologique* (CSE) of Dakar has implemented a methodology to monitor fire activity using NOAA-AVHRR satellite data received locally through their own station installed in 1992. While not exhaustive, it is well accepted that fire information obtained from AVHRR provides a good indication of fire activity over a large territory. Initially, only the territory of Sénégal was covered, and information was used operationally by both the Forestry, Waters, Hunting and Conservation Department and the Livestock Direction. Now the CSE monitoring activities are also providing fire information to neighbouring countries. The CSE has also recently become one of the nodes of the World Fire Web of the Joint Research Centre (EU). In 1999, an agreement was signed with the Global Fire Monitoring Center (GFMC) which allows the GFMC to disseminate CSE fire products on the GFMC homepage.

Analysis of fire information from the period 1993 to 1998 led to a better understanding of fire activity in Sénégal and the identification of important issues that are briefly described below.

The fire season takes place from October to May. The most troublesome period is often January and February, when there is a high volume of senescent vegetation and the weather is very dry. During that period, large uncontrolled wildfires can be very destructive. The spatial and temporal distribution is generally heterogeneous and variable. Figure 2-11 illustrates this variability and clearly indicates peak fire activity in February 1994 and January 1996. These

two periods can mostly be explained by high rainfall that lead to increased fuel loads as well as unsuccessful prescribed fire programs.

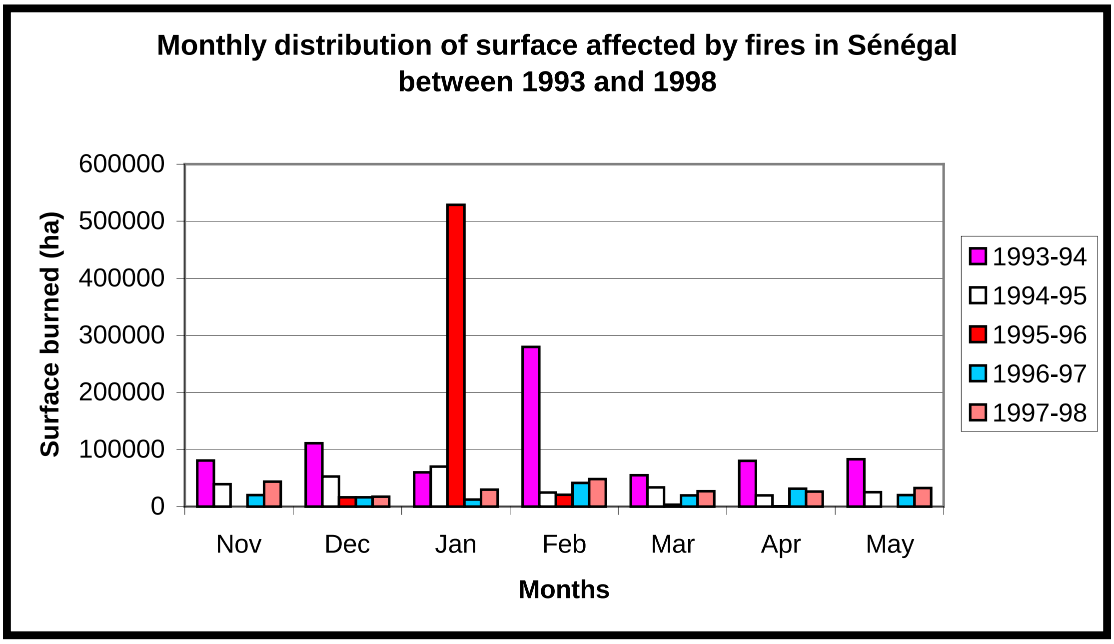

Figure 2-11 Monthly burned area in Sénégal between 1993 and 1998.

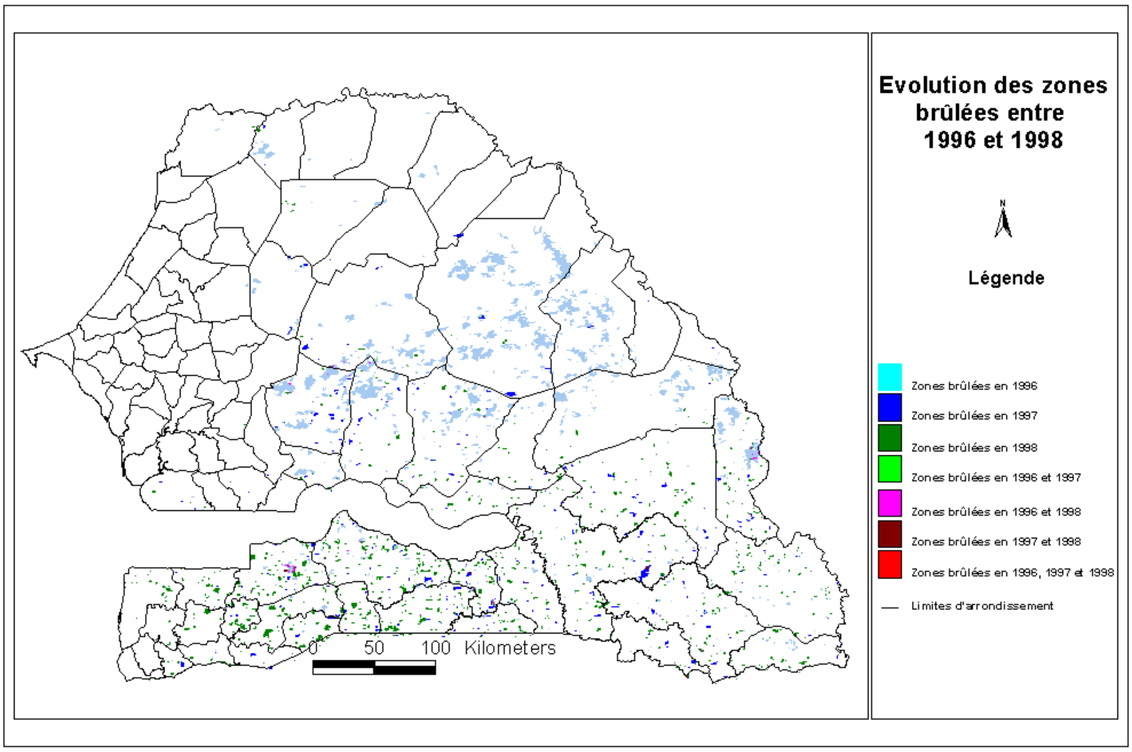

Figure 2-12 Fire occurrence in Sénégal between 1996 and 1998**.**

Spatially, as illustrated in Figure 2-12, most fire activity occurs in the centre, south and southwest. Most of this activity takes place in the regions of Kolda, Tamba and Ziguinchor because of their continuous vegetative cover combined with human activities such as honey and gum gathering, hunting and charcoal production. In the northern part of the country, the little vegetation available is usually quickly used by cattle and fire activity is consequently very low.

Fire management organization

The Directorate for Water, Forests, Hunting and Soil Conservation (Direction des Eaux, Forêts, Chasses et Conservation du Sols - DEFCCS) is the main Organization responsible for wildland fire management. DEFCCS promotes fire prevention but lacks adequate tools and funding. The CSE provides information that allows the government to determine the location and size of fires. For fire management purposes, the fire maps, together with maps of primary production and fire statistics, allow the recognition of vulnerable areas and the mobilization of firefighting forces.

The Directorate of Livestock Breeding (Direction de l'Élevage) manages the pasturelands, which are indispensable for the nutrition of domestic livestock under the extensive management system common in Sénégal. The Directorate is faced with two major problems. First, wildfires destroy considerable areas of important grazing resources, resulting in overgrazing of the remaining vegetation. Second, the mobility of the migrant (nomadic)

pastoralists increases the fire risk. The information generated by the CSE allows the authorities to better manage pasture resources in space and time.

Source

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2.4.4 Fire situation in Sudan

By
Abdel Aziz M. S. Bayoumi
Faculty of Forestry, University of Khartoum, Shambat, Sudan

The fire environment

Climate and fire regimes

The dry season starts two to three weeks after the rains end in northern Sudan, i.e. November to April/May. Tall and short grasses are increasingly desiccated during the dry season. Increased wildfire hazard is associated with low humidity, high fuel loads and the presence of moving graziers. Annual wildfires are common and spread rapidly due to northeast winds and flat terrain. This is the case in central, western and southern Sudan. Repeated fires occur if the hot dry weather continues, i.e. late rains.

Ecological role of forest fires

In the high-rainfall savannah ecosystems of southern Sudan fires kill certain fire-sensitive trees, e.g. *Isoberlinia doka, Daniellia oliveri*, etc. and reduce the growth of other species. Fires may reduce gum yields from *Acacia senegal* by up to 50 percent. This is considered a big economic loss. In an average year fires affect about 70 percent of the open rangelands.

Fires may also encourage the spread of some species, e.g. *Acacia mellifera* in central Sudan on clay soil where the "*Acacia*-grassland cycle" takes place. The occurrence of *Acacia* alternates with tall grasses. *Acacia* takes over if the fires are of low severity. Grasses become dominant with increasing fuel loads and high-intensity fires.

Impacts of wildfires

Lightning fires or fires caused by nomads often damage or destroy whole villages with huts that are built from grass and wooden materials. This problem is very common in central Sudan. Villagers in many instances are caught by surprise.

Wildfire database

Fires statistics for the period 1980 to 1999 are lacking except for limited incidents in Jebel Marra where some 3 000 feddan (1 feddan = 0.42 ha) of *Cypressus lusitanica* were destroyed in the 1990s. Large tracts are often swept over by wildfires in central and western Sudan. Nothing is presently known of the situation in southern Sudan where fires are presumably set by the army to improve visibility and for control of the terrain. More than 60 million ha are affected annually.

Organizational set-up

A fire management organization is not in place. However, the traditional system of constructing or maintaining forest fire lines (firebreaks) is adhered to through an annual budgeted program , but funds are always short. Surface vegetation, especially grasses, may dry very quickly after the end of the rainy season and the firebreak programme is never completed in time.

By law, fire lines are supposed to form the boundaries and protect Government forest reserves. The law states that fire lines should be at least two metres wide but these are inadequate and normally five- to eight-metre-wide lines are cleared, but fires may still jump over. Cleaning fire lines is an expensive operation.

In colonial times and up to the end of the 1960s the Native Administration, under the supervision of the Range and Pasture Department and in close collaboration with the Forestry Department, maintained a firebreak network extending north-south over North Kordofan and North Darfur to protect grazing lands and gum gardens. Usually four-metre-wide lines are cleaned and spaced parallel to each other and separated by an 80 m wide area that is burnt just before the end of the rains. This pattern is repeated systematically over the semi-arid lands. Early warning, detection and monitoring systems are not available. No volunteer fire fighters are available but people and communities are obliged by the forest law to report and help fight wildfires. Fire research is absent.

Use of the prescribed fires

Prescribed burning is used in natural forests in western Sudan (Jebel Marra) and used to be practised as early burning in southern Sudan but stopped due to the war. The use of backfiring for controlling wildfires is forbidden except for certain conditions and under control of appropriately trained foresters.

Sustainable land use practices to reduce wildfires

Very wide fire lines (50 m) have been used to separate blocks of *Eucalyptus* plantations in the Khartoum green belt. Fuelbreaks (greenbelts) consisting of teak (*Tectona grandis*) were used in the south to protect fire-prone species. In traditional agricultural areas, people and farmers are guided by extension workers to protect their villages and lands. At present there is no method other than burning to clear forest lands for cultivation. The forest law, however, prevents wasteful burning and obliges cultivators to make use of cleared woody material (shrubs, trees) by converting it into useful products, e.g. charcoal.

Public policy concerning fires

The forest policy of 1986 emphasizes the protection of forests against fire. The forest law of 1989 prohibits trespassing of people and their animals into reserved forests and prohibits the carrying of ignited material into the forests, making fires for cooking or other purposes in or near forests and obliges people to help extinguish forest fires.

Reduction of fires will definitely conserve the natural resources of the country and will improve the growth of many tree species.

Fire management needs cannot be detailed here due to the complexity of the different environmental conditions and the need for different management techniques. The very large size of the country, the various local factors and weather conditions, the trend toward repeated severe droughts and desertification, the increase in population and domestic animals, the displacement of rural people to cities, the expansion of unplanned rain-fed cultivation, the poverty of the people and the lack of knowledge of decision makers regarding forest conservation are all major problems and impediments.

Sudan needs extension capability to teach people how to protect their lands. Research is needed to find safer methods to prepare land for agriculture or forest plantations. Above all, trained personnel and supporting equipment are needed for transport, detecting and fighting forest fires.

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3 Asia Region Fire Assessment

3.1 Introduction

The report on the Asia region has been divided into three sub-regions, 1) Insular and continental Southeast Asia, 2) South Asia, and 3) Middle East, Central and East Asia. For each of the sub-regions, a short overview is given on biogeographic features and fire regimes. A number of selected country reports provide an exemplary and representative insight into the fire conditions. For other countries, brief descriptions are provided as well as bibliographic or Internet (websites) references.

Narrative summary of major wildfire impacts on people, property, and natural resources during the 1990s (to include effects on public health)

The Asian region suffered extreme wildfire and smoke episodes during the 1990s. Insular Southeast Asia was most affected by several El Niño - Southern Oscillation (ENSO) events in the 1990s, particularly during the extreme ENSO in 1997-98. Extended droughts favoured the application of land-use fires, forest conversion burning (use of fire in land-use change) and extended wildfire situations. The fires have caused impoverishment or destruction of primary and secondary equatorial rain forest ecosystems over large areas. Indonesia was the main source of smoke-haze that affected the entire region for almost one year and affected the health of more than 100 million people living in the region.

Continental South and Southeast Asia continued to experience extended wildfires in the seasonal (deciduous) forests, e.g. monsoon forests and forest savannahs. Human-induced wildfires in the deciduous forests are common since historic times. As a traditional element of forest utilization, especially for improving grazing conditions (silvopastoral land use), or to improve productivity or facilitate harvest of non-wood forest products, these fires partially represent prescribed burning systems. However, many of the fires are not contained and tend to escape as extended wildfires.

In Central Asia, the most challenging fire region is between the steppe and southern boreal forests. Steppe fires exert a tremendous pressure on the adjoining forests. Recent socio-economic changes have led to an increasing occurrence of wildfires in Mongolia and its neighbour countries.

The Asian countries bordering the Mediterranean Basin are included in the Mediterranean section (reported under the Europe region).

Fire management organizations present in the region

National fire management organizations and capabilities are described in the country reports. However, there are attempts to organize regional efforts in fire management such as in the ASEAN region. The aim of the ASEAN-wide activities are described under Southeast Asia. Several bilateral (border-crossing) agreements for mutual assistance are also in place, e.g.

between Malaysia and Indonesia, Indonesia and Brunei, Mongolia and Russia and China and Russia.

Fire databases

A complete regional database does not exist. The country reports contain statistical data if these were available. Some of the Asian countries belong to the ECE (United Nations Economic Commission for Europe) region which is regularly collecting fire statistics of their member states (see ECE fire statistics included in the Europe regional report). Occasional reports of individual years are published in the pages of International Forest Fire News (IFFN) and the Global Vegetation Fire Information System (GVFI) – both available on the Internet through the website of the Global Fire Monitoring Center (GFMC 2000).

Use of prescribed fire

Within the Asian region the application of fire in forest and other land-use systems often follows traditional patterns, e.g. in sustainable slash-and-burn agriculture of smallholders and maintenance burning in permanent farming and pastoral systems. However, increasing land-use pressure associated with migrations of populations and the increasing loss of traditional skills in safe and sustainable fire application are causing widespread deterioration of forests and other wooded land.

Application of fire also includes the maintenance of grasslands, predominantly occupied by the aggressive invader *Imperata cylindrica*, which have replaced former forest ecosystems. In Bangladesh, for instance, fires are set intentionally to stimulate the growth of sungrass (*Imperata cylindrica*). The grass is used for thatching and therefore has a high commercial value. Ironically, the situation in all countries of South East Asia is very different. These grasslands are often fired without immediate economic and land-use objectives, simply to keep the land open, to purposely prevent the regeneration of a forest cover in order to maintain a controllable space for living around villages and farmlands. The *Imperata* grassland fires occur on potential forest land and represent a major impediment for the restoration of forest cover. Thus, although the grassland fires are not classified as “forest fires” and are not even recorded at all, they are of significant importance for rehabilitation of damaged forest ecosystems.

The use of advanced prescribed burning techniques in forestry is occasionally practised in coniferous natural forests and plantations (*Pinus* spp., *Tectona grandis*), e.g. in the Philippines. The concept of *Early Burning* is common in some other places in the seasonal forests in order to reduce fuel loads at the beginning of the dry season.

Public policies affecting wildfire impacts

Most countries in the Asia region have adopted national policies that give priority to wildfire prevention by public education and awareness raising. Legislation in many countries imposes restrictions on the use of fire for shifting cultivation and other land clearing activities (land-use change or conversion burning). However, the efficiency of enforcement of these regulations varies from country to country.

Sustainable land-use practices employed in the region to reduce wildfire hazards and wildfire risks

Efficient practices of forest management or the integration of other land-use practices to reduce wildfire hazard and risk are implemented only in a few countries. Most impressive and efficient is the systematic establishment of shaded fuelbreaks (greenbelts) in China (Shu Lifu 1998; see also country report China, this volume). These fuelbreaks are buffer zones of 10 to 20 m widths on which low-flammability hardwoods are grown commercially. They are strategically located on mountain ridges and along other topographically suitable locations and have a total length of 172 100 km.

Community involvement in fire management activities

The involvement of local communities or individuals in forest fire prevention and control by enforcement through the forest police often has proven inefficient because people were not adequately prepared (informed or trained) or took advantage of fire protection. The philosophy of *Integrated Forest Fire Management* (IFFM) represents an approach in which local communities actively participate and benefit from fire prevention, wildfire preparedness and fire suppression activities. This approach has recently been designated *Community-Based Fire Management* (CBFM).

The CBFM strategy of the Indonesia-German IFFM project in the Indonesian province East Kalimantan includes the following six steps which are exemplary for other projects (Wityanara 2000):

1. <u>Orientation process/identification of villages</u>

- Villages selected particularly in or near fire hazardous forest areas.
- Formal and informal meetings carried out with key resource persons from the local government and communities to discuss fire management approaches.
- Socio-economic studies carried out to identify and assess the motivation, potential and constraints (problems) of local communities in the project areas with respect to fire management.

<u>2. Fire prevention campaigns</u>

- Extension meetings carried at strategic locations/villages with participants from up to 10 sub-villages/hamlets.
- Villagers are encouraged to form volunteer village fire crews.

<u>3. Fire prevention and suppression training for volunteer village fire crews</u>

- Hand tools provided to each participating sub-village/hamlet.
- Crews provide for proper storage and maintenance of hand tools (small warehouse, standard operating procedures, etc.).

<u>4. Institutionalizing of fire prevention work at village level</u>

- Participatory planning workshop at village level (with representatives of village fire crews, formal and informal leaders), which also considers gender issues.
- Workshop results proposed to local and provincial government.
- Province government should provide for legal framework as part of the overall fire management system.
- Village fire crews integrated in “village structure”.

5. Training of Trainers

- Up to five trained villagers per district appointed by village crews to participate.
- Village trainers to extend village fire prevention programs in close cooperation with crews of the provincial forestry service and concession crews.
- Job descriptions provided, also compensation for services by local government.

6. Networking

- Regular meetings established between crew bosses of village fire crews, the forestry extension service and other involved government agencies, and concessions.
- Communication established. Early warning information reaches the local level in time, and vice versa.

The India country report of this regional report describes the *Joint Forest Management (JFM) Committees* that have been established at the village level to involve people in forest protection and conservation. At present there are 36 165 JFM committees throughout the country, covering an area of more than 10.24 million hectares. These JFM committees also have been given responsibilities to protect the forests from fires.

In December 2000 the IUCN-WWF supported project *FireFight South East Asia*, in cooperation with the Regional Community Forestry Training Center (RECOFTC) convened a preparatory International Workshop on: Community Based Fire Management (Bangkok, Thailand). The workshop provided a forum to review existing community-based fire management approaches and assess the different avenues for community involvement in fire management (independent and in conjunction with projects, government agencies, and NGOs) and synthesized the existing lessons learned into a workshop document that will further promote community based approaches in the region.

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3.2 Insular and Continental Southeast Asia Sub-Region

The application of fire in land-use systems and human-caused wildfires in forests and other vegetation in insular and continental South East Asia during the 1990s have reached unprecedented levels and have been leading to severe environmental problems and impacts on ecosystems and society. Traditional slash-and-burn agriculture (shifting cultivation) is still practiced in many countries of the region. During the 1990s an increase of fire application for large-scale conversion of primary and secondary forests into permanent agricultural systems and into tree plantations has been observed, particularly in Indonesia. Wildfires escaping from land-use fires are becoming more and more regular, especially during episodic droughts (inter-annual climate variability) associated with the El Niño - Southern Oscillation (ENSO) event.

A large variety of biogeographic features and climatic conditions within insular and continental South East Asia have created a high diversity of forest ecosystems and other wooded land with different fire regimes and vulnerabilities. The socio-economic conditions of wildland fires in SE Asia, including the underlying causes of fire application, and the ecological and environmental consequences of wildland fires in the region have been synoptically analyzed for the time period before the last ENSO (1997-98) by Goldammer and Seibert (1990), Goldammer and Peñafiel 1990, Stott et al. 1990, Goldammer 1993, Goldammer et al. 1996, AIFM 1997a). Several regional analyses have been published in the aftermath of the 1997-98 fire and smoke episode, notably by Schweithelm (1998, 1999), Chandrasekharan (1999), Suhartoyo and Toma (1999), BAPPENAS/ITTO/JICA (1999), Radojevic and Eaton. (2000), Barber and Schweithelm. (2000), Rowell and Moore (2000).

The following vegetation formations with distinct fire regimes are most typical in Southeast Asia:

Tropical lowland deciduous forests (based on Stott et al. 1990 and Goldammer 1996): This regime includes both monsoon and savannah forests, the latter having less tree cover and more grass. These forests occur in areas of South and Southeast Asia where the dry season is three to seven months long, total annual rainfall is usually less than 2,000 mm and the mean temperature in the coldest month is rarely less than 20 degrees centigrade. Monsoon teak (*Tectona grandis*) forests occur naturally in mainland Southeast Asia and have been planted elsewhere. Sal (*Shorea robusta*) forests occur in the northern part of the Indian Sub-continent. Dry dipterocarp savannah forests occur in mainland Southeast Asia, and open grasslands and thorn forests are spread in patches across drier parts of the region. The relatively dry Lesser Sunda Islands of eastern Indonesia contain monsoon and savannah forests with affinities to Australian flora.

These forests usually burn one or more times per year with low level litter and ground cover fires being the norm. Levels of fire adaptation vary among formations. Fires are typically ignited purposely or accidentally by humans, and increased frequency of burning places stress on these fire-adapted ecosystems. The primary objective of fire management is to control fuel loads through controlled burns, grazing, or cutting. Total fire exclusion is not practicable and prescriptions must be site specific.

Fire climax pine forests (based on Goldammer and Peñafiel 1990): Pine forests occur naturally on disturbed sites in the lower montane forests of tropical Asia, primarily in the Himalayan foothills, the mountains of mainland South East Asia, Sumatra (Indonesia), and

Luzón (Philippines). Human disturbance of forests at lower and higher elevations have caused the altitudinal range of fire climax pine forests to expand. Pine plantations have been established at lower elevations in many parts of the region. Tropical pine species have various levels of fire adaptation and are prone to burning due to the volume and flammability of their litter. These forests are productive if fire frequency and intensity are stable, but tend to become degraded if fired too frequently or fire is combined with other disturbance factors. Most fires are ignited by humans through carelessness or escaped swidden fires, but may be started purposely to improve grazing or to facilitate hunting. Most pines will not regenerate if fired annually, so managers must try to reduce fire frequency to the period required for regeneration. Total fire exclusion usually results in broad-leaved species reclaiming the site.

Evergreen equatorial rain forest (based on Whitmore 1998, Goldammer and Seibert 1990, Goldammer et al. 1996, Schweithelm 1998): Tropical rainforests occur naturally over large areas of Southeast Asia and the tropical Pacific. These forests require abundant rainfall and high temperatures year round: drought conditions prevail when monthly rainfall drops below 100 mm. Insular Southeast Asia, New Guinea and the high islands of Melanesia were largely covered with species-rich forests until recent decades. Logging and agricultural expansion have now greatly decreased their quality and extent. Other than New Guinea and protected or remote parts of Southeast Asia, the lowland rain forests of the region are a mosaic of disturbed stands, fire climax grasslands, secondary vegetation and commercial crop plantations. Within this climate type, special vegetation types have their own fire regimes. During severe droughts peat swamp forests are susceptible to fire in desiccated organic layers, some of them burning sub-surface; and heath and limestone forests are more fire-prone than other forest types due to the limited water-holding capacity of their soils.

Undisturbed lowland rainforest is very resistant to burning, but scientific evidence indicates that Borneo's forests (and by inference, those elsewhere) have burned periodically over tens of millennia during extreme droughts. Humans have used fires as they settled the forests over thousands of years to create swidden plots and facilitate hunting. Traditional use of fire is thought to have had little long term ecological effect on the forests, but increased human population density, shortened fallow periods and cash cropping have made shifting cultivation a major agent of deforestation. Careless commercial timber harvesting has greatly increased fire hazard, and logging roads have provided agricultural settlers with access to remote forest areas, thereby increasing the risk that their land clearing activities will result in wildfires. Logged and otherwise disturbed forests are being cleared by “slash and burn” of waste wood in preparation for conversion to palm oil or pulp wood plantations.

Degraded/potential forest land (based on Goldammer and Seibert 1990, Goldammer 1993). A sequence of severe ENSO-related droughts over the last two decades, combined with human disturbance of rain forests and indiscriminate use of fire, have led to massive wildfires. This burning has produced dramatic changes in fire regimes and the overall size of degraded land area. Experience in East Kalimantan and other parts of the region have shown that important rain forest species are able to survive the irregular, non-uniform impacts of a single forest fire. However, because of altered microclimate, species composition, forest structure, and fuel availability the fire hazard in these damaged ecosystems has increased. A second and a third wildfire tend to burn with higher intensity and severity, thus leading to more complete destruction of the forest structure and the overall biodiversity of the flora and fauna (Goldammer 1999a). Similar observations were made regarding the Brazilian Amazon forest (Nepstad et al. 1999). In Southeast Asia, repeated wildfires in conjunction with land use impacts have led to the formation of large areas of degraded *Imperata cylindrica* grasslands.

The majority of these grasslands are subjected to a one-year fire return interval, often purposely burned by local people to prevent the growth of woody and forest species.

The situation within the countries of the Southeast Asian region

During the 1990s the fire situation within the South East Asian nations was monitored by the ECE/FAO Team of Specialists of Forest Fire. National partner institutions and individuals were encouraged to provide analyses and statistical data that are published in the pages of International Forest Fire News (IFFN). For this regional review special country reports were delivered by individuals from Indonesia, Malaysia, the Philippines, and Thailand and provided below in full length.

The following short remarks on the fire situation in other countries of insular and continental South East Asia provide some major statements of interest and the information source. No information is available on Christmas Islands and East Timor; the small size of forest and other wooded land area in Singapore explains the lack of information in that country.

3.2.1 Brunei Darussalam

In Brunei Darussalam efforts to strengthen the institutional, technical and legal capacity to prevent and combat forest fires have been undertaken. This includes such physical measures as constructing fire breaks in forest reserves to prevent fire spread, observation towers for early detection and warning, and fences that prevent people from entering some fire sensitive areas. The ground and aerial forest firefighting capacity (in terms of equipment) has also been enhanced and improved. Brunei Darussalam has been working closely with its colleagues in Limbang, Miri and Lawas of Malaysia in combating forest fires in areas bordering the shared national boundaries.

Existing legislation, as contained in the Forest Act, prohibits persons form kindling, keeping or carrying any fire or leaving any fire burning that may endanger the reserved forests. Open burning is still a common practice. Open burning, though discouraged, is nonetheless observed during land clearing activities for development for agriculture, as well as at construction and rubbish dumping sites. Presently, open burning is not allowed at government rubbish dump sites and forest reserves. Under new provisions of section 277A of the Emergency Order (Penal Code Amendment, 1998), open burning was prohibited during dry seasons and prolonged drought. A stiffer fine of B$100 000.00 was imposed on offences relating to open burning. Where such offences cause pollution to the atmosphere or endanger human life or property the punishment is a fine of an unlimited amount and/or imprisonment for a term of up to five years (Anonymous 2000).

3.2.2 Cambodia

A country report by Savet (1999) explained that fire, though not widespread and not a serious threat to the forests of Cambodia, could become a threat if the degradation continues at the current rate creating favourable conditions for large-scale forest fire. Fires occur annually in the natural hardwood forests, pine forests, bamboo forests and forest plantations during summer months. There are three main natural forest types: evergreen, mixed evergreen and deciduous. Fires occur frequently in the deciduous, pine and bamboo forests during the dry season. Most of the species that constitute the deciduous forest shed their foliage almost

completely during the dry season that lasts from December to August, building up a heavy flammable fuel load on the ground. In addition, the leaf shed opens the ground surface to greater sun exposure leading to a high degree of fire hazard. The underlying causes of forest fires are explained as well as the fire prevention measures taken by the country.

3.2.3 Laos

According to the report by Bouaket (1999) the main causes of forest fire in Laos PDR are slash-and-burn cultivation practices without firebreaks, and traditional hunting practises used to drive out animals. It is estimated that 90 percent of the forest fires originate from slash-and-burn cultivation practices of upland farmers and lead to widespread land degradation. No reliable statistics are available. There are no appropriate methods available for forest fire control. The government also lacks forest fire control equipment. It is particularly difficult to find suitable methods to control fire in mountainous and less inaccessible area. In order to prevent and control wildfires the following measures have to be taken, (1) provision of sustainable land-use practices and job opportunities for shifting cultivators, (b) motivation of the shifting cultivators about how to prevent, detect and control fires, (c) establishment of standard working groups and the coordination of regional fire control organizations or other government agencies, (d) preparation of materials and guidelines for forest fire prevention and suppression.

3.2.4 Myanmar

In the post-independence period fire protection plans excluded natural forests, focusing on plantations, young regeneration areas and ecologically sensitive areas. Special emphasis was placed upon the protection of successfully regenerated areas in the Central Dry Zone. It was decided that according to Myanmar's situation, fire protection should be provided for five years for teak plantations and ten to fifteen years for eucalyptus and pine plantations. Nowadays fire protection in Myanmar has more or less followed the trends. Since fire protection is a costly undertaking, available resources still determine the extent that protection can be achieved. According to available data, in 1997-98 the planned target to be put under protection was 153 500 ha, out of which 53 percent could be protected effectively. The forested area under protection in 2000-2001 will be 105 000 ha (U Saw Edah, pers. comm). Thinn (1999) reports that peoples' awareness and wilful participation has been the strength behind successful protection from forest fires in Myanmar. However, slash-and-burn cultivation (Taungya) has been an age-old practice with many ethnic races who live in the mountainous areas of the country and is still being practised widely. This is the main cause behind forest fires occurring in Myanmar. However, as it is carried out merely on a subsistence scale, and as the areas that fall under this practice are buffered in by the natural forests, the spreading of fire to adjoining areas is minimal. Besides, burning is normally done under close supervision of the villagers.

As all forest estates, apart from those on private lands and community forests, are owned by the State, Forest Fire Brigades are not organized by the private sector as is the case in many countries. Protection measures are instead undertaken solely by the Forest Department, in cooperation with other ministerial departments and the local people. The fire hazardous period is normally for about four months from mid-January to mid-May. This is the period when public awareness campaigns are carried out through various mediums. Also, villagers are rallied to partake in fire-watch duties and assist in various pre-emptive activities such as construction of fire lines and fire traces, prescribed burning, etc. In 1992, the new Forest Law was enacted,

defining the offences clearly and prescribing more severe penalties for offenders. In 1992-93, Forest Conservation Committees were formed at the National, State/Division, District and Township levels. These committees involved the related ministries, the Chairmen of the State/ Division, District and Township Administrative bodies as well as the local military commanders with forest management and forest fire conservancy responsibilities. In 1996-97, a new directorate called the Dry Zone Regreening Department was formed to rehabilitate once forested areas of the Central Dry Zone and provide fire protection.

Myanmar Foresters have traditionally placed prevention above suppression of forest fires, as they had understood that forest fires once out of control were almost impossible to suppress. The priority focus was therefore placed upon the monitoring of combustible fuel, and this was normally controlled by prescribed burning in situations where surface fires had not consumed them. Because the forests are predominantly natural, and mostly of the Tropical Evergreen type, the forest floor is naturally damp and the undergrowth mostly moist and green. The leaves and branches that fall each year are consumed by the annual surface fires, so fuel does not normally accumulate enough to pose a threat. Also, as the annual fires are mostly surface fires they cause very little or no adverse impact to the soil. They do not consume the forest litter to the extent that forest soils are deprived of nutrients or its capability to conserve water.

3.2.5 Viet Nam

One of the few sources available to the Special Report on Forest Fires was the country analysis by Goldammer (1992). The report defined the following main fire regimes:

Regularly occurring wildfires in seasonally flammable deciduous forests

Due to seasonal climate, large tracts of Viet Nam's forests are characterised by deciduous or semi-deciduous tree species. Both the regular dry seasons and the seasonal availability of the shed leaves make these forests very fire-prone. In many of the deciduous dipterocarp forests wildfires occur almost annually, e.g. in the Central Plateau areas near the border with Cambodia. The dominant dipterocarps, e.g. *Dipterocarpus intricatus*, resprout after fires. Like in the neighbouring countries, e.g. in Cambodia, Laos, Thailand, Myanmar, and India, the seasonal forests (or "monsoon" forests) are quite adapted to the regular occurrence of fire. Fire exclusion would lead to a progressive development toward less fire-adapted broadleaved forests.

Wildfires in pine forest ecosystems

Indigenous pine forests occur in submontane and montane elevations throughout Viet Nam. The main species involved are *Pinus merkusii* and *Pinus massoniana* (in the lower elevations up to ca. 1000 m a.s.l) and *Pinus kesiya* (above 600 m a.s.l.). These forests occur over an area of ca. 135 000 ha and are highly endangered by overcutting due to illegal logging, expanding shifting agriculture, grazing practices and increasing demands for fuelwood and charcoal production. All these activities are closely linked with the use of fire and the threat of escaping wildfires. One of the areas with the highest wildfire risk in the Da Lat area (Lam Dong Province, northeast of Ho Chi Minh City). This mountain region is mainly populated by the Kinh, but also frequently visited by tourists from throughout the country because of the cool mountain climate and the beauty of the landscape. Both the local inhabitants and the tourists bring an increasing fire pressure to the ca. 42 000 ha of protected pine forest land. Many of the pine forests are considered as fire climax communities, meaning that at certain

stages of forest development (e.g. mature, open stands) the trees are not severely affected by the frequent surface fires. The understorey of pine regeneration, as well as the hardwoods (dipterocarps), are killed by these fires, thus resulting in an overall loss of young age classes and species diversity. Too frequent burning in general has led to severe erosion and surface runoff. This problem has been observed throughout the pine belt of the mountain zone.

Wildfires in other natural and degraded vegetation

Much of the lowlands and the high plateau of Viet Nam formerly covered by seasonal or evergreen broadleaved forests is now degraded toward a shrub-tree-grass savannah. This vegetation is utilized extensively. Wildfires are occurring frequently. The fires are not set for specific purposes. They are occurring largely as a result of carelessness or intentional setting without any land-treatment purpose. The amount of former dipterocarp forest lands now degraded to a fire-climax savannah is not known exactly. It must be assumed, however, that several hundred thousands of hectares are to be classified in that category.

Other vegetation types frequently affected by fire are found in the Mekong Delta region. The economically very valuable *Melaleuca leucadendron* forests, which cover ca. 34 000 ha (of which 19 400 ha are in Minh Hai Province), are very fire-prone. Honey collectors cause many of the wildfires; and other fires are intentionally set in order to get permission for salvage logging. During the extended pan-Pacific drought of 1982 wildfires affected more than 20 000 ha of *Melaleuca* forests in the Southwest of the country.

A recent report by Shulman (2001) highlights the needs for advanced fire management in Tram Chim National Park which is one of the last remaining remnants of freshwater wetland habitat in the Mekong Delta. The park receives international recognition as seasonal habitat for endangered wildlife species, including the *Sarus* crane. Objectives of restoration and biodiversity conservation conflict with local people's need for economic subsistence and development. Arson is a major cause of fires and will require an economic incentive based fire prevention programme. Management objectives of fire exclusion drive decisions relating to water levels, thus impacting all ecological processes within the park. Maintaining high water levels as a tool for fire exclusion conflicts with other management objectives integral to the park. There is an opportunity for development of a fire use programme within the park, in conjunction with fire effects research to expand the knowledge base.

Other fire-prone vegetation types are the result of the second Indochina war. During the war approximately 12 percent of South Viet Nam's forest cover was sprayed and damaged by herbicides, other forest areas were damaged by explosives, mechanical land clearing and burning operations. Formerly closed evergreen inland forests degraded to grasslands dominated by extremely flammable grasses, e.g. *Imperata cylindrica* and the exotic invader *Pennisetum polystachyon*. Fires are occurring almost annually and prevent the rehabilitation of these war-damaged forests.

Wildfire Data

The Forest Protection Department of the Ministry of Agriculture and Rural Development released statistical data of wildfires in forests and other wooded land for the years 1997 to April 1999 (Table 3-1). The data reveal that the country experienced a higher occurrence of wildfires during the El Niño year 1998 as compared to the years before and after.

Table 3-1 Wildland fire statistics for Viet Nam, 1997-1999.

Year	Total No. of Fires on Forest & Other Wooded Land No.	Total Area Burned ha	Area of Forest Burned ha	Area of Other Wooded Land Burned ha	Human Causes No.	Natural Causes No.	Unknown Causes No.
1997	302	1 360	1 331	29	NA	NA	NA
1998	1 345	15 088	13 811	1 277	NA	NA	NA
1999	460	2 191	2 098	93	NA	NA	NA

Source: Forest Protection Department, Ministry of Agriculture and Rural Development, Vietnam

Atmospheric impacts of land-use fires and wildfires

In the second half of 1997 and in early 1998, large areas in Southeast Asia were severely affected by a smoke-haze pollution episode caused by the emissions of forest conversion burning and wildfires on the Indonesian islands of Kalimantan and Sumatra. The episodes constituted an acute health risk to the public, exposing almost 100 million people in five countries in Southeast Asia to increased air pollution (WHO 1998, Phonboon 1998). An estimated 20 million suffered from respiratory problems in Indonesia alone (WHO 1998). The pollutant of major concern in respect to adverse health outcomes was particulate matter (WHO 1998), especially the fine particle fraction. To document the impacts of these fires on air quality, data for total suspended particulate matter (TSP) and for particulate matter below or equal to 10 microns in diameter (PM_{10}) from selected sites in Indonesia, Malaysia and Singapore were analysed by Heil and Goldammer (2001). These data were supplemented by meteorological data, satellite-derived data (e.g., the spaceborne air quality measurements by the Total Ozone Mapping Spectrometer [TOMS] Aerosol Index), and a summary of related research. TSP was above 2000 $\mu g\ m^{-3}$ for several days in Indonesian locations close to the most extensive fire activity. Characteristically for emissions from vegetation burning, the additional atmospheric particle loading during the smoke-haze episode was predominantly due to an increase of the fraction below or equal to 2.5 microns in diameter ($PM_{2.5}$). Due to the dominance of respirable particles ($PM_{2.5}$) in the smoke-haze, current air quality monitoring based on TSP or PM_{10} may be inadequate to assess the health risk. Upgrading of $PM_{2.5}$ monitoring facilities is therefore needed. Reducing the probability of similar smoke-haze events in future would require appropriate fire use and smoke management strategies.

A number of measurement campaigns have been made to identify the chemical composition of smoke plumes and the fire-affected regional atmosphere. However, no comprehensive set of accurate measurements is available that would allow one to summarise the overall impacts of fire emissions generated in 1997-98 on the regional or global atmosphere. Several estimates that are based on assumed fuel consumption rates indicate a magnitude of emissions of 350 million to one billion tons of the active trace gas carbon dioxide that acts as a greenhouse gas. The assumable release of 6 to 16 million tons of particulate matter mainly

effects human health, visibility (including traffic safety), and the reduction of photosynthetically active radiation that may also affect growth of agricultural crops and to an atmospheric cooling effect.

At this stage it is considered premature to add another best guess estimate on the total release of trace gases and aerosols to the atmosphere. The major reason for this statement is the lack of available data on fuel consumption and combustion efficiency during the episode 1997-98 and a systematic, quantitative and qualitative regional research approach. The South East Asian Fire Experiment (SEAFIRE) in the first half of the 1990s attempted to provide such a regional research activity under the scheme of the International Geosphere-Biosphere Programme (IGBP) and its core project International Global Atmospheric Chemistry (IGAC), but was never realized (Goldammer 1997).

In June 1998 the *World Meteorological Organization* (WMO) called for a Workshop on Regional Transboundary Smoke and Haze in South-East Asia. The workshop was one element of WMO's efforts to enhance the capacity and capability of National Hydrometeorological and Meteorological Services (NMHSs) in South-East Asia to monitor and model smoke and haze episodes and the long range transport of anthropogenic pollutants., The workshop also aimed to improve the NMHS's abilities to advise, alert, and generally manage these pollution events. It involved a review and discussion of regional plans such as the WMO *Programme to Address ASEAN Regional Transboundary Smoke* (WMO-PARTS) (WMO 1999).

Regional policy initiatives to reduce "Transboundary Haze Pollution" in the South East Asian region

The Association of South East Asian Nations (ASEAN) forms a political and geographic entity that seeks intra-regional and international cooperation in solving transboundary fire and fire-generated smoke pollution problems. ASEAN has appreciated inputs by ECE member countries to overcome the past and future environmental and humanitarian crises caused by indiscriminate burning of forests and other vegetation.

The regional smog events of 1991 and 1994 triggered a series of regional measures towards cooperation in fire and smoke management. In 1992 and 1995 regional workshops on "Transboundary Haze Pollution" were held in Balikpapan (Indonesia) and Kuala Lumpur (Malaysia). This was followed by the establishment of a "Haze Technical Task Force" during the Sixth Meeting of the ASEAN Senior Officials on the Environment (ASOEN) (September 1995). The task force is chaired by Indonesia and comprises senior officials from Brunei Darussalam, Indonesia, Malaysia and Singapore. The objectives of the work of the task force is to operationalize and implement the measures recommended in the ASEAN Cooperation Plan on Transboundary Pollution relating to atmospheric pollution, including particularly the problem of fire and smoke (ASEAN 1995).

In December 1996, the ASEAN Institute of Forest Management (AIFM) convened the "Conference on Transboundary Pollution and its Impacts on the Sustainability of Tropical Forests" in Kuala Lumpur (AIFM 1997a). At that conference the ASEAN Fire Forum was formed, which came up with a proposal for an ASEAN-wide programme in fire management and research (Goldammer et al. 1997).

The Fire Forum discussed, among other issues, the "AIFM Plan of Action Regarding Forest Fire Management". That proposal dated back to 1995 and aimed to fulfil the actions required

by the ASEAN Cooperation Plan. Although Canada had offered ca. 50 percent of the total costs for preparing the action plan, the proposal was not accepted by ASEAN. The plan was based on an attempt to survey the forest fire situation in the ASEAN region (AIFM 1997b).

In late 1997, a part of the original core of the AIFM Action Plan was again submitted to the ASEAN nations. The proposed "Fire Danger Rating System for Indonesia: An Adaptation of the Canadian Fire Behaviour Prediction System" is now being prepared on a cost-share base in a joint effort between the Canadian Forest Service and ASEAN member countries. Indonesia (BPPT) and Malaysia (Primary Industries) have agreed to contribute to the programme.

On 12 December 1997 Malaysia and Indonesia signed a bilateral memorandum of understanding allowing the two countries to work together to tackle the haze problem and manage any other form of disasters that may occur. On 20 December 1997, the ASOEN Task Force on Haze finalised the Regional Haze Action Plan.

In response to the ASEAN Environmental Ministers' Jakarta Declaration on Environment and Development on 18 September 1997, the Asian Development Bank (ADB) provided funding through a Regional Technical Assistance (RETA) grant for a regional cooperation project in the following areas:

- Catalyzing fire and haze prevention measures.
- Improving fire and haze prediction and monitoring.
- Improving fire management.
- Human resources development, (v) economic and scientific studies.
- Institutional support and information management.

The project *Strengthening ASEAN´s Capacity to Prevent and Mitigate Transboundary Atmospheric Pollution Resulting from Forest Fires* (RETA 5778-REG) was implemented in 1998-99 (Scarsborough 1998).

Because of the South East Asian fire and smoke-haze pollution episode of 1997-98, a series of international workshops were held to assist the ASEAN region in developing strategies to reduce the impacts of vegetation burning on the atmosphere and public health. In May 1998, the "Asia-Pacific Regional Workshop on Transboundary Pollution” was organized in Singapore by the *Germany-Singapore Environmental Technology Agency* (GSETA). Main focus of the workshop was to investigate common transboundary issues related to fire and industrial or smoke-haze in the ECE and the ASEAN region (Anonymous 1998). This ECE-ASEAN activity was followed by the above-mentioned WMO Workshop on Regional Transboundary Smoke and Haze in South-East Asia (Singapore, June 1998). At a later stage of the SE Asian fire crisis the *International Cross-Sectoral Forum on Forest Fire Management in South East Asia* (Jakarta, Indonesia, 7-8 December 1998) provided another international forum on regional wildland fire and smoke pollution issues (BAPPENAS/ITTO/JICA 1999).

Smoke originating from land-use fires and wildfires in the South East Asian region in 1997-98 affected more than 100 million people and caused acute and long-term respiratory health problems. Consequently WHO proposed the development of a comprehensive strategy based on broad international consensus. In November 1998, WHO convened a meeting in Peru to prepare the *Health Guidelines for Vegetation Fire Events.* The Global Fire Monitoring Center (GFMC) chaired the meeting and co-edited and co-authored the Health Guideline Document and a comprehensive set of background documents on behalf of UNEP, WHO, and WMO (Schwela et

al. 1999, Goh et al. 1999). The guidelines are designed to support decision-makers in preparedness and management of health problems arising from wildland fire smoke pollution.

Conclusions

Within the South East Asian / ASEAN region a joint, concerted approach is needed to cope with the problem of transboundary pollution caused by vegetation burning and to create mechanisms of mutual, border-crossing assistance in extreme fire situations. However, since fire is an essential tool in land use in the tropics a response strategy must be developed in which the benefits from fire use would be encouraged, at the same time that the negative impacts of fire are reduced. National and regional fire management plans and policies must take into consideration the complexity and diversity of fire uses in different vegetation types and land-use systems.

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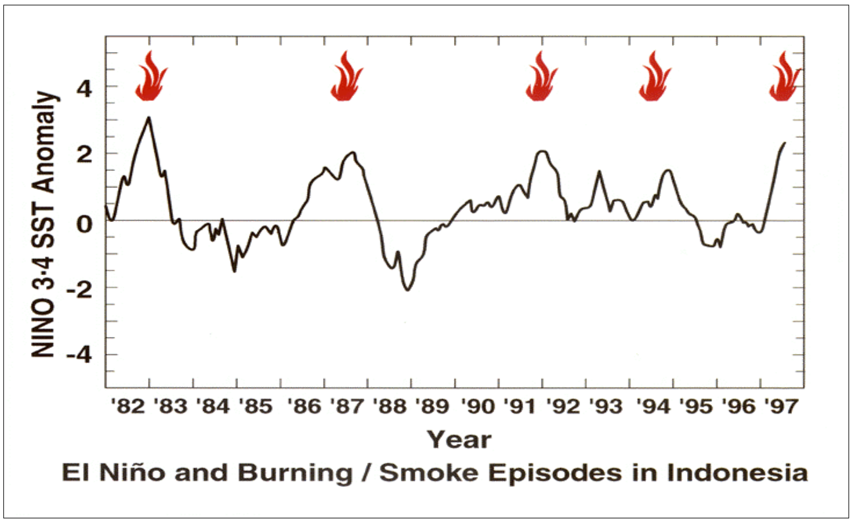
3.2.6 Fire Situation in Indonesia

By
Johann G. Goldammer
Global Fire Monitoring Center (GFMC), Freiburg, Germany
&
Anja A. Hoffmann
Integrated Forest Fire Management (IFFM) Project, Samarinda, East Kalimantan, Indonesia

The situation between 1982 and 1997

Preface

The wildland fire and smoke-haze episodes in Indonesia during the 1980s and 1990s have been largely influenced by the occurrence of droughts triggered by the El Niño-Southern Oscillation (ENSO) (Figure 3-1) and the associated increase in wildland fire danger (Figure 3-2).



Source: Global Fire Monitoring Center (GFMC).

Figure 3-1 Sea-surface temperature (SST) anomalies in the NINO 3-4 region coincide with the occurrence of ENSO events and droughts associated with increased burning activities in Southeast Asia**.**

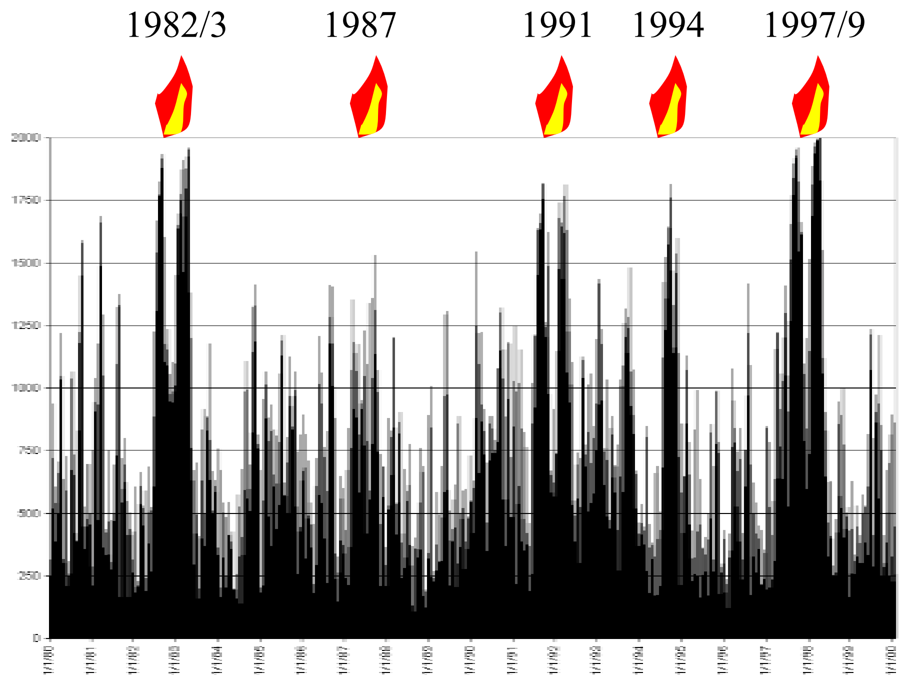


Figure 3-2 The Keetch/Byram Dryness Index (KBDI) for East Kalimantan, 1980-2000.

Source: Fire Information System of the Integrated Forest Fire Management (IFFM) project, Samarinda, East Kalimantan, Indonesia (IFFM 2000).

The KBDI is a metric fire danger index based on rainfall and temperature data and expresses the moisture deficiency according to the maximum possible moisture content of the soil. It indicates the dryness condition of the vegetation and therefore the level of fire danger. The Indonesian-German Integrated Forest Fire Management project (IFFM) has been working with this Fire Danger Rating system in East-Kalimantan since 1995 and has established a historical analysis dating back to 1979.

The fires of 1982-1983

The first documented large fire and smoke episode in the second half of the twentieth century in Indonesia occurred during the ENSO event of 1982-1983. The fire scene in the Indonesian and Malaysian provinces of Borneo was set by extreme drought and by extensive slash-and-burn land-clearing activity that resulted in a large number of escaped fires. In East Kalimantan alone, ca. 3.5 million ha were affected by drought and fire. Of the total area, 0.8 million ha was primary rain forest, 1.4 million ha logged-over forest, 0.75 million ha secondary forest (mainly in the vicinity of settlement areas), and 0.55 million ha peat swamp biome (Lennertz and Panzer 1984). It has been assumed that the overall land area of Borneo affected by fires exceeded 5 million ha (Goldammer and Seibert 1990).

One of the first aerial and ground surveys of the fire damage was carried out in a burned area in Kutai National Park, to the west of heavily logged and farmed areas (Leighton 1984). It was found that fire damage was higher in secondary forest than in primary forest, although the degree of damage varied greatly. The fires had twice swept through the ITO timber concession southwest of Kutai National Park, the first causing defoliation of many trees and

lianas; the second completely burning this accumulated litter. No surviving trees were observed in areas that had burned twice.
In his 1983 ground survey of the northern part of the National Park, Leighton (1984) found that the primary forest had been badly damaged. He was unable to report any unburned primary forest on hills, ridges, or slopes that could have served as a control plot to distinguish damage by drought or fire. Narrow belts (width 5 to 20 m) of unburned primary forest flanking streams were also observed, but these accounted for only 5-10 percent of the total area. In the burned areas, 99 percent of the trees below 4 cm DBH had died, although about 10 percent were resprouting. Mortality was 50 percent for trees 20-25 cm DBH and 20-35 percent for trees larger than 25 cm DBH.

A series of studies on regeneration of the fire-affected rain forest were conducted in the mid-1980s and reviewed by Goldammer and Seibert (1990). Another review is currently prepared by Dennis et al. (2001). In 1988-1989, a comprehensive research project was carried out on the cause and effects of forest fires of the 1982-1983 fire season in East Kalimantan. Goldammer et al. (1996) provided a summary of the findings. The study area was the Mahakam basin, which was most seriously affected by drought and forest fires. The research area, mapped by satellite remote sensing and aerial videotaping, has a total size of 4.7 million ha and stretches from the east coast of Borneo to the mountainous areas in the centre and the north. A line from Balikpapan to Long Iram forms the southern boundary.

Within the study area the actual area affected by fire was ca. 3.2 million ha, of which 2.7 million ha were tropical rainforests. Forests on sites with low water retention capacity were most seriously affected by fire, especially peat swamp forests, heath forests (kerangas), forests on limestone hills and rocks and all other forests on shallow soils. Logged-over forests were also particularly affected by fire, especially those growing on drought-sensitive sites. There is a close correlation between the year of logging and fire intensity. Those forests that had been logged shortly before the fire event were very seriously damaged. Finally, the fire particularly affected forests in the vicinity of settlements and along rivers and roads.

<u>Wildfires and land use fires after 1982-1983</u>

During and after the ENSO and fire episodes of 1987, 1991, 1994 and 1997, only limited research has been accomplished on the extent and damage caused by fire and atmospheric pollution. In 1996 the Environmental Impact Management Agency (BAPEDAL) released fire statistics for the period 1984-1994 that were published in International Forest Fire News (Makarim and Deddy 1997). They revealed that in most years wildfires affect between 15 000 and 25 000 ha. Extreme years were 1991 (199 000 ha) and 1994 (406 000 ha). The figures on fire occurrence released by the Indonesian Ministry of Forestry for 1994 included burning activities other than wildfires for the first time. According to the Ministry a total land area of ca. 5.1 million ha was affected by fire in 1994in the following categories:

Traditional dryland farming	2.8 million ha;
Shifting cultivation	1.5 million ha;
Transmigrant farming	260 000 ha;
Plantations	221 000 ha;
Transmigrant settlements	39 500 ha;
Reforestation areas	20 500 ha;
Timber estates	17 000 ha;
Natural forests	8 000 ha.

<u>National Indonesian fire management and related projects before 1997</u>

Because of the smog episode of 1991 in Southeast Asia, which was mainly caused by fires burning on the Indonesian archipelago, the Government of Indonesia called for international cooperation to support national fire management capability. In June 1992 an international conference on "Long-Term Integrated Forest Fire Management" was held in Bandung. Participants included national agencies involved in fire management and the international community, represented by national and international development organizations and potential donors. The objective of the conference was to develop the framework for a concerted international action plan on "Long-Term Integrated Forest Fire Management" for Indonesia. In this programme all partners involved share expertise and fire management resources (BAPPENAS 1992).

The implementation of the "Bandung Strategy" is underway. In 1994 a bilateral Indonesian-German project "Integrated Forest Fire Management" (IFFM) became operational. The project will build up fire management capability in the Province of East Kalimantan (project duration: 1994-2002). The IFFM system includes community-based fire management approaches. IFFM aims to serve as a model for other Indonesian provinces.

After 1994 several additional foreign assisted projects were established:

Fire management projects supported by the Japan International Cooperation Agency (JICA) in Sumatera (Jambi) and West Kalimantan;
The European Union "Forest Fire Prevention and Control Project" (FFPCP) in Sumatera (Palembang);
The UK Overseas Development Administration (ODA) "Tropical Forest Management Project" with a fire management support component in Central Kalimantan;
The Food and Agricultural Organization of the United Nations (FAO) at the national level (Ministry of Forestry; since terminated); and
The fire management training courses conducted by the United States Department of Agriculture (USDA) and USAID (inter-project).

In 1995, legal provision was made to establish a "National Coordination Team on Forest and Land and Fire Management" under the Ministry for Environment (executed by BAPEDAL). The purpose of this group was to coordinate fire and atmosphere pollution management measures at the national level in case of a large fire and smog disaster. This coordination body was also active in 1996 in public awareness campaigns (Makarim and Deddy 1997). Also in 1995, the Ministry of Forestry was designated to establish national and provincial fire coordination committees.

The International Tropical Timber Organization (ITTO) and the Common Fund for Commodities (CFC) sponsored the development of "National Guidelines on Protection of Forests Against Fire". The guidelines were finalized in 1999 (ITTO 1999). This project followed the framework provided by the international "ITTO Guidelines on Fire Management in Tropical Forests" (ITTO 1997).

All the ambitious projects initiated in the first half of the 1990s had only a limited impact on the overall fire and smog situation during the 1997-1998 episode. In the province of East Kalimantan the institutional approach of the GTZ-assisted IFFM Project obviously had a strong impact on the provincial government in the first phase of the 1997-1998 ENSO event. The integration of IFFM into the structures of the Ministry of Forestry (Kanwil) and the Provincial Forest Service (Dinas) provided direct access to the governor and the provincial

Pusdal Committee through which all agencies concerned with fire and smoke issues make joint decisions.

The operational use of the Early Warning System (Fire Danger Rating System) was proven to give a realistic and meaningful assessment of the build-up of fire danger during 1997-1998. The provincial governments were alerted in early August and immediately took the necessary steps to reduce burning by concessionaires and villagers. It was very important that the foreign-assisted project had begun to create line Organization structures in the Provincial Forest Service, Dinas (top-down development of lines of responsibility and command). On the other hand, the IFFM project – like the EU- and JICA-assisted projects in Sumatra – has a distinct grassroots-level (community-based, participatory) approach by involving the villagers in the fire prevention program. Furthermore, IFFM assists the fire users by providing extension service. In 1998, however, East Kalimantan was extremely affected by the illegal use of fire and escalating wildfires (see part II).

The government of Indonesia took the first measures in 1995 to discourage the use of fire in land clearing activities by issuing a decree to the forest plantation industry *(Hutan Tanaman Industri* - HTI) that banned the use of fire in converting forests. In December 1997 the government imposed another ban on the use of fire in forest conversion and slash-and-burn agriculture. However, this fire ban was not enforced and was largely ignored by both smallholders and large forestry enterprises.

The search for alternatives to burning for forest conversion and traditional slash-and-burn agriculture must receive high priority. Until 1997 only a few cases are known in which HTI enterprises used conversion methods not involving fire. Pt. Adindo Hutani developed an interesting alternative system for its conversion program in East Kalimantan (Tarakan). This non-fire conversion procedure involves a three-step mechanical treatment of non-commercial wood/plant biomass, the extraction of commercial timber and mechanical site preparation. Research projects are underway within the international program "Alternatives to Slash-and-Burn" supported by the Center for International Forestry Research (CIFOR). Little research and development has been devoted to the utilization of woody biomass for chip or briquette production and to the exploration of potential markets.

Projects initiated during and after the fire/smoke episode of 1997

In response to the fires of 1997-1998, a large number of bi- and multilaterally-supported projects were initiated and implemented in Indonesia. Detailed information is available at the Global Fire Monitoring Center (GFMC 2000) and in a survey prepared by CIFOR (Dennis 1998). Major new activities include the *East Asia and Pacific Environmental Initiative* (EAPEI), supported by the U.S. Agency for International Development (USAID 2000), and a project supported by IUCN-WWF, *FireFight South East Asia* (IUCN 2000).

In November 1997, the Government of Indonesia convened an "International Conference on Science and Technology for the Assessment of Global Environmental Change and its Impacts on the Indonesian Maritime Continent" in Jakarta. The conference resulted in recommendations for a national action plan in research and technology development, increasing international research cooperation and the establishment of a multinational research centre to serve the countries within the region in the areas of climate prediction, crop estimation and disaster mitigation. This centre is still in the process of being established as the "Indonesian Research Institute for Climate, Environment and Society" (INRICES) under the founding initiative of the Indonesian Ministry for Research and Technology (BPPT).

Following discussions with senior government officials in Jakarta and Manila regarding the fire and smoke situation in Indonesia, assistance was requested from the Asian Development Bank (ADB). An Advisory Technical Assistance, "Planning for Fire Prevention and Drought Management and Mitigation of their Impacts", was prepared by the ADB. Under the coordination of BAPPENAS (the executing agency) the program was to be implemented through the Environmental Impact Management Agency (BAPEDAL) in 1998.

The initiative of the Consultative Group on Indonesian Forestry (CGIF), under the GTZ-supported program "Strengthening the Management Capabilities of the Indonesian Ministry of Forestry", restored the lost momentum of cooperation between the national agencies and foreign-assisted projects in fire management.

The fire episode of 1997-98

In 1997-1998 Indonesia experienced a fire episode that exceeded the size and impact of the 1982-1983 fires (Goldammer et al. 1999; Hoffmann et al. 1999a; Siegert and Hoffmann 2000). A prolonged and severe fire season occurred during the ENSO of 1997-1998. Six months of drought occurred in 1997. Following a short period of rainfall in December 1997, the drought continued through May 1998. During the 1997 ENSO event large fires occurred in Sumatra, West and Central Kalimantan and Irian Jaya/Papua. In 1998 the greatest fire activity occurred in East Kalimantan. These widespread fires resulted in dense haze across Southeast Asia, causing respiratory health problems as well as transportation delays and accidents on land, air and sea. Economic costs were estimated at over US$9.3 billion (ADB 1999) and the smoke-haze resulting from the fires led to disagreements with neighbouring countries (i.e. Malaysia, Brunei, and Singapore).

All the fires of 1997-1998 were human-caused. The majority of the fires were due to land speculation and large-scale forest conversion as a result of inadequate and unenforced land use policies. In addition, fires in settlement/transmigration areas were caused by land use conflicts, carelessness or hunting. However, the lack of inter-agency coordination to respond and suppress the fires played an important role in the severity and extent of the fire situation.

Although strong winds and prolonged drought contributed to the rapid spread of wildfires, Indonesia's inadequate initial attack and large-fire suppression capacities were not sufficient to deal with the situation. These conditions continue to exist. The Indonesian province of East Kalimantan was the area most severely affected by the fires. Burned area is estimated at 5.2 million ha for 1997-1998, about 25 percent of the entire province (Hoffmann et al. 1999b). As a result of the 1997-1998 fires, East Kalimantan's forests are now more susceptible to fire during normal dry seasons due to the degraded forest condition and the accumulation and alteration of native fuel complexes.

In 1999, fires occurred in Sumatra, West Kalimantan and Central Kalimantan. In Kalimantan over 400 fire events were detected in a single day in August using NOAA-AVHRR imagery. Although the 1999 fires did not reach the extent of those in 1997-1998, the risk of severe fires remains if another ENSO event occurs as predicted in 2001-2002.

Fire damage assessment

Several approaches using optical and microwave sensors were undertaken to determine the extent of the 1997-1998 forest fires in Indonesia. Studies by several agencies, projects,

organizations and institutes, both in Indonesia and overseas, were based on the visual interpretation of multi-temporal SPOT quicklook mosaics, the evaluation of NOAA (National Oceanic and Atmospheric Administration) AVHRR (Advanced Very High Resolution Radiometer) imagery and the combined use of ERS-2 SAR (European Radar Satellite-2-Synthetic Aperture Radar) coherence data and ATSR (Along Tracking Scanning Radiometer) data. Liew et al. (1998), using SPOT quicklook mosaics, estimated the total burn scars in Sumatra at 1.5 million ha and 3.06 million ha in Kalimantan for the period January-December 1997. Fuller and Fulk (1998) estimated 2.3 million ha by using NOAA-AVHRR data within the IFFM GTZ NOAA\AVHRR processing window, which did not completely cover Sabah and West Kalimantan.

Through the combined use of ERS-SAR and ATSR, Antikidis et al. (1998) produced a first estimation of the forest area burned in Central Kalimatan in 1997. Out of an area of 21.76 million ha analysed, 588 000 ha of forest was classified as burned at that time. This number was later corrected to 1.8 million ha (Antikidis et al., pers. comm.). For the province of East Kalimantan, Hoffmann et al. (1999), using ERS-2 SAR and NOAA-AVHRR data, estimated that in 1997-1998 some 5.2 million ha, about 25 percent of the entire province, was affected by fire. A number of assessments and estimates by several Indonesian agencies and international organizations, based either on satellite assessments, aerial surveillance or ground assessments were compiled by the Asian Development Bank Project (ADB 1999) into a general estimate of 9.7 million ha, as shown in Table 3-2.

Table 3-2 Estimated extent of fire-affected forests and other lands in Indonesia, 1997-1998.

Land use/land cover / Island	**Lowland Forest**	**Peat and Swamp Forest**	**Dry Scrub and grass**	**Timber Plantations**	**Agriculture**	**Estate Crops**	**Total (ha)**
Kalimantan	2 375 000	750 000	375 000	116 000	2 829 000	55 000	6 500 000
Sumatra	383 000	308 000	263 000	72 000	669 000	60 000	1 755 000
Java	25 000		25 000		50 000		100 000
Sulawesi	200 000				199 000	1 000	400 000
Irian Jaya	300 000	400 000	100 000		97 000	3 000	900 000
Total (ha)	3 283 000	1 458 000	763 000	188 000	3 844 000	119 000	9 655 000

Source: BAPPENAS (1999)

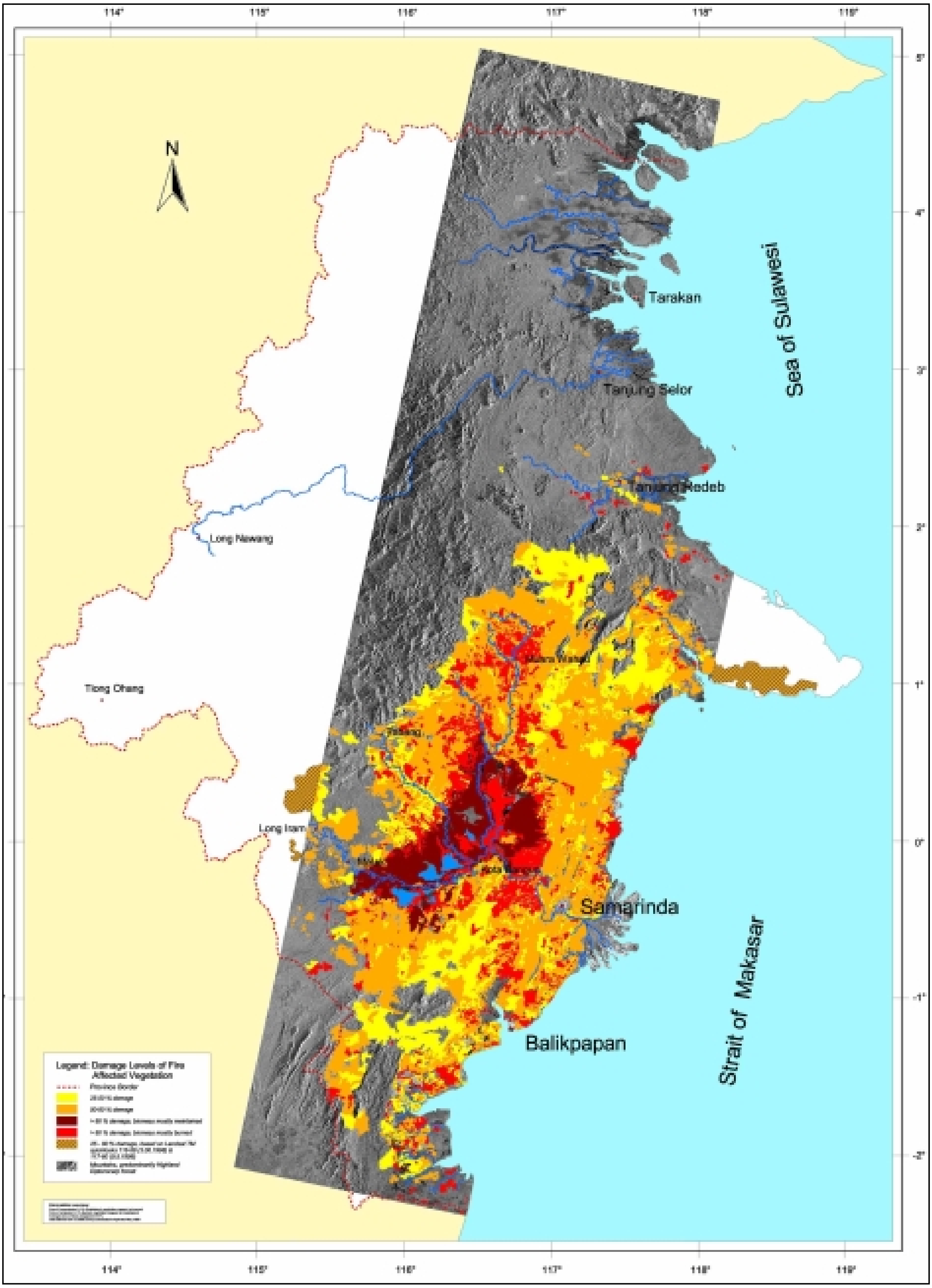


Figure 3-3 Fire damage classification of the 1997-1998 fires in East Kalimantan, Indonesia, based on ERS-SAR images.

Source: Hoffmann et al. (2000).

Fire management organization

The economic and ecological loss due to the 1997-1998 wildfires exceeded several billion dollars (US) (ADB 1999). However, not all losses are accounted for, i.e. decreased biodiversity, increased soil erosion and the resulting loss of productive agriculture land. In the forest concessions of East Kalimantan, the estimated loss of 23 million cubic meters of harvestable timber due to the 1997-98 fires was estimated to be worth approximately two billion dollars (US) (Hinrichs 2000). This does not include reduction of biodiversity or loss of non-wood forest products, regeneration and small-diameter trees. Rehabilitation costs in the fire-affected concessions of East Kalimantan are estimated to be in the range of US$330-385 million.

The reasons for uncontrolled fires in Indonesia are manifold and complex. However, one factor is the lack of a functioning fire management organization. Considering the huge financial losses caused by past wildfires, a fire management organization is needed with the organizational capability to deal with the underlying technical, logistical, operational and social obstacles involved in managing human-caused fires.

At the national level, a new Directorate of Forest and Estate Fire Operations was established in early 2000 under the Directorate of Nature Protection and Conservation, Ministry of Forestry and Estate Crops (recently renamed the Ministry of Forestry). The new Directorate consists of four Sub Directorates (Figure 3-4) that are committed to dealing with the fire problem at a national planning level. However, past experience has shown that national planning efforts have little impact at the provincial and district levels. Although the root causes of wildfire problems in Indonesia are inadequate and conflicting land use planning policies and a lack of enforcement, a practical, “on-the-ground” approach is needed to deal with wildfires. Development of institutions and organizational structures at the provincial and district levels are needed to focus on environmental and fire prevention education in addition to fire suppression operations.

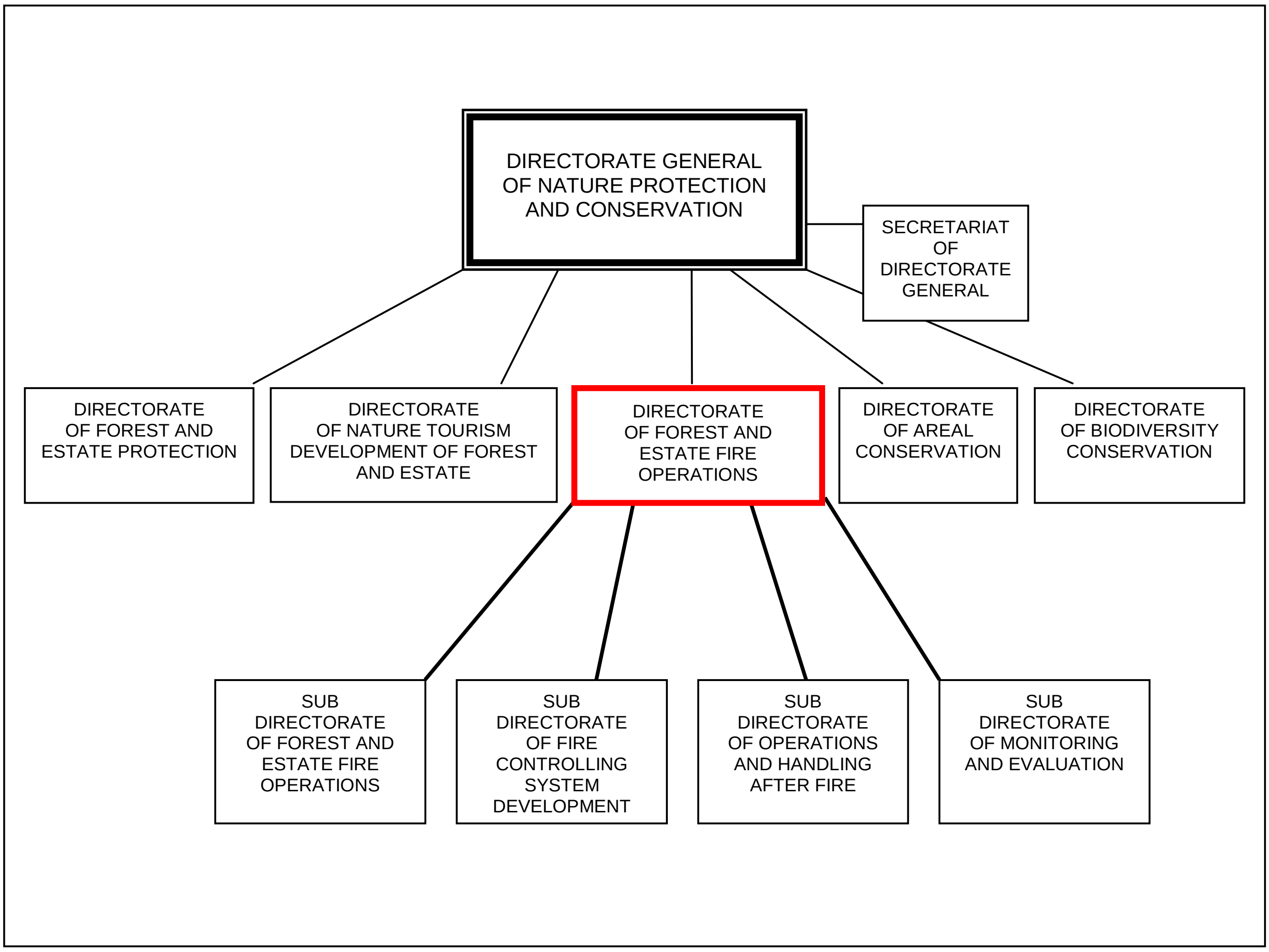


Figure 3-4 Organizational structure of the Directorate of Forest and Estate Fire Operations at national level.

In the Province of East Kalimantan, no single organization is currently responsible for overall fire management, prevention or suppression activities. Instead, fire management responsibilities are distributed among several provincial agencies with no clear lines of communication, responsibility or coordination. Additionally, fire management responsibilities are also unclear at the district level. This has resulted in a confusing and dysfunctional situation, causing conflicts and inefficiency.

The model of an integrated forest fire management system

Since 1994, the Integrated Forest Fire Management (IFFM) project, a cooperative development project under bilateral agreement between Indonesia and Germany, is attempting to establish a fire management system for the Province of East Kalimantan (IFFM, 2000). IFFM is under the responsibility of the Ministry of Forestry (Directorate General of Forest Protection and Conservation, Sub-Directorate of Forest and Estate Fire Operation). The IFFM project is implemented by the two provincial forestry agencies, KANWIL and DINAS Kehutanan. The IFFM concept consists of three major modules that include fire prevention, fire operations and fire information.

To institutionalise the IFFM concept and its long-term application in a legal and sustainable framework, KANWIL, DINAS and IFFM are proposing an integrated fire management organization at both the provincial and district levels.

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3.2.7 Fire Situation in Malaysia

By
Wan Mohd Shukri Wan Ahmad
Natural Forest Division, Forest Research Institute Malaysia (FRIM)
Kepong, Kuala Lumpur, Malaysia

Abstract

Forest fires and the resultant smoke-haze are relatively new experiences to Malaysia. However, the problems seem to be increasing in intensity and recurring periodically. Last year, the haze and forest fires caused a serious environmental problems in Malaysia, Singapore, Brunei and Indonesia. Most of the forest fires reported in Malaysia occurred in degraded or logged-over peat swamp forests, both in the east and west coasts of Peninsular Malaysia and the coasts of Sabah and Sarawak. The extent of peatland destroyed by fires is not known precisely, but a prolonged extremely dry period early in 1998 had exacerbated the resurgence of peat fires over a wide area in Malaysia.

Although peat forest fires in Peninsular Malaysia were not of the same magnitude as in neighbouring Indonesia, they have caused significant damage to property, vegetation, wildlife, environment and public health. Fire has been identified as one of the major threats causing the loss of peat swamp forests in several states in Malaysia. Serious occurrences of forest fires during recent years are due to improper peatland management, slash and burn activities and poor water management, rather than climatic factors such as a long dry spell. The condition is made worse because mitigating measures were not in place and the understanding and technical knowledge in forest firefighting was lacking.

The fires mainly involved peat and beris (heath) forest and bush areas. The fires burned in a slow and patchy manner, but were widespread. The fires spread slowly through the thick peat layers, making it extremely difficult to detect and extinguish them. In such areas, although the surface fires are extinguished, the peat underground will continue to burn unless a large amount of water is used to completely drench the peat layers. Consequently, those involved in extinguishing the fires had a difficult time, because they lacked the necessary tools and experience and they were not trained to handle forest fires. In addition, the remoteness and ruggedness of the terrain exacerbated the problem even further. In many of the affected areas, there were also logistical problems.

The forest fire and haze problems also resulted in government agencies such as the Fire and Rescue Department, Forestry Department and the Department of Environment in Malaysia to seriously re-examine their capacity to deal with wildfires. Relevant measures are being undertaken by these agencies to address the issue. In the long-term, an awareness campaign on the importance of peat swamp forests and forest fire hazards needs to be initiated at all levels by the relevant government agencies. An integrated approach of managing peatlands (agriculture, forestry, aquaculture etc.) is the best solution to avoid serious forest fires from recurring.

Introduction

Various issues related to the conservation of natural resources and the environment have been given much attention lately at the local and international levels. The problems caused by the

haze throughout Malaysia and her neighbours, mainly resulting from the rampant fires in various parts of Indonesia since the 1990s, has received much negative publicity. On the other hand, these effects have also improved the awareness of the transboundary nature of the impacts of forest fires, the need for better management of our resources and the need to enhance forestry cooperation within the region.

Forest fires and the resultant haze are still generally considered new problems facing Malaysia. However, their intensity and recurrence have been increasing. In 1997/98, one of the worst episodes of haze struck this region, engulfing Malaysia, Indonesia, Singapore and Brunei. The main source of the haze was attributed to the forest/bush fires that occurred in various parts of Sumatra and Kalimantan coupled with the *El Niño* phenomenon, although there were also forest and bush fires reported in Malaysia. At the height of the fire episode about 1000 new fires were recorded by satellite sensors in Indonesia within a two-week period. The Malaysian Air Pollutant Index (API)[4] exceeded the hazardous level of 500 in Sarawak, forcing the government to close schools and offices. The haze caused the Malaysian public much discomfort and resulted in disruption to air travel, increased respiratory and related health problems and a significant decrease in tourists visiting the country. Had the haze conditions persisted a little longer, it would have embarrassed the nation and disrupted the prestigious Commonwealth Games that the nation proudly hosted in September 1998.

However, the haze cannot be totally attributed to the forest fires in Indonesia alone as there were also fires reported in various parts of Peninsular Malaysia, Sabah and Sarawak. Many of these fires occurred in degraded peat lands, logged-over forest reserves and secondary state forests. They have caused significant damage to property and loss of valuable timber as well as biological diversity. In this regard, however, there were no detailed studies on the extent and impact of the forest fires undertaken, making it difficult assess the actual situation.

Extent of forest fires in Malaysia

The worst forest fires experienced by Malaysia were in 1982/83 when almost one million hectares of natural forest burned in Sabah. This was at the same time when numerous fires affected Borneo and 3.2 million ha in Kalimantan. However, for Malaysia this was the only case where natural forest fires of this magnitude were ever recorded. Subsequently, forest fires continued to occur in Malaysia but the extent was less and mainly located in secondary conversion forests, forest plantations and degraded forests. Forest fires have been reported as early as the 1970s in the pine plantations and the 1980s in the *Acacia mangium* plantations. However, many of these fires were not recorded properly. Table 3-3 and Table 3-4 show the occurrences of fires that were recorded in Malaysia beginning in 1992-1997 and 1998 respectively.

[4] Malaysian Standard of Air Pollutant Index (API) is measured in $\mu g/m^3$ of air sampled. The scales of the index are categorised as follows: 0-50 = Good; 51-100 = Moderate; 101-200 = Unhealthy; 201-300 = Very Unhealthy; 301-500 = Hazardous.

Table 3-3 Forest fires in Malaysia 1992-1997.

Year	Location	Forest Type	Area burned (ha)	Probable Causes
1992	Terengganu	*Acacia Mangium* plantation	265	Nearby land clearing and from picnickers at nearby recreational Forest
	Johor	*Acacia Mangium* plantation	3	Unknown
	Selangor	*Acacia Mangium* plantation	10	Power transmission undergoing maintenance
		Pinus Carribaea plantation	16	Adjacent land clearing by villagers
	Sabah	Natural forest	2 500	Cooking by hunters
		Natural forest	1 000	Arson
		Natural forest	825	Nearby land clearing, picnickers and cigarettes
		Primary forest reserve	65	Adjacent land clearing by farmers
1994	Perak	*Acacia Mangium & Tectona grandis* plantation	333	Adjacent land clearing by farmers
	Sarawak	*Acacia Mangium* plantation	15	Unknown
		Plantation (various species)	50	Adjacent land clearing by farmers
1995	Selangor	Degraded peat-swamp forest	155	Adjacent land clearing by villagers
1996	Perak	Secondary forest	24	Cigarettes
1997	Perak	Natural forest & FRIM research plots	22	Adjacent land clearing by farmers and hunting
	Pahang	Natural forest state-owned)	202	Adjacent land clearing for oil palm plantation
		Peat-swamp forest	202	Adjacent land clearing by villagers
Total			5 687	

Table 3-4 Forest fires in Peninsular Malaysia 1998.

Location	Forest Type	Area burned (ha)	Probable Causes
Kelantan	Forest plantation	15	Snapped Electrical Transmission lines
	Secondary forest	240	Adjacent land clearing by farmers and private land owners
	Degraded heath forest	310	Adjacent land clearing by farmers and private land owners
	Degraded peat forest	40	Adjacent land clearing by farmers and private land owners
Selangor	Forest plantation	5	Cigarettes
	Peat-swamp forest	250	Burning of rubbish by adjacent villagers
Perak	Secondary forest	60	Unidentified
	Peat-swamp forest	40	Hunting
Johor	Peat-swamp forest	41	Unidentified
	Montane forest	15	Unextinguished carbide lamps by mountain climbers
Kedah	Secondary forest	41	Adjacent land clearing by farmers
Trengganu	Peat-swamp forest	900	Adjacent land clearing by farmers and private land owners
	Logged forest	120	Unidentified
	Heath forest	250	Unidentified
	Freshwater swamp forest	15	Fishing by nearby villagers
	Forest reserve	30	Adjacent land clearing by farmers and private land owners
Pahang	Peat-swamp forest	360	Land clearing by indigenous people and adjacent farmers
	Forest plantation	6	Unidentified
	Secondary forest	61	Unidentified
Total		2 799	

Source: Forest Department Peninsular Malaysia and FRIM statistics.

It is obvious from the above records that incidences of forest fires mainly occurred in forest plantations, degraded peat swamp forests and logged-over forests. The frequency of occurrences also increases appreciably during the El Niño-Southern Oscillation (ENSO) years where prolonged dry spells are experienced.

Causes of forest fires

Under normal conditions, the undisturbed tropical moist forests of Malaysia and Indonesia will not catch fire easily and even if they do burn, the fire will not be widespread. With an average annual rainfall of about 2 540 mm, humidity exceeding 75 percent and the rate of litter decomposition on the forest floor relatively fast, the climatic conditions are generally humid and fuel build-up on the forest floor is minimal. Unless these conditions are changed, there is very little chance of the forest catching fire. However, when the forest is disturbed

and degraded with much debris available on the forest floor and canopy cover opened, the forest becomes more vulnerable to forest fires (especially after a prolonged dry spell). Particularly for the peat swamp forests, the soil is always moist. However, when water in these areas is drained during development projects, the peat becomes completely dry and is very prone to fire. Under these conditions the fire spreads underground and can stay burning for a long time.

The recent prolonged dry spell caused much of the **lalang** (*Imperata cylindrica*) and **gelam** (*Malaleuca cajuputi*) areas of the secondary **beris** (heath) forests and degraded peat swamp forests to dry up. Since the soil consists of mainly sand and humus in the beris areas and dried peat in the peatlands, small amounts of rain were not sufficient to retain adequate soil moisture. Most of the smaller rivers had also dried up. In such conditions, these areas are very vulnerable to fire. The sources of the fire are mostly human-cased. Some of the major reasons for the cause of fire are as follows:

- Land preparations in establishing agricultural plantations
- Land preparation by farmers
- Shifting cultivation by indigenous people
- Camping and picnicking
- Hunting
- Snapped electric cable
- Natural Causes – lightning, spontaneous combustion, etc.

In many cases fires get out of control during burning carried out during establishment of agricultural plantations. The same may also happen when smallholders and farmers undertake land clearing in preparation for the next planting. Improper burning techniques and strong winds may cause the fires to spread to nearby secondary forests. There were also cases where campfires made by campers and hunters were not extinguished properly, resulting in the occurrence of forest fires. Some areas were deliberately burned to facilitate hunting. The burned areas seem to attract game, making them easy targets for hunters.

In Selangor and Kelantan, part of the *Acacia mangium* plantations were burned because of a snapped high voltage electric transmission cable. In both cases, fortunately, the fire was quickly contained and damage was not extensive.

In Pahang, Sabah and especially in Sarawak, the practice of shifting cultivation by the indigenous people (*Orang Asli*) is also a major factor contributing to the occurrence of fires.

It is estimated that approximately 65 000 ha. of forest in Sarawak are cut and burned by shifting cultivators. Not only do they degrade valuable prime forestland, their practice of clearing small patches of the forest by burning can sometimes cause widespread damage during the dry spells.

According to the Director of the Fire and Rescue Department (FRD), the awareness among the public, especially in rural areas, on the dangers of open burning during dry periods was clearly lacking. People are not aware that taking the easy path of burning to facilitate land preparation for agriculture can be extremely dangerous. He advised that it would be appropriate that the FRD be consulted before any burning is undertaken, especially during the dry periods.

It was also found that the public is more concerned about the haze rather than the destruction of forests by fires. If forests were burned without causing too much haze in the populated centres, then the outcry would have been far smaller.

Irresponsible cigarette smokers are also a great concern. People who smoke cigarettes often simply throw the butts without ensuring that they have been properly extinguished. A large portion of fires that originated from the roadsides and then spread inwards to the forest reserves are suspected to be caused by smokers who throw unextinguished cigarettes while travelling along the roads.

Impacts

The fires caused extensive damage to vegetation, wildlife, environment and the health of people surrounding the affected areas. The haze and air pollution were at a dangerous level in most of these areas and at times reached unbearable and hazardous levels. Although there were increased respiratory and related ailments, the long term health implications of affected people in the vicinity of the forest fires is difficult to predict and are a cause for concern. Conditions in Peninsular Malaysia and Sarawak became so critical that the Malaysian Government decided to assist Indonesia in putting out the fires. A total of 1 262 firefighters (the largest ever recorded) from Malaysia were deployed to Sumatra and Kalimantan to combat the forest fires.

Areas affected by fire are rapidly colonised by resam and lalang. Consequently, as the fires occur every year, more and more highly rich and varied ecosystems will be replaced by weeds such as **resam** (*Glychenia* spp.) and **lalang** (*Imperata* spp.). There is a real danger that besides loss of biodiversity, the areas will never be regenerated by trees. The extensive *Imperata* grasslands in many parts of the Philippines and Papua New Guinea are clear examples. Forest fires have also been identified as a major cause for the loss of peat swamp forests in Malaysia.

Although direct financial estimates due to fires were not available, many hours were spent in fighting fires. This involved personnel from the FRD, State Forestry Department, Police, Drainage and Irrigation Department, Public Defence Department (JPA 3), Public Works Department, Local Town Councils and also members of the community. During the period, air travel was often disrupted, the tourism sector adversely affected and cost of medical treatment for haze related ailments increased.

Other smoke/haze related losses

The 1997 haze reached a critical level, both in terms of intensity and duration, causing much inconveniences and economic disruptions to the Malaysian economy. Other than health impacts, the haze has caused various other quantifiable losses including:

<u>Production losses</u>

The haze in 1997 reached a new urgency in Malaysia when the readings from the Air Pollution Index (API) reached 500. A state of emergency was declared for 10 days in Sarawak. The haze can result in various production losses of economic activities. These haze-related production losses included:

- A reduction in crop yields resulting from reduced sunlight. The appropriate method to adopt is a dose response function relating sunlight to yield. Data on sunlight would be needed.
- A reduction in fishing effort due to reduced visibility. The fishing days foregone would have to be multiplied by the expected profit per day. A more encompassing evaluation requires the computation of losses in consumer and producer surpluses.
- A reduction in industrial and commercial activity due to delays in transportation inputs and outputs; and an increase in cleaning and maintenance of equipment due to dust and corrosion. During production shutdown, profits foregone would have to be estimated.

In principle, as for all damages, estimates should be for profits foregone, not gross value. As a proxy, it is suggested to use days of work lost due to shutdowns at a minimum or average wage.

Tourism losses

Losses incurred by the tourism industry can be estimated by the reduced tourist arrivals from non-ASEAN sources. This is done in order to control for the effect of the 1997 ASEAN economic crisis which in itself is expected to effect incoming ASEAN tourists. Like the case in fishing effort, the losses occurring in August-October 1997 were compared to the "normal" August-October period of 1996. In this way any change in impacts caused by other factors are controlled.

Airline and airport losses

To obtain the losses incurred from airport closures due to poor visibility, estimates of the number of cancelled flights and forgone sales were obtained and multiplied by the airline's average profit rate. Any profits foregone from operation of the airports themselves are then added to the above.

Averting Expenditures

Apart from the loss arising from the haze, the Malaysian Government and firms have incurred averting expenditures to contain the impacts of the haze and to help control the source, i.e. in forest firefighting and cloud seeding operations.

Although the cost of the health impacts is small, the overall impacts from other sectors were quite large. According to the Economy and Environment Program for Southeast Asia (EEPSEA) study, the estimated incremental cost of the haze damage to Malaysia during the months of August to October in 1997 was RM816 million (Table 3-5). The largest component is the productivity losses during the declaration of a 10-day state of emergency in Sarawak. The health impacts contributed only 4.4 percent.

Table 3-5 Aggregate incremental costs of the damage caused by smoke haze.

Type of Damages [1]	RM Million	Percentage
Adjusted cost of illness	36.16	4.43
Productivity loss during the emergency	393.51	48.19
Tourist arrival decline	318.55	39.02
Flight cancellations	0.45	0.06
Fish landing decline [2]	40.72	4.99
Cost of fire fighting	25.00	3.06
Cloud seeding	2.08	0.25
Total	**816.47**	**100.00**

(1) Cost to Malaysian MNCs of RM2.5 million is not included as this amount might have been used by the Government to pay for various avertive expenditures.
(2) Only declining consumer surplus is taken into account as the gain in producer surplus is not a cost.

Source: Mohd Shahwahid and Jamal (1999).

Issues in combating forest fires

In Malaysia, the Fire and Rescue Department is the agency responsible for combating all kinds of fire including forest fires. However, during the combating of forest fires the agency is assisted by other relevant agencies such as the Forestry Department, Public Defence Department, Drainage and Irrigation Department, the police and the local town councils.

The fires that occur in the peat and heath forest/bush areas are relatively slow and patchy but widespread. The fires spread through the forest floor. Thus, even if whole trees were not felled, the root systems could be completely damaged and often the trees would fall and die. In peat lands, the fires spread slowly through the thick peat layers making it extremely difficult to detect and extinguish fires. In such areas, although the surface fires are extinguished, the peat underground will continue to burn unless a large amount of water is used to completely drench the peat layers. Consequently, in peat lands, the most effective way of containing the fires will be by flooding the area.
In Kelantan and Terengganu, the areas that were burned had relatively shallow peat layers. As such, a single heavy rainfall would be sufficient to ensure that the fires are extinguished. Much of the fire that finally came under control in Terengganu was due to some heavy showers that occurred in early May. However, this was not the case for Pahang and Selangor where peat layers were found to be relatively deep. In such conditions, to fully extinguish the surface as well as the subterranean fire, the area would need a continuous heavy rainfall or an artificial flooding with water from nearby sources. The latter method was implemented effectively in Selangor by pumping water from adjacent tin mining pools and rivers. Although the fires in some areas were put out by the Fire Department, the fires recurred. In such areas, although the fires on the surface were controlled, the peat fire underneath was not

fully extinguished. This was also the case for the **beris** forests. In this regard, the Director of FRD reported that 800 gallons of water had to be used to douse the fire in an area of about 10 square meters. During the dry ENSO period, such large amounts of water is difficult to obtain.

In many of the affected areas, there were logistical problems that arose from poor access. The Fire and Rescue Department's vehicles were designed for structural firefighting and not for travelling in forested areas and thus they were unable to venture into interior areas that were affected by fires. There was a serious lack of water sources to enable the Fire Department to fight the fires effectively. Even in cases where pits and canals were dug, they dried up quickly.
Some of the firefighting equipment used needs to be improved, e.g. the conventional water pumps used were too heavy and could not work for long hours. In Kelantan, however, firefighters tested a new pump provided by Canada. Apparently the pump was not only lighter, it could also work for long hours.

Under such conditions, according to the FRD, the best way to tackle forest fires is to contain them by preventing their spread, especially to sensitive areas and communities. This is undertaken by creating fire breaks.

There is no specific legislation on forest fires under the Malaysian National Forestry act of 1984 (revised 1993). However, there is a provision prohibiting fire-related activities in the permanent reserve forests and there are penalties for such offences. Likewise, the Environmental Quality Act of 1974 explicitly prohibits open burning without a permit to curtail air pollution and the occurrence of haze.

Control Measures

From past trends, the possibility of recurring fires in Malaysia is very likely in the natural and plantation forests. The severity of future fires will depend on weather conditions as well as the awareness and discipline of the public at large. Past experience shows that the possibilities of fires occurring in fire prone areas are very high during ENSO periods. Steps need to be taken to identify these areas and institute prevention and control measures. There seem to be sufficient measures in place to prevent and combat fires in the forest plantations. However, similar measures are grossly lacking for the natural forest areas as managers still view lightly the threat of fires in such forests.

Some of the immediate steps are to ensure that surrounding communities are informed of the detrimental effects of open burning and uncontrolled land clearing practices. There also is a need to adopt conservation measures while in or near the forest, build fire breaks and develop permanent water sources. It will take a combined effort of government agencies, private agencies and others to overcome fire problems in the future. The severity of the 1998 fire season and the involvement of various agencies and the community in fighting the fires should have increased the awareness for the need to take precautionary measures in the future.

Some of the recommended control measures include:

- <u>Increasing public awareness</u>

The FRD has an on-going program of creating awareness among the public. However, such programmes need to be improved and intensified. It should also involve other agencies and should reach a wider range of people. This is a long-term, but very effective strategy.

- Sustainable forest management

Natural forests that are managed in a sustainable manner, where the structure and overall integrity are not compromised, are very resilient to fires. It is when they are disturbed that they become prone to fire as indicated clearly in the statistics provided in Tables 1 and 2. Most of the secondary and degraded forests that were burned were not forest reserves but state forests that were earmarked for conversion. Often the spread of fire halts when it reaches the undisturbed forests.

- Creating buffer zones

There should be an effective buffer zone or fire breaks constructed surrounding Permanent Reserved Forests and State Forests adjacent to agricultural lands and communities. This would help to ensure that the forests are protected from fire which often originate from more populated areas.

- Construction of canals

In degraded peat forests where fires are likely to recur, canals should be constructed. The canals could be used to collect water and facilitate firefighting in the future.

- Notification of FRD and DOE

In any land preparation involving burning, the FRD and Department of Environment (DOE) will have to be notified for approval.

- Development of Forest Fire Squads

The FRD should endeavour to set up a forest fire squad. This squad should have the necessary training and skills in forest/bush firefighting. They should also be equipped with the necessary equipment. The use of suitably equipped helicopters should be further explored. In this regard, initial efforts have already been implemented when training was provided for the FRD in basic forestry knowledge.

- Development of Risk Index

Fire prone areas will have to identified and located. An early warning system together with a risk class index should be developed. With such a system, mobilisation of resources could be optimised and targeted to areas with higher risks of fire.

The Forest Fire Prevention and Control Plan

The State Forestry Departments of Peninsular Malaysia have developed a plan on the prevention and control of fires within the natural and plantation forests (Figure 3-5). Each state also has assigned a forestry officer to handle all matters pertaining to forest fires. The plan details precautionary measures to prevent fire in forest areas in natural and plantation forests, allocation of equipment and personnel and forest firefighting protocols. The development of this plan began in 1999 and is an excellent effort undertaken by the Forestry Department.

Rehabilitation of degraded areas

Forest areas affected by fire, be it in the Permanent Reserved Forest or state-owned land, should be rehabilitated quickly to prevent further degradation of the area through soil erosion and colonisation of pioneers and weeds. The burned area needs to be regenerated to restore the area into a productive forest again.

Forest fire research

To date, research efforts have not given sufficient focus into issues related to forest fires. The reason for this may be that in the past no serious fires had occurred in the Permanent Reserved Forest. It is also felt that issues concerning forest fires are mainly social and management in nature. However, the current situation warrants that priority be accorded to undertaking research in order to address such issues as:

- Impacts of fires on the forest vegetation and environment.
- Water management of peat lands.
- Socio-economic implications of forest fires.
- Development of zero burning techniques in land preparations for plantations.
- Development of fire risk classes and early warning systems.

Networking

The transboundary nature of forest fire problems has suggested a network approach for sharing of information and experience. Networking is a cost-effective mechanism for strengthening institutional capacity, facilitating transfer of technology and enhancing cooperation. For example, Indonesia has more experience in combating forest fires and is also more advanced in research in forest fire management. As such, a country like Malaysia would be able to identify and use some of this knowledge and expertise available in addressing similar issues.

Conclusions

Problems caused by forest fires in the ASEAN region have assumed a new and serious dimension that needs to be addressed sufficiently. Large areas of forestlands have been devastated, resulting in economic losses that run into billions of dollars, degradation of our environment and irreversible losses of valuable biological diversity. The episodes of forest fires and haze in the last two decades, namely in 1982/83, 1990, 1991, 1994 and 1997/98 should serve as useful lessons to be more cautious and undertake all efforts to ensure that we are prepared in the future. The ENSO dry spells will come and the fires will recur. The

intensity of the problem will then depend on our state of preparedness to face the crisis, as well as the degree in which we are able to implement the various preventive measures.

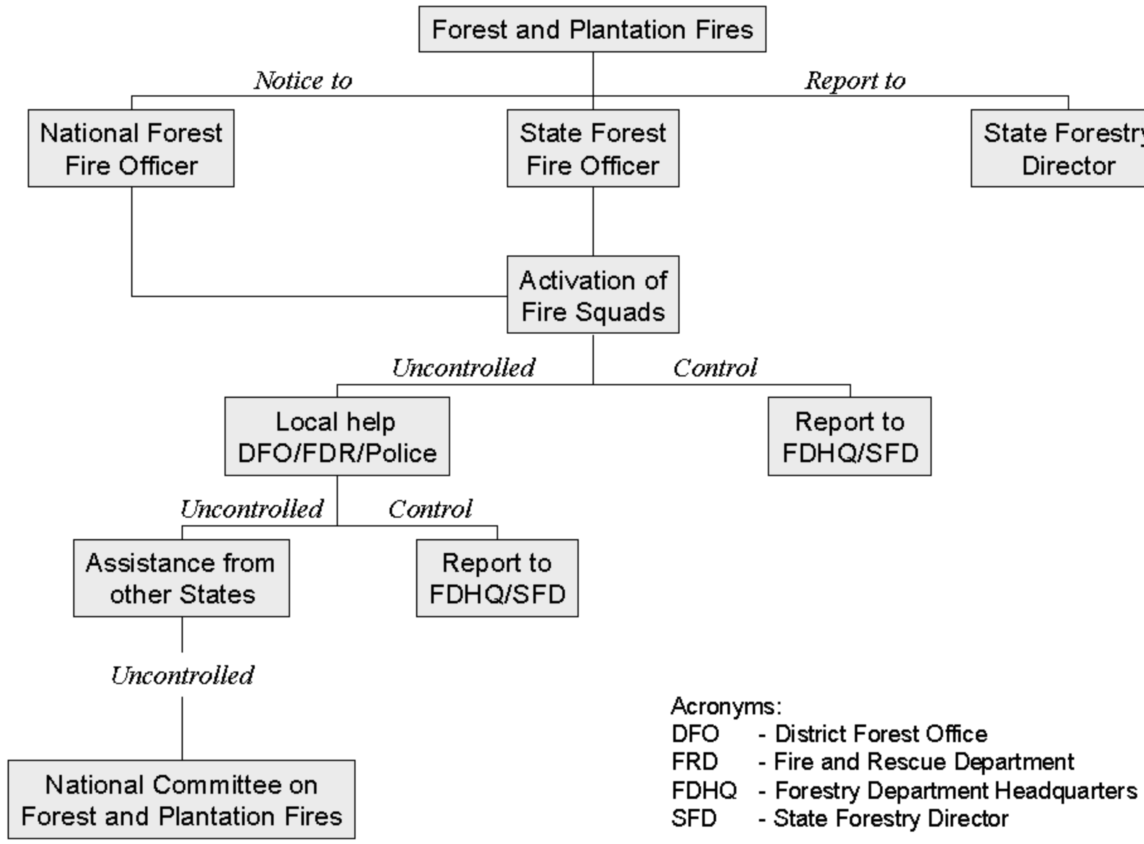

Figure 3-5 Forest fire management organization in Malaysia.

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3.2.8 Fire Situation in the Philippines

By
Manuel L. Pogeyed
Department of Environment and Natural Resources, Cordillera Administrative Region, Baguio City, Philippines

Introduction

In the Philippines, about 5.49 million ha or roughly 18 percent of the total land area are still covered with forests. The remaining old growth, or primary dipterocarp forests, comprises only about 0.804 million ha, far from the 12 million ha of old-growth forest that existed 55 years ago (Igsoc 1999). A close look at the causes of this reduction indicates that the major factors of denudation are *kaingin,* or shifting cultivation, forest fires, illegal occupancy, conversion to other uses, clearing in the process of logging, pests and diseases. Fire is obviously a very serious problem that threatens the few remaining forests of the country. Humans have caused most of the reported forest fires, either intentionally for economic gains such a *kaingin*, charcoal production, etc., or unintentionally through negligence or carelessness.

The major forest vegetation types of the Philippines include:

- Dipterocarp forest at 0-800 meters above sea level (m. s. l.).
- Mangrove and beach type forests (within the coastlines).
- Molave forest (premium hardwood at 0-800 m. s. l.).
- Pine forest (800-2 000 m. s. l.).
- Mossy forest (*Lithocarpus* and *Podocarpus* species at the higher fringes).

Four climatic zones are distinguished in the country by distribution of precipitation:

- Six months dry and six months wet.
- No definite dry season, wet from November to January.
- Dry from November to April, wet during the rest of the year.
- Rainfall evenly distributed throughout the year.

Southeast Asia is periodically affected by the El Niño-Southern Oscillation (ENSO) phenomenon that induces prolonged dry or wet seasons. If a prolonged drought occurs, the aforementioned forest vegetation types are prone to disturbance by wildfires, except for mangrove and beach type forests.

Prior to massive land-use changes (1960s-1970s) in the different forest vegetation types, fire protection efforts were concentrated in the pine forests, predominantly in *Pinus kesiya* and *Pinus merkusii* stands. These pine forests are still the most fire-prone forest ecosystems in the Philippines, although grasslands, plantations and agricultural areas are also vulnerable and at high risk for wildfires that threaten adjacent forests.

During the drought of 1983, the first large fire was experienced in the dipterocarp rainforest in the southern part of the country (Mindanao). The massive build-up of understorey fuels, coupled with drought and the presence of a large number of ignition sources resulted in an unprecedented fire situation in the Philippines and Southeast Asia. The major factors that contributed to the abnormal situation in the Southeast Asian rainforest were:

- Land-use changes brought about by forest resource exploitation
- Agricultural expansion due to the survival needs of an ever-increasing population
- Erratic climatic changes with prolonged droughts.

The montane "mossy forest" stretching above the pine forest belt is not usually prone to fire. Regular burning of the pine forests in the lower slopes is slowly reducing the mossy forest area at its edges, causing the intrusion of pine and grassland vegetation. This situation threatens the valuable mossy forest with its biodiversity-rich vegetation, which is high in medicinal, scientific and ecological values. This type of forest is an important habitat of migrating birds from mainland Asia.

The indigenous pine forest on the island of Luzón is a fire climax forest due to its long history of regular fire influence. Evidence is given by dendrochronological analyses (fire scars in tree stems) and by reports of villagers on large fire events in the hinterlands of the Cordillera mountain range in the northern part of Luzon Island. According to these reports, fires could burn whole villages when houses were made with thatched grass roofs. In 1975, a sawmill and its surrounding residential houses were burned when crown fires occurred on the steep slopes of the nearby pine forest. This happened again in the same spot in 1987. In 1981, two firefighters were killed when they were trapped in the rugged terrain of a watershed. During the drought of 1983, a vehicle was burned while at a fire scene.

Large fires in the pine forest often burn for weeks and are difficult to control due to the rugged mountainous terrain, lack of appropriate equipment and the unavailability of trained manpower. Large fires in different parts of the country, along with other neighbouring Southeast Asian countries, contributed significantly to the smoke-haze in Asia, especially during the drought of 1997-1998. Fire data for the 1990s in different regions of the country are shown in Table 3-6.

Table 3-6 Forest destruction in the Philippines by cause.

Year	Total ha	Kaingin ha	Fire ha
1993	17 862	90	15 329
1994	10 234	1 528	7 719
1995	24 102	408	10 330
1996	5 185	94	4 557
1997	22 321	4 707	1 368
Total	79 704	6 827	39 303
Annual Average	15 941	1 365	7 861

Source: DENR Annual Reports cited by Igsoc (1999).

Fire management organizations

Operational experiences in fire protection and management are more specialized within the pine forest area and forestry projects where external assistance has been provided. In the 1970s and 1980s, a fire control council for the pine forest area existed whereby all involved organizations (government agencies, local government, industries and private sector) were being coordinated by the Bureau of Forest Development. The reorganization of the operations of the Department of Environment and Natural Resources (DENR), which included the Bureau, resulted in the council's discontinuance. Fire protection was relegated to the regular operations of the DENR's field units.

A technical cooperation project, which focused on basic fire research and provided a fire management operational force within the Cordillera Administrative Region, was implemented with FAO assistance from 1987-1990.

With the shift of DENR's operations in the 1990s, the regular forest protection units of DENR have to contend with meagre government funds and limited personnel. While the communities in the field were enjoined to help in fire protection, operational facilities and large fire organization needs cannot be met, which in some aspects discourages volunteerism.

In the case of industries, they maintained their own organizational capabilities and on several occasions the DENR provided training at their request. The decentralization of power to the local governments has also fostered innovation in isolated cases, depending on priorities. In Mountain Province, a fire prevention incentive mechanism was implemented with the political leadership (concept published with IFFN in 1997) for a short period.

The large fires that occurred during the 1997-1998 drought highlighted the need for a national fire organization. The Armed Forces were involved in the suppression activities that led to the declaration of forest fires as a national disaster. At present, a national coordination and operational capability is still needed in case of a drought where wildfires are expected. Research activities to improve capability and draw up a national programme are needed in the following areas:

- An appropriate fire danger rating system in various forest vegetation types.
- Fuel assessment at various locations and forest vegetation types.
- Development of appropriate technologies.
- Impact assessments.
- Development of burning prescription guidelines.

Prescribed burning

The use of prescribed burning as a management tool has been in use in various areas in the country, although policy guidelines for such actions have not been provided. This is most common in the areas such as:

- Pasture areas to induce forage.
- Fuel reduction (pine forest).
- Natural regeneration (pine forest).
- Debris burning in farm lots especially within forest and nearby communities.

In most forestry projects implemented by the government, hazard and risk reduction are conducted as an integral part of the activity. However, these are not being monitored and studied for proper technology improvement.

Public policies

The forestry policy in the Philippines is outdated with a bill on sustainable forest management yet to be passed by Congress. The discouragement of private ownership of forest resources puts pressure on government agencies with the responsibility for fire protection.

Igsoc (1999) stated: *"The Philippines has not been successful in forest protection and conservation as manifested by the present state of the Philippine rain forests. Forest fire control and management is only one of the many conservation issues that have been inadequately addressed as shown by the absence of appropriate legislation.*

To its credit however, the government through the DENR, when confronted with problems arising from forest depletion, has demonstrated its willingness to make drastic but appropriate revisions of its forest policies. The basic lesson learned by government is that when local people possess secure land tenures, they strive hard to maintain the productive capacity of such land resources. Thus, the government logically concluded that local people can be tapped as effective forest managers by granting them tenurial instruments on public forestlands that need rehabilitation and protection under the community based forest management program.

The full implementation of the DENR's reorganization in 1988 provided the abolition of the Forest Protection and Law Enforcement Division and transform the defunct Bureau of Forest Development (BFD) as staff bureau which is now called Forest Management Bureau (FMB). In other words there is no longer a definite Office or Division in the Central Office who will oversee, coordinate, monitor and evaluate the nationwide implementation of forest fire control and management program. Thus, it is recommended that the former Forest Protection and Law Enforcement Division be restored in the FMB who shall be given the task, among others, to see to it that field offices have adequate manpower and trained forest protection personnel; recommend appropriate fire fighting tools and communications facilities to be procured and distributed to CENROs; should take the lead in the training of forest protection personnel and firefighting crews in coordination with the DENR Human Resources Development Office.

While it is true that personnel training is vital for the effective forest fire prevention and control, equally important is to provide these trained firefighters with appropriate firefighting tools, vehicles for mobility and transport and communication facilities.

The Information, Education and Communication (IEC) campaign using a multi-media approach has made some impacts in the forest consciousness of the public that has greatly helped in curbing illegal logging but not so much in preventing and controlling forest fires. While the companies are able to advertise their consumer products on television as frequently as every 30 minutes, the government seldom used this medium in fire prevention campaign on the grounds that TV airtime is relatively expensive. It is high time now to redirect priorities and the IEC approach to create greater impact to the general public awareness in fire prevention and suppression aspects."

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Source

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3.2.9 Fire Situation in Thailand

By
Siri Akaakara
Forest Fire Control Office, Royal Forest Department, Bangkok, Thailand

Introduction: Fire environment, fire regimes, and the ecological role of fire

In Thailand, 25 percent of the country is covered by forests, or 12.97 million hectares. The Deciduous forests comprise 53 percent of the total forested area, while evergreen forests make up 47 percent. Human-caused fires have long been a component of various forest ecosystems. They occur annually during the dry season from December to May with the peak period in February and March. In a normal year, the most common surface fires mainly take place in Dry Dipterocarp forests and in Mixed Deciduous forests. During extended drought conditions related to the El Niño-Southern Oscillation (ENSO) event, fires spread, to a certain extent, into Dry Evergreen, Hill evergreen or even into some parts of the Tropical Rain forest. In certain extremely dry sites, forests may burn twice per fire season. Although other types of fire are not typical to the forests of Thailand, in the recent El Niño episode of 1997-1998, a notable number of crown fires took place in Pine (*Pinus* spp.) plantations. Peat-swamp forests desiccated appreciably and a number of ground fires occurred as well.

Fire has long been playing a significant role in most of forest ecosystems, and the impacts caused by fire are very significant. However, the degree of damage caused by fire depends on the type of fire as well as the type of forest burnt. The deciduous forests are prone to fire and have long been subjected to annual surface fires. Therefore these forests are well-adapted to fire and are fire-resistant. Surface fires are usually not lethal to mature trees. However, too frequent fires impede and retard natural regeneration, and alters forest structure. Repeatedly burned forests will gradually deteriorate, changing into more arid sites and eventually into grassland dominated by *Imperata cylindrica*.

In evergreen forests fires cause abrupt and very severe damages. Fires kill more that 50 percent of mature trees, and destroy all sapling and undergrowth. In addition, fires drastically increase soil erosion as well as surface runoff. Fires also destroy food and habitat of wildlife, jeopardising the functioning of the whole forest ecosystem.

Summary of major wildfire impacts during the 1990s

The most severe fires took place in 1998 when the country was affected by the last El Niñoepisode. During that time, a number of large fires broke out in various parts of the country. These major fires included:

<u>Doi Intanon Fire</u>

This fire took place at Doi Intanon National Park in Chiangmai Province, Northern Thailand in mid March. The fire lasted for five days and consumed 480 ha. of Dry Forest as well as Hill

Evergreen Forest in the sensitive watershed area. The fire killed about 20 percent of mature trees. Damages caused to the watershed area were far beyond the assessment capabilities.

Phu Kadong Fire

This fire took place at Phu Kadong National Park in Leoi Province, Northeastern Thailand in early March. One thousand nine hundred and twenty ha. of Pine Forest and Hill Evergreen Forest were severely burnt. Impacts caused by this fire were tremendous because the burnt site is not only a watershed area but also one of most famous tourist spots in the country.

Kao Yai Fire

This fire took place at Kao Yai National Park in Nakornrachasima Province, Northeastern Thailand in late March. This fire lasted for seven days and burnt 1 440 ha. of Dry Evergreen Forest. In addition to killing 30 percent of mature trees, the fire caused high mortality of wild animals, mainly wild chickens and their eggs, snakes and other small reptiles.

Pru Todang Fire

This fire took place at Pru Todang Swamp forest, which is the country's only true Peat-Swamp Forest. This peat fire lasted for nearly two months from late April to late June. Fire destroyed 1 280 ha. of invaluable Peat-Swamp Forest. About 80-90 percent of mature trees were killed, along with all undergrowth. The affected area was nearly denuded after this fire. Smoke emitted from this fire covered the sky over Naratiwat Province in southern Thailand for almost two months. Hundreds of patients, mainly children and elderly, were treated in hospitals for their respiratory problems. A number of firefighters, including the correspondent who commanded the fire suppression operations, were also treated due to the same sickness.

Forest fire database

Table 3-7 Wildfire statistics of fire numbers, area burned and fire causes for the period 1985-2000.

Year	Total No. of Fires on Forest Lands		Area of Forest Burned (ha)		Human Causes %	Natural Causes %	Unknown Causes %
1985			3 535 110	-	100	-	-
1986			3 797 289	-	100	-	-
1992			2 030 160	-	100	-	-
1993			1 459 617	-	100	-	-
1994			763 648	-	100	-	-
1995			643 799	-	100	-	-
1996			490 303	-	100	-	-
1997			660 208	-	100	-	-
1998			1 145 452	-	100	-	-
1999			407 964	-	100	-	-
2000			93 324	-	100	-	-

Source: Forest Fire Control Office, Royal Forest Department of Thailand

Operational fire management system and organization

There is a single organization responsible for all forest fire control activities in Thailand, called the *Forest Fire Control Office* which is under the Royal Forest Department (Figure 3-6). This office is composed of:

- Divisions
- Forest Fire Control Centres (FFCC)
- 92 Forest Fire Control Stations (FFCS)
- Forest Fire Control Development Camps (FFDC)

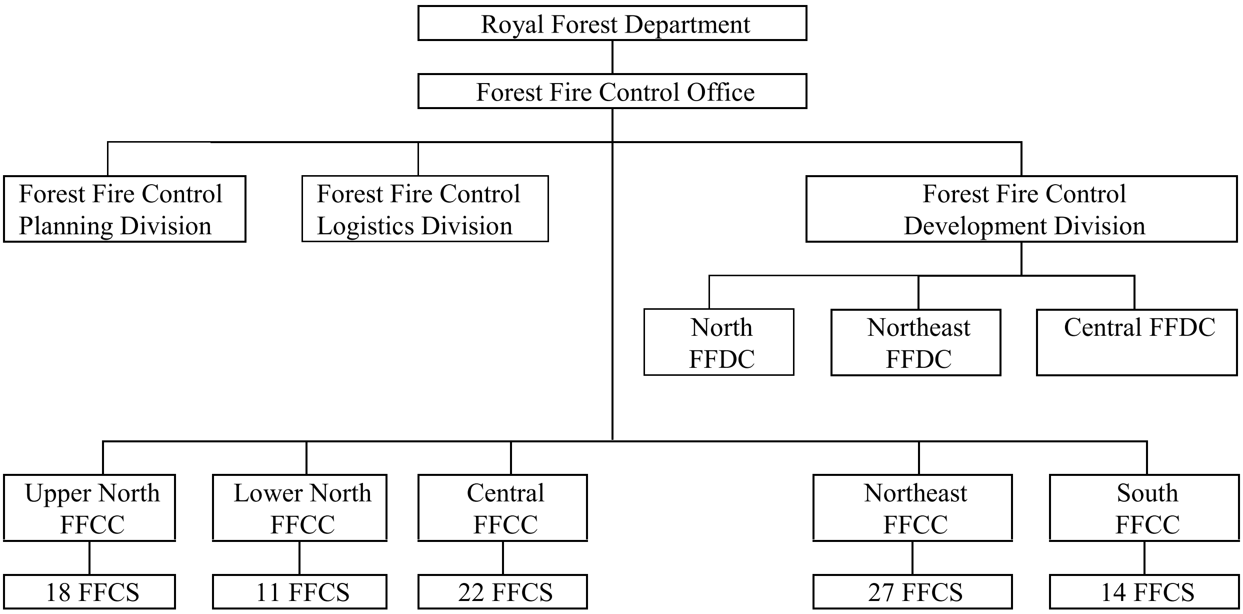

Figure 3-6 Organizational structure of the Forest Fire Control Office, Royal Forest Department, Thailand

<u>Responsibilities at different levels of the forest fire control organization</u>

Forest Fire Control Planning Division
- Planning and budgeting
- Supervise, coordinate and evaluate fire control centres and stations nationwide
- General affairs

Forest Fire Control Development Division
- Develop fire prevention materials, prevention campaign strategies, fire suppression equipment as well as techniques and tactics in fighting fire
- Supervise, coordinate, and evaluate fire control centres and stations nationwide
- Train fire control personnel
- Train, maintain and command the *Fire Fighting Special Task Force (Fire Tiger Unit).*
- Research and study
- Coordinate with concerned Organizations locally and internationally

Forest Fire Control Logistics Division

- Procure and mobilize all human and technical resources to support fire suppression operations
- Logistics, first aid and rescue during large fire suppression operations

Forest Fire Control Centres (FFCF)
- Supervise fire control stations under its responsibility
- Support the operation of its fire control station
- Coordinate with all agencies concerned

Forest Fire Control Stations (FFCS)
The FFCS is the executing unit of Forest Fire Control Office. Each station has subordinate units called *Forest Fire Suppression Mobile Teams*. The number of Forest Fire Suppression Mobile Teams of each Fire Station varies depending on amount of responsible area of each Station. It carries out two main tasks which include:
Forest fire prevention campaign. This campaign is carried out throughout the year, and comprises these following activities :

- Mobile campaign unit (direct contact)
- Campaign via mass media
- Billboard and printed materials
- Education programme
- Exhibition

Forest fire suppression. This task is carried out by the Forest Fire Suppression Mobile Teams. There are 272 teams nation-wide. Each team is composed of 15 fire crews and generally responsible for suppression operations within 10 000 hectares of forest. Due to budget limitations, only 4.68 million hectares, or equivalent to 35.7 percent of total forestland, are placed under the fire suppression programme. The suppression activities include :

- Training of fire crews as well as fire volunteer brigades
- Fuel management (fire breaks, control burning etc.)
- Fire detection and reporting
- Pre-suppression
- Fire suppression
- Evaluation

Forest Fire Control Development Camp
It is the executing unit of Forest Fire Control Development Division. It carries out all kinds of development tasks, including:

- Develop and produce fire prevention campaign materials
- Develop and produce fire suppression equipment
- Train fire crew as well as fire prevention campaign personnel
- Train and operate *the Fire Fighting Special Task Force (Fire Tiger Unit)*
- Conduct research and study

Responsibilities at the different levels of government

Central level (national)
The *National Forest Fire Management Committee* is appointed by the prime minister and is responsible for fire management policy at the national level.

State (provinces)
The *Provincial Forest Fire Management Committee* is appointed by the National Forest Fire Management Committee and implements the fire management policy at the provincial level. There are committees in each of the 63 provinces where forests still exist. The local administrations have a mandate to protect the forest resources in their respective areas, including the protection of forests against fire.

Voluntary firefighters / brigades
The fire problem will not be solved without full cooperation with local people. The Royal Forest Department has devoted all its efforts to obtain people's participation in fire management. Approximately 10 000 fire volunteers are trained annually. Unfortunately, without financial incentive, the concept of fire volunteers does not work well in this country.

Main forest fire research issues

A few fire research programmes have been conducted since 1980. The main research projects are on fire behaviour, fuel characteristics and the attitude of people towards fire. However, since 1999 a national *Forest Fire Research Centre* was established and a Master Plan for Forest Fire Research was formulated. It includes the research on fire impacts, fire prevention, fire suppression and the use of fire.

Use of prescribed fire to achieve management objectives

<u>Forestry</u>

Early burning has long been practised in all areas under fire control programmes as a means to prevent forest fires and to reduce the hazard of fire. However, the practice is conducted on a small scale due to the inadequacy of know-how as well as experience in this field.

<u>Other vegetation management (grasslands, bushlands)</u>

Prescribed fire has been used in some very specific areas in order to maintain grassland for wildlife management purposes.

<u>Agricultural maintenance burning</u>

Open burning in farmlands to eliminate residue after harvesting is still the common practice of all local people throughout the country.

<u>"Let burn" (or integration) of natural (lightning) and human-caused wildfires</u>

100 percent of the forest fires are caused by humans. There is no "let burn" policy in place.
Sustainable land-use practices employed in the country to reduce wildfire hazards

Presently there is no dedicated programme underway to employ land-use practices for wildfire hazard reduction.

Public policies concerning fire

Policies in place

- *The National Forest Policy*

The latest National Forest Policy No.18 (1985) states that a substantial plan for tackling the deforestation problem (e.g., shifting cultivation, forest fire) must be determined. Suppression as well as law enforcement measures must be clearly set.

- *The Royal Forest Department Policy*

The Royal Forest Department has a forest fire control policy "to minimise damages caused by forest fires by using all means either prevention or suppression strategy."

The needs of fire management

The management of forest fires in Thailand has been intensively carried out for almost two decades. Considerable amounts of knowledge and experiences have been obtained during this long period. To a satisfactory level, Thailand has developed a unique fire management system which is proved to fit the local situation. However, some aspects of management and fire research are still insufficiently developed. In this regard, assistance from the fire science community is badly needed.

Source

Akaakara, S. 2001. The forest fire situation in Thailand. *Int. Forest Fire News* 26.

3.3 South Asia Sub-Region

The South Asia region stretches from the tropical evergreen forests of Sri Lanka and India in the South to the mountain forests up to the tree line, or alpine forests, in the Himalayas in the North. As in continental and insular Southeast Asia, a large variety of biogeographic features and climatic conditions within the region have shaped a high diversity of forest ecosystems and other wooded land with different fire regimes and vulnerabilities. Surveys on the state of wildland fires in the 1980s and 1990s have been conducted in several countries and are included in monographs and reviews for the region by Goldammer (1990, 1993), for Bhutan by Chetri (1994), for Nepal by Schmidt-Vogt (1990) and Sharma (1996). Also, there are numerous papers for India, including the IFFN publications by Bahuguna (1999), Srivastava (1999a,b, 2000) and the FAO papers (FAO 1984, Saigal 1990), and Sri Lanka by Ariyadasa (1999). Updated country reports are provided from India, Nepal, and Sri Lanka. No information on forest fires in Pakistan is available.

The deciduous, seasonally dry forests of the lowlands and the coniferous (pine) forests in the higher elevations are regularly burned. As cited in the report by Bahuguna (this volume), the Forest Survey of India in a country-wide study in 1995 estimated that about 1.45 million ha of forest area is affected by fire annually in the country. According to an assessment of the Forest Protection Division of the Ministry of Environment and Forests, Government of India, 3.73 million ha of forests are affected by fires annually in India. Under similar conditions of seasonal forest fire regimes in neighbouring Burma, Goldammer (1986, 1993) estimated that between 3.5 and 6.5 million ha of forests were affected annually by fire in the 1980s. Regional vegetation fire patterns in South and Southeast Asia by satellite remote sensing have been established by Malingreau et al. (1997) and confirm the high regional fire activity during the dry season.

Bangladesh: An unpublished report of the Bangladesh Agricultural Research Council (Farid Uddin Ahmed, pers. comm.) directed to the Global Fire Monitoring Center (GFMC) in 1998 states that the incidence of forest fires in Bangladesh is considered to be insignificant. The total forested area affected by wildfire is ca. 1 500 ha per year. Damages are limited to plantations that are established in the south and southeast of the country. The teak forest of the Chittagong Hill Tracts in the south experience fire which is set intentionally by the Jhumias (hill people) for cultivating the land for agriculture. Some forests of Cox‘s Bazar area (Napitkhali Range) are also affected. In this forest Dipterocapus turbinatus seedlings or regeneration are affected. Most forest fires occur in the Sitakundu Range (near Chittagong). These fires are set intentionally to stimulate the growth of *Imperata cylindrica*. The grass is used for thatching and therefore has a high commercial value. In the southeastern part (Sylhet) fire incidence are observed in bamboo forest. These fires are not considered a serious problem.

Bhutan: According to Chetri (1994) forest fires are considered one of the biggest threats to the forest resources. Conifer (pine), mixed conifer, broadleaf with conifer, plantations and degraded forests, which cover approximately 40 percent of the total forest area, are most susceptible to frequent forest fires. Repeated forest fires, combined with heavy grazing pressure, can completely degrade vegetation cover. In Bhutan, forest fire incidence is normally high during the dry winter months. Freezing temperatures and lack of rainfall are responsible for drying of perennial grasses, and increasing wind velocity quickens the drying process thereby making the grass covered area flammable. In the freezing winter, it becomes difficult to live without warming fires.

In addition, land preparation for agricultural, horticultural and shifting cultivation purposes is done during or at the end of the winter months. Fire is used as the cheapest tool for cleaning such land by the villagers and shifting cultivators. Therefore, uncontrolled use of fire in or adjacent to the forest occurs frequently. Often such fires escape to the forest accidentally. In some cases, fires are set wilfully by the cattle grazers to obtain a new flush of good grasses. According to an analysis of the Ministry of Agriculture, Forest Protection Cell, 100 percent of forest fire incidents are human-caused. Every year 20 to 75 (average 50) forest fires are reported. Some years like 1979, 1981, 1982, 1983 and 1989 were comparatively dry years and in most parts of the country pre-monsoon rains were delayed and very much limited. Therefore, the number of fire cases increased.

Most parts of the country in the Western and Eastern region receive no rain or very little (only up to 10 mm) during the months from November to April. In some parts of this region, total rainfall for seven months (October to April) is only 150 mm. Based on the local rainfall regimes the country has been divided into three zones of fire risk. The pine forests (*Pinus roxburghii*) are in the High Fire Risk Zone (<1000 mm annual rainfall) and Medium Fire Risk Zone (1000-2000 mm annual rainfall). Areas with more than 2000 mm annual rainfall fall within the low fire risk zone. The floor of the evergreen forest is covered throughout the year with green grasses, but the floor of deciduous forests is covered with dry fallen leaves and is prone to catch fire during extended droughts.

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3.3.1 Fire Situation in India

By
Vinod K.Bahuguna
Ministry of Environment and Forests, New Delhi, India
&
Satendra Singh
Ministry of Rural Development, New Delhi, India

Introduction

India, with a forest cover of 76.4 million hectares, contains a variety of climate zones, including the tropical south, northwestern deserts, Himalayan mountains, and the wet north-east. Forests are widely distributed in the country. India's forests are endowed with a variety of biomes and biological communities. The forest vegetation in the country varies from tropical evergreen forests in the West Coast and in the Northeast to alpine forests in the Himalayas in the North. In between the two extremes, there are semi-evergreen forests, deciduous forests, sub-tropical broad-leaved hill forests, sub-tropical pine forests, and sub-tropical montane temperate forests.

With increasing population pressure, the forest cover of the country is deteriorating at an alarming rate. Along with various factors, forest fires are a major cause of degradation of Indian forests. According to a Forest Survey of India Report, about 50 percent of forest areas in the country are fire prone (ranging from 50 percent in some states to 90 percent in the others). About 6 percent of the forests are prone to severe fire damage.

Ecological, economic and social impacts of the forest fire

The ecological and socio-economic consequences of wildland fires in India include:

Loss of timber, loss of bio-diversity, loss of wildlife habitat, global warming, soil erosion, loss of fuelwood and fodder, damage to water and other natural resources, loss of natural regeneration. Estimated average tangible annual loss due to forest fires in country is Rs.440 crore (US$ 100 millions approximately).

The vulnerability of the Indian forests to fire varies from place to place depending upon the type of vegetation and the climate. The coniferous forest in the Himalayan region comprising of fir (*Abies* spp.), spruce (*Picea smithiana*), *Cedrus deodara, Pinus roxburgii* and *Pinus wallichiana* etc. is very prone to fire. Every year there are one or two major incidences of forest fire in this region. The other parts of the country dominated by deciduous forests are also damaged by fire (See Table 3-8).

Table 3-8 Susceptibility and vulnerability of Indian forests to wildfire.

	Type of Forests	Fire frequent (%)	Fire Occasional (%)
1	Coniferous	8	40
2	Moist Deciduous	15	60
3	Dry Deciduous	5	35
4	Wet/Semi-Evergreen	9	40
5	Northeastern Region	50	45

Various regions of the country have different normal and peak fire seasons, which normally vary from January to June. In the plains of northern and central India, most of the forest fires occur between February and June. In the hills of northern India fire season starts later and most of the fires are reported between April and June. In the southern part of the country, fire season extends from January to May. In the Himalayan region, fires are common in May and June.

Summary of major wild fire impacts on people, property, and natural resources during the 1990s

During the 1990s, several forest fires occurred in the hills of Uttar Pradesh and Himachal Pradesh. From 1995 to 1999, fire hazards in these two states assumed dangerous dimensions. An area of 677 700 hectares was affected by these fires. The estimated timber loss from these hazards was US $ 43 million. Other losses due to these fires included loss of soil fertility, soil erosion, loss of employment, drying up of water resources, and loss of bio-diversity. These fires brought a major change in the microclimate of the region in the form of soil moisture balance and increased evaporation. The dense smoke from the fires affected visibility up to 14 000 feet.

Beside these major forest fires, the losses from the other fires reported from 13 states for the period 1994-1996 came to US $ 20 million. One other major fire, reported from the state of Tamil Nadu, for the year 1996-1997 in sandal wood forest caused a loss of approximately US $ 43 million.

Losses in productivity of the land, impacts on regeneration of species, and deleterious impacts on water shed also resulted from the forest fires.

Wildfire statistics

In India there are no comprehensive data to indicate the loss to forests in terms of area burned, values, and volume and regeneration damaged by fire. The available forest fire statistics are not reliable because they under estimate fire numbers and area burned. The reason behind this is attributed to the fear of accountability. However, Forest Survey of India in a country-wide study in 1995 estimated that about 1.45 million hectares of forest are affected by fire annually. According to an assessment of the Forest Protection Division of the Ministry of Environment and Forests, Government of India, 3.73 million hectares of forests are affected by fires, annually in India.

Table 3-9 Extent of fire incidence in forest areas of the country.

State/ District	Forest Area	Sample Plots	Extent of fire incidents						Total
			Very Heavy	Heavy	Frequent	Occasional	No Fire	Unrec	
Andhra Pradesh	14826.71	2037	60.58	5.75	521.99	3335.27	10016.34	886.78	14826.71
Assam	15427.88	2482	70.91	0	590.25	4551.13	10176.68	38.01	15427.88
Bihar	5317.01	296	57.718	0	452.6223	3330.7426	1505.927	0	5317.01
Himachal Pradesh	10269.40	4878	163.7	0	671.45	3811.38	5054.92	567.98	10269.40
Jammu & Kashmir	3331.75	428	7.5	0	60.98	1089.58	2088.05	85.64	3331.75
Haryana & Punjab	1180.72	45	0	0	41.54	332.48	807.7	0	1180.72
Karnataka	13223.30	1780	59.71	30.33	470.64	3342.94	9309.79	9.89	13223.30
Manipur	15154.00	1880	0	151.54	454.62	5758.52	8789.32	0	15154.00
Madhya Pradesh	1962591	1947	136.53	23.07	1838.83	10644.29	6983.19	0	19625.91
Maharashtra	8165.54	1355	0	0	186.83	4222.57	3756.94	0	8165.54
Meghalaya	9905.00	1659	26.75	0	269.12	3347.25	5230.91	1031.6	9905.66
Nagaland	14954.91	1128	0	0	1084.231	12038.703	1831.976	0	14954.91
Orissa	20143.38	2972	204.42	78.5	923.19	11345.345	5258.182	333.52	20143.38
Rajasthan	20178.79	2446	71.39	0	99.03	4348.12	14763.26	896.99	20178.79
Sikkim	1707.77	401	47.12	0	18.14	544.84	1097.67	0	1707.77
Tripura	6445.36	555	34.59	0	361.75	5293.65	755.37	0	6445.36
Uttar Pradesh	23164.09	2825	871.43	0	2092.51	11124.1	907605	0	23164.09
West Bengal	5764.81	1471	4.77397	0	656.4338	1356.5246	3444.318	302.76	5764.81
Dadra & Nagar	186.49	62	0	0	0	180.8953	5.5947	0	186.49
Grand Total	**208973.48**	**307.47**	**1817.122**	**289.19**	**10794.16**	**89998.3305**	**101952.188**	**4154.07**	**208973.48**
Percentage			**0.87**	**0.14**	**5.16**	**43.06**	**48.79**	**1.99**	**100.00**

Based on the inventory conducted by the Forest Survey of India since its inception.

In India there are very few cases of fire due to natural causes. The majority of the forest fires (99 percent) in the country are human caused. It is widely acknowledged that most of these fires are caused by the people deliberately and have a close relationship to their socio-economic conditions. Grazing, shifting cultivation, and collection of minor forest products by villagers are major causes of fires in India. Carelessness of the picnickers, travellers, and campers are also responsible for forest fires.

Operational fire management systems and organizations

According to the Constitution of India, the central and state governments in the country are enabled to legislate on forestry issues. The implementation part of the forest policy/programmes lies with the state government. Thus, fire prevention, detection, and suppression activities are the responsibility of the state governments' forestry departments. The policy, planning, and financing are the primary responsibility of the Central Government. There is generally no separate department for carrying out forest fire management in the states. The regular staff of the forest departments in the states carries out various activities of

forest fire management. During forest fire seasons in some of the divisions, fire watchers are recruited by the state governments as a special provision. At the central level, the Ministry of Environment and Forests is the ministry responsible for forest conservation and protection. Forest fire management is administered by the “Forest Protection Division” of the Ministry, which is headed by a Deputy Inspector General of Forests. The Ministry is implementing a plan called “Modern Forest Fire Control Methods” in India under which state governments are provided financial assistance for fire prevention and control. This assistance is being used by the state governments for procuring hand tools, fire resistant clothes, firefighting tools, radios, fire watch towers, fire finders, creation of fire lines, research, training, and publicity on firefighting. This project is carried out in fourteen states and covers more than 70 percent of the forest area of the country.

Community involvement

In India, Joint Forest Management (JFM) Committees have been established at the village level to involve people in forest protection and conservation. At present there are 36 165 JFM committees throughout the country, covering an area of more than 10.24 million hectares. These JFM committees also have been given responsibilities to protect the forests from fires. For this purpose, the Modern Forest Fire Control plan is being revised and JFM is being made an integral component of the forest fire prevention strategy. Use of aircraft and helicopters has not been very cost effective in the fire management program and the Air Operation Wing is being closed down. For emergency purposes, however, a provision for hiring aircraft for transportation of crews and water is being maintained. The Government of India has issued national forest fire prevention and control guidelines. Salient features of the guidelines include identification of vulnerable areas on maps, creation of a data bank on forest fires, evolving fire dangers, fire forecasting system, provisions for a crisis management group, involvement of JFM committees, and efficient enforcement of legal provisions.

Research Issues

In India, there is an urgent need to initiate research in the fields of fire detection, suppression, and fire ecology for better management of forest fires. The research and technology developed in western countries always suitable for the Indian environment. Thus, it is essential that original research specific for Indian conditions be conducted. The Government is considering setting up a National Institute of Forest Fire Management with satellite centres in different parts of the country to bring the latest forest fire fighting technologies to India through proper research, training of personnel, and technology transfer on a long term basis.

Public policies concerning fire

India’s National Forest Policy (1988) presents a visionary strategy for forest conservation and management and emphasizes protection of forests against encroachment, fire, and grazing. It states that “The incidence of forest fires in the country is high. Standing trees and fodder are destroyed on a large scale and natural regeneration annihilated by such fires. Special precautions should be taken during the fire season. Improved and modern management practices should be adopted to deal with forest fire”. This policy provides a positive step towards protection of forests from fire. The legal and policy framework exists in support of fire protection in the country.

The needs of fire management

The incidence of forest fires in the country is on the increase and more area is burned each year. The major cause of this failure is the piecemeal approach to the problem. Both the national focus and the technical resources required for sustaining a systematic forest fire management programme are lacking in the country. Important forest fire management elements like strategic fire centres, coordination among Ministries, funding, human resource development, fire research, fire management, and extension programmes are missing.

Taking into consideration the serious nature of the problem, it is necessary to make some major improvements in the forest fire management strategy for the country. The Ministry of Environment and Forests, Government of India, has prepared a National Master Plan for Forest Fire Control. This plan proposes to introduce a well-coordinated and integrated fire-management programme that includes the following components:

- Prevention of human-caused fires through education and environmental modification. It will include silvicultural activities, engineering works, people participation, and education and enforcement. It is proposed that more emphasis be given to people participation through Joint Forest Fire Management for fire prevention.

- Prompt detection of fires through a well coordinated network of observation points, efficient ground patrolling, and communication networks. Remote sensing technology is to be given due importance in fire detection. For successful fire management and administration, a National Fire Danger Rating System (NFDRS) and Fire Forecasting System are to be developed in the country.

- Fast initial attack measures.
- Vigorous follow up action.
- Introducing a forest fuel modification system at strategic points.
- Firefighting resources.

Each of the above components plays an important role in the success of the entire system of fire management. Special emphasis is to be given to research, training, and development.

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3.3.2 Fire Situation in Nepal

By
Keshar Man Bajracharya
Royal Nepal Academy of Sciences and Technology, Kathmandu, Nepal

Fire environment, fire regimes and ecological role of fire

Nepal is a small country of 14.7 million hectares and 23 million people situated in the central Himalayas, covering the northern edge of the Indian Gangetic plain to the high Himalayan ridges bordering the Tibet region of China. The country has topographic variation from 150 meters above sea level at the southern border to the highest mountain in the world (Everest at 8 848 m) in the north. Due to the east-west orientation of the mountain ranges, the country has a tropical climate in the south and temperate and alpine climates in the north. Accordingly, there are many different forest types in Nepal.

The Terai-Bhaber Region

The southernmost physiographic region of Nepal, called the Terai-Bhaber region, has an average altitudinal range between 150 and 300 m above sea level. It has a tropical climate with the main forest type comprised of sal (*Shorea robusta*) with smaller proportions of moist evergreen forest, dry deciduous forest, and khair-sisoo (*Acacia catechu*/*Dalbergia sissoo*) forest. The total forest area in this region amounts to about 475 000 ha within a total regional area of 2.11 million ha. There are also some 111 000 ha of shrubland and grassland.

In this region, the accumulated glabrous sal leaf litter is burned every year and during the process naturally regenerated sal seedlings and other herbs and shrubs are burned. However, larger green trees are usually not damaged and neither are the root systems of the sal seedlings, although the aerial parts are burned. Sal forests appear to be able to regenerate only when there are no surface fires.

The Siwaliks Hills and the Inner Terai Region

The next northern physiographic region includes the Siwaliks Hills and the Dun valleys (also called the Inner Terai in Nepal) and has an altitudinal variation between 300 and 1 000 m. It is characterized by a subtropical climate. The major forest types in this region include *Schima-Castanopsis* forests on the northern slopes of the Dun valley; the subtropical pine (*Pinus roxburghii*) forests on the Siwaliks ridges, dry scrubby forests on the southern slopes of the Siwaliks and moist *Lauracea* forests in the northern moist localities along with patches of sal forest. This region has 1 438 000 ha of forests and 104 000 ha of shrubland, grassland, and other non-cultivated woodlands within a total regional area of 1 886 000 ha.

Here, too, the vegetation along the southern drier slopes is burned during the dry season starting in March. Occasionally, bamboo brakes and grassy areas are destroyed, but the larger trees are usually spared. Nevertheless, the smoke created by forest fires and from agricultural burning make the valleys and the countryside very hazy and drab throughout the dry season.

The Middle Mountain Region

From 1 000 m along the southern foothills of the Mahabharat Range (ridge tops up to 3 000 m) to the hills of Nepal to an altitude of 2 500 m is called the Middle Mountain Region. It has mostly lower temperate forests. These are mainly broadleaved forests with *Pinus roxburghii* up to 2 000 m and *Pinus wallichiana* at the higher elevations. The river valleys in this region may be as low as 400 m. and sal forests (also called hill sal, a somewhat less luxuriant variety of *Shorea robusta*) and other subtropical broadleaf forests can occur here. The region has a total area of 4 442 000 ha with 1 811 000 ha of forests and 1 349 000 ha of shrubland, grassland and non-cultivated woodland.

Usually the pine forests and pine plantations, which are more susceptible to fire due to resin content, are frequently burned. As a result, the extensive chir pine (*Pinus roxburghii*) forests, which grow in the main habitat zone between 1 000 to 2 000 m, have become greatly fragmented.

The High Mountain Region

This region extends from 2 000 to 3 500 m above sea level, mostly with upper temperate forests of *Quercus semicarpifolia*, other broad-leaf forests composed mainly of *Rhododendron* spp., as well as coniferous forests of *Pinus wallichiana*, *Abies pindrow* and *Picea smithiana*. There is also a narrow belt of *Tsuga brunoniana*. This region has 1 630 000 hectares of forests together with 832 000 ha of shrubland, grassland and non-cultivated woodland within a total regional area of 2 960 000 ha.

In this region, coniferous forests are susceptible to extensive fire damage during the dry season, especially on windy days.

High Himal Region

This region mainly has alpine forests of birch (*Betula utilis*) as well as bushy rhododendrons and junipers. The total area of the region is 3 350 000 ha with only 155 000 ha of forests but with some 953 000 ha of shrubland and grassland. There is little cultivation here and a lot of snow- and rock-covered barren lands.

In all cases, the fire problems are acute for three to four months during the dry period between March and June every year. In most cases fires are caused by negligence. Sometimes grazers burn dry grassy areas purposely in order to get young shoots immediately after the first few pre-monsoon showers.

Narrative summary of major wildfire impacts on people, property, and natural resources during the 1990s

Every year wildfires destroy considerable forest resources in Nepal. Such destruction includes both timber and non-timber forest products. Although quantitative information is not available, forest fires are definitely degrading biological diversity in Nepal's forests. In addition, fires cause soil erosion and induce floods and landslides due to the destruction of the natural vegetation. Occasionally, embers from forest fires also cause fires in nearby villages, especially in the Terai region where the roofs are made of thatched grass. Many villages are burned every year with loss of lives, cattle and other property.

At least one hundred villages are burned annually in Nepal, some of which are definitely destroyed by forest fires.

Fire management organization used in Nepal

There is no Organization for fighting forest fires in Nepal. The Department of Forests does not possess any special unit or team to deal with the problem of forest fire, including firefighting or management. None of the 75 district forest offices, with a number of graduate foresters and forestry technicians, has either the capacity or capability for preventing or fighting forest fires. It is probable that these offices under-report forest fire incidences and subsequent damage. Unless forest fire surveillance and monitoring are carried out by satellite imagery it will be difficult to make a good assessment of forest fire numbers, area burned and damage.

In Nepal some 10 000 local forest user groups have been formed with a total of 600 000 ha handed over to them as local community forests. Most of these community forests are located in the Middle Mountain Region where forests are severely fragmented and surrounded by villages. Here the community forest users are able to protect their respective forests from cutting and grazing. However, occasional forest fires occur due to the negligence of smoking travellers. The forest users are able to fight forest fires although they do not have proper tools and technical support. In fact, community forests are not managed properly, nor are forest fires fought in an appropriate manner.

Wildfire database

A wildfire database or other wildland fire statistics are not available. However, the magnitude of the forest area annually affected by fire is known. Sharma (1996) observed that in 1995 about 90 percent of the Terai forests were burned. Earlier observations by Goldammer (1993) confirmed this statement. Accordingly, the forest area burned annually must be in the order of more that 400 000 ha.

Use of prescribed fire to achieve resource management objectives

Prescribed fire is not used in Nepal to prevent forest fires. However, pine needles are collected for cattle bedding. Similarly, forest litter in the hills is collected and mixed with cattle dung for composting.

Public policies affecting wildfire impacts

Although the government devotes considerable attention in parliamentary discussions and the politicians and bureaucrats highlight the importance of forest fire prevention and firefighting, fire events are soon forgotten after the monsoon starts in June. During the fire season, Nepal Radio and Nepal Television broadcast old clips on forest fire prevention and firefighting.

Sustainable land use practices used in Nepal to reduce wildfire hazards and wildfire risks

In the past, district forest offices hired temporary fire guards, even though they were not effective in forest fire prevention. Of course, these temporary staff, as well as the permanent forestry staff, cannot achieve much in terms of forest fire prevention and firefighting without appropriate tools and organization.

Community involvement in fire management activities

Community involvement in fighting forest fires exists only in the community forests that have been established. Community involvement does not exist in the state forests and national parks, which constitute 90 percent of the Nepalese forests and related wild lands.

Conclusions

Forest fires occur annually in all the major physiographic/climatic regions of Nepal, including the Terai and Bhabar , the Siwaliks or the inner Terai, the Middle Mountains, and the High Mountains regions.

The main causes of forest fires are anthropogenic due to negligence and occasionally by deliberate burning to induce succulent grass growth for domestic animals.

Forest fires occur during the dry season from February to June and the nature (surface fire, crown fire, etc) as well as the severity varies greatly depending upon fire weather, fuel conditions, and physiography. Once the monsoon is established, usually by the middle of June, the fire problem disappears.

Forest fires destroy timber and non-timber forest products, although no data are available about the number of fires, severity and the amount of loss. Fires also reduce the biological diversity of the forests to a great extent. In addition, fires degrade the soil, inducing flood and landslide damage. Forest fires make the entire countryside hazy, thereby reducing aesthetic values for eco-tourism during the dry season.

Forest fire management is not practiced in Nepal. The community forest user groups control forest fires in their own forests, although they do not have a plan for systematic prevention and control of fires.

Systematic arrangements for prevention, control, and management of forest fires can be instituted in Nepal only when scientific forest management is implemented within the Department of Forests for state and community forests.

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3.3.3 Fire Situation in Sri Lanka

By
K.P. Ariyadasa
Forest Department, Battaramulla, Sri Lanka

Introduction

Sri Lanka is a tropical island with a land area of 65 000 km^2. Current population is estimated at 18 million and population growth is around 1.1 percent per annum. The economy is predominantly agriculture and the per capita income is around US$ 740.

The total area of natural closed-canopy forest in 1992 is estimated at 1.58 million ha or 23.9 percent of the total land area. Sparse and open forests occupy a total area of 463 842 ha or 7 percent of the land area while the total extent of well-established forest plantations amounts to 72 340 ha or 1.1 percent of the land area. The status of forest resources is given below.

Table 3-10 Forest resources of Sri Lanka.

Forest Type	Area (ha)	Share of total land area (%)
Montane Forests	3 108	0.04
Sub-montane forests	68 838	1.04
Lowland rain forests	141 549	2.13
Moist monsoon forests	243 877	3.68
Dry monsoon forests	1 094 287	16.53
Riverine dry forests	22 411	0.33
Mangroves	8 687	0.13
Sparse forests	463 842	7.01
Forest plantations	72 340	1.09
Total	**2 118 939**	**32.02**

Source: Remote Sensing Unit, Forest Department (1992)

<u>Land use classification</u>

According to the FAO classification, all of the above lands fall under the category of "forest". All coconut plantations, rubber plantations and a majority of home gardens also have more than 10 percent tree crown cover and are more than 0.5 ha in extent. The total area in each category is 326 000 ha, 230 000 ha and 835 000 ha, respectively. Under normal circumstances, these lands are not considered as forests and there is no wildfire problem in these lands as well.

There are about 1.2 million ha of lands classified as "sparsely used crop lands" that are comprised of scrub and grasslands. These lands are used for upland dry cropping, mainly

under shifting cultivation. These lands fall into the FAO category of “other lands”. Fires are closely associated with these lands.

Fire environment and fire regimes

The problem of forest fires in Sri Lanka can be summarized by examining weather conditions, fuel types in the forests and human attitudes in the area.

Weather

The climate of Sri Lanka is a monsoon climate. That is, weather conditions are mainly determined by the prevailing winds. There are two major monsoons, the southwest monsoon from April to July and the northeast monsoon from September to January. The southwest monsoon is stronger than the northeast monsoon and lasts longer. During the southwest monsoon rainfall is concentrated on the windward slopes of the central highlands, so on the lee side the winds are very dry. The contrary happens during the northeast monsoon, but this monsoon is weak and shorter compared to the southwest monsoon.

Based on rainfall, the country can be divided into two climatic zones, a wet zone with annual rainfall ranging from 2 500 to 5 000 mm and a dry zone with annual rainfall around 1 000 mm. Although the rainfall figures are quite high, the distribution of rainfall is very uneven, especially in the dry zone. Much of the rainfall in the dry zone comes with the northeast monsoon during a three-month period from October to December, leaving seven to eight months virtually dry. This considerably increases the fire hazard during the dry period.

The wind pattern and topography create two marked fire seasons. There is a short but important fire season from February to March in the wet zone and a longer fire season from June to September in the dry zone. In the central highlands, only a short dry season prevails during the first three months of the year but the risk of fire is often high due to low humidity and the topography of the area.

Fire hazard

There is no significant fire hazard in most of the native vegetation of the country. The climax vegetation of the south and central highlands is tropical rain forests and sub-tropical montane forests. In the intermediate zone it is mainly evergreen forests, while in the dry zone it is tropical semi-deciduous forests. Land not occupied by permanent agriculture is mainly covered with grasses such as *Imperata cylindrica* and *Cymbopogon* spp. Fuel loads in this area are between 4-12 tons/ha (dry weight). Mean height of the grass is about one metre and grasslands are ready to burn during the dry season.

Fire hazard is very high in forest plantations, especially in eucalypt (*Eucalyptus* spp.) and pine (*Pinus* spp.) plantations. Over the past 40 years 18 000 ha of pines and 19 000 ha of eucalypts have been planted. Besides being a pyrophitic species most of the pine plantations are situated on the steep slopes of the central highlands. This situation creates a very high fire hazard.

Fire risk

The number of fires reported annually ranges from 50 to 200 depending on the prevailing weather conditions. Almost all fires reported are in forest plantations.

The area burnt by a single fire varies from 0.2 to 150 ha with an average of 10 ha. Nearly 2 percent of newly planted areas are burnt annually. Most of the forest plantations are of small size and scattered over the country. Therefore, the risk is also scattered. However, the risk of a big fire is not very high due to the small size of the plantations. Almost all fires are surface fires and crown fires are very rare.

Nearly 55 percent of all fires reported are in pine plantations while 20 percent are in eucalyptus plantations. Young plantations are more vulnerable compared to old plantations. Nearly 60 percent of all fires reported are in plantations that are less than five years of age. Very few fires last longer than 24 hours and most are in the range of 3 to 10 hours.

Main causes of forest fires

The agents causing natural forest fires, such as dry thunderstorms or volcanic eruptions, are not present in Sri Lanka. Therefore, almost all forest fires in Sri Lanka are of human origin. Carelessness seems to be the main cause. The main causes reported are:

- Throwing cigarette butts when travelling by train or walking through forest
- Burning of debris by workers maintaining highways and railway tracks without taking proper precautionary measures
- Burning dead grass in order to obtain fresh grass for cattle. These fires often spread to nearby forests
- Burning of degraded forests for shifting cultivation
- Setting fire to the forest by hunters to drive animals out.

Major wildfire impact on people, property, and natural resources

Forest fires in Sri Lanka are of comparatively small size and occur mainly in forest plantations and grasslands. These fires rarely pose any threat to human life or property and no fatalities due to forest fires have been reported in the recent past. Most of these fires are surface fires; crown fires are very rare even in forest plantations. There is no significant health hazard associated with forest fires due to the small size and relatively short burning period. The direct economic losses are mainly due to damage to forest plantations. Environmental damage caused by forest fires is often much greater and takes many forms.

Forest fire database

The following tables show the number of fire occurrences in forest plantations and estimated damage during 1990-2000.

Table 3-11 Forest fires in Sri Lanka reported during 1990-1999.

Year	Total No. of Fires on Forest, Other Wooded Land, & Other Land No.	Total Area Burned on Forest, Other Wooded Land, & Other Land ha	Area of Forest Burned ha	Area of Other Wooded Land and Other Land Burned ha	Human Causes No.	Natural Causes No.	Unknown Causes No.
1990	114	549					
1991	100	186					
1992	234	259					
1993	58	174					
1994	60	191					
1995	126	372					
1996	136	271					
1997	205	610					
1998	114	204					
1999	47	417					
Average	119.4	323.3					

Table 3-12 Forest fires and economic damage in Sri Lanka, 1990-2000.

Year	Number of fires reported	Area burned (ha)	Estimated Damage ($US)
1990	114	549	9 788
1991	100	186	15 245
1992	234	259	6 861
1993	58	174	8 204
1994	60	191	18 588
1995	126	372	19 458
1996	136	271	21 465
1997	205	610	44 958
1998	114	204	7 480
1999	47	417	42 227
2000 (up to May)	8	36	3 645

The economic loss shown in Table 3-12 is an estimated figure based on the cost incurred in the establishment and management of plantations up to the time of the fire.

Organizational setup

All natural forests in the country are managed by the Forest and Wildlife Departments. These forests are not prone to big wildfires. Forest plantations and "sparsely used crop lands" are the most vulnerable areas. Forest plantations are managed by the Forest Department while other lands are under the purview of different state agencies. The Forest Department is the only agency at present engaged in systematic forest fire prevention and suppression activities. Most of the activities, except awareness programs, are mainly confined to areas under the purview of Forest Department.

Forest fire management activities are handled by the Silviculture Division of the Forest Department at the national level. At the provincial level the District Forest Officers are

responsible for fire control activities in their respective districts. They are assisted by Range Forest Officers and Beat Forest Officers at the village level. These officers work very closely with the village communities as well.

Fire prevention is the main strategy used in forest fire control in Sri Lanka, especially in regard to forest plantations. This is mainly done by creating firebreaks around the plantations. Interior fire breaks are also used if the fire risk is relatively high.

Village communities voluntarily involve themselves in fire suppression activities whenever the assistance is needed. However, few programmes have been developed to promote community involvement in specific areas. A new approach is being tested in pilot areas, especially in *Eucalyptus* and teak plantations. Each management plan contains a "participatory management working circle" under which forest user groups are formed. Following are the main features of this approach:

- Local communities involved in fire prevention are allowed to collect dead fire wood from the plantations free of charge.

- The Forest Department informs the community of future forestry activities in the area so that they are aware of future employment opportunities in their locality.

- Agricultural and forestry activities are coordinated. This includes:
  - Finding out from villagers when they intend to burn their gardens or shifting cultivation areas so that appropriate measures can be taken to protect the plantations from fire;
  - Permitting grazing and grass cutting without charge in plantations where there is a fire risk due to a build up of grassy vegetation.

In addition, regular fire control training is provided to these communities.

Once the trial period is over the most promising communities will be selected for formal participatory forest management programs. It is expected that the fire prevention program will be more efficient through a combination of direct involvement of the Forest Department and community participation in fire prevention activities.

Use of prescribed fire

Prescribed fire is used in forestry only in the site preparation stage. The ground vegetation is cut and burned to clear the site for planting. The area cleared this way is around 600 ha annually.

Use of fire is the standard practice in site preparation in shifting cultivation. The area under shifting cultivation is estimated to be around 1.2 million hectares. Fire is also used in other agricultural practices to a lesser extent.

Sustainable land-use practices to reduce wildfire risk

Fires escaping from agricultural lands to the forests, especially to forest plantations, has been a problem in Sri Lanka, particularly in the dry zone. Farmers are encouraged to keep the Forest Department informed when they are ready to set fire to their fields so that necessary precautions can be taken. Forest plantations, on the other hand, are somewhat protected from outside fires through the use of peripheral (and sometime internal) fire breaks.

Public policies concerning forest fires

The current forest policy clearly states that all forests must be brought under sustainable management. Management plans have been developed for both natural forests and forest plantations and forest fire prevention is one of the activities in these plans. Depending on the status of each forest, these plans contain different strategies to be used in forest fire management.

Source

Ariyadasa, K.P. 2001. The forest fire situation in Sri Lanka. *Int. Forest Fire News* 26.

3.4 Middle East, Central and East Asia Sub-Region

This section includes the countries that are located between the boreal and subtropical/tropical zones of Asia. The Middle East countries Cyprus, Israel, Lebanon and Turkey formally belonged to this region. However, since they are part of the Mediterranean entity of vegetation types and fire regimes, these countries are included in the Europe (Mediterranean) section of this report.

The remaining countries of interest are covered with forest and other vegetation types that are either temperate or include transition types (ecotones), e.g., between temperate and boreal forests, or forest and steppe ecosystems. Fire is often an essential factor determining the characteristic composition and dynamics of these ecosystems. For instance, fires in the southern boreal (hemi-boreal or sub-boreal) forest belt favour the dominance of fire-adapted coniferous trees (*Pinus* and *Larix* spp.) at the expense of broadleaved species. At the forest-steppe interface of Central Asia the steppe fires exert a high pressure on the adjoining forests. As a consequence, the steppe-forest belt is characterised by open, fire-adapted stands which are regularly affected by large-scale wildfires.

Most striking is the increase of human-caused wildfires in the steppe and forest ecosystems of Mongolia and China (Inner Mongolia). The political and socio-economic changes in Mongolia during the 1990's are the major reasons for a dramatic increase in wildfire occurrence in the country (Ing 1999). Urban people that look for alternative income sources after the collapse of industrial structures increasingly use forest and steppe resources. Campfires set by inexperienced cattle herders and collectors of non-wood forest products, as well as an increasing amount of road traffickers, are the main cause of escaping wildfires. In 1996-97 Mongolia faced the most serious fire seasons, affecting forested and steppe lands on 10.2 million ha in 1996 (comprised of 2.36 million ha forest) and 12.4 million ha in 1997 (comprised of 2.71 million ha forest). Satellite imagery revealed that in the spring of 1999 the area burned was 3.1 million ha, including 30 000 ha forest (Erdenesaikhan and Erdenetuya 1999).

In the People's Republic of China, the main fire regions are in Inner Mongolia (with fire features similar to Mongolia), the montane-boreal forest in the Northeast and the tropical South of the country. Advanced fire management systems, including the use of remote sensing for detecting and monitoring fire, are in place in China. Early 1999 was characterised by a severe spring drought that had affected the whole of central Asia and led to widespread forest and steppe fires. Forest fires in China can cause high losses of human lives. Statistics reveal that between 1950 and 1998 an average of 92 human lives were lost; and 551 people were injured each year in wildland fire accidents.

Several analyses of the fire situation are available for Kazakhstan (see country report with references). A burned area map of the fire season 2000 is provided in Figure 3-7. The area of more than one million ha forest and steppe burned suggests that the magnitude of area burned during the last years has been similar to the year 2000.

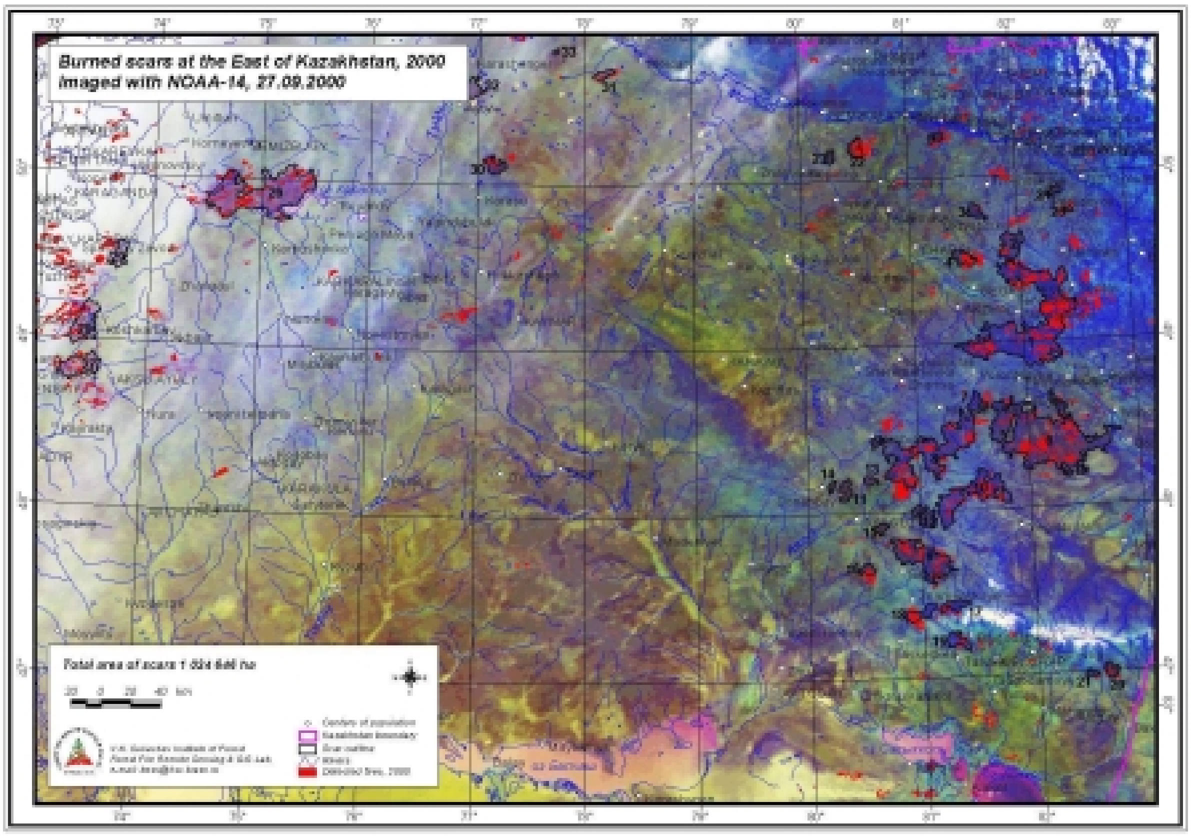

Figure 3-7 Forest and steppe area burned in Kazakhstan during the fire season 2000 (date of satellite image: 29 September 2000).

The total area burned was 1.024 million ha.

Source: A. Sukhinin, Sukachev Institute for Forest, Fire Laboratory, Krasnoyarsk, Russian Federation.

There are few to no forest fire situation reports available from other central Asian countries. An emergency situation was reported from Afghanistan in 1999. Under the headline “Wildfires burn ten villages - Fires not yet under control” the Global Fire Monitoring Center (GFMC) on 22 June 1999 provided information on a large fire in the country (GFMC 1999). According to a first report of the UN Office for the Coordination of Humanitarian Affairs (OCHA) on 16 June 1999 a forest fire broke out in the forest of the Sholake valley, Kunar province of Afghanistan, on 12 June 1999 (Ref. OCHA/GVA - 99/0072). In the following days the fire advanced rapidly through Dara Pech valley, some 30 km south of the provincial capital Asadabad. The forest fire destroyed probably more than 1 000 ha, destroyed ten villages and displaced 3 000 people. Four persons and some 300 livestock were killed.

A recent wildland fire analysis of Japan reveals that during the 1990s an annual average of 3 274 forest fires burned 2 311 ha of forest land. (Zorn et al. 2001).

The country reports of the Middle East, Central and East Asia Sub-Region include China, Iran, Japan, Kazakhstan, Korea and Mongolia.

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3.4.1 Fire Situation in China

By
Shu Lifu and Tian Xiaorui
Division of Forest Fire Research, Chinese Academy of Forestry, Beijing, China

Fire Environment and Fire Regimes

China is a country that is by no means rich in forest resources. Its total forest cover is 158.9 million ha which cover 16.55 percent of the total land area. The potential timber supply is 11 267 million steres (m^3) and the average forest area *per capita* is 0.128 ha.

The occurrence of forest fires varies from year to year depending on inter-annual climate variability. Furthermore, the variations of fire occurrence, fire size, and fire severity are closely related to the accumulation of combustible material in the forest. The major portion of forest fire occurrence is concentrated in a small number of regions (*"High Fire Occurrence Regions"*). Statistics reveal that the highest number and largest sizes of forest fires occur in the five provinces: Heilongjiang, Inner Mongolia, Yunnan, Guangxi and Guizhou. In these provinces, the numbers of forest fires accounted for 42.5 percent of the whole country, and the damaged area accounted for 75 percent of the area affected by fire in the whole country during the period 1950-1998. Within the above mentioned provinces and in other forest zones the forest fire distribution is not even. Highest concentration is in more than 100 key counties (cities) of 16 key regions. This phenomenon results from the fact that these regions have a higher share of forest cover, are exposed to more climatic extremes, including extreme wind events, and are remote with limited access and fire management (prevention and control) facilities. In combination with the complexity of fire origins, the high combustibility of forests, and the difficulty to control wildfires, the probability of large forest fire occurrence in these regions is very high.

The number of forest fires is large in forests of the South while the damaged forest area is largest in the Northeast and Inner Mongolia. Because of the gentle topography, the broad trench and embankment, the linking (ecotones) between grassland and forest, and the influence of the monsoon in spring and autumn, forest fires in the Northeast and Inner Mongolia spread quickly and over large areas. Just because of the different characteristics of various forest regions, fire prevention methods and control measures are also different in the South and in the North.

The seasonality of high forest fire danger phases among the various forest regions is different. China lies in the northern hemisphere. Influenced by atmospheric circulation, climate, and monsoons patterns, the occurrence of forest fires in the Northeast, Inner Mongolia, the South, the Southwest (mainly in Xinjiang Uigur Autonomous Region), and the North-East have different fire-danger phases. This is due to such natural phenomena as drought, windiness, precipitation patterns, low temperature, and accumulated snow, all of which attribute to different fire-danger phases. These periods are synonymous with *Fire Prevention Phases*.

Narrative summary of major wildfire impacts on people, property, and natural resources that occurred historically

Statistical evidence reveals that the number of forest fires and the area affected by fires is subject to high variability. During the second half of last century more than 15 000 forest fires occurred and affected more than 20 million ha of forest lands. The most prominent fire years were 1951, 1955, 1956, 1961, 1962, 1972, 1976, 1977, 1979 and 1987.

In 1987, a large fire situation occurred in the Greater Xingan Mountains, Heilongjiang province. During these fires, 213 persons were killed and the burned area reached l.33 million ha. Of this area, 890 000 ha were damaged, with a loss of 39.6 million cubic meters of wood volume. Thus, the forest cover rate of these regions has decreased by 14.5 percent from 76 percent to 61.5 percent. The fires caused high mortality to large areas of young, mature, and overmature forest stands. The extreme fire severity not only led to the destruction of forest and forest floor cover, but also affected forest structure, biodiversity, micro- and macroclimate, and water regimes. It resulted in the reduction of the protection function of the forests, e.g. the protection of watersheds, soil conservation, and climate. Research revealed that the denudation of land surface resulted in changes of micro-climatic patterns, destruction of organic layers, and loss of water retaining capability.

Narrative summary of major wildfire impacts on people, property, and natural resources during the 1990s

During the 1990s (1990-1999) an average annual number of 5 324 fires affected forests with an average annual area burned of 122 036 ha (non-forest lands are not included in this figure). Although the number of forest fires in the Northeast accounts for just five per cent of all forest fires in China, these fires involve as much as 60 percent of national fire losses. The South and Southwestern regions account for 95 percent of fires, but just 40 percent of total annual fire losses. Fire seasons peak in May and October in the Northeast, while in the Southwest the peak fire season is from January to April. Across China, humans cause more than 95 percent of forest fires. In the Northeastern forest regions, however, lightning accounts for up to 30 percent of fire occurrences in some years.

Fire management organization

As far as forest fires are concerned, the policy of "take prevention first and extinguish fire second" should be followed. A nation-wide system of forest fire prevention and suppression needs to be established. The work of the country's forest fire management program underwent a turn for the better after the very large forest fire in the Greater Xingan Mountains in 1987. In order to strengthen the leadership of forest fire management, Forest Fire Offices were set up successively in 30 provinces, autonomous regions, and municipalities. These offices are under the jurisdiction of the central government, and special working bodies were established accordingly.

Rules and regulations on forest fires

Clearly defined responsibilities of governments at different levels and of the different units in the forest regions are an important aspect of forest fire prevention. Through this system the

fundamental and crucial problems in forest fire prevention have been tackled in the recent years, resulting in strengthening of forest fire prevention and a visible reduction of forest fire occurrence and damages. In the period 1960-1987, 16 000 forest fires damaged an area of 950 000 ha in the whole country, representing a forest damage rate of 8.5 percent. Compared with these figures, the number of forest fires, the damaged forest area, and the forest damage rate from 1988 to 1998 was cut down by 49 percent, 98 percent, and 95.4 percent, respectively.

Important steps were taken to revise and improve regulations on the use of fire in the agricultural and forestry sectors. Several important laws, decrees, regulations, and stipulations became effective after being passed by the local people's congress, and promulgated by the governments. Many villages have developed community regulations and agreements and have strengthened forest fire management at the local level with successful achievements.

Special firefighting teams arranged

In the forest region of the Northeast and Inner Mongolia, permanent professional firefighting teams were established in every forest industrial enterprise and in large state forest complexes. In the collectively owned forest regions of the south, seasonal special firefighting teams, mainly consisting of military personnel, were set up. These special teams are guided and provided with equipment by the forest department, trained by people's armed forces, and commanded by Forest Fire Prevention Headquarters.

Aerial forest fire protection

Aerial forest protection is an important part of forest fire prevention, detection, and suppression. The 14 aviation stations are subordinate to the Northwest Aerial Forest Protection Centre and the Southwest Aerial Forest Protection Station, respectively. They are responsible for patrol, protection, and aerial fire suppression, including the application of chemical retardants, in the Northeast, Inner Mongolia, Southwest, and other remote forest regions.

The development of a fire management infrastructure

The development of infrastructure is the way to improve forest fire prevention and suppression efforts. The conflagration of the Greater Xingan Mountains in 1987 educated people that the investment must be made, and Organizational improvements should be made as quickly as possible. From 1988 on, the state has appropriated special fund every year, and provinces, prefectures, and counties take out their related necessary funds at a certain rate. These new developments since 1987 have played an important role in preventing and extinguishing forest fires.

Table 3-13 Wildland fire database in China: total number of fires and area burned in China between 1990 and 1999 on forest, other wooded land, and other land.

The management of the wildland fire database is computerized. There is no website to access the fire database.

Year	Total No. of Fires on Forest, Other Wooded Land, & Other Land No.	Total Area Burned on Forest, Other Wooded Land, & Other Land ha	Area of Forest Burned ha	Area of Other Wooded Land Burned ha	Human Causes No.	Natural Causes No.	Unknown Causes No.
1990	5 681	67 608	9 666	57 942			
1991	5 899	90 713	16 515	74 198			
1992	8 728	160 440	47 605	112 836			
1993	5 699	78 572	22 102	56 470			
1994	3 317	144 196	10 050	134 146			
1995	5 197	270 686	25 574	245 112			
1996	4 948	116 054	44 770	71 284			
1997	2 465	82 980	34 656	48 324			
1998	4 455	74 820	19 263	55 557			
1999	6 847	134 293	38 412	95 881			
Average	5 324	122 036	26 861	95 175			

Use of prescribed fire to achieve resource management objectives

Following the experiences in prescribed burning in other countries, a number of experiments were carried out in China. In the early 1980s it was concluded on the base of scientific research that prescribed burning not only prevents high-intensity forest fires, but also helps to improve the growing conditions of forest trees.

Prescribed burning is being used in the forest regions of the Northeast, Inner Mongolia, and Sichuan. The major goal of prescribed burning is to reduce the load of fuels (combustible materials) which, in conjunction with the meteorological factors, are determining the intensity and severity of a forest fire. Because of this, no large forest fires occurred in these regions recently.

In some provinces or regions, such as Jilin province, the reduction of large-scale burning of forests in the past ten years and more have led to an increasing accumulation of combustible materials inside the forest. This situation has led to a high hazard of very large and destructive forest fires. Thus, the use of prescribed fire to reduce forest fuels is of significant importance for preventing very large and destructive wildfires.

Prescribed burning operations observe meteorological factors (wind, temperature, humidity and relative humidity), moisture of fine fuels, and stability of the atmosphere. Downed woody materials and the litter layer are burned out under control. In the Northeast forest region, the most common method is to burn after frost, or immediately after snow melt. Forest sites with difficult topographical characteristics can be treated by prescribed fire efficiently.

There are also plans to use herbicides to clear the weeds in the young or mid-age forests in the southern broadleaf forests, or in the broadleaf/conifer forest ecotones. This method will reduce fire danger levels by accelerating the decomposition of flammable materials.

Besides the prescribed burning techniques, the establishment of green belts and firebreaks have proven to effectively prevent the spread of wildfires. Aerial patrols and increased use of watchtowers combined with satellite remote sensing monitoring and satellite communications have resulted in earlier fire detection and initiation of firefighting activities. In the Daxinganling forest region (Northeast China), a lightning detection and monitoring system has been established to identify and locate fires started by lightning.

Construction of greenbelts (fuelbreaks)

The construction of fuelbreaks is a long term effort that can reduce the impacts of future fires. Their benefits will accrue over a long period of time. Fuelbreaks on which fire-resistant trees, fruit trees, and other economic plants are grown are designed to slow down or halt the spread of a wildfire. These systems can produce economic benefits to the area, conserving the water and soil, and improving ecological conditions. The change of tree and other vegetation composition on fuelbreaks can prevent the spread of forest disease or insect pests. Economic, socio-economic, and ecological benefits all can be achieved through a network of fuelbreaks. The total length of greenbelt fuelbreaks in China at the end of the year 2000 is 172 100 km.

Public policies affecting wildfire impacts

A nation-wide publicity and education campaign helps in raising awareness of the importance of fire management. Activities include billboards and slogans, and the use of radio and television to reach all communities. These fire prevention awareness measures are implemented in accordance with fire weather predictions.

During the fire season, fire prevention efforts are intensified. Planning and financial departments at all levels increase funding to expand and strengthen fire management infrastructure.

Community involvement in fire management activities

Much progress has been made over the last forty years in forest fire prevention in China. However, problems and differences do exist in this field among the different provinces or districts, reflected mainly in the form of unbalanced development, poor fundamental facilities, inefficient bottom-level Organizational work, and incompleteness of networks. Compared with other countries, China has to catch up with prevention technologies. The current situation is characterized by insufficient capabilities to predict and control forest fires. As for administrative management, striking progress has been achieved. A framework of a forest fire prevention system has been established based on administrative leadership, regulations, information, firefighting units, socio-economic cooperation and fundamental firefighting facilities. Therefore, the frequency of destructive forest fires and area burned has dropped sharply.

Following increases in population, science and technology will be challenged in future years to improve capabilities in fire prevention, fire prediction, and fire control. Through sustained

efforts, higher levels of fire prevention work will be achieved and the annual burned area could be less than 0.1 percent of the total forest cover of China.

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3.4.2 Fire Situation in Islamic Republic of Iran

By
Gillian Allard
FAO Forestry Department, Rome

Introduction

The Islamic Republic of Iran is sparsely forested with around one percent forest cover and an additional six percent of other wooded land. The majority of Iran's forests are found in the north around the Caspian coastal plain and on the northern slopes of the Alborz mountain range. The Zagros range in the western part of the country also has significant areas of forest, though much of the Zagros has been converted to grazing land. The majority of forests are closed broad-leaved deciduous forest, with the dominant species including *Quercus castaneifolia* and *Carpinus* spp. At high elevations *Juniperus* spp. forest is common. Around 60 percent of Iran is arid desert or semi-desert, where vegetation is primarily sparse *Acacia* and *Prosopis* scrub. Iran has an extensive conservation network comprising seven national parks and around 60 other protected areas. These encompass approximately 12 percent of the country's forests.

Fire environment, fire regimes, and the ecological role of fire

Every year Iran experiences pasture fires that impinge upon the sparse forest resources. The losses caused by forest fires are estimated to be equal to the total area of reforestation. The fire season depends on location and associated climatic conditions. In the northern part of Iran most fires occur from August until the end of December when there is a decrease in humidity and increase in winds, while the eastern part of the country is more prone to fires in summer and winter. In central and southern Iran there is an increase in temperature and drought from March until September, so the worse fire season occurs then.

The recorded fires are mainly pasture fires and the land is able to recover, although grazing is obviously affected for some time and there is always the concern that fires will spread to forested areas. Fires that start in or around forests are mainly surface fires and seldom crown fires. Fires in coniferous forests are the most significant. Fire suppression is difficult due to high winds and temperatures and extremely dry conditions. Helicopters are used to move personnel over difficult terrain as it may take hours or days to reach the fires and terrain may be impassable for ground vehicles. The army, police and local communities are all mobilized during fire suppression activities but generally only hand tools are used.

Some fires are transboundary, i.e. along borders with Iraq, and are difficult to access and to control. In fact, the situation in Iran is unusual in that conflicts at border areas and unmapped landmine fields exacerbate the fire control situation.

Some of the most fire-prone areas are outlined as follows:

Kordestan (Western Iran)

Most forest fires occurred during the war, resulting from landmines triggered by cattle or by artillery fire. Mined areas are not cleared and no maps are available of their location, and mine detectors are not effective. Now most of the fires in this region are caused by arson.

There were 300 fires in 1997 during which 1 500 ha of forest and pasture were burnt and 400 hectares of forest. Most of these fires are in the mountains and with difficult access. It can take up to two days to reach them.

Golestan (North East Iran)

This is the most important forest area, next to the Caspian Sea area. There were 52 fires in 1998, seven in natural forests and the remainder in pastures. The fires in this region are mainly caused by arson. Records show an average of 20 to 70 fires in a 10-year inventory.

Khuzestan

There is a high occurrence of wildfires in this state where the climate is characterized by extremely high temperatures. In 1998, 5 000 ha of pasture was burnt in five fires and there were also 9 fires in natural forests, burning 300 ha. Most fires are caused by arson and are mostly pasture fires.

Narrative summary of wildfire effects on people, property, and natural resources

Fires are a very important problem and uncontrolled pasture fires are particularly devastating with associated losses of fodder. Fires destroy lots of investments and rehabilitation is very costly; most are caused by human activities.

Previously good forest is now degraded, due to both human activities and climatic conditions. Some areas are now deserts and the forest area is much reduced; thus, the impact of uncontrolled fires can be very serious. Land management issues include unlimited grazing by cattle causing damage both to pastures and natural regeneration in forests (the main source of reforestation), conversion of forested land to agriculture, cutting trees illegally, overlogging, wrong production systems and damage due to wood collection for fuel, fencing and cattle food. Pasture is an important natural resource for cattle food but the land is degraded and productivity is reduced; thus, there is a continuous need for more land and water resources to maintain the same level of production.

Between 1991-1997 there were 3 063 fires, during which 13 700 ha burned. In 1998 there were 998 fires and the burned area was estimated at 206 713 hectares, mostly shrubs. Losses were estimated at more than 5.6 million Rials, including 8 761 tons of cattle feed lost.

Few deaths are directly attributed to fires but injuries and deaths do occur because of landmines, which makes firefighters and foresters wary of fighting fires in the border regions.

Fire Management Agencies in Iran

Fire management responsibilities are under the jurisdiction of the Office of Protection and Conservation of the Ministry of Jihad-e-Sazandegi, Forest and Range Organization. The Office of Protection and Conservation has been in operation since 1993 and is in charge of managing forest protection, including fires and other natural phenomena including earthquakes, winds, extremes of temperature and droughts.

Wildfire Database

Data on fires are collected every year using standard forms filled in for each Province. Forms are revised every year. The number of fires and area burnt of both forest and range land is recorded every year but the collection system needs some improvement. All data are sent to the Office of Protection and Conservation in Tehran.

The causes of fires are different in the various states and provinces. They include land-use change (vegetation conversion), conflict and resulting arson, carelessness of hunters and picnickers, landmines, smuggling of opium and oil through Iran and refugee activity. No database is available on the causes of fire.

According to the ECE/FAO database on forest fires the average number of fires per year is 130 and the average area burnt per year is 5 400 ha (maximum 33 000 ha in 1993). The number of fires seems to be increasing (Alexandrian and Esnault 1998).

Table 3-14 Wildfire database for Iran for the period 1982-1995.

Year	Total number of fires on forest, other wooded land, and other land (rangeland) No.	Total area burned on forest, other wooded land, and other land (rangeland) ha	Area of forest burned ha	Area of Other wooded land burned ha	Human causes %	Natural causes %	Unknown causes %
1982	15	3 141					
1983	n.a.	7 431					
1984	30	1 508					
1985	75	2 233					
1986	79	8 426					
1987	10	5 407					
1988	73	611					
1989	116	407					
1990	16	1 133					
1991	146	288					
1992	100	3 923					
1993	192	33 379					
1994	143	6 119					
1995	722	1 977					

Source: Alexandrian and Esnault (1998).

Use of prescribed fire

During the last 25 years, forest plantations were established to meet local needs for timber and for environmental protection. By 1999 the total planted area reached 2.2 million ha (Mohammad, 1999). The species planted are generally limited to indigenous and exotic pine species such as *Pinus nigra, P. sylvestris, P. brutia, P. taeda, P. elliottii* and *P. pinea* (Jafari and Hossinzadeh, 1997). Despite high fuel accumulations in these plantations and prevailing drought conditions there are no prescribed burning programs underway.

The management plan recognizes the importance of fire and in Golestan 156 km of green strips have been planted in the forest and 936 ha of protection channels 1 m deep have been dug between the farms and forest, serving, as fire/fuel breaks.

Public policies affecting wildfire impacts

The Congress in Iran makes the law on important subjects. Protection and conservation are the most important topics under consideration. Support for fire protection is through the Congress but there is a movement for more direct involvement of the Islamic Council, which is responsible for the prevention of forest fires and conversion of agriculture lands. The Council is newly established and is responsible for helping the governors of the states with forest protection. There are also local councils for forest protection that work with local staff and the community and coordinate with the Islamic Council in helping fire suppression.

A law was passed in 1965 and approved by Congress that the penalty for arsonists is a prison sentence of 5-6 years. Also, if the police do not provide assistance in preventing or fighting fires then they can also be punished. There is a proposal to use police to patrol the forests. These laws have succeeded in decreasing the number of fires and area burnt.

Sustainable land use practices used in Iran to reduce wildfire hazards and wildfire risk

Forest protection is one of the most important objectives of the Forest and Range Organization and several improvements are being undertaken in this field. In the Hyracian (Caspian) Region animals are gradually being removed from the forests and being settled outside forested lands. Traditional husbandry is being converted into industrial husbandry through rehabilitation projects with emphasis on the prohibition of grazing. In other regions, grazing is being prohibited to enhance forest regeneration and to prevent accidental fires. In protected areas, fuelwood is replaced by petroleum.

In Shiraz a model programme has started to help reclaim semi-arid areas by planting walnut and peach trees, using drip irrigation. The land is then apportioned and given to government staff in return for management of the trees. To physically protect the forest in areas of urban/forest interface, individual households are being relocated outside the forests and recreational areas are being provided and designated as ecotourism zones.

Community involvement in fire management activities

Prevention is well recognised as being cost-effective and local communities are involved in prevention activities. Public awareness campaigns include brochures, TV, radio and prayers. Specific information is provided during the fire season through the use of fire risk signposts. The most senior member of the community is trained, as are voluntary students. In the provinces all members of the community, including nomads and hunters, are trained in fire prevention.

Police are responsible for helping people to fight fire and provide transport. Fire alerts are communicated through a dedicated telephone number.

There is a lack of personnel and facilities, including vehicles. Community involvement is therefore essential in fire suppression activities.

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3.4.3 Fire Situation in Japan

By
Tobias Zorn
Global Fire Monitoring Center (GFMC), Freiburg, Germany
&
Kouji Nakayama and Osamu Hashiramoto
Forestry Agency Japan, Tokyo

Introduction

Forests are deeply embedded in Japanese culture. This is not only represented by abundant traditional wooden buildings. Many tree reserves around temples and shrines indicate the high value of trees and forests. With 25 million ha of forests, corresponding to a forest cover rate of 67 percent, Japan is one of the most densely forested countries in the world (Japan FAO Association 1997).

The territory of Japan extends from 20° N to 46° N with climatic features ranging from subtropical to boreal conditions. The overall climatic conditions are characterized by high precipitation and a generally mild climate. During the winter, the continental high-pressure weather system is dominant, replaced in summer by the Pacific high-pressure system. The onset of monsoons in June-July and at the end of September coincide with this change of high-pressure areas. Annual rainfall is between 1 000 and 4 000 mm (Forestry Agency Japan 1990).

Stretching over 3 000 km, the archipelago of Japan consists of four major islands, Hokkaido, Honshu, Shikoku and Kyushu. Mountainous and hilly areas cover about 75 percent of the land area. Mountain slopes are generally very steep and dissected by short rivers of all sizes. Forestry is concentrated in mountainous regions with steep terrain, which makes forest firefighting countermeasures difficult and complex. Because of the scarcity of flat land, these areas are suitable for farming and settlement (Forestry Agency Japan, 1990; Japan FAO Association, 1997; Ota, 1993; The National Land Afforestation Promotion Organization 1991).

The climax vegetation is forest, reflecting the warm monsoon climate with high precipitation. However, the species composition and the distribution of forest types differ from region to region because of marked climatic differences in Japan's long, narrow land area and also because of complex differences in topography, geology and soil. These forests are classified into four types or zones: (1) sub-frigid (including sub-alpine), (2) cool temperate, (3) warm temperate, and (4) subtropical (Japan FAO Association 1997).

The sub-frigid forest zone (also called sub-alpine forest where its occurrence is governed by height above sea level) is located in the mountains of central Honshu and in central Hokkaido. In northeastern Hokkaido it occurs even close to sea level. The dominant tree species are white fir (*Abies mariana*), yezo spruce (*Picea jezoensis*), Glehn's spruce (*Picea*

glehnii) and, in Honshu, Veitch fir (*Abies veitchii*), northern Japanese hemlock (*Tsuga diversifolia),* and hondo spruce (*Picea jezoensis* var. *hondoensis).*

The cool temperate forest zone is characterized by the beech belt (*Fagus crenata*; in Japanese, *buna*). This type of forest occurs at elevations higher than 1 000 m above sea level in Kyushu, at 600 m around the Kanto district (greater Tokyo and Yokohama) and at sea level from the central part of Honshu north to western Hokkaido. Other tree species are Japanese lime tree (*Tilia japonica),* Japanese horse chestnut (*Aesculus turbinala),* katsura tree *(Cercidiphyllum japonicum),* and Japanese walnut (*Juglans ailanthifolia).*

The warm temperate forest zone itself is characterized by laurel *(Machilus thunbergii),* live oak (Quercus *phylliraeoides),* and camphor tree *(Cinnamomum camphora*).

In addition to these three main zones, a subtropical forest zone is found in Okinawa and in the southwestern part of Kyushu Island.

The forest fire situation in Japan

Influenced by its climatic and topographic conditions, it is a widely accepted perception that natural disasters such as floods and landslides are common in Japan (Forestry Agency Japan 1994). Despite the humid climate, the annual number of forest fires often exceeds 4 000, affecting an average area of more than 4 000 ha in the 1980s and 2 300 ha in the 1990s (Table 3-15 and Table 3-16).

Table 3-15 Number of fires and area burned in forests and other vegetation in Japan, 1980-1989.

Year	Total No. of Fires on Forest, Other Wooded Land & Other Land No.	Total Area Burned on Forest, Other Wooded Land, & Other Land ha	Area of Forest Burned ha	Area of Other Wooded Land and Other Land Burned ha	Human Causes* No.	Natural Causes No.	Unknown Causes No.
1980	4 120	5 307			2 850		
1981	3 709	1 969			2 471		
1982	4 579	3 136			3 198		
1983	3 918	7 666			2 624		
1984	4 786	3 727			3 261		
1985	4 155	4 924			2 743		
1986	4 838	4 893			3 137		
1987	4 120	4 890			2 702		
1988	3 589	3 176			2 388		
1989	2 894	2 117			2 894		
Average	4 071	4 181			2 827		

Source: Forestry Agency Japan (2000).

Table 3-16 Number of fires and area burned in forests and other vegetation in Japan, 1990-1999.

Year	Total No. of Fires on Forest, Other Wooded Land, & Other Land No.	Total Area Burned on Forest, Other Wooded Land, & Other Land ha	Area of Forest Burned ha	Area of Other Wooded Land and Other Land Burned ha	Human Causes* No.	Natural Causes No.	Unknown Causes No.
1990	2 858	1 333			1 990		
1991	2 535	2 739			1 853		
1992	2 262	2 323			1 652		
1993	3 191	3 260			2 313		
1994	4 534	2 776			3 150		
1995	4 072	2 016			2 914		
1996	4 339	2 420			3 038		
1997	3 766	3 124			2 606		
1998	1 913	808			1 346		
1999	-	-			-		
Average	3 274	2 311			2 318		

Source: Forestry Agency Japan (2000).

Figure 3-8 shows that 99 percent of the wildland fires are human-caused (Nakagoshi et al. 1987), such as from the misuse of fire during afforestation and cultivation, bonfires, campfires, playing with fire, burning of rubbish, cigarettes, matches and fire works.

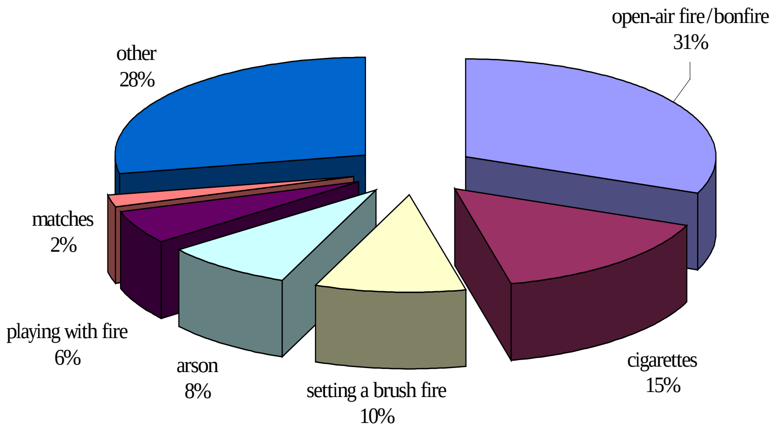

Figure 3-8 Causes of forest fires in Japan related to the number of fire incidents.

Explanation: "Setting a brush fire" (Japanese: *hiire*) may include setting a prescribed fire (NTT 1999). Open-air fires include fires set at the occasion of *Obon* (Festival of the Dead), a Buddhist ritual that is celebrated annually in July (Western Julian calendar) or August (Chinese lunar calendar), depending on the location. For several consecutive evenings, in the cemetery next to the temple, family members hang lit paper lanterns or deposit lighted candles. Wind and animals (often crows) are some of the reasons for the spread of fire into the open landscape.

In the early spring season (due to the longitudinal range of the chain of the islands the spring season stretches over two and a half to three months, from February in Kyushu to May in Hokkaido), a lot of dry litter is accumulated on the forest floor and the forest floor itself is also dry. Since rainfall or downpours usually accompany thunderstorms, lightning is rarely a fire cause in Japan. The occurrence of fires is highly correlated to human activities in this densely populated country. Propagation of forest fire is highly influenced by weather, human activity and forest conditions. As Figure 3-9 shows, the frequency, the distribution over the year and the number of forest fires are high during the season with the lowest precipitation and relative humidity and during the months when outdoor activities are high.

Most of the broadleaved forests do not burn easily. Because of the generally cool and wet weather conditions, only a few forest fires occur in the sub-alpine conifer forests. Forest fires are more common in western Japan, where secondary forests of *Pinus densiflora* are widely distributed. Pine forests *(P. densiflora, P. thunbergii* and *P. lutchuensis*) tend to burn easily.

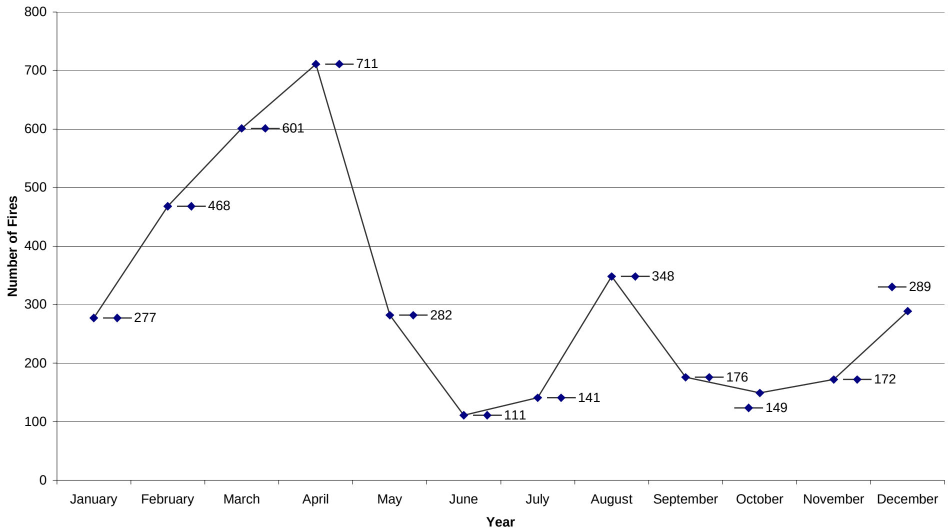

Figure 3-9 Distribution of the number of fire incidents over the year (5-year average between 1994-1998).

Source: NTT (1999).

Fire control organization

In Japan, the fire services of cities, towns and villages are responsible for wildland fire suppression. For large fire situations support systems are available (Table 3-17 and Table 3-18), such as dispatch of the fire services of neighbouring cities, towns and villages and the Japan Self-Defence Forces.

Table 3-17 Fire services of cities, towns and villages in 1998.

Municipal Agencies	Number
Fire prevention headquarters	920
Fire departments	1 662
Fire houses	3 232
Fire brigades	3 643
Fire squads	25 393

Source: White Book on Fire Service in Japan (1998).

Table 3-18 Forest fire protection facilities subsidized by the Government of Japan.

Classification		Quantity
Water tanks		3 694
Natural water supply facilities		21
Aerial fire–fighting supply bases		12
Forest fire-fighting equipment	Fire defence radios	1 743
	Receivers	1 340
	Chainsaws	290
	Portable sprayers	24 150
	Portable water dischargers	297
	Light portable pumps	96
Utility vehicles		118
Water trucks with small water pumps		23
Brush Cutters		1

To ensure that adequate fire-fighting capability can be deployed to forest fires, the Agency has developed fire defence support systems for large areas, is promoting the use of helicopters for information collection and aerial fire-fighting and provides guidance to prefectures and municipalities on timely requests for wide-area assistance. Helicopters are increasingly used for detection and communication in addition to being used in aerial fire suppression, including the use of fire retardants (White Book on Fire Service in Japan 1998).

Fire defence program for special forest fire regions

Since 1970 the Fire and Disaster Management Agency has been promoting a special forest fire defence programme in high risk areas in cooperation with the Forestry Agency. In municipalities bordering large areas of forest where there is a high risk of fire, the fire defence program includes the following measures:

- Forest fire prevention through public education, patrols and monitoring;
- Forest management with regard to fire prevention, such as the establishment and maintenance of firebreak belts;
- Establishment of communication systems;
- Development and improvement of fire fighting facilities;
- Restriction of fire use during the fire season; and
- Fire fighting training.

By 1997, this programme had been implemented successfully in 226 areas involving 940 municipalities in 38 prefectures (White Book on Fire Service in Japan 1998).

The early deployment of helicopters for reconnaissance and fire-fighting is an important concept in Japan. Further use of this strategy, in which helicopters work in close cooperation with ground firefighting operations, will require the development of additional bases for helicopter operations. In addition, water tanks and other water supplies are required for use during forest fires, especially in regions where residential areas are adjacent to forests and homes are at risk. There is a need to establish and continually update forest fire defence plans covering essential items about forest fire characteristics and firefighting operations. These plans allow firefighters to accurately grasp the state of a forest fire, determine firefighting tactics, deploy firefighting resources effectively and ensure reliable communications and a sufficient supply of water in the affected area. The effective use of simulation systems based on these forest fire defence plans has to be ensured.

Forest fire prevention campaign

A joint initiative by Fire and Disaster Management Agency and the Forest Agency, the national forest fire prevention campaign is held in conjunction with the spring national fire prevention campaign to raise public awareness and increase the effectiveness of fire prevention. This yearly educational campaign focuses on spreading the forest fire prevention message through educational activities aimed primarily at hikers, local residents and primary and junior high school students; banners and posters placed in stations, municipal offices and at the entrances to mountain routes; advertisements in the various media services, fire prevention training and study meetings.

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3.4.4 Fire Situation in Kazakhstan

By
Karim Khaidarov
Bourabai Research Institution, Borovoye, Kazakhstan
&
Vladimir Arkhipov
Shutschinsk, Kazakhstan

Introduction: Fire environment, fire regimes, ecological role of fire

Kazakhstan is a large country covering a total surface of 2.7 million km^2 The climate of Kazakhstan is extremely continental. The North of the country is characterized by cold and long winters and dry, short summers. Conversely, the South experiences short and low-snow winters and long, dry and hot summers. Summer droughts accompanied by dusty storms and dry winds are very common (Gvozdetski and Nikolaev 1971). During such drought periods, the fire danger increases sharply and the number of wildfires occurring on wooded land is extremely high. An overall trend of increasing aridity of the climate of Kazakhstan has been observed for about half a century. Consequently, a destabilisation of forests and woodlands and an increase of wildfire danger have been observed.

The large size of the territory of Kazakhstan has produced a great diversity in natural landscapes. Five major natural zones and wildland fire characteristics have been identified (Arkhipov et al. 2000):

- High-mountainous landscape zone consisting of three sub-zones: nival with eternal snow, alpine meadows, and high-mountainous coniferous forests. Fires occurring in the coniferous forests spread uphill and develop as crown fires.
- Forest steppe landscape zone consisting of two sub-zones: southern forest steppe and typical forest steppe. The forests in the typical forest steppe are frequently ignited by steppe fires.
- Temperate steppe landscape zone consisting of two sub-zones: northern grassland-cereal steppes and southern dry *tipchak-kovyl* steppes. The fire regimes of timber islands, embedded in the steppe, depend on the fire conditions in the steppe.
- Semi-desert landscape zone consisting of two sub-zones: lowhill-foothill semi-desert and flat semi-desert.
- Desert landscape zone consisting of two sub-zones: *wormwood-saltworty* (*Artemisia-Salsola rigida*) deserts and *ephemerial-wormwood* deserts.

Saksaoul (*Haloxylon* spp.) is the main element of woody vegetation in the two last zones. Saksaoul stands are usually not affected by wildfires if understorey vegetation and the herb-shrub layer are intensively grazed and browsed by livestock. If understorey fuels are present, these forests can be damaged severely by wildfires. Tougai, the flood-plains forest of Central Asia, represent a separate class of woodlands and a microclimatic zone with its own particular fire regimes.

The Forest Fund of Kazakhstan is divided into natural fire danger classes (Table 3-19). Figure 3-10 shows the types and pyrological classification of forests in Kazakhstan.

The forest-steppe zone is located at the limits of the West-Siberian Lowland and occupies the northern part of Kazakhstan (territory of North-Kazakhstan, Aqmola and Pavlodar administrative provinces) with a total share of more than ten percent of the territory of the country. This is occupied by intensive agriculture (grain, pastures and grasslands for hay production) and large areas of wooded lands. Fires occurring in these territories cause high losses in the agriculture and forest sectors. Systematic wildland fire protection is therefore required by state forest and agricultural enterprises. The fires usually occur in the early spring and in autumn, especially in dry years. The basic causes of wildfires are agricultural burning and violation of the requirements of fire safety.

The steppe landscape zone comprises up to 20 percent of the total territory of the republic. All steppe vegetation and the grain crops quite often suffer from human-caused fires, mainly from agricultural burning. The steppe phytomass after drying, becomes a dangerous fuel. The fires occurring in kovyl (*Stipa capillata* L. - “feather grass”) and tipchak (*Festuca sulcata* Hack) grassy steppe usually last for long time and spread over large areas. The fuel load of dry herb material on such sites ranges from 0.22 up to 0.38 t/ha. The fires start due to the negligence of shepherds, fishers and hunters, machines, members of expeditions, agricultural burnings and dry thunder-storms, and cause considerable damage to the national economy. The crops of agricultural cultures, pastures, hay production and groves are damaged and destroyed by fires. The rate of spread of a steppe fire is directly dependent on wind velocity. Flame heights usually reach 0.9-1.0 m in grass fuelbeds of 30 to 40 cm height. In the kovyl steppe, fire can spread against the wind with a rate of 5 to 10 times below the wind-driven spread rate. During such a wind-driven headfire, a convective movement is formed, and the fire quite often "runs" along the tops of grass stands. When it reaches either a natural barrier or a mineralised strip (firebreak) it stops, and the fuel on the whole area burned over by the headfire gradually burns out.

Table 3-19 Fire danger classes in Kazakhstan (after V. Arkhipov)

Danger Class	Groups of Forest Types, Planted and Deforested Territories	Characteristic Fire Types and phases of their origin
1 Very High	Coniferous saplings. Logged sites of dry and fresh pines, larch, fir and grassy cedar forests, bushy broad grassy silver fir forests. Dry and rocky pine forests. Damaged and dying tree stands (dead dry stands, sites of storm debris and wind falls, unfinished harvest sites, slash, insect-damaged stands).	Surface fires during the whole fire season. Crown fires occur on sites with high fuel loads.
2 High	Young pine forests, especially with pine undergrowth. Periodically dry larch forests. Cedar forests on country rocks of southern slopes. Dry growing conditions of flood-plain forests.	Surface fires are possible during the whole fire season. Crown fires occur during the phase of highest fire intensity.
3 Medium	Continuous harvest areas of coniferous forests in moist and wet sites. Dry fir forests, fresh larch and fir forests, wet pine forests. Mountainous-valley silver fir and fir forests. Cedar forests of remaining types of forest. Fresh growing conditions of flood-plain forests. Radical and derivative fresh birch and aspen groves and their cut sites.	Surface and crown fires are possible during the peak of the summer fire season. In mountains, forests fires occur during spring and autumn dry spells.
4 Low	Wet pine forests. Wet dark-coniferous taiga forests. Wet larch forests. Mossy-grassy silver fir forests, wet fir forests. Mossy fir forests. Bushy, dog-rose and aspen fir forests. Apple, birch and aspen groves. Wet growing parts of flood-plain forests. Black saksaoul.	The occurrence of fires is possible during dry spells in spring and autumn. During the summer, fire occurrence is possible in pine forests
5 Very Low	Sub-alpine coniferous forests. Cedar forests on bare rocks. Wet birch and aspen groves. Damp poplar groves. Willow groves of all types. All types of saksaoul (except black saksaoul).	The start of a fire is possible only under extraordinarily unfavourable conditions.

Figure 3-10 A forest fire map of Kazakhstan.

The legend at the left side of the map shows forest types and fire danger classes.

The Central Kazakhstan Low Hill Land is located in a woody zone of the northwest part of Sary-Arka (Aqmola province, Baian-Aoul of the Pavlodar province, Karkaraly of the Karagandy province). Wood and steppe vegetation, climate and relief of the region promote the origin, distribution and development of wildfires, especially in hot, dry and windy weather. The control of fires is hampered here due to inaccessibility of the woody sites. At the same time, rocky ledges and the stony material act as natural obstacle to further fire spread.

Fires in the pine forests of Sary-Arka represent a major factor influencing plantings and causing considerable damage to the forest economy. Afforested wood species here are pine (*Pinus sylvestris*) and birch (*Betula verrucosa* Ehrh.). Fire hazard and flammability are highest in the following forest types: very dry stony-rocky pine forests, dry stony lichen-pine forests and dry cereals-berry pine forest. The average annual number of fires here is about 100; and the average area of a fire is 5.4 ha during an average fire season. The basic cause of forest fires here is the violation of the fire prevention rules by many people in sanatoriums, boarding houses, camping sites, motels and tourist bases; and by the local population. Lightning represents only a minor fraction of all fire starts. Coniferous trees occur as undergrowth and plantations. Their flammability is determined by the high fire hazard of coniferous stands, dryness of the climate and availability of a large area of combustible materials, from 9 to 30 t/ha. Special attention in the forests of this region should be devoted to fire prevention and the regulation of recreational activities.

The Band (Strip) Pine Forests (Lentochnyie Groves) of Western Siberia and Kazakhstan are located in a steppe between the Irtysh and Ob Rivers. The forests are important for the protection of water resources, soils and the agricultural sector. They are also of high aesthetic importance and represent an important basic source of wood in the region. The main afforestation species is Scotch pine (*Pinus sylvestris*). Fire hazard and flammability are highest in the following pine forest types: dry forest of high dunes, dry forests of sloping hillocks, topographic depressions and lowlands. In the indicated forest types, fires are even common in wet years. In the very dry 1997 extremely large, catastrophic fires occurred in the timber enterprises of Semey (Semipalatinsk) Forest Management Department, totalling 511 fires affecting an area of 58 893 ha. In timber enterprises of Band Pine Forests of the Pavlodar province, 316 forest fires burned 17 672 ha in the same year. The basic reason for forest fires is violation of the fire prevention rules. In regard to the high fire danger and flammability of Band Pine Forests, the basic fire protection strategy should be one of prevention and development of a detection and suppression system for fire-prone areas.

The island pine forests of Kostanai province are located as green islands among extensive unforested areas on flat terrain. The climate is extremely arid with annual precipitation varying from 240 to 350 mm. The duration of an average fire season exceeds 180 days. These forests are exposed to frequent fires. For instance, the large fires in the territory of Naurzum Reserve have essentially reduced the total size of forests. There is no natural regeneration on burned sites. Regeneration is found only occasionally in “saucer”-shaped depressions where pine, aspen and birch are regenerating.

The remaining pine forests of the region also experience frequent fires. The fire history of these stands has been reconstructed by fire scars in tree rings. Despite the damages, pine forests represent favourite recreational places for people from the cities Kostanai, Rudnyj, Lissakovsk; and tourists from other regions also visit the area. During the summer season numerous youth camps, recreation houses and tourist bases are functioning here.

The semi-desert that covers the central part of the country (22 percent of the territory) represents the transitional zone between steppe and desert. Typical landscapes are hillock-sandy plains with wormwood-grassy and bushy vegetation. Under these conditions, wormwood-salsola (*Artemisia* / *Salsola regida*) vegetation is characteristic and does not form closed grass stands. In valleys of the drying rivers and in crevices of hills there are small meadows. The climate is rather droughty: cold and low-snow winters and dry and hot summers. Fires occur frequently. Steadfast attention is required to protect the area from fires, especially in pastures and haymaking grasslands. The zone of deserts reaches to the central and southwest parts of Kazakhstan, between 48°N and 41°N. The deserts of Kyzyl-Kum and Kara-Kum (drainage-basin of Syr-Darya river) and the southern Balqash region (drainage-basin of Ile river) are sand deserts (Aral sands) and cover about 47 percent of the territory of the country. The continental climate is characterised by high insolation and aridity. The large rivers (Ural, Syr-Darya, Ile, Lepsy) and other rivers originate outside the desert zone. Landscapes are characterised by black saksaoul (*Haloxylon aphyllum*), white saksaoul (*Haloxylon persicum*), zhuzgun (*Calligonum arborescens*), tamarisk (*Tamarix ramosissima* Ldb., *Tamarix gallica*), chingil (*Halimodendron halodendron* (L) Voss.), sandy acacia (*Ammodendron* Fish. ex. DC) and zhantaq (*Alhagi pseudalhagi*).

Narrative summary of major wildfire impacts on people, property, and natural resources during the 1990s

The largest number of wildfires of the 20th Century occurred in the 1990s. A recent analysis reveals that the number of wildfires and the area burned in Kazakhstan grew exponentially during the last 50 years (Arkhipov et al. 2000). Extreme fire years were 1963, 1974 and 1997. The most extreme fire season occurred in 1997 when a total of 2 257 wildfires affected 216 950 ha. Forests were affected in all landscape zones, e.g. in the Band Groves (Lentochnye Groves) along the Irtysh River, spruce groves on the slopes of the Ile Alatau mountains, the insular coniferous groves in Kostanai province and the forests of North of Kazakhstan and Altai. The large crown fire in Altai in 1997 (Markakol ranger station) generated a fire storm in which 17 firefighters were killed. The causes of the forest fires during the 1997 fire season are summarized in Table 3-20. The wood losses from wildfires in Kazakhstan for the period 1991 to 2000 were ca. 92 million $US in domestic wood prices (Table 3-21). The costs of these losses in world prices exceeded 400 million $US. Considering the need for increasing the import of wood, job losses in the wood industry, expenses for reforestation, rehabilitation of fire-affected land and other expenditures, the amount of damage caused by this fire episode is much higher.

Table 3-20 Number and causes of forest fires during the 1997 fire season.

Forest Management Associations and Reserves	Total Number of Fires	Violation of the Fire Prevention Rules (%)	Lightning (%)
Aqmola	204	99.5	0.5
Almaty	22	100.0	0.0
Aqtobe	0	0.0	0.0
Taldy-Qorgan	18	100.0	0.0
East Kazakhstan	141	65 *	35 **
Semey	511	67 *	33 **
Zhambyl	5	100.0	0.0
West-Kazakhstan	5	100.0	0.0
Karagandy	143	99.3	0.7
Kyzyl-Orda	3	100.0	0.0
Kokshetau	353	99.2	0.8
Kostanai	127	97.0	3.0
Pavlodar	316	64 *	36 **
North-Kazakhstan	152	?	?
South-Kazakhstan	4	?	?
Baian-Aoul GNPP	107	97.2	2.8
Ile-Alatau GNPP	19	100.0	0.0
Kokshetau GNPP	114	100.0	0.0
Almaty State Reserve	2	100.0	0.0
Naurzum Reserve	12	100.0	0.0
Total	2 258		

* data are probably underestimated ** data are probably overestimated

Fire database: Wildfire statistics of fire numbers, area burned and fire causes for the period of 1990-1999

In addition to the information on the fires in 1997, the statistical data for the period 1980-2000 are given in Table 3-21.

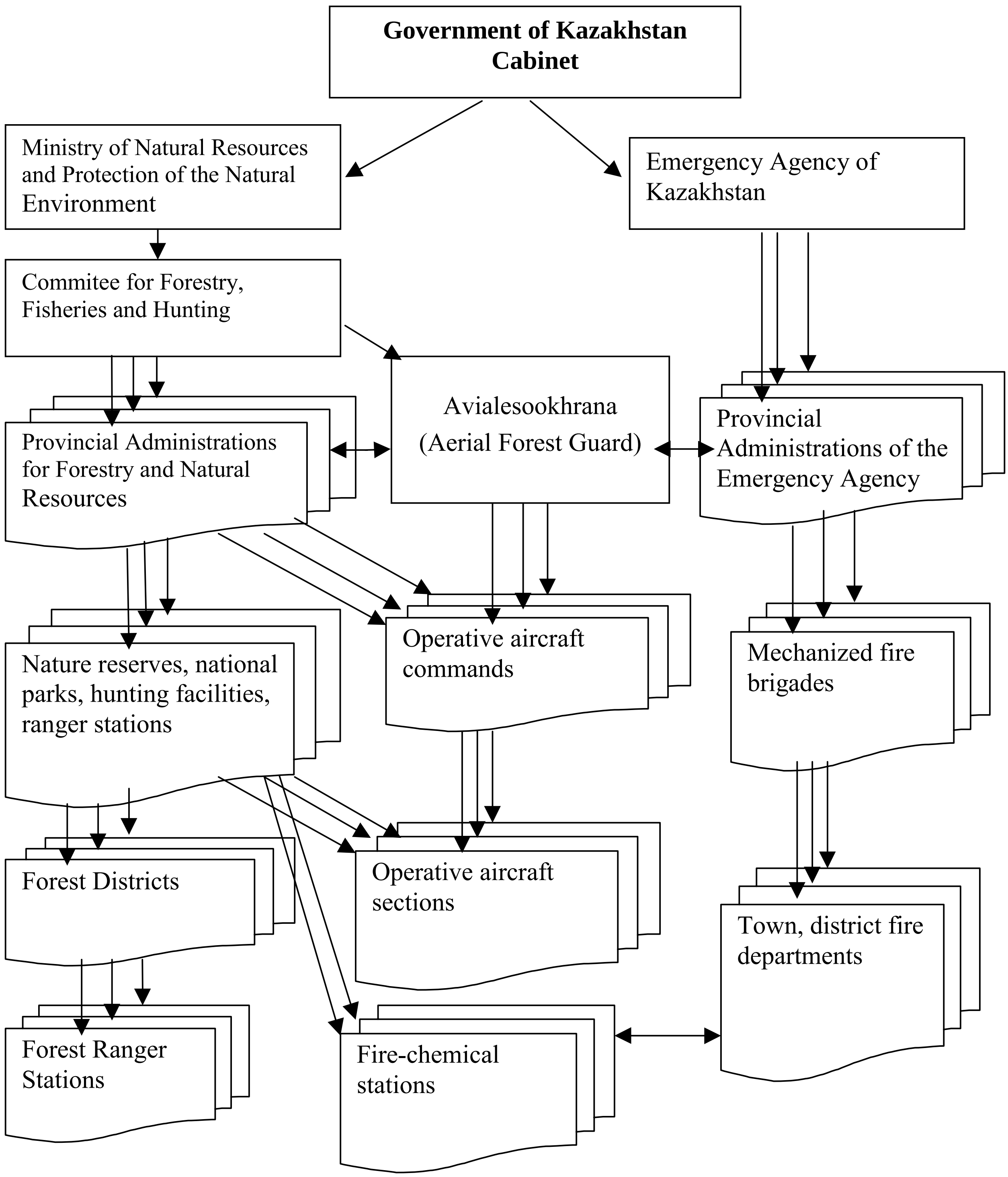
Table 3-21 Forest fire statistics of Kazakhstan for the period 1980-2000.

Year	Number of fires	Area burned (ha)	Damages from wood losses (x 1000 US$)
1981	892	5 853	1 697.4
1982	1 004	2 086	604.9
1983	722	992	287.7
1984	685	2 082	603.8
1985	421	692	200.7
1986	605	2 467	715.4
1987	601	652	189.1
1988	641	1 112	322.5
1989	917	4 891	1 418.4
1990	605	1 277	370.3
Total 1981-1990	**7 093**	**22 104**	**6 410**
1991	1 194	4 942	1 433.2
1992	518	1 175	340.8
1993	354	731	212.0
1994	881	5 046	1 463.3
1995	1 320	22 540	6 536.6
1996	1 002	10 305	2 988.5
1997	2 257	216 950	62 915.8
1998	1 053	16 322	4 733.4
1999	948	20 691	6 000.4
2000	943	12 930	5 559.5
Total 1991-2000	**10 470**	**311 632**	**92 183.5**

Operational fire management system and organizations present in Kazakhstan

All forest land in Kazakhstan is the property of the state. Thus, the task of forest protection, including fire protection, is exclusively the responsibility of government agencies. An organizational diagram is given in Figure 3-11.

Figure 3-11 Organization of forest fire protection responsibilities in Kazakhstan.



Fire management practices

The traditional system of wildfire protection used in Kazakhstan includes the establishment and maintenance of firebreaks around forest stands. There are also restrictions for agricultural and other activities in buffer zones (defence bands) around forests. Prescribed fires are not used in Kazakhstan, since they are officially forbidden.

Public policies concerning fire

Because humans are the main cause of forest fires, the public policy regarding wildfires comprises public awareness and educational campaigns. The government is gradually transforming hunting and forest facilities to nature reserves and national parks. In 1998, Karkaraly National Nature Park was established, and in 2000 Borovoye Timber Enterprise was transformed to National Park called "Bourabai". In the same year Markakol Ranger Station (in East Kazakhstan) was transformed to Markakol Nature Reserve.

In 2000, the government established a moratorium for the industrial harvest of wood in all forests and groves of Kazakhstan. Wood harvest is permitted only on damaged sites for sanitary reasons. This regulation has generated two problems: deficit of wood fuel in the rural regions of the country and, as a consequence, a sharp increase in illegal cutting. Significant funding was made available for 2001 to rehabilitate the Band Groves along Irtysh River and insular groves of Kostanai Province which had been extremely damaged by wildfires in recent last years.

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Gvozdetski N.A. & Nikolaev, V.A. 1971. *Kazakhstan*. 296 p. <in Russian>

Source

Khaidarov, K. & Arkhipov, V. 2000. The forest fire situation in Kazakhstan. *Int. Forest Fire News* 24: 60-67.

3.4.5 Fire Situation in Republic of Korea

By
Joo-Hoon Lim
Korea Forest Research Institute, Forest Fire Laboratory, Seoul, Republic of Korea

Introduction

This report covers forest fires in South Korea only, because limited information is available on North Korea.

Fire environment, fire regimes, ecological role of fire

Korea is located between 33°06' to 43°01'N and 124°11' to 131°53' E, a peninsular country in the eastern part of the Continent of Asia and in the western part of the Pacific Ocean. The peninsula has a continental climate, except for the month of August when its climate characteristics are oceanic. The summer is characterized by a wet monsoon climate and is hot and humid with frequent rain showers; and it is cold and dry in winter. Seasonal changes are gradual but distinctive, and spring and autumn are relatively shorter seasons than those of summer and winter. Forest fires in Korea occur frequently in spring and autumn because those seasons are drier than summer and winter; summer has considerable rainfall and winter has appreciable snow. Forest fire prevention periods of South Korea are from 15 February to 15 May in spring and 1 November to 15 December in late autumn to early winter.

Table 3-22 Forest fire occurrence by season during the period 1995-1999.

Season	Mean of 5-years period		Year				
	Number of fires	Portion (%)	1995	1996	1997	1998	1999
Total	452	100	630	527	524	265	315
Spring	284	63	414	326	310	171	197
Summer	4	1	2	3	7	1	5
Autumn	29	6	27	12	79	14	14
Winter	136	30	187	186	128	79	99

South Korea is classified into 16 eco-regions by cluster analysis of such variables as latitude, longitude, seasonal mean temperature, and seasonal precipitation measured at 28 Weather Forecast Offices and 40 Weather Observation Stations for 30 years from 1961 to 1990. Among the 16 eco-regions, the forests of three regions, Kangwon coastal, Woolyong coastal, and Hyung-Taewha coastal (eastern coastal region of Korea), are vulnerable to fire because they have very low rainfall in the spring; and foehn and quasi-foehn winds abruptly interchange many times in a day. Under these meteorological conditions, wildfires spread rapidly and over large areas. Moreover, vegetation is mainly composed of *Pinus densiflora*

that is inclined to ignite easily. In April 1996, a large forest fire burned 3 762 ha in Kosung, Kangwon coastal eco-region.

It must be noted that forest fires in Che-ju Province are the consequence of intentionally set fires in bushlands to control insects (ticks) that are harmful to humans.

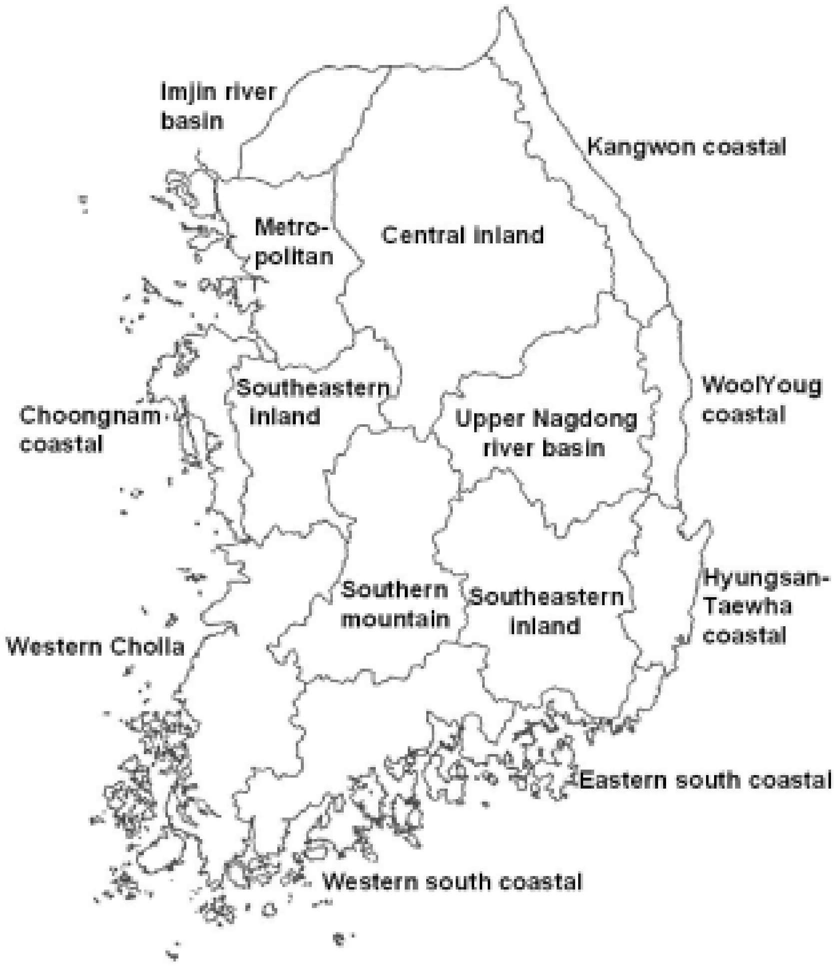

Figure 3-12 Eco-regions of South Korea.

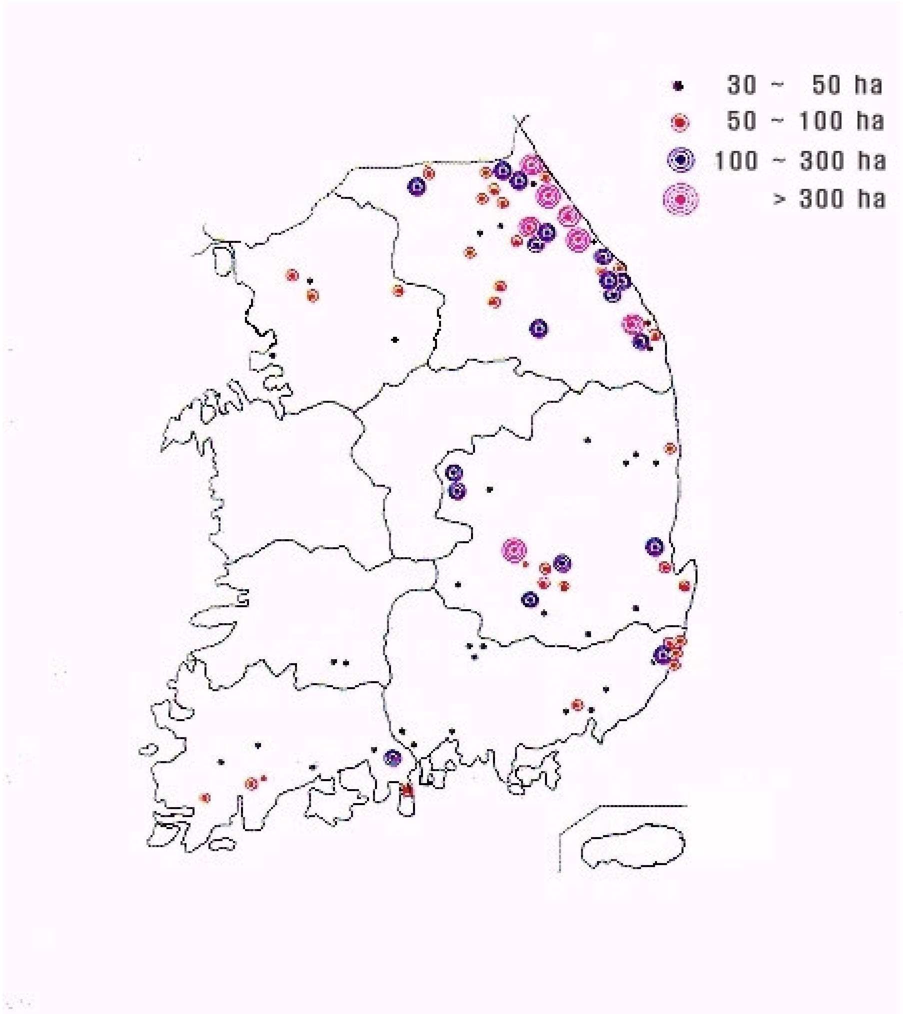

Figure 3-13 Large-scale forest fires during the period 1980-1999.

Major wildfire impacts on people, property, and natural resources during the 1990s

Forest fires are commonly ignited in the lower part of a mountainous area and spread to the top of the mountain. Thus, fires generally did not affect people or dwellings. However, the 1996 Kosung forest fire impacted natural resources and people. According to the investigation, it burned 3 762 ha of forest, 16 215 kg of pine-mushrooms (*Tricholoma matsutake*), and many tombs. Damage cases totalled 66; and the amount of damages awarded reached 15,268 million. In addition, it damaged many residences and structures.

Wildfire statistics

Statistical data on forest fires during the period 1990 to 1999 are given in Table 3-23. There is no typical tendency, but in the 1990s a few large forest fires occurred due to the failure of initial attack. For comparison with the 1980s, Table 3-24 shows the wildland fire database for the period 1980-1989.

Between 1990 and 1999 an average of 336 fires occurred annually and affected an average area of 1 399ha. Between 1980 and 1989 only 238 fires occurred, affecting 1 102ha. Table 3-25 shows the details of fire causes for the period 1995-1999. The category "other causes" of fires have been incorporated in Table 3-23 under the column "unknown causes".

Table 3-23 Wildfire database for the period 1990-1999.

Year	Total No. of Fires on Forest, Other Wooded Land, & Other Land No.	Total Area Burned on Forest, Other Wooded Land, & Other Land ha	Area of Forest Burned ha	Area of Other Wooded Land and Other Land Burned ha	Human Causes No.	Natural Causes No.	Unknown Causes No.
1990	71		175				
1991	139		429				
1992	180		640				
1993	278		1 752				
1994	433		781				
1995	630		1 031		502		128
1996	527		5 368		389		138
1997	524		2 330		393		131
1998	265		1 014		233		32
1999	315		473		318		38
Average	336.2		1 399.3		367		93

Table 3-24 Wildfire database for the period 1980-1989.

Year	Total No. of Fires on Forest, Other Wooded Land, & Other Land No.	Total Area Burned on Forest, Other Wooded Land, & Other Land ha	Area of Forest Burned ha	Area of Other Wooded Land and Other Land Burned ha	Human Causes No.	Natural Causes No.	Unknown Causes No.
1980	403		1 218				
1981	252		814				
1982	136		509				
1983	135		919				
1984	359		1 164				
1985	165		363				
1986	275		3 417				
1987	87		91				
1988	270		878				
1989	294		1 652				
Average	237.6		1 102.5				

Table 3-25 Details on wildfire causes during the period 1995-1999.

Causes	5-year mean		Year				
	Number of fires	Portion (%)	1995	1996	1997	1998	1999
Total	460	100	630	527	524	265	356
Mountain visitor's accidental fire	222	47	312	248	247	104	197
Levee fires	87	19	138	73	103	65	57
Cigarettes	14	3	-	-	-	37	34
Tomb visitor's accidental fires	28	6	34	38	33	16	20
Children's accidental fires	16	4	18	30	10	11	10
Others	93	21	128	138	131	32	38

Fire management organization

Forest fire management in Korea is under the responsibility of the Korea Forest Service, Department of Forest Fire Prevention, and the Aerial Forest Control Offices. Their tasks include:

- Wildfire prevention
- Establishment and operating the headquarters for wildfire prevention
- Supervision of wildfire prevention
- Administration of Forest Service personnel
- Operation and managing of forest protection equipment
- Education for wildfire prevention
- Improvement of wildfire management
- Forest preservation

Tasks in wildfire suppression include:

- Pre-suppression planning
- Coordination of wildfire suppression
- Supervision of the forest aerial control offices
- Planning and command of aerial operations
- Operation and management of the communication system
- Personnel management for air/ground wildfire suppression, including training
- Damage assessment and rehabilitation

These latter tasks are implemented by the autonomous forest departments at provincial and municipal/local levels.

Using data of the Meteorological Service and fuel moisture data, the Korea Forest Research Institute assesses forest fire danger (forest fire danger map) and reports it to the Korea Forest Service. The Korea Forest Service notifies provincial, municipal, and local autonomous entities on fire danger. The public is informed by mass media, if fire danger is extreme. When large-scale forest fires occur, the Forest Service establishes a Central Headquarters for fire emergency response coordinated by the director of the Forest Service. The directors of

provincial, municipal, and local autonomous entities establish and coordinate local headquarters for comprehensive countermeasures. The heads of all headquarters have authority to mobilize civil defense forces for fighting forest fires.

Forest fire research

Forest fire research in South Korea currently is focusing on:

- Development of forest fire danger rating models
- GIS-based forest fire danger index forecasting
- Ecology and fuels research
- Fire effects and rehabilitation

Use of prescribed fire

Before the 1950s, prescribed fire was used in Korea for site preparation. However, this method is not used for planting today. In Che-ju Island (Province), prescribed fire is often used in bushlands to control insects and ticks. At Mt. Whawang in Kyungsangnam-Do province fire is prescribed to maintain mountain grasslands composed of *Miscanthus* spp. In early spring prescribed fire is also used for preparing the farming of paddy fields. Generally speaking, the forest fire policy of Korea is hardly interested in "let burn" or prescribed burning, but concentrates on fire suppression.

Sustainable land-use practices employed to reduce wildfire hazards and wildfire risks

Several decades ago, firebreaks were constructed on the ridges of mountains. These are still visible in some areas, but this practice has been abandoned today.

However, planning to set up a systematic firebreak system is under consideration in the east side of the Tae-back Mountains, Kangwon coastal eco-region and Woolyong coastal eco-region, where forest fires occur frequently.

Public policies concerning fire

The public perception of forest fire is rather negative in Korea. Therefore, the forest fire policy of Korea is focussing on reduction of fire incidents, area burned, and other damages. For example, the statute provides that any use of fire must be practiced under the direct supervision of county officials.

Recently, Korea experienced several large fires that burned more than 100 ha and involved major losses. It is now planning to create laws and regulations on forest fires that would provide compensation to those who have suffered losses from forest fires.

Source

Lim, J.-H. 2001. The forest fire situation in Korea. *Int. Forest Fire News* 26.

3.4.6 Fire Situation in Mongolia

By
J.G. Goldammer
Global Fire Monitoring Center (GFMC), Freiburg, Germany

Introduction

Mongolia is located in Central Asia with an area of 1 565 000 km^2 and a population of 2.3 million, which makes Mongolia one of the least populated countries in the world. The country borders Russia in the North and China in the South. Mongolia is a highland country located deep within the interior of Eurasia and has a marked continental climate with poor soil fertility, scanty surface water resources and harsh natural conditions.

Forests and grasslands play an important role in the economic development of the country. Forest cover is 12.5 million ha or 8.1 percent of the Mongolian territory. Forests consist mostly of larch (*Larix sibirica*), pine (*Pinus sylvestris*), birch (*Betula platyphylla)*, cedar (*Pinus sibirica*), spruce (*Picea* spp.) and saxaul (*Haloxylon ammodendron*). Grassland covers 70 percent of all territory. It is assumed that most of today's steppe vegetation is on former forest sites that have been degraded by fire. The Mongolian climate and geography, coupled with its economic and social structure, account for its considerable vulnerability to natural disasters. Winters are often very cold and springs are difficult with blizzards, tornadoes and regular wildfires. Heavy rains and floods occur in summer and heavy snowfalls occur in autumn; frosts and blizzards are common. Thus, throughout the year the country is under pressure from these natural disasters.

Wildfires constitute a major factor that determine spatial and temporal dynamics of forest ecosystems. Out of the total of ca. 17 million ha of forest land, 4 million ha are disturbed to varying degrees, either by fire (95 percent) or by logging (5 percent). Logged areas have increased drastically over the past 25 years. More than 600 000 ha of timber harvest have not recovered.

Fire environment, fire regimes and the ecological role of fire

The highest fire hazard is found in the submontane larch (*Larix sibirica*) and pine (*Pinus sylvestris*) stands growing on seasonally freezing soils. These stands are distributed on Khentey, East Khentey and Khubsugul foothills that are characterised by an extremely continental climate. During the year, air temperature fluctuations can amount to 90°C, with the summer maximum being +40°C. Annual precipitation ranges from 250 to 350 mm. In exceptionally dry years, precipitation is less than 200 mm.

Forest fire statistics for the period 1963 to 1997 (see also Figure 3-14) reveal that the majority of fires burned within the central and eastern parts of the forested area. This can be attributed to the predominance of highly fire susceptible (highly flammable) pine and larch stands. Moreover, economic activity is much higher here as compared to other parts of the region. Extreme fire seasons are caused by long droughts. Fires burn from April to July under such conditions. The average fire season usually has two peaks. One peak is during spring (from

March to mid June) and accounts for 80 per cent of all fires. The other fire peak falls within a short period in autumn (September to October) and accounts for 5 to 8 percent of all fires. In summer, fires occur very rarely (only 2 to 5 percent of the total) because of heavy rains.

The intra-annual distribution of fires has been documented by seven forest protection air bases for the Khanngai and Trans-Baikal forest zones for the period 1985 to 1994 (Table 3-26). In these zones, fire activity is the highest in April and May with 33.3 percent and 48.1 percent of their total number in a fire season, respectively. Fires start in late March and early April, immediately after snow melt when forest fuels are drying rapidly on southern- and western-facing slopes.

Table 3-26 Intra-annual distribution of forest fire distribution in Mongolia, 1985-1992.

Local Airbase	**Month**									
	March	**April**	**May**	**June**	**July**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Total**
Ar. khalgai	2	18	8				2	4		**34**
Khovsgol		19	23	11			2	2		**57**
Bulgan	11	58	117	5			3	3		**197**
Selenge		27	52	8			3	9	1	**100**
Khentij	10	19	23	3						**55**
Dornod	1	9	6					1		**17**
Ulan-Baatar		25	24	7		2		7		**65**
Total	**24**	**175**	**253**	**34**		**2**	**10**	**26**	**1**	**525**
Percentage	**4.6**	**33.3**	**48.1**	**6.5**		**0.4**	**1.9**	**5.0**	**0.2**	**100**

Steppe fires under certain weather conditions often invade the adjacent forest-steppe and sub-taiga zones. In the mountain forest belt, especially in the high elevations, lightning fires are most common. Lightning storm activity increases considerably at the end of May and in early June. High fire danger is largely due to the prevalence of light-needled conifers in stands adjacent to steppe areas. These are mainly pine stands with mixed herbaceous ground cover, which are characterised by high fire danger in spring and autumn. Steppe vegetation and surrounding pine stands attain high flammability practically simultaneously. Fire occurrence depends on forest type, precipitation distribution and availability of ignition sources. Fires are frequent in pine and larch stands of the forest-steppe and sub-taiga zones, while they are more rare in larch and Siberian pine stands of the mountain taiga.

In one of the most sparsely populated countries in the world, it is difficult to get accurate information on fire causes. It is known, however, that during the main fire seasons (spring and late fall), no natural fire causes exist. The recent increase in the number of fires is related to the opening of markets once highly controlled or restricted. The vast majority of fires are not deliberately set to clear land. Rather, it is a function of carelessness. One example is the collection of elk antlers for sale to European and Chinese markets. During the previous regime, a single, state run enterprise managed this market under strict controls and guidelines. Today, it is open to virtually anyone.

Fires start for three reasons:

1. Antler collection starts in the bitter cold of February when fire is simply a survival tool.

2. Sparks from vehicle exhaust pipes in remote forests.
3. Tracer bullets left by the Russian military have entered the game hunting market and are used to hunt elk for the blood antlers which have a higher value in the market place.

The most obvious consequence of frequent and intense fires is the loss of forested land. The current fire pattern is affecting 14 percent of this resource annually. The brief growing season and low growth capacity of the trees means that these forests may take 200 years or more to regenerate. In addition to their commercial value, these forests are a precious ecological resource. They contain the sources of virtually all rivers in the country including the inflow to Lake Baikal (Russia), the largest fresh water lake in the world. They protect soil, rangelands, provide habitat for wildlife and serve as windbreaks.

Narrative summary of major wildfire impacts on people, property, and natural resources during the 1990s

In an average year, 50-60 forest fires and 80-100 steppe fires occur annually. About 95 percent of steppe and forest fires in Mongolia are caused by human activities. Winters and springs from 1996 to 1998 were extremely dry and were lacking snow in most areas. From late February to early June of these years, Mongolia suffered from large-scale forest and steppe fires that devastated large parts of the country. During these fire episodes 29 people died, 82 people were injured and 11 700 livestock were killed. Also, 218 family houses, 1 066 communication facilities, 750 fences and 26.3 million ha of pasture and forest burned. The total costs of property losses amounted to 820.2 million MN¥ (Mongolian Tughrik). Ecological and economical damage were estimated as 1 850.5 million MN¥ (December 1999 value: ca. $US 1.8 million).

Fire management organization

Until recently, a branch of the military known as the Civil Defence centrally managed fire events in Mongolia. The military maintained all training regimes, equipment and personnel with virtually no support to local communities. With the transition and associated economic difficulties, this centrally managed firefighting system has collapsed. Perhaps the single most important contributor to the *increase in fire spread* is the grounding of the Aerial Patrol Service. In 1969 the Mongolian Fire Protection and Aerial Patrol Service was established to provide early detection and rapid initial attack on fires. This Service was a Soviet-style aerial detection and airborne firefighting programme. The Service was staffed by 200 to 300 smokejumpers and helicopter rappellers; including a fleet of helicopters for helitack and tactical aerial support. The aerial forces operated out of seven bases distributed throughout the fire-prone regions of northern Mongolia. Smokejumpers on routine aerial patrols detected a high percentage of the fires and handled approximately 90 percent of the suppression workload. In the early 1990s, when the communist government and Soviet financial support abruptly disappeared, the Mongolian aerial programme sharply declined. At present, Mongolians cannot afford to maintain and fly their aerial patrol aircraft. Instead, they must rely on NOAA satellite imagery as their primary early warning system with a spatial resolution of 1.1 km^2. The decline of the aerial program through the mid-1990s resulted in the creation of a “fire suppression void” and no doubt greatly contributed to the horrendous fire losses experienced in the 1996 and 1997 fire season

Immediately following the 1996 fires, Mongolia received assistance from international organizations to help local people recover from the losses. The German government contributed to these efforts in the form of an Emergency Fire Aid project carried out in the northern and eastern parts of the country (October-December 1996). Since then, the government has been working to find long-term solutions to improve fire management. In a first step, the parliament passed a law designed to organize and improve firefighting efforts at all levels.

In February of 1998, the German and Mongolian governments signed an agreement to start an Integrated Fire Management Project to be implemented over the next three years (1997-2000). The GTZ, responsible for the German contribution, provided long and short-term experts, support staff, training and equipment.

The project region selected by the Integrated Fire Management Project is the Khan Khentii Strictly Protected Area and its buffer zones – one of the harder hit areas during the 1996 fires. A primary task was the establishment of a fire management plan compatible with the protected area goals and the responsibilities of the local communities. Fire Management Units in the local communities received professional training and basic hand tools suitable for the regional conditions. Information and Training Centres provided the necessary infrastructure for fire prevention activities, management information, training exercises, dispatch and field organization.

Community involvement in fire management activities

The IFM project supported Mongolia by strengthening local capacities to effectively address the issues of fire prevention, pre-suppression and suppression. This is accomplished by helping to organize cooperative efforts between protected area staff and local and national administrations responsible for fire management. Additional goals include establishing the necessary infrastructure, providing training in-country and abroad and by including all stakeholders in the planning and implementation of fire management activities.

Integrated Fire Management, like other community-based programs, focuses on flexible, pragmatic approaches designed to support local people's role in resource management. Specifically it entails the application of the art and science of modern wildland fire technologies and practices to the local fire problem – i.e. the community level.

In the development of the program, the IFM Project started with the philosophy that an ounce of prevention is worth a pound of cure. Hence, the most effective fire suppression strategy is an effective fire prevention program. In the summer of 1998, the IFM project began pilot activities in the buffer zone communities surrounding the Khan Khentii Special Protected Area. Specifically targeted were the potential multipliers including Information Training Centre (ITC) "extension" officers, educators, protected area rangers and key community persons. This cooperative effort led to a number of educational materials that were developed and introduced:

- A fire prevention curriculum for school children.
- A fire prevention video.
- A ranger's handbook to be used as an outreach tool in remote areas.
- A colouring book for small children.
- A fire mascot to carry the prevention message.

The central focus of pre-suppression work has been the drafting of a fire management plan for the protected area administration and local communities.

Suppression goals include (1) the establishment of fire management crews, (2) provision of equipment and (3) the development of a locally run "Fire Training Programme" adapted to Mongolian conditions of fuels, fire behaviour and available suppression resources and logistics. In the spring of 1998, six *Soum* (district) governors in the protected area buffer zone formed fifteen-person (15) fire management units (FMU's – or suppression crews) for their respective *Soums*. Each crew consists of a crew boss, assistant crew boss and thirteen unemployed volunteers. The crew is jointly managed through a Memorandum of Understanding between the local community and the protected area administration. After establishment of the crews, the project identified equipment to match the fuel conditions. Fuel conditions throughout northeastern Mongolia closely resemble the fuel types of the western United States, British Columbia and interior Alaska: tough steppe grass with deep dense roots, brush, larch, pine, spruce, birch, moss and muskeg like valley bottoms. GTZ equipped the crews with fire swatters, fire shovels, pulaskis, adze hoes, Council-type fire rakes , backpack pumps, crosscut saws, chainsaw and hardhats. Each crew has been equipped with personal portable radios, a vehicle mobile radio and mobile repeaters for communications with the dispatch centre. Stationary repeaters are being installed to link the *Soum* dispatch centers with the national coordination centre in Ulaan Baatar.

Starting in March 1999, the project assisted Mongolian fire specialists in developing a series of training materials, including a 32-hour Basic Firefighter Course with accompanying Instructor's Manual, Student Workbook, training videos and Crewboss Manual. The training programs were adapted from existing Mongolian training and the basic courses used to train American wildland firefighters: Introduction to Wildland Fire Behavior (S-190), Firefighter Training (S-130) and basic Incident Command System concepts. Approximately one half of the course was conducted in the field, including "practice fires" for mop-up and a live fire exercise on the final day. Crews were instructed in the bump-up progressive crew method of fireline construction. A fire instructor's training course for Mongolian instructors was established. In a subsequent phase, we observed and coached Mongolian instructors as they trained "rookie FMU crew members" and community (*Soum*) fire support crews. Due to unusually high precipitation during the winter, however, the project has been unable to evaluate crew performance on fires.

Wildfire database

Since the establishment of a NOAA satellite receiving station at the National Remote Sensing Centre of Mongolia in 1987, the staff of the Centre has developed and tested technologies for natural disaster monitoring, such as forest and steppe fire, drought, floods, meteorological phenomena etc.

The recent fire danger situation in forest and steppe zones challenged staff of the National Remote Sensing Centre to test and improve their operational technology to quickly process and transfer fire locations and other data to disaster related and administrative organizations. In the last three years, 788 fires were detected primarily by satellite data and thus millions of money was saved. The accuracy of detected hot spots as a fire is estimated to be 76.9 percent of the total number of cases between 1995 and 1999.

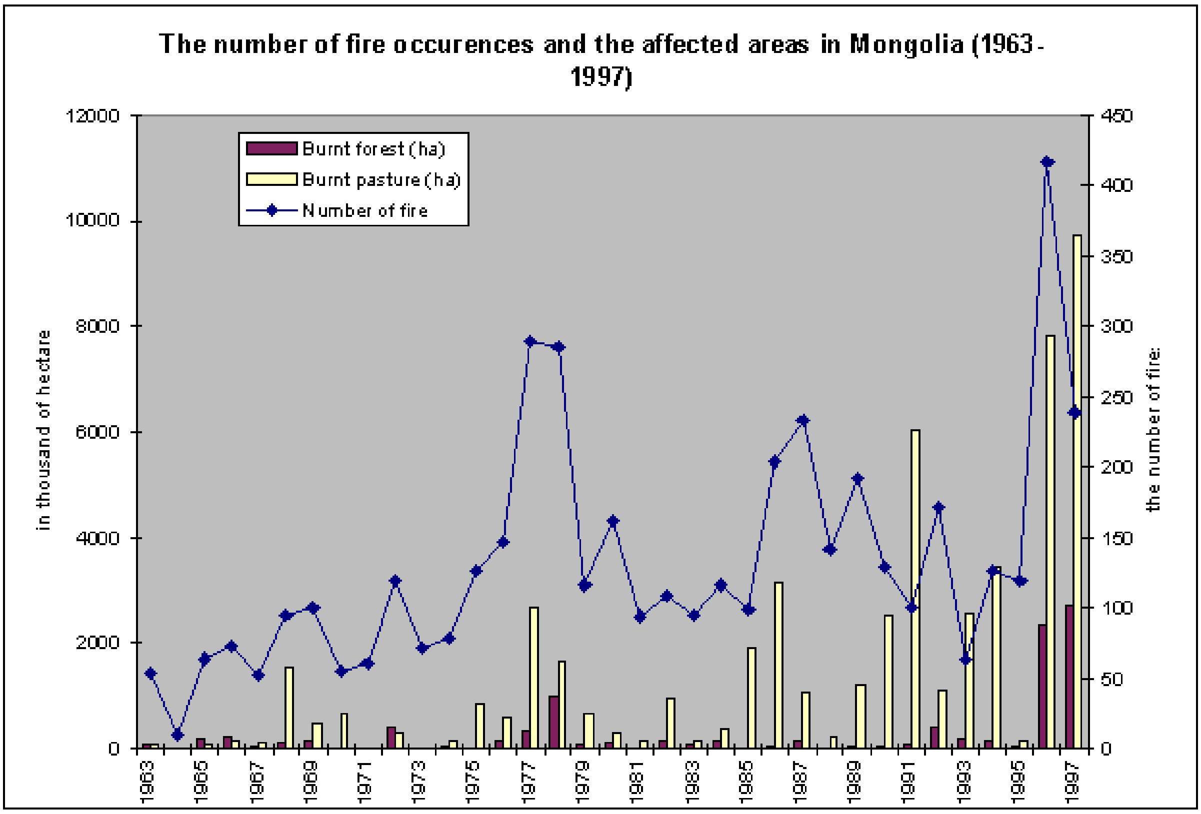

Figure 3-14 Number of fires and area burned in Mongolia 1963-1997.

It is clear that Mongolia is experiencing a dangerous increase in wildfires. From 1981 to 1995, forest and steppe fires burned an average of 1.74 million ha annually. In 1996 and 1997, the area affected by fire was 10.7 and 12.4 million ha respectively – an increase of more than six-fold. The areas hardest hit by these increases have been the forested regions. The typical forest fire season (1981-95) swept through some 140 000 ha (on average 8 percent of the total area burned), already a large area. However in 1996 and 1997, this figure radically increased to nearly 18 times the previous average - some 2.5 million ha annually, corresponding to ca. 22 percent of the total land area affected by fire. In these two years alone more forested areas burned than were harvested over the last 65 years. Figure 3-15 and Figure 3-16 provide maps showing the forest and steppe areas burned in 1996 and 1997. Figure 3-17 shows the area burned in Mongolia during spring 2000. The fire statistical data for the 1980s and 1990s are given in Table 3-27 and in

Table 3-28.

Table 3-27 Wildfire statistics of Mongolia, 1981-1989.

Year	Total No. of Fires on Forest Other Wooded Land & Other Land No.	Total Area Burned on Forest, Other Wooded Land, & Other Land ha	Area of Forest Burned ha	Area of Other Wooded Land & Other Land Burned ha	Human Causes No.	Natural Causes No.	Unknown Causes No.
1981	94	169 200	4 600	164 600			
1982	109	1 100 000	156 300	943 700			
1983	95	245 400	87 400	158 000			
1984	116	513 900	156 200	357 700			
1985	99	1 896 700	3 400	1 893 300			
1986	204	3 187 000	30 600	3 156 400			
1987	233	1 228 000	143 300	1 084 700			
1988	142	243 000	2 300	240 700			
1989	192	1 281 000	51 000	1 230 000			
Average	**160**	**1 096 022**	**82 400**	**1 060 000**			

Table 3-28 Wildfire statistics of Mongolia, 1990-1999.

Year	Total No. of Fires on Forest, Other Wooded Land, & Other Land No.	Total Area Burned on Forest, Other Wooded Land, & Other Land ha	Area of Forest Burned ha	Area of Other Wooded Land and Other Land Burned ha	Human Causes No.	Natural Causes No.	Unknown Causes No.
1990	129	2 577 000	55 000	2 522 000			
1991	101	6 099 000	639 000	6 035 100			
1992	171	1 541 000	390 700	1 123 300			
1993	63	2 763 000	202 000	2 561 000			
1994	126	3 600 000	165 000	3 435 000			
1995	120	168 570	34 200	134 370			
1996	417	10 194 400	2 363 600	7 830 800			
1997	239	12 440 000	2 710 000	9 730 000			
1998	132	5 200 000	700 000	4 500 000			
1999	76	3 130 000	30 000	3 100 000			
Average	**157**	**4 771 297**	**731 950**	**4 0971 570**			

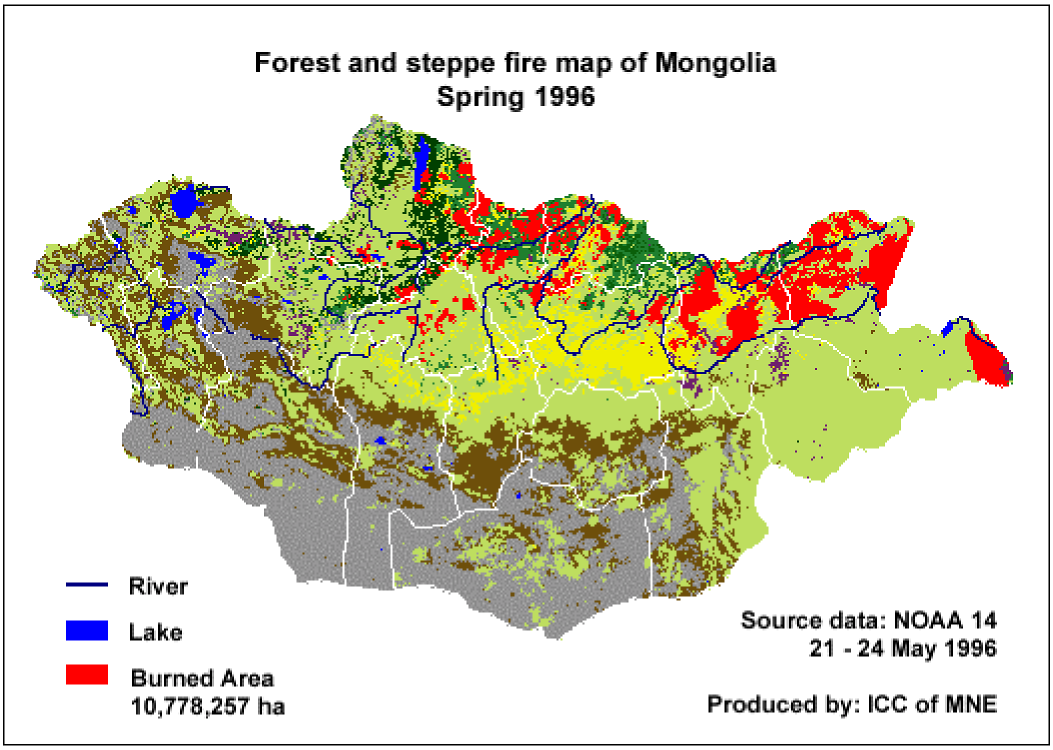

Figure 3-15 Forest and steppe fire map of Mongolia for the spring fire season 1996.

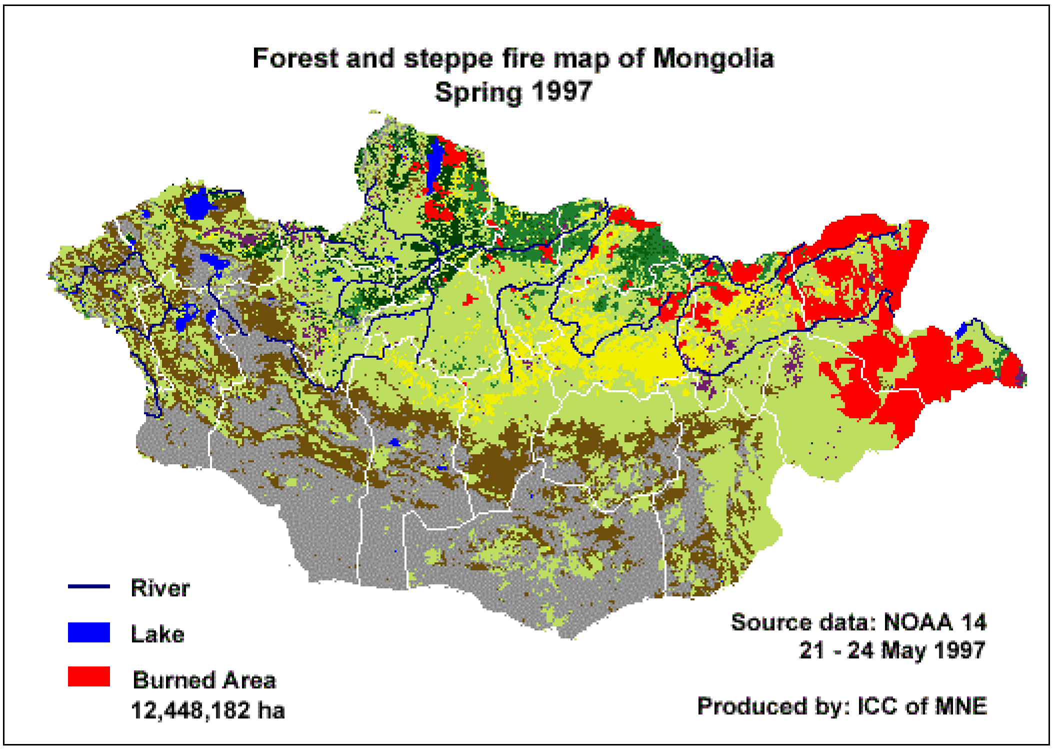

Figure 3-16 Forest and steppe fire map of Mongolia for the spring fire season 1997.

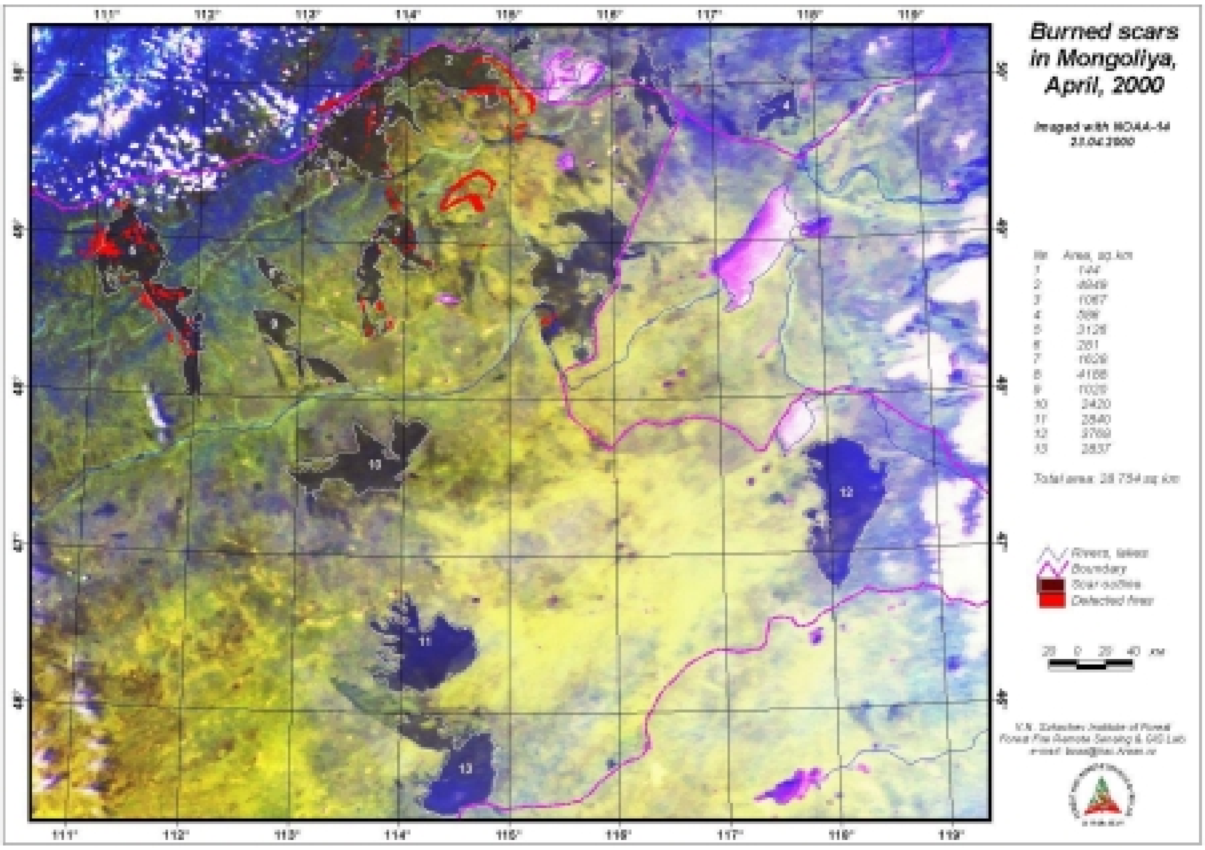

Figure 3-17 Forest and steppe area burned in Mongolia in spring 2000.

Date of satellite image: 24 April 2000. The total area burned was 2.87 million ha.
Source: A. Sukhinin, Sukachev Institute for Forest, Fire Laboratory, Krasnoyarsk, Russian Federation.

Public policies

The underlying causes for a dramatic increase of forest and steppe fires in Mongolia are deeply rooted in the changing socio-economic conditions of the country. The government has recently taken significant steps in this direction through the establishment of *a Fire Management Agency*. Pursuant to newly enacted legislation, the Mongolian Civil Defence and State Police will transfer their responsibilities to the new agency including associated resources (personnel, budget and equipment).

National endeavours to strengthen fire management capabilities of government institutions as well as local communities have been supported by the Integrated Fire Management (IFM) Project. The GTZ project was terminated at the end of 2000. The FAO in 2000 granted a Technical Cooperation Project (TCP) to improve fire management in Mongolia that will be implemented in 2001. It is planned that FAO and GTZ will collaborate in assisting the country to upgrade its fire management capabilities. For future development the areas of particular concern are:

- **National Oversight –** Appropriate oversight will be required: (1) to ensure quality control and preparedness; (2) to help with the standardisation of training, procedures, and safety; (3) to provide technical assistance and specialised training; (4) to facilitate

cooperation/coordination among agencies; (5) to evaluate training and determine need for additional training; and 6) to determine fire management program needs.

- **National Level Training Centre** - Mongolia has a major and complex fire problem. Only a handful of firefighters has received basic fire training. To effectively fight complex and large fires requires training beyond the basic level. Wildland firefighters in developed and some undeveloped countries take several higher courses that are more specialised. Large and complex fires require a higher level of understanding of fire behaviour, strategy and tactics and organization. ICS requires multi-agency training of ICS principles.
- **Coordination and Cooperation –** A remaining challenge is the coordination of management planning with other institutions and agencies responsible for fire management at the regional and national levels. The project has not had sufficient time to adequately address this need. Nevertheless, experiences tell us that this kind of coordination is an integral part of the decentralisation process in Mongolia and will require profound changes at all levels of affected government.
- **Communications System -** All interagency team members need a common radio system - one they can program to an incident fire frequency. All agencies should be linked to local and regional dispatch centres.
- **Early Warning Systems** - Faster detection means smaller fires, a need for fewer firefighters and greatly reduced expenses associated with firefighting. A system of staffed observers, ground and air, would significantly increase detection capability and significantly speed up fire crew attack and containment time.

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4 Europe Region Fire Assessment

4.1 Introduction

The report on the Europe region has been divided into two sub-regions, 1) Mediterranean, including other nations bordering the Mediterranean Sea, and 2) Western, Eastern and Northern Europe, with special emphasis on the Baltic region. For each of the sub-regions, a short overview is provided. A number of selected country reports provide an exemplary and representative insight into the fire conditions. For other countries, brief descriptions are provided as well as bibliographic or Internet (websites) references.

Narrative summary of major wildfire impacts on people, property, and natural resources during the 1990s

Europe

During the decade of the 1990s, approximately 50 000 forest fires per year throughout the Mediterranean basin burned about 600 000 ha of forest and other wooded land. This is almost twice as much as during the 1970s. Inter-annual fluctuations of fire occurrence and impacts within individual countries, however, are quite significant. Greece is a striking example of recent variability. In 1998, the year in which the reOrganization of responsibilities in fire control were moved from the Forest Service to the Fire Service, the country faced a difficult fire situation. More than 9 000 fires burned 112 000 ha, compared to the annual area burned between 1988 and 1997 between 24 000 and 66 000 ha.

Because of institutional strengthening and a relatively mild fire season, the area burned in 1999 was reduced to 10 700 fires affecting 19 000 ha of wildlands. This brought the average area burned to a record low of 1.8 ha per fire. The prolonged drought in the Eastern Mediterranean region in mid-2000, however, confronted the country with another extreme situation. By end of September 2000 a total of more than 150 000 ha had been burned (see country report of Greece; Figure 4-1). At the same time, the Balkan region suffered high fire occurrence, particularly in Bulgaria, Romania, and Croatia. Turkey also experienced an extreme fire season (Figure 4-2).

An overall comparison of fires in the Mediterranean between the 1980s and 1990s shows that within the two decades there is inter-annual variability of forest fire occurrence and area affected by fire, but no general trend towards more or less fires damage. The same is concluded for the situation in Northern Europe.

Eastern Europe: The Russian Federation

It is difficult to compare the statistical databases of the 1980s vs. the 1990s. Reliable remotely sensed data on area burned for the two decades are not yet available (the 1980s are currently evaluated on the base of NOAA AVHRR archived data). There is a consensus that the official statistics in both decades underestimate the area burned in the territory of the Former Soviet Union and the Russian Federation. Extreme fire events occurred in both decades, e.g., large fires during the 1987 drought that probably burned more than 14 million ha.

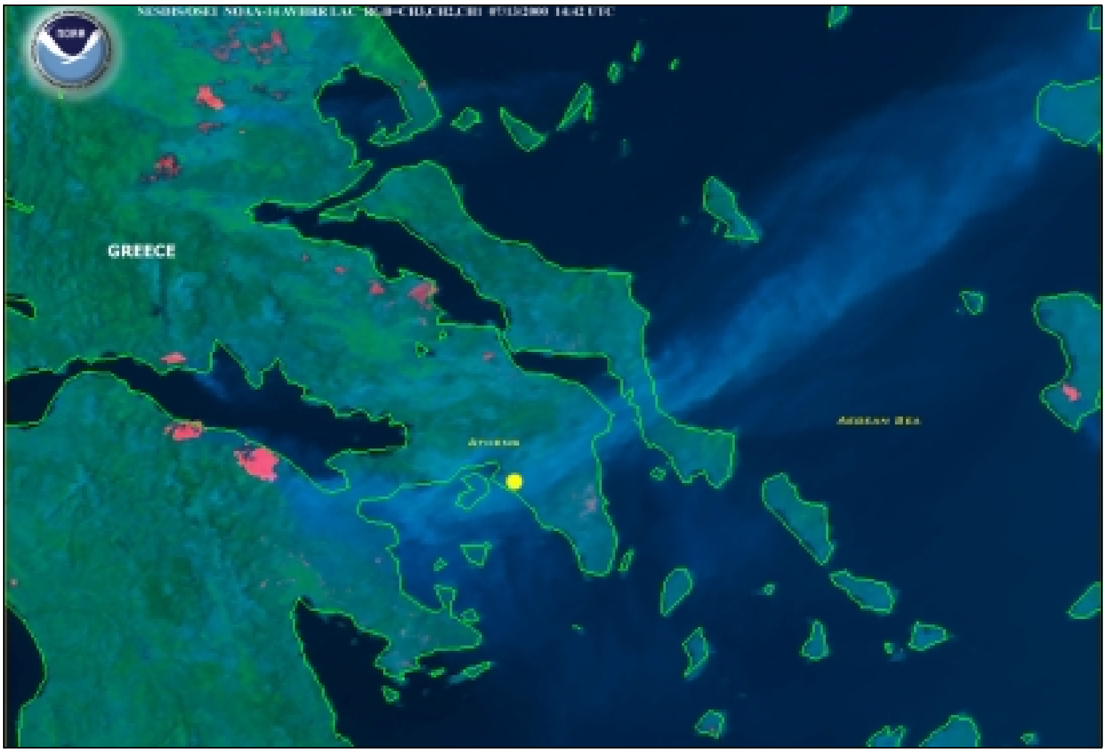

Figure 4-1 Numerous heat signatures (red) and large smoke plumes (light blue) are visible from fires burning in central Greece on 13 July 2000.

One exceptionally large smoke plume extends from a large fire located west of Athens across the Aegean Sea into Turkey near the Sea of Marmara. Source: NESDIS/OSEI (displayed with the daily Greece situation report on the GFMC Website on 14 July 2000 at: www.ruf.uni-freiburg.de/fireglobe/current/archive/gr/2000/07/gr_07142000.htm

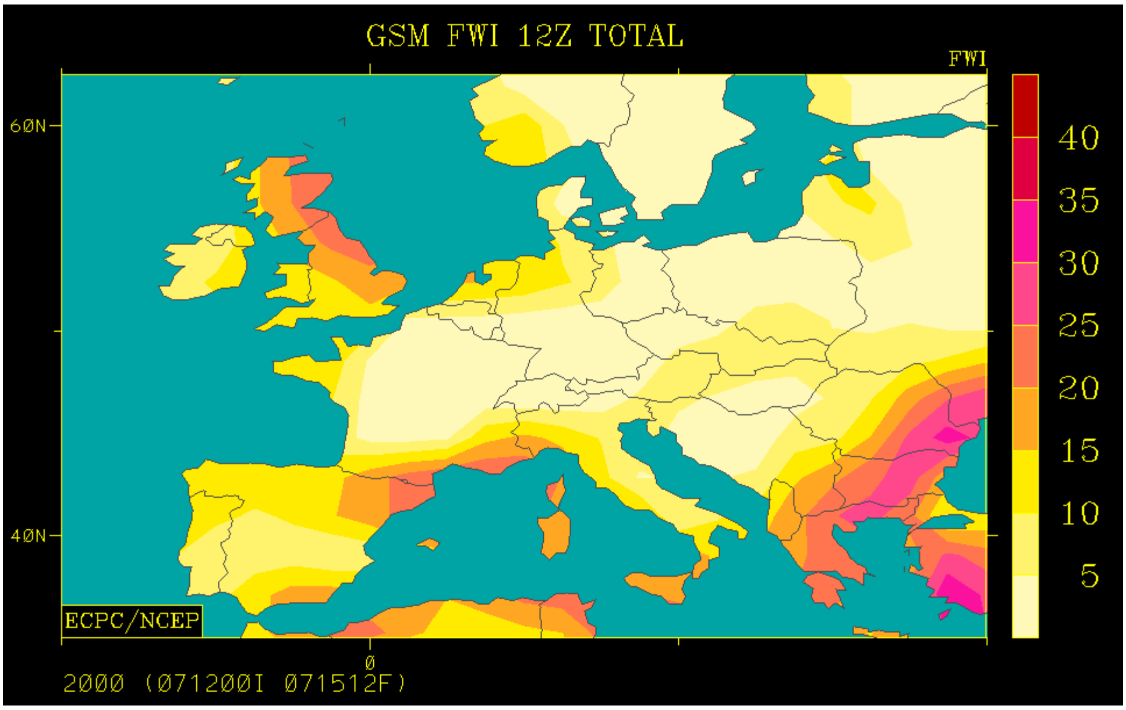

Figure 4-2 The Europe fire-weather forecast for 15 July 2000 indicates the extreme fire danger in the Eastern Mediterranean Basin.

Source: Experimental Climate Prediction Center (ECPC). Daily displayed during the large fire situation on the GFMC Website (same Internet location as given in Figure 4-1).

According to the database of the Russian Aerial Fire Protection Service *Avialesookhrana* during the fire season 1998, 4.27 million ha of forest and other land under fire protection had been affected by fire. However, a preliminary satellite-based analysis by the International Institute for Applied Systems Analysis (IAASA) was conducted in 1998. This analysis indicated that 9.4 million hectares burned between the Urals and the Pacific Coast and between the southern border of the country and 75°N (7.1 million ha of forested land). In 1999 the area burned was 752 000 ha.

According to official statistics of the Aerial Forest Fire Protection Service (*Avialesookhrana*), 18 017 fires occurred in forests under the control of the Ministry of Natural Resources of Russia during fire season 2000. These fires burned a total of 907 693 ha of forest and 277 036 ha of non-forested areas. However, burned area mapping by satellite in the same year indicated that 1.9 and 1.4 million ha respectively of forest and other land were burned in Amurskaia Oblast and the Buryatia Republic (see country report of Russia and Figure 4-3). It is assumed that in average years ca. 3 to 5 million ha of forested lands are affected by fires (predominantly surface fires), and in extreme years 10 million ha and more. These discrepancies between the different providers of fire data need to be explored further. They indicate the need for an improved fire information system, not only for Russia but also for those countries that are facing difficulties in obtaining reliable information on active fires and fire impacts.

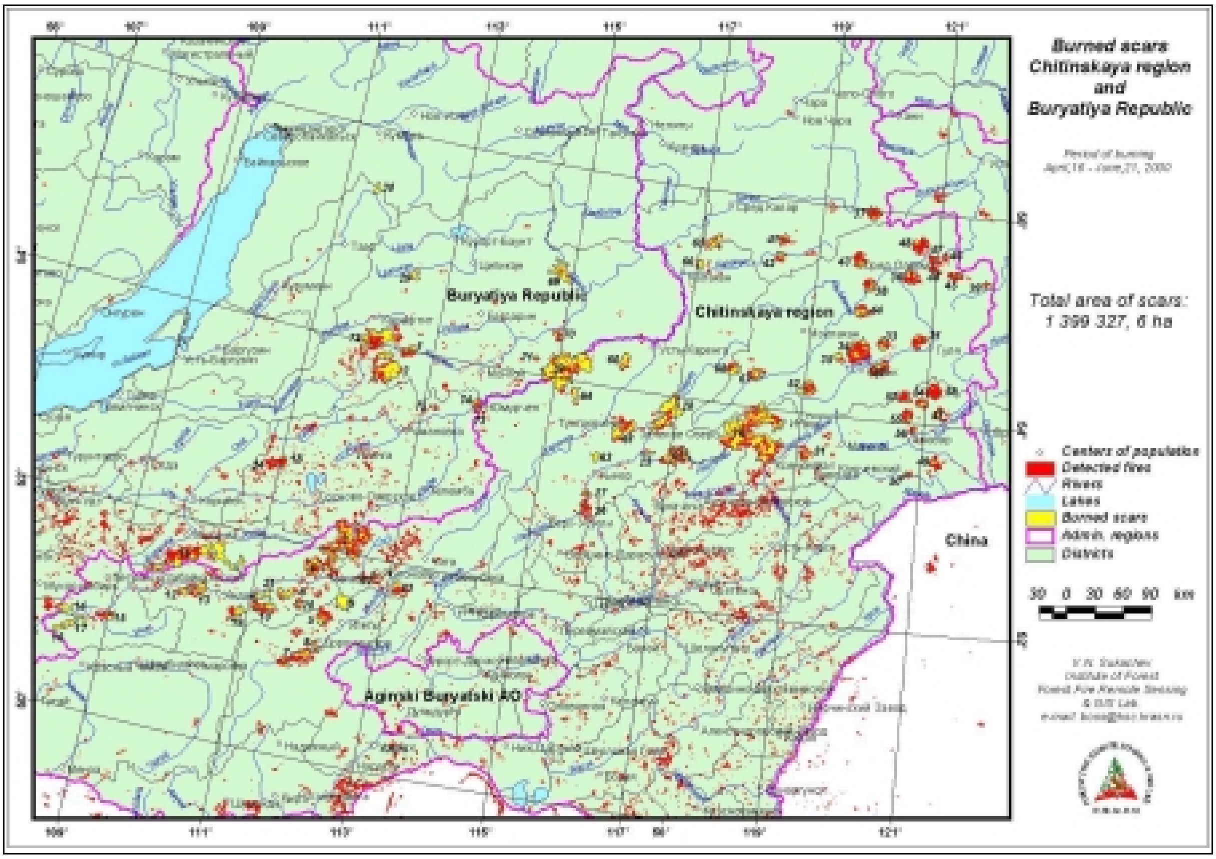

Figure 4-3 Burned area map of Chita Region and Buryatia Republic for the period 16 April to 21 June 2000.

The area burned is 1 399 327 ha.
Source: Fire Laboratory of the Sukachev Institute of Forest, Russian Academy of Sciences, Krasnoyarsk..

Fire databases

The European countries all belong to the ECE region that is the only regional entity within the UN system that regularly collects and evaluates statistical data on wildland fires. The fire statistics are collected and evaluated by the UN-ECE Trade Division, Timber Section, Geneva. The statistics include all Western and Eastern European countries, countries of the former Soviet Union, the U.S.A. and Canada. The last data set covers the period 1995-97. The statistics can be obtained on the Internet (ECE/FAO 1998).

Summary tables with forest fire statistics of the European and Asian ECE member states for the period 1990-1997 are given in Table 4-1 to Table 4-4. The data in the tables are taken from the ECE Forest Fire Statistics and compiled by the FAO Temperate and Boreal Forest Resource Assessment 2000 (Chapter V: Forest Condition and Damage to Forests and Other Wooded Lands). Remarks commenting on the data of individual countries are included in the Annex to Chapter V. Countries missing in this table did not provide data or did not experience wildland fires in the period concerned.

The Commission of the European Union has established the Community Information System on Forest Fire which by 1997 covered 319 provinces of France, Germany, Greece, Italy, Portugal and Spain (Lemasson 1997).

Furthermore, the UN-ECE Trade Division, Timber Section, regularly publishes ECE/FAO International Forest Fire News (IFFN). This newsletter is produced at the Global Fire Monitoring Centre (GFMC) since 1988 and contains numerous country reports with statistical data. Meanwhile 66 country reports are available in the Internet starting with the issues of 1990 (GFMC 2001b). The GFMC also publishes regular updates of wildland fire statistics and individual fire reports on the GFMC Website. Different information sources often provide data that are not matching officially reported data (cf. examples cited above).

Table 4-1 Number of forest fires in the European and Asian ECE member states, 1990-1997.

Country	Year							
	1990	1991	1992	1993	1994	1995	1996	1997
	(Number)							
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Albania	269	147	695	560	585	110	490	395
Austria	225	78	165	178	94	64	41	66
Belgium	82	65	26	36	43	40	185	35
Bosnia and Herzegovina		139	139	158	104	156	139	139
Bulgaria	208	73	602	1 196	667	114	246	200
Croatia		218	325	372	181	109	305	305
Cyprus	64	47	18	16	35	24	20	19
Czech Republic		961	2 586	1 951	2 052	1 331	1 421	1 398
Denmark	2	6	2	14	6	6	14	7
Estonia	164	39	348	207	289	188	273	359
Finland	571	287	852	286	1 054	1 031	1 289	1 125
France	5 881	3 888	4 002	4 769	4 618	6 563	6 401	7 200
Germany	1 610	1 846	3 012	1 694	1 696	1 237	1 748	1 467
Greece	1 322	858	2 582	2 406	1 763	1 438	1 508	3 113
Iceland	0	0	0	0	0	0	0	0
Ireland	721	194	156	123	149	143	143	143
Israel	1 211	697	1 057	939	765	1 030	1 031	942
Italy	14 477	11 965	14 545	15 380	8 669	6 225	9 093	11 408
Latvia		1 110	1 510	965	854	582	1 095	844
Lithuania	236	147	1 154	635	714	472	889	565
Luxembourg	23	11	8	15	7	4	3	5
Malta	3	8	8	1	3	8	12	4
Netherlands	95	117	76	83	51	77	77	68
Norway	578	976	892	253	471	181	246	510
Poland	4 137	3 008	9 305	4 421	5 152	4 143	4 546	3 624
Portugal	18 507	13 118	14 954	13 919	18 104	28 044	29 078	24 429
Romania	134	44	187	160	121	50	87	34
Slovakia	369	142	305	674	366	254	662	535
Slovenia	58	66	113	211	66	25	50	59
Spain	12 474	13 011	15 895	14 254	19 263	25 827	16 772	22 479
Sweden					2 500	1 100	6 240	3 280
Switzerland	216	157	111	99	52	56	61	77
The FYR of Macedonia		150	150	294	137	18	41	73
Turkey	1 725	1 445	2 110	2 547	3 221	1 768	1 631	1 339
United Kingdom	412	475	328	61	349	906	508	375
Yugoslavia		240	313	113	140	26	220	
Armenia	7	2	3	4	6	5	24	5
Azerbaijan		6	6	8	1	6		
Belarus	2 471	1 517	7 743	1 887	3 052	3 257	4 123	1 466
Georgia		6	6	6	6	1	6	11
Kazakhstan	605	1 194	518	354	881	1 320	1 003	2 257
Republic of Moldova	91	18	14	1	33	3	0	12
Russian Federation		17 965	25 777	18 428	20 287	25 951	32 833	31 300
Turkmenistan		9	9	2	16	9	2	9
Ukraine	2 714	2 771	5 869	2 967	7 411	3 754	4 928	2 309

Table 4-2 Total area of forest and other wooded land burned in the European and Asian ECE member states, 1990-1997.

COUNTRY	YEAR							
	1990	1991	1992	1993	1994	1995	1996	1997
	(1000 ha)							
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Albania	0.42	0.25	1.01	0.52	0.71	0.15	0.41	0.42
Austria	0.20	0.05	0.13	0.11	0.06	0.03	0.03	0.04
Belgium	0.02	0.05	0.02	0.11	0.05	0.07	1.45	0.28
Bosnia and Herzegovina		0.88	0.88	1.30	0.71	0.63	0.88	0.88
Bulgaria	1.04	0.51	5.24	18.16	19.11	0.55	2.15	0.78
Croatia		4.54	11.13	20.16	7.94	4.65	11.21	11.12
Cyprus	1.45	0.11	0.01	0.07	0.18	0.07	0.12	0.17
Czech Republic		0.08	1.28	1.15	0.81	0.40	2.04	3.48
Denmark	0.14	0.14	0.28	0.01	0.00	0.00	0.06	0.01
Estonia	0.19	0.06	1.79	0.65	0.46	0.19	0.58	1.15
Finland	0.43	0.23	1.08	0.58	1.58	0.64	0.92	1.05
France	72.60	10.13	16.61	16.70	25.00	18.14	11.40	21.00
Germany	0.95	0.92	4.91	1.49	1.11	0.59	1.38	0.60
Greece	38.59	13.05	71.41	54.05	57.91	27.20	25.31	52.37
Iceland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ireland	0.84	0.67	0.57	0.54	0.28	0.46	0.46	0.46
Israel	5.77	3.48	6.70	7.17	3.79	8.30	6.49	6.19
Italy	195.32	99.86	105.70	203.14	68.83	22.63	23.81	65.78
Latvia		3.10	8.37	0.57	0.35	0.54	0.93	0.60
Lithuania	0.12	0.05	0.86	0.31	0.30	0.32	0.39	0.17
Luxembourg	0.009	0.004	0.002	0.008	0.002	0.001	0.003	0.002
Malta	0.000	0.000	0.000	0.001	0.002	0.003	0.007	0.005
Netherlands	0.22	0.41	0.17	0.10	0.28	0.23	0.16	0.22
Norway	0.09	0.53	1.37	0.22	0.23	0.11	0.51	0.63
Poland	5.03	2.11	33.33	3.68	2.50	1.74	5.31	2.17
Portugal	129.84	182.49	59.07	49.96	77.32	169.61	83.05	26.07
Romania	0.46	0.28	0.73	0.55	0.31	0.20	0.26	0.06
Slovakia	0.57	0.21	0.59	0.52	0.10	0.09	0.22	0.04
Slovenia	0.60	0.71	0.67	1.86	0.91	0.26	0.29	0.49
Spain	204.04	244.71	104.59	89.33	437.64	143.48	59.82	88.29
Sweden			5.81	1.00	3.10	0.40	2.18	1.89
Switzerland	1.10	0.15	0.05	0.04	0.29	0.44	0.23	1.93
The FYR of Macedonia		5.18	5.18	10.07	5.37	0.13	1.78	5.31
Turkey	13.00	7.64	12.31	13.73	21.00	4.79	14.92	6.17
United Kingdom	0.46	0.11	0.19	0.15	1.04	0.54	0.59	0.33
Yugoslavia		1.54	1.97	6.90	1.58	1.65	4.59	
Armenia	0.01	0.02	0.01	0.00	0.02	0.15	0.10	0.02
Azerbaijan		0.06	0.08	0.03	0.01	0.05		
Belarus	1.04	0.32	23.82	1.25	2.11	3.78	8.95	0.97
Georgia		0.11	0.11	0.11	0.11	0.01	0.20	0.11
Kazakhstan	1.30	4.90	1.20	0.70	5.98	28.93	12.86	347.98
Republic of Moldova	0.12	0.02	0.02	0.00	0.22	0.00	0.00	0.07
Russian Federation		1.126.22	1.142.78	1.200.44	723.08	462.86	2.311.93	983.72
Turkmenistan		1.25	1.25	0.01	2.34	1.40	1.05	1.60
Ukraine	2.43	1.78	4.25	3.21	10.04	4.00	127.06	47.03

Table 4-3 Total area of forest burned in the European & Asian ECE member states, 1990-1997.

COUNTRY	YEAR							
	1990	1991	1992	1993	1994	1995	1996	1997
	(1000 ha)							
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Albania	0.42	0.25	1.01	0.52	0.71	0.15	0.41	0.42
Austria	0.20	0.05	0.13	0.11				
Belgium	0.02	0.01	0.02	0.01	0.02	0.01	0.78	0.01
Bosnia and Herzegovina				1.16	0.56	0.55		
Bulgaria	1.01	0.47	4.15	10.15	9.71	0.53	1.87	0.68
Croatia		0.81	1.70	3.62	4.59	3.02	6.51	6.99
Cyprus								
Czech Republic		0.08	1.28	0.57	0.20	0.21	0.35	3.48
Denmark	0.08	0.00	0.07	0.01	0.00	0.00	0.01	0.00
Estonia	0.11	0.03	0.78	0.13	0.13	0.07	0.15	0.31
Finland	0.43	0.23	1.08	0.58	1.58	0.64	0.92	
France	56.50	6.50						
Germany	0.48	0.92	4.91	1.49	1.11	0.59	1.38	0.60
Greece	18.49	13.05	49.56	24.20	23.39	9.04	7.59	12.60
Iceland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ireland		0.28	0.15	0.05	0.28			
Israel								
Italy	36.59	9.21	12.48	43.99		5.94	7.10	28.27
Latvia			3.00	0.29	0.20	0.20	0.50	
Lithuania		0.04	0.72	0.28	0.24	0.24	0.32	0.11
Luxembourg	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Malta	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
Netherlands	0.04	0.03	0.02	0.03	0.02	0.04	0.03	
Norway	0.09	0.53	1.37	0.22	0.23	0.11	0.51	0.63
Poland	5.03	2.11	33.33	3.68	2.50	1.74	5.31	2.17
Portugal	69.78	98.77	33.52	23.84	13.49	87.55	28.72	10.57
Romania	0.36	0.28	0.72	0.54	0.31	0.20	0.26	0.06
Slovakia						0.09	0.22	0.03
Slovenia		0.30	0.33	1.05	0.43	0.08	0.10	0.23
Spain	37.77	109.88	39.96	33.42	250.43	42.39	10.54	21.87
Sweden			3.25		2.40	0.28	0.59	
Switzerland	1.10	0.15	0.05	0.04	0.29	0.44	0.23	1.51
The FYR of Macedonia				10.07	5.37	0.01	0.84	0.53
Turkey	6.13	5.23	7.95	9.52	20.16	3.93	10.17	4.53
United Kingdom	0.46	0.11	0.19	0.15	1.04	0.54	0.59	0.33
Yugoslavia		1.54	1.97	6.90	1.58	1.65	3.93	
Armenia	0.00	0.00	0.00	0.00	0.00	0.15	0.02	
Azerbaijan		0.06	0.07	0.01	0.01	0.04		
Belarus	0.75	0.30	18.60	1.20	2.10	3.78	5.60	0.60
Georgia								
Kazakhstan	1.00	4.30	1.20	0.70				
Kyrgyzstan								
Republic of Moldova		0.02	0.02	0.00	0.08		0.00	
Russian Federation		682.05	691.48	748.62	536.79	360.14	1.853.51	726.74
Turkmenistan								
Ukraine	2.39	1.72	4.10	3.18	10.04	3.14	126.67	

Table 4-4 Total area of other wooded land burned in the European and Asian ECE member states, 1990-1997.

COUNTRY	YEAR							
	1990	1991	1992	1993	1994	1995	1996	1997
	(1000 ha)							
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Albania	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Austria	0.00	0.00	0.00	0.00				
Belgium	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.05
Bosnia and Herzegovina				0.14	0.15	0.09		
Bulgaria	0.00	0.04	0.28	0.62	9.40	0.02	0.07	0.00
Croatia		1.33	2.78	5.91	3.20	1.07	3.52	2.52
Cyprus								
Czech Republic				0.00	0.00	0.00	0.79	
Denmark		0.00		0.00	0.00	0.00	0.00	0.00
Estonia	0.04	0.00	0.10	0.30	0.12	0.05	0.03	0.16
Finland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
France	16.10	3.60						
Germany		0.00	0.00	0.00	0.00	0.00	0.00	0.00
Greece				23.73	29.25	10.14	11.66	16.92
Iceland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ireland		0.00	0.00	0.01	0.00			
Israel								
Italy	0.00	0.00	5.66	9.57		2.22	1.55	9.25
Latvia				0.04	0.12	0.12	0.16	
Lithuania			0.07	0.01	0.05	0.06	0.04	0.02
Luxembourg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Malta	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Netherlands	0.00	0.00	0.00	0.00	0.00	0.05	0.01	
Norway								
Poland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Portugal	50.78	53.75	18.45	26.12	63.84	82.06	54.32	15.49
Romania	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Slovakia						0.00	0.00	0.01
Slovenia		0.30	0.16	0.41	0.45	0.07	0.14	0.15
Spain	0.00	27.42	2.56	1.59	17.88	6.20	5.55	
Sweden			2.29		0.70	0.12	0.66	
Switzerland		0.00	0.00	0.00	0.00	0.00	0.00	
The FYR of Macedonia				0.00	0.00	0.11	0.86	0.08
Turkey	3.33	2.34	4.35	3.41	0.80	0.75	4.33	1.49
United Kingdom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yugoslavia							0.66	
Armenia	0.01	0.02	0.01	0.00	0.02	0.00	0.08	
Azerbaijan		0.00	0.01	0.02	0.00	0.01		
Belarus	0.04	0.00	5.20				0.10	0.00
Georgia								
Kazakhstan	0.30	0.60	0.00	0.00				
Kyrgyzstan								
Republic of Moldova							0.00	
Russian Federation		444.17	451.30	451.82	186.30	102.72	458.42	256.97
Tajikistan								
Turkmenistan								
Ukraine								

Use of prescribed fire

Mediterranean Region. In France, prescribed burning has been expanding substantially for a decade or so, and now involves 6 000 to 10 000 ha, depending on weather conditions. Teams of specialists (foresters, pastoralists, firefighters), identified by the local authorities, work in a given geographical area. The cost of prescribed burning varies according to the conditions under which it is carried out. But in all cases it is relatively low: from $US 40 to $US 80/ha for treeless land in foothill areas to $US 160 to $US 800/ha for clearing land with large trees before burning. Even in this last case, prescribed burning nevertheless is only half as expensive as mechanical treatment.

Elsewhere in the Mediterranean region, prescribed burning is used marginally (in Italy, Portugal and Spain), or not at all (in Greece and in the North African and Near Eastern Mediterranean countries). Where it is in use, administrative authorities have found it to be less costly than the suppression of wildfires resulting from rural populations' attempts to incinerate standing vegetation.

National and international research programmes are currently studying the effects of prescribed burning on the different components of the Mediterranean and mountain ecosystems (the different strata of plant communities, the surface layers of the soil, the fauna and biodiversity). A recent study "Prescribed burning as a tool for the Mediterranean region: a management approach" was prepared by the EU-funded project *Fire Torch*, which brought together research teams from Portugal, Spain, France, Italy and Greece.

Northern, western and Eastern Europe. In Northern and Western Europe prescribed burning in forestry, landscape management and nature conservation is increasingly used. Prescribed burning in forestry is becoming a key element of sustainable forest ecosystem management in the Nordic countries (see country report of Finland). In other countries (Germany, Netherlands, United Kingdom) fire is increasingly used in landscape management and nature conservation. The main goal of fire use is the maintenance of open vegetation types and the prevention of bush and tree encroachment (halting of succession towards forest). This is done to maintain or improve habitat conditions for a range of plant and animal species that occur in seral stages of vegetation development. These are species that would disappear without mechanical, biological and/or fire treatment (see Goldammer 1997a, 1997b; Goldammer 1998 a, 1998b; Page and Goldammer 2000).

Community involvement in fire management activities

In the Mediterranean section of this report it is mentioned that in the Maghreb countries the involvement of local populations in fire prevention activities is still maintained, especially in forest villages. The demand for food and energy (fuelwood) has increased to the point of seriously reducing the forest area and the inhabitants view forest fires as a direct threat to their living conditions. In these countries, the incidence of forest fires has remained at a relatively constant level.

In many other European countries, especially in the countries of Central and Northern Europe, volunteers play a major role in rural fire suppression activities. In Germany, for instance, fire brigades outside of large cities consist primarily of volunteers. Thus, in the case of forest and other wildland fires, the main burden of fire suppression, especially in initial attack, depends on the availability of local people and their rapid mobilisation. Experience has shown that the

involvement of enthusiastic volunteers and their specific knowledge of local conditions are helpful for successful intervention. In the case of Germany, however, the availability of modern fire suppression technologies, communication and command systems and the favourable road access create favourable conditions to involve volunteer firefighters who have not been trained for extreme wildland fire conditions.

Public policies

Fire policies or policies that are affecting wildfire prevention or fire management within the ECE region have been investigated in depth by Goldammer (1986) and reviewed in the frame of the FAO consultation “Public Policies Affecting Forest Fires” (Goldammer 1999). Thus, the particular national policies are not re-visited in this report. Instead, a brief review is given about the activities of the Economic Commission for Europe (ECE) in the field of forest fires. These include: (1) the above-mentioned periodic collection and publication of fire statistics of the member states, and (2) the work of the ECE/FAO/ILO Team of Specialists on Forest Fire.

As a result of limited secretariat resources, representatives of the Joint ECE/FAO/ILO Committee on Forest Technology, Management and Training have taken on the challenge to undertake more work themselves. This is accomplished by entrusting several of its activities to Teams of Specialists, especially those where specific expertise is required. The Team of Specialists on Forest Fire was created in the 1980s and reorganized in 1993.

The team's main task is to provide a critical link in communication and cooperation among fire scientists, managers and policy makers. The main activities embrace (1) the production of International Forest Fire News (IFFN) in support of the Global Fire Monitoring Centre (GFMC); (2) organization of seminars; and (3) promotion of synergistic collaboration among governments, non-government institutions and individuals, especially science and technology transfer. The scope of the work of the Fire Team includes the countries outside the ECE region because there is no similar institutional arrangement available in other FAO regions.

International Forest Fire News. International Forest Fire News (IFFN) has been published bi-annually since 1988. It produced a steadily increasing communication process in international fire matters. Since then, IFFN provides an international information platform on which advances in fire research, technology and policy development are reported and disseminated. Currently the printed version of IFFN is subscribed to by more than one thousand agencies, research laboratories and individuals all over the world. Starting with its 19th issue (August 1998) the IFFN is available on the homepage of the "Global Fire Monitoring Centre" (GFMC 2001a, 2001b). The GFMC Website includes country and special reports published since 1990. Country reports are organized in 66 country folders.

Seminars: The seminars conducted by the ECE/FAO/ILO Team of Specialists on Forest Fire between 1981 and 2000 focused on topical fire policy issues:

- Fire Suppression Technologies (Poland 1981)
- Fire Prevention (Spain 1986)
- The Socio-Economic Environment of Fire (Greece 1991)
- Forest, Fire, and Global Change (Russian Federation 1996)
- The First Baltic Conference on Forest Fires (Poland 1998)

- The Baltic Exercise on Fire Information and Resources Exchange - BALTEX FIRE 2000 (Finland 2000)
- Forest Fire in the Eastern Mediterranean, Balkans and adjoining Regions of the Near East and Central Asia (2002)

The bibliographic references of the conference results are available on the GFMC homepage (GFMC 2000b).

The Fire Team was reorganized in May 1998. The list of team members is continuously updated on the website of the GFMC (GFMC 2000c). The last two team meetings were held in May 1988 (in conjunction with the First Baltic Conference on Forest Fires) and in 2000 (at BALTEX FIRE 2000). The complete meeting reports are available in the pages of IFFN (Goldammer 1998c, Goldammer 2001).

The new Baltic focus of the ECE/FAO Fire Team is described in part 2 of this regional report (Western, Eastern and Northern Europe). Close contacts are maintained with the FAO Committee on Mediterranean Forestry Questions *Silva Mediterranea*.

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4.2 Mediterranean Sub-Region

Preface

An analysis of trends in forest fire occurrences in the Mediterranean, including comments on underlying policy-related causes of forest fires, has been prepared for the "FAO Meeting on Public Policies Affecting Forest Fires", Rome, Italy, 28 - 30 October 1998 (Alexandrian and Esnault 1999) and published in an additional short version in UNASYLVA (Alexandrian et al. 2000). It analyses the situation in the 23 Mediterranean countries: Albania, Algeria, Bosnia, Croatia, Cyprus, Egypt, France, Greece, the Islamic Republic of Iran, Israel, Italy, Jordan, Lebanon, the Libyan Arab Jamahariya, Malta, Morocco, Portugal, Slovenia, Spain, the Syrian Arab Republic, Tunisia, Turkey and former Yugoslavia. The following Mediterranean section of the Europe report is an edited and updated version of the UNASYLVA publication. Country reports for Cyprus, Greece, Italy, Lebanon, Morocco, Spain and Turkey have been added separately.

Introduction

Fire is the most important natural threat to forests and wooded areas of the Mediterranean basin. It destroys many more trees than all other natural calamities: parasite attacks, insects, extreme wind events, frost, etc. All countries analysed for this report have a more or less long dry season. The dry season lasts between one and three months on the French and Italian coasts in the north of the Mediterranean; and more than seven months on the Libyan and Egyptian coasts in the south (UNEP 1988).

Today, the average annual number of forest fires throughout the Mediterranean basin is close to 50 000, i.e. twice as many as during the 1970s. It is not easy to form an accurate picture of the overall increase, however, owing to the varying databases. In the countries where data have been available since the 1950s, a large increase in the number of forest fires can be observed from the beginning of the 1970s: Spain (from 1 900 to 8 000), Italy (from 3 000 to 10 500), Greece(from 700 to 1 100), Morocco (from 150 to 200) and Turkey (from 600 to 1 400). Only former Yugoslavia deviates from the general trend (from 900 to 800).

The average annual accumulated area burned by wildfires for the Mediterranean countries is approximately 600 000 ha. This number is also almost twice as much as during the 1970s. The trend observed is, however, much less uniform than for fire numbers. A worsening situation is clearly observed in Greece (from12 000 to 39 000 ha), Italy (from 43 000 to 118 000 ha), Morocco (from 2 000 to 3 100 ha), Spain(from 50 000 to 208 000 ha) and former Yugoslavia (from 5 000 to 13 000 ha). In Portugal, the situation has also worsened, although its statistical series starts later. In Algeria and Cyprus, no apparent trend emerges from the statistics, but some years present a very high maximum (e.g. 1957, 1958 and 1983 in Algeria; 1974 in Cyprus). Finally, the total burnt area has remained relatively stable in Croatia, France, Israel and Turkey. It is significant to note that no country shows an improved situation, despite all the measures taken (Le Houérou 1987).

Causes of fire

Unlike other parts of the world, where a large percentage of fires are of natural origin (lightning), the Mediterranean basin is marked by a prevalence of human-caused fires. Natural causes represent only a small percentage of all fires (from one to five percent, depending on the country), probably because of the absence of climatic phenomena such as dry storms.

Another characteristic common to the entire Mediterranean basin is the high number of fires for which the cause is unknown. This group accounts for the majority of forest fires in most countries: 56 percent on average in the five countries of southern Europe and between 50 and 77 percent in most of the others (Cyprus, Israel, Morocco, Tunisia, Turkey). A point to note, however, is that some countries are characterised by a relatively low proportion of fires resulting from unknown causes, between 25 and 47 percent in Croatia (Alexandrian 1998), Greece (Anonymous 1995) and Portugal (Delattre 1993).

Among the known causes, those that are involuntary (negligence or accidents) are the most frequent in all countries, except in Turkey where voluntary fires seem to be in the majority (Canakcioglu 1986).

The accidental causes vary among countries. Some are associated with fixed installations (power lines, rubbish dumps) and some are directly related to human activity (badly controlled charcoal kilns, uncontrolled burning, smokers, campfires, fires set by shepherds). The list is very long and any synthesis is impossible. It seems, however, that these involuntary fires are directly related to agricultural and forestry activities. The parties at fault in the case of forest fires are mainly permanent inhabitants (and seldom passing tourists).

Paradoxically, the fundamental cause of forest fires is linked to increased standards of living among the local populations. Far-reaching social and economic changes in Western Europe have led to a transfer of population from the countryside to the cities, a considerable deceleration of the demographic growth, an abandonment of arable lands and a disinterest in the forest resource as a source of energy. This has resulted in the expansion of wooded areas, erosion of the financial value of the wooded lands, a loss of inhabitants with a sense of responsibility for the forest and, what is important, an increase in the amount of fuel (Le Houérou 1987).

In contrast, in the Maghreb countries the involvement of local populations was maintained, especially in forest villages. The demand for food and energy (fuelwood) has increased to the point of seriously reducing the forest area and the inhabitants view forest fires as a direct threat to their living conditions. In these countries, the numbers of forest fires has remained at a relatively constant level.

Control policies and programmes

For the purpose of discussion, policies related to forest fire have been grouped into four traditional categories: prevention, including all measures intended to prevent the occurrence of forest fires; pre-suppression, covering all provisions intended to improve interventions and safety in the event of fire; suppression, including all means of intervention; and rehabilitation, i.e. the measures taken after a fire to limit its negative consequences.

Prevention

Knowledge of the causes of forest fire is a precondition for the implementation of suitable solutions. An original technique for establishing the cause of fire has been developed in Portugal. Responding to an increase in the incidence of forest fires at the end of the 1980s, the Portuguese authorities set up fire research brigades made up of forestry guards to investigate the cause of each fire that occurred. Scientific methods of investigation were progressively developed and, within a few years, the country passed from 80 percent of fires being attributed to unknown causes to less than 20 percent. This experiment, moreover, made it possible to show that the great majority of fires were due to negligence (43 percent), followed by arson (34 percent) (Delattre 1993).

Almost all Mediterranean countries have adopted measures to increase public awareness of forest fires, and the focus is nearly always on accidentally caused fires. The target is the adult public - residents or tourists - located in areas of risk. School children are also the target of specific programmes (Calabri 1986).

All the current mass communication channels are used to reach the public, including television campaigns, posters and radio advertisements. In Spain, stage performances focusing on the consequences of forest fires are also used in rural zones. The messages have evolved over time: in the beginning posters tended to invoke fear but, later, the emphasis was on ecological risks. Current messages are rather utilitarian (e.g. what to do in the event of fire).

Provisions for the prevention of accidental fires associated with installations (railways, rubbish dumps, power lines, etc.) exist in almost all countries in the Mediterranean. Identifying the causes of accidental fires in these situations is generally easy. The mechanisms of ignition are referred to as technical measures, yet their prevention is generally poorly considered in the list of available policy and administrative measures.

Most of the countries concerned have differing and often more severe penalties associated with deliberately set fires. In a number of cases - e.g., Portugal and Israel (Rosenberg 1986) - the punishments were made more severe after the countries experienced waves of arson. It has been observed, nevertheless, that the heavier the punishments provided by the law, the more difficult it is to prove arson and the more the courts hesitate to condemn arsonists (Goldammer 1986).

Among the legal provisions that are implemented, two merit special consideration:

1. Punishment for the parties at fault in the case of fire. The majority of Mediterranean countries have a variety of legal instruments to punish the guilty parties in the case of a forest fire. The punishments for deliberately set fires are always much more severe than those for involuntary fire. They range from forced work - e.g., in Morocco (Zitan 1986), Algeria (Grim 1989) and Tunisia (Chandoul 1986) - or jail sentences of only a few months (e.g. in Cyprus) to life imprisonment (e.g. in France).

2. Regulations restricting the right to light fires. Many countries prohibit the use of fire (including smoking) in forests and near their boundaries during the period regarded as high risk, including on privately owned land. Infraction of these regulations is generally punished by way of a fine, which is sometimes very costly. Other countries (Spain, Italy, France, Cyprus) prohibit access to forests both with the aim of prevention and to promote civil safety (to prevent people from being caught in fires) (Goldammer 1986).

<u>Pre-suppression</u>

The weather forecast is used to mobilise means of suppression in advance. From this point of view, the American fire behaviour model is often used, for example in Israel (Woodcock 1994) and Spain (Commission on Agriculture and Fisheries 1993). The countries also make a considerable effort to establish weather stations that record temperature, humidity, wind speed and wind direction.

Monitoring from lookout towers is a very widespread technique. For example, it is used in the Syrian Arab Republic (Abou Samrah 1995), Israel (Rosenberg 1986), Jordan (Government of Jordan 1986), Turkey (Serez 1995), former Yugoslavia (Government of Yugoslavia, SFR, 1986) and Morocco (Zitan 1986). This activity is usually supplemented by ground patrols made up of foresters with a good knowledge of the area, for example in Tunisia (Chandoul 1986), Morocco (Zitan 1986) and Algeria (Grim 1989). In many countries (Algeria, Croatia, France, Spain), private planes are used to monitor forest areas on days of highest risk (Government of Portugal 1998). In some cases, visual assessment is complemented by automated infrared systems (Government of Spain 1992). Interestingly, statistics reveal that, in spite of sophisticated monitoring systems, fires are often first reported by local inhabitants.

The management of forests for the prevention of fires is carried out in a very similar way 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).

These infrastructures, which may date back several years, often do not take into account recent technical developments such as the advent of large water carriers or air-tanker helicopters.

Several countries (France, Israel, Italy, Spain and Turkey) have adopted provisions in their forestry laws aimed at obligating forest owners to clear the undergrowth along roads and/or railways (Goldammer 1986). Undergrowth clearance can be interpreted as much as a measure of prevention (aimed at preventing ignition) as a measure of pre-suppression (aimed at making roads safe). In France, the law requires owners to clear the undergrowth within a perimeter of 50 m around their house (self-protection). In reality, this provision is rarely applied because of the expense of such an operation and the opportunity cost of this form of land use.

Prescribed burning in France and in the areas surrounding the Mediterranean

Prescribed burning is a land management technique that uses fire in a planned and supervised way over a predefined zone, without endangering adjacent areas. This ancient practice, often employed to clear land for agricultural and pastoral use, has become a modern tool for wildfire prevention by controlling the level of combustible materials on the ground. As prescribed burning has developed, further benefits have emerged. Prescribed burning is also used to maintain landscapes and open environments, to improve the habitat of fauna (particularly hunted species), to regenerate land in the aftermath of farming and to carry out thinning operations. In addition, the firefighters who perform the prescribed burns benefit from the excellent fire control training opportunity it affords.

National and international research programmes are currently studying the effects of prescribed burning on the different components of the Mediterranean and mountain ecosystems (the different strata of plant communities, the surface layers of the soil, the fauna and biodiversity). A recent study "Prescribed burning as a tool for the Mediterranean region: a management approach" was prepared by the EU-funded project *Fire Torch*, which brought together research teams from Portugal, Spain, France, Italy, and Greece.

Suppression

Recent data on this subject are very difficult to obtain in terms of human, physical and financial resources. For the air tankers (planes or helicopters), which are fewer and thus easier to record than vehicles, a range from 1 to 4 in absolute value can be seen between two neighbouring countries: a little more than 30 units in Portugal against 140 in Spain. In terms of relative value, on the other hand, the five countries of southern Europe all have approximately one airborne unit per100 000 ha of Mediterranean forest. International cooperation in this area is therefore a high-priority issue and a concern of the European Union (EU) (Goldammer 1994, Delattre 1993).

Regarding suppression strategy, information is even more difficult to obtain. In France, the objective is an initial attack in less than ten minutes. This strategy is based on anticipation: according to the risk level, vehicles are placed close to forested areas so air tankers are already airborne when a fire is reported. Under particularly unfavourable conditions, it has been shown that initial attack needs to be carried out even more quickly in order to be effective.

A good knowledge of the area is necessary to optimise fire fighting. In countries with a high density of inhabitants close to the forest, mapping does not appear to be necessary (e.g. in North Africa). In European countries that have undergone a strong rural depopulation, it is an absolute necessity and is subsidised by the EU (European Parliament 1994). Sometimes the military authority is the owner and exclusive user of the maps, so it is difficult for the forest services to access the data.

Conclusion

With an average of 50 000 fires and 600 000 ha burned, the Mediterranean basin represents a significant wildland fire region in the world. Several estimates indicate that the total annual cost of wildland fire prevention and suppression in the region is more than US$1 billion (LeHouérou 1987).

Despite the efforts made, particularly in the countries of southern Europe, fire threats are far from stabilising and even appear to be increasing significantly in most of the 23 countries studied.

Nowadays, forest statistics are better than 20 years ago. Some of the fire increases observed might in fact be due only to an improvement in the reliability of the data.

The growth in the area of forest, particularly of unmanaged forest in most of the countries to the north of the Mediterranean, increases the likelihood of larger fires now than in the past. This is the case for some recent fires in Spain.

The policies adopted until recently have given priority to firefighting (and the preparations for related activities, i.e. pre-suppression) to the detriment of efforts aimed at prevention or control. Paradoxically, in some areas, successful prevention efforts have resulted in an increase of fuel loads and therefore an increase of the risk of more severe wildfires that will be difficult to control.

Policies affecting wildland fires are numerous and many of them are beyond the direct control of the forest sector. National and international politics that influence political changes and create tensions, unrest, and war, and policies that determine rights of ownership and use of land, employment, urbanisation and agricultural subsidies all have an impact on wildland fires. It is in these areas that a "solution" to the forest fire problem may be found.

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The section "Prescribed burning in France and in the areas surrounding the Mediterranean" was authored by Eric Rigolot (France)

4.2.1 Fire Situation in Cyprus

By
Georgios Hadjikyriakou
Department of Forests, Ministry of Agriculture, Natural Resources and Environment, Nicosia, Cyprus

Introduction

Cyprus is the third largest island of the Mediterranean with a total land surface of 925 148 ha. It is divided into three geomorphological zones with a variable topography: (1) the Pentadactylos mountain range, including the Karpass peninsula; (2) the Troodos mountain range; (3) the Mesaoria plain. The central core of the two mountain ranges is characterized by steep slopes, vertical cliffs, deep gorges, narrow streams, and long mountain ridges, while their foothills are characterized by rounded, trapezoid or conical hills, usually with steep lateral slopes. The Mesaoria plain is situated between the two mountain ranges and it is characterized by extensive flat areas and trapezoid or conical hills, usually with steep lateral slopes.

The climate is Mediterranean, characterized by hot dry summers from mid-May to mid-September and rainy, rather changeable, winters from November to mid-March, which are separated by short autumn and spring seasons of rapid change in weather conditions.

The main forest vegetation types are:

- Forests, dominated by *Pinus brutia, Pinus nigra* ssp. *pallasiana, Cupressus sempervirens, Platanus orientalis,* and *Alnus orientalis*, with an understorey of tall and low shrubs, sub-shrubs and herbaceous vegetation;

- Other wooded land (Maquis and Garrigue), dominated by *Juniperus phoenicea, Ceratonia siliqua, Olea europaea, Pistacia lentiscus, Arbutus andrachne,* and *Quercus coccifera* ssp. *calliprinos*;

- Other land (Phrygana), dominated by sub-shrubs, dwarf shrubs of about 50 cm high, like *Sarcopoterium spinosum, Thymus capitatus, Cistus* spp. etc. These forest vegetation types cover 42.32 percent of the total area of Cyprus (see Table 4-5).

Acording to the witness of Eratosthenis, quoted by Strabo, «… *in ancient times the plains (of Cyprus) were thickly overgrown with forests and therefore were covered with woods and not cultivated* …» (Geography of Strabo 1989). The reverse course for the forests of Cyprus started from the Copper Age onwards. The existing fragmentary evidence shows that they suffered from heavy and uncontrolled fellings, till the end of the Turkish occupation in 1878, but there is no supporting evidence of the contribution of fire to the devastation of the forests. Despite the lack of evidence about fire occurrence, we can not exclude fire from the factors which contributed to their devastation. After the arrival of the British in 1878, the Colonial Government introduced the Forest law. Since that time, extensive areas were officially

declared as State Forest lands and their protection was based on the existing laws. The great majority of the State Forest lands consist of large areas with definite boundaries. Although these lands had better management, wildfires continued to affect them in a serious way. The causes were mainly: opposition to the forest laws, political upheavals, the conversion of forest land into agricultural land, grazing, and the production of fuel.

During the last decades, due to the gradual abandonment of the agricultural lands, extensive privately owned areas are covered with forest vegetation. Recent surveys showed that 17.58 percent of the total area of Cyprus are State Forest lands and 24.74 percent are privately owned forested lands (see Table 4-5). The privately owned forested lands consist of numerous small holdings, which belong to many individuals scattered all over Cyprus. Hence, they are not officially declared as forest lands. The protection of these areas is not based on an integrated fire management plan and periodically they are subject to destructive fires. The main fire causes are: agricultural activities such as the burning of stubble and grasses, hunting, recreation activities, military exercises, and burning of rubbish.

Table 4-5 Percentage of the forest vegetation types based on the total area of Cyprus.

Forest vegetation type	State forest lands (%)	Private and other lands (%)	Total
Forest	11.44	7.11	18.55
Maquis and garrigue	3.87	9.76	13.63
Phrygana	1.62	7.87	9.49
Other uses	0.65	-	0.65
Total	**17.58**	**24.74**	**42.32**

Wildfire was one of the major agents that contributed to the degradation of forests in Cyprus. There is a strong relationship between wildfires and forest degradation. The impacts get worst if wildfires are accompanied by grazing. However, the ecological role of wildland fires is different depending on the vegetation type. In *Pinus brutia* forests that represent more than 90 percent of the forest vegetation type, the understorey vegetation is totally burned after a fire and bare soil is exposed - a condition that favours natural regeneration. However, a number of other factors intervene that make successful natural regeneration a rare case. These factors include: destruction of mature stands which are able to produce viable seeds, the time period of fire whereby cones are destroyed as they ripen, and the weather conditions during the first summer which affect seedling mortality. In the other forest vegetation types (other wooded land and other land), natural regeneration is successful since coppice and seedlings are easily established. However, the fire frequency along with the slope of the area, grazing practices, and weather conditions can lead to severe degradation of these other vegetation types.

Major wildfire impacts

During the 1990s, the fires affected both privately owned and government owned lands. Some of these fires had serious impacts on climax vegetation. Juniper trees, which are destroyed by fires, do not regenerate. Basic recolonization is usually of poorly diversified shrub associations (*Cistus* spp.). Fires affect not only forest vegetation but also agricultural crops;

and they can cause mental anguish to people and affect their welfare. Productive forests were destroyed resulting in serious economic losses; planted trees and natural regeneration were destroyed; the removal of plant cover in combination with torrential rainfall resulted in excessive erosion and lost of soil; sites of ecological value, sites of aesthetic value, and important flora and fauna species were affected; agricultural crops and other properties were seriously damaged; part of the natural habitat of the endemic moufflon (*Ovis gmelini ophion*) was affected, and a few animals were burned. Furthermore, houses were partly or totally destroyed; and a Forest Officer lost his life during fire fighting, being the first human loss during the fire history of Cyprus since 1878.

Wildfire database

During the decade 1990–1999, the number of wildfires, in the State Forest lands was 196 and the area burned was 7 770 ha. For detailed information see Table 4-6. For the time being there are no records for the privately owned forested areas. For comparison with the 1980s Table 4-7 shows the wildland fire database for the period 1980-1989.

Table 4-6 Wildfire database of Cyprus for the period 1990-1999.

The data include fires that broke out in State Forest Land, or fires that broke out in the private land within a distance of 1 km from the boundaris of the State Forest lands (the responsibility for suppression of these fires lies under the Department of Forests). Note: Fires in occupied areas are not included.

Year	Total No. of Fires on Forest, Other Wooded Land, & Other Land No.	Total Area Burned on Forest, Other Wooded Land, & Other Land ha	Area of Forest Burned ha	Area of Other Wooded Land and Other Land Burned ha	Human Causes No.	Natural Causes No.	Unknown Causes No.
1990	11	314	9	305	2	2	5
1991	14	32	27	5	12	1	1
1992	18	9	9	0	9	6	3
1993	16	1 344	69	1 275	14	1	1
1994	35	1 021	178	843	9	18	7
1995	24	309	70	239		4	14
1996	20	284	116	168	6	4	11
1997	19	397	167	230	4	2	13
1998	19	4 056	566	3 490	9	3	7
1999	20	4	3	1	4	5	11
Average	20	777	121	656	8	5	7

Table 4-7 Wildfire database of Cyprus for the period 1980-1989.

Year	Total No. of Fires on Forest, Other Wooded Land, & Other Land No.	Total Area Burned on Forest, Other Wooded Land, & Other Land ha	Area of Forest Burned ha	Area of Other Wooded Land and Other Land Burned ha	Human Causes No.	Natural Causes No.	Unknown Causes No.
1980	23	97	97	-	11	0	12
1981	23	16	16	-	15	0	8
1982	32	30	30	-	12	7	13
1983	21	15	15	-	4	2	15
1984	14	233	160	73	4	3	7
1985	15	856	46	810	11	1	0
1986	21	870	467	403	10	5	5
1987	18	153	96	57	12	0	6
1988	26	2 554	750	1 804	20	1	4
1989	19	65	15	50	12	2	4
Average	21	489	169	320	11	2	7

Operational fire management system and organization

In Cyprus, the Government is responsible for fire prevention, detection, and suppression of wildland fires. Wildland fires in Cyprus are distinguished into two categories: (1) the fires occurring in State Forest land or in the privately owned lands, situated within a distance of 1 km from the boundary of the State Forest land; (2) the fires occurring in the privately owned lands, other than those specified in category (1):

Category 1: The responsible Authority is the Department of Forests of the Ministry of Agriculture, Natural Resources, and Environment. The prevention, pre-suppression, and suppression of these fires are the exclusive responsibility of this Department. Furthermore, the Department is responsible for the detection of forest fires within the State Forest land using a well-organized detection system. All these actions are achieved through the organization and integrated fire management plan of this Department.

Category 2: The prevention and suppression of these fires are based on an action plan. According to this plan, the technical aspect of the suppression of these fires is shared between the Fire Brigade Service of the Ministry of Justice and Public Order and the Department of Forests and other Government Services. The preventive measures and the co-ordination of the suppression are handled by the District Officers of the Ministry of Interior. The detection of the fires in this category is based partly on the detection system of the Department of Forests and partly on other means.

The municipalities and the communities do not participate in the fire management activities, apart from the co-operation, to some degree, with the authorities involved. Furthermore, an effort is made to create voluntary groups in the various communities. There is no fire research program at the present time.

Use of prescribed fire in order to achieve management objectives

The whole structure of the forested areas of Cyprus, in connection with the structure of the agricultural lands, does not favour prescribed fire in order to achieve management objectives. In exceptional cases, the Department of Forests applies prescribed fire in areas adjacent to the State Forests only for the purpose of reducing the fire hazard. Farmers, too, use prescribed fire as a management tool to clear and prepare the land for agricultural purposes.

Sustainable land-use practices employed in the country to reduce wildfire hazards and wildfire risks

Unfortunately, land-use practices are not employed as a tool to reduce wildfire hazards and risks. However, other measures are taken to reduce the wildfire hazards in the State Forest land, including fuelbreaks along ridges, around picnic and camping sites, along boundaries, the construction of roads, the pruning of roadside vegetation and plantations, and thinning operations. Wildfire risks are addressed through education and information, law enforcement, and patrolling.

The reduction of wildfire hazards in the privately owned-forested areas is not sufficient because the owners are not willing to co-operate. The government or the local communities construct fuelbreaks in a few places, but not as a part of agricultural, pastoral, or recreational activities. Wildfire risks are addressed through general education, information programs, and law enforcement.

Public policies concerning fire

Effective protection of the State Forests against fires is provided by the Forest Law. The responsible Authority for the enforcement of this law is the Department of Forests. Fire suppression is governed by a Fire Suppression Action Plan. Furthermore, the Forest Policy and National Program provide for the protection of forests and ecosystems and the suppression of fires in the State Forests. More specifically, the Forest Policy includes these objectives: (a) protection against fires and other hazards, (b) conservation of ecosystems, flora, fauna, and heritage, and (c) watershed management and protection.

The protection of the areas of the countryside, which are not covered by the Forest Law, is covered under the provisions of the Law for the Prevention and Control of Fires in the Countryside. A Fire Suppression Action Plan is in force and the responsible Authority for the co-ordination and administration of the firefighting effort is the District Officer of each District. Fire management in these areas faces many problems. For overall fire management preparedness, it is important to have an integrated set of measures covering prevention, detection, pre-suppression, and suppression.

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4.2.2 Fire Situation in Greece

By
Gavriil Xanthopoulos
Natural Resource Technologies Consulting, Athens, Greece

Introduction

Greece occupies an area of 130 875 km^2 at the southern tip of the Balkan Peninsula. Its population is approximately 10 million. Nearly half of these people live in the two largest cities, Athens and Thessaloniki. The country's topography is mostly mountainous. Small plains and valleys are interspersed between the mountains and constitute the main agricultural areas.

The climate is typically Mediterranean over most of the country, with warm-to-hot summers and mild winters. Usually there is little or no rain in the summer, but quite often the dry season may start as early as April and continue well into fall. Only some of the wettest locations at high elevations have more than 100 days of rain per year. Yearly precipitation may exceed 2 000 mm at those locations. On the other hand, the southeastern tip of Greece, including the area around Athens and the Cyclades Islands in the Aegean Sea, has annual precipitation of less than 400 mm, which is one of the lowest in Europe.

Mean yearly temperature varies between 14.5^o C in the north and 19.5° C on the southernmost island of Crete. Absolute minimum temperatures at high elevations in northern Greece may approach -25^o C. In the summer, maximum temperatures occasionally reach 42-45^o C at various inland locations. The influence of the Mediterranean Sea that surrounds the country on three sides helps moderate the air temperature in most areas.

Forest vegetation

Forest vegetation reflects the climate and topography of the country as well as the soil condition, which is generally quite poor. The influence of man, active in the area for more than three thousand years, is also reflected in the distribution and usually degraded condition of the forests. Drought-resistant evergreen broadleaved species *(Quercus ilex, Laurus nobilis, Ceratonia siliqua, Olea europaea, Arbutus* spp., *Cistus* spp., *Erica* spp., *Pistacia* spp. etc.), mostly forming shrublands, and pine trees (*Pinus halepensis, Pinus brutia, Pinus pinea*, etc.) occupy the lower elevations in the country (up to 300 m above sea level in northern Greece and 800 m in the south). Next, there is a zone of deciduous broadleaved species (*Quercus* spp., *Fagus orientalis, Castanea vesca*, etc.) and conifers (*Pinus nigra, Pinus maritima, Cupressus sempervirens, Abies cephalonica*, etc.) that reaches 900 m in the north and 1 200 m in the south. At higher elevations, up to 1 800 m, vegetation includes cold-tolerant broadleaved tree species (such *as Fagus silvatica, Fagus moesiaca, Quercus sessiliflora, Quercus pedunculata, Populus tremula, Betula pendula, Fraxinus excelsior, Acer* spp., etc.) and conifers (*Pinus nigra, Pinus silvestris, Abies alba*, etc.). Finally, at elevations up to 2 200 m, vegetation mostly includes cold tolerant conifers and a few broadleaved species (*Picea excelsa, Abies alba, Pinus peuce, Pinus silvestris, Pinus heldreichii, Populus tremula, Sorbus aucuparia*).

Forest flammability is generally high. The most flammable types are the pine forests (*Pinus halepensis, Pinus brutia*) and the shrublands at the lower elevations, by the sea, in the middle and southern part of the country. This vegetation is also adapted to fire either through cone serotiny (pines) or re-sprouting (shrubs).

Area, distribution and condition of forests

Approximately 19.8 percent of the surface area of Greece (about 2.5 million hectares) is characterized as forested. However, less than half of this area is covered by "tall" timber producing forests. Most of these are conifer forests. “Low” or coppice forests that mostly produce fuelwood occupy the remaining forest area. In addition to these forested areas, there are approximately 3.2 million ha of partially forested areas and shrublands (occupied mostly by evergreen broadleaved shrubs). There are also approximately 1.9 million ha of grasslands and phrygana (mostly areas covered by the low spiny shrub *Sarcopoterium spinosum* or the non-spiny shrub *Flomis fruticosa*). These shrublands and grasslands are mainly used for grazing.

Destruction of forests started in ancient Greece and took place mainly near highly populated areas, such as Athens and Crete. Clearing of land for use in agriculture, woodcutting for shipbuilding, housing construction, fuelwood and grazing, together with repeated fires through the centuries, resulted in a sharp decrease in the forested area to its present size. The remaining forests are in poor condition. As a result, less than a quarter of the total wood production of Greek forests is suitable for construction and industrial purposes; the rest is used for fuelwood. Many areas have been denuded to such an extent that reforestation is practically impossible.

Most forests in the country are state-owned. Nowadays all forests (state and private) are managed on a "sustained-yield" basis. A management plan is required for all forests larger than 100 ha. At higher elevations, where population density has decreased in the last three decades as people moved to the cities, signs of a forest comeback have started to appear. This is due to reduced grazing and abandonment of marginal agricultural lands. However, at lower elevations close to the sea, the forests are still in danger due to the ever-increasing frequency of wildfires.

Grazing of sheep and goats, traditional in the country, in recent times has become one of the main causes of wildfires. Many areas are overgrazed. Shepherds react to the resulting reduction of feed for the animals by burning to stimulate new growth of shrubs and grasses. However, as desirable plants gradually disappear due to overgrazing, the fire frequency increases. The soil is unprotected by vegetation when it is burned every few years and is soon eroded, resulting in lost site productivity and finally desertification. Often, when an area is denuded, fire is then used to convert forest land into grazing land, and the vicious cycle is repeated.

Forest fire statistics for Greece

The Greek Forest Service, which was responsible for forest fire fighting in Greece until 1997, collected statistics on forest fires for many decades. The data for 1990-1999 are given in Table 4-8. Forest Service officers at the local offices were required to file a report on each forest fire in their area. The Fire Service, which has become responsible for forest firefighting since 1998, has continued this practice. However, the statistics collected, especially in regard to the number of fires recorded, is not comparable between the two sets of data. Table 4-9 shows the wildland fire database for the period 1990-2000 for comparative purposes.

Table 4-8 Wildfire database for Greece for 1990-2000.

Year	Total No. of Fires on Forest, Other Wooded Land, & Other Land No.	Total Area Burned on Forest, Other Wooded Land, & Other Land ha	Area of Forest Burned ha	Area of Other Wooded Land and Other Land Burned ha	Human Causes No.	Natural Causes No.	Unknown Causes No.
1990	1 322	38 593	21088	17 506	643	44	635
1991	1041	23 574	8 000	15 574	539	18	484
1992	2 042	66 346	23 194	43 153	868	61	1113
1993	2 406	54 049	24 200	29 849	860	61	1485
1994	1 763	57 908	21 157	36 751	742	84	937
1995	1 438	27 203	9 645	15 541			
1996	1 757	24 000	7 592	17 718			
1997	3 117	41 839	16 760	25 178			
1998	9 282	112 802					
1999	10 723	19 050					
2000	14650	167006					
Average	**4502**	**55988**	**16 455**	**25 159**			

Source: Forest Service of Greece.

Table 4-9 Wildfire database for Greece for 1980-1989.

Year	Total No. of Fires on Forest, Other Wooded Land, & Other Land No.	Total Area Burned on Forest, Other Wooded Land, & Other Land ha	Area of Forest Burned ha	Area of Other Wooded Land and Other Land Burned ha	Human Causes No.	Natural Causes No.	Unknown Causes No.
1980	1 207	32 965	4 355	28 610	850	20	337
1981	1 159	81 417	38 653	42 764	719	12	428
1982	1 045	27 372	10 843	16 529	695	48	302
1983	968	19 613	10 907	8 706	545	38	385
1984	1 284	33 656	12 018	21 639	917	18	349
1985	1 442	105 450	48 631	56 819	804	38	600
1986	1 082	24 514	10 109	14 404	596	30	456
1987	1 266	46 315	13 605	32 711	659	63	544
1988	1 898	110 501	27 370	83 131	898	49	951
1989	1 284	42 364	23 600	18 763	599	48	637
Average	**1 264**	**52 417**	**20 009**	**32 408**	**728**	**364**	**499**

Source: Forest Service of Greece.

Number of fires and burned area per year

The number of fires and the burned area per year are two of the most important forest fire statistics. Table 4-8 summarizes these two statistics for Greece from 1990 to 2000 and Table 4-9 does the same for the 1980-1989 period.. In a long-term fire analysis (1955-1999) Xanthopoulos (2000) showed that forest fires in Greece burned, on the average, 11 500 ha per year until 1973. Approximately a third of this area was forests. The remaining two-thirds was brushland and grassland of various types. A sharp increase in both the number of fires and the size of burned area was recorded in 1974. At that time, an ever-increasing trend was established that has continued until today.

The increase in the number of fires in the 1980s can be attributed to many factors, one of which is a more thorough effort to record forest fires. However, a large part of this increase is due to increased activity of people in or near the forests and forested lands. New roads and an ever-increasing number of private cars offered easier access to forests. The number of people leaving the cities in the summer, seeking cooler places along the coastline and in the mountain villages for their vacation, has gradually increased, increasing the probability of accidental fires. The same is true for international tourists who visit Greece every summer at the peak of the fire season. Most importantly, a trend that started in the late 1970s of building secondary summer housing along the coasts, accelerated in the 1980s. These housing areas were poorly planned, creating a troublesome urban/wildland interface and increasing the risk of wildfires. The activities of these people, starting with construction and continuing with their everyday activities (barbecues, burning debris, parking cars on cured grass, etc.) have very frequently resulted in accidental wildfires.

Another factor that led to increased forest arson in the 1980s and 1990s is a spin-off of the demand for land to build secondary summer housing and to develop tourist accommodations. This demand far exceeded supply, as most forests in Greece are public and protection laws make change –of use very difficult. Furthermore, an exact and complete land register has only recently started to be developed. The lack of land for development drove prices extremely high, and the lack of a land register and poor law enforcement allowed those burning forested lands to illegally occupy them. On more than one occasion, many years later, when the number of people in this category became too many and it was evident that it would be practically impossible to evict them from the areas they had occupied, the Greek government legalized these occupied lands. In this way, a motive for arson was created.

In the 1990s the number of fires continued to increase due to an increase in the factors mentioned. While in the 1980s the average yearly number of fires was 1 264, during the 1990-1997 period this average increased to 1 848 fires per year. A new factor contributing to this increase was fires started by immigrants illegally entering the country, mainly from Albania. Using forest trails high in the mountains, they started fires to cook or to warm up at night and did not properly extinguish them when leaving in the morning.

After 1997 the number of fires, as shown in Table 1, nearly tripled. This is because the Fire Service, which became responsible for forest fires in 1998, records every call that they respond to, while the policy of the Forest Service until 1997 was to only record those fires on which they had to take action because they were spreading toward or burning on forest lands.

As the number of fires increased in the late 1970s and 1980s, the size of the yearly burned area also started to rapidly increase. The larger number of fires, however, was not the only reason. Fires gradually became more difficult to fight due to the changing condition of forests and to the

development of urban/wildland interface zones as described above. An example of the latter is the worst fire in 1981, one of the most difficult fire-years in the 1980s, which burned a large area and some houses in the northern suburbs of Athens.
The forests became denser and dead downed woody material increased as a result of the abandonment of villages, especially in mountainous areas, in the 1950s, 1960s and 1970s, as people immigrated abroad or moved to the big cities, mainly Athens. As dead forest biomass, especially around villages, stopped being used for cooking and heating as in the past, either due to decreasing population or due to replacement by oil, electricity and propane gas, it started building-up, making forests flammable right to the first houses of each village. Fires reaching there, rather than slowing down, now often burn homes and occasionally kill people.

In the past, resin collectors contributed to safer forests (mainly those of *Pinus halepensis* and *Pinus brutia*) by maintaining forest trails for their need to move from tree to tree and by managing the forest, selectively removing older trees that were useless to them in order to favour regeneration. Furthermore, since the forests were their field of production and the storage area of their product, they exercised maximum fire prevention care and immediately suppressed any fire. Unfortunately, by the end of the 1970s this profession started to slowly die out as the demand for resin decreased, income dropped, and no subsidies were provided by Greek or European Union policies.

The Forest Service, which is responsible for managing Greek forests, lacks personnel and resources and has concentrated on the management of the more valuable (in regard to timber quantity and quality) high-elevation forests. When the number of resin collectors decreased in the low-elevation pine forests, these forests were practically left unmanaged. Subsequently, they became more flammable, often impenetrable, and fighting fire in them became much more difficult.

In the 1980s, the burned area exceeded the 100 000 ha mark twice. Unfortunately, and in spite of a steep increase in firefighting means, this negative record was repeated again in 1998 and 2000: Unofficial figures bring the area burned in 2000 to more than 150 000 ha.

Another interesting fire statistic is presented in Table 4-10, which summarizes the frequency of forest fire occurrence by month, as a percent of the total, for 1964-1994. As shown in this table, July, August and September are the three busiest months for the firefighting forces, as is the case for most countries with Mediterranean climates in the northern hemisphere.

Table 4-10 Average percentage of fires occurring each month, based on the data from 1964-1994.

Month	Percent of fires
January	1.4
February	2.8
March	4.3
April	3.6
May	2.6
June	6.5
July	15.7
August	24.4
September	22.8
October	12.7
November	2.6
December	0.8

<u>Damage to life and property caused by forest fires</u>

Information on loss of life and property in Greece due to forest fires is sparse until 1960. A notable exception is a large wildfire, in a *Pinus halepensis* forest with shrub understorey, that burned 3 000 ha in 1916 at Tatoi, Attica. The forest belonged to the crown. That fire killed three people, injured 300, and destroyed the summer palace and other buildings. Since then, and until the end of the 1970s, there were only a few, isolated cases of property damage due to wildfires. Only a few small, temporary, mostly wooden country buildings used by woodsmen and shepherds are known to have burned in this time period.

From 1950 to 1976 there was no recorded loss of human life due to forest fires. In 1977, however, the death of a nun trapped by a wildfire in a monastery on Mount Parnassos signalled the beginning of a new era in which the loss of human life due to wildfires became quite common. Two people where killed in the 1970s and 37 people were killed in the 1980s, nine in 1985 and 12 in 1988, two of the worst fire years. The reported fatalities included both firefighters (Forest Service personnel, soldiers and volunteers) as well as people trapped by fire. In addition to these fatalities, there were also many injuries during firefighting and the deaths of five Air Force pilots who fly the CL-215 waterbombers that have been used in aerial fire suppression operations since 1973. Four CL-215s were destroyed during the 1980s. There were also losses in the squadron of smaller, single-seat PZL M-18 Dromader planes used since 1984.

In the 1990s, the death toll was similar to that of the 1980s. A fire on the island of Ikaria in the Aegean Sea cost the life of 13 civilians, creating a nationwide sensation. Three Army pilots and seven firefighters were killed in 1994 when their UH-1H “Huey” helicopter hit power lines on its way back from a fire. Three Fire Service firefighters and a volunteer were trapped by flames and died near Athens in 1998. A fast-moving fire on the island of Chios in 1999 overcame three firefighters. In 2000, seven people died in one night near the Greek border with Albania when a fast-moving fire burned through their sparsely populated villages.

In 1993 and 2000 two more CL-215s were lost, killing four more pilots. The loss of a PZL M-18 on Corfu Island in 2000 cost the life of another pilot.

The development of urban/wildland interface areas, either due to the expansion of large cities or the development of summer housing started in the mid 1970s. This trend coincides with both the increase in forest fire numbers and burned area and the beginning of significant losses in life and property. Loss of property, for a time, was surprisingly low, even during fierce wildfires. This was due to the traditional use of non-combustible building materials for houses (concrete, bricks, stone, clay roof tiles, etc.). Wood is seldom used for building houses, except for certain specific uses (roof support frames, doors, windows, etc.) (Xanthopoulos, 1988). However, as the number of houses increased it became impossible for the firefighting forces to defend all of them. As a result, property damage started to rise sharply. For example, a fierce fire in 1981 in the northern suburbs of Athens resulted in the complete destruction of at least two houses and partial damage to others. These losses are surprisingly low in view of the fact that this fire burned approximately 1 120 ha in a wildland/urban interface area in addition to 550 ha of *Pinus halepensis* forest. Fifteen years later, in 1995, a large fire (6 500 ha) on Penteli Mountain near Athens burned about 100 buildings, many of them homes. A second large fire on Penteli Mountain that burned 7 500 ha in 1998 resulted in the destruction of even more homes.

Damage to property due to wildfires is not limited to buildings. Significant economic losses each year result from forest fires that burn agricultural land adjacent to forests. Especially important are orchards, which can be completely destroyed. Production losses include the long

time necessary for reestablishment of the burned orchards. Olive (*Olea europaea*) orchards, in particular, are especially susceptible to complete destruction due to their flammability.

Forest fire causes

Data on fire causes after 1998 are quite unreliable. However, the causes are not expected to be drastically different from those indicated by the data previously collected by the Forest Service. Table 4 summarizes the distribution of fire causes in two difficult fire years and also presents average values for 1968-1993 (Kailidis and Xanthopoulos, 1991; Markalas and Pantelis, 1996).

As Table 4-11 shows, few forest fires in Greece are due to natural causes. Lightning-caused fires account for less than 3 percent of the total number of fires. The rest of the fires with known causes have been categorized as accidental, due to negligence or deliberately started.

A large number of fires are reported due to "unknown causes". Most of them are suspected to be deliberately set. For example, 428 out of the 602 fires listed in the "unknown causes" category for 1988 are suspected to belong in the "deliberately set" category; 241 of them were probably started for rangeland improvement. A significant number of the "unknown causes" fires may be lightning caused, since determination of this cause can be quite tricky when a fire remains dormant and undetected for some time after a storm and then starts spreading when conditions became favourable.

In terms of importance, arson fires for land use change, fires from burning garbage dumps and power line fires are considered to be the worst since they usually occur on days with high wind. Shepherd fires are also a problem, both due to the cost of fighting them and to the fact that even when firefighting efforts are successful the shepherds merely wait for more difficult conditions and try again.

Table 4-11 Distribution (%) of fire causes in Greece in 1988, 1993 and 1968-1993.

Cause	1988 (%)	1993 (%)	1968-1993 (%)
Lightning	**2.6**	**2.7**	**2.4**
Accidental causes	**3.1**	**2.5**	**3.5**
1. Power lines	0.8	1.0	0.7
2. Engine sparks	1.4	1.0	2.1
3. Use of explosives	0.3	---	---
4. Army target shooting	0.6	0.5	0.7
Negligence	**27.3**	**28.2**	**36.0**
1. Stubble burning	11.8	9.0	16.0
2. Cigarettes	4.0	2.1	8.7
3. Garbage burning	4.2	2.5	3.9
4. Workers in the countryside	3.8	4.0	3.2
5. Recreationists and hunters	1.6	0.8	1.3
6. Other known causes	1.9	9.8	2.9
Deliberate causes	**33.5**	**18.0**	**29.2**
1. Rangeland improvement	15.6	6.6	---
2. Arson			
a. Bad intentions (for profit, revenge, etc.)	17.2	10.8	---
b. By people with reduced mental capacity			
-- Children	0.3	0.2	---
-- Pyromaniacs	0.2	0.2	---
-- Other psychopaths	0.2	0.1	---
-- Mentally retarded	0.0	0.1	---
Unknown or suspected causes	**33.5**	**48.6**	**28.9**
Total	**100.0**	**100.0**	**100.0**

Fire management organizations

As mentioned earlier, the organization responsible for forest fires in Greece until 1997 was the Forest Service. Then, in May 1998, a new law gave responsibility for forest firefighting to the Fire Service, which until then was responsible for municipal fires but also contributed to forest firefighting. Most aspects of fire prevention remained with the Forest Service. However, the Forest Service was weakened significantly as approximately one fourth of its personnel as well as many pieces of equipment (vehicles, radios etc) were moved to the Fire Service.

The Fire Service clearly failed to control fires in 1998. Forest fires proved to be quite different from municipal fires and this, combined with a difficult fire season, brought the burned area to 112 802 ha. After that, the Fire Service started an effort to prepare for forest firefighting by training its personnel, preparing pre-suppression plans, acquiring appropriate equipment (e.g.

1-inch hoses, backpack pumps, appropriate boots, etc.), creating additional fire stations in previously poorly protected areas and adopting the use of a daily fire danger prediction map through the summer months. The government supported the Fire Service fully, both morally and financially, ordering, among other measures, ten new CL-415 Canadair waterbombers and allowing contracting of additional private aircraft in 1999.

The fire season of 1999 was a relatively mild one and, with the help of the contracted aircraft, the results were extremely good. However, weaknesses still remained. In 2000, predicting a difficult fire season, the Fire Service contracted an even larger number of aircraft. Unfortunately, the difficulty of the fire season often exceeded the capacity of the firefighting forces and on some difficult days fires burned rampant. The burned area, exceeded 160 000 ha, thereof 110 000 ha forest lands and the rest mainly agricultural. At least seven people (civilians) were killed, and hundreds of houses were lost to fires. Two Canadair CL-215 pilots and one PZL M-18 pilot were killed when their planes crashed during firefighting. Also, one Fire Service officer died as a result of injuries sustained by a rock falling down on of the slopes of Taygetos mountain near Sparta in Peloponnesus. Many weaknesses in firefighting became evident and a new circle of improvements is clearly imminent.

The permanent personnel of the Fire Service reached 10 000 in 2000. Four thousand seasonal employees were added in the summer. There were 1 100 fire trucks, including a variety of types and capacities, while the number of support vehicles (vans, mini-buses, off-road 4x4s, etc.) reached 200. Additionally, in fires in the wildland/urban interface, water trucks from the local authorities were available to bring water to the fire trucks.

State-owned aircraft, which are operated by the Greek Air Force, include four new CL-415 Canadair waterbombers, 14 older CL-215 waterbombers, 20 PZL M-18 Dromader airplanes (after the loss of one CL-215 and one M-18 in 2000) and 6 Grumman biplanes. Up to two C-130 cargo planes fitted with MAFFS retardant delivery systems can be added to this fleet on short notice. Two Army Chinook CH-47D helicopters with Bambi buckets are also made available when needed.

In 2000, the state aircraft fleet was augmented by three contracted CL-215s and 16 heavy-duty helicopters (one Ericsson Air-Crane, three MI-26s, 4 MI-8s, and eight Camovs). Seven of the Camov helicopters were contracted in mid-July after the first disastrous fires of the season. Also, two light helicopters were contracted for coordination of firefighting forces.

The Fire Service has a top-down structure, one of the few state organizations that has not been broken down into a regionalized structure in the 1990s. This is a significant advantage for the task of firefighting as it allows easy mobility of resources between regions and good central coordination. On the other hand, the military-like structure of the Fire Service that includes Army-equivalent ranks often results in firefighting being coordinated not by the best qualified people but by those of the highest rank.

The Forest Service, which is responsible by law for fire prevention, has been broken down into a regional structure without provision for effective central coordination. This change has reduced its effectiveness, or at least made it completely variable by region. Also, its personnel have been reduced in number after approximately 1 000 forest guards were transferred to the Fire Service. The remaining personnel are generally over 45 years old and retiring at a high rate. The number of employees is less than 2 800. This is clearly inadequate to successfully carry out all the forest management and protection tasks required. Range management is minimal and prescribed burning is only discussed at a theoretical level. Lack of appropriate

funding for fire prevention work (e.g. fuel management) further compounds the problem. With poorly managed forests and fire prevention work practically non-existent the fire problem in the country, in meteorologically difficult fire seasons, can only be expected to worsen.

Another state organization that is involved in forest fires is the General Secretariat for Civil Protection (GSCP). It was established by law in 1995 and was gradually organized in the late 1990s. It is part of the Ministry of Interior and has a coordinating role for all types of disasters, including forest fires. In this area it provides support to the Fire Service from local authorities (Regions, Prefectures, Municipalities) in regard to equipment (water trucks, dozers, etc.) and auxiliary personnel. Its planning includes, among other things, coordination for evacuations.

Both the Fire Service and the GSCP try to mobilize volunteers who will help in firefighting and other disasters. The effort to date has had some results, and the number of volunteers offering serious help in firefighting is estimated at around 500 people.

The Army generally supports firefighting activities upon request. During difficult periods soldiers undertake the task of surveillance and mop-up of fires that have been brought under control, reducing the number of firefighters needed to remain on site for this task. It also offers heavy equipment such as dozers upon request.

The police are also involved in forest fire related activities. They provide traffic control and, when needed, coordinate the evacuation of villages, camps, etc. They also cooperate with the Fire Service in arson investigations. The police often undertake surveillance of suspects in order to catch them in the act of arson.

Conclusions and Outlook

As can be seen, Greece has a serious fire problem. The money and effort devoted to coping with the problem is significant. Actually, especially in terms of aerial forces, the country should probably be rated first in the world on a per-hectare-protected basis. However, the poor results of the last few years clearly indicate that there is need for improvement, especially in regard to knowledge and organization of the whole effort. Also, there is a clear need for better managed forests and serious fire prevention efforts. The latter objective requires an upgraded and modernized Forest Service that will work in close cooperation with the Fire Service.

The Fire Service needs to improve its initial attack capability. Indirect attack should be recognized as a true alternative to direct attack and the methods for its application should become part of basic training at all levels. The ground forces should learn to rely less on the help of aerial forces because they may be unavailable under certain conditions (extreme winds, too many simultaneous fires, night hours). Also, the Fire Service should evaluate its pre-suppression planning in order to maximize the effectiveness of its forces, especially the aerial ones. Good cooperation with the Forest Service is clearly necessary.

Some of the improvements needed in the Forest Service are:

- Hiring new permanent, competent staff.
- Changes in structure that will permit a central policy to be applied in all regions, including training in modern concepts and methods.

- A mission for active rangeland management by the Forest Service and education of shepherds.
- Active management of the low-elevation Aleppo and Brutia pine forests.

Of course, these changes in the Forest Service will require additional funding compared to the current low level, but in the long term will reduce damage and the cost of firefighting . Otherwise, given the natural flammability of Greek forests, the problem may become worse in spite of spending more money in the battle against forest fires.

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Source

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4.2.3 Fire Situation in Italy

By
Anna Scipioni, Bernardo Gabellini, Franco Caldari & Roberto Cavalensi
State Forestry Corps, Forest Fire Protection Service and Statistics Office, Rome, Italy

Introduction

This report has been compiled by the Global Fire Monitoring Center (GFMC) based on a publication by Scipioni et al. (1999) which covers the fire situation in Italy in the extreme fire year 1998. Recent (1999 and 2000) and long-term fire data provided by Leone (2000) have been added to Table 4-12 and Table 4-13.

The 1998 Fire Season

Between 1 January and 31 December 1998 9 450 forest fires occurred in Italy, burning a total area of 155 553 ha (73 017 ha wooded and 82 536 ha non-wooded).

Compared to 1997, forest fires worsened greatly, not so much in terms of the number of fires but more in terms of the area burned. The area burned in 1998 was 60 percent higher than the average of the last ten years. The total area affected by forest fires was three times that of 1995 and 1996, despite the increase in defence capabilities. This increase depended largely on the weather conditions. In fact, the summer was the hottest and muggiest of the last six centuries. Compared to the same period, the wooded area affected by fires increased by four times during 1998.

Fire statistics for the 1980s and 1990s are given in Table 4-12 and Table 4-13. In the fire season 2000 more than 10 000 fires burned close to 100 000 ha of forest and other land (Leone 2000).

Table 4-12 Wildfire database for Italy, 1980-1989.

Year	Total No. of Fires on Forest, Other Wooded Land, & Other Land No.	Total Area Burned on Forest, Other Wooded Land, & Other Land ha	Area of Forest Burned ha	Area of Other Wooded Land and Other Land Burned ha	Human Causes No.	Natural Causes No.	Unknown Causes No.
1980	11 963	143 919	45 838	98 081			
1981	14 503	229 850	74 287	155 563			
1982	9 557	130 456	48 832	81 624			
1983	7 956	212 678	78 938	133 740			
1984	8 482	75 272	31 077	44 195			
1985	18 664	190 640	76 548	114 092			
1986	9 398	86 420	26 795	59 625			
1987	11 972	120 697	46 040	74 657			
1988	13 588	186 405	60 109	126 296			
1989	9 669	95 161	45 933	49 228			
Average	**11 575**	**147 150**	**53 440**	**93 710**			

Source: Corpo Forestale dello Stato

Table 4-13 Wildfire database for Italy, 1990-1999.

Year	Total No. of Fires on Forest, Other Wooded Land & Other Land No.	Total Area Burned on Forest, Other Wooded Land, & Other Land ha	Area of Forest Burned ha	Area of Other Wooded Land and Other Land Burned ha	Human Causes No.	Natural Causes No.	Unknown Causes No.
1990	14 477	195 319	98 410	96 909			
1991	11 965	99 860	30 172	69 688			
1992	14 641	105 692	44 522	61 170			
1993	14 412	203 749	116 378	87 371			
1994	11 588	136 334	47 099	89 235			
1995	7 378	48 884	20 995	27 889			
1996	9 093	57 988	20 329	37 659			
1997	11 612	111 230	62 775	48 455			
1998	9 540	155 553	73 017	82 536			
1999	6 932	71 117	39 362	31 755			
Average	**11 1163**	**118 576**	**55 305**	**63 266**			

Source: Corpo Forestale dello Stato

What is alarming about theses statistic is the average area per fire, which went from 9.6 ha per fire in 1997 to 16.3 ha per fire in 1998. Extending the observation period from January to December, the Regions most affected in terms of the areas affected by fire are consistently Calabria, Sicily and Sardinia. In Calabria, each fire burned an average of 49.2 ha, in Sicily 40

ha and in Abruzzo 32.2 ha, values clearly over the national average registered in the past 10 years.

Forest fires in the last decade have taken on a specific characteristic in terms of time and space, affecting the regions of Southern Italy and the Tyrrhenian Coast mainly during the summer, and the Alpine regions in the winter. Also, in 1998 climate influenced the winter fires: wind and a lack of precipitation made the vegetation prone to fire.

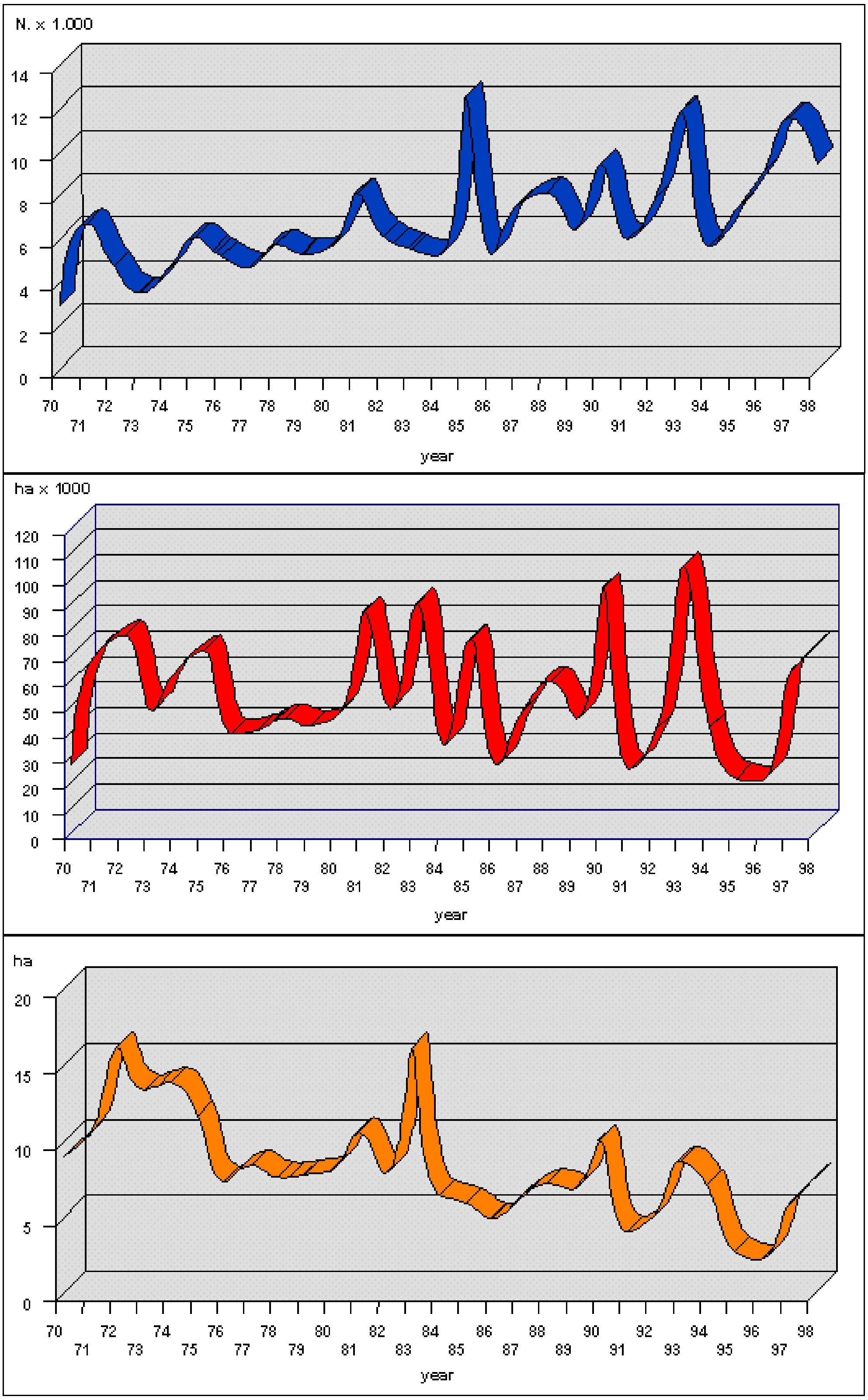

Figure 4-4 Long-term fire statistics of Italy for the period 1970-1998.

Annual number of fires (upper), area affected by fire (middle) and average area burned per fire (lower).

Table 4-14 Forest fires in 1998 in Italy by Region.

Regions	Number of fires	Area burned by fire		
		Wooded (ha)	Non-wooded (ha)	Total (ha)
Piedmont	459	2 096	2 224	4 320
Aosta Valley	17	51	13	64
Lombardy	455	3 320	1 430	4 750
Trentino A. A.	102	148	34	182
Veneto	101	454	235	689
Friuli V. G.	118	401	264	665
Liguria	499	3 879	2 118	5 997
Emilia Romagna	207	855	622	1 477
Tuscany	567	3 640	1 040	4 680
Umbria	138	608	346	954
Marches	83	589	85	674
Latium	439	2 746	2 218	4 964
Abruzzo	77	1 407	1 069	2 476
Molise	44	121	375	496
Campania	533	2 150	1 564	3 714
Puglia	345	2 424	1 858	4 282
Basilicata	263	1 362	1 317	2 679
Calabria	1062	17 446	26 537	43 983
Sicily	894	16 543	19 243	35 786
Sardinia	3 137	12 781	19 943	32 724
TOTAL	**9 540**	**73 017**	**82 536**	**155 553**

Table 4-15 Numbers and area burned by forest fires in Italy in 1998 by month.

Month	Number of fires	Area burned by fire		
		Wooded (ha)	Non-Wooded (ha)	Total (ha)
January	68	158	149	307
February	647	2 717	2 746	5 463
March	1 045	6 650	3 221	9 871
April	240	930	209	1 139
May	88	263	116	379
June	874	9 448	9 852	19 300
July	2 637	33 471	49 520	82 991
August	2 469	15 459	11 601	27 060
September	1 076	2 306	3 451	5 757
October	117	658	293	951
November	164	521	199	721
December	115	436	1 179	1 615
Total	**9 540**	**73 017**	**82 536**	**155 553**

Over the winter period of 1998 (January to March), 1 760 fires occurred, burning 15 641 ha (of which 9 525 ha was wooded). This was over ten percent of the wooded area that burned in the entire year of 1998. During the winter, the Regions most affected were, in decreasing order: Liguria, Lombardy, Piedmont and Tuscany in terms of total burnt area.

In the summer period of 1998, characterised by prolonged drought, very high temperatures, strong winds and tourism mobility, fires were particularly serious: 6 182 fires occurred (65 percent of the annual total) burning a total area of 115 808 ha (74 percent of the annual total). Of the total area burned, 51 236 ha were wooded (70 percent of the annual total).

The Regions most affected were in decreasing order: Calabria, Sicily, and Sardinia, both for the total area burned and for the wooded areas burned. Again, Sardinia, Calabria and Sicily were the Regions that registered the largest number of fires in the summer period (Figure 4-5).

Most fires began on Sundays, confirming the trend of previous years. Highest damages are caused by fires larger than 100 ha. In 1998, such fires affected 54.2 percent of the wooded areas. More than half of all fires (52.1 percent) were fires smaller than one hectare.

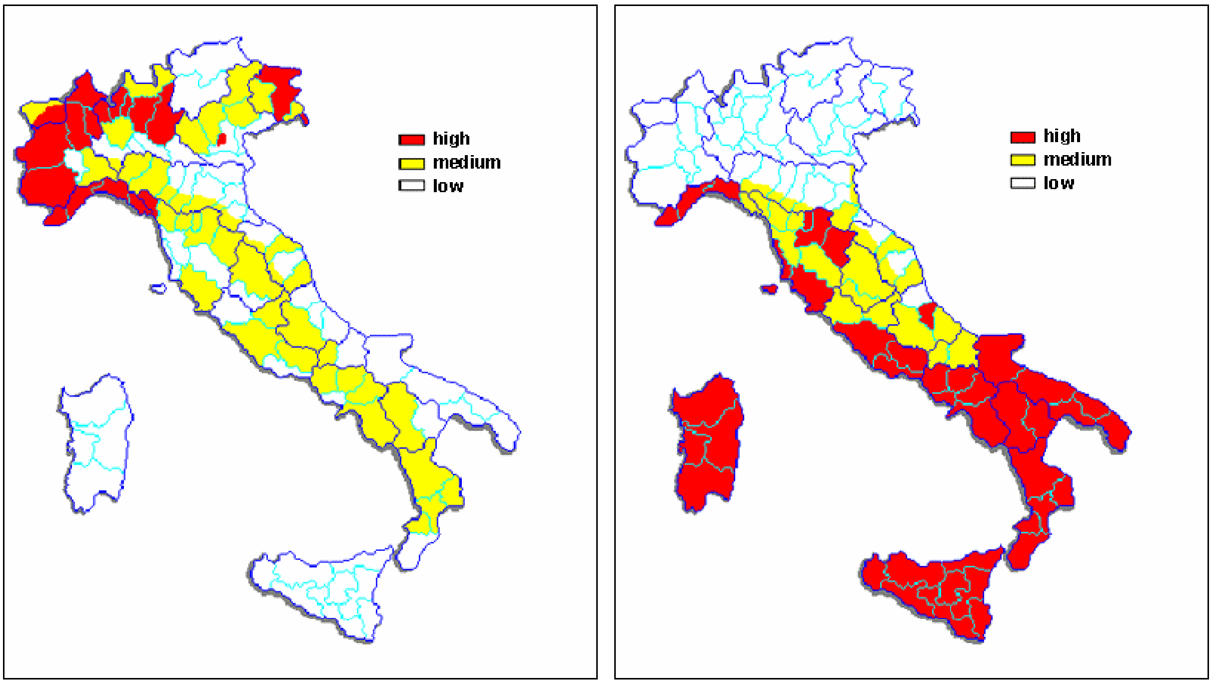

Figure 4-5 Left: Areas at risk of forest fires in the first quarter (1989-1999 period). Right: Areas at risk of forest fires in the third quarter (1989-1999 period).

The worst fires of 1998 took place in winter time in Lombardy and Veneto, and in summer time in Calabria and Sicily. In all cases, the average area per fire was extremely high. In Calabria, 17 fires averaged over 1 500 ha in size.

Table 4-16 Number of fires greater than 100 ha affecting wooded land.

Regions	Number of fires	Average area burned per fire
Piedmont	2	370
Lombardy	7	275
Friuli V.G.	1	210
Liguria	7	238
Emilia Romagna	2	235
Tuscany	5	376
Marches	1	225
Latium	2	174
Abruzzo	2	615
Campania	2	345
Puglia	4	175
Calabria	17	1 853
Sicily	31	549
Sardinia	20	827
Total	**103**	**730**

The analysis of the percent of fires by the orographic type of territory shows that 61.9 percent of fires developed in the hillsides and 30.9 percent in the mountains (Table 4-17). The majority of fires developed at altitudes under 1 000 m a.s.l. Only 7.4 percent of all fires occurred at altitudes >1 000 m a.s.l.. Conditions of moderate or strong winds favoured the spread of 50.3 percent of fires, while conditions of very strong winds affected one percent of the fires.

Table 4-17 Percentage of wildfires by orographic type of terrain and by altitude in 1998.

Flat lands	6.4	up to 500 m altitude	53
Hillsides	61.9	from 500 to 1000 m	39.6
Mountains	30.9	from 1 000 to 1500 m	6.6
Mountain tops	0.08	over 1 500 m	0.8

Causes of Fires in 1998

The analysis of the causes of fires in 1998 confirms again the high incidence of human responsibility for the destruction of wooded areas affected by fires, as 76.3 percent of the fires were due to deliberate action (Table 4-18). The analysis of accidental causes in 1998 showed that most fires that occurred for these reasons were due to agricultural activity, followed by cigarettes and matches. All of these causes contributed significantly to the starting of fires. Recreational activities had a modest effect, confirming that civic responsibility is continuously increasing among citizens.

Table 4-18 Causes of fires in Italy, 1998.

Causes	Percentage of the number of forest fires	Percentage of the total area burned
Natural	1	0.3
Deliberate	50.7	73.7
Accidental	12.6	8.1
Unknown	35.7	17.9

Fire Impacts

In order to put out fires in 1998, 155 752 interventions were necessary in all of Italy (excluding Sardinia), including forestry personnel, fire brigades, police, armed forces, workers and volunteers.

Unfortunately, fires took victims again in 1998. Six people, specifically one worker, one member of the police force, two citizens and two arsonists died in Piedmont, Emilia Romagna, Calabria and Sicily. Eighty-one people were injured, of which 34 were workers and volunteers, 12 were forestry personnel, 13 firemen, 14 from local organizations and 8 arsonists.

The global evaluation of damages in terms of wood destroyed and costs related to the restoration of forest cover amounted to approximately 90 billion lire, of which 60 billion lire for fires caused deliberately.

Fire Suppression

In 1998, the Unified Aircraft Operations Centre co-ordinated the use of aircraft for 1 400 fires, carrying out 2 787 missions for a total of 6 464 hours of flying time. The Aircraft Operations Centre of the State Forestry Corps, which has its own helicopters for firefighting, deploys 13 Breda Nardi NH500 helicopters and nine Agusta Bell 412. The helicopters of the State Forestry Corps operate both in preventive activities and in direct intervention on fires by dropping water from helibuckets. The helicopters of the State Forestry Corps are also used for the transportation of personnel and firefighting equipment. They are also used to coordinate work of other firefighting aircraft sent by the Unified Aircraft Operations Centre of the Civil Protection Forces. The helicopters of the State Forestry Corps are stationed at the main base of Roma–Urbe Airport. They are repositioned over the national territory in high risk periods to reduce as much as possible the time required to respond to fires.

Public policies

The government of Italy supports international cooperation:

- Activation of Resolution No. 3 of the Ministerial Conference of Strasbourg related to the protection of forests in Europe against fires (Strasbourg, 1990). The objective of this Resolution is to facilitate and encourage the exchange of information on forest fires as homogeneous as possible among the various signatory states, with the intention of jointly promoting and improving preventive measures.

- In the sphere of the activities of the ECE/FAO committee, concerning forestry statistics.

- In the Mediterranean basin, in the context of the work of the CFFSA/CEF/CFPO committee regarding Mediterranean forestry questions, "*Silva Mediterranea*" and the International Centre for Mediterranean Agronomic Studies.

Legal references in the forest fire sector are published by Scipioni et al. (1999).

References

Scipioni, A., Gabellini, B., Caldari, F. & Cavalensi, R. 1999. Forest fires in Italy 1998. *Int. Forest Fire News* 21: 60-70.

Leone, V. 2000. Italy: fires in summer 2000. *Int. Forest Fire News* 23 (in press)

4.2.4 Fire Situation in Lebanon

By
Michel Bassil
Ministère de la Agriculture, Chiya-Beirut, Lebanon

In Lebanon the term forest fire indicates all fires occurring in forests, wildlands, pasture land, and even in agricultural land. Most fire-prone forests are stands of *Pinus pinea, Pinus brutia* and *Quercus* spp. Wildfires occur both on private and government property.

The fire database in Lebanon was established in 1998. However, data are available for the last four years (Table 4-19). It is often difficult to determine the causes of fires. It is known, however, that in addition to the traditional and well known causes, the war in Lebanon and all military actions sometimes cause forest fires.

Table 4-19Number of forest fires and area burned in Lebanon, 1996 and 1999.

Year	Number of fires	Area burned (ha)
1996	79	468.5
1997	127	437.12
1998	195	6 091.27
1999	188	1 521.04

The civil defence, which operates under the Ministry of Interior, is responsible for fire control. The Ministry of Agriculture is also establishing a fire protection unit. It operates a radio communication system for early warning, 26 vehicles for initial attack and four engines with a tank capacity of 7 500 litres. The Lebanese army has three functional *Bambi* buckets that were used for the first time in 2000.

To reduce forest fire risk, the Ministry of Agriculture directs people, NGO’s and municipalities to prune forest trees at least near roads to reduce "ladder fuels" and prevent crown fires.

The Ministry of Agriculture intends to build water reservoirs next to forests and lookout towers for fire detection.

Source

Bassil, M. 2000. The forest fire situation in Lebanon. *Int. Forest Fire News* 23: 87.

4.2.5 Fire Situation in Morocco

By
Royaume Du Maroc, Ministère de l'Agriculture, du Développement Rural et des Pêches Maritimes, Ministère Chargé des Eaux et Forêts, Direction de la Conservation des Ressources Forestières, Rabat, Chellah

Introduction

The forests of Morocco cover about nine million hectares, thereof forest formations (natural forests, plantation forests) cover 5,814,000 ha and alfa grasslands 3,186,000 ha.
The forest formation is dominated by broadleaved species (63.09 percent or 3,668,000 ha), followed by conifers (20.14 percent or 1,171,000 ha) and secondary species (16,17 percent or 974,894 ha). Forest plantations cover 530,000 ha out of which 75 percent (395,500 ha) are part of the forest fund (*domaine forestier*).
The forest land is an open space where access (except rare exceptions) is free. The population, especially those living at the forest edge, lives from subsistence economy (using forests for construction wood and firewood needs, the gathering of various non-timber forests products, and pasture). Consequently, forests are under a very strong human pressure and are overexploited.
This human pressure increases the fire risk, since Moroccan forests, as all Mediterranean forests, are extremely flammable, particularly during the summer season when the fuel moisture content of plants is very low.

Impacts of forest fires since 1990

The impact of fires is especially severe on forests. The economic loss of forest products (timber and NTFP) are estimated with 18 million DH (dirham) per year (approx. 1.8 million $US). However, considering the semi-arid climate conditions of a country like Morocco the impact on watersheds, soils, and biodiversity is much more significant.

Forest fire statistics

<u>Number of fires and burned area</u>

The fire situation during the years 1960 to 1999 is shown in Table 4-20 (number of forest fires and area burned) and Table 4-21 (Classification of areas burned by vegetation type and by burn size class for the period 1994-1999).

Table 4-20 Number of forest fires and area burned in Morocco between 1960-1999.
(For fire causes: see text)

Year	Total No. of Fires on Forest, Other Wooded Land & Other Land No.	Total Area Burned on Forest, Other Wooded Land & Other Land ha	Area of Forest & Other Wooded Land Burned ha	Area of Other Land Burned ha
1960	59	1 247		
1961	105	2 470		
1962	122	757		
1963	138	1 042		
1964	329	3 633		
1965	124	1 447		
1966	108	2 686		
1967	150	1 493		
1968	110	923		
1969	191	3 131		
1970	207	4 497		
1971	124	1 779		
1972	168	1 497		
1973	168	1 871		
1974	213	2 643		
1975	293	4 866		
1976	184	2 220		
1977	217	3 212		
1978	348	5 358		
1979	162	1 661		
1980	211	6 278		
1981	233	1 782		
1982	182	2 049		
1983	338	11 289		
1984	211	1 461		
1985	249	1 969		
1986	183	1 857		
1987	145	678		
1988	277	4 222		
1989	156	822		
1990	179	2 118		
1991	247	3 965		
1992	182	2 579		
1993	187	3 078		
1994	417	6 072	3 675	2 397
1995	528	7 018	3 950	3 068
1996	220	1 185	498	687
1997	391	3 845	2 325	1 520
1998	416	1 855	1 501	354
1999	385	1 688	775	913

Note: The data 1994-1999 in the columns “forest burned” and “other wooded land and other land burned” were taken from Table 4-21. The FAO standard table format therefore has been changed.

Table 4-21Classification of areas burned by vegetation type and by burn size class for the period 1994-1999.

	1994	**1995**	**1996**	**1997**	**1998**	**1999**
1- Area burned (ha):						
* Forest and other wooded land	3 675	3 950	498	2 325	1 501	775
* Secondary species, alfa and herbaceous layer	2 397	3 068	687	1 520	354	913
- Total area affected by fire:	6 072	7 018	1 185	3 845	1 855	1 688
2- Number of wildfires by size class (S):						
S ≤ 1 ha	52	189	111	174	246	226
1 < S ≤ 5 ha	58	154	58	137	106	109
5 < S ≤ 10 ha	102	99	29	35	33	22
10 < S ≤ 20 ha	32	41	8	17	9	17
20 < S ≤ 50 ha	51	14	10	12	14	7
50 < S ≤ 100 ha	12	19	3	9	6	1
100 < S ≤ 500 ha	8	9	1	6	2	2
500 < S ≤ 1000 ha	1	3	-	1	-	1
S >1000 ha	1	-	-	-	-	-
Total number of fires	**417**	**528**	**220**	**391**	**416**	**385**

<u>Fire causes</u>

It is often very difficult to determine the fire cause for the following essential reasons:

- The very criminal character of the fire setting: according to Moroccan forest law, arson is heavily fined, even with imprisonment.
- The multitude of stakeholders in forest areas: commercial loggers, logging sites, shepherds, farmers, bee-keepers, distillers of aromatic essences, illicit charcoal production, and hikers.

In general, the analysis of information and reports on forest fires allows the following conclusions:

- more than 50 percent of the fires are of unknown cause,
- more than 40 percent of the fires are due to negligence (burning of fields, honey collection, camp fires, vehicle exhausts, cigarettes, etc), and
- 10 percent of the fires are intentional (destruction of the forest for gaining agricultural land. This is the primary cause of forests fires in the north of the country).

It should be noted that the high percentage of fires of unknown cause renders it difficult to set up an efficient prevention policy.

Operational system for forest fire management

<u>Technical measures</u>

The current national forest fire policy is based on the following principles:

- Reinforcement of the forest fire prevention, detection, and suppression. Within this framework, the Ministry of Forestry started following activities:

  - Procurement and installation of the following equipment
    - Nine rapid intervention units (with 12 vehicles) with the prospect of setting up 52 units (104 vehicles)
    - 14 400 km of forest access roads
    - 1 700 km of fuel breaks
    - 123 fire watchtowers
    - 1 800 radios

  - Signing of a convention with the Royal Gendarmerie for the use, in the event of a fire, of four turbo-prop planes with a water capacity of 1500 to 2000 litres each.

  - Establishment of a network with persons in charge of the Civil Protection equipment

- Creation of water points in forests

- Reinforcement of the fire surveillance system in the summer season by involving contributions of all partners responsible for forest fire fighting

- Intensification of public awareness campaigns targeting the general public and forest dwellers, especially on preventive fire measures

- Intensification of preventive silviculture programs

- Adoption of a master plan for fire prevention and forest fire control in the Rif area (see appendix attached).

Administrative activities

Before the fire season, the administration starts a certain number of activities, such as:

- Sensitising and education of the public and the forest users by:

  - the organisation of conferences on fires in central meeting places of the population in order to explain the precautions to be observed in the event of fire use in order to avoid a spreading into the forest.
  - The design and broadcasting of television and radio spots, films and posters

- The reinforcement of forest surveillance

- The implementation of stand-by watch service at all levels, i.e., for the nine Regional Directions of the Forest Service, 49 Divisions (*Arrondissements*), 49 Primary Forest Development Centres, 198 secondary Forest Development Centres, and 685 Forest Districts

- The organisation of forest worker camps dispersed in the forest with the objective to have personnel available for the rapid interventions (initial attack) in the event of a fire

- The co-operation with other administrations charged with the forest fire management, namely:

  - The Ministry for Public Labour which takes part in the installation of traffic signs "ATTENTION - FIRE DANGER" along the routes which cross the forest
  - The Railway Service (ONCF) which carries out the weeding along the railway which cross forest areas. It informs the passengers of the consequences of arson (throwing burning cigarette out the train windows)
  - The civil aviation which helps to detect fires by its pilots
  - The National Electricity Office (ONE) which weeds the area under powerlines crossing forest areas
  - The Royal Gendarmerie with its aircraft (water helicopters and air tankers) takes care on the application of the law with regards to fire use

- The National Meteorological Service which takes part at the development, during the fire season, of a special bulletin on the fire danger that is sent to the Forest Services to put the field staff in maximum alarm when the weather conditions are fire prone.

Use of prescribed fires in forestry

This possibility is not considered for the moment by the Ministry of Forestry due to the fact that the understorey, woody debris after logging operations and the grass in forests are used by local people and their livestock.

Practices employed to reduce the fire hazard and fire danger

Participation of the various services

According to Article 48 of the *Dahir* of 10 October 1917 on the *Conservation and Use of Forests* the local administration has the right of requisition and has the responsibility for all fire fighting activities. The personnel of the Forest Service, regardless their rank, must be at its disposal, assisting with all its technical know how.

This obligation does not, however, inflict on the following fundamental principle: *"Any forester who notes or learns of a fire event, even a small fire, within his forest district, has the duty to reach immediately the site, while taking all necessary provisions to inform the local administration and his direct superior."* The forestry personnel of the Forestry Service is obliged to remain on the fire site until the final mop-up.

Fire prevention

Starting on 1 June of each summer the following fire prevention measures are activated:

- Posting (activation) of all fire lookouts

- Checking of all telephone lines, telephone sets, and radios

- Setting up a 24-hrs telephone or radio watch service at the following levels:

– Regional Directorate of the National Forestry Commission
– Provincial Service of the National Forestry Commission and *Arrondissement*
– Primary Forest Development Centres
– Secondary Forest Development Centres
– Forest districts

A list of the foresters in charge of the watch service on these levels will be submitted to the Ministry of Forestry. A list of telephone numbers will be also prepared. The list must contain the telephone numbers of all levels of the same forest *Arrondissement* (from the Head of the *Arrondissement* to the district forester). The telephone numbers of the forest engineers who have an official telephone in their residence will be included. If a radio station has replaced the telephone, the frequency will be indicated.

For the entire fire season, day and night, every forester must be on constant radio or telephone alert. Thus, all ranks, as soon as they leave their office, have to inform the Forest Service where they go and how to be reached. The vacation of foresters has to be co-ordinated within the same CDF (Forest Development Centre) and the same forest district and organised to ensure permanent presence:

– For the same rank, the personnel on leave has not to exceed one third of the total staff strength during the months August, July and September; and half for the other months.
– The forester takes leave only at the same time as its trooper.
– All personnel in leave have to be in reach by telephone or radio.

- Particular surveillance of the forests, rounds taken of the officer in charge, in the forest and along the perimeters to enforce the interdiction of lighting fires in the forest and within a distance of 200 m zone and of camp within a 100 m zone (Article 1 and 2 of the Decree of 4 September 1918 relating to the measures to be taken in order to prevent forest fires).

- Also the enforcement of the Article 4 of the above quoted Decree by the residents regulating the post-harvest burning of fields.

- Intensification of control of forest exploitation sites, in particular of those where char-coal production is authorised in summer, in order to enforce strictly the application of the authorisation (permanent surveillance of charcoal kilns and ground clearing in a radius of 30 m the kilns and around camp sites, etc). Strict application of the suspension of charcoal production where it was not authorised, for the period of 15 June to 31 October.

- Maintenance and provision of forest camps (for maintenance or opening of forest access roads, tree nurseries and planting sites for afforestations) to be distributed as widely as possible and staffed moderately (10 workers for each working site). These crews are acting as first rapid intervention crews equipped with hand tools, thus being able to respond quickly and effectively.

- Checking the hand tool deposits (caches) at the forest stations and provision of additional hand tools for fire fighting. The Districts and C.D.F., having road graders and vehicles with water tanks, will assure regular maintenance and will position these strategically for rapid intervention in fire fighting.

- Weeding of the fire breaks along certain roads and tracks.

- Control of work by the National Railroad Service (ONCF) of weeding along railways in forests or within 200 m (Article 3 of the Decree of 4 September 1918 on measures against forest fires).

- Protection of the wood and cork deposits:

  – Weeding to bare soil between the piles and around the piles at a distance of at least 30m by also using the guards of the deposits remunerated from an autonomous budget
  – Maintaining a permanent team for guarding and intervention
  – Maintaining, permanently, fire fighting hand tools in good operating condition including, particularly high-capacity fire extinguishers, filled water cisterns, water pumps, pipes, backpack pumps, shovels and Pulaski tools, and tractors with trailers

- During the month June the organisation of conferences (*conférences d'incendies*) organised by the forest engineers, in the presence of the local administrative authorities and if required by the vigilance committees in order to remind the instructions for forest fire prevention, the obligation for everybody to take part in fire fighting and the attention of the repressive provisions of the *Dahir*, dated 10 October 1917. The forest personnel must attend these conferences. A report will have to be sent to Ministry of Forestry. In exceptional case where a conference was not organised by a forest engineer, a justification has to be formulated.

<u>The role of the forest personnel in the case of a fire</u>

Any forester which discovers or learns of a fire warns his direct supervisor as soon as possible. It is necessary to warn at the same time (or to assure that he will be informed) the representative of the local authority. The forester goes then immediately to the fire site. It is an absolute duty for the district forester to reach the fire, if it is within his or neighbouring district. He will gather the workers of the logging sites in the vicinity and all available people around in order to set up a first rapid intervention fire crew which will either engage in firefighting or support any ongoing fire fighting activities.

The chief of the C.D.F. must, as soon as a fire is reported to him, alarm the chief of the *Arrondissement* or his assistant who must alarm on his turn the central service immediately. The head of the C.D.F. will take all necessary steps to sent in all fire fighting equipment (hand tools, water supply, vehicles) and will go then immediately to the fire site in order to take part, under the direction of the local administrative, in the fire fighting.

When the fire is controlled, the administrative authority must ensure efficient mop-up by the fire fighters.

Public policies affecting forest fires

The Moroccan forest legislation contains provisions relating to the prevention of forest fires as well as to the punishment of the arsonist.
<u>Preventive measures</u>

There are provisions which regulate the use of fire in forest or in the vicinity during the period of summer dryness, between 1 July and 31 October:

- charcoal production is prohibited at the logging sites of legal forest exploitations;
- dwellings, structures, camp sites, logging sites located inside the forest or in a radius of 200 m in where fires is used for domestic or industrial purposes, must be surrounded by a fire break of 25 m width removed from any understorey or herbaceous vegetation;
- burning of brush, grass, standing fields, between 1 July and 31 October, cannot be carried out by private individuals on areas located at a distance less than 4 km from the forest boundary;
- from 1 November to 30 June, no burning of standing vegetation can be carried out within a radius of 500 m starting from the forest boundary without preliminary authorisation.

<u>Punitive measures</u>

Both the Moroccan penal code as well as the forest law envisage rather heavy sanctions against arsonists. The Moroccan legislation distinguishes between voluntary and involuntary fires. First case is punished as a crime. Any person who refuses to fight a fire is punished by law.

Outlook and perspectives

The perspectives relate to:

- The elaboration of a regional master plan for forest fires protection:

  - to analyse and evaluate the requirements for basic equipment taking into account the defence of values at risk;
  - to direct the selection of fire fighting equipment by the various partners charged with fire fighting (services responsible for landscape management and direct fire fighting);
  - to establish a set of priorities in the choice of forest areas to be equipped and forest fire fighting infrastructures to be realised in function of values at risk.

- The establishment of Civil Protection intervention units at the level of forest provinces, specialised in forest fire fighting and equipped with suitable hardware.

- The utilisation of the C-130 planes of the Air Force, water dropping equipment for large fire fighting operations in order to reinforce the park of Turbo-thrush planes used by the Royal Gendarmerie.

- Creation on the level of all Forest Development Centres (52) of support units (forest fire crews) for initial attack equipped with 600 litres tank vehicles.

- The installation of a network of automatic weather stations in the principal forest areas by the National Meteorology Service in order to facilitate the calculation of fire risk indices and the fire fighting.

<u>Annex</u>

Master Plan for Forest Fire Prevention and Suppression in the Rif:

Provisions for the 5-year-plan 2000-2004

The following provisions in fire management in the Kingdom of Morocco have been planned for the period 2000 to 2004

Year 2000

- Creation and installation of the first Center of Operations based on the existing facilities of the tree nursery of Ain Rami (Chefchaouen), which will function as provisionally Center of Operations at regional level.
- Acquisition of two new patrol and first intervention vehicles for a dissuasive surveillance in the northern parts of the region.
- Construction of a fire lookout and a water tank with a capacity of 50,000 litres at the forest station of Bouhachem.
- Upgrading of the forest access road to Bouhachem.
- Equipment and training of the first twenty forest fire suppression specialists.

Year 2001

- New development and equipping of the future Regional Center of Operations located in the Province of Tétouan, which will be equipped with a weather station as it is the case of the Center of Operations located at Chefchaouen.
- Construction of four new fire lookouts and two buildings, staffed and equipped, preferably in the Provinces of Eastern Larache and Southern Tétouan.
- Equipping and training of ten fire crews as reinforcements which will be based in the forested zones with a fire detection system.
- Improvement of the existing communication network by the installation of newly procured equipment.
- Acquisition of two heavy fire suppression vehicles for the Provinces of Eastern Larache and Southern Tétouan, zones chosen for the construction of six water points for this year.
- The repair of two water points located in the Province of Tétouan.
- Conservation and repair of the roadway system network, preferably in the territory of Eastern Larache.

Year 2002

- Construction and equipping of the future Provincial Center of Operations for the Province of Larache, including a weather station.
- Construction, equipping and staffing of four fire lookouts and two buildings, which will be located preferably in the Provinces of Northern Tétouan, Chefchaouen and Mokrisset.
- Incorporation of eight fire crews as reinforcements equipped with all necessary means to fight fires. These specialists will receive an appropriate training as well as the remainder of the personnel lately assigned to the Center of Operations. The personnel will be assigned to units that will be equipped with a detection network during this year.
- Acquisition of a new heavy fire extinction vehicle, with all its equipment, intended for the territory of Mokrisset. Five water points will be built in the Provinces of Chefchaouen and Mokrisset.
- Upgrading of forest roads, preferably in the Provinces of Mokrisset and Chefchaouen. The construction of a new runway for aircrafts close to the Provincial Center of Operations of Chefchaouen from where the planes of the Royal Guard will operate.

- Installation of new communication hardware procured during this year.

Year 2003

- Construction and equipment of the Center of Operations of the Province of Tangier. A weather station will be included.
- Construction and equipment of four fire lookouts and two buildings in the Provinces of Bab Berred, Bou Ahmed and Tangier.
- Incorporation of seven new fire crew reinforcements perfectly trained and equipped. These will be deployed in the zones equipped with fire detection systems.
- Acquisition of a heavy fire suppression vehicle equipped with suitable hardware as well as the remainder of the other vehicles already mentioned above. Its personnel will be trained and located in the Territory of Bab Berred, where five water points with a capacity of 50,000 litres will be constructed.
- All means recently deployed to the Centers of operations will be equipped with compatible communication systems.
- The upgrading of the roadway network will be concentrated in the Provinces mentioned above during this year.

Year 2004

- Construction and equipping of the last Center of Operations in the Province of Tétouan, which, once operational, will carry out the tasks of a Regional Center of Operations. Finally, the network of weather stations will be completed and the stations will be interconnected.
- Construction of a helicopter port in the Provincial Center of Operations of Chefchaouen. The precise future rendez-vous points for reinforcement forces of the area will be determined.
- During this last year, three fire lookout towers and annex buildings will be built and equipped in priority in the Provinces of Western Larache and Tangier.
- The last five reinforcements of forest fire crews will be implemented this year in the Territories previously mentioned. As during previous years, the reinforcements will be equipped with all necessary standardized tools and staffing, including training courses.
- The provincial units of Chefchaouen will receive a new heavy fire suppression vehicle and will then be a unit perfectly equipped and trained. There will remain only five water points to be built as scheduled.
- All forest fire suppression forces will be equipped with radio communication equipment.
- During this year, the repair work of the roadway system will be carried out in the Provinces of Tangier and Tétouan.

Acknowledgements

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Source

Royaume du Maroc. 2001. Forest Fire Situation in Morocco. *Int. Forest Fire News* 25.

4.2.6 Fire Situation in Spain

By
Ricardo Vélez
National Forest Fire Service, Ministry of Environment, Madrid, Spain

Introduction

A steadily increasing number of fires and the high intensity of fire seasons every four to five years have marked the last two decades in Spain. A generalised First Attack System supported by aircraft and new technologies have achieved a main goal: more than 70 percent of fires burn less than one hectare. Nevertheless, fuel accumulations on large areas because of rural land abandonment have increased the risk of large fires by lightning. This same socio-economic phenomenon increases the risk of large fires by traditional agricultural and bush burnings. Budgets devoted to fire management attained in 1995 an average in $US5/ha for prevention and $US10/ha for suppression. The protected area is nearly 25 million ha including forest, brushlands and grasslands in the mountains. However, suppression resources are difficult to maintain because of declining public budgets because of the present economic policies in Europe. An in-depth analysis of the situation has been performed by the *Forest Fire Committee* (FFC), the Spanish equivalent to a National Forest Fire Coordinating Group. Two *Red Books on Prevention and Suppression* were approved in 1997. Their approaches to implement new policies are summarised in this paper.

The Red Book of Prevention

This summarised description of the current situation is documented by the National Forest Fire Data Base, started in 1968, when the Forest Fire Law was approved. The Red Book includes a series of tables and graphs for every region in Spain. The number of fires is increasing in the northwestern regions and shows stability in the Mediterranean areas, although it is not decreasing anywhere.

<u>Fire Causes.</u>

Lightning fires in the annual average cause less than ten percent of the fires. However, they are frequently the cause of the largest burned areas. Light fuel accumulations (grass and brush) are the predominant fuels in which most fires start. A classification of fire causes can be established as:

High probability motives in all regions
Agriculture and grazing land burning
Private vengeance

The following probable motives for starting fires were identified in various localities:

- Conflicts related to game hunting rights
- Conflicts related to wildland ownership

- Conflicts related to forest policy: reforestation in communal areas; restrictions of local use in protected areas (National and Natural parks)
- Fires set to chase off wild animals (Wild boars, wolves)
- Fires set to create jobs in firefighting or in reforestation
- Rubbish burning at the tourism areas where the urbanisation process is expanding

Other motives may possibly include:

- Fires set to influence (drop) timber prices
- Fires set for political reasons

A list of Problems and Recommendations

A questionnaire was circulated by the FFC to collect views from all the people concerned with forest protection (central and regional administrations, forest owners, farmers organizations, forest companies, journalists, police, etc.). The analysis of the answers is summarised in Table 4-22.

Table 4-22 Summary of main fire problems and recommendations to solve the problems.

(as recommended by central and regional administrations, forest owners, farmer's organizations, forest companies, journalists, police and other).

Problems	Recommendations
Definition and database of forest fires	- Strict use of the legal definition of a forest fire
Investigation of fire causes	- Training courses on investigation techniques - Permanent crews devoted to investigation
Forecasting fire danger	- Coordination of the weather station networks - Forecasting of lightning storms - Dissemination of forecasts on drought, dry storms, dry winds.
Fuel accumulations in wildlands	- Promoting and supporting economical programs of preventive silviculture - Development of prescribed burning programmes - Coordination of European Union subsidies for crops, livestock and burning (a fire would cancel the subsidy) - Coordination of reforestation of former agricultural land and preventive silviculture - Promoting self protection at the wildland/urban interface - Promoting research on fuel management and fire effects
Fire prevention	- Promoting coordinated programmes of patrolling between the Forest Services and the different police departments - Promoting volunteer associations of local people for patrolling (provision of vehicles and other equipment) - Enforcement of rules on traffic within forests, and on garbage burning
Sensitisation	- Enlarging current propaganda campaigns for urban people, farmers and school children. - Spreading standardised information on forest fires to the media. - Periodical inquiries of the public opinion on forest fire management.

Fire causes and the related prevention programs are defined according to the recommendations of *The Red Book of Prevention* (Figure 4-6).

Figure 4-6 Fire causes and prevention policies in Spain

The Red Book of Coordination

The analysis of the performance of the suppression system is also documented by the National Forest Fire Data Base. The Red Book includes a series of tables and graphs for Spain and for every autonomous region. The average area per fire shows a slight decreasing trend. Although the total number of small fires (< 1 ha) is increasing, the number of fires >1 ha is stable or decreasing in several regions.

The average fire in the northwestern regions is around five hectares; and in the Mediterranean regions it is over ten hectares. Nevertheless, large fires over 500 ha (0.3 percent of the total) burned 45 percent of the total burned surface. In 1994, 79 fires out f a total of 20 000 burned 80 percent of the total burned area.

Dry winds blowing from the continental areas create high danger in the coastal regions. This problem is less serious at the inland regions.

The lookout network is still the basic system, although mobile patrolling has detected an increasing number of fires. This system is working only during the summer fire season (June to October). During the other months, the cooperation of local people is increasing.

Aircraft and infrared sensors are considered of limited use for detection, but very useful for monitoring and transmission of images to the Operation Centres.

By the middle of the 1980s the introduction of helicopters brought a high reduction in the delay of initial attack. Now the response time is less than 15 minutes in nearly 50 percent of fires. Direct attack is the technique in 85 to 95 percent of fires. Firelines prepared by hand tools and dozers are typical of extended attack. Counter fire (backfiring) is used in very few cases, because of limited experience and problems of responsibilities.

The 1990s have seen first expansion and later stability in the number of aircraft involved in firefighting. The state fleet of 20 Canadair aircraft is the core of this use. Agricultural aircraft are still in use in many places, but the big increase has been in the use of helicopters. Crew transportation is their main role, but dropping water and foam is also an important activity. Aircraft are presently operating on 15 percent of all fires.

Problems and Recommendations.

The same procedure described for the Red Book of Prevention was followed for Coordination. Several lists of 30 main problems and recommendations were identified for a general suppression event.

Table 4-23 Summary of main fire problems and recommendations to solve the problems of fire suppression coordination.
(as recommended by central and regional administrations, forest owners, farmers Organizations, forest companies, journalists, police and others).

Problems	**Recommendations**
Function: General plan Limited by the annual budgets.	The need for multiyear plans, adapted according to the budget allocated every year. Coordination between the regional and the central plans. Reports on large fires and on accidents with victims: A systematic input for planning.
Function: Coordinator Procedures and rules non-homogeneous at provincial, regional and central levels, because of the structural diversity of the regions.	Establishing of a common Handbook of Coordination for central support to the regions and for border operations. Designing a model Operations Center, according to the present technologies. Auditing the regional communications systems to improve their compatibility. Standardizing the information flow to the media.
Function: Director of a fire Lack of a comprehensive legal definition of this job.	Updating the legislation supporting a certification system based on training courses and real experience. Documenting all decisions by written operations plans. Covering responsibilities by a general insurance. Increasing the number of Mobile Units for Meteorological and Communication Support, receiving images from the air observation aircrafts.
Function: Planning of operations Lack of written operation plans, including forecasts of fire behaviour. Lack of cost control mainly in large fires. Excessive use of direct attack with water in all circumstances. Structural fire services, with responsibilities also in forest fires, are to never counterfire (backfire) even in large fires.	Establishing a common Handbook for Operations Planning. Analysis of cost/efficiency according to previous rules to verify the correct use of the suppression resources.
Function: Operations Multiplicity of systems, making difficult the integration of resources from different agencies.	Standardising rules for personnel selection and training. Establishing a certification system for all levels of responsibility. Standardising the equipment for personal protection. Standardising work shifts in a fire, and compensating extra time of suppression with vacation time. Coordinating suppression jobs (summer) and silviculture jobs (winter) to retain the personnel. Following written operations plans. Designating air coordinators when more than two aircraft are operating.
Function: Logistics Difficulties in large fires when there are resources from several agencies or regions.	Establishing rules for logistics, taking into account the arrival of resources from different places. Giving sanitary training to one person per brigade.

Conclusion

Forest fire services in Spain have attained a good level of effectiveness with a high proportion of professionalism. However, there are several main difficulties to keep pace with the fire problem:

- Increasing fuel accumulations because of rural land abandonment.
- A huge number of simultaneous fires in certain regions.
- Diversity of the regional administrations that have the responsibility for first attack.
- Coordination at the large fires.

The Red Books of Prevention and Coordination are a common exercise to look for new ways to improve the quality of the suppression services and to design stronger policies for prevention.

Statistical Database

Table 4-24 Forest fires statistics for Spain, 1990-1999.

Year	Fires < 1 ha	Fires > 1 ha	Forested (ha)	Total (ha)	% of National forest area burned
1990	4 521	8 392	72 993	203 032	0.752
1991	6 079	7 452	116 896	260 318	0.965
1992	8 619	7 336	40 438	105 277	0.390
1993	9 269	4 985	33 161	89 267	0.331
1994	10 961	8 302	250 433	437 635	1.622
1995	15 222	10 605	42 389	143 484	0.532
1996	10 902	5 870	10 538	59 825	0.222
1997	14 136	8 183	21 326	98 503	0.365
1998	14 301	8 037	42 659	132 813	0.492
1999	11 991	5 888	21 471	69 196	0.256

Reference

Vélez, R. 1999. *The Red Book of Prevention and Coordination: A general analysis of forest fire management policies in Spain*. Paper presented at the Symposium on Fire Economics, Planning, and Policy: Bottom Lines, 5-9 April 1999, San Diego, California.

4.2.7 Fire Situation in Turkey

By
Ertugrul Bilgili
Faculty of Forestry, Karadeniz Teknik Üniversitesi, Trabzon, Turkey

Fire Environment and Fire Regimes in Turkey

Turkey is a country with a land mass of 76.96 million hectares, of which 20.749 million hectares is forested. About 12 million hectares of forested land are subjected to forest fires. Most fires occur where the Mediterranean climate is characterized by high temperatures and low to non-existent precipitation.

In terms of fire regimes, 65-70 percent of the burned area is found in *Pinus brutia* forests, 15-20 percent in *Pinus nigra* forests, five percent in other coniferous forests, ten percent in bushy and degraded coppice forests and one percent in broad-leaved forests.

Narrative summary of major wildfire impacts on people, property, and natural resources during the 1990s

Most of the fires in the country occur between June and October and in the vicinity of tourist areas. There is a growing national concern for the damage caused by forest fires due mainly to its impact on tourism and on eco-tourism and the environment.

Arson fires are set for several reasons. People with low income and low standards of living see the forests as an earning ground for their sustenance. So people set fire to the forests to create jobs or improve their subsistence.

A number of people have died while fighting forest fires.

Systematic fire management organization used in Turkey

Fire management in Turkey is a federal responsibility. Duties are carried out by the state forest enterprises functioning under regional directorates. Although fire control policies in the past were developed around a strong emphasis on total fire control, these policies are rapidly evolving today. A national database on forest fires is being created containing information on all aspects of forest fires. Information gathered on the location and causes of fires are used to develop fire prevention techniques and prevention planning. Forest fire prevention efforts are being mounted in terms of mass media awareness campaigns for the public and through fire law enforcement.

The construction and maintenance of firebreaks have been instrumental in breaking up continuous expanses of fuels. The firebreaks often are supplemented by planting fire resistant species.

Fire suppression strategies are based on early detection, fast initial attack, and a strong suppression effort. Each region has been provided with sufficient resources and fire crews to combat forest fires. Available resources include 208 fire trucks, 12 helicopters, 11 airplanes, 882 fire lookout towers, 8 472 radios, 650 initial attack crews (12-15 people), and 120 standby forces (of 40-50 people). These forces are allocated to each district based on fire danger levels and the area in question.

Overall, 71 percent of the fires are controlled at less than 5 hectares and account for only 8 percent of the area burned. In contrast, only one percent of the fires exceeds 200 hectares in size. These fires account for 37 percent of the total area burned. See Table 4-25for detailed wildfire statistics.

Wildfire Database

Table 4-25 Total number of fires and area burned in Turkey between 1990 and 1997 on forest, other wooded land and other land.

Year	Total No. of Fires on Forest, Other Wooded Land & Other Land	Total Area Burned on Forest, Other Wooded Land & Other Land ha	Area of Forest Burned ha	Area of Other Wooded Land Burned ha	Human Causes No.	Natural Causes No.	Unknown Causes No.
1990	1 725	13 000	6 127	3 331	684	30	1 011
1991	1 445	7 642	3 230	2 113	n/a	n/a	n/a
1992	2 110	12 312	7 951	4 349	997	56	1 057
1993	2 547	13 734	9 520	3406	1 270	40	1 237
1994	3 221	20 997	20 155	801	1 158	135	1 928
1995	1 768	4 791	3 928	750	941	129	698
1996	1 631	14 922	10 127	4 329	902	56	673
1997	1 339	6171	4 525	1 486	888	76	375
1998							
1999							

Fires started by people account for 97 percent of the total fires. Lightning starts the remaining three percent. Of the people-caused fires, 23 percent are classified as arson, 27 percent are caused by negligence and carelessness, and 50 percent of the fires are due to unknown causes.

Use of prescribed fire to achieve resource management objectives

At the present time, the policy in Turkey is to practice fire exclusion through fast and aggressive fire suppression. Although Turkey has no experience in the use of prescribed fire, it can be an important management tool in pine forests where the accumulation of pine needles can become a fire hazard due to increased fuel load. In view of the fact that *Pinus brutia* forests account for 65 to 70 percent of the total burned area in Turkey, trials of

prescribed burning on an experimental basis in pine forests are being considered. Research results on this practice would be necessary before general application could be recommended.

Public policies affecting wildfire impacts

Public policy and legislation to prohibit agricultural burning near forest boundaries during fire season to reduce fire risk has actually had the opposite effect. The ban is not working, since 15 percent of the fires are due to agricultural burning, the largest single cause of forest fires. Consideration is being given to modifying this legislation to permit agricultural burning under controlled conditions coupled with farmer training in better burning practices.

Following a review of national fire policies in November 1998, new policy guidelines were developed. Some of this policy direction included the development of a Forest Fire Management Centre, implementing plantation practices and fuel management to reduce fire risk, involving all stakeholders in fire management planning, involving village communities in fire protection activities, rehabilitating burned areas, and making fire management more cost effective.

Sustainable land use practices used in Turkey to reduce wildfire hazards and wildfire risks

Although grazing is banned in most forest areas, there is a need to evolve proper grazing policies and practices. Controlled grazing could be used to help reduce fuel loads to more acceptable levels. Such changes are being considered.

Consideration also is being given to the development of "Green Firebreaks" of less flammable species to complement the systems of roads and traditional firebreaks in disrupting the continuity of fuels.

Community involvement in fire management activities.

Since most fires are started by people, awareness and education campaigns that involve the community are expected to bring down the extent of damage. There is increasing recognition that participation of rural people in the development process of natural resources is the most important driving force for responding to present day challenges and opportunities.

Reference

Bilgili, E. 1999. Forest fires and fire management policies in Turkey. In*: Proceedings. FAO Meeting on Public Policies Affecting Forest Fires*, p. 357-361. FAO Forestry Paper 138.

4.3 Northern, Western and Eastern Europe Sub-Region

During the preparation of the global fire report, requests were sent to national agencies or correspondents of Western, Eastern and Northern Europe. Replies were received that covered the following countries: Belarus, Estonia, Finland, Germany, Latvia, Lithuania, and the Russian Federation. These reports are included in full length. For other countries brief situation reports are presented based on the regional report "Europe and temperate-boreal Asia" that was prepared for the "FAO Meeting on Public Policies Affecting Forest Fires", Rome, Italy, 28-30 October 1998 (Goldammer 1999). References published in International Forest Fire News (IFFN) are added.

In the second half of the 1990s, the FAO/ECE/ILO Team of Specialists on Forest Fire initiated a process to establish or improve fire management cooperation in the northern European region, particularly in the Baltic Basin. Major emphasis is therefore given to highlight this regional initiative. It will be followed by the country briefs and the full country reports.

Forest fire management in the Baltic Basin: a concerted regional approach

In the second half of the 1990s, the need has been recognised to create a forest fire forum in the Central-Northern European region where the fire problems are entirely different from the Mediterranean part of Europe. The FAO/ECE Team of Specialists on Forest Fire is promoting a cooperative approach for the nations bordering the Baltic Basin to share fire management expertise and resources.

In September 1996 the FAO/ECE/ILO Team of Specialists on Forest Fire called for a regional Baltic action plan concerning collaboration in forest fire protection and to convene a first regional conference. This proposal was submitted to the government of Poland. The government responded positively and hosted the First Baltic Conference on Forest Fires in Radom-Katowice in May 1998. The meeting was attended by scientists, managers and representatives from administrations of the host country (Poland), the Baltic States (Estonia, Latvia, Lithuania), the Nordic countries (Denmark, Finland, Norway, Sweden), Germany and Russia.

At the conference the establishment of pan-Baltic programs and exchange mechanisms encompassing fire research, fire management training, the use of prescribed fire (in forestry, nature conservation and landscape management) and mutual fire emergency assistance were proposed. The conference participants agreed to develop a concerted regional Baltic Forest Fire Action Plan within the framework of the Baltic 21 Action Programme.

A meeting of the FAO/ECE/ILO Team of Specialists on Forest Fire was held in conjunction with the First Baltic Conference on Forest Fires (Goldammer 1998). At the meeting it was agreed to strengthen regional cooperation in fire management in the Baltic Basin. The team members, which belong to the countries neighbouring the Baltic Sea, hereinafter referred to as Baltic States, will be members of a Baltic Task Force on Forest Fire. It was also agreed that three countries, Belarus, The Netherlands, and the United Kingdom, will have observer status because they are either directly connected to the Baltic region or share common problems or developments in fire management. The Task Force leader is Finland.

A follow-up process to the conference was agreed upon, starting with a pan-Baltic forest fire exercise BALTEX FIRE 2000 (the Baltic Exercise in Forest Fire Information and Resources

Exchange). BALTEX FIRE 2000 was held in Kuopio, Finland (Goldammer 2000, 2001). The results of the meeting were grouped under three topic headings; and general conclusions will direct future cooperation among Baltic countries:

Forest Fire Risk Assessment; Detection and Monitoring of Forest Fires

- There is a need for common understanding and sharing of fire management information in the Baltic region. All Baltic countries should therefore summarise and circulate information on their national fire danger, prevention, detection and suppression systems. This could also be achieved through development of standardised country report forms (templates).

- To develop a general understanding of variation in fire danger/risk that exists across the Region, which would facilitate better transboundary cooperation in terms of both operational fire management and fire research. The fire danger/risk throughout the Baltic Region should be evaluated using a common fire danger system (likely the Canadian FFDRS). Daily fire danger maps would be posted on the GFMC website. Current country systems could still be used. However, a common, over-arching system should be developed, perhaps with the European Forestry Institute taking the lead, with the help of meteorological institutions and country representatives.

- To develop a Baltic Region-wide land cover, vegetation, fuel classification system (or approach) to assist in converting fire danger calculations into prediction of fire behaviour for specific fuel types.

- To develop fire-specific satellite technology (e.g., BIRD and FOCUS of the German Center of Aeronautical and Space Research - DLR) in support of aerial and tower-based detection systems.

Forest Fires and Environment

Due to the broad range of issues and multi-faceted nature of forest fires and the environment, each country should develop a specific *Action Plan* which contains a list of elements or objectives. For each of the objectives an action plan (descriptive) and an implementation time scale needs to be prepared. The elements of the action plan should be priority ranked.

Transboundary Operational Cooperation in Fire Management, Training and Technical Development

At BALTEX FIRE 2000 the meeting of the FAO/ECE/ILO Fire Team further elaborated on the formation of the INSARAG Fire Group and particularly on the Subgroup *Wildland Fire*. The BALTEX FIRE 2000 recommendations for INSARAG Europe-Africa include:

Establishment of a Database

For the Europe-Africa Region a database should be developed on the base of circulated questionnaires which include information on:

- Human resources for assessment of fire situations, technical assistance and fire fighting. It was stressed that fire specialists to be selected for deployment to international wildland fire emergency situations should be experienced, or at least trained to work in national to local conditions of the recipient country.

- Equipment: Hardware and software for use in international emergency assistance operations (including national to regional fire equipment warehouses), availability and mobility of equipment (time, space). The need was underscored to observe and improve technical compatibility of equipment.

- Information sources: Provider of data (real-time, near-real time) for fire situations, e.g. fire reconnaissance (from air and space), fire-weather or -danger forecasts, environmental and socio-economic conditions, etc.

International Fire Management Training Courses

The need is recognised to train fire management specialists to be used in international response groups. Training programmes still need to be defined, but should certainly include elements which would prepare these specialists for foreign situations such as the specific conditions of a target nation or region, e.g.:

- Natural fire environment (fuels, fire characteristics, fire behaviour).

- Geographic conditions (topography, water sources).

- Climate and weather (typical fire weather, local particularities such as wind patterns).

- Socio-cultural conditions (land-use systems, fire use, involvement of land users or the public in fire management activities, public response to foreign intervention, limitations of use of advanced technologies).

- Infrastructures and technical facilities (fire fighting resources).

- Policies and administrative settings and policies in place (legal framework, law enforcement, responsibilities of agencies, role and capabilities of NGOs).

- Information sources (provider of national to local real-time or near-real time data needed for fire situations assessments, e.g. aerial and spaceborne fire reconnaissance, fire-weather or fire-danger forecasts).

The training programme should include a link to the UN-OCHA/UNDAC system through which wildland fire specialists would be prepared to become candidate members for UNDAC missions in wildland fire emergencies. International certificates should be issued in order to guarantee the competence and quality of fire management specialists deployed to international tasks. The existing forest fire network organized under the ECE/FAO/ILO Team of Specialists on Forest Fire and the Global Fire Monitoring Centre should be used for further strengthening the regional Baltic and global collaborative processes and coordination efforts.

General Conclusions and follow up

The final discussion of the BALTEX FIRE 2000 plenary and the subsequent meeting of the ECE/FAO/ILO Team of Specialists on Forest Fire and the INSARAG Fire Group fully supported the recommendations of the three Working Groups. The following short- to medium-term steps will be taken:

- Establishment of a special website on the Baltic Region on the Homepage of the GFMC.

- Design of a comprehensive and standardised format of a country profile in which the Baltic Region countries fully describe the basics of their fire situation and the available fire-fighting resources for national, transboundary and international forest firefighting, including contact numbers.

- Distribution of the country profile questionnaire to the governments; subsequent placement of country profiles on the website.

- Establishment of links and extraction of existing open Internet and intranet websites which are currently constructed, e.g. in Finland (fire danger rating system, automatic regional fire detection system), Russia (fire information system), and Germany (GIS-based Fire Information System for the State of Brandenburg: integration of data and information from an automatic ground-based fire detection system, fire danger rating and fire behaviour modelling).

- Publication of the national reports presented at BALTEX FIRE 2000 in the pages of UN-ECE/FAO International Forest Fire News (IFFN).

- Exploration of host countries and conveners for working group activities and the next BALTEX FIRE (possibly 2002).

- Conduct a first INSARAG Wildland Fire short introductory course in 2001. Finland has offered to investigate the possibility to host such a seminar.

At the and of BALTEX FIRE 2000 the meeting of the FAO/ECE/ILO Fire Team further elaborated on the formation of the INSARAG Fire Group and particularly on the Subgroup Wildland Fire. The final format of INSARAG Wildland Fire was submitted to the INSARAG Europe Africa Regional Meeting (Tunisia, November 2000).

<u>Agreements in place</u>

Several agreements on mutual assistance in forest fire management along common national boundaries are active in the Baltic Region:

- Finland - Russia (since 1994).

- Creation of a special emergency unit "Finn-rescue-Forces (FRF)" in Finland to respond to needs outside of Finland. Participating countries include Estonia, Finland, Latvia, Russia and Ukraine.

- A fully automatic system has been developed to detect forest fires in the Baltic region using data from the meteorological NOAA satellites. The system has been developed in Finland and tested in four experiments in Finland and its neighbouring countries of Estonia, Latvia, Russian Karelia, Sweden and Norway.

- Poland - Germany. The Joint Committee for Programming and Monitoring of Transboundary Cooperation between Poland and Germany approved the transboundary project on forest fire prevention, monitoring and control "Euroforst Peitz/Zielona Góra". Funding was granted by the CEC through the funding mechanisms of PHARE (Poland and Hungary Assistance to the Reconstruction of the Economy).

- Nordic countries: Annual forest fire conferences of the government services involved in forest fire management.

<u>TACIS Project ENVRUS-9701 "Improvement in Forest Fire Response System"</u>

The framework for a forest protection project designed by the Federal Forest Service of Russia in the mid-1990s was submitted to the European Commission Directorate DG1a and approved as Technical Assistance to the Commonwealth of Independent States (TACIS) Project ENVRUS-9701 (TACIS 2000). The project officially started in 1998 and has a lifetime of two years. The Federal Forest Service of Russia is the beneficiary, and its Central Base for Aerial Forest Fire Protection (Avialesookhrana) is the project partner (see country report for Russia)

Country briefs and country reports

<u>Baltic and Central-Eastern European countries</u>

The fire problem zones in the countries bordering the Southern Baltic Sea (Estonia, Germany, Latvia, Lithuania, Poland) and Belarus are dominated by pine forests which are favoured by the continental climate. Full country reports are available for Belarus, Estonia, Germany, Latvia, and Lithuania. Most of the territory of the Nordic countries lies within the boreal and hemi-boreal zone. A country report is provided by Finland.

Denmark. With an annually burned area of 38 ha, forest fires constitute a minor problem in Denmark.

Norway. In Norway, the oceanic climate determines the composition and fire hazard of forests. Boreal coniferous forests stretch from the east towards the Scandinavian mountain range and its alpine ecosystems. The coastal area has been classified as a boreonemoral zone characterised by temperate coastal forests. In the south, there are smaller areas in a nemoral zone which today are strongly influenced by human activity. Lightning is frequent in Norway, but high precipitation and prevailing high humidity in the Western and Central parts of the country do not allow ignition by lightning. The highest frequency of natural fires occurs in the boreal forests of the country's eastern lowlands, southwestward to the divide and in the most continental part of central Norway (Mysterud et al. 1998, Mysterud and Bleken 2001). The forested area burned between 1986 and 1996 was 564 ha/year.

Poland. Similar site and forest conditions are more common in Poland where fires predominantly occur in pine forests. The average annual area burned between 1980 and 1996

was 5 170 ha. One of the examples of fire problems in industrially polluted regions is located in Poland. The Rudy Raciborskie Forestry Administration Area includes 17 780 ha of forest (89 percent pine forest) out of which 14 215 ha are in the heavily damaged zone (Zone II). Additionally this area is affected by water table depression due to sandpit exploitation. A large fire in 1992 burned more than 9 000 ha in the superintendency. The complete consumption of the humus layer by fire and the subsequent loss of ash by strong winds together with the pollution impacts led to a severe increase of soil acidity up to <3.0 pH. The rehabilitation of such burned areas will require a complex system of planting, including successive steps from pioneer stands towards a more species-rich terminal stand (Anonymous 1998).

Sweden. Most of the territory of Sweden lies within the boreal and hemiboreal zone, with most of the terrain covered by flammable coniferous trees, ericaceous dwarf-shrubs and mosses. During the mid-1970s fire was not considered a serious problem. The collection of fire statistics was abandoned temporarily in 1975, but resumed in 1992 (Granström 1998). The average area burned between 1992 and 1996 was 2 500 ha/year, with exceptionally high numbers of fires and large areas burned in 1992 and 1994. Most fires are caused by people, directly or indirectly. Investigations reveal that in 1994 arson was assumed to have caused six percent of the fires while lightning accounted for 35 percent of the fires. These are very high figures when compared with statistics for the period 1945-1975.

Western European countries characterised by Atlantic Climate

The western European countries bordering the Atlantic Ocean, the English Channel and the North Sea have less wildfire problems as compared to the Central-Eastern countries of Europe. They only occasionally experience large wildfires.

Belgium. Forest fires in Belgium usually do not exceed 100 ha per year. Extreme years such as 1996 (1 113 ha burned) have driven the 1980-1996 average to 152 ha/year.

Luxembourg. With an average burned forest area of 4 ha/year between 1980 and 1996 Luxembourg is the country with the lowest fire risk in Europe.

Netherlands. In the Netherlands the magnitude of forest fire occurrence is similar to Belgium. In the same period 1980-1996, an average of 172 ha/year of wildfires was recorded.

United Kingdom. Fire statistical data for the United Kingdom show an average annual area burned of 428 ha between 1980 and 1996. A major report on the fire situation in the country will be published in early 2001 (Bruce 2001).

Ireland. During the same period, Ireland experienced wildfires on some 600 ha annually.

The Alps region and Southern/South Eastern European countries

Wildfire risk in the region of the Alps and Southeastern Europe (non-Mediterranean) is determined by the characteristics of either mountain mixed deciduous-conifer forest or lowland broad-leaved forest. Both in Austria (average area burned annually between 1980 and 1996: 105 ha) and in Switzerland (average area burned annually in the same period: 407 ha) a high proportion of forest fires is caused by lightning, mainly in higher elevations. In 1994 in

Austria and Switzerland 27 percent and 33 percent, respectively, of all fire starts were caused by lightning.

Switzerland. Forest fires in Switzerland predominantly occur in the southern part, a small region of 4 000 km^2 (9.8 percent of the total national area) with a forest cover of 44 percent (176 000 ha). The main fire occurrence is during the dry winter period, but recently also during the summer seasons (Conedera et al. 1996). The southern part of Switzerland is situated in a small basin, closed toward the north and the west (Alps) and open toward the south and the east (Po Valley). The climate, therefore, is characterised by dry and sunny winters with periods of north-*foehn* (main time of forest fires), occasionally strong snowfalls, wet springs and autumns and by sunny summers with very heavy rainfalls (thunderstorms). The typical vegetation under the climatic conditions in this region are chestnut forests on acid soils, deciduous broad-leaved mixed forests on limestone and beech forests at altitudes between 800 and 1 300 m a.s.l.. The winter fires usually burn as surface fires in the chestnut leaf litter layer. Surface fires of low to medium intensity cause damages to the chestnut tree layer and often lead to severe erosion and land/mudslides involving high damage to infrastructures and private property.

Bulgaria, Czech Republic, Hungary, Romania, Slovak Republic. The long-term fire statistics of Bulgaria for the period 1980-96 show an average annually burned forest area of ca. 3 000 ha. In the first half of the 1990s large fire years were 1993 (17 500 ha burned) and 1994 (14 254 ha burned) (Kurpanov 2000). There are discrepancies, however, between officially reported numbers to the ECE and otherwise reported figures. For instance, the ECE/FAO statistics for 1996 indicate a total area burned of 2 516 ha, while other sources cite 2 150 ha for the same year (Kurpanov 1998). In 1997, the burned forest area reached 860 ha with a total number of 167 forest fires, most of which burned in May and September. Most of the 133 fires in 1997 that affected 555 ha of forest took place in the South of Bulgaria were the vegetation consists predominantly of conifers. No data are available on the extended fires in Bulgaria during the extreme fire season 2000. During the period 1980-1996 the forest area annually burned in the neighbouring countries reached 512 ha in the Czech Republic, 1 066 ha in Hungary, 244 ha in Romania and 134 ha in the Slovak Republic.

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4.3.1 Fire Situation in Belarus

By
Ivan G. Mysleiko
Ministry of Forestry, Minsk, Belarus
&
Valery Shamal
Laboratory of Science and Research Institute of Applicable Physical Problems
Belarussian State University, Minsk, Belarus

As of January 1997 the forest resources of Belarus comprised 9 088 700 ha and cover 36 percent of the territory. With a share of 74.2 percent the Ministry of Forestry is the main holder of forests. The remaining 25.8 percent belong to the Department of Defence, the National Academy of Sciences, the Ministry of Education, national parks and forest reserves, and the administration of the office of the president of Belarus.

The forests under jurisdiction of the Ministry of Forestry consist of coniferous forests (67.1 percent), hard leaf forests (4.2 percent), and soft leaf forests (28.7 percent). The main trees species are pine (56.4 percent), birch (17.9 percent), fir (10.7 percent), black alder (7.3 percent), oak (3.6 percent), and aspen (1.8 percent). High wildfire hazard is prevailing in coniferous forests with understorey fuels (25.2 percent), and middle-aged coniferous forests (27.7 percent). (Note: the percentage numbers refer to forested lands.)
Five Fire Hazard Classes are distinguished. Class 1 represents the highest fire hazard, Class 5 the lowest (Table 4-26). The mean fire hazard level of all of Belarus is 2.3.

Table 4-26 Distribution of forest resources of Belarus by Fire Hazard Class.

Fire Hazard Class	1	2	3	4	5
Percentage of forest land	29 %	28.2 %	30.2 %	12 %	0.6 %

Wildfire occurrence

Between 1988 and 1997 a total of 27 612 forest fires burned an area of 34 808.7 ha of forest land (0.6 percent of all forest land). The average size of a fire was 1.26 ha. This average area burned by fire is 2.14 times greater than during the period 1978 – 1987 (0.59 ha). Some forest fires spread over several hundreds of hectares. Between 1978 and 1997 years with highest fire occurrence were 1979, 1983, 1984, 1992, and 1995. The most critical fire year was 1992 when 7 444 forest fires burned 1 9701.7 ha. The highest number of wildfires occurred in May (27.2 percent), and the largest area was burned in August (39.6 percent). Between 1988 and 1997, surface fires were most frequent (92.1 percent of all fires) and burned most of the total area affected by fire (64.9 percent).

The presence of large areas of coniferous forests with understorey vegetation provides conditions favourable for the transformation of surface fires to crowning fires (26.2 percent of

the total area burned). Ground fires occurred only during extremely dry years and had a share of 3.5 percent of all fire incidents that burned 8.9 percent of the total area affected by fire.

Table 4-27 Wildfire database of Belarus, 1990-2000.

Year	Total No. of Fires on Forest, Other Wooded Land, & Other Land No.	Total Area Burned on Forest, Other Wooded Land, & Other Land ha	Area of Forest Burned ha	Area of Other Wooded Land and Other Land Burned ha	Human Causes No.	Natural Causes No.	Unknown Causes No.
1990	2 471	1 039.1					
1991	1 517	319					
1992	7 743	23 822	1 8551	5271	5 458	14	49
1993	1 887	1618	1 253	365	997	2	890
1994	3 716	8 586					
1995	3 257	5645.1					
1996	3 872	5745					
1997	1 466	964.8					
1998	876	567.7	552.3	15.4	645	1	230
1999	3 959	6 260.8	4 214.5	2 046.3	2871	5	1 083
2000	2 569	1 931	1 760.1	170.9	1 700	5	864

Forest fire protection organization

Fire prevention in the forests under the jurisdiction of the Ministry of Forestry are is implemented by the State forestry departments, nine aerial fire protection groups and three air bases of the State enterprise *Bellesavia*. There is no private forest sector in Belarus.

The main responsibility for fire prevention is with the Regional Executive Committees and the Executive Committees of the Districts. Their tasks are:

- Planning of annual fire protection measures.
- Organization of preparedness of fire protection personnel, technical equipment, and responsibilities for fire suppression.
- Establishment and maintenance of access roads and aerodromes.
- Organization of public awareness and education campaigns for fire prevention.

There are 188 fire-chemical stations in forest districts and in areas of high fire hazard in order to allow timely response to wildfires. As of 1996 there were 636 caches of fire suppression equipment located in those forest districts where fire-chemical stations are absent. Fire brigades are set up during the fire season which consist of forest workers. In addition local people and personnel as well as engineering capabilities of local enterprises and Organizations are mobilised and integrated.

The Ministry of Forestry is responsible for the overall coordination, analysis, and financing for new technologies and methods for forest fire control. Fire detection is executed by executed by the forest service by means of ground patrol, tower observation and aerial patrol. A total of 26 lookout towers are equipped with TV and remote infrared fire detection and environmental monitoring systems. The local population plays an important role in early

forest fire detection. The Department of Science of the Ministry of Forestry coordinates the work of scientific institutions in the field of fire control through government programs and contracts.

Use of prescribed fire

The use of prescribed fire is banned by law in Belarus.

Sustainable land-use practices employed in the country to reduce wildfire hazards

For the decrease a forest fire hazard levels in the various forest types of Belarus the following actions receive priority:

- Silvicultural measures for reducing wildfire hazard in coniferous forests, particularly the introduction of less flammable and economically valuable broadleaved tree species intermixed in pure coniferous stands.
- Thinning operations and sanitary cuts.
- Construction of anti-fire barriers consisting of :
- Fire breaks and internal fuel breaks.
- Fire resistant forest edges.
- Shaded mineralised shelter belts.

Public policies affecting wildfire impacts

The Forestry Code of the Republic of Belarus was enacted on 14 July 2000. According to this legislation the main fire protection tasks include fire detection, fire containment and fire suppression.

It will be necessary to create a multilevel system of fire suppression and extinguishing on the basis of streamlined land and aerial forest fire prevention services supported by spaceborne remote sensing information. It will be necessary to use systems of early forest fire detection, and to improve fire fighting capabilities by introducing new and expanding established fire fighting technologies.

Reference

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Source

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4.3.2 Fire Situation in Estonia

By
Veljo Kütt
Ministry of Environment Forest Department, Tallinn, Estonia

Introduction: Forest fire statistics for 1990-1999

The total area of Estonian forests is 2.011 million ha. Forests cover 48 percent of the land area of the country. Altogether, 2 058 forest fires have been registered in Estonia in the years 1990–1999, affecting a total area of 6 211 ha. The average size of a forest fire was three hectares (Table 4-28).

Table 4-28 Forest fire database for Estonia, 1990 to 1999.

Year	**Number**	**Area burned (ha)**	**Average area burned (ha)**
1990	164	194.0	1.07
1991	39	58.0	1.49
1992	348	1 787.0	5.13
1993	207	647.1	3.13
1994	289	456.4	1,58
1995	188	185.9	0.99
1996	273	579.0	2.12
1997	359	1 146.5	3.19
1998	61	53.8	0.88
1999	130	1 103.0	8.48
Total	2 058	6 210.7	3.02

The number and area of fires differs from year to year. Table 1 shows that there were large fires in 1992, 1997 and 1999, their total area exceeding 1 000 hectares. The major fires occurred in Vihterpalu, Harju County, in 1992 and 1997, with almost 800 ha of forest burned in both cases. Due to a rainy summer, only 61 forest fires with the total area of 53.8 ha were registered in 1998. The average fire area was 0.88 ha, which is the lowest average area burned in the last ten years. The next year, the average area of a forest fire was 8.48 ha, which is almost ten times more than the year before and the second highest in the last 40 years. The largest forest fires took place in 1963, with the average area per fire being 13.9 ha. Statistical data for an extended time period indicate that 40 percent of all fires take place in Harju County and the major fires have also occurred there. But in 1999 forest fires occurred in other counties as well. Ida-Viru County suffered the most damage in 1999, with the biggest fire of the year also occurring there (near Narva). Major fires also occurred in Harju County (Männiku) and Lääne County (Nõva). A number of major fires occurred under extraordinary circumstances that complicated their suppression. Several examples are given below.

The most extensive forest fire in 1999 took place in the vicinity of Narva (Ida-Viru County), where 400 ha of forest and peat bog that were to be turned into open-cast oil-shale pits caught on fire. Fire brigades from a number of counties participated in the suppression of this fire. Suppression was carried out sector by sector. Both portable motor pumps and truck-mounted pumps were used and a helicopter proved to be most useful. Suppression was complicated by the fact that heavy fighting had taken place at this spot during World War II. Old bombs and warheads exploded in the fire in a number of cases, making fire suppression extremely dangerous. A special mine clearing unit was called on to prepare zones where fire brigades could act in comparative safety. Due to this complicated situation, it took four weeks to suppress the fire. None of the firefighters were hurt, as adequate safety measures were taken.

An 80 ha forest fire occurred near Männiku (Harju County) with fire brigades from various counties involved. Water was transferred with the help of portable motor-pumps and pumping stations from an open cast pit (a distance of 1.5 km) and a mire pond (a distance of 1 km). A helicopter was also used to suppress the fire. This was a dangerous fire as it was very close to the city. The fire brigades managed to stop it from spreading when it was only 300 m from the dwellings. The fire was caused by arson. Suppression lasted for 16 days, a period that could have been shorter, considering the area of the fire. But arsonists (who could not be caught) twice again ignited the forest after the fire had been brought under control.

Returning to the forest fire statistics for the last ten years, it should be noted that only approximately one percent of all the fires are caused by natural factors (lightning, etc.). The remaining 99 percent are generally related to human activities. Forest fires are caused by the following factors: natural factors (lightning) 1 percent; arson 14 percent; agricultural operations 8 percent; logging and forestry operations 1 percent; transportation and communications (railways, electricity lines) 5 percent; general public (campers, other visitors, children) 52 percent and other causes 1 percent. Unknown causes account for 18 percent of all forest fires.

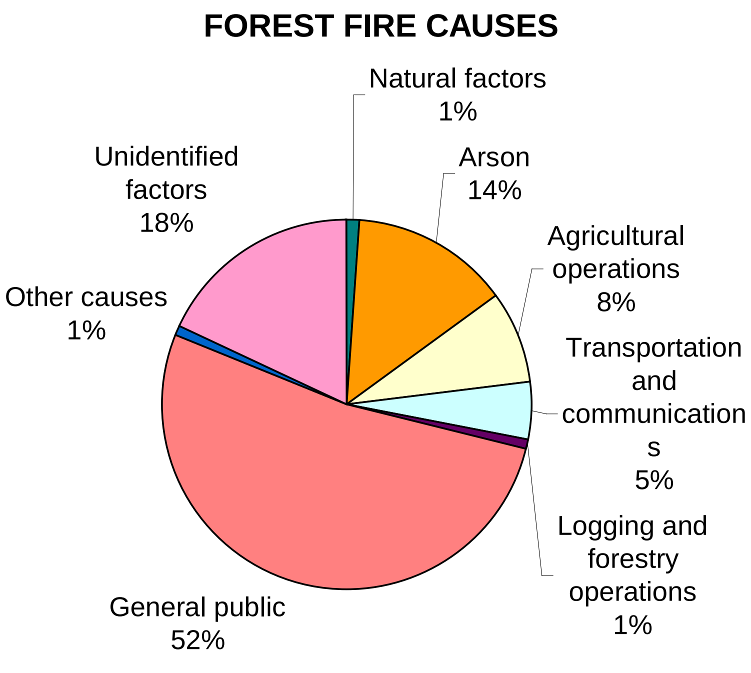

Figure 4-7 Causes of forest fires in Estonia during the 1990s.

Framework of forest fire protection

As a result of institutional rearrangements, forest fire protection in Estonia has been structured as follows:

A general emergency phone-number (112) has been established and county emergency centres have started functioning. All notices of forest fires are now received on one phone-number.

Suppression of forest fires is now the responsibility of the Rescue Board under the jurisdiction of the Ministry of Internal Affairs, as provided by the Rescue Act.

Monitoring of forest fire protection and measures to prevent widespread and especially dangerous fires are the responsibility of the Ministry of Environment, as provided by the Forest Act. For this purpose, the dissolved Forestry Board has been formed into the Forest Department of the Ministry.

Management of state forests and detection of forest fires from observation towers is the responsibility of the State Forest Management Centre, a state for-profit institution under the jurisdiction of the Ministry of Environment, as provided by the Forest Act.

Research and development projects

Consistent with the recommendations of the First Baltic Conference on Forest Fires and the corresponding Polish experience, an applied research project aimed at increasing the fire-resistance of forests in the Vihterpalu region, Harju County, was launched and financed by the Forestry Board. The project report contains practical guidelines for forest owners (including the state) on developing fire breaks in fire-prone forested areas, building artificial water bodies and fire protection roads and tending roadsides. Studies on improving the fire-resistance of forests will continue in 2000.

As the process of integrating Estonia into the European Union continues, attention will be paid to the enforcement of Council Regulation (EEC) No. 2158/92 and a number of development projects have been planned in this context. These projects will address methodologies for determining the degree of fire hazard and the planning of fire protection measures. Studies on the causes of forest fires are under way. The Ministry of Environment ordered these studies and research projects.

The Estonian Rescue Board has been upgrading its equipment for the suppression of forest fires. Its primary goal has been the creation of a mobile, quickly deployed water-transferring system that takes advantage of the number and distribution of Estonia’s lakes and rivers. Fire-pumps of different capacities and hose lines of varying diameters have been and will be acquired for this purpose. The development of these systems is region-specific.

Cooperation in the Baltic Sea Region

Estonia thinks that it is very important to carry out coordinated fire management activities with the other countries of the Baltic Sea region. The country is interested in participating in conferences and practical training sessions.

There has been good cooperation with Finland in detecting forest fires in their early phases with the help of satellites. It is intended that this project will be developed further.

A cooperative agreement concerning rescue services has been concluded with the Republic of Finland and a similar agreement is presently being prepared with the Kingdom of Sweden. These agreements give Estonia the opportunity to receive prompt technical assistance and support using previously agreed-upon procedures. So far, Estonia has not used these services and hopefully no such need will arise. However, the existence of these agreements gives a positive impetus to bilateral cooperation in the field of rescue services.

In the case of extensive and long-lasting forest fires, it would undoubtedly be useful to invite specialists from other countries to observe conditions. Exchange of experiences on the basis of real-life situations would be beneficial.

Source

Kütt, V. 2001. Forest fires in Estonia. *Int. Forest Fire News* 24: 14-17.

4.3.3 Fire Situation in Finland

By
Taito Vainio
Ministry of the Interior, Rescue Department, Helsinki, Finland

Introduction

The total area of Finland is 338 145 km^2, of which the land area is 304 529 km^2. Forests cover 68 percent of the total area, i.e. 26 million ha. Finland's forests are in the boreal coniferous forest zone. The most common species are spruce (*Picea abies*) and pine (*Pinus sylvestris*) as well as birch (*Betula* spp.). About 54 percent of the forests are privately owned, 33 percent are owned by the state, 8 percent by forestry enterprises, and 5 percent by others.

The forest fire season in Finland is relatively short, usually starting at the beginning of May and ending in September, i.e. 5-6 months. Finnish summers are cool and relatively wet. In addition, Finland is not too complicated in terms of geography for fire control purposes. There are no mountains and the forest road network is quite extensive. There are also a lot of natural obstacles, including 188 000 lakes, that help keep forest fires quite small. This helps the Finnish forest fire management system to keep the fire problem relatively small in scale as compared to southern Europe.

The Fire Management System

The Finnish fire management system consists of prevention, early warning and suppression as presented in the flow chart (Figure 4-8).

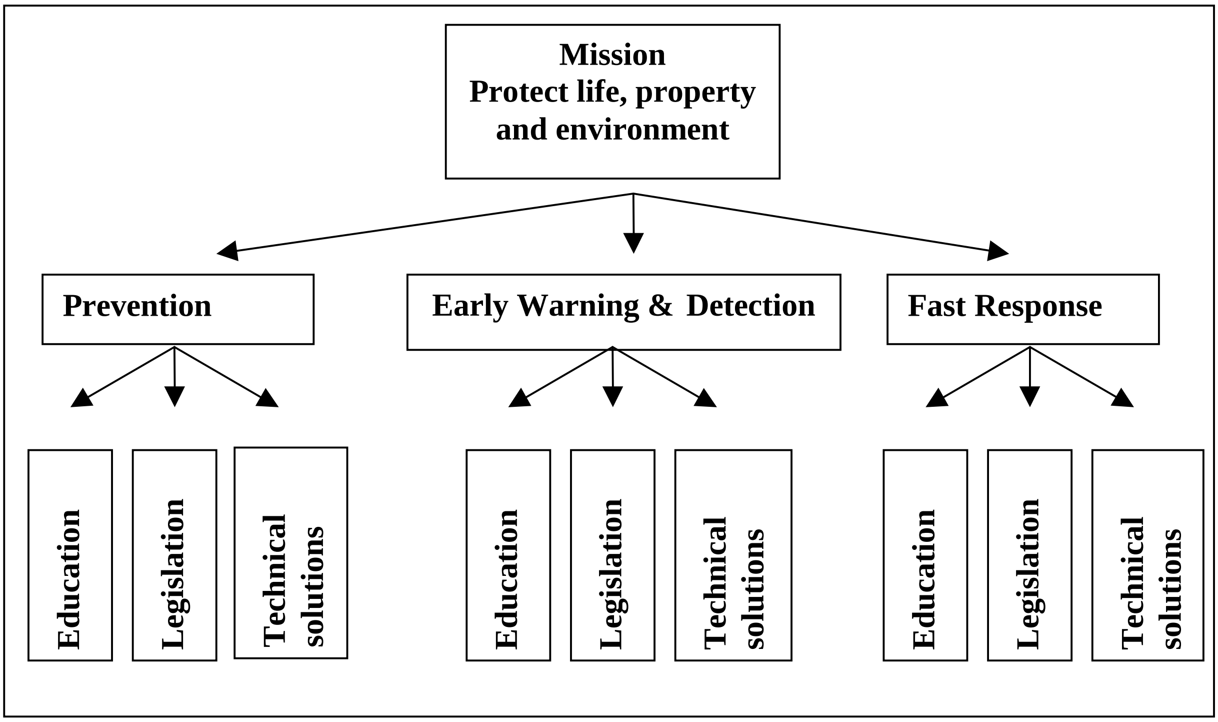

Figure 4-8 The Finnish forest fire management system.

As shown in the flow chart, educational, legislative and technical means are used in fire prevention. People need to be educated to behave in a safe way in the forests. This has been reinforced by legislation. For instance, when a forest fire warning is issued it is against the law to set an open fire inside or near a forest. A forest fire warning is issued when the forest fire index reaches a high level. The Finnish Meteorological Institute publishes a daily fire danger map of Finland. The map is based on the *Forest Fire Index Calculation System* (Heikinheimo 1998; see also http://metsapalo.fmi.fi/).

To provide early warning and information on forest fires the general public is educated to react when they see that something is wrong. In practice this means that they don't ignore the situation and that they also report by telephone using the emergency number 112. By law, everyone is obligated to inform the authorities about an incident. Airborne surveys and an operational satellite system are examples of technical applications, e.g. an automated fire detection system based on the NOAA AVHRR satellite sensor (Kelhä 1998).

The third part of the system is a fast response. According the law, people are obliged to do their best to reduce the damage in an incident. What can be done depends on the type of the incident and the person. However, the goal is to educate people to do some simple preliminary actions before the fire brigade comes to the incident site. As mentioned before, risk assessment is based on law. Municipalities have to assess the risk of forest fire and have in place suitable personnel and equipment to handle the situation. Forest fire suppression is assisted by technology such as aeroplanes, helicopters and the equipment of the fire brigades.

The Municipal fire brigades do the actual operational response. The local municipal fire officer is responsible for leading the operation inside the local municipal area. Finland is divided into 36 alarm areas. Each alarm area has several municipal fire brigades. If a situation exceeds the local capability, other municipal fire brigades can be called upon for help. In each

alarm area there is also a regional fire chief. He has the responsibility to take the lead if he thinks it is necessary. The fire officer in charge is responsible for every strategic decision.

The role of the Ministry of the Interior is to insure that all the necessary resources are functional and that in every area there are also enough resources to handle bigger situations. In the case of a large or national catastrophe the Ministry of the Interior takes the lead.

In an operational sense, the governmental and provincial levels don't have much to do as far as daily incidents are concerned. In the case of a national catastrophe, where there are hundreds of thousands of people in danger, these Organizations start to function at the operational level.

Forest officials are urged to use more prescribed burning for ecological reasons (see below). This, in fact, would not interfere with fire prevention if the prescribed burns can be properly controlled.

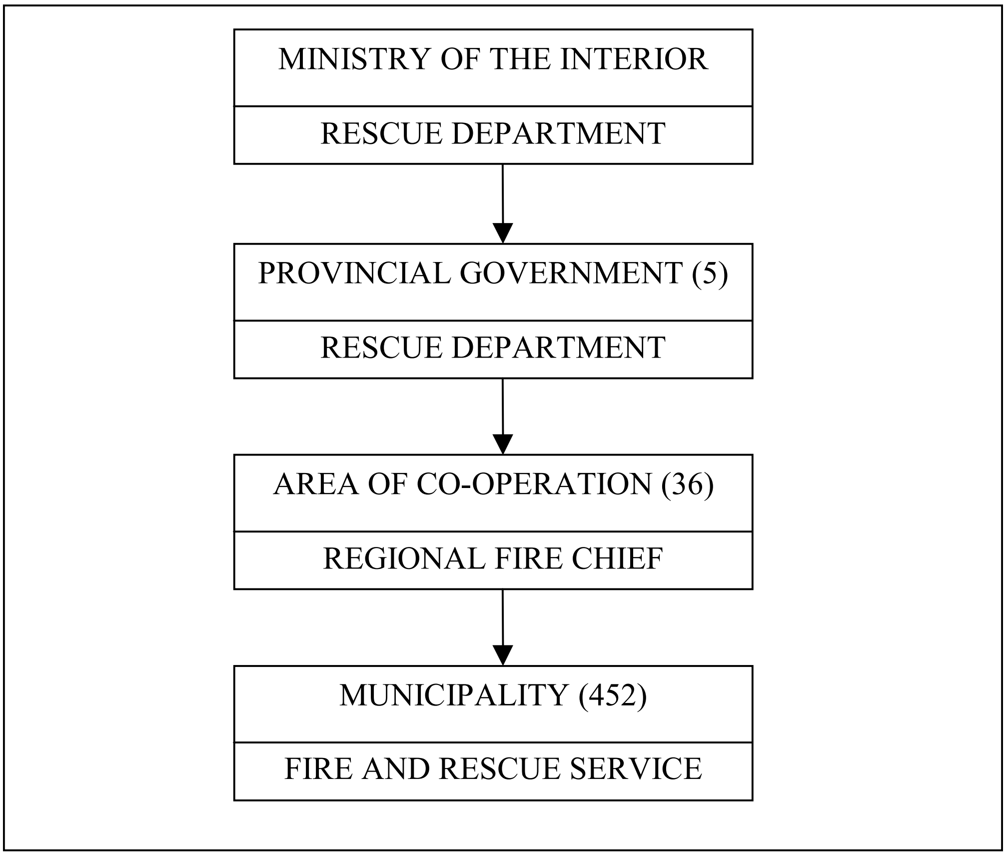

Figure 4-9 The Organization of fire and rescue services in Finland

Impact of wildfires in Finland

Forest fire is one of many incident types in Finland. We can get a general picture of this when we study the incident statistics. Forest fires form only approximately two percent of all the incidents where the fire brigades respond.

The last reported casualty in a forest fires was at the beginning of the 1980s when a firefighter got lost in a peat fire and died. There was another similar incident in the 1970s.

Property and the environment are mainly at risk from forest fires in Finland. All in all, forest fire damage in Finland has been very low indeed, i.e. less than 10 million Finnish Marks per year. There is no significant damage to ecology or public health.

Forest fire database

The forest fire database in Finland is in an electronic format from 1993 on. However, a new database has been recently introduced in which information from 1995 on is being processed.

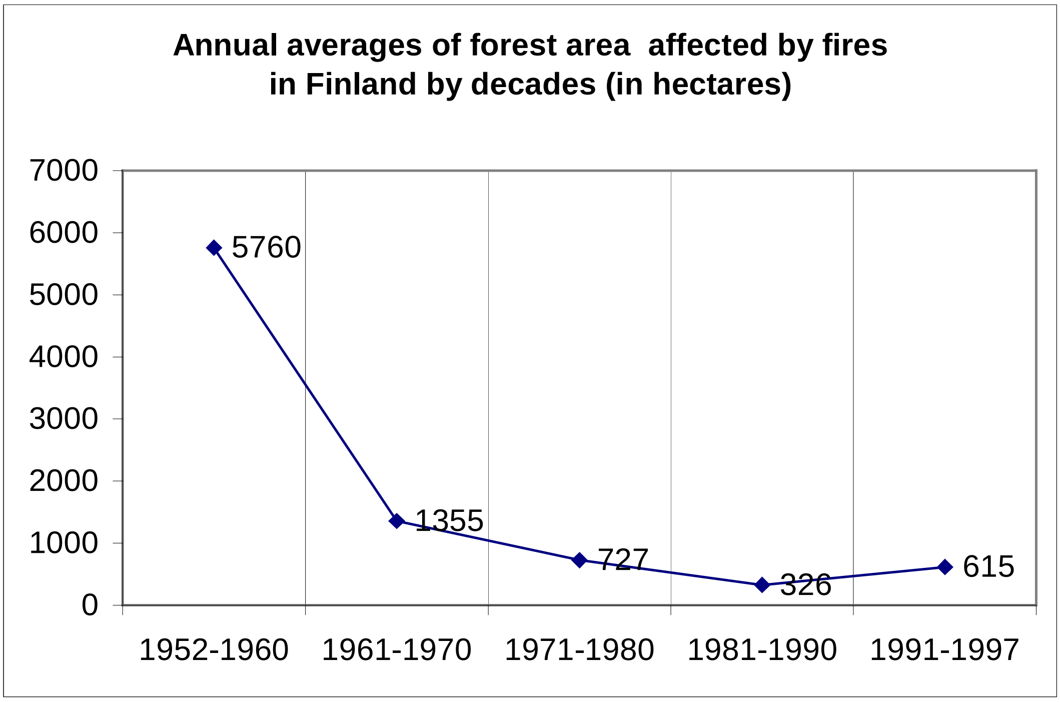

Figure 4-10 Average forest area burned annually in Finland by decades since 1952

The total area burned has been very small over the last two decades as shown in Figure 4-10 and the statistical table (Table 4-29).

Table 4-29 Wildland fire statistics for Finland, 1990-1999.

Year	Total No. of Fires on Forest, Other Wooded Land, & Other Land No.	Total Area Burned on Forest, Other Wooded Land, & Other Land ha	Area of Forest Burned ha	Area of Other Wooded Land and Other Land Burned ha	Human Causes No.	Natural Causes No.	Unknown Causes No.
1990	4 000		434				
1991	3 400		226				
1992	3 800		1 081				
1993	2 000						
1994	2 500		1 583				
1995	2 867	1 438	774	664	1 409	178	577
1996	3 181	901	446	455	1 815	80	502
1997	3 574	1 827	1 333	494	1 731	450	579
1998	1 196	323	121	202	835	38	159
1999	2 769	1 050	550	500	996	337	1 436

Use of prescribed burning

Fire is an important natural factor in forest ecosystem maintenance and dynamics. The use of prescribed fire has decreased since the 1950s. The lack of forest fires has caused an impoverishment of biodiversity. In addition, the forests have become denser than before. It is envisaged that in the future prescribed burning programmes will be expanded in order to restore biodiversity. A “let burn” policy is currently being discussed. However, more research on burning behaviour in Finnish forests needs to be done before this could be implemented.

The use of prescribed fire is rare for agricultural maintenance or other vegetation management purposes.

Reducing wildfire hazards

As it was mentioned above, the combination of climatic and biogeographic conditions in Finland does not favour the spread of large, catastrophic wildfires. Therefore, special measures for wildfire hazard reduction are not required:

Public policies concerning fire

Finnish forest officials have urged an increase in the use of prescribed fire. The forest certification procedure also requires a certain amount of prescribed burning. The Finnish Ministry of the Interior accepts prescribed fires if they are properly managed so that they do not cause damage to a third party. Together with the University of Helsinki the Finnish Ministry of the Interior is conducting a research programme on forest fire behaviour (Frelander 2000, Kuuluvainen 2000).

The role of the Finnish Ministry of the Interior is to protect life, property and the environment. With regard to forest fires the aim is to keep the damage as low as it is today. Prescribed fires are acceptable if they are properly managed and confined within prescription.

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Source

Vainio, T. 2001. The forest fire situation in Finland. *Int. Forest Fire News* 24: 17-22.

4.3.4 Fire Situation in Germany

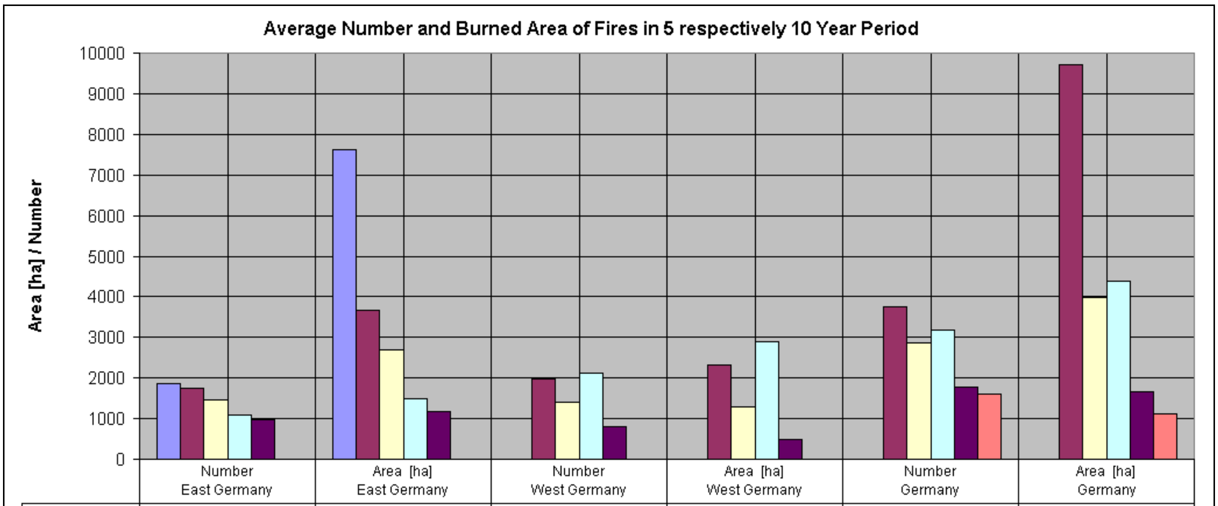
By
Peter Lex
Adendorf, Germany
&
Johann G. Goldammer
Global Fire Monitoring Center (GFMC)

Introduction

In Germany the main fire problem areas are located in the northern portion of the country where predominantly poor soils are associated with continental climate features. The forests in this region between Lower Saxony in the West and Brandenburg in the East (bordering Poland) are dominated by pine (*Pinus sylvestris*) stands characterised by a relatively high fire hazard.

The Statistical Database on Forest Fires

In 1991, the first uniform forest fire statistics were introduced in the Federal Republic of Germany. Between the end of the Second World War and the unification of the two separate German republics each system operated its own statistical database (Figure 4-11). The compilation of forest fire statistics of the former German Democratic Republic (GDR – East Germany) started in 1946. Data for the Federal Republic of Germany (West Germany) were not available before 1957. With the reunification in October 1990, a common fire statistics system was introduced in Germany that met the standards of the ECE/FAO.



	Number East Germany	Area [ha] East Germany	Number West Germany	Area [ha] West Germany	Number Germany	Area [ha] Germany
1946-1950	1869	7627				
1951-1960	1761	3660	1990	2312	3751	9723
1961-1970	1454	2685	1401	1290	2855	3975
1971-1980	1084	1504	2107	2884	3191	4388
1981-1990	978	1185	815	481	1783	1666
1991-1999					1604	1131

Figure 4-11 Average number of forest fires and area burned in Germany in 5- and 10-year periods, 1946-1999.

The majority of fire damages occurred after the war in the East German territory. Although the number of fires was sometimes smaller than in West Germany, the burned area, except from 1971 to 1980, was larger than in West Germany (Figure 4-12). Between 1951 and 1960 the highest post-war fire damage occurred in the GDR (Figure 4-13). In this period the average number of 1 761 fires per year was registered with an average burned area of 3 660 hectares per year. In this context, it is important to note that forest land comprises only 28 percent of East Germany.

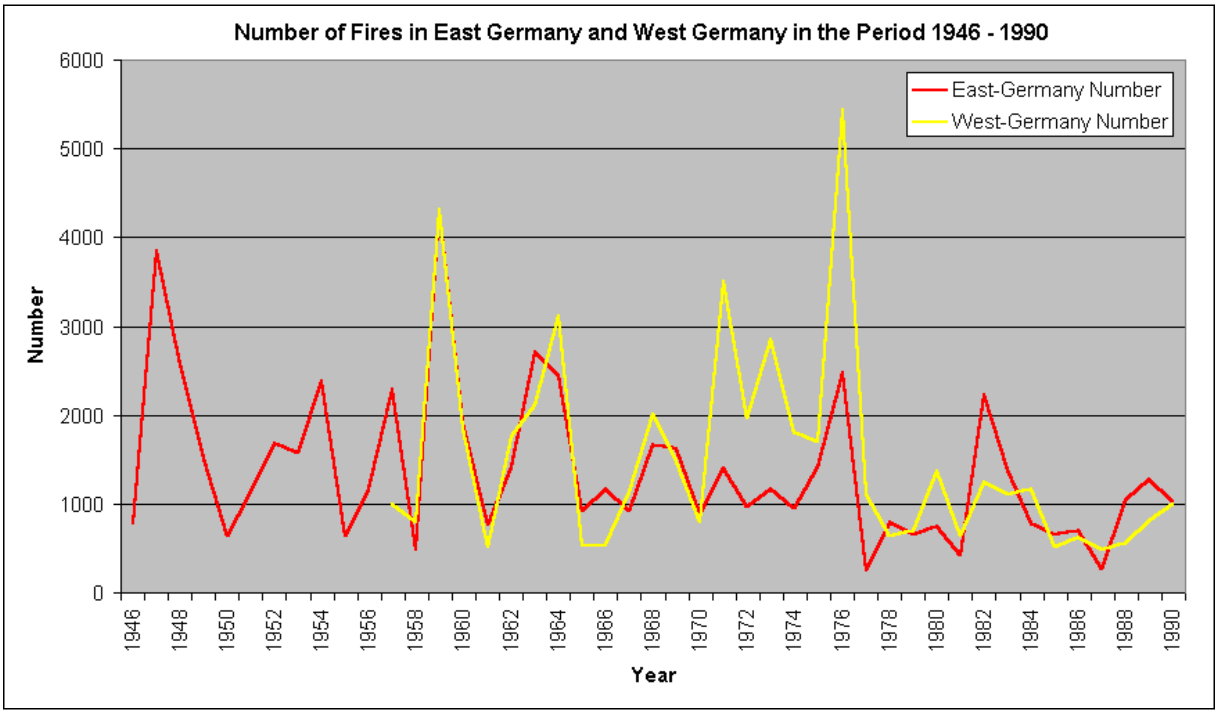


Figure 4-12 Number of forest fires in Germany, 1946-1999.

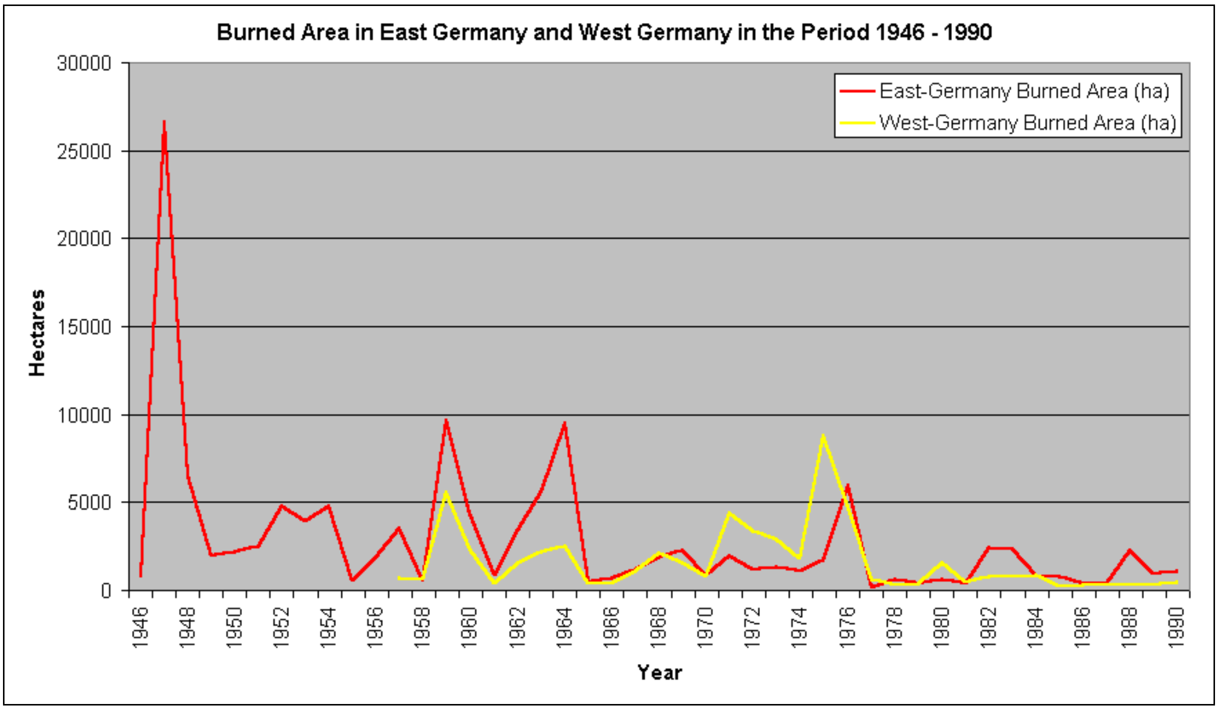


Figure 4-13 Area burned in Germany, 1946-1999.

In 1990, the real causes of fires in the GDR were published for the first time (Missbach 1990). For political reasons the issue was treated secretly. During the period 1951 to 1970 fires caused by negligence mounted 46 percent and, in the subsequent years, up to 60 percent. Railway traffic caused 28 percent of the ignitions by sparks from locomotives which were driven with brown coal. During the period from 1971 to 1988 the percentage of fires caused by military training and exercises increased to 29 percent. These fires were located outside the borders of the military exercise areas; they had been hidden in the statistics before 1990.

In West Germany, the conflagrations of the years 1975 and 1976 in Lower Saxony had a strong impact on the statistics for the period 1971 to 1980. The average number of fires rose to 2 107 with an average burned area of 2 884 ha per year. In 1975 the average size of the burned area per fire increased to 5.15 ha. The number of fires and the area burned depend on inter-annual climate variability and ranged from 242 ha in the wet year 1985 to a maximum of 8 768 ha in the hot and dry year 1975. Therefore, the West German statistical figures show that the burned area of 1975 was 36 times larger than in 1985. The importance of the climate is also represented in the average size of the burned area. In East Germany the amounts ranged from 0.52 up to 6.93 ha between 1946 and 1990; whereas West German data show areas from 0.35 to 5.15 ha (Figure 4-14).

The average burned area per fire in the period 1977 to 1999 is shown in Figure 4-15. After reunification 1992 shows a peak of burned area with 4 908 ha (Figure 4-16). More than 80 percent of these fires happened in East Germany and a considerable number started on military training areas. This phenomenon can be explained by the political circumstances. In the former GDR the fire brigades were managed by fire bosses who were members of the police force. As a result of the reunification they had quit their jobs. The democratically elected new fire bosses lacked the experience in fighting large forest fires. The inadequate technical equipment of the rural voluntary fire brigades worsened the situation.

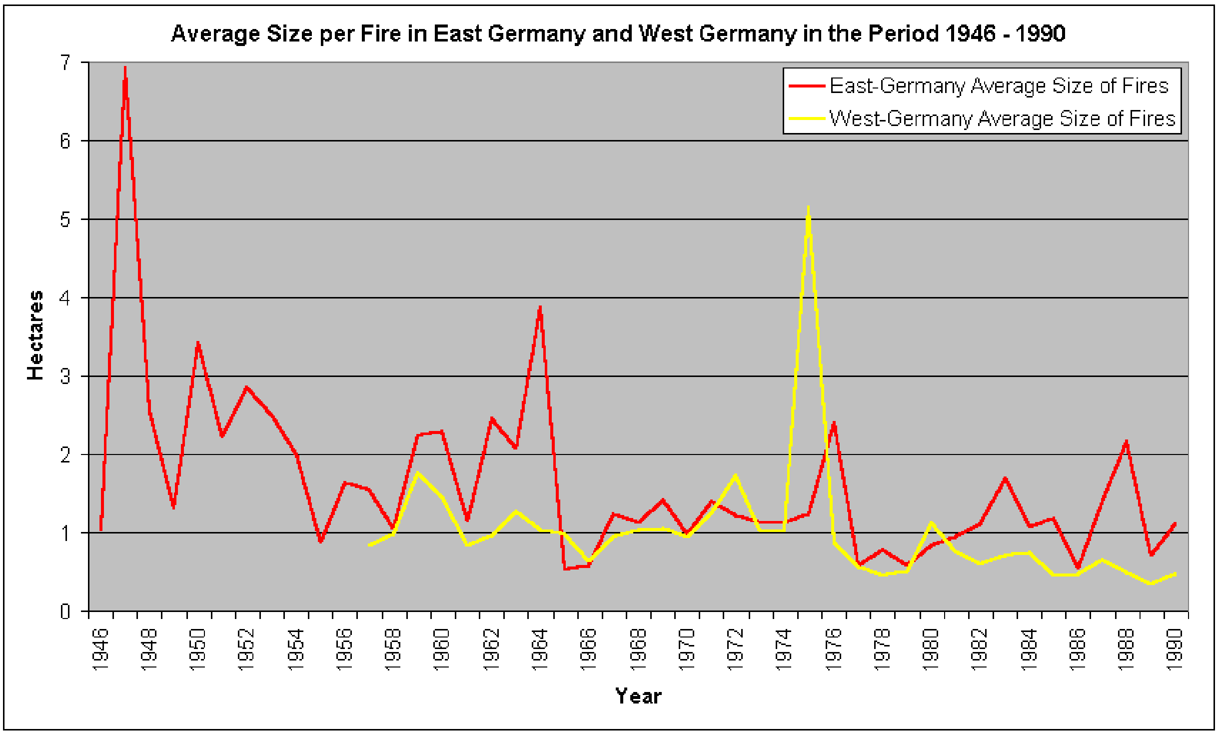


Figure 4-14 Average size per forest fire in Germany, 1946-1999.

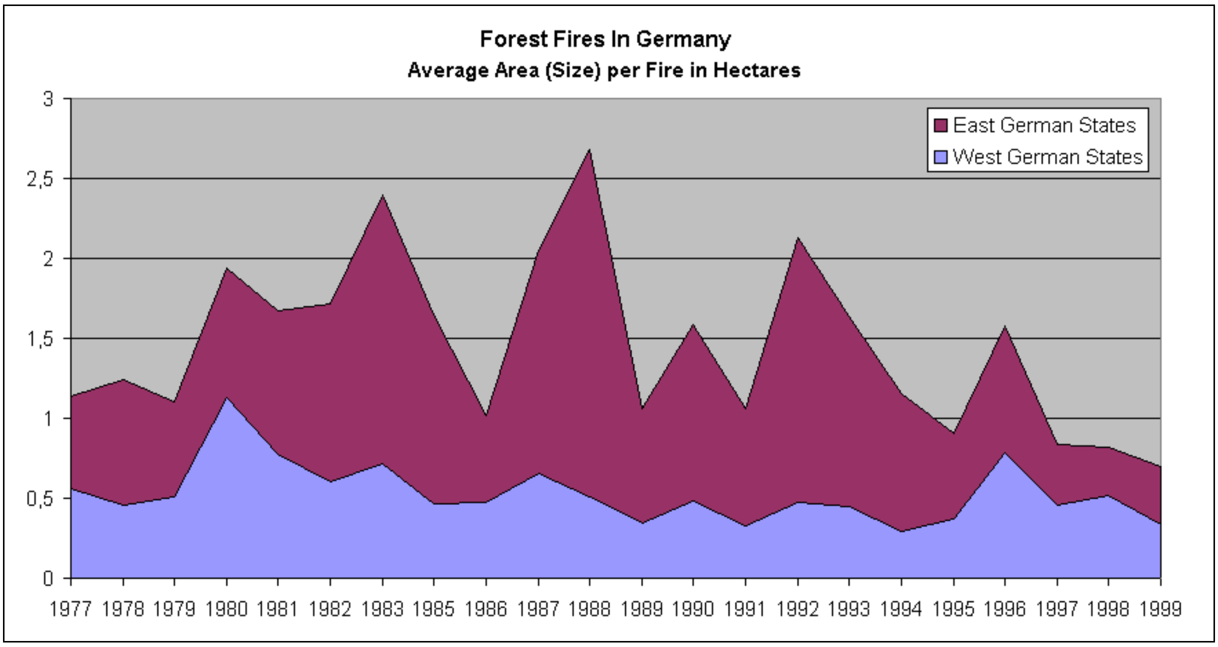


Figure 4-15 Average size per forest fire in Germany, 1977-1999.

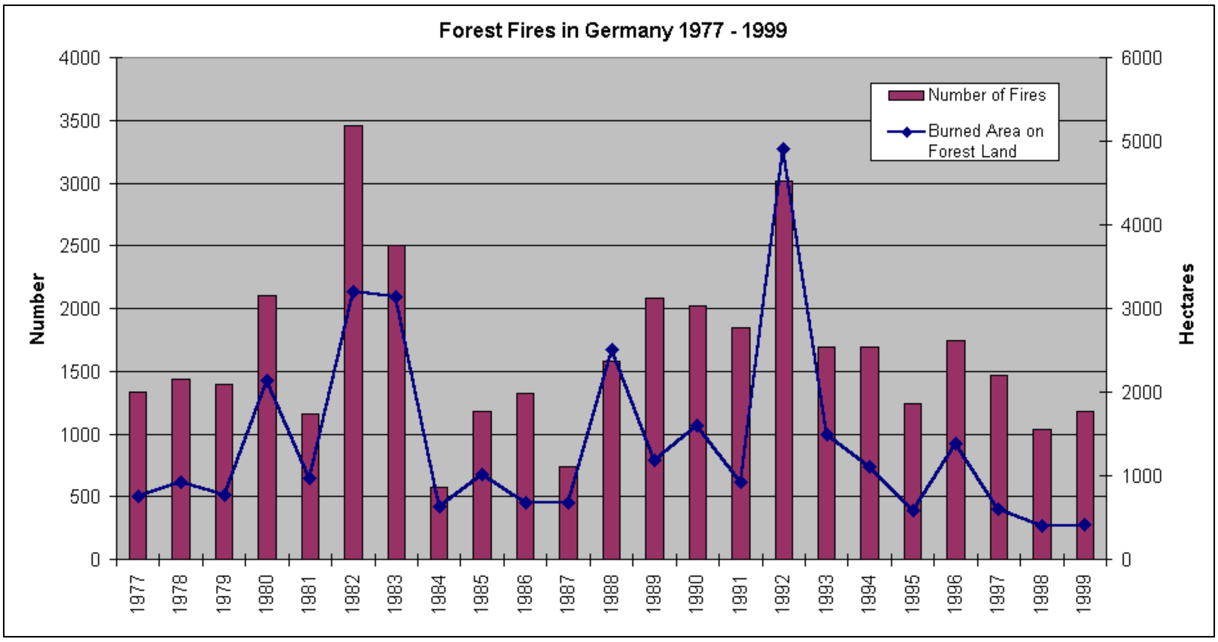


Figure 4-16 Number of forest fires and area burned in Germany, 1977-1999.

Fire causes

Only two percent of all fires are caused by lightning. The identification of fire causes is unsatisfactory because the average percentage of unknown causes is 39 percent from 1991 to 1999 (Figure 4-17, Figure 4-18). Negligence holds second place with 25 percent in the period 1991–1999. Negligence had a higher percentage in West Germany, decreasing from 50 percent to 30 percent between 1961 to 1990. There is a steady increase of arson in West Germany since 1961, with an average percentage of 22 percent in the period 1991–1999 in the

whole of reunified Germany. The reduction of military training and the electrification of railways, especially in East Germany, explain the decrease of the "other causes" to ten percent. The four most important "other causes" are the railway, public ways, agriculture and forestry. Figure 4-19 and Figure 4-20 show the monthly distribution of fires between 1995 and 1999 in Germany. The average number and the average burned area in this period indicates two peaks in April and August. This supports the earlier theses of Geiger (1948), Weck (1950), and Missbach (1982) that most fires occur in spring and in high summer.

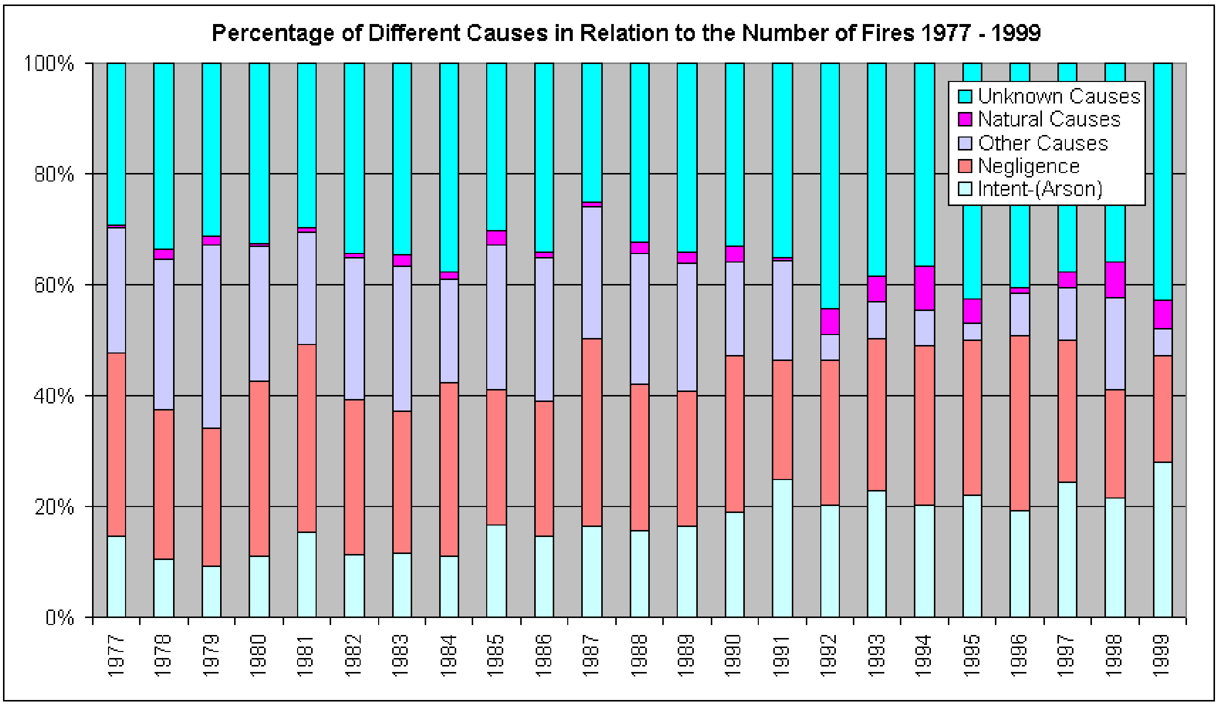


Figure 4-17 Causes of fire in relation the number of fires in Germany, 1977-1999

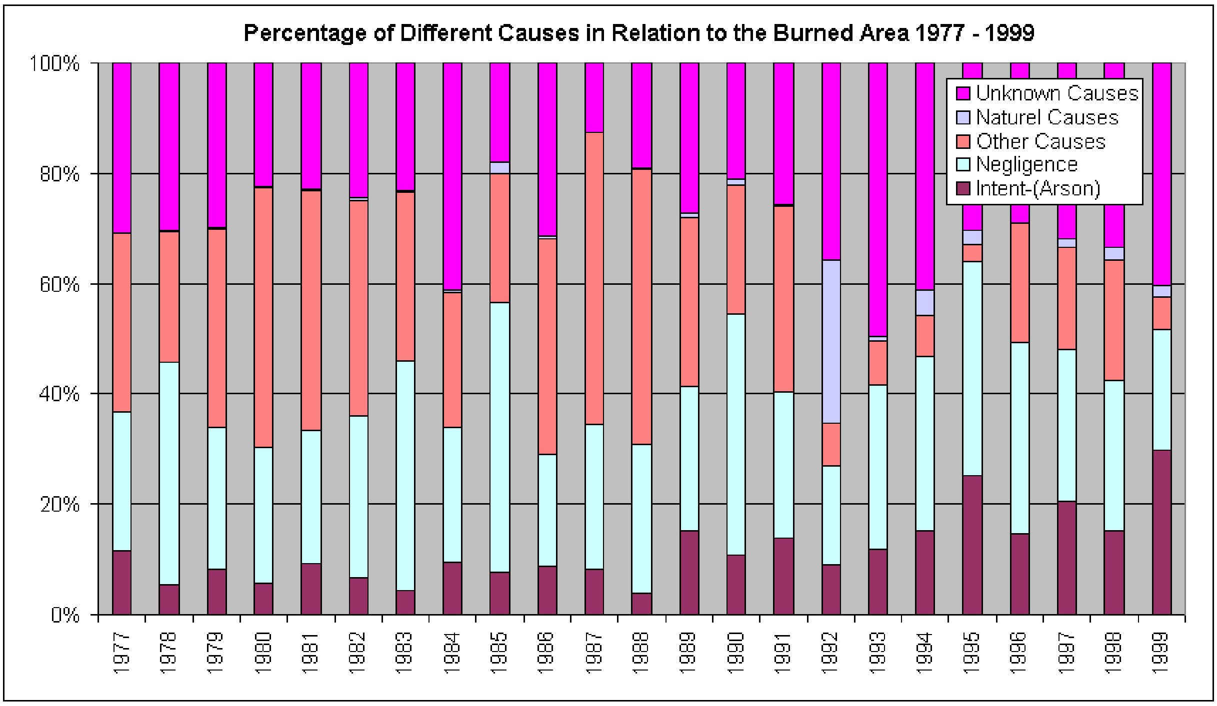
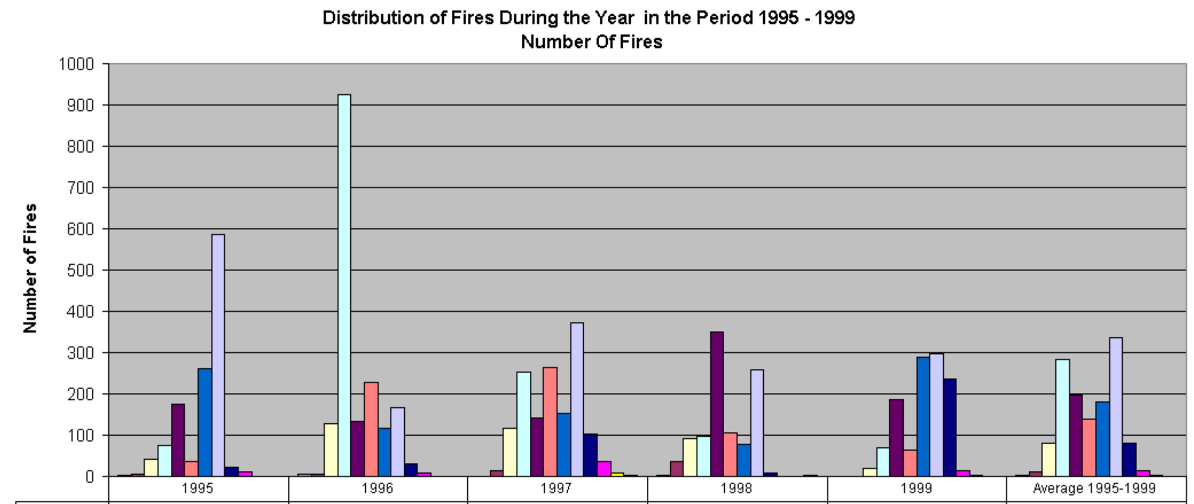
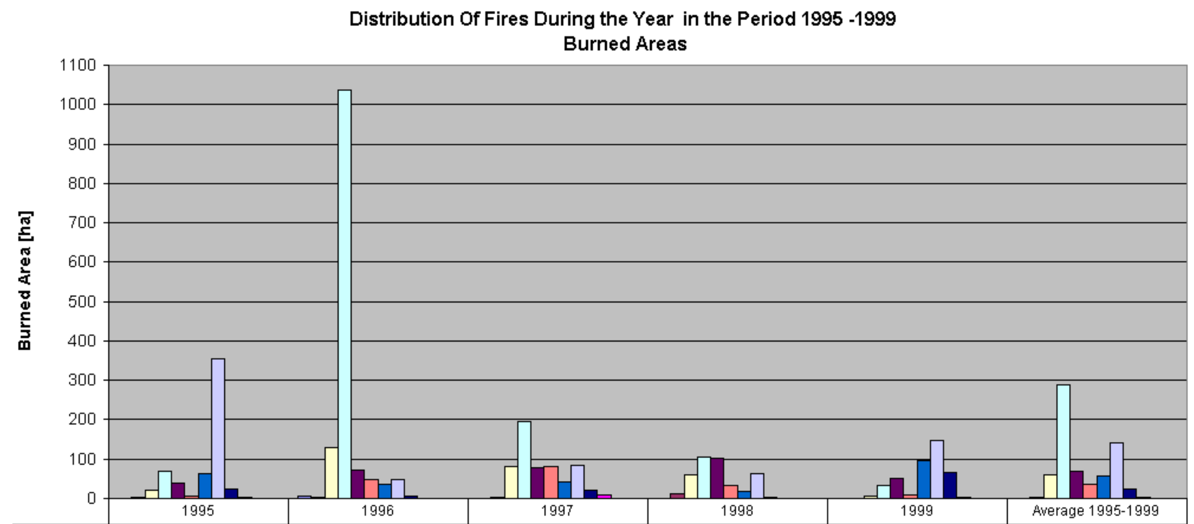


Figure 4-18 Causes of fire in relation the area burned in Germany, 1977-1999.



	1995	1996	1997	1998	1999	Average 1995-1999
January	2	5	0	2	0	2
February	6	6	13	36	1	12
March	41	128	117	92	20	80
April	74	926	253	97	70	284
May	175	134	143	349	185	197
June	37	228	264	106	63	140
July	261	116	154	79	289	180
August	587	166	373	259	298	337
September	22	31	104	9	235	80
October	12	7	37	0	13	14
November	1	1	7	1	3	3
December	0	0	2	2	1	1

Figure 4-19 Distribution of number of fires by month in Germany, 1995-1999.



	1995	1996	1997	1998	1999	Average 1995-1999
January	0,2	5,4	0	0,2	0	1
February	1,6	1,9	3	11,7	0,1	4
March	20,6	128	81,4	60,5	7,4	60
April	69,9	1035,6	194,5	106,1	32,6	288
May	39,4	72,8	79,2	101,6	52,4	69
June	5,6	46,9	80,9	32,3	9,8	35
July	64,1	36,3	43,3	18,8	95,3	58
August	355,1	48,6	84,6	62,8	148,2	140
September	25,3	4,6	21,6	2,8	66,3	24
October	2,5	1,2	9,7	0	2	3
November	0,3	0,1	0,6	0,5	0,5	0
December	0	0	0,2	0,1	0	0

Figure 4-20 Distribution of area burned by month in Germany, 1995-1999.

Prescribed burning

Since forest fire management in Germany is not faced with exceptional fire, problems the use of prescribed fire in forest stands for wildfire hazard reduction has not been seriously considered. Prescribed fire has been proposed and tested in pilot experiments during the 1970s (Goldammer 1979).

However, changing paradigms regarding the role of fire in nature conservation have been observed the past few years. At present new initiatives are demanding the restoration of fire as a dynamic and vital element to maintain biodiversity and the cultural and ecological characteristics of landscapes. Changes in many vegetation types have occurred as a consequence of abandoned traditional land-use practices. Ecologically important disturbances by land-use practices include grazing, mowing, bio-fuel utilization and burning. Traditionally fire was used to keep vegetation open and at early successional stages to regenerate grass, heath and brush, and to clear land of weeds and harvest residues. Since 1975, a vegetation burning ban has been imposed in all German states.

Targets of these initiatives are those ecosystems and landscapes that had been treated with fire historically and where prescribed fire could be used to prevent the reforestation process.

In 1997, the first large prescribed burning research programme began in the State of Baden-Württemberg. It aims to investigate the use of prescribed burning in the management of hedge and slope terrain in the viticulture region of Southwest Germany. The objective of this programme is to use fire to maintain or restore grass cover that provides habitats for endangered flora and fauna. The project was requested by the State Ministry for Rural Space of Baden-Württemberg because of the dramatically increasing subsidies necessary to mow and mulch those sites where biodiversity is lost due to succession towards bush and forest cover (Page and Goldammer.2000). Detailed references on the historic role of fire in European land-use systems and strategic concepts on the use of fire in modern nature conservation and landscape management are provided by Goldammer et al. (1997 a, b, c).

Fire research

Fire science in Germany has a traditional focus on fire ecology, fire management and fire policies at Freiburg University. The Fire Ecology Research Group (FREG) concentrated its efforts on the tropics and the boreal zone, and on the role of fire in the global environment. In 1990, the FREG was integrated into the Max Planck Institute for Chemistry. Since then the institute conducts interdisciplinary fire research in support of biogeochemistry and atmospheric chemistry studies. Since 1998, the FREG has hosted the Global Fire Monitoring Center (GFMC 2000).

Advanced sensor technologies and operational systems of dedicated fire satellites are required to improve the spatial-temporal coverage and information content for research and disaster management purposes. A prototype improved high temperature event (HTE) sensor, the Bi-spectral IR Detection (BIRD) small satellite mission, is being developed by the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt - DLR) in cooperation with the GFMC. A launch date has been set for June 2001. The development of the Innovative Infrared Sensor System FOCUS, to be flown as an early external payload of the International Space Station (ISS), is another project developed by DLR (Oertel et al. 2000).

The DLR has also developed the Autonomous Early Warning System for Forest Fires in Brandenburg State (Kührt et al. 2000).

A *German Research Network for Natural Disasters* was established in 1999. The *Forest Fire Cluster* is focusing on the development of an operational fire modeling, information and decision-support system for the State of Brandenburg (DFNK 2001).

The German fire science community is actively involved in the work of the *German Committee on Disaster Reduction* (within the ISDR) and its Scientific and Operational Advisory Boards (www.dkkv.org).

During the 1990s, the research conducted under the scientific framework of the *Biomass Burning Experiment* (BIBEX) of the *International Geosphere-Biosphere Programme* (IGBP), *International Global Atmospheric Chemistry* (IGAC) Project and an increasing number of other projects has provided a sound base for understanding the implications of wildland fires on ecosystems, planetary-scale processes (biogeochemistry, atmospheric chemistry, climatology) and humanity. Some elements of the international fire research programmes have been initiated, planned and implemented by German research institutions (BIBEX 2000).

A number of fire management projects or fire management project components within forestry development projects have been implemented or are underway at the international level. Most advanced are Integrated [Forest] Fire Management (I[F]FM), or Community-Based Fire Management projects. The projects were supported by the German Ministry for Economic Cooperation (GTZ 2001) (See also Asia regional report and country reports for Indonesia and Mongolia).

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Source

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4.3.5 Fire Situation in Latvia

By
Arnis Gertners
Forest Protection, State Forest Service, Riga, Latvia

Introduction

Forests account for 44 percent (2 870 000 ha) of Latvia's total land area (64 589 km^2). From region to region of the country the forest cover varies between 30 and 60 percent. The most wooded regions are in the west, the most sparsely forested in the south and southeast.

Of the total forest area, 1 493 000 ha (51.8 percent) are owned by the state, 1 276 000 ha (44.2 percent) by 250 000 private owners and 2.8 percent by agricultural enterprises. Other ownership categories (municipalities, church, etc.) make up 1.2 percent. Private holdings are small – on the average 10 ha. Only 0.05 percent of the private owners have forests larger than 100 ha.

The dominant tree species (in percent of the forested area) are as follows:

- Pine 40%
- Spruce 20%
- Birch 28%
- Grey alder 5%
- Other broadleaved 5%

About 20 percent of the coniferous forests (accounting for 60 percent of the total forest stock) are subject to high fire-hazard, especially young stands. Also, medium-age and near-mature stands of pine and spruce on dry mineral soils, making up 44 percent of the total forest area, have high fire hazard levels. In dry summers, fire may also become a problem in the bogs, which account for 3.8 percent of the country's land area.

Organization of the forest fire conservancy

The State Forest Service (SFS), a state civil administration institution under the Ministry of Agriculture, is responsible for enforcing a unified forest policy and supervising compliance with the forest management and utilization laws and regulations. The forest fire conservancy is one of the functions vested in the SFS by act of law. The fire safety regulations set forth the basic rules for fire conservancy and the preventive actions to be taken. These regulations are mandatory for forest owners, holders and persons visiting the forest.

The SFS effects its functions via its territorial units in 26 regions. Their area of jurisdiction is identical to the administrative-territorial regions of the country. These regional entities are comprised of 197 Forest Districts. The work of forest fire control is organized following the Instructions on Forest Fire Conservancy.

To deal with cases of fire, each Regional Forest District, depending on the fire hazard level, has one or several forest fire stations equipped with a fire truck (or trucks) and a crew of three to four members for each truck.

Before the fire season, which normally starts in mid-April, each crew takes a short refresher course of instruction. In hot and dry summers, when the SFS cannot cope with the situation on its own, other state institutions are also involved in forest fire control. Mutual cooperation agreements have been made with the State Fire Safety and Rescue Service of the Ministry of the Interior, the State Joint Stock Company *Latvijas valsts mezi*, which manages the state forests and the Forestry Board of the Riga City Municipality, which owns over 50 000 ha of forest. The closest cooperation is with the State Safety and Rescue Service, which deals with all cases of fire in the municipal and local government forests.

Moreover, each year each Regional Forest District draws up an operational plan of fire safety identifying the manpower and hardware resources needed for forest fire control. The plan is approved and its execution supervised by the local authorities.

The forest fire conservancy is financed from the state budget. The SFS fights forest fires in all forests, irrespective of ownership.

A network of fire lookout towers is intended to detect and follow up on the development of forest fires (Figure 4-21). The fire observer on the tower informs the person on duty at the forest district office and the fire station about the situation by telephone or via radio communications. The location of the fire is identified on a map and an initial attack fire crew is dispatched.

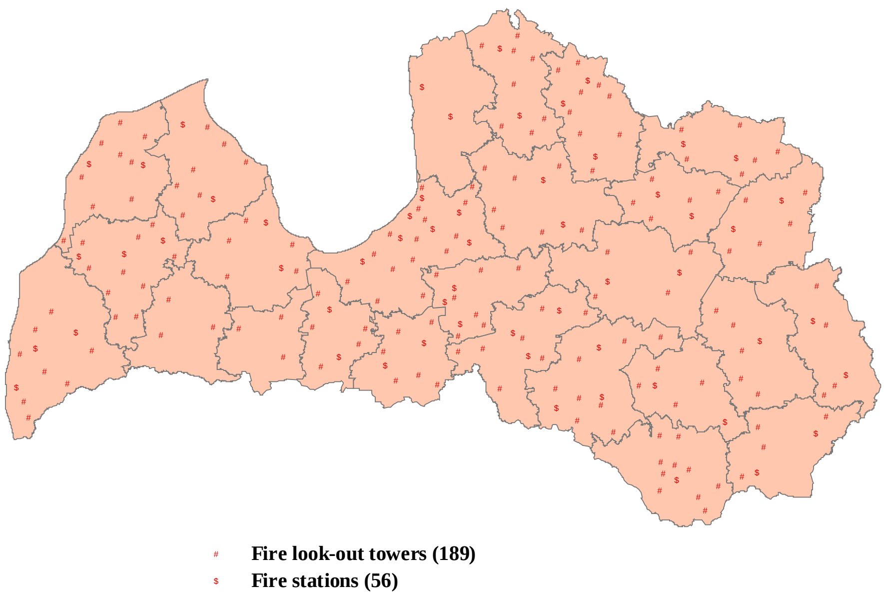

Figure 4-21 Map of fire lookout towers and fire stations in Latvia

Forest fire occurrence: fire statistics

As can be seen from the statistics for the period 1980 to 1999, some fire seasons are quite serious. An overall tendency toward a more frequent occurrence of fires and more area burned can be noted (Figure 4-22).

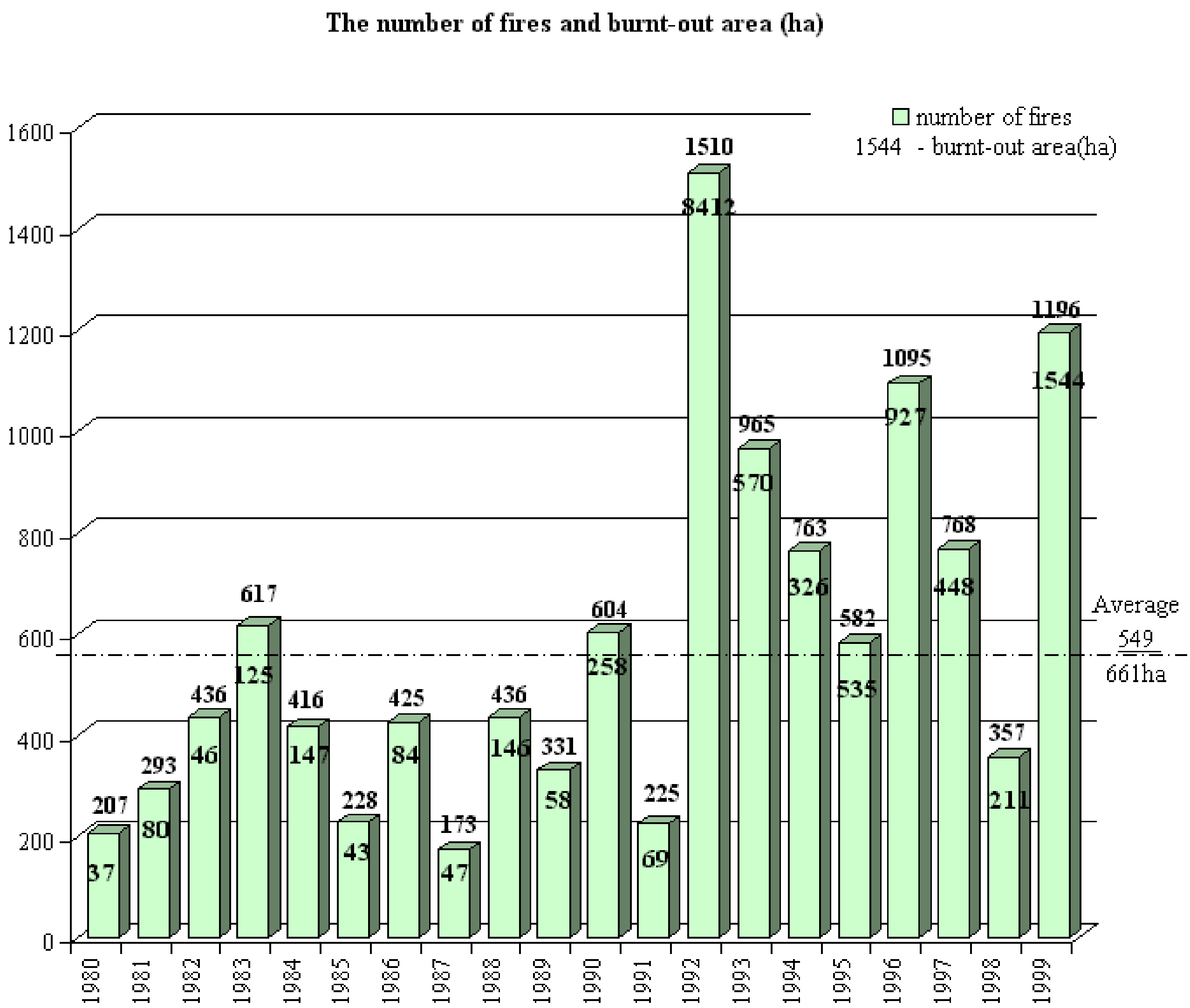

Figure 4-22 Forest fire statistics of Latvia, 1980-1999.

Differences between the regions of the country are also apparent (Figure 4-23). The frequency of forest fires is higher in the vicinity of settlements and the biggest cities – Riga, Daugavpils and Ventspils.

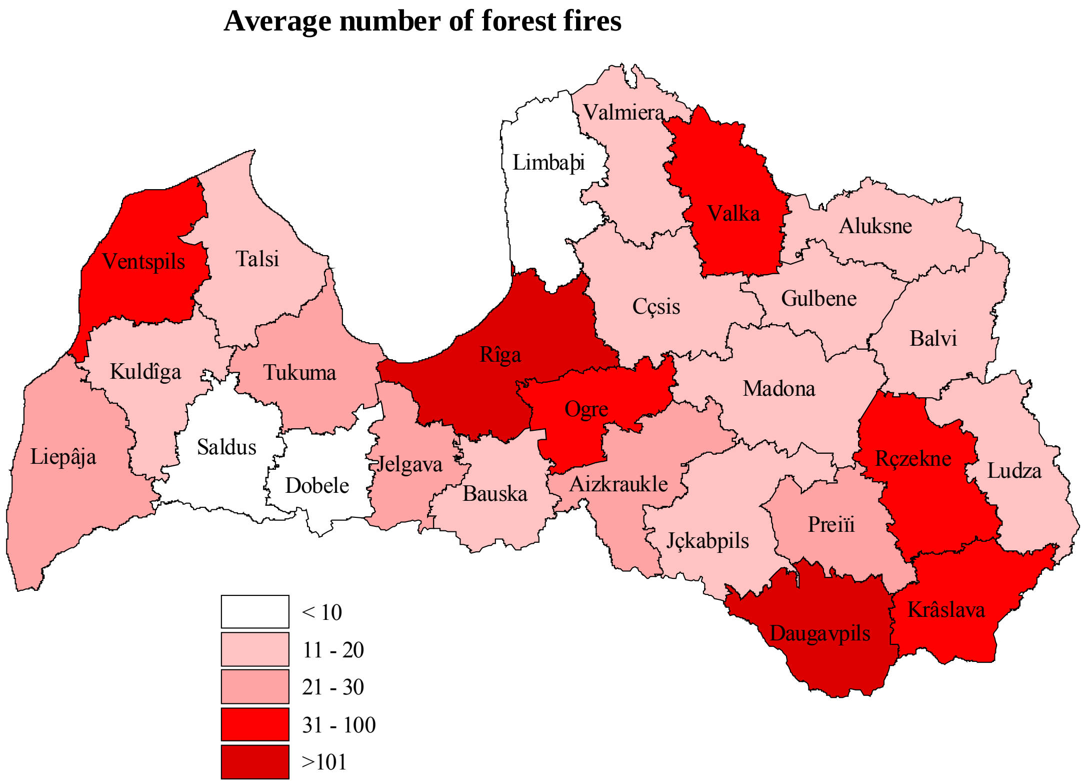

Figure 4-23 Distribution of forest fire occurrences in Latvia by region, 1980-1999

The average area burned by a fire event only exceeds 1.0 ha in some years (Figure 4-24). Occasionally, large forest fires break out. The year 1992 was especially disastrous in this respect – two conflagrations at the same time that burned 3 300 ha in each case. Large areas of peat bogs were affected, too. The most recent disaster was in 1999 in Kemeri National Park where the burned area was 377 ha. In dry summers close to the autumn season, bog fires are especially devastating because of difficult access and the shortage of water supply in the vicinity of bogs.

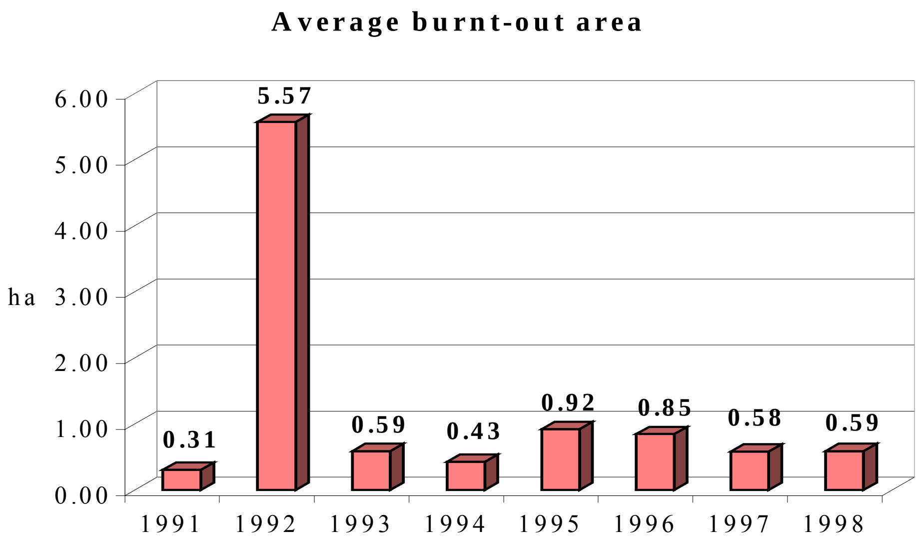

Figure 4-24 Average area affected by a forest fire event in Latvia, 1991-1998

An analysis of fires shows negligence to be the main cause (Figure 4-25). A lot of fires are started by people visiting the forest and by the burning of agricultural residues (straw, last year's grass, etc.).

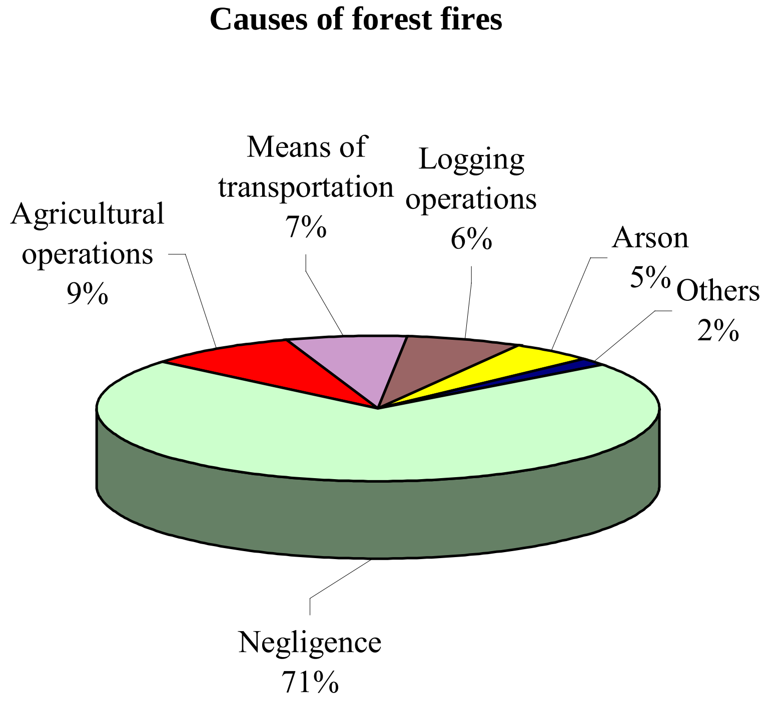

Figure 4-25 Distribution forest fire causes in Latvia, 1980-1999.

To predict the fire situation, the SFS, under an agreement with the State Hydro-meteorological Board, receives weather forecasts and a map showing the level of forest fire hazard on a daily basis.

Great attention is paid to the improvement of radio communications and the compatibility between communication systems. Thus, outdated radio stations are being replaced by Motorola products. The SFS also expects to procure a specially equipped MI-8-MTV-1 helicopter this year.

In working out a new approach in forest fire conservancy, the SFS places great emphasis on a professional, well-trained and technically equipped unit within the State Fire Safety and Rescue Service.

Source

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4.3.6 Fire Situation in Lithuania

By
Gerimantas Gaigalas
Department of Forests and Protected Areas, Ministry of Environment, Vilnius, Lithuania

Introduction

Forests cover an area of 1 978 000 ha or 30.3 percent of the territory of Lithuania. The forest area *per capita* is 0.53 ha.

As of 1 January 2000 the ownership distribution of forests is the following: State-owned forests - 53.8 percent; private-owned - 18.9 percent; the remainder of 27.3 percent are in the transition state to be privatised. Currently 150 800 forest owners who have the proprietary right to manage forests have been registered (Figure 4-26).

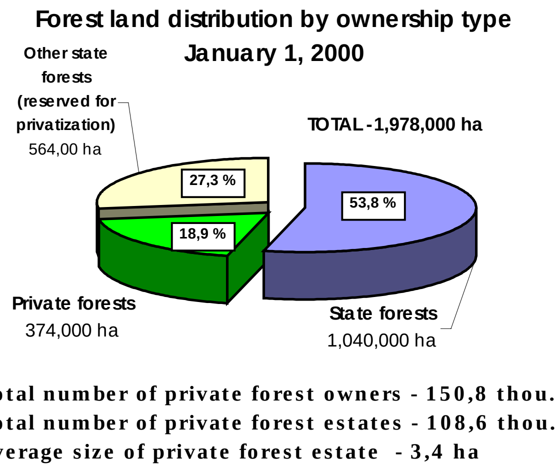

Figure 4-26 Distribution of forest ownership in Lithuania (1 January 2000)

Pine forests make up 42 percent, spruce stands 26 percent, and hardwood deciduous trees 4 percent of the state-owned forests. Private forests comprise 32 percent of pines, 20 percent of spruce and 5 percent of hardwood deciduous trees (Figure 4-27).

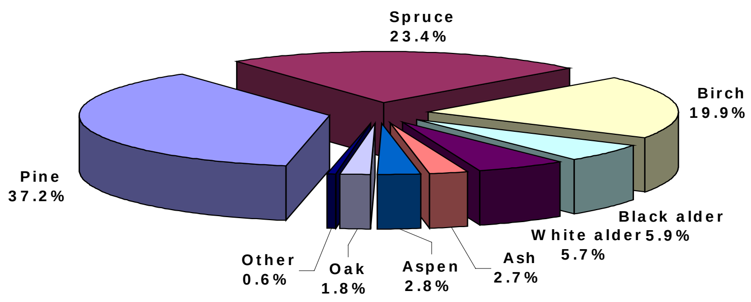

Figure 4-27 Species composition of forests in Lithuania

Forest Fire Hazard

In accordance with the Forest Fire Prevention regulations the Lithuanian forests fall into three natural fire hazard classes (high, medium and low) which are defined by the relation between the total habitat area and the coniferous undergrowth of up to the age of 40 years.

The distribution of fire hazard classes is as follows: high – 40 percent, medium – 23 percent, and low – 37 percent (Figure 4-28). Forests of heterogeneous (mixed) natural fire hazard are distributed unevenly. They fall under the class of high fire hazard, thus contribute to the overall large area of this category.

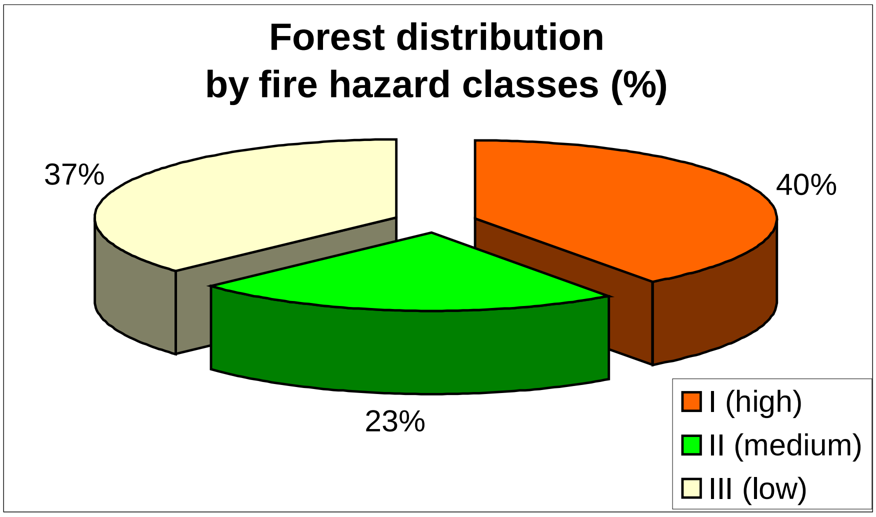

Figure 4-28 Distribution of forest stands in Lithuania classified by fire hazard

In terms of fire hazard nine forest massifs are at highest risk, including Varėna (51 400 ha), Labanoras (35 800 ha), Kazlų Rūda (45 000 ha), Rudninkai (11 100 ha), Viešvilė-Smalininkai (16 400 ha), Kapčiamietis (29 800 ha), Lavoriškės (15 600 ha), Šimonys (9 700 ha) and Kuršių Nerija (9 800 ha) (Figure 4-29).

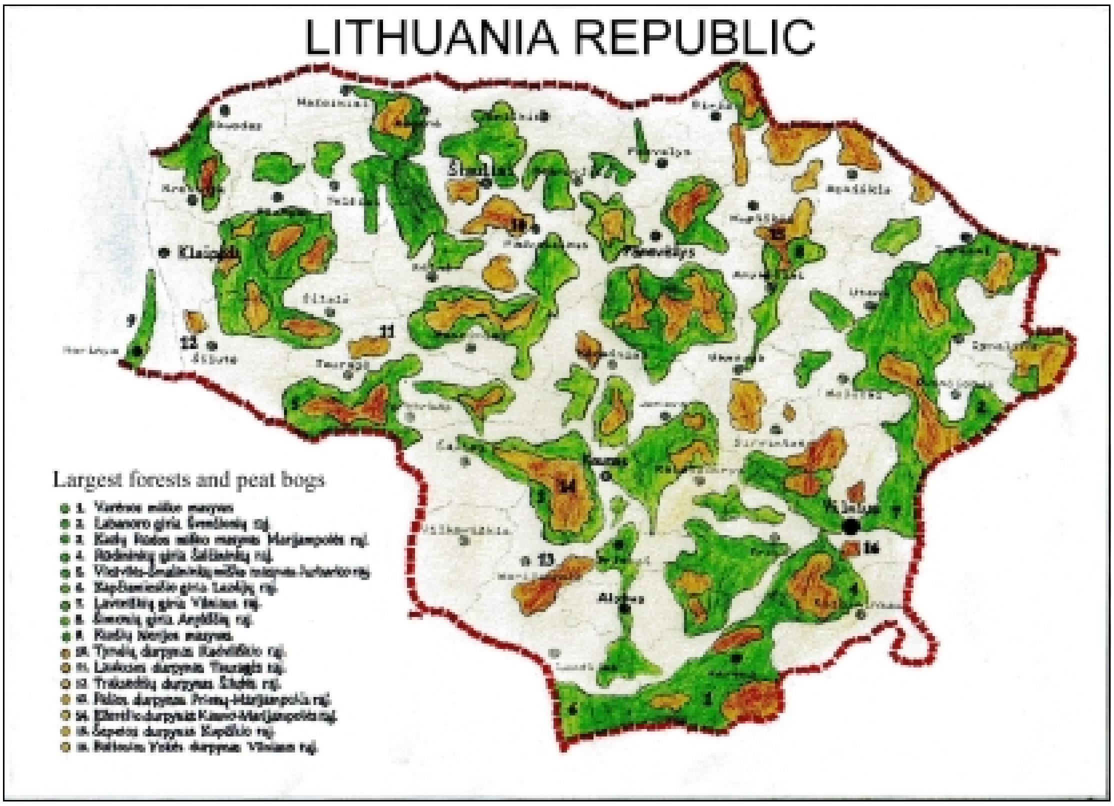

Figure 4-29 Map of large forest and bog complexes in Lithuania

The Kuršių Nerija massif is rated in the highest natural fire hazard class on nearly 100 percent of the forest cover within its territory. The entire peninsular area of Kuršių Nerija including its settlements is surrounded by water with the Baltic Sea in the West and the Kuršiai lagoon in the East. An additional factor of high fire danger in the pine forests of Kuršių Nerija is the frequent occurrence of strong winds. Recent fire events confirm this classification: 60 ha were burned in 1995 and 9 ha in 1999.

Peat fires cause a lot of problems in the country. However, in the course of privatisation a lot of peat bogs have lost their owners and become unattended. In future these peat bogs may be at high risk during the fire season.

In terms of the fire hazard nine peat bogs are the most endangered, including Tyruliai (3 000 ha), Laukėsa (2 000 ha), Traksėdžiai (1 800 ha), Palios (1 500 ha), Ežerėlis (1 300 ha), Šepeta (700 ha), Šiluvos Tyrelis (600 ha), Sulinkai (600 ha) and Baltoji Vokė (500 ha). Between 1994 and 1999 a total of 288 fires occurred in the peat bogs.

Challenges for Fire Management

State forest-enterprises are faced with the complicated task to extinguish peat fires due to the lack of special fire equipment. The fire and rescue brigades, which are subordinate to the Fire and Rescue Department, carry out the basic work of putting out peat fires. The fire brigades often enjoy assistance in receiving fire equipment from other institutions involved through the municipality level.

Pursuant to the Law on Forestry of the Republic of Lithuania the integral state system of fire prevention measures is applied within the forest territories of the Republic. Measures include forest fire surveillance, prevention and fire protection. The main objectives of the system are to reduce forest fire hazard, improve fire prevention; increase resistance of forests to wildfires, and to forecast, detect and extinguish fires.

Forest managers, owners and users are responsible for the fire protection status within their forest territories; however, they tend not to allot funds to the forest fire control.

The state forest-enterprises, state park Organizations and municipalities should allot financial resources in order to implement the integral state system for fire surveillance and extinguishing in accordance with the Law on Forestry of the Republic of Lithuania. Yet, all these activities are financed only from the funds of the state forest-enterprises and state park Organizations.

Issues of fire control in privately owned forests have not yet been resolved up till now. They do not pay any taxes either.

Prevention Measures

Officials from the State Fire Prevention Service in cooperation with the officers of the State Forest Service are in charge of supervising forest fire prevention in the forests throughout Lithuania. The State Fire Prevention Inspectorate and the State Forest Service are responsible for planning and implementation of an annual package of fire prevention measures within their area of responsibilities. Fire prevention measures include the following:

Information to the public about fire danger and fire risk through the mass media.
State forest managers and private forest owners as well as enterprises in charge of peat-bogs and railway routes are required to renew (maintenance) or establish firebreaks, to put up fire places that meet fire safety requirements in the rest areas, to repair fire watch towers and fire equipment before the beginning of the fire season and to put up warning signs and billboards.
Enforcement of strict control measures of forests and peat-bogs during the critical fire season; to pay regular inspection visits to the areas mentioned.
Information of county or city municipalities about the deficiencies discovered on site.
The State Fire Prevention Inspectorate and the State Forest Service officials shall inflict administrative penalties on the violators of the fire safety regulations.

The awareness campaigns through the mass media are functioning and the system to control the fire-prevention obligations of forest owners and managers are implemented as well.

Forest enterprises undertake measures of fire-prevention and forest management. In forests of high fire danger class the special measures are designed and implemented: Forests are divided

into blocks and separated by firebreaks (mineral strips) and fuelbreaks (belts of broadleaved trees); forest roads are cleaned. In Lithuanian forests a network of 28 500 km of roads provides approximately 14.4 km of roads per1 000 ha of forests. With this network of forest roads and the coverage of fire lookout towers it is possible to detect and suppress fires adequately.

Legislation and Law Enforcement

The main legislative documents regulating the requirements of forest fire safety include the Law on Forestry, the regulations on forest fire safety, the Code for the Violation of the Administrative Law and appropriate decisions of the Government of the Republic of Lithuania on issues of fire safety as well as legal acts of the Department of Forests and Protected Areas and the General State Forest Enterprise (GSFE).

The General State Forest Enterprise is in charge of implementing the integral state system of fire prevention measures that include measures for surveillance, prevention and fire protection. The GSFE in cooperation with the state forest managers and regional administrations as well as the city and county municipalities take responsibility in organising the implementation of this system and the forecast of forest fires as well as prevention and the announcement of the possible danger to the Lithuanian citizens through mass media.

The amendments to the Administrative Code of Law Violations were introduced in 2000 and regulate the penalties for violations of fire-prevention and environment protection rules. Private forest owners have to take full responsibility for fire-prevention measures.

Fire Management Organization

Forest fire protection in Lithuania is under the responsibility of 42 state forest enterprises and four state park Organizations. For forest fire surveillance 124 fire watch-towers equipped with surveillance and communication devices have been built in the country.

During the highly critical fire season the state forest enterprises and national park Organizations keep an elevated watch in accordance with the standard operating procedures.

The fire brigades of the state forest enterprises and the state park Organizations are responsible for extinguishing all forest fires that occur in Lithuania. Only in the case of failure to put out a forest fire the city and county fire and rescue units are called up for assistance.

In the event of an emergency caused by a large fire situation and when the fire and rescue services of the city (county) forces, the state forest enterprises, state park Organizations and other forest-peat bog managers as well as private owners fail to control the fire, the Regional (County) or the Government Emergency Management Centres take over the control of the situation through the regional and state levels concerned.

The fire and rescue services subordinate to the Fire and Rescue Department respond to emergencies in coordination with the fire teams of the state forest enterprises and state park Organizations.

Criteria for Declaration of an Emergency

On 24 February 2000 the Lithuanian Government approved the Criteria for Emergencies in the Republic of Lithuania. Natural forest and peat bog fires make up one of their fields that are described in Table 4-30.

In case of emergencies the Lithuanian armed forces and units of the National Guards also render assistance in extinguishing forest fires.

For extinguishing forest fires the state forest enterprises handle fire teams equipped with fire trucks and communication devices that include 50 fire vehicles as well as about 600 radio stations and mobile telephones.

Table 4-30 Criteria for declaration of a forest fire emergency in Lithuania.

Criteria for an Emergency		
Emergency type	**Criteria**	
	Description (including Units of measurement)	Assessment (value, size)
Forest Fires		
Extremely high fire hazard – predictable fire danger		
Favourable conditions for fire break out	Probability (%)	30 ÷ 60
	Fire danger class	IV
	Fire danger index	4 000÷10 000
Extreme conditions for fire break out	Probability (%)	61 ÷ 100
	Fire danger class	V
	Fire danger index	≥ 10 000
Fire size	Ha	≥ 3
Danger for settlements or individual households	Yes / no	yes
Distance to gas pipeline network	Distance (m)	≤ 350
In a coniferous forest	Forest fire hazard class	1 or 2
Severe injuries or fatalities	Persons	≥ 1
In forests of high fire hazard	Fire / no fire	fire
In the most hazardous forests & forests massifs in terms of fire risk	Fire / no fire	fire
Peat–bog fires		
Fire and smoke		
A nearly burnt (or completely burnt down) farmstead household or a farm building	Unit	≥ 1
In the most hazardous peat–bogs in terms of fire risk	Fire / no fire	fire
Residential areas affected by smoke		
In case of forest or peat–bog fire: densely populated residential areas downwind		
Lithuanian cities, towns, settlements	Yes / no	Yes
Towns, small towns, settlements: inhabitants need to take precautionary measures or to be evacuated	Total number of inhabitants residing in that area (%)	≥ 25

The forest fire guard or lookout of a fire team must inform the nearest fire and rescue service of the Fire and Rescue Department about each fire. The state forest functionaries and directors of the state forest Organizations are responsible for establishing such fire teams and providing them with means of fire extinguishing, transport and communications.

A forest safety engineer or other specialist is appointed as a forest fire safety leader to be charge of the fire teams. The leader is responsible for the training and control of the team members. The main and reserve fire teams are set up in the state forest enterprises. Fire teams on duty are set up in the case when forest areas of high fire danger are located more than 20 kilometres from the headquarters serviced by one fire team. The reserve fire teams consist of 15-20 firemen who are ready to quickly respond. They consist of a group of people at their work places employed in timber processing and repair shops, timber warehouses etc. These teams are accommodated with an assembly location where they usually keep their necessary stock of fire extinguishing equipment and outfit.
The Organizational questions of forest fire control (fire extinguishing, the mobilisation and deployment of technical and human resources) are being decided on the municipality, regional and city levels with the assistance of Organizations and companies from the territory of municipalities. Operational fire control plans provide special measures for reciprocity and the coordination of actions among the fire control parties involved. Access to forests in some Lithuanian regions could be restricted or other measures could be taken if required. The General Forest Enterprises control and coordinate fire detection, fire control and the implementation of fire prevention measures.

Forest Fire Statistics

During the period 1991 to 1999 the total of 5 856 forest fires occurred in Lithuania, affecting a total area of 3 100 ha. Thus, an annual average approximately 600 forest fire destroy 300 ha of forest stands and cause losses in the magnitude of 0.5 million LTL (Litas), equivalent to $US 2 million. The average size of a forest fire is about 0.5 ha. The number of forest fires has extremely increased during the favourable meteorological conditions, e.g., in 1992 and 1999 (Figure 4-30). Most forest fires are caused by negligent behaviour of tourists and forest visitors (70 percent), careless grass burning in spring 14 percent), and arson (16 percent).

The process of forest ownership restitution is still going on and many private forest owners are taking back their property. Nevertheless, the number of forest fires in private forests is increasing as well. (1997 - 14.6 percent, 1998 - 25.1 percent, 1999 - 24 percent out of total number of forest fires). Many private forest owners are living in the cities and cannot take care of their property – a major reason why the number of forest fires in private forests is increasing.

A big problem in Lithuania is the burning of dry grass in spring. This tradition is very old. However, it is often not understood that grass burning can cause a forest fire; about 40 ha of forests are ignited and damaged by grass burning every year. The State Environment Protection Inspection, its regional authorities, together with the officers of the Fire Prevention Department, make efforts to eliminate this tradition.

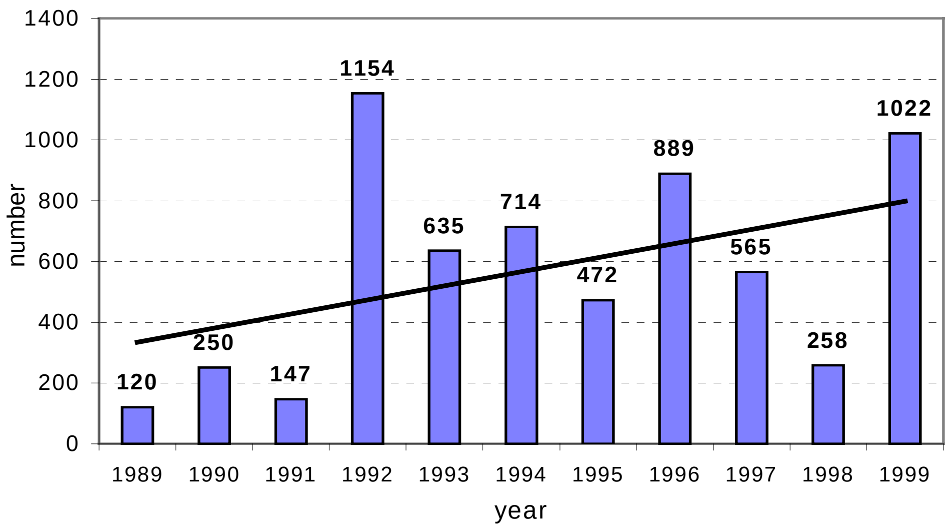

Figure 4-30 Number of forest fires in Lithuania, 1989-1999.

Problems Ahead

The main reasons why it is so difficult to organize forest fire suppression and undertake fire-prevention are:

- There is no unified program for forest and peat-bog fire prevention and suppression.
- The financing mechanism of fire prevention measures in state and private forests is not defined yet.
- The technical base in state forest enterprises and national parks is too old and inefficient; the possibility to renew it is limited due to poor funding.
- The legislative system and the damage recovery mechanisms are not efficient enough.

Source

Gaigalas, G. 2001. Forest fires in Lithuania. *Int. Forest Fire News* 24: 35-40.

4.3.7 Fire Situation in the Russian Federation

By
Anatoly Shvidenko
International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria
&
Johann G. Goldammer
Global Fire Monitoring Center (GFMC), Freiburg, Germany

Introduction - terminology and classification

Russian forest inventory manuals and basic forest legislative acts (e.g., the Forest Code of the Russian Federation, 1997) characterise forest land into two categories, Forest Fund and Forest Lands, with the latter divided into Forested Areas, or closed forests, and Unforested Areas, or lands that are temporarily not covered by forests but are intended for forests (e.g., burnt areas, dead stands, natural sparse forests, grassy glades and barrens). Official definitions of these categories are given in the Appendix.

We use Forested Areas, together with natural sparse forests and non-stocked forest plantations as equivalent to the FAO category “forest”, and the other categories of Unforested Areas as “other wooded land”. Some analysis is given for “other land”, which is mostly represented by non-forest land of the Forest Fund and northern unused territories of State Land Reserve.

As of 1 January 1998, Russian forests (FFSRF 1999) were comprised of 1.178 billion hectares (ha) of Forest Fund, 881.97 million ha of Forest Lands, 296.58 million ha of Non-forest Lands [NFL], 774.25 million ha of Forested Areas and 107.72 million ha of Unforested Areas, of which 24 percent were burnt areas and dead stands, 68 percent were sparse forests, 5 percent were unregenerated harvested areas (clearcuts), and about 3 percent were represented by grassy glades and barrens. The total growing stock volume (i.e. total volume of stem wood of all growing trees) was estimated to be 81.86 billion m^3. Russian closed forests (Forested Areas) contain 41.05 billion tons of vegetative carbon, including 32.86 billion tons of carbon in living biomass (phytomass), 3.79 billion tons in dead roots and 4.40 billion tons in coarse woody debris (Shvidenko et al. 2000). In addition, the top one metre layer of soil of forest ecosystems contains 130.4 billion tons of carbon, of which the litter layer contains 11.4 billion tons.

Fire environment, fire regimes, ecological role of fire

A tremendous diversity of climate, soil and vegetation, together with a wide variety of anthropogenic impacts, is inherent in the vast territories of Russia. Russian forests stretch through eleven time zones and ten bio-climatic zones and subzones-from tundra in the north to deserts in the south. The major factors that influence the distribution, species composition, structure and productivity of forests, as well as the fire regimes of Russian terrestrial vegetation in general and in forests particular are temperature, precipitation, continentality

and aridity of climate and land-use. Table 4-31 shows the distribution of Russian terrestrial biota by bio-climatic zone with a special emphasis on forests.

There are several reasons why fire is a major natural disturbance in Russian forests:

- About 95 percent of the forests are boreal forests, and a major part of them is dominated by coniferous stands of high fire hazard;
- A significant part of the forested territory is practically unmanaged and unprotected – large fires (>200 ha) play an important role in this region;
- Due to slow decomposition of plant material, the forests contain large amounts of accumulated organic matter;
- A major part of the boreal forest is situated in regions with limited amounts of precipitation and/or frequent occurrences of long drought periods during the fire season.

Table 4-31 Distribution of Russian terrestrial vegetation by land class and bio-climatic zone.

Bio-climatic zones	Vegetated areas by major land classes (million ha)				Species composition of closed forests[c]	Amount of potential fuel in forests (kg C/m^2)		
	Total	Including				AGB [b]	CWD[b]	Litter
		Wetland	G&ShL[a]	Forest				
Arctic desert and semi-desert	0.7	0.0	0.7	0.0	-	-	-	-
Tundra	266.9	62.3	199.0	3.8	10L[d]	0.93	0.17	0.35
Forest tundra, sparse taiga	233.0	64.7	15.5	141.2	7L1S1P1B	1.78	0.52	1.58
Middle taiga	683.6	62.0	152.0	455.0	4L2P2S1C1B	3.54	0.70	1.58
Southern taiga	211.5	30.1	19.5	126.5	3P3S2L1F1C	4.32	0.66	1.41
Temperate forests	60.3	1.8	2.6	26.4	3P2S2B1O2D	4.76	0.42	0.65
Steppe	148.4	0.7	26.7	9.3	5O1P1E2B1A	2.95	0.17	0.13
Desert and semi-desert	25.4	0.3	6.4	1.3	6O1P2E1B	1.23	0.15	0.17
Non-vegetated land	79.6							
Total	1 709.5	222.0	432.4	763.5	8.2Cn0.3HD1.5SD	3.36	0.58	1.50

Note: Abbreviations used in Table 1 are:
a – (land classes) G&ShL - grassland and shrubs.
b – (fractions of vegetation organic matter) AGB - above ground live biomass (phytomass), CWD-coarse woody debris (on-ground and above-ground dead wood with the diameter at the small end >1cm).
c – (dominant tree species) L-larch, S-spruce, P-pine, B-birch, F-fir, C-Russian "cedar" (*Pinus sibirica* and *P. koraiensis*), O-oak, A-aspen, D-other deciduous, Cn-coniferous species, HD-hard deciduous species, SD - soft deciduous species.
d – Coefficients of the species composition formulas indicate 0.1xPercent of a species in the total growing stock volume by a zone.

Forest fire in the boreal zone of Eurasia is both a geographical and historical phenomenon, and its impact on the environment has local, regional and global dimensions (Goldammer and Furyaev 1996). The diversity of forest types, growing conditions, landscape peculiarities, structure and productivity of forests, types of anthropogenic impacts, etc., define different types of fires, their distribution, intensity, ecological impact on terrestrial ecosystems and

landscapes as a whole, and even alters the general estimates of the environmental role of wild forest fire.

The double-faceted role of forest fires – destructive and dynamic – is evident in the boreal zone. In the southern and central parts of the zone, forest fires are one of the most dangerous environmental phenomena, causing significant economic losses with a strong negative ecological impact on forest ecosystems and biodiversity. On the contrary, in unmanaged and unused forests of the northern and sparsely stocked taiga and forest tundra, particularly on permafrost sites, surface fires occurring at long-return intervals of 80 to100 years represent a natural mechanism that prevents the transformation of forests to shrubland or grassland: Exclusion of fire induces the build-up of organic layers that prevents melting of the upper soil and rise of the permafrost layer, resulting in impoverishment of forests, decreasing productivity, and paludification. Nevertheless, frequent recurrent fires can significantly decrease the productivity and stability of forests (up to 40-50 percent), even in the extreme north. Under severe climatic conditions, fire is often responsible for forest decline and extension of the tundra to the south. Fire is the major reason for the "human-induced" treeless belt along the boundary between the taiga and tundra in northern Eurasia. It presently is 100-250 km wide and its area increases by 0.3 million ha per year.

Forest fire is a significant force in the transformation of vegetation cover in the boreal zone. It initiates long-term changes in all the components of a landscape. The micro-climate conditions of the atmosphere's surface layer (light, humidity, wind), the temperature and humidity of upper soil layers, soil water regimes, soil chemical properties as well as many other site characteristics, are significantly changed for long periods by fire. The soil formation processes can be changed, in particular on humid and wet sites. The partial or complete change of species, age, stand structure, reforestation peculiarities, level of productivity, etc., are common components of post-fire succession. Generally, fire generates the specific features of ecological regimes at the landscape scale. The duration of post-fire recovery of forest ecosystems depends on the type and severity of fire as well as climatic conditions and usually ranges from 5-7 to 100-150 years.

Fire is a major driving force in the succession of northern Eurasian forests. Among five classes of a comprehensive forest succession classification developed for Siberia and the Russian Far East, different phases and stages of pyrogenic succession cover 40 to 96 percent of the total forested area of most ecological regions. For instance, for a typical taiga landscape of 165 000 ha in the Kos-Yenisey plain of eastern Siberia, the total area affected by fire (including recurrent fires) for the period 1700-1956 was estimated at 5.38 times the size of the total area (Furyaev 1996). The expansion or decrease in area of different forest associations, as well as changes in dominant species and species composition, are mainly dictated by fire in the major boreal areas of Russia.

Fire hazard and fire risk depends on forest ecosystem characteristics, weather and ignition sources. Forest inventory identifies all Russian forests by five classes of fire hazard based on landscape/ecosystem indicators from Class I [highest fire danger], where fire is possible during the entire fire season (young coniferous forests, dry sites of slashed harvested areas, pine forests with lichens and mosses, etc.) to Class 5, where fires occur only under extremely unfavourable conditions, e.g. long-period drought (e.g., spruce forests with *Sphagnum*).

Russian forests (Forested Areas) are 72 percent dominated by conifers, including larch (about 37 percent), pine (16 percent), spruce and fir (13 percent) and cedar (*Pinus sibirica* and *P. koraiensis*) – (about 6 percent). The distribution of Forest Fund area in 1998 by fire danger

classes was: first class, 17.4 percent second class, 15.3 percent; third class, 30.3 percent; forth class, 26.3 percent; and fifth class, 10.7 percent, i.e., about two-thirds of all the Forest Fund area belongs to the first three fire danger classes.

The duration of the fire season is geographically dependent and ranges from 90-100 to 200-250 days per year. There is a clear zonal gradient in the seasonal distribution of fire (Korovin, 1996). On the average, for the zone protected by aviation, the distribution of fire occurrence (percentage of fires by month) is as follows: May 23 percent, June 28 percent, July 31 percent, August 13 percent and September 5 percent (Chervonny 1979).

Fire in the boreal zone is a significant source of greenhouse gases. Due to different approaches, estimates of annual carbon emissions to the atmosphere caused by fires in the early 1990s (for relatively "normal" by fire danger years) ranged from 35 to 93 million tons of carbon (Isaev and Korovin 1999) to 125±21 million tons (Shvidenko and Nilsson 2000), of which post-fire biogenic flux comprised about 50 percent. Fire generates from 30 to 40 percent of the total carbon flux emitted to the atmosphere by all human-induced and natural disturbances in the northern Eurasian boreal forests.

There is no doubt that fires also have had a significant negative impact on biodiversity, in particular in the southern part of the boreal zone. Fires and other anthropogenic impacts impoverish biodiversity at both the ecosystem and landscape levels. Southern species that are at the northern edge of their distribution are particularly vulnerable. For example, in Primorsky Kray the richness of 60 species of vascular plants, 10 fungi, 8 lichens and 6 species of mosses changed for the worse during the previous decades, mostly due to human-induced fires and fragmentation of forests. Significant fragmentation of forests inhabited by the far eastern tiger has been reported. The number of tigers, wild pigs, sable and deer *(Cervus elaphus)* on large areas burned in 1976 in the Amur River basin decreased from 1972 to 1997 by 20-50 times (Kulikov 1998). The number and species composition of wild animals has dramatically declined in territories impacted by large severe fires.

Such indicators as the extent, frequency and severity of fire determine the duration of post-fire regeneration, etc., and define the major features of disturbance regimes and their impact on the environment and the ecological functions of forests.

<u>Extent of fire occurrence</u>

Official data on the number and extent of fires have only been reported for protected areas of the Forest Fund, which, for last 40 years, have comprised about 60 percent of the Forest Fund area (e.g., official data for 1985-1990 were 62.5 percent of the Forest Fund). Areas not protected against fires are mostly located in the forested tundra and the northern and part of the middle sparse taiga of western Siberia (43 million ha in 1989), eastern Siberia (119 million ha), and the Far East (249 million ha). During recent years the area actually protected has significantly decreased. Even for the protected area, data are often not complete and, as a rule, are underestimated, in particular for fires on Unforested Areas and Non-forest Land. In addition, official statistical data on forest fires before 1988 were deliberately falsified for political reasons.

Annual forest fire statistics for fire-protected areas during 1950-1999 are presented in Table 3. During this period, the number of forest fires detected annually was between 18 000 and 37 000. After a decade with rather high fire activity (1950-1959) the burned area was reported as stabilized for the next three decades, and again increased during the last 10 years

(the average area of Forest Lands burnt annually for the decades 1950-1959, 1960-1969, 1970-1979, 1980-1989, 1990-1999 was 1.54, 0.68, 0,48, 0.54 and 1.2 million ha, respectively). The major ignition causes (as a percentage of the total number of fires) were local population 64.8 percent, lightning 16.0 percent, agricultural prescribed burning 7.3 percent, forest harvest activity 2.9 percent, expeditions 0.9 percent, activities of other enterprises 5.0 percent and unknown reasons 3.1 percent (Shetinsky 1994). The data do not include prescribed controlled burns on Forest Fund areas (which were negligible) and on "other lands" (for which no statistics exist; some expert estimates are given in Shvidenko et al., 1995).

Evidence of areas of stand-replacing fires is given by forest inventory data on areas of burnt and dead stands. These data are available for the entire country for the period from 1961 to 2000, and are of good reliability. According to the State Forest Account data, areas of burns, dead stands and grassy glades were estimated for the last 40 years for forests managed by state forest authorities, i.e., for about 95 percent of all Russian forests as of 1961, 70.6 million hectares; 1966, 68.4 million hectares; 1973, 53.6 million hectares; 1978, 43.9 million hectares; 1983, 36.8 million hectares; 1988, 34.9 million hectares; 1993, 35.0 million hectares and 1998, 28.0 million hectares (SNKh SSSR 1962; Goskomles SSSR, 1968, 1976, 1986, 1990, 1991; FSFMRF 1999). These data show significant progress in forest fire suppression during the last 40 years, but they also illustrate the incompleteness and significant bias of the official statistics.

The extent, timing and geographical distribution of fires varies greatly. The annual area burnt can vary about ten-fold. About 60 to 90 percent of the area burned annually is usually concentrated in three to six regions. In one or more of these, fires could be of catastrophic character. In Siberia, on average, about 1 percent of the fires are large (with an area of more than 200 ha) but in dry years this may rise to 10 percent. However, large fires make up 50 to 80 percent of the burned area and cause up to 90 percent of the total damage (Valendik 1990). In extremely dry years, a similar picture can be observed even in densely populated regions with intensive ground-based fire protection, e.g., during the twentieth century about 25 percent of all forests have burned twice in the Mary-El Republic (the basin of the Middle Volga) – in 1921 and 1972. In extremely dry years fire behaviour is extreme, including the occurrence of fires in wetlands. High-intensity fires are difficult to control. The consumption of large amounts of phytomass results in high fire severity with consequent long-lasting impact on ecosystem composition and function.

The areas burned annually in unprotected territories can only be indirectly estimated. Several modelling and expert approaches have reported rather consistent results. For instance, Shvidenko and Nilsson (2000), using a specially developed expert system, directly and indirectly available regional fire statistics and other information, data on the dynamics of major forest formations as well as distribution of Forested Area by age classes and types of stand age structure, estimated the average area burned annually for the period 1988-1992 in Forest Fund areas at 3.0 million ha (of which fires on Forested Areas are estimated to be about 1.2 million ha) and, in addition, 0.5 million ha on territories of the State Land Reserve in the extreme north. Official data reported for this period for the protected territories of the Forest Fund were about half of this figure. Using the modified model described in Shvidenko and Nilsson (2000) we estimated the long-term average burned area (1970s to the end of the 1990s) at 5.1 million ha, of which 4.1 million ha were on Forest Fund lands. The model results aggregated by bio-climatic vegetation zones are presented in Table 4-32.

The official fire statistics account for three types of fire on forested areas; surface, crown, and ground. The average ratio (percent of forested area burned) of the above three types of fire for the protected forested area was 83:17:0.3 in 1989-1992; 82:18.0:0.3 for the period 1986-1995 and 73.6:25.4:1.0 for the period 1971-1985. In a "normal" year, 1962, the ratio was 87:11:2. In the extremely dry year of 1972 it was 56:44 percent (no data for ground fire) and in 1978, 76:24:0.1 percent (Chervonny 1979). Shetinsky (1994) presented the ratio 81.4:18.6:0.02 based on official statistics for recent decades. Taking into account the nature of forest fire regimes in unprotected areas, our long period ratio of crown to surface fires on Forested Areas is about 15:85 percent. Taking into account a significant amount of peat burning in the carbon budget evaluation we separated peat fires (which are defined as fire on sites with an organic layer more than 15 cm deep and the depth of the consumed organic matter more than 10 cm, usually 15-20 cm) and kept the category of ground fires (which are defined as basically peat, but there are other types of underground fire) with the consumed organic layer more than 0.7 m.

Table 4-32 Model estimates of annual average forest fire area during the last three decades by bio-climatic zone and type of fire for the total Forest Fund and lands of the State Land Reserve.

Bio-climatic zone	Estimates of annual areas burned by types of fires, 1970-1999 (million ha)						
	Crown fire	Surface fire			Peat fire	Incl. GF[1]	Total
		FA[1]	UFA[1]	NFL[1]			
Arctic desert and semi-desert[2]	-	-	-	0.04	-	-	0.04
Sub-arctic and tundra[2]	-	-	-	0.89	0.07	-	0.96
Forest tundra and northern taiga	0.04	0.30	0.17	0.44	0.07	0.001	1.02
Middle taiga	0.19	0.98	0.25	0.63	0.10	0.007	2.15
Southern taiga	0.08	0.40	0.10	0.16	0.03	0.004	0.77
Temperate forests	0.01	0.07	0.02	0.01	0.01	-	0.12
Steppe	-	0.02	0.01	-	-	-	0.03
Semi-desert and desert	-	0.01	-	-	-	-	0.01
Total	0.32	1.78	0.55	2.17	0.28	0.0012	5.10

[1] Surface fires in forested areas (FA), on unforested areas (UFA), and on non-forest lands (NFL); ground fire (GF).
[2] Basically, territories of State Land Reserve areas.

There are some satellite data estimating the total extent of fire for all of Russia or its major parts. Cahoon et al. (1994), based on AVHRR data, determined the area burned in the Russian Far East and eastern Siberia in 1987 to be 14.4 million ha. VNIIZlesresurs, using Soviet satellite data for 1987 for central Siberia and a major part of the Far East, estimated about six million ha. Such huge areas of fire are possible in extremely warm and dry years. In the year 1915, with catastrophic weather conditions, forest fires were observed on 1.6 million km^2 and the total area of burnt closed forest was estimated to about 14 million ha. There are also years with rather low fire risk – for example, 1994 and 1995. Cahoon et al. (1995), using AVHRR data, estimated the burnt vegetated areas in the total Russian territory in 1992 to be about 1.5 million ha (officially reported burned areas for protected Forest Fund territories were 1.14 million ha). Based on satellite data, Shvidenko et al. (unpublished data) estimated the area of vegetation burned in 1998 for Forest Fund in the Asian part of Russia at 9.4 million ha (for details, see below).

Fire frequency

Frequency of fire depends on many factors: the spatial structure of landscapes, their ecological regimes, the fuel characteristics of forests and adjoining vegetation, typical fire weather during the burning period, inter-annual climate variability (recurrence of extreme drought), population density, accessibility, level of forest fire protection, etc.

As a rule, for basic upland forest types and geographical localities, the fire-return interval, including all types of fire, is 25 to 70 years. However, the variation is very large with an upper limit of 250 to 300 years for wet sites and a lower limit of 7 to 15 years or even less. An interval of 3 to 4 years was observed in dry pine and larch forests in densely populated areas. From a historical perspective, areas in which no fires occurred during a single life cycle of a coniferous forest (200-300 years) are negligibly small in the taiga zone (Furyaev 1996). There have been many attempts to identify temporal regularity of fires occurrence (specifically, years with extremely dangerous fires) based on climatic cycles, but the best conclusion is that available statistics and historical records do not present enough reliable data to permit any sort of prediction (Melekhov, 1979). For instance, from 1972-1982 there were extremely high fire risks in the Far East (Autumn 1976 in Khabarovsk Kray, autumn 1977 in Primorsky Kray, summer 1979 in Amur Oblast, summer 1980 and 1982 in the southern part of Khabarovsk Kray). In 1987 and 1998, extended fire episodes affected large areas of the Russian Far East and eastern Siberia.

A large amount of research on fire regimes (e.g. Furyaev 1996) has shown that: 1) wildfires have an explicit landscape nature; 2) quantitative indicators of frequency are scale-dependent; 3) the impact of forest type on the frequency of fires is more evident than impact of relief (mountain, plateau, plain, etc.); 4) high-frequency fires (e.g., in pine and larch forests on well-drained sites), as a rule, do not cause significant damage to the main canopy layers and do not lead to a change of species, but significantly impact the process of natural regeneration and the structure of stands; 5) fires in wet sites are very rare (up to 200-300 or more years), but damage is very severe; 6) the accessibility of forests to people, proximity to populated areas and the presence or absence of roads are crucial factors of fire frequency in taiga zone.

Post-fire dieback

The immediate reaction of stands to fire is expressed by post-fire mortality (dieback). The intensity and duration of post-fire dieback depends on many factors. The average period for dieback is roughly estimated to be five years, varying from two to seven years and sometimes more. The indirect consequences of fires can be seen over a longer period. For many forest formations, in particular those in the southern part of the boreal zone, other types of disturbance often accelerate the consequences of fire, e.g. by intensive outbreaks of secondary insects (likewise, fires in forests destroyed by insects are often extremely severe due to a large amount of dead, dry wood).

Post-fire tree mortality varies greatly and greatly depends on the type and intensity of the fire, relief, presence of permafrost, weather conditions, species composition, age and diameter of trees, and many other factors. The following are average estimates of post-fire mortality for growing stock in the taiga zone: for low-severity (superficial) surface fire, 6 to 12 percent; surface fire of medium-severity, 15 to 20 percent; litter fire, 30 to 50 percent; turf fire, 60 percent; peat fire, 70 percent; and crown fire, 75 percent. The variations are, however, very large, e.g., 5 to 90 percent for litter fires and 35 to 85 percent for turf fires. In many Siberian forest types, peat and crown fires cause total tree mortality (stand-replacement fires)

(Telizin 1988, Sheshukov et al. 1992). Many publications report the complete destruction of stands after only medium-intensity surface fires. Post-fire mortality on continuous permafrost with a thin melting layer is very high, and stands of all species (including larch) usually die almost completely after surface fires of medium intensity due to the large amount of dead organic matter consumed and the superficial root systems of the trees. The average annual area of forests killed due to mortality over time is approximately equal to the area killed in stand-replacement fires (i.e., the area of forests dying annually as a result of fires of current and previous years is estimated to be 0.6 million ha). For all types of fires other than stand-replacement fires, partial dieback is estimated to average 15 to 40 percent of the growing stock.

Post-fire regeneration

Post-fire natural reforestation relies on a great number of factors: geographical distribution and climate; structure of the landscape and the location of a burned area in a landscape; type and peculiarities of relief; site characteristics (parent material, soil, drainage, moisture regime, etc.); biological and ecological properties of tree species; specifics of forest types and succession stages; type and severity of the fire; size of the burnt area; availability and quality of seed; etc. The process of post-fire regeneration strongly depends on the bio-climatic zone and geographic and site conditions. As general and rough conclusions: 1) the ability of boreal forests to restore themselves is very high – the area of burnt and dead stands in Russia has decreased by 50 percent (from 70 million ha in 1961 to 28 million ha in 1998) during the last 50 years; 2) post-fire reforestation in the extreme north (forest tundra, northern and sparse taiga) is, as a rule, slow and requires a rather long time, up to 30-35 years, due to the insufficient availability and quality of seed; 3) productivity of the first post-fire forest on permafrost is 2-3-fold higher than in undisturbed areas; 4) in practically all bio-climatic zones, excluding larch stands in the extreme north, stand-replacement fire basically causes succession with a change of the dominant species; e.g., an usual scheme is: dark coniferous (spruce, fir, cedar) to soft deciduous (birch, aspen) to mixed dark coniferous-deciduous forests; 5) recurrent fires often lead to impoverishment of forests and generation of grassy glades, development of paludification processes, and finally to indefinite long periods of deforestation and "green desertification" – there are studies showing that a significant area of burns (up to 30-50 percent), if recurrent fires occur, are not restored for many years; and 6) regeneration under the canopy layer of mother stands after other than stand-replacing fires is dependent on the frequency of recurrent fires, and this is the major reason for the development of uneven-aged forests of different types.

Fire impacts in the period 1990-1999

The strong negative impact of forest fires is particularly evident during the years when catastrophic forest fires are driven by extremely unfavourable weather conditions during the fire season. During the last 15 years, Russia faced such years in 1987 and 1998.

During the summer of 1998, extremely dry weather prevailed on huge areas of Asian Russia. For instance, in Khabarovsk Kray rapid melting of snow when the soil was still frozen and subsequent lack of precipitation significantly decreased the moisture content of forest fuels by the beginning of the fire season. Precipitation in June was only 15 to 20 percent of the long-term average, in July 0 to 20 percent and in August 20 to 50 percent (Efremov et al. 2000). Hundreds of fires, a significant number of which escaped control and covered large areas, began simultaneously from May to October. Estimated burned area for the Asian part

of Russia using satellite data (Shvidenko et al. 2000, unpubl. manuscript), was 9.4 million ha of vegetated land, of which Forest Land was 7.2 million ha. The area affected by crown fires was estimated to be 1.0 million ha. The severity of the fires and amount of organic matter consumed was very high. Estimated direct emissions of carbon during the fire season totalled 172.8 million tons, of which forest fires emitted 133.8 million tons.

The total area impacted by the fires was more than 100 million ha. Dense smoke significantly decreased photosynthetic activity and reduced visibility to 100 m and less. Based on preliminary estimates, average fire and post-fire dieback is estimated to be about 80 m^3/ha of Forested Area. This means that expected losses of wood might reach 400-500 million m^3, about 4 times the current level of harvest in all of Russia. Some regions have lost a major part of their potential for industrial harvest. Due to the extreme severity of the fires, more than 2 million ha of forests have lost their major ecological functions for a period of 50 to 100 years and about 0.5 million ha of formerly forested areas, due to deep burning of the soil, were irreversibly transformed, at least for more than 200-300 years. Outbreaks of forest pests and diseases are expected during the next few years, as well as a significant increase in fire hazard due to the accumulation of large amounts of dead wood.

The impact on wild animals and fisheries will be revealed during the coming decades. Initial estimates lead to the conclusion that the total number of birds and wild animals in the regions most affected by fire decreased by a factor of ten or more. Mortality of squirrels and weasels reached 70-80 percent, boar 15-25 percent and mice and rodents about 90 percent. There were observed mass deaths of fish. Fires greatly influenced the spawning of salmon due to increased water temperatures and possibly due to high carbon dioxide levels in the air and water (Kulikov 1998). A significant increase in respiratory ailments was observed in many settlements in the Far East. There were indications that this may have contributed to several deaths during the period.

Extremely large fires have long-term and partially irreversible consequences. One of the most severe fire years in northern Eurasia was in 1915 when about 14 million ha of closed forests were completely burned within a forest area of 160 million ha in Siberia, and about 600 million ha was affected by smoke. Deep (up to several meters) peat fires continued until winter. Only 65 percent of normal solar radiation was registered in parts of the country in August, and crops matured 15-20 days later than usual. Corn and fodder for livestock were of very low quality and contributed to the poor health of the population and the loss of cattle. Large numbers of wild animals died, and a dramatic migration of animals for thousands of kilometres was observed (Shostakovich 1924, 1925).
Catastrophic forest fires in northern Eurasia should be a topic of national and international interest. The most dramatic predictions of climate change indicate an increase in annual average temperature of 4-6^{o} C, together with a significant increase in aridity and greater frequency of extreme drought during the fire season for this region (Stocks 1993, Fosberg et al. 1996). If these predictions are correct, Russia must increase its preparedness to cope with the situation. A long-term fire prevention and management strategy must be put in place with the utmost priority. If the results of these models come to pass, they indicate a high probability that during the next century major areas of Russian coniferous forests could be burnt if the current level of fire protection is not significantly improved.

Forest fire databases

Table 4-33 contains data on forest fire in the protected territory of the Russian Forest Fund during the previous decades. These data were basically derived from official data of the Russian Federal Forest Service. It should be noted that different sources, including official publications, are often not consistent and sometimes contradictory. The major historical records and databases on forest fire are at the Forestry Department of the Ministry of Natural Resources. The Central Base of Aerial Forest Fire Protection (Avialesookhrana) also maintains a multi-year database in which the geographical co-ordinates and major fire characteristics are provided for each registered fire. IIASA also has a database on disturbances in Russian forests that contains aggregated regional data on the number of fires and burned areas by type of fire for the last decades.

Table 4-33 Number of wildfires and forest area burned on protected territories of the Forest Fund, 1950-1995.

Year	Number of fires	Area burned (1 000 ha)							
		Total FF [b]	of which FA [b]				incl. UFA [b]	FL [b]	incl. NFL [b]
			CF [c]	SF [c]	GF [c]	Total			
1950-1959 [a]	*12 662*	*na*	*na*	*na*	*Na*	*na*	*na*	*1535*	*na*
1960-1969 [a]	*18 684*	*na*	*na*	*na*	*na*	*na*	*na*	*675*	*na*
1970-1979 [a]	*18 906*	*771*	*125*	*301*	*2*	*428*	*50*	*478*	*293*
1980-1989 [a]	*16 244*	*1 134*	*99*	*413*	*5*	*517*	*26*	*543*	*591*
1980	15 384	234	15	140	1	156	11	167	67
1981	19 876	511	26	223	1	250	5	255	257
1982	16 092	519	38	256	33	326	24	351	168
1983	11 831	260	49	101	<0.5	151	17	167	93
1984	14 977	502	53	257	<0.5	310	5	315	187
1985	11 719	694	91	395	<0.5	486	3	489	205
1986	16 353	1 159	207	487	1	695	10	705	454
1987	13 439	4 414	123	413	1	537	32	569	3 845
1988	18 573	1 011	144	613	1	758	29	787	224
1989	21 934	2 040	247	1 249	8	1 504	124	1 628	412
1990-1999 [a]	*25 481*	*1 602*	*174*	*927*	*5*	*1 106*	*94*	*1 200*	*402*
1990	17 672	1 670	274	1 043	1	1 318	48	1 366	304
1991	17 965	1 126	116	411	4	531	151	682	444
1992	25 777	1 142	56	544	3	603	88	691	451
1993	18 428	1 201	104	619	1	724	25	749	452
1994	20 287	723	61	465	2	528	9	537	186
1995	25 951	463	23	326	3	352	8	360	103
1996	32 833	2 312	205	1 523	9	1 737	131	1 854	458
1997	31 300	984	127	566	4	697	30	727	257
1998	27 970	5 340	607	3 234	2	3 843	426	4 269	1 071
1999	36 629	1 048	164	543	20	727	25	752	296

Based on data from the Russian Federal Forest Service.

Notes:
[a] Average annual data by decades.
[b] The abbreviations of forest land-cover categories: FF - Forest Fund area, FA - Forested Area, UFA - Unforested Area, NFL - Non-Forest land.
[c] Types of fires: CF - crown fire, SF - surface fire, GF - ground fire.

Operational fire management systems

Under the Forest Code (1997), practically all Russian forests are federal property. There are some inconsistencies between the Russian Constitution and the Forest Code and the Russian Government is currently investigating the possibility of privatising some lands and forests.

Russia has a hierarchical system of state forest fire protection that includes two major responsible players; the state forest management authority and the aircraft forest protection system (Avialesookhrana) (Figure 4-31). In severe fire situations, the Ministry of Extraordinary Situations is also significantly involved.

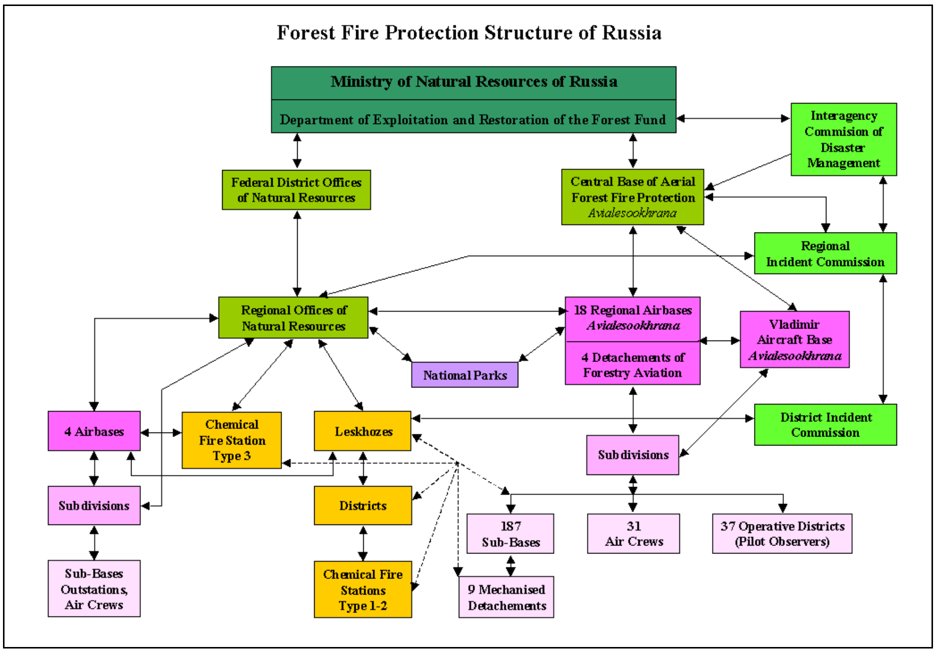

Figure 4-31 Organization of forest fire protection in Russia after the reorganization in 2000.

The distribution of protected territories by the type of forest fire protection is as follows (percentage to the total area of the Russian Forest Fund; official data for 1985-1990):

Regions covered by aerial forest protection, including sub-regions:		**62.5 %**
- extinguishing of fire by aviation means alone	50.9 %	
- detection of fire by aviation, extinguished by ground methods[1]	11.6 %	
Area covered by ground protection including sub-regions		**49.1%**
- forest guards, fire-chemical stations, and mechanized detachments	11.0 %	
- other organizations	2.3 %	
- sub-regional reserved unprotected forests	35.8 %	

[1]Also included in the area covered by ground protection

The state forest authority divides Forest Fund areas into aerial and ground protection regions and the regional and subregional boundaries are indicated on maps. There are two types of aerial forest fire protection. One uses aviation as a major tool for all operations while the second provides only detection of fires by aircraft. In the latter case local ground forces of the forest management authorities provide fire suppression. The reserved unprotected forests are formally included in the area of ground protection, but practically no protection is provided. There were some attempts to divide the Russian Forest Fund and its large regions into homogeneous pyrological regions based on the different characteristics of the forests, indicators of fire risk and historical level of fires, but this has not been implemented in practice.

The State Forest Guard (SFG, currently the State Forest Service of the Ministry of Natural Resources) and managers of Avialesookhrana are the major responsible authorities for forest fire protection. The Forest Code (Article 77) and a special *Statute on State Forest Guard of*

the Russian Federation, approved by the Decision of the Government of the Russian Federation in 1998, defines the rights and duties of the State Forest Guard. The most important duties of the SFG are prevention, detection, warning and extinguishing forest fires and mitigation of the consequences. Rangers are the lowest level in the hierarchical structure of the SFG. They are responsible for a forest territory of several hundred to several thousand hectares. As of 1 January 1998 there were 69 963 units managed by rangers with an average area of 15 900 ha. Masters are managers of 3-5 rangers. Foresters are managers of forest districts, which include 2-5 territories managed by masters. Currently Russia has about 8 000 forest districts (7 875 in 1998). An individual forest district has jurisdiction over several thousand to over a million hectares (the average area was 141 000 ha in 1998). Three to ten forest districts are combined into forest management enterprises. As of 1998 there were 1 826 forest enterprises with an average area of 608 200 ha (FSFMRF 1998). At the forest enterprise level, the Director, Main Forester and Engineer of Forest Protection are responsible for all aspects of forest protection. Simultaneously, a main forester of the forest enterprise acts as Main State Inspector on Forest Protection in a district. Correspondingly, the forester acts as Senior State Inspector. In addition there are special fire protection subdivisions (Fire Chemical Stations) strategically located in forest management enterprises. Their technical capacity depends on the regional economic and social conditions and the level of fire hazard. There are also regional and federal levels of the SFG.

Avialesookhrana provides forest fire monitoring and all types of forest fire protection using aircraft as its major technical tool. It has its own hierarchical structure (Figure 4-31). Managers and forest professionals of Avialesookhrana are also members of the SFG. Avialesookhrana includes special detachments of parachute jumpers (smokejumpers). During the last few decades, about 80-85 percent of all fires have been detected by aviation and about 50 percent of all detected fires are extinguished during the first day. Fires that are not extinguished during the first day often become very large and difficult to extinguish.

Operational regimes of the forest fire protection services are based on the weather and forest fire danger, which is usually measured by the Nesterov fire index (for a definition see Shetinsky, 1994) or some regional improvement or modification of it. Five different fire danger classes are used depending on the value of the index: 1) no fire risk, B<300; 2) small risk, 301<B<1 000; 3) medium risk, 1 001<B<4 000; 4) high risk, 4 001<B<10 000; and 4) extremely high risk, B>10000. For example, aircraft patrols are usually not provided under the first fire danger class , once every one or two days at noon under Class 2 conditions, one to two times per day from 10 a.m. to 5 p.m. under Class 3 conditions and not less than two times per day for each route under Class 4. Under Class 5 conditions the Forest Guard must devote all its time to fire protection and aircraft patrols should be provided not less than three times per day over each routine.

The State Forest Guard and Avialesookhrana operate in close coordination with the local and regional authorities of state forest management. Under severe fire situations, the local population, military detachments, etc., can be involved in firefighting. In spite of intensive preventive work with the population, wide use of mass media before and during each fire season, special lessons in schools, organization of special voluntary fire brigades and school forest districts, etc., not all social groups and members of society are educated and conscientious enough about fire prevention and humans continue to be a major source of forest fires. Nevertheless, the awareness of the population, participation in voluntary fire brigades, etc., has been constantly increasing, although this process is slow and different in different regions. The role of non-governmental organizations (Greens and other ecological movements) has also increased during the last decade.

The large fire situation in Khabarovsk Kray in 1998 illustrates how forest fire protection operates in Russia. From the middle of May to 15 July, when 30-40 active forest fires occurred daily, fire suppression was mostly provided by the fire protection sub-units of forest enterprises, the Far Eastern Aviabase and forest industry enterprises (44 chemical fire stations with about 350 firefighters, 290 members of the aerial protection service, and brigades of the forest logging enterprises). In addition, 18 caterpillar cross-country vehicles were bought, re-equipped and delivered to forest enterprises. During these two months, 480 forest fires with an area of 80 000 ha were extinguished. Sixty-five percent of the fires were extinguished during the first two days.

Due to an increased fire threat, an extraordinary situation was implemented in the Kray on 17 July. Free access of vehicles and the population to forests was prohibited. All available reserves were called up. A month’s reserve of food for 1 000 persons and 33 million roubles were allocated for firefighting. In addition, 120 people and 25 mechanized units (all-terrain vehicles, caterpillars, tankers, etc.) from the Ministry of Extraordinary Situations situated in the Kray, 360 persons and 96 mechanized units from the Ministry of Defence, and 220 fire brigade members and 25 mechanised units from the Ministry of Interior were allocated. Other regions of the country provided 140 people from the aerial protection service. Two BE-12P amphibian aircraft worked in the Kray. All the above prevented burnt settlements and industrial enterprises and the loss of human life. During the most dangerous days about 2 000 people and 500 mechanized units were involved in fire fighting.

Although results were more or less satisfactory, many fires, particularly in remote regions, escaped. Many of these covered areas of 25 000 to 30 000 ha per fire. The regional estimate of ecological and forestry losses due to fire was 4.56 billion roubles. It probably would be difficult to organize effective forest fire protection in the Kray under these conditions due to the catastrophic character of fires. Nevertheless, the situation highlighted serious shortcomings in forest fire protection. A major problem is the shortage of funds and the lack of centralised financing. In 1997, only 9.3 percent of the total finances for forest management were allocated for forest protection, and only 24 percent of that was paid from the state budget. In 1988 and 1998, only US$0.25 and US$0.06 per ha of protected area was allocated for forest protection, respectively. The number of the State Forest Guard Staff (lower levels) in the Kray decreased by ca. 75 percent during the period 1988-1998, and Avialesookhrana's staff decreased by 30 percent.

During recent years there has been some practical implementation of remote sensing for early warning. NOAA-AVHRR receiving stations are functioning in some Siberian cities (Tomsk, Krasnoyarsk, Irkutsk, etc.). Nevertheless, in general, there are serious shortcomings in the functional and operational activities of the different forest fire protection organizations. Following are some of the most important:

- Lack of both up-to-date financing of aviation for fire prevention and control and sufficient use of it as an operational tool for fire suppression. At the end of the 1980s, Avialesookhrana used about 700-800 aircraft during the fire season. Currently, the number of aircraft and patrol time has decreased by more than 50 percent.
- The number of State Forest Guard staff has significantly decreased in many regions, particularly at the lower levels.
- Due to significantly decreased activities in sustainable land-use management of forests, huge areas still remain without any protection.
- Lack of advanced equipment; in particular, a unified system of radio communications.

- Insufficient use of satellite information.
- Lack of special autonomous mobile detachments equipped with transport and trained in relevant techniques.
- Lack of real integration between the ground and aerial fire protection services.

However, some projects that are currently being implemented are encouraging and point toward the right direction:

<u>TACIS Project "Improvement in Forest Fire Response”</u>

A project for the "Improvement in Forest Fire Response”, funded by European Commission Directorate DG1a as Technical Assistance to the Commonwealth of Independent States (TACIS) Project ENVRUS-9701, is operational between 1998 and 2001. TACIS partners are the Federal Forest Service of Russia (currently the Department of Exploitation and Restoration of Forest Fund of the Ministry of Natural Resources) and its Central Base for Aerial Forest Fire Protection, Avialesookhrana (TACIS 1999, 2000). The goal of the project is to improve the response to forest fires, pests and diseases. Project activities include:

- Adaptation of existing satellite data acquisition.
- Tests of fire detection algorithms based on existing NOAA capability.
- Development and implementation of a federal and regional GIS.
- Development of a forest fire information network.

Applied fire management research

The Fire Laboratory of the Sukachev Institute of Forest, Russian Academy of Sciences, Krasnoyarsk, provides new fire information products to the State Forest Service. These products include fire location maps generated daily that are also displayed on the homepage of the Global Fire Monitoring Center (GFMC). The Institute for Solar Terrestrial Physics, Irkutsk, provides daily maps with fire locations depicted by NOAA-AVHRR and also a summary of the last ten days of fire occurrences as well as a map for the whole fire season. These maps are also displayed daily on the GFMC homepage (Figure 4-32 and Figure 4-33). An example of a regional burned area map for a whole fire season is provided in Figure 4-34 (Amur Oblast).

Figure 4-32 Example of a daily fire monitoring map

(date: 29 May 2000) generated by the Fire Laboratory (A. Sukhinin) of the Sukachev Institute of Forest, Krasnoyarsk, in collaboration with the Emergency Situation Monitoring and Forecasting Agency, Krasnoyarsk branch.

The maps are produced on the basis of satellite data (classification by NOAA-AVHRR). They show fire locations (by latitude and longitude) and the area affected by fire (red signature, size in ha). The red arrow at each fire location points to the nearest populated place. The fire maps are provided to the GFMC.

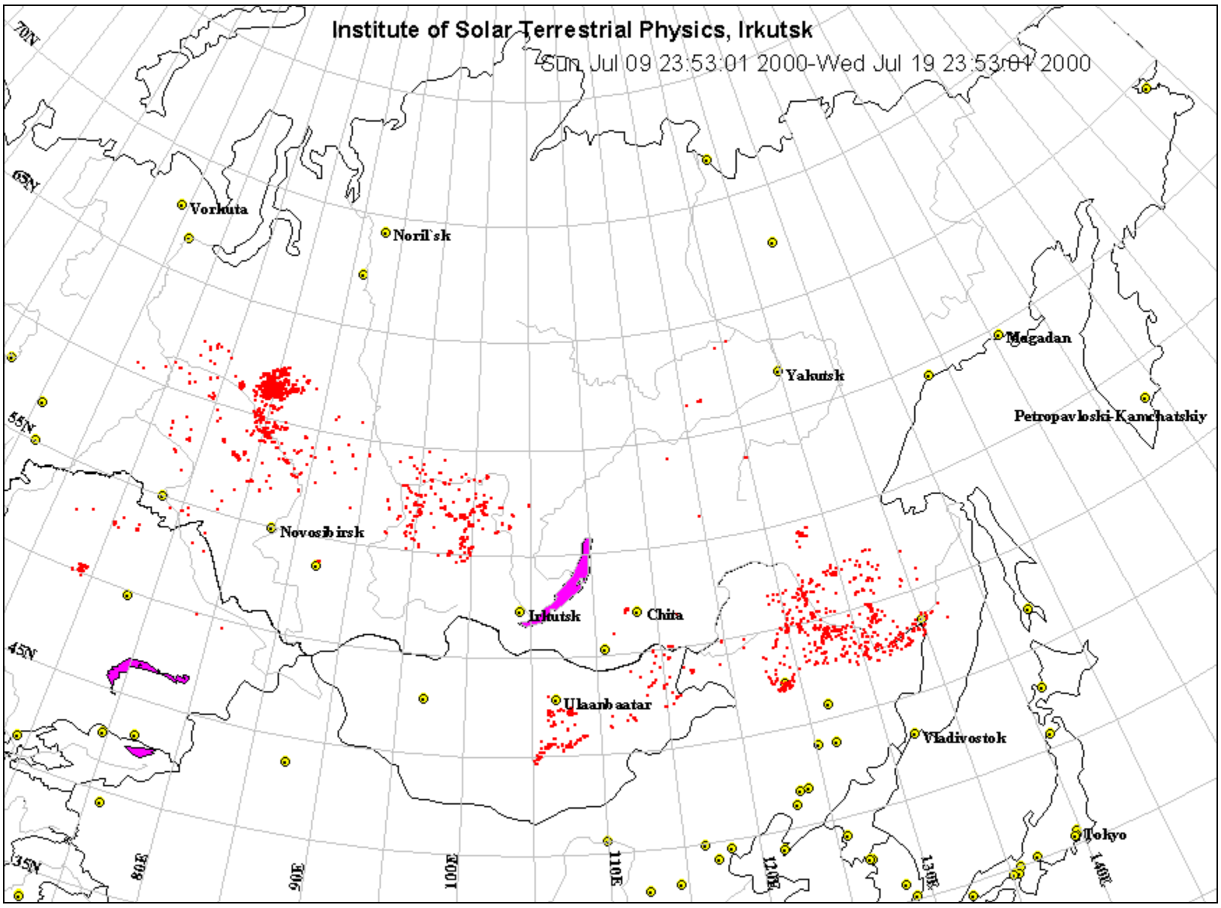

Figure 4-33 This map shows a 10-day product (9-19 July 2000).

The Institute for Solar Terrestrial Physics, Irkutsk, generates daily fire observations (high-temperature events depicted by the NOAA-AVHRR sensor) in the territory of the Russian Federation and the neighbouring territories of China and Mongolia (within the range of the receiving station). The Institute provides daily fire occurrence summaries, 10-day fire summaries (accumulated fires during the last ten days) and a total fire season summary. The map products are displayed daily on the GFMC homepage.

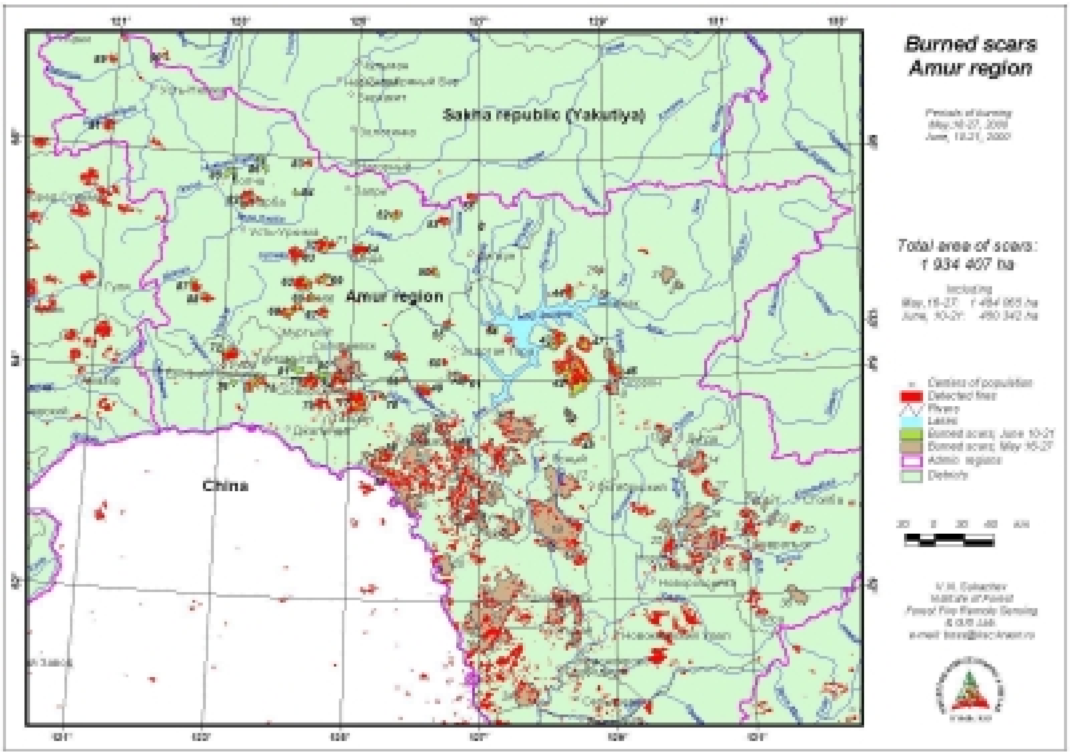

Figure 4-34 Burned area map of Amurskaia Oblast for the period 16-27 May 2000 and 10 to 21 June 2000. The area burned is 1 934 407 ha.

Source: Fire Laboratory of the Sukachev Institute of Forest, Russian Academy of Sciences, Krasnoyarsk.

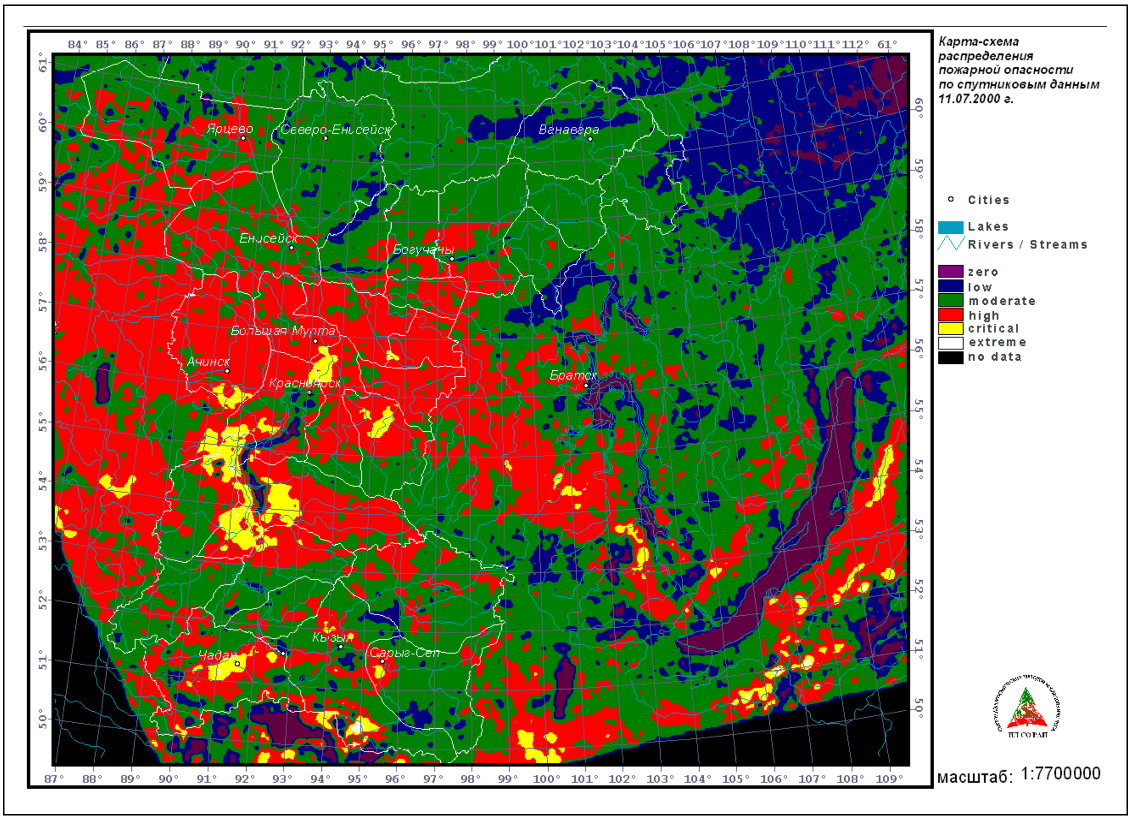

Figure 4-35 Fire weather forecast map for 11 July 2000 for the Krasnoyarsk and Irkutsk regions.

Prescribed fires

Agricultural prescribed burning in Russia is estimated to total 30 million ha annually, of which about 5 million ha is stubble burning and 25 million ha are pastures and hayfields (Shvidenko et al. 1995). These burns often escape and cause forest wildfires. In forest management activities, fire is used for disposal of debris on harvested areas, preparation of land for planting, reduction of fuel along railways, etc. Other types of prescribed burning, particularly as a direct fire protection tool, are not used in Russia. There is concern about the threat of large fires if prescribed fires escape control. The high cost and organizational and technological difficulties of safely conducting large-scale prescribed burning in the vast taiga with poor infrastructure are also important impediments. For these reasons prescribed burning is not currently part of the official forest fire protection policy of the country.

However, it has been repeatedly urged that high priority be given to formulating and introducing a new fire policy that would allow the integration of prescribed natural fires and the use of prescribed burning to restore the ecological balance of forest ecosystems in which fires have been suppressed over many decades. A number of experiments in Siberia and the Russian Far East support the concept of using prescribed burning as an important fire management tool. Recent publications have suggested the development of adequate prescriptions, manuals and technical requirements (Goldammer and Furyaev 1996, Sedykh 1997).

Sustainable land-use practices

There are two types of documents that regulate the practice of sustainable land-use as a tool to reduce wildfire hazard and risk. The first is a Perspective Plan of Fire Protection Arrangement of Forests that is prepared by a special institution (usually by the so-called All-Russian Designing and Prospecting Institute of Forest Management, Roshiproleshoz) for administrative regions of the Russian Federation with high fire danger. Regional Forest Inventory and Planning Enterprises prepare the second, a Plan of Fire Protection Arrangement, simultaneously with a forest inventory (lesoustroistvo) of each forest enterprise.

The Perspective Plan defines the forest fire protection strategy in a region, the distribution of areas by type of forest fire protection (ground, ground with aerial patrol, aerial), the area of responsibility of chemical fire stations, regional coordination of fire protection efforts, etc. The Plan of Fire Protection Arrangement is based on the fire hazard of individual forest stands, potential sources of fire (fire risk), peculiarities of climate and weather during the fire season and recent fire history (for the last 8 to 15 years). It also includes fire prevention activities, early detection and monitoring of fires and initial attack. Furthermore, the plan includes technical measures to reduce ignition, flammability, intensity and spread of forest fires through construction of roads, firebreaks, and fuelbreaks consisting of planted deciduous forest belts. However, a common shortcoming of these plans is insufficient funding for them to be effectively implemented (forest fire protection is still basically financed from the state budget).

More effective is a third document, an Operative Plan of Fire Protection Activities, that is developed on an annual basis (and is partially drawn from the two above-described plans) as part of the planning of forest management activities for each forest enterprise based on available financing. Briefly, this plan includes all relevant activities that support a core

integrated fire management system, with special emphases on all types of fire prevention work with the local population, children, etc. Unfortunately, these plans are fully realized and relatively effective only in areas of intensive forest management, e.g., in the centre of European Russia.

By 1998 Russia had 8 822 artificial water reservoirs and specially equipped areas to provide water for fire suppression, of which 7 138 were in European Russia and 1 684 in the Asian part. The total length of fire prevention barriers (fire breaks) is 211 161 km (of which about 60 percent are in European Russia). The total length of forest roads is 997 400 km (57 percent are in the European part). Large territories of the European North, Siberia and the Far East are insufficiently covered by forest protection activities.

Public policies concerning fire

Russia has a well-developed legal basis for forest fire protection. It includes:

- The Forest Code of the Russian Federation (special Chapter 12, Articles 92-102, directly devoted to fire protection problems).
- Regulations on Fire Safety in Forests of the Russian Federation, approved by the Russian Government on 9 September 1993.
- Article 261 of the Criminal Code of the Russian Federation ["Destruction and damage of forests"].
- A number of Instructions/Regulations/Manuals that are obligatory for all bodies of state forest management, i.e., Instruction on fire prevention prophylactic in forests and regulation of activities of forest protection services, approved by the Federal Forest Service [1993], Instruction on detecting and extinguishing of forest fire, approved by the Federal Forest Service [1985], Instruction on forest fire protection by aviation [1993], Statute of Chemical-Fire Stations [1993], etc. (Shetinsky and Sergeienko 1996).

These laws cover all relevant aspects of forest fire protection and are obligatory for people, state and private organizations, all forest stakeholders, etc. However, implementation of the legal requirements is poor. In many regions, forest authorities do not have enough human and financial resources to provide effective forest management and control. Russia is still undergoing a period of transition from a centrally planned to a decentralized market economy and is suffering severe economic, social and moral stress. Unfortunately, the country has not yet developed a clear long-term national forest policy addressing problems of forest protection and conservation. The major current problems of the forest sector are of an institutional nature. Many unsolved forest problems are dramatically reinforced by ineffective legislation and unresolved state economic and social policies. The country has no long-term forest strategy. The elimination of the State Forest Committee and the Federal Forest Service in mid 2000 and the new administration under the Ministry of Natural Resources (see Figure 4-31) will lead to decentralization of tasks to the regional and local forest management levels but positive results of this reorganization are yet to be seen. However, an increased interest in the fate of Russia’s forests by the public and various stakeholders has been evident during the last two to three years. This process has been facilitated by a number of international institutions such as the World Bank, the International Institute for Applied Systems Analysis (IAASA), the World Conservation Union (IUCN), the Russian office of the Worldwide Fund of Nature (WWF) and the Global Fire Monitoring Center (GFMC).

Forest fire science, including fire ecology, protection, etc., is well developed in Russia. Nevertheless, a rather modest part of this knowledge is really used. The Russian experience is clear evidence that during catastrophic fire years such a big country with a huge boreal zone is not able to adequately protect its forests against fire. Taking into account expected climate change, the need to develop and, of crucial importance, implement a new forest fire protection paradigm for Russia is evident. This paradigm should be part of a philosophy of sustainable forest management and include an anticipatory strategy with a solid background of relevant long-term activities supported by appropriate human and financial resources in the following areas:

- Zoning of Forest Fund territories by relevant fire protection regimes based on estimates of current and future fire danger and the ecological role of fire.
- Development and implementation of a forest fire monitoring system using a combination of multi-sensor remote sensing observations along with a comprehensive characterisation of the landscape, e.g., an integrated land information system.
- Consistent implementation of sustainable land-use practices and fire protection arrangements, e.g. regulation of species composition, development of appropriate infrastructure, regulation of the amount of on-ground fuel, etc., in particularly in territories of taiga zone.
- Introduction of forest fire protection services that correspond to the basic philosophy and criteria of sustainable forest management.
- Involvement of the population and all forest stakeholders as a very important part of forest fire protection.
- Increasing international cooperation in all aspects of forest protection.

Conclusions and Recommendations

It is quite obvious that forest fire management in Russia has a large potential – a potential for both opportunity and failure. More than seventy percent of the global boreal forest cover is in Asia, mainly in the Russian Federation, and this economically and ecologically important area represents the largest undeveloped forested area of the globe. The carbon stored in boreal ecosystems corresponds to ca. 37 percent of the total terrestrial global carbon pool (plant biomass and soil carbon). Thus, the magnitude of the boreal forest area suggests that it may play a critical role in the global climate system, e.g. as a potential sink or source of atmospheric carbon. Vice versa, climate change models indicate potentially dramatic changes in the continental climate of the country. Prolonged vegetation growth and an increasing occurrence of extreme summer droughts, with consequent extreme wildfire danger, are elements of climate change scenarios.

As a consequence of the increasing occurrence of wildfires under extreme drought conditions, as was experienced in 1987 in the Trans-Baikal Region and in 1998 in the Far East, it is expected that natural recovery cycles will be disturbed as well. Fires affecting forest ecosystems on permafrost sites could lead to the degradation or disappearance of eastern Siberian larch forests. Melting permafrost could lead to the decay of presently frozen organic matter and the release of radiatively active (greenhouse) gases. In addition, fires penetrating into desiccated organic terrain (swamps) could release large amounts of terrestrial carbon into the atmosphere. That the boreal ecosystems of Eurasia represent such a potential threat, recently called the "carbon bomb", requires significant national and international attention.

This brings the authors of this report to the conclusion that the proper management of the Russian forests and associated vegetation resources and ecosystems needs to receive high priority. The responsibility of managing and protecting these resources should not be given solely to the private sector, and there are limitations on delegating resource protection to the regional and local levels. The establishment and strengthening of a central institution to protect forests and other ecosystems is not only in the best interest of the country but must also be supported by the international community.

International responsibility is two-sided and includes "taking" and "giving". Russia must receive continuing international assistance to protect its vegetation resources. During times when they are not needed, however, Russia can pay back other countries by making available human resources and equipment to address fire problems in other parts of the world.

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Annex

Translations of major forest land-use/land-cover definitions from the "Manual on Forest Inventory and Planning in Forest Fund [sometimes designated Forest Reserve] of Russia". Volume 1. Organization of Forest Inventory and Planning. Field observations. Approved by the Federal Forest Service of the Russian Federation on December 15, 1994, N 265. Published by VNIIZlesresurs, Moscow, 1995, 175 pp [in Russian].

Comment: Forest Fund is not defined in the Manual cited above. Forest Fund, Forest Lands and Non-Forest Lands are defined by the Russian Forest Code (Articles 7 and 8), but not in a quantitative way. For instance, page 6:

Article 7. The Forest Fund
All forests except of those located on defence lands and the lands of settlements, as well as lands of the Forest Fund not covered with forest vegetation (forest lands and non-forest lands) make up the Forest Fund…

Article 8. Lands of the Forest Fund
The lands of Forest Fund include forest lands and non-forest lands. Forest lands include lands covered by forest vegetation or those not covered by it but intended for its restoration (cutovers, slashes, perished forest stands, open stands [comment: better-s*parse forests*], wastelands, glades [comment: better-*grassy glades and barrens*], areas occupied by nurseries, free-growing forest cultures [comment; i.e., forest plantations], and others. Non-forest lands include lands that are part of the forestry system (land occupied by cutlines between forest compartments or blocks, roads, arable lands, and other lands), as well as other lands located within the borders of the Forest Fund (lands occupied by bogs, rocky places, or other lands unsuitable for use.

Manual on Forest Inventory, Page 53

"5.1.2.
…
All lands of Forest Fund are divided in two major categories: Forest Lands and Non-Forest Lands. Non-Forest Lands include lands that are not designated, or which are not suitable for forest or shrub growth without preliminary melioration or recultivation. All the rest of the lands are inventoried as Forest Lands, i.e., suitable and designated for forest growth. Forest Lands are divided into following categories:

- Forested Areas.
- Non-Stocked Planted Forests [comment: i.e., planted stocked forests, not plantations in the tropical sense].
- Forest Plantations and Nurseries.
- Natural Sparse Forests.
- Unforested Areas.

5.1.2.1. Forested Areas include:

- Lands covered by young stands with a relative stocking of 0.4 and more and stands of other age groups with a relative stocking of 0.3 and more.
- Cutovers, burns and other territories of naturally reforesting Forest Lands, on which the amount and quality of natural regeneration, or young trees, protected under harvest, are corresponding to requirements, developed for conversion of these categories into Forested Areas; areas covered by shrubs in regions where tree species cannot grow due to severe natural and geographical conditions, or where special shrub management is provided. [comment: the definition of closed forests (i.e. Forested Areas) has not been changed after 1961; see, for instance, cl. 152, page 66 of the *Manual on Inventory and Survey of Forests of State Meaning of the USSR,* Moscow, 1952; approved by the Minister of Forest Management of the USSR on June 29, 1951].

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…

Planted forests of which indicators are not corresponding to the requirements for the conversion of them into Forested Areas, are identified and inventoried as non-stocked planted forests.

5.1.2.2. Natural sparse forests include stands with a relative stocking of 0.1-0.2 that grow under extreme climatic conditions, where forming stands with higher relative stocking is impossible. …

5.1.2.3. Unforested areas are presented by areas of Forest Lands on which at the time of the tree and shrub vegetation is absent, which by their relative stocking, canopy closure or amount of regenerated young trees cannot by identified as Forested Areas.

Primary inventory units of Unforested Areas include the following categories:

- Burned areas (burns) - areas on which woody vegetation has been killed by fire.
- Dead stands - areas of dead stands as a result of the damage caused by insects or diseases, natural calamity (blowdown, windfall, snowbreak), atmospheric pollution and other natural or anthropogenic impacts.

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Cutovers (unregenerated harvested areas) - areas on which stands have been clear cut due to final felling or entire sanitary cuts and natural regeneration on those either is absent or its amount and quality do not correspond to requirements on conversion into Forested Areas.…

Grassy glades and barrens; grassy glades are presented by small unregenerated areas caused by windfall or harvest of a stand due to any negative impact of the local character; barrens include significant by area old harvested areas, burns and others territories with destroyed forest vegetation which was not restored during the period after the previous forest inventory" [comment: the period between two inventories is usually from 10 to 15 (20) years].

5 Oceania Region Fire Assessment

5.1 Introduction

The Oceania region is dominated by Australia, a fire-prone continent with a large variety of vegetation types and fire regimes. According to the Australia fire report about 115 000 and 230 000 fires per year have been depicted by satellite remote sensing during the fire seasons 1998-1999 and 1999-2000, burning a vegetated area of 31 and 71 million hectares respectively. Earlier evidence suggests that between 50 000 ha and 1 000 000 ha of forested land (or land administered by forestry authorities) have been burned annually by wildfires in the period 1956-1971. The Australia report provides an area of ca. 600 000 ha of forest land burned during the fire season 1983 (ENSO year 1982-1983) and between 500 000 and 600 000 ha per year in the mid 1990s.

The emissions generated by large areas burned have a strongly visible impact on regional and global atmospheric chemistry. Figure 5-1 to Figure 5-3 highlight the very typical fire and emissions situation in Australia in the year 2000. Figure 5-1 shows a satellite image with large burn scars and active fires in early October 2000. Figure 5-2 provides an example of a daily active fire map that is generated in the Global Fire Monitoring Center (GFMC) using the geo-referenced dates of active fires depicted by the NOAA AVHRR. Figure 5-3 shows the smoke (aerosol) plume from forest and bush fires in Australia depicted by the Total Ozone Mapping Spectrometer (TOMS).

Three country reports from temperate and tropical Oceania cover the most important natural vegetation types, traditional and modern land-use systems, including fire problems in plantations: Australia, Fiji and New Zealand.

Figure 5-1 True-color image taken over northern Australia on 2 October 2000, by the Moderate-resolution Imaging Spectroradiometer (MODIS), flying aboard NASA’s Terra spacecraft.

The wildfires are visible in the scene, which covers parts of the Northern Territory.

Source: NASA Earth Observatory
http://earthobservatory.nasa.gov/Newsroom/NewImages/images.php3?img_id=4341

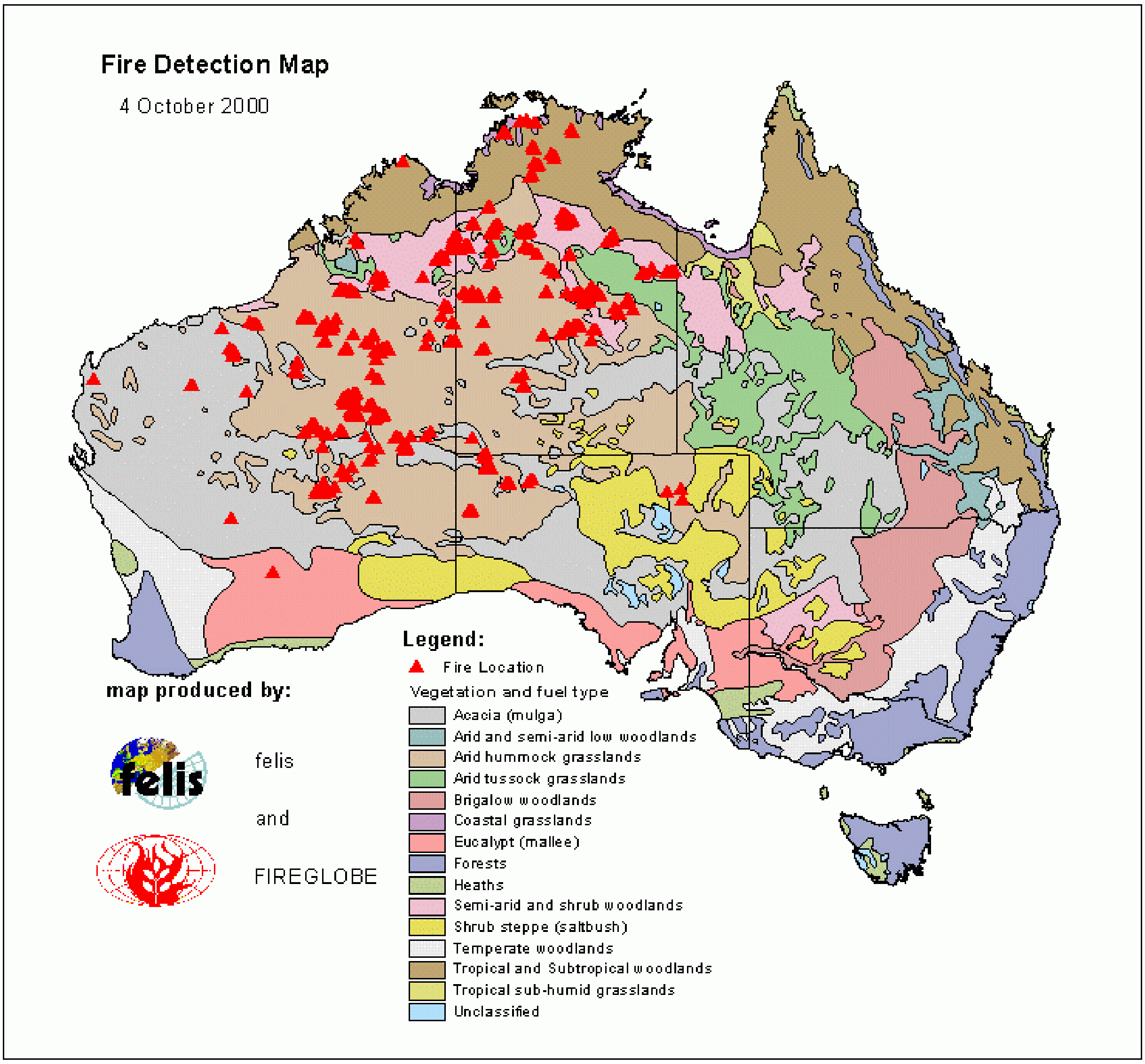

Figure 5-2 Fire Detection Map for Australia for 4 October 2000 overlaid on a pan-Australian vegetation cover map.

Source: Global Fire Monitoring Center (GFMC)
www.ruf.uni-freiburg.de/fireglobe/current/archive/aus/2000/10/aus_10042000.htm

The maps are generated daily on the base of fire coordinates of the Satellite Remote Sensing Services Department of Land Administration (DOLA) which are overlaid on a simple vegetation and fuel type map (Luke and McArthur 1977; reference in Australia report). The fire coordinates represent fire events in Western Australia and Northern Territories.

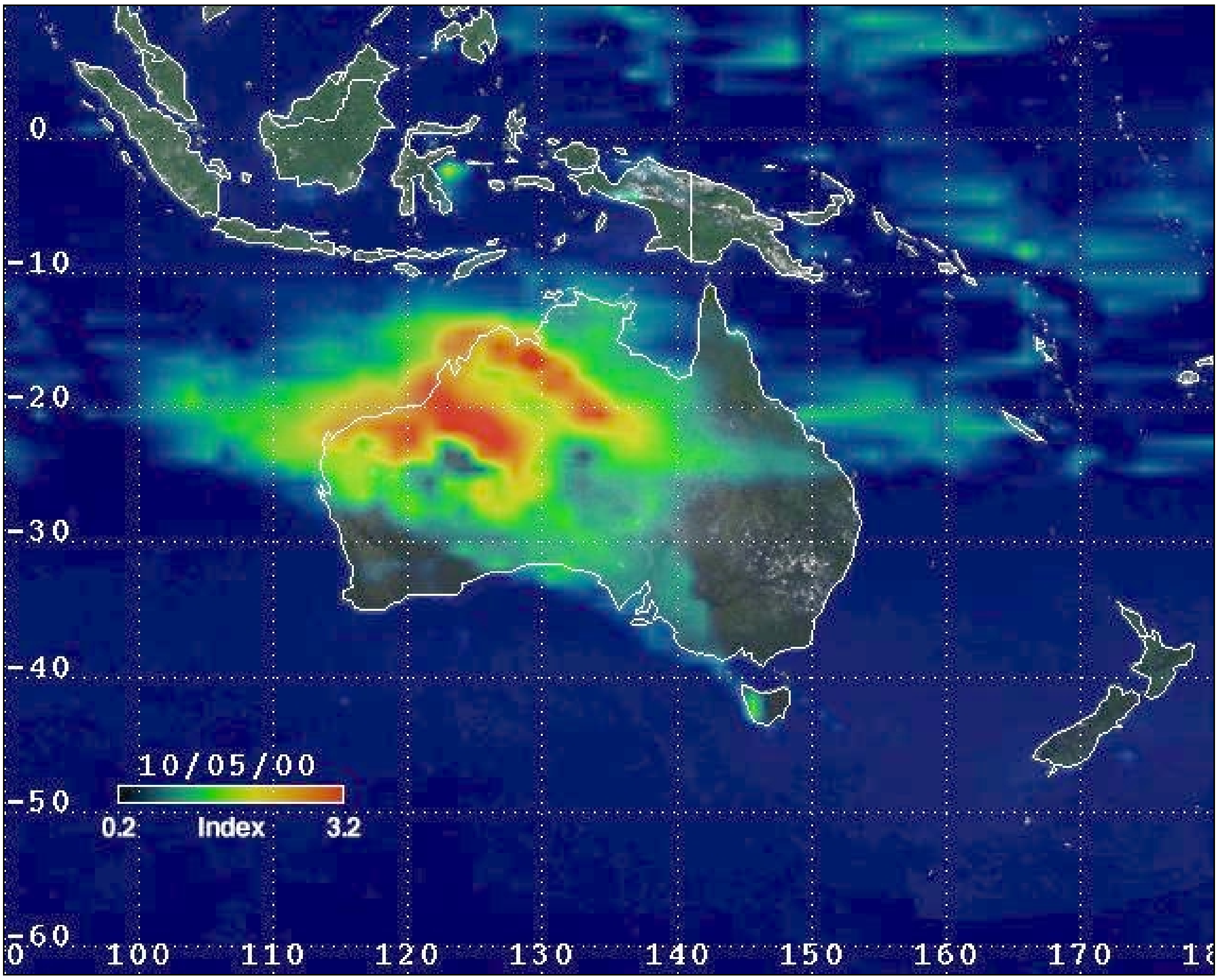

Figure 5-3 Smoke over Australia, 5 October 2000 depicted by the Total Ozone Mapping Spectrometer (TOMS) products.

Earth Probe TOMS, launched on 2 July 1996, depicts aerosols emitted from vegetation fires, desert dust storms and other sources.

Source: TOMS Global Aerosol Hot Spots Page, NASA GSFC http://toms.gsfc.nasa.gov/

5.2 Fire Situation in Australia

By
Malcolm Gill
&
Peter H.R. Moore
Centre for Plant Biodiversity Research, CSIRO Plant Industry, Canberra, ACT, Australia

Introduction

This report describes the environments of Australia, points out the variety that exists in fire regimes, and provides statistics on the occurrences of fires. It also notes some of the social impacts of wildfires in recent years, presents an outline of the agencies involved with fires and touches on the community policies and infrastructure that have developed in response to fires. To keep the report brief, comprehensive referencing has been foregone. General Australian references to fires and their effects are: 'Bushfires in Australia' (Luke and McArthur 1978); 'Fire and the Australian Biota' (Gill et al. 1981); 'The Ecology of Fire' (Whelan 1995); and, the forthcoming book 'Flammable Australia: the Fire Regimes and Biodiversity of a Continent' (Bradstock et al. in press).

Fire environment, fire regimes and ecological role of fire

Australia is a large, geographically diverse continent straddling the tropic of Capricorn. It is relatively flat, dry and warm although it also has mountains of moderate height (particularly along the eastern seaboard), rainforests and ski-fields - as well as a large arid and semi-arid zone. This report covers the Australian mainland and its largest offshore island, the State of Tasmania. Australia has an area of 7.9 million km^2 (Luke and McArthur 1978).

Across the tropical north is a large savannah region with a monsoonal (wet-dry) climate. In the southwest is a region of eucalypt forests, woodlands and shrublands with a largely Mediterranean climate. In the southeast, including Tasmania, there are forests and woodlands, but the climate there is quasi-Mediterranean with the dry summer conditions due to high evaporation rather than low rainfall. A large area of the continent is arid and semi-arid, both tropical and temperate, and is dominated by hummock grasslands and *Acacia* shrublands. Prominent, species-rich woody plant genera in Australia are *Acacia* and *Eucalyptus*. Among the vertebrate animals, marsupials are particularly noteworthy.

Australia is a fire-prone continent. Fires occur in rainforests and in deserts. Its people have ignited and lived with landscape fires for perhaps 60 000 years, the current antiquity considered for Aboriginal people in Australia (see Miller et al. 1999). Consideration of fires without consideration of people in Australia is sometimes difficult, sometimes impossible, often unwise.

Fire regimes and their effects are wide ranging. Fires occur with a mean interval of 1 to 2 years in parts of the savannah in the tropical north and of the order of 300 or more years in the temperate rainforests of the southeast. Fires occur at all times of the year in some part of the

continent. Intensities of surface fires probably reach a maximum of the order of 100 000 kWm^{-1} (Gill and Moore 1990). Peat fires, which occur especially in Tasmania, can have long-term ecological significance, but are not widespread on a continental scale.

Australia has a large and diverse flora and fauna, much of it unique to the continent. This diversity, combined with the fact that there is a wide range of fire regimes and physical environments, means that there is an enormous range of potential fire regime effects. These effects include local extinction of flora and fauna, changes in water yield and quality, changes in pasture palatability, and woody plant encroachment.

Major wildfire impacts on people and property during the 1980s and 1990s

Most socio-economic damage from wildfires in Australia occurs in the southeastern part of Australia (see Cheney 1979 for 'fire-hazard areas'), but more generally where forests and woodlands abut cities and their suburbs. In the 1980s, there were extensive fires in South Australia and Victoria; 76 people died and there was massive property damage including the loss of 2 463 houses and 30 000 stock (see Ramsay et al. 1996). In the 1990s, there were fires in Sydney, New South Wales, where 206 houses were destroyed and four people died (see Ramsay et al. 1996). The impacts of such circumstances can last decades or more for the people involved.

Most human deaths in wildland fires in the last decade have been those of firefighters. At least 52 have died on active duty since 1980: in South Australia (10), Victoria (19), and in NSW (23) (Paix 1999). In early 2000, three more firefighters were killed in Sydney.

Fire database: fire numbers, areas burned, and fire causes

Various problems arise in the use of statistics for forest fires in Australia. The use of differing classifications of vegetation types creates difficulties. For example, 'forest' in the Food and Agriculture Organization (FAO) definition includes trees at least 5m tall having a cover of more than 10 percent, but the Australian National Forest Inventory, while using the same 5m height threshold, requires a "projected foliage cover of overstory strata about equal to or greater than 30 per cent" (Resource Assessment Commission [RAC] 1992). The definition of 'forest' used by forestry Organizations, for fire-reporting purposes, has been the vegetation of the land under forestry jurisdiction.

Forest fire statistics usually apply to data collected by State Forest Authorities and may not include the forests in National Parks, Crown Lands, and private property. Some State forestry Organizations have been amalgamated into agencies with larger jurisdictions and the way that statistics are published may reflect this.

The area base for the statistics is continually changing so care should be taken in the use of fire statistics. Changes occur due to tenure and land-use changes. The area of forest in Australia around 1790 has been estimated as 69 million ha while about 43 million ha survived to about 1990 (RAC 1992).

The following caveats apply generally but unevenly across the vegetation types and tenures of land in Australia:

- The methods used for the establishment of a database of areas burned varies (e.g. ground observation, aerial photography or satellite imagery) and thus the accuracy of the data varies.
- The diligence of reporting fires and the areas they burn may vary.
- Data may, or may not, include areas burned by prescription. For example, satellite sensing of areas burned will not discriminate between causes of fires. The major cause of burning in some major forest areas is due to prescription (see Gill and Moore 1997 for south-western Australian eucalypt forests).
- Data are often presented for short periods only.

Estimating the numbers of fires in Australia by any means is difficult even with a constant methodology. Data on High-Temperature Events (HTE) which represent vegetation fires depicted by satellite remote sensing gives a national coverage. Numbers of HTE's for the past two years (1998-1999 and 1999-2000) are 115 000 and 230 000 per year for Australia as a whole (Western Australian Department of Land Administration [DOLA] - data courtesy of Mr R. Craig). However, the number of HTE is inflated, on the one hand, by multiple counts of single fires and deflated, on the other, by the many fires that are missed by the evening pass of the satellite used for the daily detection of HTE.

The areas of burned surface estimated from satellite imagery by DOLA (viz. 'fire-affected areas' or FAA), for the two years were 312 000 and 712 000 km^2. This wide difference was apparently caused by large differences in the area of FAA in arid Western Australia (WA). These figures indicate an average proportion of the continent burned per year of 6.5 percent. This average contrasts with the extreme year of 1974-1975 when 15.2 percent of the continent was estimated to have been burned (Luke and McArthur 1978). In that same extreme year, a massive 33.5 percent of the entire Northern Territory was burned (Luke and McArthur 1978).

For 'forests' in the period 1956-1971 there was an average of 1945 fires per year with an average area of forest burned of 362 000 ha, or 1.8 percent of the total area (Luke and McArthur 1978). Forests in this case probably represent the vegetation managed by forestry agencies (see above). Taking the *average* area burned is a bit misleading, however, because the range in the area burned was from 53 000 to 1 061 000 ha (Luke and McArthur 1978). Estimates of areas of forest burned in more recent times are shown in Table 5-1. The Table is a summary of those produced by the National Greenhouse Gas Inventory for the period 1991-1996 (see Table 5-1 for the URL). The tables showed nominal, constant, figures for some years; where these extended for more than two years they were not included in Table 5-1.

It is suspected that the numbers in Table 5-1 were for 'forests' in the broad sense, whereas the data from the Forest Services quoted from Luke and McArthur (1978) were from forestry jurisdictions. Drawing comparisons between the two sets of figures would be unwise. For a detailed study of historical trends in areas burned and number of fires in southwestern Australian forests, see Gill and Moore (1997).

The Victorian Department of Natural Resources and Environment has posted the average figures for fire causes on public land over a 20-year period (www.nre.vic.gov.au/). Of the average 584 fires per year, 26 percent were caused by lightning, 25 percent were deliberately lit, and 26 percent were caused by agricultural sources and campfires combined. These fires did not burn areas proportionate to their numbers, however. Nearly half the area burned, on average, was due to lightning-caused fires; deliberate fires burned 14 percent, while agricultural sources and campfires, collectively, accounted for only 8 percent of the burned area.

Estimates of the areas burned by prescription are shown in Table 5-2. ‘Areas burned’ are usually the sum of the areas of burning blocks, not necessarily the actual area burned, which is less than that of the burning block (see Gill and Moore 1997).

Table 5-1 Estimated areas of forest land (ha) burned by wildfires in Australia.

Year	NSW	Tasmania	WA	SA	Victoria	Queensland	ACT
1983	326 000	62 385	12 000	20 000	21 000	197 000	
1984	8 000	20 283	9 000	100	486 000		
1985	242 000	2 230	60 000	4 000	240 000	19 000	
1986	35 000	873	73 000	100	15 000	15 000	
1987	249 801	5 079	235 678	101	24 958	44 000	
1988	158 954	30 861	76 543	293	32 352	14 000	
1989	79 452	8 833	78 431	138	30 744	33 000	
1990	99 340	14 529	247 147	300	26 297	73 930	
1991	251 252	9 675	1 221 102	101	51 943	28 945	
1992	449 800	15 466	279 320	102	4 815	37 925	
1993	10 000	5 623	144 200	1	4 815	39 855	200
1994	123 604	12 735	199 200	21	16 000	14 464	200
1995	23 716	52 572	101 692	7	19 000	81 860	180
1996	32 764	2 822	10 101	7	25 612		500

Source: National Greenhouse Gas Inventory 1991-1996 (<www.greenhouse.gov.au/index.html>).
Abbreviations: NSW - New South Wales; WA - Western Australia; SA - South Australia; ACT - Australian Capital Territory

Table 5-2 Estimated areas of forest land (ha) burned by prescribed fires in Australia.

Year	NSW	Tasmania	WA	SA	Victoria	Queensland	ACT
1983	65 000	16 722	273 000		167 000	119 000	
1984	101 000	32 042	253 000		62 000	96 000	
1985	72 000	26 183	282 000		106 000	164 000	
1986		41 811	269 000		96 000	141 000	
1987	160 917	30 476	208 569		211 000	165 000	
1988	133 574	22 423	227 281		200 000	151 000	
1989	103 253	5 356	234 514		34 171	28 000	
1990	158 675	22 239	277 364		105 000		
1991	171 077	19 442	365 164		205 000		
1992	61 777	5 101	309 350		100 000		
1993	93 971	11 317	270 680	12	100 000		300
1994	205 469	6 532	248 330	140	180 000		300
1995	131 629	6 700	278 887	142	141 000	101 039	20
1996	168 798	2 269	233 758		131 000		200

Source: National Greenhouse Gas Inventory 1991-1996;(www.greenhouse.gov.au/index.html).
Abbreviations: see Table 5-1.

Fire-suppression and fire-management organizations

There are many agencies in Australia concerned with suppression of wildland fires. In Table 5-3, agencies listed as "Fire Suppression Agencies" are those State government agencies that have as their major role the immediate suppression of any wildfire. Assisting them in suppression are, often, the State fire-management Organizations and, less often, the metropolitan fire brigades. "Fire-management Organizations" are government land management agencies which, if large enough, have a dedicated branch concerned solely with fire management. No private suppression organization is known to us, but many farmers, graziers and forest-plantation owners have their own fire suppression equipment.

Wildland fires in Australia are fought largely by volunteers belonging to a local brigade. Luke and McArthur (1978) estimated that there were 300 000 volunteer fire-brigade members in Australia. Volunteers are coordinated, equipped and trained by paid employees of the suppression agencies. State governments are the primary source of funding for the suppression agencies, but local government and communities are often heavily involved as well.

Among the State Government agencies which have significant capability for firefighting, but are primarily land-management agencies, are those in Western Australia (Department of Conservation and Land Management), Victoria (Department of Environment and Natural Resources) and New South Wales (State Forests of New South Wales). For further information, see the web page of the Australasian Fire Authorities Council (www.ausfire.com).

Both fire-suppression agencies and land-management agencies may be involved in the production of educational and training literature for firefighters and the public. They advise householders and rural people about preparedness for fire.

Table 5-3 Fire Suppression Agencies.

Australian agencies that have as their primary role the suppression of landscape fires. Abbreviations: see Table 5-1.

State	Authority	Internet Contact
ACT	ACT Bushfire Service	www.esb.act.gov.au/bs/bs.htm
NSW	NSW Rural Fire Service	www.bushfire.nsw.gov.au/
Victoria	Country Fire Authority	www.cfa.vic.gov.au/
Queensland	Queensland Fire & Rescue Authority	www.fire.qld.gov.au/
Tasmania	Tasmania Fire Service	www.fire.tas.gov.au/
WA	Fire and Emergency Services Authority of Western Australia	www.fire.wa.gov.au/
SA	South Australian Country Fire Service	www.cfs.org.au/splash.shtml
Northern Territory	Northern Territory Fire Service	www.nt.gov.au/bfc/

Use of prescribed fire to achieve management objectives

Prescribed burning is used widely in Australia. In forestry it is used primarily for crop protection, disposal of debris after silvicultural operations, and for the protection of human lives and property (e.g. see Williams and Gill 1995 for New South Wales, and Gill and Moore 1997 for southwestern Western Australia). In Western Australia, the extent of prescribed burning has been in gradual decline for many years (Gill and Moore 1997), possibly because of reactions by the public to smoke.

For land uses outside of forestry there are many reasons for prescribed burning. In the pastoral areas Leigh and Noble (1981) list, among other reasons, removal of top hamper (dead grass), extension of the growing season, control of woody weeds, assistance with the establishment of improved pasture species, fuel reduction, and nutrient release. In conservation areas, fires may be prescribed for the maintenance of natural values (Good 1981). In agricultural areas, fires may be used just before the harvest of sugar cane and just after the harvest of cereal crops (Johnson and Purdie 1981), although such practices have often been criticised in recent decades.

In most land uses where native vegetation is predominant there will often be some burning designated for the protection of human life and property.

Systems employed to reduce wildfire hazards and wildfire risks

Australian societies have many levels of interacting mechanisms pertaining to wildland fires. These differ widely from place to place but here we try to indicate a range of activities that, in various combinations, affect the responses of communities and governments to wildfires in Australia.

The infrastructure surrounding responses to fires in Australia includes:

- Fire-detection systems (which may involve dedicated observers using fire towers and aircraft, citizens using mobile phones, and analysts using satellite systems).
- Networks of safe outdoor cooking facilities for campers (e.g. gas barbecues).
- Firefighting equipment (4-wheel drive vehicles including tankers; graders; bulldozers; air tractors; helicopters).
- Networks of tracks, roads, fuel breaks, and buffer strips.
- Supply systems for the use of water-enhancing agents such as foams.
- Systems of regular fuel-condition assessment (models, ground observations, satellite data).
- Systems for the assessment of fire behaviour (models, ground observations, infra-red airborne systems).
- Systems of assessment of weather conditions (models, ground measurements, radar, satellite imagery).
- Systems for data display and manipulation such as Geographic Information Systems.
- Communication systems (control rooms, radio networks, computer networks, phones, vehicle-tracking devices).
- Training systems and ranking structures for firefighters (e.g. the Incident Command System [ICS]).

- A system for the integration of emergency services in disaster situations (e.g. through police, paramedics, caterers, structural and rural firefighters).
- A system of recruitment, training, and record keeping for firefighters.
- A system for the recording of mapped and other data for each fire to enable analysis, retrieval, and review.
- A research program.

A suite of mechanisms exists in relation to the setting of policy and its implementation. Tools that assist in the education, communication, and establishment of responsibility for fire matters include Codes of Practice (see www.nre.vic.gov.au/), Fire-threat Analyses (e.g. Mueller 1993), Plans of Management, interagency fuel management plans, and published Annual Reports. Programs for the creation of public awareness of wildfires include Community Fireguard (see www.cfa.vic.gov.au). There is a vast quantity of printed material available from firefighting and land-management agencies suited to community education (e.g. accessed through the home page of the Australasian Fire Authorities Council <www.ausfire.com/>).

Public policies

There is a large and complicated set of legal documents affecting fire suppression and management in Australia. There are:

- International treaties and agreements
- Within Australia inter-government agreements
- Australian Standards
- State laws and regulations
- Local government regulations

There are Acts and Regulations pertaining to:

- Set-up and responsibilities of government agencies
- Protection of human life and property
- Land tenure
- Biodiversity conservation
- Greenhouse gas emissions
- Smoke pollution
- Building design
- Total fire bans; etc.

An 'Environmental Impact Statement' may be required for some activities. A source of detailed information on legislation and regulation may be found at <www.austlii.edu.au>.

Having an impact on land-use practices has been the widespread membership of the 'National Landcare Program', a government-based program through which funding is provided to the community (<www.landcare.gov.au>). Though not specifically addressing wildfires, the projects undertaken by community groups can involve fires. The farming community is heavily involved in this movement. Community-based 'Park Care' groups exist in the Australian Capital Territory; their involvement in the management of conservation areas

includes fuel manipulation. There is a range of Community Organizations that may affect policy such as various National Park Associations (State based) and Conservation Councils.

Conclusion

Responding to wildfires in various ways are, among others, pastoralists in Northern Territory savannahs, traditional (Aboriginal) owners in desert grasslands of northern South Australia, managers of eucalypt forests of southwestern Australia, National Park managers in the semi-arid mallee shrublands of NSW, pine-plantation foresters in southeastern Queensland, and urban-interface residents in Tasmania. In this variety of circumstance, there is no single, planned, integrated system. Rather, there has developed a set of responses varying from the very simple to multi-faceted, multi-level, multi-agency mechanisms that vary regionally in accord with the diverse environments, tenures, population densities, and resource supplies present in different parts of the nation.

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5.3 Fire Situation in Fiji

By
Trevor King
c/o Institute of Development Studies, School of Global Studies, Massey University
Palmerston North, Aotearoa, New Zealand

Introduction

Fiji, one of the larger clusters of islands in the tropical southwest Pacific, includes several large, hilly, islands of volcanic origin (Hasni 2000). Some of these, especially the two largest, Viti Levu and Vanua Levu, are divided climatically into dry leeward and wet windward regions. The context for this report is the leeward region, where wildfires are a common occurrence during the May-October dry season.

The leeward vegetation is varied: from coastal mangroves, indigenous forest, exotic *Pinus* spp. (mainly *P. caribaea*) plantations, secondary swidden forest, sugar cane plantations and large areas of grassland (with some ferns) made up of various species.

Fire environment

The main threat to indigenous forest is logging, but fire damage occurs along the margins. Destructive wildfires are a seasonal problem for the activities of Fiji Pine Limited which manages the large plantations of *Pinus* species (Were 1997). Secondary forest is managed as part of an increasing population of swidden and permanent agriculturists, whose increasingly frequent cultivation cycles have lead to an increase in uncontrolled burning and complaints of soil erosion and declining fertility (King 2000). Sugar cane plantations exist mainly on the fertile lowlands where intentional burning during the harvest period has constituted an increasing problem (Davies 1998). Finally, large areas of grassland are burned annually (Whitehead 1952).

There are no comprehensive records of wildfire events in Fiji apart from Fiji Pine Limited records, with some contributions from the Fiji Sugar Corporation.

Perhaps because the centre of power lies in the wet windward region there is a lack of interest by the Fiji government. Other factors, including historical circumstances, are relevant. Before independence in 1970, the British colonial government enforced (sometimes in a draconian manner) a conservationist ethic regarding fire prevention. There were various laws enacted to sustain conservation, including the cutting of firebreaks for intentional fires. Fire wardens were employed and village headmen had the authority to punish offenders. Upon independence, however, there was a general relaxation of control. Fire wardens were no longer employed and the ability of village headmen to enforce the fire prevention laws was undermined. Consequently, local villagers now report that uncontrolled fires are more prevalent than before 1970. The older people in the villages complain of the indiscriminate firing and harvesting of the younger generation who, among other things, sell wild yams for

cash in the towns (often without replanting the reproductive head of the yam). This is despite a decree originating in 1969 which prohibits the burning of vegetation over a large part of the leeward region in the dry season of any year (unless authorised by a government officer) (Government of Fiji 1985 a). This law, and other fire prevention laws (Government of Fiji 1985 b), are ignored and not enforced.

Part of the problem is that these laws take little account of the practicalities of managing land in order to make a livelihood in the region. For example, the temperatures during the late fire season in the central hills are often extreme and the effort of making four metres wide firebreaks on steep hillsides in these circumstances is very strenuous, and simply not practicable, especially for large areas. In addition, the local enforcement agency (the police) often sympathise with these farmers or are simply unreachable in many of the remote locations where fires are prevalent. In effect, the laws are alien to the local situation in that they do not allow for compromise approaches to fire prevention where livelihood circumstances are difficult. Research has shown that local people have many specific reasons to start fires that are part of making a livelihood in the region (King 2000). These reasons should be acknowledged and ways of controlling fires that are practical should be developed in order to prevent their spread. In the Navosa region of the central highlands, 71 percent of burned land was the result of escaped land-use fires. The percentage of land burned annually is difficult to estimate, but certain large areas of grassland are burned every year. Much of the non-forested interior leeward landscape is probably burned at least every few years. The local people are well aware of the need to prevent fires, and complain of the lowering of fertility on hillslopes, the drying of the land, and the poor growth in native trees. However, various social structural, leadership, knowledge and policing issues need to be addressed in order to make improvements in this area. For example, traditional chiefs or village headmen (often lacking the power to police) sometimes urge their fellow villagers to minimise firing, but will admit privately later that `the people don't listen.'

The main reasons for fires are (a) clearing land for planting, (b) new grass for the animals (fodder in the season of scarcity), and (c) harvesting wild yams. Clearing land for planting in this dryland context is sometimes more appropriately termed ‘burn and slash’ rather than ‘slash-and-burn’ agriculture. Fires are often created to do the initial clearing in low-growth secondary forest, and then the remaining vegetation is cleared and small trees are trimmed to provide supports or shade for crop plants. The shift to cassava as the main subsistence crop in historical times may have contributed to a more careless use of fire because it tolerates poorer soils and growing conditions. In contrast, burning was less, and mulching used more, where yams (*Dioscorea*), dalo (*Colocasia)*, plantain, dalo ni tana (*Xanthosoma)*, bele (*Hibiscus)* and yaqona (kava) were grown because of their higher fertility requirements.

During the dry season there is little fodder for domestic animals so areas of mission grass (*Pennisetum polystachyon*) with unpalatable mature leaves are burned. Young shoots quickly arise from the stumps and are palatable to the animals for a few weeks.

Wild yams often grow among dense stands of a tall grass (or reeds, *Miscanthus floridulus*) whose thickets are difficult to penetrate and where the emerging shoots of yams are hidden from view. Fijians burn the thickets over large areas so that the emerging shoots can be easily seen and the tubers dug up free of the hindrance of dense vegetation.

Fire also helps to control wild pig activities, either by keeping them away from the village and gardens, or by making it easier to hunt them. This was especially important in those villages

on forest margins where the wild pigs can devastate the gardens. Gardens are sometimes relocated in deference to the threat of pig damage.
There are many other reasons for starting fires, many of which were only important in specific communities. The destruction of pests and disease is one that was mentioned by a Fijian agricultural official but not volunteered by local people (who may have subsumed it under clearing land for planting).

Rangeland wildfire has been a perennial part of leeward-climate Fijian life. Early European visitors of the 19th century inevitably made comments on the prevalence of human-caused wildfires. This was understandable given that such visitors came from relatively cold and wet climates where wildfires were absent. The indigenous Fijian view is that human-caused fires are an inevitable, but sometimes excessive, occurrence that is a normal part of the Fijian calendar. Many Fijians 'like to burn'. However, as yet unpublished thesis research done by the author shows that despite this cultural more, detailed evidence of opinions within farming villages shows that excessive burning is done only by certain households (King 2001).

Forest wildfire data

The only continuous fire data comes from the reports of Fiji Pine Limited (FPL) and to a small extent the Fiji Sugar Corporation (FSC). Outside of these sources, no records of wildfire have been kept despite the annual firing of the hilly savannah-like rangelands. Estimates of firing can be ascertained readily from aerial photographs held in the Fiji Lands Department, but no one has quantified these data for Fiji as a whole. According to the estimates of the author of this report and the data collected in Navosa province, about 70 percent of the land has been fired at least every few years.

In many years a portion of the pine plantations are written off due to fire damage. For example, 8 566 ha were written off over the 10 year period between 1987-1997 (Were 1997) out of the total of 43 201 ha managed in 1997 (Fiji Pine Limited 1997). In addition, many areas are burned but not written off. For example, in 1992 no plantations were written off but fire crews fought 156 plantation fires which burned 2 905 ha, responded to 56 wildfires near pine plantation boundaries, and undertook 952 control burns over 1 642 ha (Fiji Pine Limited 1992). There has been a reduction in the number of fires that occur inside plantation boundaries in recent years (Were 1997). The occurrence of the El Niño-Southern Oscillation (ENSO) event and government elections are associated with the worst years which were 1987, 1988 and 1994 (Were 1997). Records for the 1998 El Niño episode were not available. The causes of fire in FPL plantations between 1995 and October 1997 were: (a) arson (51 percent), (b) escaped agricultural burnings from adjacent farms (39 percent), (c) grazing (7 percent), (d) negligence by FPL employees (2 percent), and (e) lightning (1 percent).

The cause of the high arson rate involved conflict with landowner communities. Issues included low returns, loss of alternative means of income, employment prospects for community members, drying-up of community water supplies and other resource degradation, social equity issues, and party politics. In order to lower the rate of loss, prescribed burning for fuel reduction is being experimented with, and attempts are being made to increase benefits to landowners.

Sugar cane burning

The rate of sugar cane burning has increased steadily from a rate of 19 percent in 1968 to an average of 62 percent in 1997 (Fiji Sugar Corporation 1998). Cane burning is discouraged and penalised under certain conditions but is practised by farmers to speed the task of harvesting, clear weeds and undergrowth, destroy insects, solve labour problems, minimise labour costs, increase crop weight, advance milling priority, and voice industrial or political disapproval. Over 95 percent of cane burning is deliberately started by the farmer. The residual i percent is attributed to lightning, carelessness or neighbourly sabotage (Davies 1998). Cane fires sometimes spread to grasslands, forest and pine plantations, thus contributing to the increased prevalence of wildfires.

Operational fire management

Most of the indigenous forest is in the windward wet zone of Fiji where fire management is of minimal concern. The only fire management system is that of FPL which is a state-sponsored public company operating in the dry leeward zone. Prescribed burning is being practised, and has been successful in reducing wildfires, but damage occurs to the lower trunks of *Pinus caribaea* if the heat of the fire is too intense. This damage manifests in reduced timber quality (see also below).

In FPL plantations fire detection systems are in place, but there is a low rate of consistency in the time of response to wildfires even when the need for control is urgent (Were 1997). There are complaints about the level of preparedness, the lack of accountability of all parties, reductions in the number and quality of staff, and the efficiency of the firefighting system.

There have been complaints that the fire management system is inadequate for non-plantation fires, and could be much improved if a more efficient system of detection and communication with rapid-response tenders was put in place, especially in cane-growing areas. The government is challenged to become active here.

Use of prescribed fire

Prescribed burning as a forest management tool is only practised in FPL pine plantations as described before. However, in the savanna rangeland zone, burning is practised in a locally-prescribed way according to the livelihood and security needs of the subsistence-commercial communities of farmers in the region. It needs to be recognised that local farmers have their own needs that are prescriptive for their own purposes, and which are different from the needs of forest plantation managers. In Navosa province, local people prescribe fire to:

- Clear land for planting
- Promote the growth of new grass
- To find and harvest wild yams
- Help grow certain 'wild' green vegetables
- Help with fuelwood harvest
- To keep wild pigs away from gardens
- To help hunt wild pigs
- Clear tracks (of obstructions, and bristly or thorny vegetation) for both people and animals
- To help harvest 'wild' turmeric
- To clear land for pine planting
- To help control or find domestic animals (King 2000)

- To temporarily improve fertility
- To help control insects (especially snails, slugs, and army worms) and disease (especially anthracnose and yam rot, mildew on cassava)
- To remove undesired vegetation from rangelands

Reduction of wildfire hazards

There is little emphasis on techniques to reduce wildfire hazards apart from those used by FPL in plantation situations. In Navosa an average of 71 percent of land was needlessly burned because intentional fires were not controlled. Wildfire is commonly accepted a normal event and no attempt is made to alter the course of uncontrolled fires which in most cases burn uphill away from the villages which are mainly located in river valleys. Most open rangeland is burned relatively frequently: thus fuel loads are low and fires are of low intensity. Therefore, fires are rarely considered dangerous. However, if an uncontrolled fire destroys other peoples gardens or plantations, especially those containing valuable cash crops such as yaqona (kava), there will be conflict and some form of locally-arranged restitution will occur if the fire starter can be identified).

The topography of much of the uplands is hilly and the maintenance of firebreaks is difficult and very costly. Variations in the type of vegetation will influence the build-up and the amount of the fuel load. Much of the regularly burned land is composed of grass species which will not increase their fuel load beyond a threshold for a number of years and cannot be considered at risk of having excessive fuel loads. However, some shrub and tree species can regenerate quickly in the tropical environment and increase their fuel load to a point where they may pose a serious fire risk in certain locations if not burned regularly. Thus, the firing of this vegetation may be considered a form of sustainable land management that reduces wildfire hazards caused by a build-up of fuel load. It is worth commenting, however, that this reason was not proffered by the local people in the Navosa study, and this reason may be applicable only in a relatively few contexts near villages.

Public policies concerning fire

There are few policies that address fire outside of the relevant legal provisions. There have been opportunities to address fire and sustainability through a recent environmental bill, but this document mainly concerns itself with urban concerns such as pollution rather than rural interests. In effect, responsibility has been devolved to FPL, which does not have any mandate over rangeland fires.

The current legal provisions are contained in the legislation concerned with Land Conservation and Improvement (Government of Fiji 1985 a, b). In brief: (a) the legislation covers the requirements for firebreaks of 4 metre width around any prospective fire, (b) notification for adjoining landowners, (c) responsibilities and duties for extinguishing wildfires (d) responsibilities of fire rangers (police), and (e) punishments. In addition, another order prohibits fires to be ignited in most of the leeward regions of Fiji during the dry season without permission (cane farmers excepted).

It is apparent that the livelihoods of many hill communities are suffering from increased erosion and a decline in soil fertility because of excessive burning. Pine forests and the quality of sugar cane are suffering. With an increasing population and an increased prevalence of fires in the region, there is a need for informed debate on the present role of fire in land management. In the author's view, changes need to be made in many areas, and appropriate

education about the various impacts of fire and creative or constructive ways of preventing uncontrolled burns are a necessity. Fiji needs to develop new informed policies on the role of fire on its land.

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Source

King, T. 2001. Report on the fire situation in Fiji. I*nt. Forest Fire News* 26.

5.4 Fire Situation in New Zealand

By
Alison Craig
National Rural Fire Authority, Wellington, New Zealand

Fire environment, fire regimes and the ecological role of fire

The vegetation cover of New Zealand has never been static. Indeed, even before the arrival of humans a thousand years ago, natural processes such as volcanism, glaciation, earthquakes and high winds caused landscape-wide changes in vegetative cover.

With the arrival of humans the pace and extent of vegetation cover changes increased dramatically, resulting in a large proportion of the natural forest being destroyed. Fire, both deliberate and accidental, played a large part in these changes.

Although changes in vegetative cover continue to occur, the overall outcome in terms of vegetation types and quantity of available fuels has been reversed in more recent times, from a reduction in overall biomass (or fuel) to an increase in biomass. Before the middle of the last century many of the native forest, tussock land, wetland and scrubland areas were generally converted to pasture lands. Today many of these pasture lands are economically non-viable and are either reverting to scrublands, or have been planted with exotic forest species.

Since 1951 the area in planted production forest has increased from 338 000 ha to 1 761 000 ha, an increase from 1.3 to 6.5 percent of the total land area of New Zealand. This area is predicted to increase to 2.5 million ha by 2010, equivalent to nine percent of the total land area.

Changes in the management of South Island tussock lands will see around one million hectares of these lands retired from the pastoral lease system and included in the conservation estate. This land use change will result in much greater volumes of fuel accumulating on these former grazing lands.

The vegetation changes in plantation forests and tussock lands, in addition to the reversion of previously productive pasturelands to scrublands, are significantly transforming the land cover of New Zealand. The change is now clearly from less complex to more complex fuel types, from low fuel loads to high fuel loads and from fragmented to continuous areas of fuel.

These changes have a two-fold impact on the consequences of wildfires on rural lands. First, the higher fuel loads and larger areas of continuous fuels will make fires harder to control and will result in larger areas being burned. Second, the increase in economically and ecologically valuable vegetation types will result in future fires having a greater overall impact in terms of loss of valuable assets.

The overall results of these fire environment and fire impact changes will not become apparent until a prolonged period of drought and extreme fire danger coincides with a number

of fire ignitions. The average return period for these extremely damaging fire seasons, although difficult to quantify, is probably in the order of 15 to 25 years.

Narrative summary of major wildfire impacts on people, property and natural resources during the 1990s

Large and devastating wildfires occur relatively infrequently in New Zealand when compared with countries such as Canada, Australia and the USA.

The number of hectares that are burned annually by wildfires varies considerably, being driven predominantly by weather conditions during the summer season. The worst fire season since 1980 occurred in 1982-1983 when 45 000 ha were burnt. More recently, the 1998/1999 fire season resulted in 18 000 ha burnt, half of which can be attributed to two fires around Alexandra during February 1999 that destroyed two dwellings and many sheds and outbuildings. The average area burnt per annum since 1980 is 10 000 ha. Wildfire statistics for the decade 1990-1999 are given in Table 5-4.

The total economic and environmental cost that rural fires impose on New Zealand is not currently measured. This figure would have to include the loss of biodiversity, the destruction of production forests and other property and the reduction in water and soil quality following fire.

Table 5-4 Wildfire statistics of New Zealand for the fire seasons 1990-1991 to 1999-2000.

Year	Total No. of Fires on Forest, Other Wooded Land and Other Land No.	Total Area Burned on Forest, Other Wooded Land and Other Land Ha	Area of Forest Burned Ha	Area of Other Wooded Land and Other Land Burned Ha	Human Causes No.	Natural Causes (lightning) No.	Unknown Causes No.
1990/1991	1 234	7 279	240	7 039	not available	not available	not available
1991/1992	1 153	1 889	152	1 737	1 116	not available	37
1992/1993	990	3 129	151	2 978	948	not available	42
1993/1994	2 198	7 350	177	7 173	2 142	not available	56
1994/1995	2 023	4 594	466	4 128	1 965	not available	58
1995/1996	1 646	4 586	348	4 238	1 602	not available	44
1996/1997	2 374	6 937	746	6 191	2 331	not available	43
1997/1998	3 610	6 253	1 296	4 957	3 563	not available	47
1998/1999	3 165	17 699	213	1 ,486	3 107	not available	58
1999/2000	2 944	2 054	141	1 913	2 880	5	59

Notes:
Human Causes: includes "miscellaneous" causes of fire
Natural Causes (i.e. lightning): not recorded separately until 1999/2000
1990/1991: breakdown of causes not available

Operational fire management systems and Organizations present in the country

The New Zealand Fire Service Commission governs fire services in New Zealand by administering the Fire Service Act (1975) and the Forest and Rural Fires Act (1977). These two acts provide the framework within which the New Zealand Fire Service, the National Rural Fire Authority and Rural Fire Authorities carry out their responsibilities.

The New Zealand Fire Service, under the Fire Service Act (1975), is responsible for protecting life and property from fire, primarily within urban areas. Outside urban areas, the National Rural Fire Authority promotes and encourages rural fire coordination under the Forest and Rural Fires Act (1977), with the responsibility to prevent, detect and extinguish fires falling under the jurisdiction of Rural Fire Authorities.

Rural Fire Authorities are independent Organizations with responsibilities for fire control measures including prevention, restriction and suppression of fires in forest and rural areas.

Each Rural Fire Authority falls into one of the three following categories:

State Areas

The Minister of Conservation, through the Department of Conservation, is the Rural Fire Authority for the lands administered by the Department. This may include a one-kilometre fire safety margin around Conservation land.

Rural Fire Districts

Landowners looking to provide greater fire protection for their lands, or territorial authorities that wish to amalgamate their fire protection responsibilities with neighbouring authorities, may establish a Rural Fire District. Rural Fire Districts ranging in size from several thousand hectares to three million hectares are currently in existence. The New Zealand Defence Force is the Rural Fire Authority for eight Rural Fire Districts covering their lands.

Territorial Authorities

Areas that are not covered by an Urban Fire District, a Rural Fire District, or a State area are the responsibility of the Territorial Authority, who becomes the Rural Fire Authority.

The National Rural Fire Authority provides support and co-ordination to Rural Fire Authorities, including the following:

- Developing and managing the Rural Fire Management Code of Practice and conduction compliance audits of Rural Fire Authorities against this Code.
- Promoting and delivering rural fire training.
- Monitoring and reporting fire danger conditions throughout the country to Rural Fire Authorities and the media.
- Providing technical advice to Rural Fire Authorities.
- Providing grants to Rural Fire Authorities for equipment purchases.

Use of prescribed fire

Forestry

Little controlled forestry burning has been carried out in the last ten years.

Other vegetation management (grasslands, bushlands)

Little prescribed burning is carried out.

Agricultural maintenance burning

Burning is still used quite extensively in the high country areas of New Zealand as a land management tool, predominantly in tussock areas to encourage new growth and enable oversowing with grass species in an effort to improve the pasture. Burning is also carried out to remove weed species. Access for stock is also improved after burning.

Most high country burning is carried out in the spring when soil and moisture levels are generally high.

"Let burn" or integration of natural (lightning) and human-caused wildfires

Fires are extinguished rather than left to burn.

Research

Research burning trials are being undertaken.

Practices to reduce wildfire hazards

Fire hazard reduction and forest management preventive measures include construction of bulldozer track fuel breaks, windrowing of materials and silvicultural treatment of forests

Public policies concerning fire

The policies of the country are included in the following legislation:

- Fire Service Act (1975)
- Forest and Rural Fires Act (1977)
- Forest and Rural Fires Regulations (1979)

A National Fire Prevention Campaign is supported by local campaigns.

Fire management needs and challenges

Rural Fire Authorities are responsible for all aspects of fire management outside urban fire districts, including fire suppression. There are a number of options available for Rural Fire Authorities to carry out fire suppression, ranging from using their own staff or contractors,

using Volunteer Rural Fire Forces, or contracting with the New Zealand Fire Service. Most Rural Fire Authorities use a combination of these options to effectively protect their area and meet their statutory responsibilities.

The New Zealand Fire Service attends all fires, including vegetation fires, inside urban fire districts. The Fire Service also responds to some fires outside the urban fire districts every year. There are, however, vast areas in New Zealand outside Fire Service coverage.
The Department of Conservation responds to approximately 150 to 200 fires per year, most of which are attended by the Department's staff.

Other Rural Fire Authorities respond to approximately 2 000 to 3 000 fires per year, some of which are also attended by the New Zealand Fire Service.

Most Rural Fire Authorities have mutual aid agreements with their neighbouring authorities, recognising the fact that regional cooperation is the only efficient manner to deal with larger vegetation fires.

Continued changes in the rural area, the increased use of forest and rural lands and the greater emphasis on environmental protection necessitate the development of new strategies to adequately manage fire in the rural landscape.

These strategies need to be developed cooperatively with the rural fire sector to ensure ownership of the solutions, effective implementation and long term sustainability of any change.

Suggested strategies are:

- Develop rural fire risk management tools;
- Increase the level and focus of fire prevention and mitigation activities;
- Develop regional and national incident management teams;
- Establish seasonal firefighting teams.

Wildland fire research

The aim of the Forest and Rural Fire Research project is predicting where wildfires are most likely to break out, what fuels them and helps them burn and how fire managers can be best prepared to fight them.

The main aim is to develop a New Zealand fire danger rating system; a decision support tool that predicts likely fire behaviour based on weather, fuel and topographic variables. The programme has five main objectives:

- Development of fire behaviour models for New Zealand fuel types that predict how fast fires will spread under different weather conditions.
- Development of a method of assessing curing (or die-off) of grasslands, an essential element in grassland fire behaviour prediction.
- Describing New Zealand's fire climate using historical weather and fire danger data from the network of remote automatic weather stations around the country.

- Using Geographic Information Systems (GIS) to combine the climatic and physical factors that influence fire behaviour so that maps of current and expected fire danger conditions can be produced.
- Combining this information into a decision support system that provides fire managers with the information to better prevent, predict and fight damaging wildfires.

Source

Craig, A. 2001. Wildland fires in New Zealand in the 1990s: Retrospective and challenges. *Int. Forest Fire News* 26.

6 North America, Central America and Caribbean Region Fire Assessment

6.1 North America Sub-Region

6.1.1 Introduction

The North American continent has been classified into 15 fire climate regions based on geographic and climatic factors. Major fire seasons, or periods of peak fire activity, can be used to alert fire management personnel and wildland users of the most probable times of year for serious burning or life-threatening situations. Although the fire season for the southern Pacific U.S. coast is June through September, critical fire weather can occur year round in the most southerly portion. Fire seasons are most active during spring and fall in the Great Plains, Great Lakes and North Atlantic regions. The typical fire season in the western United States occurs during the summer months of July, August and September.

Together, Canada and the U.S. cover nearly 18.8 million square kilometers, about 14 percent of the world's land area. The two countries share one of the longest common borders in the world, creating numerous opportunities for trans-boundary cooperation and agreements. Mexico has a forested area of 141.7 million hectares, of which 56.8 million hectares are temperate and tropical forests and 58.4 million hectares are zones with arid and semi-arid vegetation.

International and Regional cooperation in fire management has increased significantly during the last decade. In North America, under the North American Forestry Commission, there is a Fire Management Working Group that brings together specialists from Canada, the United States and Mexico to work on common problems. The Northeast Fire Compact between Canada and the northeast States has been in place for many years; and a Northwest Compact is being developed to share firefighting resources both ways across the border between Canada and the United States. A more general agreement also exists between Canada and the United States for the exchange of firefighting resources.

Agreements also exist along the border between Mexico and the United States to share resources. Central America has been especially pro-active in developing cooperative efforts among all countries in this area. Central America countries meet periodically to establish common fire management policies and strategies to help each other.

Forests are a dominant feature of the North American landscape. Forests comprise almost half of Canada (Natural Resources Canada 1996) and a third of the United States (Brooks 1993). Provincial governments are responsible for managing 71 percent of Canadian forests and 23 percent are managed by Federal and Territorial governments (Natural Resources Canada 1996). The remaining 6 percent of Canada's forests are growing on private land.

Many public forests in the United States are managed by the Forest Service, Bureau of Land Management, Bureau of Indian Affairs and the states to achieve multiple use objectives: recreation, water, timber harvest, wildlife habitat and rangelands for domestic cattle. Private

forests are managed primarily for fiber production. The National Park Service and Fish and Wildlife Service manage National Parks and Wildlife Refuges, respectively. All of these agencies and organizations maintain their own fire management capacity; and cooperate with each other on a regular basis.

Depletion of old growth forests and the last remaining temperate rain forests in British Columbia, Canada, and in the Pacific Northwest of the United States have generated public concerns to stop logging in such areas. A movement has developed that makes it increasingly difficult to harvest timber on federal lands, posing difficulties in using thinning and silvicultural prescriptions to sustain viable ecosystems producing multiple objectives.

Many forests in the western U.S. especially are experiencing declines in health attributed to the exclusion of fire from fire-dependent ecosystems, changes in stand density and composition, widespread insect and disease epidemics and drought. Many of these dead and dying forests are now more susceptible to high intensity, stand replacement crown fires. Costs of fire suppression, the size of wildfires and the damages due to fires have increased significantly in the U.S. since the mid-1980s due to extended drought and unnatural accumulations of forest fuels.

6.1.2 Fire Management in Canada

By
Brian J. Stocks
Canadian Forest Service, Sault Ste. Marie, Ontario, Canada

Introduction

Forests occupy approximately 40 percent of the vast Canadian landscape, cover approximately 417 million hectares, and constitute ~10 percent of the global forest resource. Of the total forest area, approximately 57 percent (~235 million hectares) is considered commercial forest, managed for a variety of purposes, including timber production. Approximately 1 million hectares are harvested each year. Canada's non-commercial forest, situated to the north, is made up primarily of open forests comprising natural areas of small trees, shrubs and muskeg, and is rich in biodiversity.

Fire is natural to Canadian forests, particularly in the boreal zone (Canada has 30 percent of the world's boreal forest) which has been shaped by periodic wildfire for millennia, to the point that fire is essential to boreal ecosystem structure and function. Crown fires dominate in the Canadian boreal zone, with the result that tree species have adapted to lethal fire, regenerating from seed released soon after the passage of the fire. Large contiguous areas of crown fire-prone even-aged forest dominate the boreal landscape.

For much of the first half of the 20th century Canadian fire management practices were strongly influenced by European approaches to forest management. Fire was seen as an enemy and something to be eliminated from the forest whenever and wherever possible. Over time there has been a gradual recognition that eliminating fire in Canadian forests is neither economically possible or ecologically desirable. Modern fire management programmes in Canada now balance the protection of human lives and property with an awareness and consideration of the natural ecological role of fire.

Canadian Forest Fire Statistics

Forest fire statistics have been archived in Canada since 1920 and, within limits, this extensive record permits a general analysis of trends in this country (Figure 6-1). However, it is recognized that the Canadian fire record prior to the early 1970s is incomplete, as various regions of the country (particularly in the north) were not consistently monitored during this period. For example, the Yukon and Northwest Territories have only reported burned areas since 1946, while the province of Newfoundland began reporting in 1947. It is expected that incomplete records are much more of a problem prior to 1950, and the advent of satellite coverage in the early 1970s has resulted in a virtually complete record over the past 3 decades.

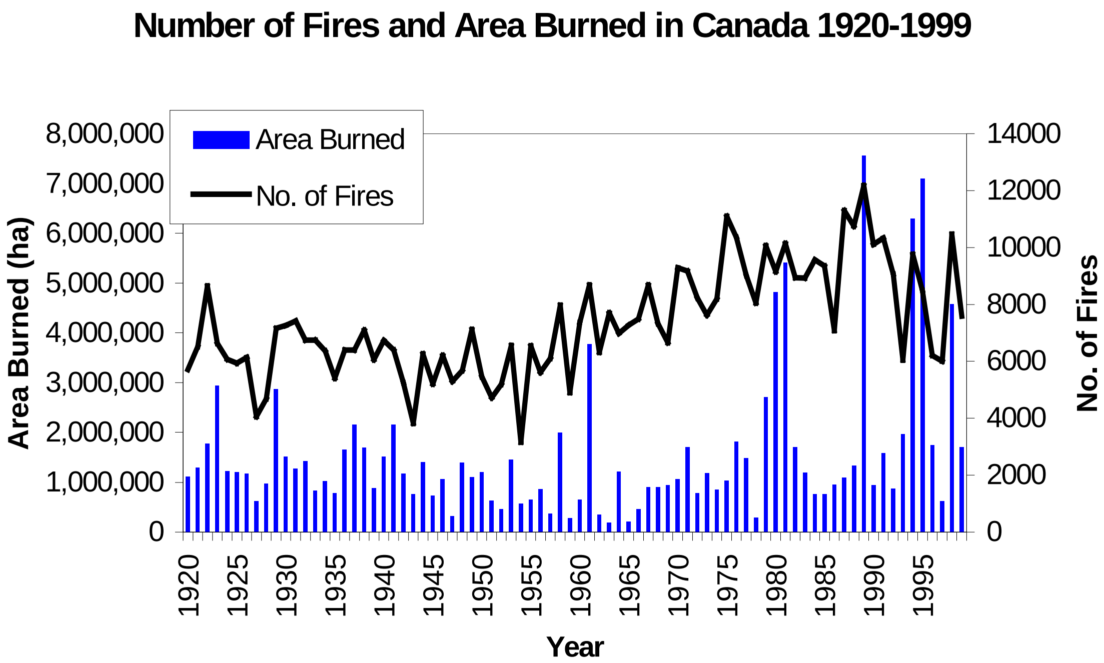

Figure 6-1. Number of fires and area burned in Canada, 1920-1999.

Keeping these uncertainties in mind, fire occurrence in Canada has increased steadily (primarily due to increasing population pressures and forest use) to average close to 9000 fires annually since 1980. The average annual area burned has increased post-1970, to an average of 2.8 million hectares during the 1990s. Annual area burned is highly episodic and can vary by an order of magnitude (e.g., from 0.76 million hectares in 1984 to 7.28 million hectares in 1989).

Regional-scale lightning fire occurrence varies significantly across Canada, but on average lightning accounts for 35 percent of fires nationally. However, lightning fires account for ~85 percent of the total area burned, largely due to the fact that lightning fires occur randomly and often in large numbers, presenting access problems not normally associated with human-caused fires. The result is that lightning fires generally grow larger, as detection and subsequent initial attack is often delayed.

There are two primary reasons why the impact of fires on the Canadian landscape varies significantly at a regional scale:

1. Extreme fire weather/fire danger conditions occur in the boreal forest zone of west central Canada.

2. Fires occurring in remote or “unmanaged” forest zones are often allowed to burn in a natural manner.

Sophisticated fire management programmes in all Canadian provinces and territories are largely successful in controlling the vast majority of forest fires at an early stage, particularly in the intensively protected forest zone. As a result, only ~3 percent of the fires in Canada

grow larger than 200 hectares in size, but these fires account for ~97 percent of the area burned nationally. A large majority of the larger fires occur in the "limited suppression" or "modified suppression" zones of Ontario, Manitoba, Saskatchewan, and the Yukon and Northwest Territories – regions where unmerchantable timber values permit more natural fire regimes. An examination of the spatial distribution of large Canadian fires (Figure 6-2) shows by far the greatest fire activity and area burned occur in the boreal region of west-central Canada. This is due to a combination of fire-prone ecosystems, extreme fire weather (a continental climate), frequent lightning activity, and reduced levels of protection in the region.

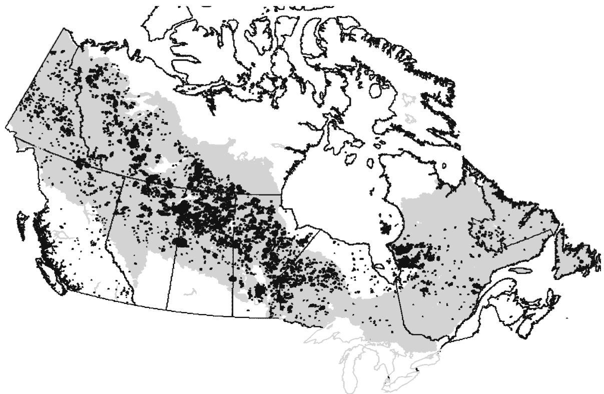

Figure 6-2. Greatest fire activity and area burned occur in boreal region of west central Canada.

The preponderance of large fire activity in west-central Canada is also reflected in Figure 6-3. The shortest fire cycles occur in this region, particularly in the boreal shield areas of northwestern Ontario, northern Manitoba and Saskatchewan, and the Northwest Territories.

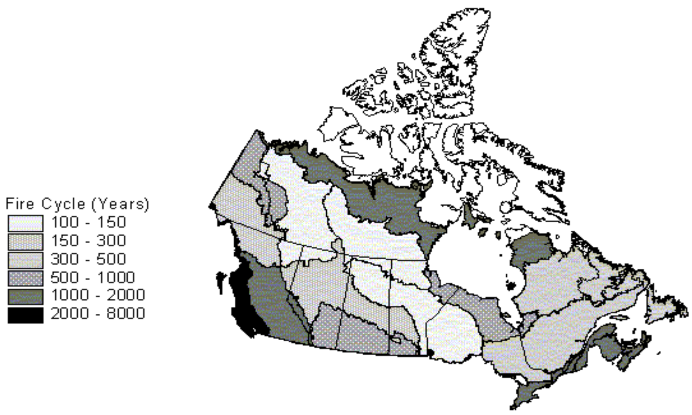

Figure 6-3. Typical fire cycles in Canada.

Canadian Fire Management Capacity

In Canada the ten provinces and three territories own the land and are responsible for all land management activities, including forest and fire management. The federal government, through Parks Canada, operates a fire management programme in a number of national parks across the country. All fire management agencies in Canada are autonomous and have unique organizational structures and approaches.

Fire suppression resources in Canada are shared as required between agencies under the Canadian Interagency Mutual Aid Resources Sharing (MARS) Agreement, and the Canadian Interagency Forest Fire Centre (CIFFC) in Manitoba coordinates the sharing and movement of resources. Canada also has a reciprocal agreement with the United States that provides for the fast movement of resources between the two countries during severe fire incidents. Canada has a fleet of fifty Canadair CL-215/415 aircraft. These aircraft are operated by the provincial/territorial governments, and were purchased as a cooperative federal/provincial undertaking.

Fire management is a costly undertaking in Canada. Both fixed and variable costs have risen dramatically over the past 25 years, and this trend is expected to continue. At the present time fire management costs are averaging $500 million CDN annually.

Forest Fire Research in Canada

Canada has conducted a national forest fire research programme for the past 75 years. Under the auspices of the federal forestry agency (currently the Canadian Forest Service), this programme has traditionally addressed major and topical fire management issues, and has evolved in concert with, and in support of, changing fire management practices nationally. Although fire research activities are carried out at academic and provincial/territorial institutions in Canada, research at the federal government level has been dominant, providing the much-needed stability and continuity required to build a relevant and adaptable research programme. Despite fluctuating levels of funding support and the associated continual opening/closing of research establishments, fire research at the federal level in Canada has endured, building on previous research and producing leading-edge scientific solutions to Canadian fire management problems. A prime example is the Canadian Forest Fire Danger Rating System (CFFDRS), developed over a half-century and completed in 1989, now in use throughout Canada and in a number of countries internationally. Canada has also been a leader in the development of computerized fire management decision support systems that have revolutionized operational fire management in Canada, and have been exported extensively.

At the present time the Canadian Forest Service fire research programme has a complement of 25 (16 professionals), located primarily at the Northern Forestry Centre in Alberta and the Great Lakes Forestry Centre in Ontario, with smaller complements at the Pacific Forestry Centre in British Columbia and the Laurentian Forestry Centre in Quebec. Research is primarily focused in four areas: fire behavior/fire danger, fire management systems, fire ecology, and fire and global change.

Future Directions

Fire management in Canada has evolved in response to regional and national priorities over the past century. While these pressures are expected to continue, larger international environmental issues are becoming increasingly important. Awareness of the potential impacts of climate change on forest fire regimes at northern latitudes, particularly the circumpolar boreal zone, are raising international concerns over the effects of increasing fire activity on the global carbon budget. Any movement towards warmer and drier spring/summer weather in Canada can be expected to translate directly to more frequent and severe fire activity, with resulting impacts on the global carbon budget. In a post-Kyoto world, Canadian fire management agencies must deal with the impact of increased fire activity on the Canadian forest resource, while at the same time recognizing, and responding to, international concerns over the global implications of changing fire regimes in the carbon-rich boreal zone.

6.1.3 Fire Situation in the United States

By
Robert W. Mutch
Missoula, Montana, USA

Fire environment, fire regimes and the ecological role of fire

There have been several different systems used in classifying fire regimes in the United States (Heinselman 1978; Agee 1993; Morgan et al. 1998; and Frost 1998). Brown and Smith (2000) classified fire regimes based on fire severity. Use of fire severity as the key component in describing fire regimes is appealing because it relates directly to the effects of disturbance, especially on survival and structure of the dominant vegetation. Brown and Smith (2000) described fire regimes as follows:

- Understorey fire (applies to forests and woodlands)--fires are generally non-lethal to the dominant vegetation and do not substantially change the structure of the dominant vegetation. This fire regime typically applies to the 39 million acres of ponderosa pine in the western U.S. where fires historically occurred every 10-15 years as low intensity surface fires. Southern pines in the southeast U.S also belong in this fire regime.

- Mixed severity fire (applies to forests and woodlands)--severity of fire either causes selective mortality in dominant vegetation, depending on different tree species' susceptibility to fire, or varies between understorey and stand replacement. Lodgepole pine in the western U.S. fits in this regime because fires can be characterized as both understorey surface fires in younger stands and later as stand replacement crown fires in older stands.

- Stand replacement fire (applies to forests, woodlands, shrublands and grasslands)--fires kill aboveground parts of the dominant vegetation, changing the aboveground structure substantially. Approximately 80 percent or more of the aboveground dominant vegetation is either consumed or dies as a result of fires. Plant communities in this regime include chaparral in California, sagebrush in the Interior West, grasslands in the Great Plains and spruce-fir forests in the West.

- Non-fire regime--little or no occurrence of natural fire. Most plant communities in the U.S. fall into one of the three previous fire regimes. Sitka spruce in Alaska, however, would fall into the non-fire regime class, because fires are rare or absent in this wet environment.

Narrative summary of major wildfire impacts on people, property and natural resources that occurred historically

The Peshtigo, Michigan, Hinckley, Yacoult and Maine fires burned hundreds of thousands of hectares and killed more than 2000 people between 1871 and 1947. On the same day, October 8, 1871, that fire wiped out the town of Peshtigo, Wisconsin, the great Chicago fire

devastated urban Chicago. Comparative statistics for those two fires highlight the destructive potential of wildland fires. The Peshtigo fire covered 518,016 hectares and killed 1150 people, whereas 860 hectares burned and 300 lives were lost in the Chicago fire. The 1910 wildland fires in northern Idaho and Montana had several common elements: many uncontrolled fires burning at one time; prolonged drought, high temperatures and moderate to strong winds; and mixed conifer and hardwood fuels with slash from logging and land clearing. These large fires occurred primarily in conifer forests north of the 42nd meridian, or roughly across the northern quarter of the contiguous United States. One critical element, which is not as likely to occur today as formerly, was the simultaneous presence of many uncontrolled fires. The effectiveness of modern fire suppression organizations has been greatly enhanced by their rapid growth and by the air deployment of firefighters and retardants to even the most remote wildland locations. High-velocity winds and more than 1700 individual fires contributed to the spread of the 1910 fires.

Prolonged drought, high winds and flammable fuel types, however, are as significant to the behavior of high-intensity fires today as previously. In 1967 the Sundance fire in northern Idaho burned more than 22,627 hectares and killed two firefighters (Anderson 1968). In 1970, other fires burned approximately 40,470 hectares near Wenatchee, Washington. During the drought-stricken 1977 fire season in California, 21 major fires burned almost 150,000 hectares. The largest of these fires, the remote Marble Cone, spread through 70,418 hectares (174,000 acres) of flammable chaparral and mixed forest. The Sycamore fire near Santa Barbara, California, although only 324 hectares in size, destroyed more than 200 homes.

The benefits accrued by decreasing the number of uncontrolled fire starts have been offset by the tendency of people to live in fire-prone areas. For example, some of the fires most potentially damaging to human lives and property occur in areas rich in chaparral shrub fuel in California. Several wildfires in southern California in 1970, fueled by a prolonged drought and fanned by strong Santa Ana winds, produced 14 deaths, destroyed 885 homes and burned more than 242,820 hectares. Ten years later the situation recurred over 28,330 hectares in southern California, resulting in the deaths of 5 persons and loss of more than 400 structures.

Wildland fires that threaten human lives and property are not exclusively located in southern California, since the exodus to wildland regions has become a national phenomenon. Fires burned more than 80,940 hectares in Maine in October 1947, killing 16 people; another 80,940 hectares burned in New Jersey in 1963. On July 16, 1977, the Pattee Canyon fire in Missoula, Montana, destroyed 6 homes and charred 486 hectares of forests and grasslands in only a few hours.

The 1985 wildland fire season was one of the most severe in this century. The national toll for that year paints a stark picture: 44 civilians and firefighters died, 1400 homes and structures were destroyed or damaged and 1.2 million hectares were burned. On one day in Florida, May 17, a firefighter died, 40,470 hectares burned, 600 homes and other buildings were destroyed or damaged and more than 1000 residents were safely evacuated. During 1986, in three states alone, wildfires forced 13,500 people to evacuate their homes.

A human-caused fire, starting on July 9, 1989, near Boulder, Colorado, raced through residential areas among the trees, destroying 44 homes and other structures and burning over 850 hectares. Losses for homes and natural resources were estimated at $10 million and the cost to control the fire was another $1 million. This Black Tiger fire produced the worst fire losses in Colorado's history. The causes were familiar: lack of rainfall, high temperatures, strong winds, steep topography, buildup of forest fuels, construction factors affecting the

susceptibility of the homes to fire, combustible construction materials, poor access for emergency vehicles and lack of home site maintenance for fire protection. The conditions that led to the Black Tiger fire are still prevalent in many parts of Colorado as well as in other states.

Narrative summary of major wildfire impacts on people, property and natural resources during 1990-2000

This narrative summary of wildfire impacts was compiled from reports maintained by the National Interagency Fire Center in Boise, Idaho.

A wildfire in Arizona in 1990 resulted in the death of six firefighters who were overrun as they were attempting to protect a group of homes. In late June California experienced extreme fire behavior on several fires due to dry conditions and high winds. Over 500 structures and two shopping malls were destroyed. Air tankers were in short supply, necessitating the activation of eight military C-130s equipped with airborne retardant delivery systems and three airtankers from Canada. In August, dry lightning storms occurred in northern California, Oregon, Washington and the Great Basin, calling for the mobilization of hundreds of firefighters and other firefighting resources. By August 9 all domestic firefighting resources were fully committed and the military was asked to provide personnel to be trained to assist with the fire emergency.

The 1992 fire season was dominated by the El Niño weather phenomenon. Most El Niño episodes produce a split flow in the upper air pattern west of the Pacific Coast. This produces above normal precipitation over the southern United States and drier than normal conditions in the Pacific Northwest and Great Basin. From October 1991 to April 1992, the Pacific Northwest received 50 to 70 percent of normal precipitation, while the Desert Southwest and the southern states received up to 150 percent of normal precipitation. The Foothills Fire started near Boise, Idaho, in late August on a Bureau of Land management area and quickly burned into ponderosa pine forests on the Boise National Forest. This fire grew to 257, 600 acres before it was controlled, making it the largest wildfire of the year. Where it burned into the overly dense ponderosa pine forest, it burned as a stand replacement crown fire and killed most of the trees over a 70,000-acre area.

On October 20, 1992, a devastating fire occurred in the hills above Oakland and Berkeley, California. Burning embers carried by high winds from the perimeter of a small fire resulted in a major wildland/urban interface conflagration that killed 25 people, injured 150 others and destroyed nearly 2449 single-family dwellings and 437 apartment and condominium units. It burned over 648 hectares and did an estimated $1.5 billion in damage.

Although the 1993 fire season was well below average in terms of numbers of fires and area burned, strong winds in southern California in late October and November contributed to wildfires burning about 200,000 acres. Three people died and over 1000 homes were destroyed in multiple fires.

In terms of length and scope of the fire activity, the 1994 fire season was the most demanding on record to date. Major fires throughout the western United States occurred from the end of May until September. Demand for firefighting resources often exceeded the supply. Thirty-four firefighters lost their lives from one end of the country to the other. Fourteen firefighters lost their lives on a single fire, the Storm King fire in Colorado in early July. Also, for the first

time in history $1 billion was spent in fire suppression by all agencies. Seven military battalions were mobilized for firefighting during July and August in the western U.S. A battalion contains approximately 600 people. At the peak of activity in August, more than 25,000 firefighter, 900 engines, 155 helicopters, 54 air tankers, 31 mobile kitchens and 42 shower units were assigned to the fires.

In 1996, record fire activity occurred in Kansas, Oklahoma and Texas with very large areas burned on primarily state and local lands. By mid-August, there were 48 major fires burning in the West; and 90 Incident Management Teams were mobilized to fires. The fire season finally ended in early November. The following year, 1997, exhibited a low level of fire activity nationwide.

The El Niño weather pattern in 1998 produced extremely dry conditions from New Mexico and Texas all the way east to Florida and southern Georgia. Florida and Texas were especially hard hit by wildfires, with many evacuations and losses of homes in Florida.

Intense drought conditions in the western United States in the 2000 fire season contributed towards wildfires burning 120,000 hectares on and near one National Forest in Montana (Figure 6-4), destroying more than 70 homes and forcing the evacuation of nearly 1000 people. In June, the Hanford fire ripped across 77,700 hectares of southeastern Washington, destroying more than 20 homes and threatening the Hanford Nuclear reservation. Throughout the nation, wildfires burned about 2.5 million hectares of forests and grasslands. More than 29,000 firefighters attacked the fires with the assistance of 1200 fire engines, 240 helicopters and 50 air tankers. Montana, Idaho and Oregon were declared national disaster areas. The National Guard, Army and Marines were called to action, as were firefighting personnel from Australia, Canada, Mexico and New Zealand.

Figure 6-4 Elk taking refuge from Montana wildfire, August 2000

(Photo: John McColgan)

About 80,000 wildfires occurred in the country and most were controlled at small size by aggressive initial attack efforts. As is usually the case, about 2 percent of the wildfires caused over 90 percent of the area burned. The firefighting efforts cost the United States nearly $1

billion, but it was the onset of September rains that quelled the firestorms. It took appreciable rainfall towards the end of the fire season to overcome the effects of record heat and drought in the western United States in 2000 (Figure 6-5).

In May 2000, the National Park Service in New Mexico ignited a prescribed fire. The fire eventually was called a wildfire and three days later suppression actions contributed to the fire spreading out of the project area into the town of Los Alamos. The fire in Los Alamos destroyed more than 200 homes.

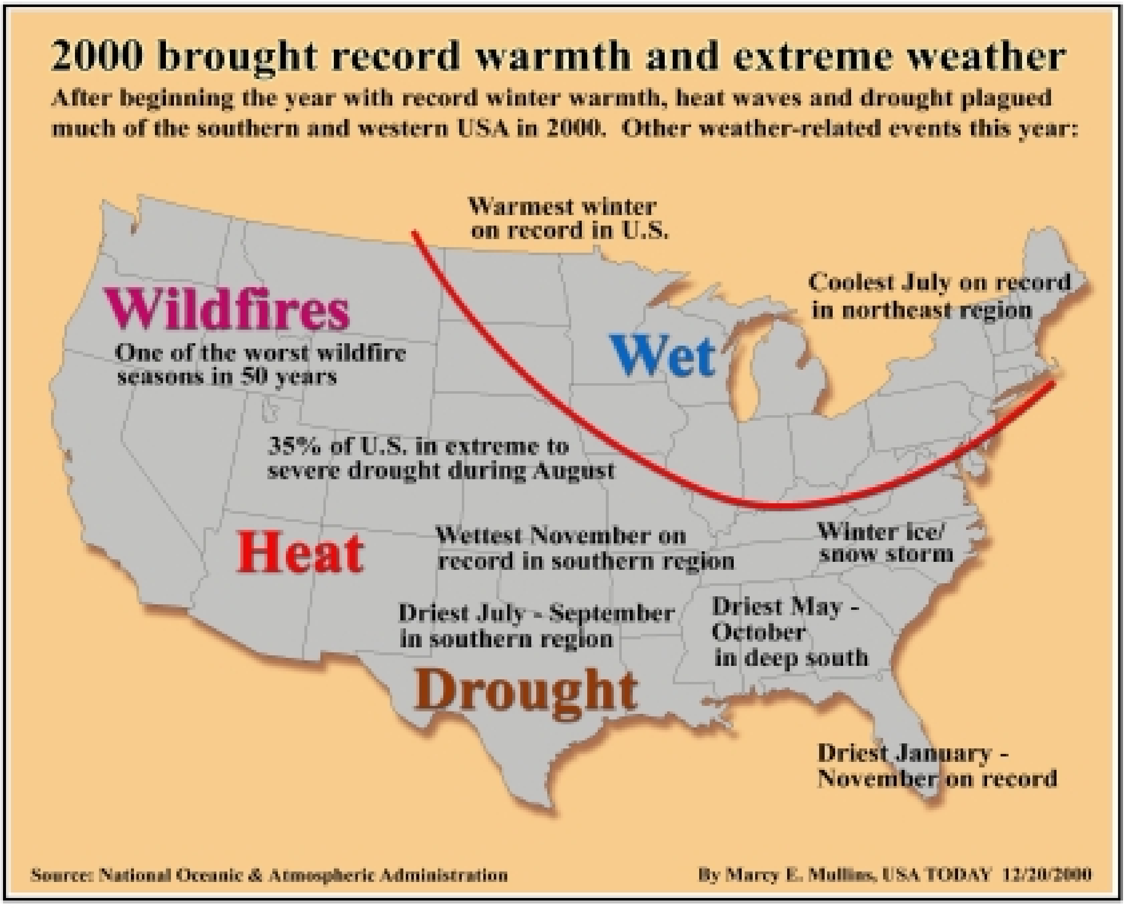

Figure 6-5 Record heat and drought made 2000 one of the worst wildfire seasons in the West in 50 years.

Fire management organization

All Federal and most State wildland fire organizations operate under the National Interagency Incident Management System (NIIMS), which consists of five major subsystems providing for an integrated response to wildfires and other emergencies. The five subsystems include:

1. Incident Command System for the on-site management of any emergency.
2. Training (development and delivery of courses in support of wildfires and prescribed fires).
3. Qualification and Certification (national standards that include training, experience and physical fitness requirements for all wildland fire agencies).

4. Publications management (development and control of publications, suppliers and distribution of fire-related materials).
5. Supporting technology (Orthophoto mapping, danger rating system, lightning detection, infrared, communications).

The National Interagency Fire Center in Boise, Idaho, coordinates wildfire response activities for all five national resource mangement agencies; and assists the State fire services as well. In addition, the National Weather Service issues two fire-weather forecasts daily during the fire season to all agencies and prepares spot weather forecasts on request for prescribed fires. The fire management organization is backed by a strong and diversified fire research programme in the United States. Fire research is conducted at two fire research laboratories in California and Montana and at other locations throughout the country. Long duration fire research programmes have been instrumental in providing fire managers with fire behavior models, fire effects information, a fire danger rating system, fire retardant information, smoke management protocols and numerous other advances. Technology Development Centers in California and Montana have provided essential support in terms of physical fitness standards, personal protective equipment and firefighting equipment specifications.

Wildfire database

The following wildfire data were summarized from the computerized records maintained by the National Interagency Fire Center located in Boise, Idaho.

Table 6-1Wildfire Database for the United States, 1990-1999.

Year	Total No. of Fires on Forest, Other Wooded Land, & Other Land Federal State & Private	Human Causes (Campfires, Smoking, Debris Burning, Arson, Equipment, Railroads, Children,Misc). No. of fires	Natural Causes No. of fires	Total Area Burned on Forest, Other Wooded Land & Other Land ha	Human Causes Area burned (Campfires, Smoking, Debris Burning, Arson, Equipment,Rail roads, Children, Misc). ha	Natural Causes Area Burned ha
1990	122,763	105,784	16,979	2,207,546	702,302	1,505,244
1991	116,941	104,777	12,164	905,240	709,107	196,133
1992	103,946	89,701	14,245	994,349	569,939	424,410
1993	97,030	87,725	9,305	934,621	472,024	462,597
1994	114,066	94,265	19,801	1,913,127	775,138	1,137,989
1995	130,019	120,045	9,974	937,525	588,586	348,939
1996	115,166	99,606	15,560	2,712,235	1,361,836	1,350,400
1997	89,517	79,484	10,033	1,482,155	398,501	1,083,654
1998	81,043			942,833		
1999	93,702			2,291,401		

Note: Total number of fires and total area burned by human or natural causes on Federal, State and Private land.

Use of prescribed fire to achieve resource management objectives

Prescribed fire, the intentional ignition of grass, shrub, or forest fuels for specific purposes according to predetermined conditions, is a recognized land management practice. Objectives of such burning vary: to reduce fire hazards after logging, expose mineral soil for seedbeds, regulate insects and diseases, perpetuate natural ecosystems and improve range forage and wildlife habitat.

How widespread is the use of prescribed fire, fires designed to produce beneficial results, in the United States today? A survey (Ward and others 1993) indicated that over five million acres are treated annually by prescribed fire in the United States. Over 70 percent of all prescribed burning, or about 3.5 million acres, was in the Southeast. Purposes for using prescribed fire included hazard reduction, silviculture, wildlife habitat improvement, range improvement, vegetation management, and other reasons. The survey lumped such prescribed burning reasons as watershed management, pest control, disease control, and research in the category called "other".

Resource management agencies and private timber companies cooperate with State Air Quality Bureaus to prescribe burn in a way that reduces adverse effects on human health and visibility. This survey demonstrates that prescribed burning practices are concentrated in the southeastern states. Also, although 5 million acres burned annually appears to be a large number, people are projecting a much greater need for prescribed fire in the future to maintain, or restore, the health of fire-adapted ecosystems.

For example, the new Federal Fire Policy (USDI/USDA 1995)states that: “Managing for landscape health requires expansion of cooperative interagency prescribed fire programs. Agencies must make a commitment with highly qualified people, from leader to practitioner, and provide funding mechanisms to conduct the programme.” Recent fire fatalities have focused attention on the need to reduce hazardous fuel concentrations. Many areas need immediate treatment of live and dead vegetation to prevent large, life-threatening, high intensity wildfires (Mutch 1994). Fuel treatment alternatives include mechanical, chemical, biological, and manual methods, in addition to the use of fire.

In some areas managed by the National Park Service, USDA Forest Service and Bureau of Land Management, naturally ignited fires may be allowed to burn according to approved prescriptions (Kilgore and Heinselman 1990). Fire management areas have been established in national parks and wildernesses from the Florida Everglades to the Sierra Nevada in California. Visitors are increasingly aware that wildland fires can provide an important environment for the enjoyment of park and wilderness experiences.

Fires are not simply allowed to burn. Their spread is monitored to ensure that they remain in designated areas. Suppression measures, backed by modern fire control technology, are employed to protect human life and property and to contain fires within the management unit.

Public policies affecting wildfires and fire management

Recent tragedies in the West focused attention on the need to reduce hazardous fuel accumulations. In the summer of 1994, 34 firefighters lost their lives. The events of that season created a renewed awareness and concern among federal land management agencies and their constituents about wildfire impacts. Federal agencies conducted a combined review

of their fire policies and programmes. The result was the enactment of a new interagency federal wildland fire management policy, which provided a common approach to wildland fire among all five federal land management agencies (USDI/USDA 1995). The new policy also called for close cooperation with tribal, state and other jurisdictions. Nine major issues were addressed in the new fire policy:

1. The challenge of managing wildland fire is increasing in complexity and magnitude. Public and private values are seriously at risk and severe ecological deterioration is possible from catastrophic wildfire. The new Federal wildland fire policies are critical and help to strengthen cooperative relationships:

2. Firefighter and public safety remains the first priority in wildland fire management. Protection of natural and cultural resources and property are the second priority.

3. Wildland fire, as a critical natural process, must be reintroduced into the ecosystem, accomplished across agency boundaries and based on the best available science.

4. Where wildland fire cannot be safely reintroduced because of hazardous fuel accumulations, pretreatment must be considered, particularly in the wildland/urban interface.

5. Wildland fire management decisions and resource management decisions are connected and based on approved plans. Agencies must have the ability to choose from the full spectrum of actions--from prompt suppression to allowing fire to have an ecological function.

6. All aspects of wildland fire management will involve all partners and have compatible programmes, activities and processes.

7. The role of federal agencies in the wildland/urban interface includes firefighting, hazard fuel reduction, cooperative prevention and education and technical assistance. Ultimately, the primary responsibility, rests at the State and local levels.

8. Structural fire protection in the wildland/urban interface is the responsibility of tribal, state and local governments.

9. Federal agencies must better educate internal and external audiences about how and why we use and manage wildland fire.

Sustainable land use practices used to reduce wildfire hazards and wildfire risks

Numerous ecosystem indicators from the Southeast to the West are highlighting alarming examples of declining forest health. Attempted fire exclusion practices, prolonged drought and epidemic levels of insects and diseases have coincided to increase wildland fuels, produce extensive forest mortality and cause major changes in forest density and species composition.

Quigley and Cole (1997) reported that fire severityand frequency in the Columbia River Basin have changed across the landscape. Before the settlement of America by Europeans, most fires in the Basin at low to mid elevations were low intensity fires. Forest and

rangelands benefited from these frequent surface fires, which thinned vegetation and favored growth of fire-tolerant trees. In recent times, the area in the Columbia Basin with high intensity, stand repalcement fire regimes has more than doubled. This poses a significant threat to ecological integrity, water quality, species recovery and homes in wildland areas.

Gray (1992) called attention to a forest health emergency in parts of the western United States where trees have been killed across a large area in eastern Oregon and Washington. He indicated that similar problems extend over a much larger area south into Utah, Nevada and California and east into Idaho. Denser stands and unnatural fuel accumulations are also causing high intensity crown fires in Montana, Colorado, Arizona, New Mexico and Nebraska. Historically fires in these long-needled pine forests were more frequent low intensity surface fires.

Since the 1980s, large wildfires in dead and dying western forests have accelerated the rate of forest mortality, threatening people, property and natural resources (Mutch 1994).

The solution to this problem lies in managing these fire-dependent forests in a more sustainable manner, recognizing that fire is an important ecosystem process vital to forest health (Mutch 1993). The management strategy begins with thinning and harvesting the dense understorey of fir; and retaining old growth ponderosa pine, larch and Douglas-fir in the overstory as a seed source. Where large quantities of standing dead trees are present, salvage logging is encouraged to remove large accumulations of fuel. Prescribed fire is carried out on a large scale to reduce the fuel hazard, re-cycle nutrients and stimulate the regeneration and growth of fire-adapted vegetation. This strategy reduces the density of fir in the stands and abates the future insect infestations and large-scale wildfires. Over the long term, silvicultural partial-cutting and underburning favour retention of more open stands that have a lesser fire hazard.

The U.S. Government Accounting Office (1999) recommended that the Secretary of Agriculture direct the Chief of theForest Service to develop, and formally communicate to Congress, a cohesive strategy for reducing and maintaining accumulated fuels on national forests at acceptable levels.

Community involvement in fire management activities

The problems of living in a fire environment are no longer unique to southern California, as was thought when these wildland/urban interface fires gained national attention in the 1950s and 1960s. In recent years wildland/urban fire disasters have occurred from coast to coast. As more people move out of cities and into wildlands, these tragedies will recur. Following the recent disastrous fires in several states, recommendations for mitigating the impact of fires in the wildland/urban interface have been developed. The combined efforts of fire protection services, legislators, planners, developers and homeowners will be required to prevent the tragic loss of lives and homes in the wildlands. In other words, community involvement by residents in conducting fire safe measures around their homes is absolutely essential in community protection.

The homeowner has the ultimate responsibility to take the necessary measures to ensure that a home can survive a wildfire. If the proper precautions are taken, a house can survive a wildfire even when the fire services are not able to respond. However, to this day a large number of homeowners throughout the country have not responded in fireproofing property well in advance of the inevitable fires.

Recommendations to reduce the loss of life and property in the wildland/urban interface will be useless unless all stakeholders implement them at the grassroots level. An excellent example of a community-based programme is one implemented at Incline Village and Crystal Bay in the Lake Tahoe basin. The objective of this programme was to reduce the potential for natural resource, property and human life losses due to wildfire by empowering the residents with the knowledge to address the hazard. The three major components of this defensible-space programme included neighborhood leaders, creation of survivable space and agency coordination. The key to protecting life and property in the wildland/urban interface is the property owners' realization that they have a serious problem and that their actions embody a significant part of the solution. In the Incline Village/Crystal Bay Plan, neighborhood leaders are trained in survivable-space techniques. They are expected to teach these techniques to their neighbors and to coordinate neighborhood efforts. Such concerted community action will minimize the threats from fires in the interface.

It is also wise to have sensible land development practices, since tragedies arise not only from ignorance of fuels and fire behavior, but also from a greater concern for the esthetics of a homesite than for fire safety. Several aspects of development detract from fire safety in the wildland/urban interface:

1. Lack of access to adequate water sources.
2. Firewood stacked next to houses.
3. Slash (that is, branches, stumps, logs and other vegetative residues) piled on homesites or along access roads.
4. Structures built on slopes with unenclosed stilt foundations.
5. Trees and shrubs growing next to structures, under eaves and among stilt foundations.
6. Roads that are steep, narrow, winding, unmapped, unsigned, unnamed and bordered by slash or dense vegetation that make them impossible to drive on during a fire.
7. Subdivisions on sites without two or more access roads for simultaneous ingress and egress.
8. Roads and bridges without the grade, design and width to permit simultaneous evacuation by residents and access by firefighters, emergency medical personnel and equipment.
9. Excessive slopes, heavy fuels, structures built in box canyons and other hazardous situations.
10. Living fuels that have not been modified by thinning, landscaping, or other methods to reduce vegetation and litter that contribute to fire intensity.
11. Homes constructed with flammable building materials (wooden shakes, shingles).

Conclusions

Resource management agencies, regulatory agencies and society have failed to implement programmes in the past to sustain the health of fire-adapted ecosystems to benefit people, property and natural resources. Today, however, many decades of research results have provided the basis for managing ecosystems more in harmony with disturbance factors to foster the health, resilienceand productivity of wildland ecosystems. The principles of ecosystem management can guide society and managers in developing strategies to achieve a range of desired future conditions that will sustain or restore ecosystem health. It has taken 6 or 7 decades to produce today's decline in many forested ecosystems in the United States. It will take an equally long time to reverse this trend. Fortunately many resource management agencies are commencing ecosystem restoration programmes at this time.

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6.1.4 Fire Management in Mexico

By
Oscar Cedeño
SEMARNAP, Mexico City, Mexico

Fire environment, fire regimes and ecological role of fire

Mexico has a total area of 1,967,183 km2 and a forest area of 141.7 million hectares, of which 56.8 million hectares are temperate forests and tropical forests and 58.4 million hectares are zones with arid and semiarid vegetation.

The forest fire season normally occurs between January and July. March and April are the major fire months because they coincide with the dry season. Human activities cause 97 percent of the wildfires, with agricultural and cattle activities causing 54 percent of the fires. In tropical zones, the main cause of fires is the practice of slash and burn agricultural practices. Burns to improve grass conditions for cattle are the main cause in temperate forests. Ninety-five percent of the fires burn on the surface, affecting mainly herbs, shrubs, and grasses.

The average number of wildfires for the 1990-1999 period was 7,767. These fires affected a total surface area of 251,697 hectares (a national average of 32 hectares per fire).

Fire regimes can be described in terms of how severe they burn and how much they change the vegetation that burned. Fire regimes can be classified in the following terms:

1. **Understorey fire** (applies to forests and woodlands)--fires are generally non-lethal to the dominant vegetation and do not substantially change the structure of the dominant vegetation. Examples include: pine communities and pine-oak communities.

2. **Stand replacement fire** (applies to forests, woodlands, shrublands, and grasslands)--fires kill aboveground parts of the dominant vegetation, changing the aboveground structure substantially. Approximately 80 percent or more of the aboveground dominant vegetation is either consumed or dies as a result of fires.

3. **Mixed severity fire** (applies to forests and woodlands)--severity of fire either causes selective mortality in dominant vegetation, depending on different tree species' susceptibility to fire, or varies between understorey and stand replacement.

4. **Non-fire regime**--little or no occurrence of natural fire. Examples include montane rainforest and tropical rainforest.

A forest fire is considered to be any fire which affects forest vegetation by natural or human causes, and occurs and spreads in an uncontrolled manner.

Narrative summary of major wildfire impacts on people, property, and natural resources that occurred historically.

- The average number of fatalities due to wildfires is 2 persons per year.
- Forest fires mainly cause mortality to natural regeneration in temperate forest zones, causing economic loss from the affected trees.
- In tropical areas wildfires enhance the growth and spread of a fern (*Pteridium sp.*) that contributes to rapidly spreading and difficult to control wildfires (Figure 6-6). In tropical forests wildfires affect biodiversity, wildlife, and the ecology in general. However, people also deforest tropical areas as they look for agricultural alternatives.

Figure 6-6 A forest fire in Lagunas de Montebello National Park in 1998 resulted in the widespread establishment of bracken fern.

Narrative summary of major wildfire impacts on people, property and natural resources during 1990s.

- During the 1990s, Mexico had a drought of seven consecutive years (1994-2000). In 1998, "El Niño" caused one of the most severe droughts, creating the most difficult wildfire season in Mexico's history. Mexico had 14,445 wildfires affecting 849,632 hectares--the largest area ever burned in Mexico in a single season.

- Because of the large fires that occurred in 1998, 72 people died during fire control activities.

- In order to control the widespread wildfires it was necessary to gain support from the military, (SEDENA), State Governments, many federal agencies, and volunteers. Mexico also received valuable support from the United States Government in terms of equipment, technical support, and financial resources.

- In 1998,18 helicopters of different types and an airtanker were used; and 17,000 firefighters were transported. The helicopters dropped 15.1 million liters of water and foam on the fires.

- Due to the large area burned by wildfires in 1998, actions were taken for reforestation, soil and water conservation, and natural regeneration. Eighty-five areas were selected in 21 States to restore 188,288 hectares through reforestation.

Fire management organization used in Mexico

Fire prevention and control are a Federal responsibility and take place through the Secretary of Environment, Natural Resources, and Fisheries (SEMARNAP). SEMARNAP has 32 state delegations distributed throughout the country with personnel, crews, equipment, and infrastructures.

SEMARNAP has about 2000 firefighters, more than 200 vehicles, about 800 radios, and the tools and equipment necessary for fire control. Thirteen Type II helicopters are rented each year on the average. To control forest fires SEMARNAP receives the support from the military, other federal agencies, state governments, and volunteers.

National programmes of wildfire prevention, detection, and control are prepared each year. These programmes establish different actions, with emphasis on risk areas and critical zones.

Fire prevention programmes are designed to inform people about being careful with fire. Television, radio, posters, booklets, flyers, and press conferences are used to communicate fire prevention messages to the public.

Firebreaks and prescribed burns are used to help limit the spread of fire and reduce the fuel hazard.

Watch towers, ground detection, commercial aircraft reports about forest fires, aerial detection, and satellite detection are all valuable resources used in the detection of fires.

Canada provides support with maps about fire danger indexes based on the assessment of vegetation, temperature, humidity, etc. The danger rating system permits the prediction of fire risk and fire behavior.

Wildfire Database

Table 6-2 Number of fires and area burned, 1990-1999.

Year	Total No. of Fires on Forest, Other wooded land, and other land No.	Total Area Burned on Forest, Other wooded land, and other land ha	Area of Forest Burned ha	Area of Other wooded land burned ha	Human causes %	Natural causes %	Unknown causes %
1990	3443	80400	23316	57084			
1991	8621	269266	113092	156174			
1992	2829	44401	12432	31969	93	5	2
1993	10251	235020	54055	180965	93	5	2
1994	7830	141502	32545	108957	89	4	7
1995	7860	309087	114362	194725	95	3	2
1996	9256	248765	57216	191594	95	3	2
1997	5163	107845	23726	84119	94	3	3
1998	14445	849632	195415	654217	97	2	1
1999	7979	231061	41591	189470	96	2	2
AVERAGE	7767	251697	66775	184927	94	3	3

The database is managed by computer and paper records.
Average annual fire size: 32 ha per fire.

Use of prescribed fire to achieve resource management objectives.
The use of prescribed burns and control lines (firebreaks) were intensified in the 1990s, mainly through training courses, to reduce the presence of risky fires. More than 59,000 hectares of prescribed burns and 10,500 kilometers of control lines were completed annually on the average. These practices have been carried out in forests where people burn grasses for cattle and in places where there are large accumulations of fuels

Public policies affecting wildfire impacts.
Because the major wildfire causes are agricultural and cattle activities, SEMARNAP and SAGAR (Secretary of Agriculture, Cattle, and Rural Development) published a "Fire Standard", which recognizes that people are using fire in agricultural and cattle practices; and provides norms for its proper use (Figure 6-7). One of the most important issues in this standard states that farmers must build control lines when they use fire for their activities.

Figure 6-7 In 1998, many agricultural fires were free-burning, often escaping into adjacent forests.

Another important policy is the promotion of programmes of economic incentives and agricultural alternatives to motivate people to avoid the use of fire as a tool. These actions are accomplished with the execution of the programme named “Productive re-conversion”.

Also, television and radio spots are used to induce people to avoid the use of fire and to report detected wildfires to the toll free telephone lines.

Sustainable land use practices used in Mexico to reduce wildfire hazards and wildfire risks. Commercial exploitation of natural forests in Mexico is carried out with a “Management Programme”. This programme contains the necessary information and issues to practice sustainable forest management. Usually these forests have a low occurrence of forest fires because the owners get economic income from forests.

In forests with cattle activities the *“veza de invierno”* programme is implemented. *Vicia villosa* is a leguminous plant used to feed the cattle and reduces the need to use fire within these zones.

In tropical forests, different alternatives with economic support from government take place (the “Agricultural Sedentarisation” and “Enhancing plantations on second growth tropical forests” are two examples).

In another tropical zone, different practices are used like perennial cultivation and agro-forestry systems to keep land in constant production and diminish the need to practice slash and burn agriculture.

In 1999 the Federal Government executed the programme named “Temporary Employment Programme”. This programme basically consists in making new job opportunities by building control lines in low-income non-productive forest zones. This programme has diminished the presence of wildfires in the zones where it has been implemented.

Community involvement in fire management activities.
Since the extraordinary presence of fires in 1998, people have been made aware of the risks that wildfires represent and the damage they do to wildlife, vegetation, and the environment (Figure 6-8).

Figure 6-8 SEMARNAP officers conducting a public fire prevention meeting with people from Zinacantan (Los Altos de Chiapas) in 1998.

Note the hazy atmosphere from nearby fires.

Today nine different federal agencies, state governments, and municipalities work together with SEMARNAP on wildfire prevention and control.

Common people and land proprietors have an important role to play in the protection of Mexico's forests from wildfire. The media also has an important educational role to play in transferring information to various audiences.

During the fire season, a widespread awareness programme is implemented using television, radio, and printed material. People report detected wildfires to the Wildfire Prevention and Control National Center.

6.1.4.1 Forest Fire Situation in the State of Chiapas, Mexico[5]

By
Rosa Maria Román Cuesta
Barcelona, Spain

Fire Environment, fire regimes, and ecological role of fire in Chiapas

Chiapas is a southeastern Mexican state with a land area of 75.634 Km^2 (4 percent of the national territory, 8^{th} biggest state in Mexico (INEGI, 1997)) (Figure 6-9). Sixty-eight percent of the State is forested. Sixty-four percent of the forested area is covered by woods (22 percent) or jungle (42 percent) (SARH 1994). Chiapas is divided into 111 adminitrative units. During the period 1993-1999, 75 (68 percent) of them suffered from at least one forest fire (> 0.5 ha), and 20 of them (18 percent) suffered from "large forest fires" ≥ 500 ha.

About 4.1 million hectares of forested land are subjected to forest fires (83 percent)[6].

A "forest fire" is defined by State law for fire prevention, fighting and control, in the State of Chiapas (POE, 1999), as: "*A harmful event caused intentionally or fortuitously by fire, which occurs in areas covered by vegetation, trees, grasslands, scrubs, brushwoods and, in general, in every different plant association*".

Forest fire regimes common to Chiapas can be summarized as follow:

- **Understorey fire** (applies to forests and woodlands)--fires are generally non-lethal to the dominant vegetation and do not substantially change the structure of the dominant vegetation. This situation would be the case for pine communities (and its mixed communities: pine-oak; pine-oak-liquidambar) and oak communities. Fire does not always benefit genus Pinus, especially its most mesophyll species (in Chiapas' case: *Pinus ayacahuite* and *P. pseudostrobus*). Fire can be harmful for the establisment and the permanence of many pinewoods that, even if they are not destroyed, are prone to have regeneration difficulties (Miranda 1952; Rzedowski and McVaugh 1966, *in Rzedowski, 1978*). Oaks are not pyric communities, especially in Chiapas, where they usually inhabit very humid places. This fire regime does not kill them, but it affects the quality of its habitat. Although it is not as frequent, when drought is a factor, there can be understorey fires in wetter communities such as tropical deciduous forests, evergreen seasonal forests, montane rain forest, lower montane rain forests, evergreen cloud forests, or even tropical rain forests (*as in Breedlove, 1981)*

[5] This study was part of the SUCRE project, sponsored by the European Union, Com. XII

[6] We have to remark that this value corresponds to the total forested area of the administrative units that had fires, but overweighted, as fires are recurrent in many places.
Fire results are based on SEMARNAP's fire field registers.
Another consideration refers to the fact that, during these years (1993-1999), there has been an unusual succession of ENSO's: 1991-1992; 1993; 1994; 1997-1998 (NOAA website 2000). The last one (1997-1998) had a global repercussion and also affected Chiapas' fire dynamic, by leading to the occurrence of fires in jungle communities, so area available to fire is overwighted compared to "normal conditions".

- **Stand replacement fire** (applies to forests, woodlands, shrublands, and grasslands)--fires kill aboveground parts of the dominant vegetation, changing the aboveground structure substantially. Approximately 80 percent or more of the aboveground dominant vegetation is either consumed or dies as a result of fires: This fire regime is not frequent in tree communities in the State, but when it occurs it usually has catastrophic connotations. Stand replacement fires are associated with severe drought conditions (which might be caused by global climatic phenomena like El Niño). Under these conditions, not only flammable forest types can burn (pines or its mixed communities), but even potentially non-flammable types like *Abies* communities, tropical rain forests, and evergreen cloud forests. This was the case with the 1998 forest fires. Stand replacement fires in tropical communities represent future fire-hazard (if there is no land use change) during the following decades, as unburned fuels remain there and dry out. Secondary succession can be initiated by opportunistic very flammable species, like ferns, that greatly increase fire-hazard.

Figure 6-9 Geographic location and administrative division of Chiapas.

Mixed severity fire (applies to forests and woodlands)--severity of fire either causes selective mortality in dominant vegetation, depending on different tree species' susceptibility to fire, or varies between understorey and stand replacement. This regime can be typical for pine communities and their mixed variations (pine-oak; pine-oak-liquidambar). The result is a patchwork effect that rapidly turns green, but the habitat's quality is diminished. Moreover, those opened gaps are frequently occupied by very flammable, opportunistic species like ferns, so fire-hazard is increased during the decades after fire.

Non-fire regime--little or no occurrence of natural fire: High humidity levels are responsible for this non-fire regime, under normal climatic conditions. In Chiapas this generally would be the case for Abies communities, rain forests, and evergreen cloud forests.

Forest fires regimes in Chiapas have an important human component that can be summarized as the combination of different causes (Vélez, 1990):

<u>Structural causes</u> (permanent social and ecological conditions that cause the fire problem):

- *Climatic and topographic characteristics*: Chiapas, as other tropical states in Mexico, has a natural seasonal variation in rainfall, which is divided into a rainy season (May to October) and a dry season (November till April). Dry seasons also are characterized by the highest temperatures. Forest fires in Chiapas follow, more or less, this rainy scheme and they are concentrated in a part of the dry period (from January to May, or June, when there are special conditions of drought, affected by global climatic phenomena like ENSO). So it seems there's a tendency to extend the fire season to the first months of the rainy season, either because rain comes later, or because accumulated drought stress requires some time to recover. There are no recorded forest fires outside of these months. This implies a concentration of resources (human and material) in a specific part of the year. On the other hand, the complex topography of the state makes it difficult to attack fire, and steep topography makes fires spread faster (Deeming et al 1977; Rothermel 1984).

- *Fire is habitually used as a traditional tool*. Fire and agricultural/farming activities have always been very common in this region.[7]

- *A socio-economic framework that does not help conservation measures.* Sixty percent of the population are rural inhabitants (INEGI 1997). There is high demographic pressure and the cattle sector is evolving.

- *Existence of natural resources potentially transformable into agricultural fields*. This creates a migration of farmers from high demographic pressure regions to lower

[7] The relationship between fire and "slash and burn" activities is often confused in Chiapas. Slash and burn activities are agricultural systems which respect the natural cycles of vegetation in order to maintain productivity and land regeneration. The problem is that these systems require low demographic pressure (< 25 inhab/Km2), as well as extensive forest resources that can be left in fallow long enough to recover (Sanders & Price, 1968; Wolf, 1983; *in Alemán.T, 1997)*. If not enough time is allowed for fallow in the agricultural fields, then slash and burn activities are being deprived of an important feature. There are very few places in the world, as well as in Mexico, were there are still the natural and socio-economic conditions that allow the preservation of slash and burn techniques. Instead we have what is known as "milpa que camina", which is an irreversible, unidirectional, and rapid system for transforming woods into agricultural lands, with the exploitation of a few agricultural species (Alemán, 1997).

demographic pressure regions; as well as migration from neighboring states with a lower amount of potential lands for agricultural.

- *Inefficient fire and land use change legal measures.* (See section on Public Policies Affecting Wildfire Impacts).

Immediate causes: they refer to human activities that provoke forest fires, in a direct or indirect way.

- 52 percent of the fires are due to negligence (agriculture or farming activities), while 29 percent are related to arson. Over 17 percent of the fires are from unknown causes.

In terms of affected area:

- Pine-oak communities represent 74 percent of the fires, and 61 percent of the total area burned in the state. Fifty-four percent of the total area affecting pine-oak communities was due to surface fires, 7percent was affected by crown fires, and the rest were ground fires. Most common pines in the State are (Miranda, 1975*): Pinus oocarpa, P. pseudostrobus, P.montezumae, P. teocote, and P.tenuifolia* (these live between 750-3000 meters and are the ones to suffer more frequent fires). *P.hartwegii and P. rudis* occur between 2800-4000 meters and don't frequently suffer from fires due to the cold, wet conditions.

- Tropical rain forest and montane rain forest represented 7 percent of the fires, and 18 percent of the total burned area in the State. Fifty-five percent of its total burned area was due to fires that affected crowns. Twenty-seven percent of its total burned area was due to ground fires and 16 percent was related to surface fires.

- Evergreen cloud forests represented 0.3 percent of the fires; and less than 1 percent of the total burned area in the State. Ninety-nine percent of the total area burned in the cloud forest was due to surface fires.

In general terms, forest fires in Chiapas are mainly surface fires (80 percent of the fires and 51 percent of the total burned area) (Román et al 2000)). High intensity crown fires that severely affect the forests occur mainly in years of extreme drought, like 1997-1998, or 1986-1987.

Narrative summary of major wildfire impacts on people, property, and natural resources during the 1990s

Forest fires in Chiapas do represent a problem in the State (Valera, 1994). In 1987, Chiapas was considered, together with Madagascar, one of the hottest points in the world (State Government, 1992, in *Villafuerte et al, 1997).* If we use standarized indexes that represent fire frequency and area affected by fires in Chiapas[8], compared with those indexes for the whole Republic, we'll see that fire frequency in Chiapas used to have much higher levels during the 1980s. But during this last decade it has decreased until it is lower than the national level. However, the area index has always been much higher in Chiapas than in the

[8] Fire frequency index= Number of fires/ [Forested area (ha)/10.000]
Fire area index=[Total area affected by fires (ha)/ Forested area (ha)]*100

rest of Mexico. It was 20 times higher in 1986 and 8 times higher in 1998. Mean burned area in Chiapas is more than 10 times the national level.

During 1993-1999, there were 1362 forest fires in Chiapas, affecting an area of 327,534 ha (SEMARNAP 1999)[9]. This represents 6 percent of Chiapas' forested land. Twenty-six percent of that area included trees with different severities of burning. Forty-six percent of the area affected herbaceous layers. The mean area of each fire during these 7 years was 210 ha.

The importance of forest fires in this southern State refers to the value of its vegetation. Mexico ranks third in the world in terms of megadiversity (Mittermeier 1988; Toledo and Eccardi 1989; Mittermeier and Mittermeier 1992, i*n Challenger, 1998*) [10]. Among the States, Chiapas has, together with Oaxaca, the most diverse flora of the Republic (Miranda 1975). It presents 8,248 flora species, 80 percent of the tropical tree species, 33 percent of the reptiles (with important endemisms), 33 percent of the amphibians, and 80 percent of the known butterflies in the Mexican tropical rain forests (State Government 1992).

Although forest fires mostly affect non-arboreal layers (74 percent of the total burned area during 1993-1999), 79,011 ha of arboreal communities were affected by several classes of intensity. Fifty-eight percent of the total arboreal layer affected by fires during these 7 years was due to 1998's forest fires (Román et al 2000):

- Surface fires were responsible for 50 percent of the arboreal layer affected. This type of fire (that reaches the lower part of the crown at some points) doesn't necessarily kill the tree. But the trees can be weakened and become more vulnerable to pests. For example, *Dendroctonus frontalis* pests, in the National Park of Las Lagunas de Montebello, were enhanced by forest fires that happened there in 1997 and 1998. On the other hand, surface fires can severely affect trees that have not evolved in a fire environment (evergreen cloud forests, or tropical rain forests in their several categories).

- The other 50 percent of the fires affecting the arboreal layer were crown fires, which were especially important in the years 1997 and 1998. In 1998, the drought conditions were severe due to El Niño. During this period, crown fires affected pine-oak communities, as well as potentially non-flammable communities like tropical rain forest, montane or lower montane rain forest, and evergreen cloud forests (*as in Breedlove, 1981*). Taking into account the State area occupied by these communities, pine-oak burned the most (3 percent of the State pine-oak communities, or 176,548 ha); tropical rain forest and montane/lower montane rain forest occupied the second position (1.5 percent of the State area, or 53,005 ha); and the evergreen cloud forests represented the smallest area affected (0.05 percent of the State area affected, or 2384 ha). Of special interest are two tropical rain forest areas that burned in the 1998 fires: Los Chimalapas and The Biosphere Reserve of El Ocote (corridor of Chimalapas, Ishiki, pers.communication, 1999).

Chimalapas fires case example (García M.A., 1999): La Selva de los Chimalapas is 600,000 hectares located in the Tehuantepec isthmus. Part of its area is placed in Oaxaca and part in Chiapas. Its northern edge is bounded by Uxpanapa and Veracruz and its western boundary

[9] SEMARNAP official data of fires during 1993-1999 were a bit higher than the data obtained with the fire field registers. (Published data were: 1362 forest fires and 327,534 affected hectares versus 1438 forest fires and 301,759 affected hectares reported in the fire field registers).

[10] There are 7 Megadiverse countries in the world and they support (altogether) between 50 and 80 percent of the world's species diversity (Mittermeier 1988; The Economist 1988; *en Challenger, 1998*).

contacts the transisthmic road (carretera transístmica). In 1996, almost 80 percent of its area was in excellent conservation condition, consisting of 9 natural ecosystems (*as in Breedlove, 1981*) (tropical rain forests, montane rain forests, evergreen seasonal forests, evergreen cloud forests, temperate forests (pine-oak), and even *Abies* formations (oyameles). This biological diversity has given Chimalapas an exceptional ecological value. Moreover, this tropical formation, together with la Selva Lacandona and La Selva del Ocote, represent the northern location of this type of tropical community, which makes them even more valuable. These areas are found in the confluence of different biogeographical regions, which increases the number of endemisms.

Chimalapas, as is true of the rest of the tropical rain forests in Chiapas, suffers from several pressures: 1) agrarian conflicts and cattle invasion, 2) increase of the cattle area, 3) State legal border conflicts, 4) increase of narco-traffic settlements, and 5) new population settlements (high immigration rates and demographic pressure concentrated at some points). These pressures at areas of higher fire risk (associated with the higher flammability of temperate forest fuels) are the reason for several smaller forest fires at the eastern side.

Fires in Chimalapas started between the 4th and 6th of May in 1998 and burned for 45 days. These fires were characterized by surface, crown, and ground types of fires (SEMARNAP 1999). During the first 3 days there were 17 fire fronts in a horizontal line of 100 km, almost at the same latitude, affecting the heart of the tropical rain forest and the evergreen cloud forests. This is a very inaccesible location, where there are no villages, nor agrarian or cattle activities. The extreme drought associated with the El Niño event of 1997-1998 helped establish the conditions for these fires to spread. On the 7th of June when rain started, there had been 68 forest fires in the area; 17 of them in the heart of the jungle. Only 9 of the fires could be fought. The rest were inaccesible due to topographic reasons and were obscured by smoke. Four hundred farmers helped fight the fires initially, and the number grew to 1000 civil persons later. National and international help also assisted with the firefighting. Finally, the burned area was considered to be more than 100,000 ha, although SEMARNAP reports refer to 25,000 ha.

The SEMARNAP fire field register indicates that the fires burned 15,600 ha in the arboreal layers, 1400 ha in the shrub layers, and 5000 ha in the herbaceous communities (Román et al 2000). After the fires, land use changes and new population settlements of "unlanded people" have put obstacles in the way of restoration processes (Ishiki, pers. Communication, 1999).

The fires of 1998 created a high "environmental"concern for the Chiapas population and its authorities due to several reasons:

- Smoke produced by the fires covered the sky for almost one month (spreading to several areas of southern USA). Visibility was reduced, the environment was very warm, and combustion particles were responsible for severe breathing diseases in the whole State.
- Several airports had to close their facilities as visibility didn't allow the landing of planes.
- Newspapers and radios were constantly communicating the occurrence of new fires in the State. So the chaotic use of fire and its consequences were more apparent during that year.
- Potentially non-flammable communities were affected by fire, so the conviction of "ecological disaster" was a constant.
- Severe drought occurred during the end of 1997 and the first 6 months of 1998, not only in forested areas, but also in agriculture lands. Farmers were concerned about lowered production.

- Chiapas is a State with important tourism due to its Mayan archeological sites and its natural resources. Fires that affect national parks and other tourism attractions can produce negative consequences on that sector's income.

The cause of fires is mainly associated (according to SEMARNAP's fire field registers) with negligence arising from agrarian and farming activities. These two activites are responsible for 46 percent[11] of the fires and 66.2 percent of the total area affected by fires (Román et al 2000). However, it is difficult to determine where negligence ends and intentional fires start. In Central America, burns are sometimes done with deliberate negligence, letting fires affect much higher areas than the areas that will be cultivated. The objective is to weaken woods in order to obtain forestry cut authorizations or land use changes. This is due to the fact that legislation allows cuts to improve forest health, but restricts commercial cuts, for which several studies have to be presented, as well as paying a fee (Vélez, 1986).

Public policies affecting wildfire impacts

There are several laws related to the problem of forest fires in the State. We can divide them into federal and State legislation:

- Federal:
  - Forestry and hunting legislation. December of 1992, reformed in May of 1997.
  - General law of ecological equilibrium and environmental conservation. January of 1988, reformed in December of 1996.
  - Penal code

- State (there are 9 documents. Some of the most important are):
  - Law for the prevention, fighting, and control of forest fires in the State of Chiapas. February of 1999.
  - State law of ecological equilibrium and environmental protection. July of 1991. Reformed by the decree law number 26, in February of 1992.
  - Decree law number 35: Declaration of municipalities in Chiapas with high fire risk. July of 1990.
  - Cattle law for the state of Chiapas.

Main points of these laws can be summarized as follow:

Until 1999

- State legislation did **not** forbid burning for traditional agriculture and/or cattle activities (decree law number 26)
- State laws **did** regulate the use of fire, forcing the establishment of several precautionary measures, in order to prevent forest fires when fire was used for traditional activities:

  Decree law number 35:
  - Creation of security corridors around the area meant to burn: minimum sizes, periods of the year when these corridors must be done, etc.

[11] Negligent acts are responsible of 52 percent of the fires. Negligent acts include several causes. The main ones are agriculture and farming activities, which represent 46 percent of the total fires. The other 6 percent is due to forestry activities, mountaineering, campsites, etc

    - Correct location of fuels meant to be burned, as well as several measures referred to fire behaviour in the presence of steep slopes and wind.
    - Obligation of notifying the intention to burn to the local authorities and neighbors.
    - Number of persons that must take care of the burning process, as well as the prohibition of starting fires in neighboring field plots at the same time.

- Federal legislation **did** consider and restrict land use changes, without prohibiting them in those areas that fitted the requirements established by the law. (Forestry and hunting law).

- Federal legislation **did** force civil participation in fighting and extinguishing fires, with administrative and/or penal sanctions:

    <u>Forestry and hunting law (administrative sanctions)</u>:
    - To whom, having the obligation, doesn't prevent nor fight forest fires.
    - To whom, by negligence, provokes forest fires.
    - To those owners of burned areas who don't notify to the authorities the presence of fire.
    - To whom, without authorization, changes land uses in forested land.
    - To whom intentionally provokes forest fires (administrative or penal sanction).

After 1999

Severity of forest fires in 1998 lead to the publication of the State law for the prevention, fighting, and control of forest fires in Chiapas, which:

- Forbids "slash and burn" activities in those municipalities considered at high risk in the decree law 35 (46 percent of the municipalities in Chiapas), but it does **not** forbid the use of fire in any areas if it is for agriculture and/or cattle activities. (There are contradictions in those measures).

- Includes new type of sanctions, in addition to administrative and penal sanctions:
    - Authorities can decide to eliminate state "field support", as federal support to any producer that does not take into account the legislation referred to forest fire prevention, fighting, and control.

- Includes several incentives (preference support, prizes, and federal financing) to those who demonstrate several measures of environmental protection, among them:
    - Having avoided fire, traditional practices of "slash and burn", or any other environmental impact.
    - Having reduced environmental impacts (deforestation, rational water use...).
    - Having promoted the culture of "no burning".
    - Having introduced sustainable measures in their agriculture and/or cattle activities.

- Creates actions destined to enhance the culture of "no burning" (educational measures).
- Increases the services related to fire prevention and fire warning.

There are several laws in Chiapas related to the problem of forest fires, but there are few measures to control their applicability. Moreover, measures proposed in some of this legislation depend on federal financing and there is the possibility this might not occur. On

the other hand, fire has always been a traditional tool in Mayan culture and it fits into their natural and social conditions. Fire is not, "per se", the problem, but it is the negligent use of fire together with a socio-economic framework that enhances environmental impacts. It's impossible to control the use of fire in a State where approximately 60 percent of the inhabitants are rural population (INEGI, 1997). This is especially true if alternatives are not proposed or are not useful. In this sense, fire legislation is quite removed from social reality in the State of Chiapas.

Together with the legislation, there are other activities in the state established to create some environmental concern about forest fires:

- SEMARNAP's informational activitites like speeches and courses.
- Advertising related to prevention of forest fires (wall paintings, radio messages, institutional calls, etc.).

Referring to civil participation in the State, there is a very satisfactory response to firefighting and detection activities. During 1993-1999 civil participation provided, on the average, 65 percent of the total number of firefighters. In several years (1993, 1994), civil firefighters comprised three times the number of official staff (Román et al, 2000). So, although negligence by the civil sector is mainly responsible for starting forest fires in Chiapas, it's also the civil sector that mainly fights the fires.

Wildfire Database

Table 6-3. Number of fires and area burned in Chiapa, between 1990-1999.

Year	Total number of fires on Forest, other wooded land and other land	Total area burned on forest, other wooded land and other land (ha)	Area of forest burned (ha)	Area of other wooded land burned (ha)	Human causes (%)	Natural causes (%)	Unknown causes (%)
1990	161	5559	4148	1411			
1991	234	16429	12181	4248			
1992	121	4912	4234	678			
1993	105	6545	4165	2380	89.4	0.8	6.5
1994	121	7154	4301	2853	86.0	0.0	10.7
1995	150	13185	8006	5179	88.7	0.0	10.7
1996	197	11078	5740	5338	81.2	0.0	18.8
1997	181	24263	11195	13068	80.1	0.0	22.7
1998**	405	113473	45771	67702	90.4	0.0	24.7
1999	203	1784	274	1510	76.4	1.5	17.7
Average	**188**	**20438**	**10002**	**10437**	**85.0**	**0.3**	**18.2**

** This year includes 22,000 ha of Los Chimalapas forest fire, that should be divided into two parts, as this fire was located between Oaxaca and Chiapas.

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6.2 Central America Sub-Region

6.2.1 Introduction

There are many approaches to fire management in Central America. Costa Rica has a well-developed programme that is based on community involvement. Nicaragua is working to redefine their program. In Guatemala, there is recognition that an effective programme is essential and they initiated training and programme development before the onset of the fires of 1998.

Most of the countries in Central America were affected to some degree by the effects of the drought in 1998 caused by the El Niño event. Escaped agricultural burns were a common problem throughout Central America.

The following wildfire data are for the serious 1998 season for all the Central-American countries. [12]

Table 6-4 Wildfire data for 1998 season.

Country	Total number	Forests ha	Agro-pastoral land ha	Total area ha
Nicaragua	15 196	161 685	234 778	396 464
Guatemala	10 906	116 040	168 498	284 538
Honduras	9 594	102 080	148 227	250 307
Panama	4 196	44 645	64 828	109 474
Costa Rica	1 511	16 077	23 345	39 422
Belize	656	6 980	10 135	17 115
El Salvador	227	2 415	3 507	5 922
Total	**42 286**	**449 922**	**653 318**	**1 103 242**

Government Ministers and Programme heads for Forestry and National Parks from throughout Central America gathered in San Pedro Sula, Honduras. The purpose was to discuss the impacts that the1998 fire season had on the region and what collectively the countries might be able to do. Some of the important considerations from the meeting included the following:

- Assure that the farmers and indigenous people are included in the proposed solutions.
- Search for and develop alternative solutions for agricultural burning.
- Adopt and regionalize a farmer-to-farmer extension program as a mechanism to encourage sustainable use of natural resources and to improve agricultural techniques.

[12] Alvarez, R. and R. Benítez. 1998. Ponencia: Incendios forestales en Centroamérica. Foro Regional sobre prevencion y combate a los incendios forestales y regeneracion de areas afectadas. Mexico DF, 26-28 August 1998. 119-121.

The Central America Commission for Environment and Development (CCAD) is a good example of regional-level policy making in Central America. It was created in 1989 by the Presidents of Central America countries. It is composed of the heads of the ministries and agencies most directly responsible for environmental policy in each of the seven Central American countries. CCAD's principal mission is to promote policy coordination, develop new funding, build institutional capacities, make information available and foster citizen participation in addressing the region's environmental problems.

Brief country profiles will be presented for Costa Rica and Guatemala based on information presented at FAO's "Meeting on Public Policies Affecting Forest Fires" held in Rome, Italy, in October 1998. These two reports will be followed by a more in-depth treatment of the fire situation in Nicaragua.

6.2.2 Costa Rica

Before 1985 there was not a strong fire management programme. Loss of tropical habitat, indiscriminate burning and several large fires hastened the need to develop a fire management programme. Officials is Costa Rica sought international assistance to help improve their fire programms. Legislation passed in 1986 was designed to discourage the rampant use of uncontrolled fire. There were fines associated with the law. An additional forestry law in 1996 raised even further the awareness that uncontrolled fire had to be eliminated.

The formation of regional and local fire management committees has been instrumental in improving fire management responses in the country. The current emphasis in Costa Rica is to decentralize federal efforts and encourage the provinces and local communities to get involved and to be responsible for their areas. There is an economic incentive for the communities to be involved. The Central Government provides funding for tools, equipment, training, education, etc. Also, the National Security (Insurance) Institute is also providing funding to ensure success of the programme.

The committees are formed by volunteers, with professional and technical assistance provided by the government. These committees are responsible for preventing fires, as well as organizing to suppress fires. In the Guanacaste region, for example, there are 85 volunteer firefighting brigades.

6.2.3 Guatemala

Guatemala was fairly well prepared for the fire events of 1998. Like many other Central American countries, the number of fires and the scale of the fires eventually overwhelmed their capabilities.

Fire management responsibility lies mainly with local authorities. Initial response is done by local volunteers, or, on State lands, by government personnel. Effective use of specialized firefighting tools is on the increase. When the situation becomes too complex or large, the regional governor assumes emergency management responsibility. There is a governmental structure for emergency response. The Petén region of northern Guatemala was well prepared for the fire events of May 1998. The situation overextended their abilities, but their

organizational expertise facilitated their ability to manage the situation. Previously that year, international specialists worked on emergency management techniques with Emergency Coordination Management officials in the Petén. The training was evident in their efficiency in coordinating activities (Perkins 1998). There were military, Civil Defense, volunteers and local forestry officials working together to achieve control of the wildfire situation.

There is no national authority for fire suppression. Each region is responsible for initiating fire suppression, preparedness and prevention actions. There is a high degree of international involvement, since areas within Guatemala are under development and the Mayan Ruins serve as a catalyst for action. Wildfire protection programmes are divided among the respective natural resource agencies with Civil Defense having the ultimate authority. The Civil Defense authority does not actively engage in suppression actions at the national level. They do become involved locally as was evident in the Petén. The national civil defense agency steps in once there is a presidential disaster declaration.

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6.2.4 Fire Situation in Nicaragua

By
Arnold Jacques de Dixmude
Environmental Science Department, Natural Resources Institute, University of Greenwich

Fire environment, fire regimes, ecological role of fire

Fires in Nicaragua are a seasonal event and essentially occur between January and May, coinciding with the dry season. In the context of land management practices, two groupings of fire types can be considered:

- Intentional fires: used for clearing of agricultural lands, burning of agricultural residues, forest management, hunting, etc.
- Wildfire: escaped intentional fires, lightning, maliciousness.

The ecological role of fire varies according to the type of ecosystem involved. Natural vegetation in Nicaragua can be classified into three broad categories: broadleaf evergreen forest, broadleaf deciduous forest and pine forest.

In the absence of human activity, fire plays a minor role in the dynamics of moist broadleaf forests, where a natural greenhouse climate encourages high rates of decomposition. Under specific conditions, however, such as those caused by unusually long periods of warm and dry weather, catastrophic fire events can occur.

Fire does not play a significant role in the dynamics of the deciduous broadleaf forests. While forests with large trees and a relatively open understorey can tolerate an occasional surface fire, dense forests of young trees suffer extensive tree mortality. These forests become extremely dry during the fire season and are highly susceptible to wildfire.

In contrast to the previous two categories, fire does play a significant role in the dynamics of pine forests. Open, pure pine forests with a grass understorey are maintained by fire episodes occurring at relatively frequent intervals (1-5 years). It has been suggested that the extensive pine forests which occupy the north central mountains may have been largely the result of slash and burn agriculture practised during pre-Columbian times (Denevan, 1961, cited in Ciesla, 1997). If fire is excluded from these areas through effective forest fire control programmes, the first response is the establishment and growth of pine regeneration. In the continued absence of fire, hardwoods will gradually replace the pines. Too frequent fire intervals, on the other hand, will not permit establishment of pine regeneration.

Extensive areas of native forest in the Pacific lowlands and into the Segovian mountains were cleared and the margins of the broadleaf forests were pushed back through an extensive use of fire to support shifting agriculture and to drive game. There has been traditionally little concern about the spread of fire into surrounding forests. In addition, the need for pasture for cattle, sheep and goats has created another reason for clearing forests. Fire remains a primary tool for clearing land, disposing of agricultural residues and improving forage conditions.

Summary of major wildfire impacts on people, property and natural resources in the 1990s

There are not many records of especially large fire events taken individually. Fire impacts are generally considered from a seasonal perspective. In the nineties, 1998 ranks as the most dramatic season in terms of impacts. The overall total of economic losses is estimated at US$ 127,000,000.
Some major events were reported in the press:

- 3 000 ha were burnt (mainly dry broadleaf forest) near the Cosiguina volcano.
- More than 2,000 ha were reported burnt in the municipalities of Dipilto and Mozonte in the municipalities of Dipilto and Mozonte and the fire lasted more than a week (in the Northern pine forest region).
- The smoke plume produced by the fire outbreak in April 1998 caused the international airport of Managua to be closed for nearly two weeks. The same happened to the airport of Tegucigalpa in Honduras.

As far as impacts on health are concerned, April and May 1998 were the months during which the highest increases of respiratory problems were reported in the capital city Managua. All the schools had to remain closed on several occasions during those months.

Wildfire statistics of fire numbers and area burned

Table 6-5 National fire statistics from the Ministry of Environment and Natural Resources (MARENA).

Year	Number of fires	Area burned (agricultural) ha	Area burned (forest) ha	Total area burned ha
1985	13 184	222 599	327 940	550 539
1996	12 557	217 170	319 942	534 112
1987	11 416	210 845	310 624	521 469
1988	10 379	206 711	301 624	508 288
1989	9 877	196 868	287 217	484 085
1990	8 981	186 541	273 540	460 081
1991	7 810	169 541	248 673	418 214
1992	6 787	205 545	114 825	320 270
1993	2 529	140 876	41 102	181 963
1994	2 161	102 013	26 757	128 788
1995	1 511	58 311	24 467	82 778
1996	12 150	64 431	33 467	97 898
1997	15 314	not available	not available	not available
1998	24 113	not available	not available	not available
1999		not available	not available	not available
2000	not available	not available	not available	not available

Until 1995: data from the departmental delegations of MARENA across the country (ground observations). From 1996 to date: data from the remote sensing unit of MARENA (NOAA/AVHRR satellite data).

Operational fire management system

Several state bodies deal with fire issues in Nicaragua:

- Ministry of Agriculture and Forest (MAG-FOR), which has overall responsibility for forest management and production.
- The National Forest Institute (INAFOR), created in 1998, which actually is the former Forest Directorate. It now lies under the Ministry of Agriculture's authority and includes the forest protection department.
- The Ministry of Environment and Natural Resources (MARENA), which hosts and manages a NOAA/AVHRR remote sensing unit with fire monitoring capability.
- The Army, which is the main provider of logistics for fire suppression operations.
- The National Institute for Territorial Studies (INETER), which relies on a country-wide network of meteorological stations, rules air traffic over the country and is the national authority in terms of cartography and geographical reference.
- The Civil Defense, the Fire Corps (Cuerpo de Bomberos) and the local councils (municipalities) are the main groups providing fire suppression and prevention actions.

The effectiveness of state programmes may have been somewhat hampered by repeated restructuring within the ministries and state institutes; and by weak communication among institutions. Responsibilities are often diluted among different ministries (MAG-FOR, MARENA, INRA, National Institute for Agrarian Reform) whose interests are not always compatible.

A number of internationally funded forest sector development projects in Nicaragua, mostly locally focused, have included a forest fire management component. Bilateral donors involved include:

- Dutch cooperation/FAO along the volcanic range off the Pacific coast.
- Danish cooperation in the southeastern rain forest region.
- German cooperation in the Bosawas biosphere reserve.
- Finnish cooperation in the northern Nueva Segovia pine forest region.
- IDB/USAID/FAO in the northeastern Caribbean pine forest region.
- UNDP/Italian cooperation in the northern Nueva Segovia pine forest region.
- EU (around the Bosawas biosphere reserve in the northeast and the SI-A-Paz reserve in the southeast.
- The private sector in privately owned or industrial forests.

The private sector (timber industry) is particularly active in the northern pine forest regions, which are largely private properties and commercially managed. A good level of coordination exists between timber companies such as *Pinares del Norte* or *Pinosa* and local authorities for setting up prevention and suppression programmes.

As for the broadleaf rain forests of the eastern Atlantic, there is a great uncertainty about actual forest ownership. Three main forces are present here:

- Thousands of individuals emigrating from the West and once settled on formerly forested/pristine areas, claim for entitlement and convert the original forest into a woodland/cropland mosaic. Being poor (individual small slash-and-burn agriculture) or rich

(large scale livestock), fire is definitely the main tool used for land management, with a clear lack of concern about controlling fire propagation.

- Foreign timber companies who, through concessions from the state, extract as much timber as they can within the period stated in the concession. So far, they do not seem to be committed to an effective control as far as sustainability is concerned. Fire is not directly used, but the altered ecosystems left behind are much more prone to fire and further settlement.

- Indigenous people have lived in these remote areas for ages and in opposition to the two former categories, claim a legal demarcation of their territories. Multilateral donors such as WB favour this claim and indicated that government recognition of these rights is a preliminary condition for releasing further aid to development programmes (e.g. Atlantic Biological Corridor). It is uncertain, though, if indigenous people's attitude toward the use of fire is different in their land management approaches.

Both the municipalities and INAFOR are responsible for organising fire brigades on a voluntary basis. The army may intervene in some cases. The brigades are poorly equipped. Unless they benefit from the support of an externally funded agriculture or forest development project active locally, the only fire fighting tools available are machetes and tree branches. Vehicles and fuel for transporting brigades to wildfires are generally not available.

Community involvement in fire management activities

A relevant case of community involvement is the Farmer-to-Farmer Programme active around the Bosawas biosphere reserve. This programme is based on the promotion of *frejol abono* (manure bean) as the most promising alternative tool to the use of fire. As an intermediate coverage crop, it is meant to prevent the fields from being invaded by unwanted weeds between successive crops.

The main forest fire management and research issues

- Need for further international donor assistance to improve forest fire management capacity in selected areas, which should emphasise:

    1. Training of fire brigades and technical support personnel in basic map reading skills, fire planning, fire behaviour and fire fighting techniques.
    2. Purchase of fire fighting tools, personal safety equipment, vehicles and communications equipment to support fire brigades.
    3. Development of an improved communications capacity to facilitate timely reporting of wildfires and dispatching of fire brigades.

- Need to encourage the integration of a forest fire management component in all future internationally funded rural or forest sector development projects in Nicaragua.

- Need to improve the basic communication infrastructure (e.g. telephone network throughout the whole country).

- Need to increase the means of control in remote areas.

- Need to harmonise institutional visions and missions according to a coherent legislative framework.
- Need to develop a system to reliably assess burnt areas (current NOAA/AVHRR system enables to 'count' the number of fires; yet estimating burnt areas from this is much more difficult).
- Need knowledge about the social, cultural, political and economic factors that influence fire activity.
- Need to develop a system for fire danger rating; and develop a linkage to the national weather service for fire weather forecasts.

Use of prescribed fire in the region to achieve management objectives

- **Forestry:** Fire is used as a prescribed management tool in pine forest, particularly in the Nueva Segovia department, but no documented description is available.

- **Other vegetation management (grasslands, bushlands):** Livestock occupies a large part of the southeastern departments (Boaco, Chontales, RAAS (*Región Autónoma Atlántica Sur*)) and fire is commonly used as an easy way to rejuvenate fodder.

- **Agricultural maintenance burning:** Besides the "slash-and-burn" scheme accompanying human settlements in broadleaf moist forest areas, fire is also used in intensive cash crops such as sugar cane or maize in the more densely inhabited Pacific plain. The fires occurring there generally are the earliest ones in the season, starting in December, January, or February.

- **"Let burn" or integration of natural and human-caused wildfires:** Other cases of human-caused fire which are mentioned are hunting / driving game, careless practices such as tossing cigarette butts into dry vegetation and abandoned campfires. Also, there is intentional burning which is a criminal offence (political pressure against municipal or state authorities, land tenure conflict between communities, etc.).

Sustainable land-use practices employed to reduce wildfire hazards and wildfire risks

There have been awareness raising campaigns led by MARENA, later by INAFOR, in order to promote the development of fuelbreaks in agro-pastoral activities. However, there is little evidence that these recommendations are actually followed.

Locally, green manure is promoted as an alternative to fire (e.g. Oxfam-funded Farmer-to-Farmer programme, with the support of EU-funded Agricultural Frontier Programme), with a very good rate of community involvement.

Public policies concerning fire

The legal authority to conduct forest fire management in Nicaragua is contained in the Decree No207-DRN about "Regulation for the defence against forest fires" of July 1972. This authorises the government to conduct measures to prevent and suppress forest fires. It also authorises

prosecution of individuals whose actions either purposely or as a result of carelessness result in a wildfire. Specific fines are given for various infractions.

A National Forest Action Plan, drafted in 1993, includes a component that specifically addresses forest fire management, covering prevention, detection and suppression.

Initiatives also exist at a regional level in the framework of ALIDES (Alianza Latinoamericana para el Desarrollo Sostenible) with CCAD (Central-American Commission for Environment and Development) as the lead, in order to harmonise fire protection policies.

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Contact for correspondence: Arnold Jacques de Dixmude
Environmental Science Department, Natural Resources Institute, University of Greenwich
Fax: ++44 1634 883232 Tel: ++44 1634 883227
e-mail: A.Jacquesdedixmude@greenwich.ac.uk

6.3 Caribbean Sub-Region

6.3.1 Fire Situation in Cuba

By
Marcos Ramos

Fire environment, fire regimes and the ecological role of fire

In Cuba, five principal environmental problems have been identified by CITMA (Science, Technology and Environment Ministry) (1997) in the National Environment Strategy. These problems are: degradation of the soil, deterioration of security and environmental conditions in human settlements, contamination of the water, deforestation and damage to biological diversity. Forest fires have a strong influence on these problems and the government is paying special attention to them.

In the country, the number of forest fires by lightning (main natural cause) in recent years represent only 10.64 percent of the total. The forest ecosystems appear to have no connection with fires, thus indicating the presence of a non-fire regime. Some authors say that the *Pinus* spp. exhibit adaptations to fire, especially *Pinus tropicalis.* It is possible that fires facilitate the regeneration in this species. In fact, no studies have been reported about this adaptation.

Forest fire defined: Fire that occurs in an uncontrollable form in the natural and artificial forest (Law No. 85, Forestry Law).

Narrative summary of major wildfire impacts on people, property and natural resources that occurred historically

Fires cause negative effects on the stability of nutrients, flora and fauna, the structure of the soil; and on the ecological stability as well. All of these changes cause an unfavorable environmental impact and can bring about global climatic changes.

The major wildfire impacts historically have been related to the burning of the forest that degrades habitat for fauna, soil, wood and biodiversity. Forest fires make sustainable forest management difficult. In the period 1990-1998, a mean of 307 forest fires occurred annually and 6,507 hectares were affected.

Narrative summary of major wildfire impacts on people, property and natural resources during the 1990s

Extreme weather conditions of drought and wind velocity in April and May of 1999 caused the most important fire season in the last 8 years. The two biggest fires in modern history occurred during this period. The wildfires affected 11,657 hectares.

Fire management organization

The organization and management of fire protection in Cuba is undertaken by the Forest Guard Department in the Ministry of the Interior, as set out in the Forest Law. This Department, in conjunction with the Ministry of Agriculture, has developed specialized measures for fire prevention. As established by the Forest Law, the system for forest fire protection comprises activities for prevention, control and suppression, as well as research and training. These activities are regulated by a National Program created by the Ministry of Interior in collaboration with the Ministry of Science, Technology and the Environment and the National Civil Defense.

Cuba is divided into six ecological regions. In these regions are the Professional Brigades of Prevention and Suppression of Forest Fires. These brigades are located in the highest risk forests and operate all year.

Wildfire database

Table 6-6 Number of fires and area burned in Cuba between 1990-1999.

Year	Total No. of Fires on Forest, Other Wooded Land & Other Land No.	Total Area Burned on Forest, Other Wooded Land & Other Land ha	Area of Forest Burned ha	Area of Other Wooded Land & Other Land Burned ha	Human Causes No.	Natural Causes No.	Unknown Causes No.
1990	307		3127		178	36	93
1991	566		6582		203	26	337
1992	312		4442		161	19	132
1993	182		5380		87	51	44
1994	237		6152		151	21	65
1995	363		3731		189	15	159
1996	211		3905		90	24	97
1997	255		4708		117	49	89
1998	259	10672	4144	6528	80	36	143
1999	382	32520	22900	9620	185	50	147
Total	**3074**	**43192**	**65071**	**16148**	**1441**	**327**	**1306**

Computers are used to manage the Integrated System for the Management of Data Bases on Forest Fires (designed by Ramos 2000).

Use of prescribed fire to achieve resource management objectives

According to the Forest Law (Law 85/98) in Cuba, the use of fire in forests and adjacent areas (up to 200 m from forests)is prohibited. In exceptional cases the Forest Guard Department facilitates a permit for burning.

However, fire is used frequently as a management tool in Cuba. Burning is practiced at the end of the dry season in order to renew grass to feed livestock. It is also used by farmers to

eliminate crop waste and to clean the soil before planting. Despite fire regulations, negligence in these activities and using fire in other land use systems frequently cause forest fires (Ramos, 2000).

Public policies affecting wildfires and fire management

Since forest fires affect sustainable development (ecological, economic and society), public policies support the fire management programme. The State supplies resources for this activity; and every year a different person participates in international courses. Also, projects concerning wildfire are being developed. According to Ramos (2000), in case of extensive forest fires, the government and political authorities help with resources. Also, headquarters and other temporary infrastructures are set up from which collective decisions are analyzed to take the most effective action.

Sustainable land use practices used to reduce wildfire hazards and wildfire risks

In some places cattle are raised in the forest and different agro-silvicultural practices are promoted. Some silvicultural management improves the structure of the forestry.

Community involvement in fire management activities

According to the National Program for Forest Fire Management, different Ministries, Institutions, Organizations and entities are involved in activities during the prevention campaign and into suppressions activities. Volunteer brigades are also used for wildfire management.

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E-mail address of correspondent: cmramos@af.upr.edu.cu

6.3.2 Fire Situation in Trinidad and Tobago

By
Kenny Singh
Forestry Division

Fire environment, fire regimes and the ecological role of fire

Each dry season, roughly January to May, open areas, roadsides, agricultural lands and forests are ravaged by bush and forest fires. The nature and extent of damage and losses resulting from these fires varies from year to year depending mainly on the severity of the dry season, which in turn is a function of the amount and frequency of rainfall. Relative humidity plays a lesser role in contributing to prevailing levels of fire danger. Trinidad and Tobago consists of two relatively small islands and relative humidities seldom drop below 50 percent, even in the dry season.

The term "bush fire" refers to fires burning in open, non-forested areas such as vacant lots in urban and semi-urban settings, roadsides and agricultural lands.

A ***forest fire*** is defined as an unplanned fire, which burns vegetation on lands under forest cover, including grasslands, which were once under forests, or found within Forest Reserves. Our forested lands consist of natural forests, commercial plantations of teak and Caribbean Pine and savannahs, or grasslands, classified as forests lands. This includes fragile wetlands which may dry out during the dry season. Teak plantations are particularly susceptible to annual fires, as leaf-fall during the early dry season results in a substantial accumulation of fuel on the ground that vandals routinely ignite. While teak is often described as fire resistant because trees are seldom killed by fires, annual burning does result in significant damage to the lower bole and site degradation. The eventual result is a decline in timber quality and quantity due to reductions in growth rates and the onset of disease problems, particularly heart rot.

The critical watersheds of the Northern Range of Trinidad are also quite vulnerable to fires. These exposed slopes rapidly dry out during the early dry season and fires started in these areas easily burn out of control. Over the years, repeated fires have resulted in the maintenance of fire-climax grasslands on several ridges of the Northern Range. These grasslands also serve as corridors for the spread of fires onto adjoining forests. These fire prone grasses are therefore replacing more and more forests. The end result is a series of environmental disasters including siltation and flooding of low-lying areas.

During harsh dry seasons, drought-like conditions render the natural forests more susceptible to fires. For example, during the drought of 1987, it is estimated that over 10,000 acres of natural forests were burned. Evidence of this damage is still observed as most of the trees were killed and toppled by fire; and natural regeneration has been quite variable. Recovery also has been set back by subsequent fires. During average dry seasons, the ability of natural forests to recover from surface fire is much more evident.

Narrative summary of major wildfire impacts on people, property and natural resources that occurred historically

People. Historically, fires have been successfully incorporated as a tool in land clearing for slash-and-burn cultivation. Traditionally, such farmers were careful to border their plots with fire-traces and to burn in small heaps (or "boucans"). Thus, fires were generally restricted to the plots being worked.

On those somewhat rare occasions when a combination of harsh (dry) conditions and negligence, or vandalism, resulted in major forest fires, "squatters" seized the opportunity to occupy and cultivate these lands that were previously under forests.

Property. Damage to property due to fires up to the mid-eighties was relatively small and generally restricted to damage to fences and low-cost structures on agricultural lands.

Natural Resources. Historically the impact of fires on natural resources have reflected the land settlement patterns over the years. The northwestern part of Trinidad, including the western Northern Range, with the highest population density, has been most affected by fires. Here, the forest cover and cocoa and coffee plantations, which once occupied these hillsides, have been replaced by primarily housing and to a lesser extent short-term cultivation. It is not surprising that this region, including the capital city, is quite prone to siltation of watercourses and flooding.

Fires also have been used as a precursor to land settlement in other regions of the country. However, these settlements were less intensive and therefore the impacts were generally localized. Such impacts include loss of productive forests, disruption of wildlife habitat and site degradation.

Narrative summary of major wildfire impacts on people, property and natural resources during the 1990s

People. By the 1990s the increased incidence of forest and bush fires began to have serious impacts on a wide cross-section of the community. Housing shortages and a lack of employment opportunities in the urban centers led to massive influxes of people seeking to settle on forested lands. This ad-hoc, unplanned and chaotic establishment of squatter communities has resulted in a series of environmental problems associated with the removal of trees, the use of fires and other undesirable land-use practices. These practices have further resulted in degradation of the same resources (land, watercourses, access) that initially attracted settlers into the area. It should be noted that an estimated fifty percent of these squatting communities are on State forest reserves.

Disadvantaged groups have not been the only ones settling into rural areas. The upper class has been escaping urban congestion by establishing high cost housing in rural areas adjacent to forested lands. These communities are sometimes threatened by forests and bush fires.

Generally, all sectors of the national community are affected directly or indirectly by fires. The nature of these impacts include disruptions in water supply, damage to infrastructure, the effects of higher levels of dust and smoke in the air and higher prices of local agricultural

produce made scarce by direct damages to crops due to fires in the dry season and floods in the rainy season. There has been no direct loss of life due to fires.

Property. Property damage due to forest and bush fires ranges from damage to infrastructure (roads, bridges affected by landslides and flooding), direct destruction of houses (mainly low-income dwellings, average of four per year with a total estimated value of US $50,000) and loss of agricultural crops and property (estimated at an average of US $500,000 per annum).

Natural Resources. The impacts of forest fires on natural resources include:
permanent loss of forest cover – estimated at 100 acres per annum.

- Loss of biodiversity. Fires have simplified many ecosystems and have even resulted in major expanses of fire-climax grasslands.
- Loss of forest cover and changes in species composition and structure have adversely affected wildlife. In the late 1980s there was a two-year moratorium on hunting after the devastation caused by fires in 1987. No studies have been conducted to determine the specific impacts of fires on wildlife.
- Loss of fish habitat. Fresh water fish also have been negatively impacted as a result of higher siltation levels and the drying out of streams.

Fire Management Organization

No separate structure exists for forest fire management. Fire prevention and control are carried out by six Conservancies which are responsible for overall forest management and protection. A small Fire Protection Unit collates plans and reports for all regions. This unit is headed by a Professional Officer who shares this responsibility with other substantive functions. This officer is supported by one clerical worker.

Wildfire database

Table 6-7 Number of fires and area burned between 1990-1999.

Year	Total No. of Fires on Forest, Other Wooded Land & Other Land No.	Total Area Burned on Forest, Other Wooded Land & Other Land ha	Area of Forest Burned ha	Area of Other Wooded Land & Other Land Burned ha	Human Causes No.	Natural Causes No.	Unknown Causes No.
1990	234	1,100	251	849	135	NIL	99
1991	239	680	297	383	150	NIL	79
1992	431	2,710	2,145	565	313	NIL	118
1993	228	1,570	1,000	570	146	NIL	82
1994	256	2,597	2,097	500	203	NIL	53
1995	198	2,664	2,096	568	121	NIL	57
1996	516	7,245	5,268	1,977	376	NIL	140
1997	156	443	272	171	120	NIL	36
1998	764	10,288	7,201	3,087	665	NIL	99
1999	167	988	678	310	130	NIL	37

Evidence indicates that all fires in Trinidad and Tobago are caused by human activity. Recurring fires on grasslands, especially on the slopes of the Northern Range, prevent succession to forests.

Use of prescribed fire to achieve resource management objectives

This is limited to some very small-scale trials in teak plantations. Trials will continue to be undertaken. Even so, these trials have yielded only moderate success, as prescribed burning must be done in early dry season. Continued leaf-fall after prescribed fire still represents a significant build-up of fuel, which invariably burns due to unplanned fires.

Extreme caution is necessary as once the public is under the impression that the Forestry Division has a programmeme to burn teak fields, individuals interpret this as encouragement to start fires on their own.

Public policies affecting wildfires and fire management

- **Regularization of Squatters.** Legal arrangements are in place to regularize, i.e. provide some security of tenure squatters who were on State lands as of December 1998. Fires have been used in the past to stake claims to parcels, many of them on fragile sites.

- **Access to Markets.** No farmer is denied the opportunity to use State facilities to market his produce, based on land-use criteria, including use of fires.

- **Incentives.** These were introduced in 1999 for fire-tracing and watershed rehabilitation. This has had a positive impact on fires on private holdings.

Sustainable land use practices used to reduce wildfire hazards and wildfire risks

- Reforestation projects emphasize use of mixed species.
- More intensive management of natural forests for variety of goods and services.
- Encouragement of agro-forestry on private lands.

Community involvement in fire management activities

- Two volunteer groups (Community-based) have been assisting the Forestry Division with fires on the Northern Range.

- One community-based fire project was launched at Nariva (Ramsar wetland site) in 1998. This effort has been quite successful, but needs to be sustained if objectives are to be realized. Inadequate resources are available for this effort.

7 South America Region Fire Assessment

7.1 Introduction

Fire as a land use tool is deeply rooted in the culture, society and traditions of most countries in the region. Fire has been used to prepare agricultural lands for crops or grazing, open impenetrable lands to new agricultural uses, facilitate hunting, or for maintaining an open nature to the landscape.

Without exception, country fire officials throughout the Southern Hemisphere believe that uncontrolled wildfire is fast emerging as a major concern. This was a recurring theme in the presentations offered at the 1st South American Seminar on Control of Forest Fires, Belo Horizonte, Brazil (Ribeiro and others 1998). The continuing use of fire for land-use practices, population pressures and a decrease in the economic stature of many of the people in the region are primary causes for the increase in the wildland fire problem (Yegres 1998).

The exact scope of the problem is difficult to determine. Fire statistics in many cases are non-existent, significantly incomplete, or misleading. There is not a common understanding or definition of what constitutes a wildland fire. Reviewing available statistics suggests that 50 to 95 percent of wildfire starts in the region are the result of agricultural burns or land clearing burns escaping control. Agricultural burning has been occurring for so many centuries that little concern is registered regarding vast quantities of smoke, or when many hectares are on fire. Satellite imagery cannot differentiate the unmanaged and uncontrolled wildfires from the controlled burns. During the early months of 1998, satellite imagery heightened government and international awareness regarding the vast number of “hot spots” in the region.

Economic, ecological and human losses can be measured monetarily as they affect local economies or by the loss of lives or real estate. Many countries have established plantations for future wood fiber needs. These plantations are at risk. Venezuela has found that as the plantations become more widespread, the risk of loss increases (Yegres 1998). Chile (Sanhueza 1998) has been proactive in the fire management program, since the creation of their vast plantations. They have an excellent fire management programme in cooperation with private industry.

Brief fire situation profiles follow for Venezuela and Uruguay based on presentations given at FAO's "Meeting on Public Policies Affecting Forest Fires" in Rome, Italy, October 1998. Longer reports prepared by correspondents will highlight fire programmes in several additional South American countries.

7.2 Uruguay

Ninety percent of Uruguay is classified as grasslands (Baptista 1998). Fire is used to improve forage for cattle. Fires do escape control and move into other lands, protected-forested areas, or into plantations. Due to the vastness of the grasslands, Uruguay does not have a serious forest fire problem.

The first forestry Law was passed in 1968 and the second one passed in 1987. The laws

attempted to discourage the cutting of indigenous forest species and encouraged the creation of artificial forests. Today there are approximately 310,000 hectares of plantations. Fire problems began to rise as the number and expanse of plantations increased. When the programme started and plantations were isolated, the fires were manageable. As the plantations aged and increased plantings placed more plantations adjacent to one another, the fire problem became more serious.

Fire suppression is the responsibility of the Director of National Firefighters. There are approximately 1,500 firefighters. These firefighters are divided into fire brigades. Initial attack is primarily done by the industrial forest land owners in the plantation areas. When the situation is severe, the Public Works Department and the Defense Ministry become involved. There are no aerial resources for suppression. Aerial detection is employed.

7.3 Venezuela

The forestry Law of 1970 placed fire control responsibility in the Ministry of Environment and Renewable Natural Resources. The fire control programme is designed to support local organizations through central operation's centres which provide transportation, food, equipment, etc. There are regional examples of excellence where there are economic incentives to prevent and control wildfires**.** Venezuela's suppression effectiveness was demonstrated by their involvement with helping Brazil during the fire events of early 1998.

Venezuela is predominantly classified as tropical. Natural fire causes are rare, thus the fire problem is a human problem. The dry tropical forests are considered those at greatest risk. There is tremendous population pressure in these areas. A rise in fire occurrence is expected (Yegres 1998).

The eastern portion of the country has experienced a rise in plantations. The programme began in 1969 through a major governmental forestation programme. There are approximately one half million hectares of plantation. This is a region of high lightning occurrence, thus there is a high risk of fire starts and fire loss. The potential economic impact to these plantations gave rise to fire control efforts.
There have been large fires in the recent past. There is a system of detection towers, aerial detection, ground patrols and trained firefighting crews. Helicopters are used to transport firefighting personnel. The program is well defined in this region. Largely due to the potential economic loss, there are many trained professionals performing the firefighting duties (Yegres 1998). More than a dozen fire technicians have taken advantage of training opportunities internationally. Yegres (1998) commented that many of the trained professionals have other duties and do not have the time to devote fully to wildfire management.

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7.4 Fire Situation in Argentina

By
Maria C. Dentoni
Argentine National Fire Management Plan, Secretary for Sustainable Development and Environmental Policies

Fire environment, fire regimes and the ecological role of fire

Extending from 22° to 55 °S, Argentina presents a great diversity of ecosystems associated with the different climates. Fire is present in the different vegetation associations, varying in frequency, intensity and time of the year in response to the different habitat types, frequency of lightning storms, strong dry winds and rainy seasons. In the southern territories where the rainy season occurs in winter, wildfires start in late spring and last until early summer. Moving northward in the country, fires tend to occur in autumn and winter associated with the dry seasons. In addition to the environmental factors, fire occurrence in the different regions is affected by such human factors as cultural practices, varying population density, tourism affluence and characteristics of fire suppression activities.

Narrative summary of major wildfire impacts on people, property and natural resources that occurred historically

According to anthropological evidence, indigenous pre-Columbian populations used fire extensively for hunting, clearing land for grazing and other purposes. These fire influence may date back to 8000 years B. P., or generally to the early Holoccene (Goldammer 1991). It should be pointed out that natural fires have been present in the different ecosystems in a degree that has not been well documented.

With the European settlement fire started to be used intensively as a management tool to convert land for productive purposes, which included agricultural activities and livestock**.** Reports of expeditions to Patagonia in 1906 and 1914 (Rothkugel 1916; Willis 1914), indicated that extensive areas burned to open land for grazing. In the northern area of the country, post Columbian fires are described in documents left by explorers and Jesuit missionaries (Kunst 1997).

During the last century, an increasing number of fires have been reported in most areas of the country, mainly due to human factors. During atypically dry seasons, as in the 40´s, 60´s and 80´s in Patagonia, human sources contributed to extreme fire situations in the region (Rodriguez unpublished). In the Mesopotamia, located in the northeastern extreme of the country, the extensive pine and eucalyptus plantations are often affected by lightning fires that did not occur with that frequency in native vegetation.

In some areas around Patagonian coastal cities, many ranchers have abandoned their ranching activities. The lack of grazing allowed the recovery of vegetation, increasing the shrub and grass components and ultimately fire hazard (Defossé *et. al* 1999).

Urban/wildland interface fires have become a very significant and constantly increasing problem during the last decade.

Narrative summary of major wildfire impacts on people, property and natural resources during the 1990s

Some of the major events were:

1993: The province of La Pampa, in the central region of Argentina, experienced an unusual fire season. 1,227,440 hectares of grassland and shrublands were affected with great economic losses. This is four times above the annual average.

1994: On January 21st, 25 firefighters died in a rangeland fire in the coastal area of northeastern Patagonia.

1995/1996: During the 1995/1996 season, large wildfires affected the Patagonian/Andean Region in general and, in particular, the oldest National Park in the country. The public was shocked because of the possible effects of the fire on the ecosystem and on the economy of the region, strongly dependent on tourism and forest resources. In response to this situation, the Federal Government of Argentina established, in late 1996, the *National Fire Management Plan.*

1999: Large fires affected the central and southern areas of the country. One of the oldest pine plantations in Patagonia was lost, causing a great impact to the community. Two fatalities were caused by two different fires.

2000: The Mesopotamic region went through an unusually critical fire situation since early summer. The fires affected large pastures and eucalyptus and pine plantations, causing great impact on the forest related activities.

A very wet spring produced an abundance of fuels in 2000. This was followed by a summer with below average precipitation, extremely high temperatures and lightning storms. Thus, there were extreme fire occurrence and behaviour conditions in the provinces of La Pampa and Mendoza . Cultural practices of burning to improve grazing also ignited many fires.

Under these conditions shrubland and grassland fires in December 2000 and January 2001 affected an area that is estimated to be over one and a half million hectares. Besides the economic losses, extreme fire behavior caused eight fatalitites, seven in Mendoza and one in La Pampa.

Fire management organization

The National Fire Management Plan provides a system of coordination and federal support to the provinces in fire management related activities in Argentina. Its administrative scheme is as follows:

Ministry of Social Development and Environment

↓

Secretary for Sustainable Development and Environmental Policies

↓

National Fire Management Plan General Coordination

↓

National Fire Management Plan Regional Centers

↓

Provinces

National Coordination. The National Coordination is responsible for providing regional centers with equipment and technical support, developing and coordinating prevention plans, promoting research activities, providing personnel training, coordinating suppression activities as required by regional authorities and organizing aerial operations. It shares with the Native Forests Resources Direction, also dependent to the Secretary of Sustainable Development and Environmental Policies, the responsibility for producing fire statistics.

Regional centers. The Fire Management Plan has grouped provinces with similar fire behaviour and occurrence problems into six regions and installed a regional center in each of them (see following map in Figure 7-1). These centers are responsible for the development and implementation of a fire management programme for the provinces under its jurisdiction. The provincial governments coordinate activities with the different local administrations and are responsible for the initial attack of fires.

Map of Regions

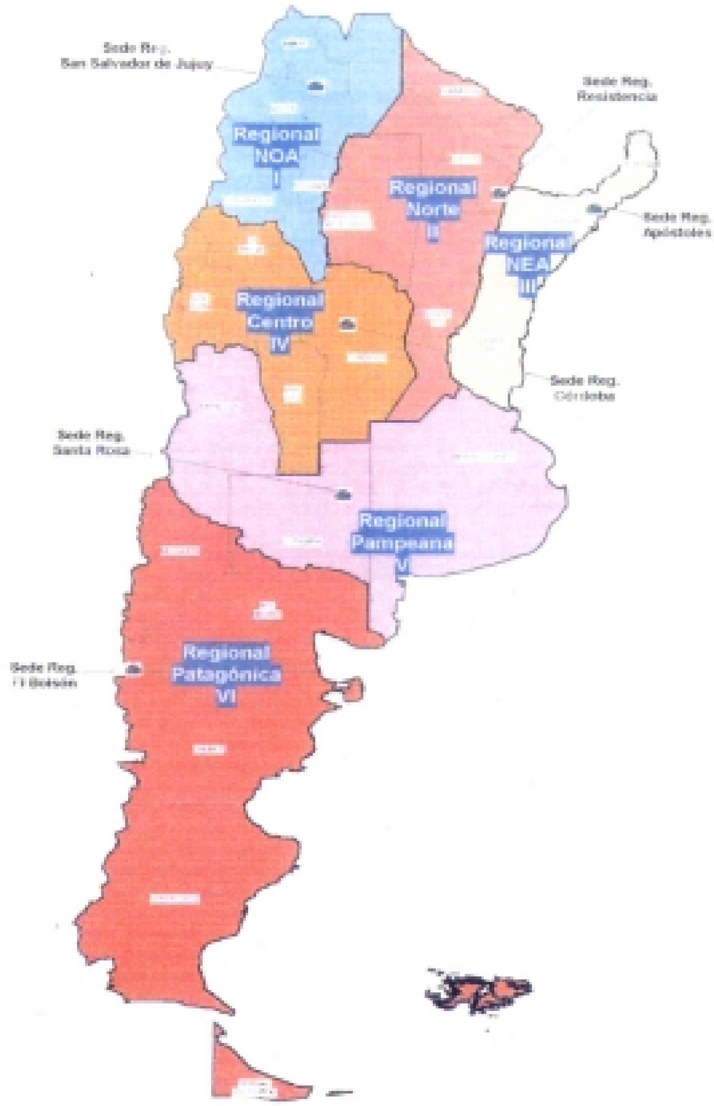

Figure 7-1 Map of the regional centers grouped by the Fire Management Plan

Wildfire database

Table 7-1 Number of fires and area burned in Argentina between 1990-1999.

Year	Total No. of Fires on Forest, Other Wooded Land, & Other Land (No.)	Total Area Burned on Forest, Other Wooded Land, & Other Land (ha)	Area of Forest Burned [2] (ha)	Area of Other Wooded Land and Other Land Burned [3] (ha)	Human Causes (%)		Natural Causes (%)	Unknown Causes (%)
					Negligence	Intentional		
1990								
1991								
1992								
1993	343	1792336	1278966	513370	27	27	-	46
1994*	773	1011749	861434	124615	29	43	7	21
1995	4146	730946	370917	360029	38	31	6	25
1996	4119	450677	185388	265289	30	34	13	23
1997	4774	281984	98369	183615	41	25	7	27
1998**	8765	890784	283494	607210	54	11	17	18
1999	10587	714621	178034	536587	39	22	7	32

Comments:
* Non-discriminated forest type: 25700 ha
** Non-discriminated forest type: 80 ha
2 includes plantations and natural forests
3 includes grasslands and shrublands

Use of prescribed fire to achieve resource management objectives

Controlled fire is being introduced as a technique to reduce fire hazard in forest plantations, through research and extension projects conducted by the Secretary of Agriculture, Livestock, Fishery and Food. In many areas of the country fire is used with different objectives, such as reducing slash and for other cleanup, though these burns are not conducted under a prescription plan and often escape and cause large fires.

Public policies affecting wildfires and fire management

The lack of common criteria and standardization of procedures for fire management among the different Argentine provinces has historically created difficulties. Recognizing this situation, the National Fire Management Plan is working towards setting standards in the country for different aspects of fire management, such as personnel training, personnel certification programmes, fire danger rating and prevention guidelines.

Community involvement in fire management activities

Communities mainly become involved in fire management through Non-Governmental Organizations with different interests, such as safety in interface areas or preservation of fauna and flora. There is also an increasing number of private consortiums strongly interested in an active cooperation with state organizations to improve fire protection for their forests.

Report prepared by:

Argentine National Fire Management Plan, Secretary for Sustainable Development and Environmental Policies. Email: pnmf@medioambiente.gov.ar

E-mail for correspondence: María C. Dentoni: dentoni@ciefap.cyt.edu.ar

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7.5 Fire Situation in Bolivia

By
Ignacio Martínez & **William Cordero**

Fire environment, fire regimes and the ecological role of fire

Every year Bolivia and other neighboring countries, such as Brazil, Paraguay and Argentina, experience forest fires resulting either from land conversion to agriculture and cattle ranching, or natural pasture burning for grass renewal. The burning period starts with the dry season, which stretches from June to November depending on the particular precipitation regime of a given year. According to estimates from the BOLFOR Project and the Forest Superintendency, more than 100,000 hectares are burned each year in Bolivia.

Narrative summary of wildfire effects on people, property and natural resources

During August and September of 1999, what could have been considered a "normal year" turned into one of the worst environmental disasters in the last decade. The word *disaster* was used to describe the situation, since fires destroyed several villages and towns, killed and injured people and burned hundreds of homes. The worst fire took place in the town of Ascención de Guarayos. This event was a warning for institutions and projects, including BOLFOR, which started a follow-up effort using satellite images provided by the National Oceanic and Atmospheric Administration (NOAA), to examine fire behavior in Bolivia.

Between August and September of 1999, more than 12 million hectares were burned in Bolivia. In order to summarize the results of the analysis of satellite imagery, the various and complex types of vegetation in the Bolivian lowlands were grouped by region. The area affected by fire in each region and broader vegetation type is shown in Table 7-2.

Table 7-2 Vegetation types grouped by region.

Burned area (ha)	Region and vegetation type
7,265,429	Grasslands
2,614,968	Chiquitano forest
1,363,884	Amazonian forest
865,584	Agriculture/land conversion areas
541,103	Chacoan forest
77,569	Chiquitano palm groves
20,938	Montane forest
12,749,475	**GRAND TOTAL**

Grasslands, where fire is used for pasture improvement and land-clearing, account for the largest burned areas and undoubtedly are where most fires started, as proven first during classification of NOAA images and later during classification of each fire by week of activity.

Fire classification by vegetation type also shows that wildfires entered forested lands in Santa Cruz and Beni Departments, especially in the former, where fire was used for land clearing within forested areas.

The 865,584 ha of agricultural lands which were burned included areas already deforested, which are under cultivation, as well as areas in process of land conversion.

In terms of production forest, the Chiquitano forest was the most affected with 2,614,968 ha burned, followed by areas under Amazonian forest.

In the year 2000, smaller figures are expected, nearing 4 million hectares (which still is a considerable amount) and to date most fires have occurred in pastures and wooded grasslands.

Wildfire impacts on people, property and natural resources (1999)

In order to determine the degree of damage caused by forest fires, over 25 field visits were undertaken to areas that were burned. In many of these visits,it was observed that no forest had been burned, particularly in Beni. However, in Santa Cruz the situation was different and a total of 30 plots were established in the forests most affected by fire, namely the Chiquitano forest.

According to the methodology used for the study, trees were classified by commercial value and the damage caused by fire. The summary of results is presented in Table 7-3.

Table 7-3 Damage caused by fires by hectare.

Cubic meters per ha in Chiquitano Forest				
Commercial value	DAMAGE CLASS			
	1	2	3	4
Very valuable	4.31	6.96	0.64	0.47
Valuable	1.76	1.51	0.16	0.09
Low value	9.08	16.72	2.32	1.69
No value	5.62	9.56	1.25	0.96

According to Table 7-3, cubic meters damaged and extremely damaged (classes 3 and 4) for the very valuable and valuable category reached 1.36 cubic meters per hectare. This figure extrapolated to the entire area of Chiquitano forest affected by fires (2,614,968 ha), corresponds to 3,556,356.5 cubic meters. According to information collected by field surveys, average stumpage value is $10 per cubic meter, which translates into a total figure of $35,563,565 (U.S. dollars).

Finally, these sources indicate that once the logs are harvested, yarded and milled, the value of timber produced would reach approximately $350 million.

It is difficult to assign a monetary value to the damage caused by the fires. The calculations above ($35 million for standing timber and $350 million for processed lumber) are only an estimate of the losses resulting from forest fires.

It is worth noting that this somewhat “symbolic” calculation includes only the most valuable timber species in the sampling and only takes into account volumes from trees whose crowns/boles were damaged by more than 50 percent (class 3) or completely burned (class 4). We could add to this value the damage or losses that the trees will experience in the future in classes 1 and 2. Also, this calculation includes only the burned area in Chiquitano forest and does not take into consideration the losses due to burning of fence posts, power lines and posts, crops, homes, etc.

Carbon Emissions

Estimations on carbon emissions indicate that 82.64 million tons were released and 165.29 million tons of biomass were consumed. It is worth mentioning that the Chiquitano forest was the largest source of emissions, followed by grasslands.

Table 7-4 Estimated carbon emission values by type of vegetation.

	Estimated carbon emissions			
Area in ha	**Vegetation type**	**Tons of consumed biomass per ha**	**Total tons consumed**	**Released carbon (million tons)**
865584.39	Agriculture/land conversion areas	20.25	17,528,083.88	8.76
1363883.61	Amazonian forest	27.00	36,824,857.40	18.41
7265429.42	Grasslands	6.13	44,561,300.46	22.28
2614967.67	Chiquitano forest	21.60	56,483,301.67	28.24
541102.71	Chacoan forest	16.20	8,765,863.89	4.38
20938.06	Montane forest	25.00	523,451.56	0.26
77569.20	Chiquitano palm groves	7.75	601,161.29	0.30
TOTALS				
12,749,475.06		**165.29**	**165.29**	**82.64**

Fire management agencies in Bolivia

In Bolivia, the agency in direct charge of fire management and prevention is Civil Defense, which is under the Armed Forces. However, it does not have the human and financial resources necessary to effectively carry out its mandate. There are also other agencies such as the Ministry of Sustainable Development and Planning and the Forest and Agrarian Superintendencies, which are in charge of controlling, monitoring and preventing fires through planning and training programmes. Bolivia does not have forest rangers or teams of firefighters specialized in forest fires. Therefore, all government efforts are focused on training and prevention. Initiatives such as training courses on prescribed burning, planning and prevention have been implemented.

Wildfire Database

Table 7-5 Number of fires and area burned, 1990-1999 (recorded only for 1999).

Year	Total Nº of fires. On Forest, Other wooded land and other land Nº	Total Area Burned on Forest, Other wooded land and other land ha	Area of Forest Burned ha	Area of Other wooded land burned ha	Human causes %	Natural causes %	Unknown causes %
1999	31,245	12,749,475	4,540,893	8,208,582	99,9	0,1	0

Use of prescribed burns to achieve resource management objectives

Bolivia has standards for burning, established by the Ministry of Sustainable Development and Planning, which emerged due to traditional fire use by rural communities. These standards provide rules for conducting burns and take into account factors such as ideal environmental conditions (absence of wind, high humidity, low temperatures) and preventive measures such as building fire breaks, as well as monitoring fire progress and intensity. Currently most efforts are focused on training community leaders in order for them to disseminate information to their communities.

Public policies affecting wildfire impacts

The most important fire users in Bolivia are farmers and cattle ranchers who use burns as an agricultural tool for land clearing and pasture improvement. Another group of users whose impact is considerable, consists of land settlers and communities that use fire as a tool for "cleaning" their fields and converting land to agriculture and cattle raising. These people are the main focus of government policies and programmes in the form of technical bulletins, flyers and radio and press ads on the advantages of controlled burns and, ultimately, the total elimination of burning.

Also worth mentioning is the fact that Bolivia does not have assistance programmes or economic incentives for producers to modify or eliminate fire use, or switch to alternative and less harmful practices.

Sustainable land use practices used in Bolivia to reduce wildfire hazards and wildfire risk

A study carried out in 1999 by the BOLFOR Project shows that voluntary forest certification seems to be a strong incentive for forest protection. Concessions managed by forestry firms have built strong links with local communities in forested areas and thus have been able to coordinate actions to detect and successfully control fires before they reached the forest. This is one example that the sustainable forestry model is working.

On the other hand, the inclusion of municipal governments in the forestry model, through local social groups, has helped to demonstrate that forest resources are valuable and should be protected by the communities themselves.

Community involvement in fire management activities

After the 1999 fires, a public and private campaign was started to disseminate the results of the analysis of the damages caused by the fires in the form of seminars targeting cattle rancher associations, municipal forestry units, local social groups, indigenous communities and the general public.

Also, workshops have been presented on prescribed burning at the community level. Posters and bulletins using clear messages have been distributed showing the risks and threats of continued fire. Cooperating agencies have allocated special resources for these tasks, as well as funding courses on the topic of fire management. Such is the case with USAID's Office of Foreign Disaster Assistance, which has coordinated with local institutions to carry out courses in fire fighting for civil defense, park rangers, community leaders and members of environmental groups.

7.6 Fire Situation in Brazil

By
Robert W. Mutch

Fire environment, fire regimes and the ecological role of fire

As the ecosystems of Brazil vary from north to south, so, too, is there a great diversity of fire behavior conditions as one moves from the tropical rain forest, to the caatinga in the northeast, to the cerrado, or savanna in the central part of the country, to the Mata Atlantica, or temperate rain forests along the coast in the east, to the forests of the south. The fire management system that evolves for Brazil must take into consideration the significant differences associated with these major ecosystems. There is a lot known about the fire relationships of the cerrado, less known about fire and the rain forest and even less knowledge available regarding the other ecosystems. The following discussion of fire in the cerrado has been adapted from Coutinho's (1982) paper on the "Ecological Effects of Fire in Brazilian Cerrado".

Cerrado. The cerrado is a complex of plant formations formed by grasslands, intermediate savanna and dry forests. The core zone of distribution of the cerrado is centered on the great plateau of central Brazil, covering 1,500,000 square kilometers. If the peripheral areas to the core zone are included, the total area for this vegetation complex may reach approximately 1,800,000 square kilometers. This enormous area covered with cerrado is a mosaic of different types determined primarily by the pattern and intensity of the fires and the soil types.

Fire is considered to be an important ecological factor in cerrado ecosystems. Charcoal fragments found in the soil of cerrado around Brasilia were carbon dated as being 1600 years old. Thus, fire was already present in this area at least 1200 years before the arrival of the Portuguese discoverers. Anthropological research has shown that people have inhabited central Brazil for more than 10,000 years. Indians undoubtedly used fire for many purposes at the time of colonization. The Caiapos Indians from central Brazil believed that fire was given to them in primeval eras by Bebgororoti, a mythological creature, who brought fire down from the sky during a violent storm. Although Coutinho stated that there are no known scientific records of natural fires in cerrado, others have reported lightning fires in places like Emas National Park. It has been estimated that each area of cerrado in long-settled regions is burned once every two years. This usually occurs during the colder and drier months of May to September. The greatest incidence of fire occurs during July and August. Fires can be widespread during these months throughout the cerrado. In 1991, for example, a prolonged drought contributed to the reported burning of one percent of the state of Mato Grosso. In 1994, 70 percent of Brasilia National Park burned, all of Emas National Park burned and all of the 562,000 hectares of Araguaia National Park burned. Araguaia National Park is located on Ilha Bananal in Tocantins State, the largest fluvial island in the world. All of this island burned as well in 1994. All of these areas are located in the cerrado. Such fires can impair ground and air transportation and cause many problems for people with respiratory diseases.

Tropical rain forest. Although the rain forest is generally believed to have little incidence of fire due to the moist environment, there is evidence that fires can occur under the right conditions. These fires are most often related to human activities, since tropical thunderstorms are accompanied by heavy rains that preclude the ignition of fires by lightning most of the time.

The abundance of charcoal of mid- to late-Holocene origin commonly found in rain forest soils of the upper Rio Negro in Venezuela indicates that fire has been a disturbance factor for a long time (Sanford and others 1985). The Rio Negro study concluded that episodes of fire disturbance have modified the forest during the mid- to late-Holocene, perhaps as a result of different climatic circumstances, perhaps as a result of human intervention alone, or possibly as a result of the interaction of human disturbance and climate.

Burning in the Amazon region today is primarily associated with the clearing of forests for agriculture, pastures, logging and other purposes. Fearnside (1990) reported that by 1988 approximately 400,000 square kilometers, or 8 percent of the Amazon region, had been cleared and the cleared area was increasing at about 35,000 square kilometers annually. In the Amazon region, most of the deforested areas are maintained in cattle pasture. The large ranchers account for about 75 percent of the clearing for pastures and small farmers account for the rest. Fearnside (1990) reported that pasture burns are done every 2-3 years in cattle pastures that are being maintained for grazing. Uhl and Buschbacher (1985) have described the increased probability of fire spreading from cattle pastures into surrounding forests where selective logging has occurred.

Amazonian fires have been classified into three major types (Nepstad et al 1998):

- **"Deforestation fires"** are associated with forests that are burned following clearcutting to prepare the land for pastures, agriculture, or plantations.
- **"Forest surface fires"** occur when fires escape into standing primary or logged forests, burning surface fuels on the forest floor.
- **"Fires on deforested land"** refers to fires burning in pastures, secondary forests and other vegetation on lands that had once been forested.

Fires can be further divided into those fires ignited intentionally for pasture and land management purposes and those fires that accidentally escape into adjacent areas.

Of the three types of fires in the Amazon, the fires associated with deforestation have the greatest ecological impacts because they lead to the rapid replacement of rain forest species by more fire prone vegetation (Nepstad et al 1998). This is a serious feedback cycle in which the flammability of Amazon vegetation increases over time.

Although the environment of the natural rain forest is not conducive to the ignition and propagation of fires, once the forest has been cut and allowed to dry for several weeks its flammability is greatly increased. Consumption rates of the biomass vary based on conditions at the time of burning. The 1982-1983 fires in East Kalimantan in Borneo demonstrated how serious fires can occur in tropical forests following severe drought and disturbance. Repeated burning in the Amazon region can lead to the dominance of the vegetation by fire resistant palm species and grass.

Forests of the Northeast. Ecosystems of the Caatinga Region and deciduous forests of the northeast are found in a hot, dry and thorny landscape (Ministry of Environment 1996).

Temperatures here are very elevated, relative humidities are low and the climate is especially arid. Ecosystems of this region occupy an area of 939,391 square kilometers. Degradation of the natural vegetation has occurred primarily due to exploitation of forests for wood, conversions of vegetation to cattle pastures and the effects of fires.

The Atlantic Forest (Mata Atlantica). Although this ecosystem is also a rain forest, it is not an extension of the Amazon Forest but an entirely different plant formation (UNDP 1993). It contains an exceptional biological diversity. At the time of Brazil's discovery, the Atlantic Forest had an area of 1.5 million square kilometers which extended almost continuously along the Brazilian coastline. Due to its closeness to population centers with their demand for wood, presently there is only 10 percent left of its original extent. The remaining forest is highly fragmented and contains many threatened species of plants and animals. The Atlantic Forest is quite susceptible to fire and current policy calls for its direct protection from fire.

Forests of the South. The ecosystems of the pine forest region cover an area of 220,363 square kilometers (Ministry of Environment 1996). Elevations here are generally greater than 500 meters and it has a temperate climate without a pronounced dry season. This is the area of the Parana pine, a species with high economic and landscape values. The remaining native vegetation represents only 23 percent of the total area. Use of the land in this area is largely dedicated to agriculture.

In the extreme south of Brazil, south of the pine forest region, is an area of about 203,875 square kilometers that consisted in the past of seasonal forests. About 50 percent of the area is still covered by some form of native vegetation. Grassy areas, shrubs and planted forests are also found here.

Narrative summary of major wildfire impacts on people, property and natural resources that occurred historically

Wildfires in Brazil's diverse ecosystems have produced many adverse effects for all segments of society:

- Atmospheric pollution.
- Smoke effects on public health in critical areas.
- Disruption of air and ground transportation services by smoke, affecting private citizens, commercial and civil aviation and the Ministry of the Air Force.
- Potential contributions to global climate change through the production of "greenhouse gases".
- Reduction in water quality.
- Disruption of electric power transmission.
- Threats to life and property.
- Loss of biological diversity.
- Threats to commercial plantations of trees.

Narrative summary of major wildfire impacts on people, property and natural resources during the 1990s

Economic losses due to accidental fires, in some areas of the Arc, reached about R$ 200.00/year to small owners, R$ 500.00/year to middle ones and R$ 9,000.00/year to big farmers. As far as public health is concerned it is estimated that the number of people hospitalized with breathing problems increases up to 3.2 percent during the burning period in Amazonia when it is compared to other months. This in turn causes troubles to the population and increases the expenditure in the health sector.

Forest fires have led to interruptions in the electrical energy supply. For example, in 1995, in the area of ELETRONORTE forty-seven interruptions took place that caused great losses to this company since the average value of each one is R$ 43,360.00. These disruptions in energy supply also impose heavy losses to society as a whole. These fires produced a great quantity of smoke and caused huge problems to air traffic, even leading to the closure of airports during critical periods. For instance, in the late 1990s airports in Rio Branco, Porto Velho, Conceição do Araguaia, Carajás, Marabá and Imperatriz were closed for a total of 420 hours. This caused a total loss of about R$ 3.15 million during the period. In addition to these monetary losses, there is a biodiversity loss as well.

The wildfires in the State of Roraima in 1998 can be used as an example of some of the fire management responses that would benefit from improvements in the future (Mutch, R. W. et al 1999). Bombeiros and others also called attention to the following issues that impeded a more successful response to the fires in Roraima:

1. Outside resources were not mobilized quickly enough to the fires to arrive early and keep the fires small. Many fires were burning in January, February and early March with only one Captain and 10 firefighters from Roraima available for fire suppression! The situation was overwhelming by the time bombeiros arrived from other States. Bombeiros worked hard under these difficult circumstances, but it was the arrival of rain later in March that kept the situation from becoming much worse.
2. There was not an integrated communication system on the fires, allowing all of the different organizations to talk to each other with a single radio with multiple channels to cover all frequencies. Each organization had its own internal communication system, but not a common system with each other. Also, there was not an effective communication link between the Area Command Center in Boa Vista and the field Command Centers.
3. Bombeiros did not have the right type of equipment for rain forest conditions; and there was not enough equipment.
4. There were not enough firefighters to be successful under the prevailing conditions in Roraima. There were maybe 700-1000 people engaged in the firefighting operations. Estimates ranged in the neighborhood of 10,000 or more firefighters needed by the time people showed up in mid-March. A smaller number of trained and well-equipped firefighters arriving in January and February could have greatly reduced the severity of the impacts and the costs.
5. Many more firefighters need to receive wildland fire training prior to the fire season, including bombeiros in the Amazon region whose training is more geared to structural firefighting. Volunteer brigades at the local level also need to be equipped and trained to serve as first responders to fire emergencies.
6. Air support was not continuously available to meet the needs of firefighters on the ground. The military diverted helicopters to missions other than the support of firefighters.

7. Farmers kept burning even during the burning ban when the fire danger was so high. It took the threat of arrest to convince the farmers to stop burning. (Note: The Yanomani tribe, on the other hand, said they would not burn until told by the bombeiros that it was okay to burn again).
8. The Command Center in Boa Vista tried to produce daily plans, but the planning process was more on the order of reporting what had occurred rather than directing priorities for future operations to guide field commanders. More experience and training in the ICS process would help to overcome this shortcoming. People should fill the ICS positions within Command Centers based on knowledge of firefighting operations and not on military rank.
9. There was not a process in place for the daily evaluation of the performance of firefighters on the various fires. Evaluations should be conducted to ensure that firefighters are meeting incident objectives.

These lessons learned from Roraima in Brazil are somewhat indicative of strengths and problems experienced on the fires in Mexico and Central America. Public policies should be developed to build on the strengths of the Roraima response and minimize the negative features. Of course, policies that serve as incentives for the local people to invest more in fire prevention and sustainable land use practices are critically important as well.

Fire management organization

The numerous adverse effects of uncontrolled fires led to the creation of PREVFOGO (A National System for Wildland Fire Prevention and Suppression) through the Federal Government's Law Decree No. 97,635, dated April 10, 1989. In a Document signed by IBAMA President Tania Munhoz in November 1990 the objective for PREVFOGO was defined as:

"...systematizing, in an integrated and objective way, the interesting information, including the prioritization of affected areas, the ways of identification of fire and burning focuses in real time, the material and human resources to be mobilized and the integrated communication system. It also envisions the implementation of an appropriate prevention programme, thus guaranteeing the effective reduction of forest fires and burnings in Brazil and their consequences; and disciplining the use of fire through controlled burning based on appropriate technical and scientific knowledge."

What this objective calls for is the development of a systematic fire protection programme for Brazil with all of the essential elements in place to provide future benefits to the diverse sectors of society. Achieving this important goal is a difficult and challenging task, but it is a task that must be accomplished with skill, motivation and continuity of effort. The antithesis of this goal is surely something that no one wants. As Jose de Paiva Netto stated, "the destruction of nature is the extinction of the human race."

The PREVFOGO strategy to produce a systematic programme of fire protection was designed around a network that included:

- A National Center at IBAMA headquarters in Brasilia. The National Center would work in an integrated manner with all public and private organizations involved with firefighting and controlled fires.

- State Centers located at the State Superintendencies of IBAMA or other agencies through agreements. The State Centers would be responsible for implementing fire policies and implementing fire programmes for the States. The effective firefighting actions in the States would be assigned to the Fire Departments, who would be provided with the resources needed to purchase appropriate equipment. Firefighting personnel also would be provided by IBAMA staff and trained volunteer brigades.

- Regional and Municipal Centers would be responsible for firefighting and executive actions in cooperation with the Bombeiros and existing forestry companies in their respective areas.

PREVFOGO is concentrating on five priority areas (Cornacchia and Pedreira 1998):

- Administer rural extension and education programmes with the farmers to reduce the number of wildfires that arise from agricultural burning.
- Develop fire management plans for IBAMA's Conservation Units to use suppression and prescribed fire to minimize adverse impacts on ecosystems.
- Monitor "hot spots" by satellite to provide information on problem areas.
- Provide training in fire prevention and firefighting, aerial firefighting methods for pilots and fire cause determination
- Prepare brigades to carry out actions to prevent and fight wildfires in Conservation Units; and work with enforcement authorities to ensure that regulations are being met.

Individual states in Brazil also have developed plans for the protection of forests from fire (Government of Parana State 1998; Cavalcanti 1998).

PREVFOGO is located within IBAMA's Directorate of Control and Supervision.

Use of prescribed fire to achieve resource management objectives

Prescribed burning is an agricultural or forestry practice that uses controlled fire in order to initiate agricultural activities, or to manage fire-adapted ecosystems. The burning must be done using controlled fire within the natural or planted vegetation under prescribed environmental conditions that allow the fire to be kept within a restricted area, with heat intensity and fire spread that meet management objectives. The burning must be authorized by IBAMA, or by the responsible state agency; and training on proper burning methods is being provided to farmers in the Amazon through PROARCO.

Public policies affecting wildfires and fire management

The Roraima fires underscored the growing realization that forests in the Amazon were becoming increasingly vulnerable to fires in drought years. Fire risk was especially acute in the "Arc of Deforestation" in the southern Amazon where timber harvest, agriculture and other land management practices have greatly increased the flammability of vegetation. This continuous arc is about 3000 kilometers long and 600 kilometers wide. The response of the government of Brazil to this problem was to request a loan from The World Bank in support of a project called PROARCO, a program for the prevention and control of burning and forest fires in the Deforestation Arc. Planning for the project began in the spring of 1998 and The

World Bank approved a loan for US$ 15 million on September 10, 1998, to prevent and control large-scale wildfires in the southern part of the Brazilian Amazon. The programme is jointly administered by IBAMA, the Brazilian Government's official Environment Agency and the Ministry for the Environment, Water Resources and the Amazon Region.

PROARCO was designed around the following components (Ministry for the Environment and IBAMA 1998):

- Monitoring agricultural burning and forest fires (including the monitoring of fire risk).
- Enforcing regulations regarding the use of fire in land management.
- Preventing forest fires (including the training of farmers to burn using appropriate precautions and safeguards).
- Combating of forest fires.
- Establishing a strategic task force (providing overall coordination).

PROARCO was expected to reduce the occurrence of large scale, damaging fires through fire prevention and fire suppression; more sustainable land use practices; improved partnerships among federal, state, municipal, and non-governmental organizations and agencies; de-centralization of actions to the local level; and better protection of the Amazon rain forest. The year 2000 indicated that many of the planned actions were beginning to produce positive results (Personal communication with Dan Gross, World Bank, 2000):

The year 2000 was significant in terms of protection of the Amazon from wildfires. The disastrous fires of 1997-1999 prompted an unprecedented response in the Amazon region. The Federal government launched a coordinated attack on illegal clearing and burning in the Amazon region. The National Environment Agency, IBAMA, and state environmental agencies (led by the State of Mato Grosso) greatly stepped up their protection activities. The PREVFOGO program also stepped up its efforts to prevent illegal occupation, clearing and burning inside protected areas such as national parks.

PROARCO was an important factor in these activities. In September 2000, 3 helicopter bases were established in strategic locations across the Amazon. The radius of operation was based on the operational range of the aircraft and provided coverage of the entire Deforestation Arc. Under this arrangement, daily sorties were flown with teams from IBAMA and State environmental agencies, using the latest satellite imagery to spot areas of recent forest clearing. There was a simultaneous campaign on the ground. Both the aerial and ground teams visited hundreds of rural properties to determine whether the landowners had followed required procedures to obtain permits for clearing forest and burning the slash.

The result was that many landowners, accustomed to clearing and burning off large tracts of land without taking out the necessary permits, found themselves subject to large fines and legal action. This had a dampening effect on new clearings and burning of forest. The State of Mato Grosso and IBAMA jointly prohibited all burning between July 1 and August 31, 2000. The result was a dramatic decrease in the incidence of fires in Mato Grosso and a lesser reduction in other areas. Other states also underwent a reduction in burning.

PROARCO also sponsored the creation, training and equipping of some 45 municipal fire brigades. In nine municipalities in Mato Grosso, local fire brigades worked to prevent burning, put out small fires and supervised controlled burning when permitted. The State of Tocantins spontaneously formed 27 fire brigades with its own resources in addition to three brigades supported by PROARCO. The States of Rondonia and Acre also formed brigades.

Fire brigades received training from the State Military Fire Companies in Amazonas, Rondonia, Acre, Mato Grosso and Tocantins. These local brigades helped suppress small fires that could have burned out of control into other properties or forested land.

The results of these efforts were that, during 2000, there were far fewer fires than in previous years across the Amazon, but particularly in areas touched by these programs. The incidence of respiratory disease was dramatically lower in areas where data are available; and there were indications that the incidence of airport closures due to smoke and smog was down sharply from previous years.

Sustainable land use practices used to reduce wildfire hazards and wildfire risks

Brazil has a structure to organize sustainable forest management practices that are fundamental in supplying the internal and external markets for natural resources. In this regard, a public network is being organized under a concession system, effective administration system and a monitoring system. Brazil also has established a network of preserved areas to assure the perpetuation of biodiversity as well as assure their use by traditional peoples. In these areas it is possible to start a program of sustainable eco-tourism which will attract people to the Amazon and other areas who can learn more about the importance of the conservation of nature.

Since agricultural practices of fire use in tropical countries can degrade forest resources over time, there is a compelling need to enlist the small farmer as part of the solution in developing a conservation ethic. Some countries have used incentives effectively in this regard to gain the commitment of farmers towards more sustainable land use methods. Efforts to change the model of natural resource uses from their current extensive exploitation in the Amazon to a more sustainable model will require the better integration of public policies aimed at promoting economic development and settlement with those designed to conserve natural resources (Nepstad et al 1998). The authors called for **policies that provide for increased agricultural productivity on deforested lands while at the same time providing disincentives for reckless uses of forested lands.**

Finally, Brazil invests in a major forest vigilance system known as SIVAM. SIVAM will be a fundamental tool to obtain information on the region and actually monitor logging and illegal deforestation. It will allow real time observation and monitoring in order to properly take care of the forests.

Community involvement in fire management activities

The main response to improve fire prevention efforts should come from society, particularly from rural areas. Training farmers in more careful fire use can result in better protection for individual farms and neighbouring farms. PROARCO is providing leadership in the Amazon to provide such training to improve the use of fire in agriculture; and reduce the negative fire impacts on agricultural lands and on natural resources.

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7.7 Fire Situation in Chile

By
Patricio I. Sanhueza
Fire Management Department, CONAF

Fire Environment, fire regimes and ecological role of fire in Chile

Chile, South America's longest country, with a length of 4,267 kilometers and a continental area of 756,945 sq. Km (excluding the Chilean Antarctic Territory), has developed an important forestry sector in recent years. Forestry holds a significant position in the country economy. Forty-five percent of Chile's territory is subjected to forest fires. There are soils preferentially suited for forestry; and forests cover 20.8 percent of the country's area. The native forests occur mostly in the Andes Range, between the central and deep south. A vast commercial plantation area (2.1 million hectares) covers mainly the Coastal Range, where Monterey pine and Eucalyptus sp. plantations sustain 90 percent of the Chilean forest industry.

With a Mediterranean climate and a long dry season, Chile's single forest fire season normally occurs between October and April, with a period of maximum activity between December and February.

On average, some 5,200 forest fires are recorded each season, mainly in Region IV, approximately 500 kilometres north of Santiago, to Region X (city of Puerto Montt). Further north, vegetation is scarce or non-existent in the Atacama Desert. In the southern Regions XI and XII, Coyhaique and Punta Arenas cities, the abundant moisture and low population density (fewer than 0.7 inhabitants per square kilometer) protect the lush, thousand-year-old *Humid Temperate Native Forests* from fires.

Fires affect an average of 52,400 hectares each season, destroying mainly native vegetation (95.7 per cent). This vegetation is composed principally of pasturelands, scrubland, shrubs and, to a lesser degree, plantations. The average size of fires has dropped from 38.2 hectares in the 1960s and 1970s to around 9.1 hectares in the 1990s. There are fewer large fires: 87.1 percent of the fires are less than 5.0 hectares and 92.4 percent are under 10.0 hectares.

Figure 7-2 Fire in Monterey pine and Eucalyptus sp. plantations.

Following Brown and other's fire regimes description, the damage in the old *Humid Temperate Native Forests* (Nothofagus sp. and other species) applies to the **Understorey fires and/or Mixed severity fire regime classes.** In the first one, the fires are generally non-lethal to the dominant vegetation and do not substantially change the structure of the dominant vegetation. In the second one, severity of fire either causes selective mortality in dominant vegetation, depending on different tree species susceptibility to fire, or varies between understorey and stand replacement.

The fires in young Monterey pine and Eucalyptus sp. plantations, *Mediterranean Native Forests* (*Bosque Esclerófilo*), shrublands and grasslands apply to the **Stand replacement fire regime class.** Fires here kill aboveground parts of the dominant vegetation, changing the aboveground structure substantially. Approximately 80 percent or more of the aboveground dominant vegetation is either consumed or dies as a result of fires.

Finally, the **Non-fire regime class** is represented in *Humid Temperate Native Forests* in high elevations of the Andes Range, in wet sites and in the deep south of the country.

National definition of what constitutes a forest fire: Any fire which spreads in an uncontrolled manner, without limits, on wildlands and interface areas, which affects any kind of vegetation, structures, powerlines, railroads, facilities, etc.

Narrative summary of major wildfire impacts on people, property and natural resources that occurred historically

Since southern and deep southern colonization began in 1850, people have used fire to clear land for grazing and for agriculture. The impenetrable native forests, with their long rotations, were an obstruction to agricultural development. Clearing fires became forest fires, which lasted for days, months and, in some cases, for more than a year. The forests suffered as they were burned often. There was no technology, knowledge, means, or organization for fighting the fires. The main damage has been soil losses and fertility losses because of the erosion.

Figure 7-3 Fire effects in *humid temperate native forests*.

In the 20th Century, the fires still affected the central area native forests, changing the natural composition of species, damaging timber and influencing the economical status of the local people. Also, the wildfires caused fatalities, structure losses and affected the biodiversity, wildlife and the ecology in general. Interface fires also have been a problem, since they disturb normal life in the main Chilean cities of Valparaíso, Viña del Mar and Concepción.

Narrative summary of major wildfire impacts on people, property and natural resources during the 1990´s

In comparison with the 1980´s, during the 1990´s Chile increased its occurrence of fires by 13 percent, from an average of 4,800 to 5,530 fires per year. The average of 5,200 fires/year was surpassed and the level of over 6,000 fires was reached during the 1992-93, 1993-94 and 1998-99 fire seasons. Nevertheless, the average size of fires dropped from 11.3 to 9.1 hectares/fire, due to improved strategies, organizational methods and co-operation among the firefighting partners.

In terms of damage, several droughts during 1992, 1993, 1997 and 1998 caused enormous costs to Chile in terms of losses in environment, facilities and miscellaneous structures. The “El Niño Southern Oscillation” brought one of the most severe fire seasons at the end of the1990´s. During the 1997-1998 fire season, the fire behaviour was extreme in the deep south (Regions X and XI).

The fire problems moved during the 1998-1999 season to the central part of the country (Regions VI to IX) and caused the most difficult fire season in Chile’s history (6,830 fires and 101,691 hectares burned). In this season, the “La Rufina” fire in Region VI burned 25,400 hectares, 14 houses, cattle and powerlines, among other losses.

Figure 7-4 CONAF and Army operations at “La Rufina” fire.

During the 1990´s, the environmental conditions also caused threats to fire crews. In 30 years, Chile has recorded 33 fatalities (firefighters, crew bosses, helitackers, pilots and, staff personnel); and 33 percent happened during the decade of the 1990s.

The local and urban border communities also have been at increased risk, because interface fires are more common than in the past. Urban development towards the forest in such cities as Concepción, Valparaíso, Viña del Mar, Santiago, Temuco and local condominiums within the wilderness areas has confronted people with fires. In addition, this new situation has increased the risk to fire personnel. The fires are more complex to fight, due to the mixture of different fuels and structures in the interface. Often this situation forces the overhead team to change the fire strategies to safeguard life and property.

During the late 1990s arson fires increased substantially in certain southern Regions, impacting Monterey pine plantations, people and private property.

Figure 7-5 Homes threatened by fires near Concepción.

Fire management organization used in Chile

Fire Control is a governmental- by law- responsibility, carried out by the Corporacion Nacional Forestal *(CONAF). CONAF* is the country's Forestry Service, an organization created in 1970 and attached to the Ministry of Agriculture. It has the mission to "G*uarantee for society the sustainable use of forest ecosystems and efficient management of the National State-owned protected Wilderness Areas System, with a view to contributing to the improvement of quality of life for present and future generations"*. The fulfilment of this mission is achieved, among others, by protecting forest ecosystems from the action of harmful agents, such as wildfires.

CONAF carries out an organized Forest Fire Management Programme through actions of prevention, pre-suppression and suppression throughout the country. With the support of the United Nations, U.S. and Canadian agencies, Chilean specialists have been able to visit other countries and receive training with the most advanced technologies. In turn, Chileans hosted specialists from those countries. This exchange of specialists has been helpful in building a successful programme.

As the only government agency in the forestry sector, *CONAF* has implemented a single national standard in forest firefighting operations. This has been the first key to success.

The second key has been the active participation of the private forestry sector, which committed to protecting its own lands according to forestry regulations beginning in the 1980s. Sixty-eight per cent of Chile's land is in private hands, so this is a significant factor. Large and medium-sized firms, adopting and adapting the government's expertise, are implementing their own forest fire protection programmes.

Based on this momentum, *CONAF* has continued to protect the country's forest heritage, such as parks and forest reserves, directly and, more importantly, to do so in a secondary role with small and medium-sized firms.

Figure 7-6 Government-private sector helitack crew, near Lautaro.

Without doubt, it is this relationship between the two forest protection participants in Chile, which constitutes our third key to success in protecting forest resources.

Each season, *CONAF* and the forestry firms programme the operation of a total of 140 ground hand/engine crews, 24 helitack crews, in addition to such pre-suppression and co-ordination resources as 153 motorcycle prevention specialists, 25 dispatch centres and 241 lookout towers.

The ground units are typically composed of 8 to 20 completely equipped and trained professional firefighters who operate manual tools, fire equipment and mechanised equipment (portable chain saws and motor pumps) with high safety standards. They are transported in light and medium vehicles (4x4 vans, minibuses, buses and trucks) and tanker trucks; and applies Class A suppressant foam.

Figure 7-7 Typical initial attack ground crews.

In Air Attack, during each fire season, a large fleet of powerful initial attack resources is operated. Twenty-two light airtankers, *PZL, M-18 Dromaders, Air-Tractors (AT602/802) and Turbo Thrushes*, work together with large airtankers such as the Canadair CL-215 and the SP-2H Neptune.

Also 25 helicopters, such as Aerospatiale, SA 316B/SA-315B, Bell 206 B, L-III, 204/205-A-1/, 407/, 222/209 and Ecureuil AS-350s, work in Helitack equipped with Bambi-buckets, Helitanks and elite personnel. This air-mobile approach has demonstrated outstanding results and efficiency in containing and controlling a large number of fires in the country.
During the 1999-2000 fire season, Chile will begin to operate its first Hispanic female Helitack crew.

Figure 7-8 Some of the air attack fleet ready for fires.

Wildfire Database

Table 7-6 Numbers of Fires and Area Burned.

Year	Total No. of Fires on Forest, Other Wooded Land & Other Land	Total Area Burned on Forest, Other Wooded Land & Other Land ha	Area of Forest Burned ha	Area of Other Wooded Land Burned ha	Human Causes (*) No.	Natural Causes (*) No.	Unknown Causes (*) No.
1990	4,114	25,545	7,308	18,237	3,649	n/reg.	465
1991	5,193	50,273	13,578	36,695	4,695	n/reg.	498
1992	4,786	24,224	3,807	20,417	4,370	n/reg.	416
1993	6,114	49,981	16,343	33,638	5,588	n/reg.	526
1994	6,210	65,606	21,052	44,554	5,719	n/reg.	491
1995	5,354	26,174	7,588	18,586	4,915	n/reg.	439
1996	5,886	40,082	19,083	20,999	5,392	n/reg.	494
1997	5,487	43,595	20,150	23,445	5,311	n/reg.	176
1998	5,329	90,888	64,147	26,741	5,057	n/reg.	272
1999	6,830	101,691	50,898	50,793	6,359	n/reg.	471

(*) Only 9.1 percent of the fire-causes are investigated.

Total number of fires and area burned in Chile between 1990 and 1999 on forest, other wooded land and other land. The data cover each fire season, i.e. 1990 corresponds to the 1989/1990 fire season. n./reg. = not registered.

Most fires are caused by human activities. Lightning or other natural causes are insignificant or not registered. People's carelessness while passing near forest or shrub areas causes 30.7 percent. Carelessness while using fire in forestry and agricultural activities is significant, with 10.7 percent. Intentional activities cause 36.1 percent, recreation sports and children playing with fire cause 9.4 percent, other activities and other causes 4.1 percent and unknown causes account for 9.0 percent.

The wildfire database is managed by computer and paper records. The fire database will be available in CONAF´s website: www.conaf.cl at the end of year 2000).
Overall average annual number of fires: 5,200 fires
Overall average annual fire size: 10.3 hectares
Average annual number of fires in the 1990s: 5,530 fires
Average annual fire size in the 1990s: 9.14 hectares

Use of prescribed fire to achieve resource management objectives

In Chile, the use of fire (average of 300,000 hectares /year) has contributed to the development of the country, but it also has damaged natural resources, either intentionally or not. The initial objective was to make some areas suitable for agriculture and livestock raising. However, the global results have been negative for the country.

The use of fire has created conditions to have many fires burning thousands of hectares of forest. Due to these results, many laws have been enacted to control and regulate the use of fire in forestry and agricultural activities; and severe penalties have been established for infractions. In addition, these laws have defined suppression responsibilities and the private forest owner's protection obligations. The principle legislation starts with the Penal Code (1874), followed by the "Forest Law" (1931) and the Supreme Decree 276 (1980). This last law stated the concept of *"controlled burning off*" to eliminate vegetation in a direct way, limited to a previously specified area, a specific day in the fire season and in compliance with stated technical rules to keep fire under control (firebreaks, burning methods, personnel support, etc).

Figure 7-9 Controlled burning off in the VIII Region.

In 1990, the concept of "prescribed burning off" was introduced for special counties that contained high risk and dangerous areas. These counties could develop hazard reduction burn plans that were signed by a forester.
Today the current policies and practices of the main forest companies are to reduce the use of fire as much as possible, limiting it to those circumstances where there are no other options. Alternative practices of using mechanical methods (chippers/biting machines, etc,) are carried

out, being more acceptable by local communities. Improving the controlled application of prescribed fires and transferring this knowledge to small landowners that use fire is the main goal of *CONAF* for the 2000´s.

Public policies affecting wildfire impacts

The 1976, 1979 and 1982 laws describe *CONAF*'s functions. The enforcement and control of all regulations that rule these matters, besides the investigation of wildfire causes, is carried out by the *Carabineros de Chile* Forest Police. In addition, *CONAF* protects small forest owners who have not enough capacity to protect their own holdings; and *CONAF* assists medium and large private companies in fire protection through various forms of coordination, support and participation. To assure the fulfillment of this policy, *CONAF* has set up fire dispatching and firefighting priorities throughout Chile.

On the other hand, according to the Decree Law 701 regulations, private forest owners must submit a wildfire protection plan for their property; including prevention, pre-suppression and suppression activities, which are reviewed and controlled by specialists from *CONAF*.

Besides the prescribed fire policies, *CONAF's* goals for 2000 are focused on improving local Government participation in prevention and suppression activities. Communities will be encouraged to adopt specific protection programmes to incorporate more technology in their operations and to safeguard human lives.

Figure 7-10 Fire prevention technology transfer day in Region IX.

Sustainable land use practices used in Chile to reduce wildfire hazards and wildfire risks

Law rules all forest management activities on forestland in Chile. The private owners must submit and follow a *Forest Management Plan* completed by a forester for their property, including forest regulation and protection activities. In these practices, inside and perimeter firebreak construction is considered. Also, the owners must have an annual maintenance programme for firebreaks.

In Monterey pine and Eucalyptus sp. plantations, where pruning, thinning and harvesting are conducted, slash is managed to reduce the fuel load.

Perhaps the most important land use practice to reduce wildfire risks is the one that reduces the use of uncontrolled fire in forestry and agricultural practices.

As in other countries, the development of green firebreak programmes that introduce less flammable species are in progress, which will help agro-silvicultural programmes for small owners.

Community involvement in fire management activities

The local community involvement in fire actions is one of *CONAF's* main goals, because people cause almost 100 percent of fires.

The communities actively participate in special *Prevention Programmes* throughout fire-prone areas of the country. There are *Recreational Journeys* with sports activities (soccer games), fire prevention painting festivals, "traditional Indian folk presentations" (music, dance and songs) and focus group workshops with neighborhood committees. *CONAF's* prevention specialists (anthropologists, elementary/high school teachers and foresters) work as facilitators to help people solve on-site fire problems.

Figure 7-11 CONAF´s prevention officer working with the future.

Using the county network programmes, local communities make their own firebreaks in high-risk interface areas every fire season.
Finally, following a *CONAF* on-site theater example where the shows are set up in high occurrence fire zones, local communities now have their own plays for their neighborhoods.

8 Conclusions

Through the FRA 2000 process, FAO was able to close out the 20th Century by instituting a system for collecting meaningful fire data for developing countries. Although the submission of wildfire data on fire numbers, area burned and causes fell short of expectations, the importance of regularly recording and evaluating such information has been established with Member countries. Strategic advantages accrue to countries when they regularly report, record, evaluate and disseminate fire statistics on national, regional and global levels. Examples have been presented in this report demonstrating that even the most basic annual information on area burned by wildfires can provide insights into making appropriate fire management programme adjustments directed at more sustainable resource management.

In addition, many countries are seeking ways to improve their fire management organization by instituting a more comprehensive fire protection system (see **Appendix 1** for a model that many countries are following).

It is apparent in observing the results of fire database development efforts like those enacted by *Silva Mediterranea* that individual country data needs can be met while still providing a consistent format in regional reporting. In addition, the *Silva Mediterranea* process underscores the value of establishing the initial database with basic and essential information, with the realization that more complex requirements can be added at a later time. Another principle demonstrated by Mediterranean countries is that an effective fire database is dependent on countries developing an internal commitment to regularly recording and reporting fire statistics to satisfy national and regional needs.

This assessment of the global forest fire situation revealed strengths and weaknesses associated with sustaining the health and productivity of the world's forests when threatened by drought, wildfires and an increasing demand for natural resources. Before describing some of the positive outcomes in more detail, it may be instructive to enumerate the current state of fire management practices throughout the different Regions:

- Wildfires during drought years continue to cause serious impacts to natural resources, public health, transportation, navigation and air quality over large areas. Tropical rain forests and cloud forests that typically do not burn on a large scale have been devastated by wildfires during the 1990s.

- Many countries, and regions, have a well-developed system for documenting, reporting and evaluating wildfire statistics in a systematic manner. However, many fire statistics do not provide sufficient information on the damaging and beneficial effects of wildland fires.

- Satellite systems have been used effectively to map active fires and burned areas, especially in remote areas where other damage assessment capabilities are not available.

- Some countries still do not have a system in place to annually report number of fires and area burned in a well-maintained database, often because other issues like food security and poverty are more pressing.

- Even those countries supporting highly financed fire management organizations are not exempt from the ravages of wildfires in drought years. When wildland fuels have accumulated to high levels, no amount of firefighting resources can make much of a difference until the weather moderates (as observed in the United States in the 2000 fire season).

- Uncontrolled use of fire for forest conversion, agricultural and pastoral purposes continues to cause a serious loss of forest resources, especially in tropical areas.

- Some countries are beginning to realize that inter-sectoral coordination of land use policies and practices is an essential element in reducing wildfire losses.

- Examples exist where sustainable land use practices and the participation of local communities in integrated forest fire management systems are being employed to reduce resource losses from wildfires.

- In some countries, volunteer rural fire brigades are successful in responding quickly and efficiently to wildfires within their home range ; and residents are taking more responsibility to ensure that homes will survive wildfires.

- Although prescribed burning is being used in many countries to reduce wildfire hazards and achieve resource benefits, other countries have prohibitions against the use of prescribed fire.

- Fire ecology principles and fire regime classification systems are being used effectively as an integral part of resource management and fire management planning.

- Fire research scientists have been conducting cooperative research projects on a global scale to improve understanding of fire behavior, fire effects, fire emissions, climate change and public health.

- Numerous examples were present in the 1990s of unprecedented levels of inter-sectoral and international cooperation in helping to lessen the impact of wildfires on people, property and natural resources.

- Institutions like the Global Fire Monitoring Center have been instrumental in bringing the world's fire situation to the attention of a global audience via the Internet.

National and International Initiatives

Between 1998 and 2000, several national and international initiatives related to wildland fire prevention, preparedness, management and response were continued or initiated:

1. As a follow up to the FAO expert consultation *Public Policies Affecting Forest Fire*, Rome, October 1998 and the *Rome Declaration on Forestry*, as adopted by the Ministerial Meeting on Forestry, FAO, 9 March 1999, FAO initiated the update of the *Wildland Fire Management Terminology* and the preparation of the *Special Report on Forest Fires* within the Global Forest Resources Assessment (FRA 2000). With the global compilation of

fire statistics and narratives by country, the comprehensive report will provide a basis for understanding the global fire situation in the 1990s.

2. As a consequence of the fire and smoke episode of 1997-98 the *Global Fire Monitoring Center* (GFMC) was established as a contribution of the German government to the UN family, particularly to the UN *International Decade for Natural Disaster Reduction* (IDNDR). The GFMC provides global fire documentation, early warning and monitoring of fires and supports decision and policy makers. It is accessible through the Internet. The GFMC was inaugurated at FAO's expert consultation *Public Policies Affecting Forest Fire* in October 1998.

3. The *ECE/FAO/ILO Team of Specialists on Forest Fire* has operated since the 1980s. The team's main task is to provide a critical link in communication and co-operation among fire scientists, managers and policy makers. The main activities embrace (1) the production of International Forest Fire News (IFFN) in support of the Global Fire Monitoring Center (GFMC); (2) organization of seminars; and (3) promotion of synergistic collaboration among governments, non-government institutions and individuals, especially science and technology transfer. The scope of the work of the Fire Team includes the countries outside the ECE region, because there is no similar institutional arrangement available in other FAO regions. The co-ordination of the Team is based at the GFMC.

4. The *International Strategy on Disaster Reduction* (ISDR) is a follow-up arrangement of the IDNDR. From the beginning of the IDNDR and particularly following the World Conference on Natural Disaster Reduction (Yokohama, Japan, 1994) and the Geneva Forum (June 1999), the international community of fire scientists and managers formulated their programmatic visions to cope with disaster fires at national, regional and international scales. These efforts shall be implemented by the International Strategy on Disaster Reduction (ISDR) under the UN Interagency Task Force for Disaster Reduction. In October 2000 the Interagency Task Force established a Working Group Wildland Fire. Starting in 2001 this group will establish an international forum for all UN agencies and programmes and for international organizations, including the civil society and the NGOs. The Working Group is coordinated by the Global Fire Monitoring Center.

5. The World Health Organization (WHO), supported by the GFMC, took the initiative to develop guidelines for the protection of human health threatened by emissions from forest and other vegetation fires. The *Health Guidelines on Vegetation Fire Events* were published as a joint activity of WHO, UNEP and WMO.

6. The UNESCO *International Scientific Conference on Fires in the Mediterranean Forests* in February 1999 released a declaration in which the Mediterranean countries were urged to improve the information and data flow to the GFMC. Such changes would create a more complete fire information system, better share expertise and enhance contributions to common international action programmes in fire management and policy development.

7. The *Committee of Earth Observation Satellites* (CEOS), in implementation of the *International Global Observing Strategy* (IGOS), is operating a fire component within the *Disaster Management Support Group* (DMSG). In December 1999, the CEOS *Global Observation of the Forest Cover* (GOFC) programme established a Fire Group in which the major institutions dealing with remote sensing of wildland fire occurrence and fire effects are cooperating.

8. Other international institutions dealing with global wildland fire problems in 1999-2000 included the *ProVention Consortium on Natural and Technological Disasters* founded in 2000 at the World Bank *Disaster Management Facility* (DMF) and the *World Institute for Disaster Risk Management* (DRM), a consortium of the Swiss Federal Institutes for Technology, Virginia Polytech, Swiss Reinsurance and the World Bank, founded in 2000. The *World Conservation Union* (IUCN) continued with its efforts to address global fire issues through partnerships with the *Global Fire Monitoring Center* and the WWF *Firefight Asia* project.

9. The *International Search and Rescue Advisory Group* (INSARAG) proposed the formation of a Wildland Fire Focus at the regional INSARAG Europe-Africa meeting in December 1999 (Germany). At a meeting at the UN Office for the Coordination of Humanitarian Affairs (UN-OCHA) in January 2000, it was agreed that INSARAG activities would encompass search and rescue and broader aspects of disaster/emergency response. This could include a variety of natural and human-made disasters, including wildland fires. At BALTEX FIRE 2000 the formation of the INSARAG Europe-Africa Fire Group, particularly the Subgroup on Wildland Fire, was further developed. The final format of INSARAG Wildland Fire was established at the INSARAG Europe Africa Regional Meeting (Tunisia, November 2000). During its preparation phase, the INSARAG Wildland Fire Subgroup became operational in managing the large forest fire emergency in Ethiopia between February and April 2000. The coordination of a multinational fire fighting task force through the GFMC involved participation of Germany, South Africa, Canada and the United States.

10. Increasingly, countries are developing policies and practices to improve institutional capacities to prevent, prepare for and combat forest fires. The Ministries of Environment and Agriculture in Mexico, for example, have collaborated since the disastrous 1998 fire season to reduce the threat of agricultural burning to forests.

11. In Brazil, measures were taken to stress fire prevention programmes with the public and to train farmers in burning practices that will better control fires used in agriculture.

12. A debate is currently ongoing in the United States to determine the extent to which tree thinning, timber harvest and prescribed burning might reduce fire hazards in the future.

13. In early 2000, a new Directorate of Forest and Estate Fire Operations was set up under the Ministry of Forestry and Estate Crops in Indonesia to strengthen the fire management capabilities of the country.

It is obvious from the many initiatives cited above that important results have been achieved at local, national and international levels to improve methods, technologies and skills in fire management. In the last decade, encouraging experience has been gained in international collaboration in wildland fire science. The development of fire management systems is increasingly based on principles of fire ecology, the involvement of indigenous knowledge and the integration of local communities.

However, increasing demographic and land-use pressures associated with fragile national economies in developing countries, and new problems arising as a consequence of global environmental changes, have led to the unprecedented occurrence of human-caused wildfires

with destructive socio-economic and environmental implications. These trends call for further actions to halt a widespread degradation of forests and other natural resources.
There are many underlying causes for destructive fires; and they are related to many sectors of society and many conflicting policies. Thus, the future development of fire management systems cannot be based exclusively on a mono-sectoral approach. Valuable experience has been gained in the development of national and inter-sectoral fire management strategies in Asia and Africa. For example, experience gained in Indonesia in 1992 in developing a "Long Term Strategy for Integrated Forest Fire Management" led to the creation of the "National Round Table for Fire Management". This "Round Table" approach was first applied in Namibia in 1999 and in Ethiopia in 2000. The participation of all stakeholders involved in fire management, the agencies, NGOs, local communities and the international community, is a prerequisite in defining successful projects that address fire problems at their roots.

A similar approach is underway at the global level. In early 2001, the Interagency Task Force *Working Group Wildland Fire* of the UN International Strategy for Disaster Reduction (ISDR), established in October 2000 and coordinated by the Global Fire Monitoring Center, intends to create a global platform, or *Global Round Table,* of an inter-sectoral nature. FAO and other UN agencies and programmes (such as UNDP, UNEP, WHO, WMO and UNESCO), international bodies and organizations (such as ITTO and the World Bank), NGOs, the civil society and academia will assume joint responsibility through their participation. With this new international and integrated approach it is hoped to create awareness at the highest political and policy-making levels that wildland fires critically affect the survival of biodiversity and humanity. Consequently, it is expected that appropriate attention will be given to global wildland fire issues by leaders in the future.

In reviewing the global fire situation it is apparent that a continued emphasis on the emergency response side of the wildfire problem will only result in future large and damaging fires. The way out of the emergency response dilemma is to couple emergency preparedness and response programmes with more sustainable land use policies and practices. There are a growing number of examples where countries are working closely with local communities and revising resource management policies. Effectively working towards more sustainable forestry practices through community outreach and policy revisions are important parts of the strategy in better conserving natural resources for the betterment of society. Policy makers and the public need to understand that a strategy that only focuses on the emergency preparedness and response side will not be sufficient in the end. Only when sustainable land use practices and emergency preparedness measures complement each other do long-term natural resource benefits accrue for society.

Appendix 1: Fire Management – A model for the operational safeguarding of forest resources from wildfires

Systematic fire management can be thought of as a series of steps, from prevention through mop-up and patrol, which managers can use in any number of implementation alternatives. This series of steps includes the following elements:

- **Fire Prevention:** Prevention activities take on two kinds of efforts--one to reduce fire brand production and one to reduce the susceptibility of the fuel bed to ignite (fuel treatment or modification). Keeping records of known fire causes helps to identify areas for fire prevention campaigns and methods.

- **Fire Presuppression:** These are preparedness activities in anticipation of a fire. This element includes training, equipping and pre-positioning firefighting resources.

- **Detection:** It is very important to detect a fire early when small and report it to the proper authorities. This can be done through infrared scanners, detection towers, aerial reconnaissance and people patrolling. Procedures also should be established for the general public to report wildfires that they encounter.

- **Location:** Fires need to be located accurately on a map to guide those who will dispatch resources to the right area. This can be done as simply as placing pins in the map at the reported coordinates.

- **Communication:** Fire location is typically communicated through radio transmissions to the forces that will control the fire.

- **Dispatch:** The act of receiving the location of the fire, deciding what suppression forces are necessary to send to the fire, sending the forces and supporting those resources once assigned to the fire.

- **Attack:** Having timely access to the fire area, whether by foot, vehicle, boat, or helicopter, is essential. The wildfire situation is evaluated and strategies and tactics are implemented to control the fire at as small a size as possible.

- **Mop-up:** Once the fire spread has been halted, it is necessary to extinguish all flames and cool all heat sources inside the perimeter of the fire. This must be done thoroughly to prevent future escapes.

These principles and elements are the minimum guidelines to be followed in implementing an effective programmeme of fire management to safeguard people, property and natural resources. It also must be recognized that these steps identify an emergency response to suppress wildfires. **Emergency responses, by themselves, will not be successful in the long run unless coupled with sustainable land use policies and practices. Strategies for sound timber harvest practices, settlement, community incentives, prescribed burning and agro-forestry projects that reduce flammability should be developed and integrated on a landscape scale to reduce the threat of future fires.**

Appendix 2: Fire template used to request information from Member Countries

Forest Fire situation in: (name of country)

Fire

Please complete the following information about forest fires and how they are managed. A summary page, using this information, will be included in the FAO Forestry web site. For an example, please see www.fao.org/forestry/fo/country/is.jsp?lang_id=1&geo_id=99&page_id=1179.

Fire environment, fire regimes and the ecological role of fire

In addition to a narrative summary, please include the national definition of what constitutes a "forest fire".

Narrative summary of major wildfire impacts on people, property, and natural resources that occurred historically

Narrative summary of major wildfire impacts on people, property, and natural resources during the 1990's

Fire management organization

Wildfire database

Year	Total No. of Fires on Forest, Other Wooded Land & Other Land No.	Total Area Burned on Forest, Other Wooded Land & Other Land ha	Area of Forest Burned ha	Area of Other Wooded Land and Other Land Burned ha	Human Causes No.	Natural Causes No.	Unknown Causes No.
1990							
1991							
1992							
1993							
1994							
1995							
1996							
1997							
1998							
1999							

Record data for all wildfires, or any fire occurring on wildland except a fire under prescription.

Note: This table needs to be completed only by those countries which do not report annual data on fires using the UN-ECE/FAO/Commission of European Communities questionnaire on forest fires.

Comments:

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Definitions:

Forest: Land with tree crown cover of more than 10 percent and area of more than 0.5 hectares. The trees should be able to reach a minimum height of 5 meters at maturity.

Other wooded land: Land either with a crown cover of 5-10 percent of trees able to reach a height of 5 meters at maturity; or a crown cover of more than 10 percent of trees not able to reach a height of 5 meters at maturity; or with shrub or bush cover of more than 10 percent.

Other land: Land with less crown cover, tree height, or shrub cover than defined under "Other wooded land". Indicate under Comments section if recurring wildfires affect "Other land" by inhibiting regeneration to the "Forest" and "Other wooded land" categories.

Date: ___________
Source of information: ________________________________
Country correspondent: ________________________________
E-mail address of correspondent: ________________________

Is fire database management by computer or by paper records: ________________.
Address of website to access the fire database, if available: ___________________.

Use of prescribed fire to achieve resource management objectives

Public policies affecting wildfires and fire management

Sustainable land use practices used to reduce wildfire hazards and wildfire risks

Community involvement in fire management activities

FRA Working Papers

0. How to write a FRA Working Paper (10 pp. – E)
1. FRA 2000 Terms and Definitions (18 pp. - E/F/S/P)
2. FRA 2000 Guidelines for assessments in tropical and sub-tropical countries (43 pp. - E/F/S/P)
3. The status of the forest resources assessment in the South-Asian sub-region and the country capacity building needs. Proceedings of the GCP/RAS/162/JPN regional workshop held in Dehradun, India, 8-12 June 1998 (186 pp. - E)
4. Volume/Biomass Special Study: georeferenced forest volume data for Latin America (93 pp. - E)
5. Volume/Biomass Special Study: georeferenced forest volume data for Asia and Tropical Oceania (102 pp. - E)
6. Country Maps for the Forestry Department website (21 pp. - E)
7. Forest Resources Information System (FORIS) – Concepts and Status Report (20 pp. E)
8. Remote Sensing and Forest Monitoring in FRA 2000 and beyond (22 pp. - E)
9. Volume/Biomass special Study: Georeferenced Forest Volume Data for Tropical Africa (97 pp. – E)
10. Memorias del Taller sobre el Programa de Evaluación de los Recursos Forestales en once Países Latinoamericanos (194 pp. - S)
11. Non-wood forest Products study for Mexico, Cuba and South America (draft for comments) (82 pp. – E)
12. Annotated bibliography on Forest cover change – Nepal (59 pp. – E)
13. Annotated bibliography on Forest cover change – Guatemala (66 pp. – E)
14. Forest Resources of Bhutan - Country Report (80 pp. – E)
15. Forest Resources of Bangladesh – Country Report (93 pp. – E)
16. Forest Resources of Nepal – Country Report (78 pp. - E)
17. Forest Resources of Sri Lanka – Country Report (77 pp. – E)
18. Forest plantation resource in developing countries (75 pp. – E)
19. Global forest cover map (14 pp. – E)
20. A concept and strategy for ecological zoning for the global FRA 2000 (23 pp. – E)
21. Planning and information needs assessment for forest fires component (32 pp. – E)
22. Evaluación de los productos forestales no madereros en América Central (102 pp. – S)
23. Forest resources documentation, archiving and research for the Global FRA 2000 (77 pp. – E)
24. Maintenance of Country Texts on the FAO Forestry Department Website (25 pp. – E)
25. Field documentation of forest cover changes for the Global FRA 2000 (40 pp. – E)
26. FRA 2000 Global Ecological Zones Mapping Workshop Report Cambridge, 28-30 July 1999 (53 pp. –E)
27. Tropical Deforestation Literature:Geographical and Historical Patterns in the Availability of Information and the Analysis of Causes (17 pp. – E)
28. Global Forest Survey – Concept Paper (30 pp. - E)
29. Forest cover mapping and monitoring with NOAA-AVHRR and other coarse spatial resolution sensors (42 pp. - E)
30. Web Page Editorial Guidelines (22 pp. – E)
31. Assessing state & change in Global Forest Cover: 2000 and beyond (15 pp. – E)
32. Rationale & methodology for Global Forest Survey (60 pp. – E)
33. On definitions of forest and forest change (13 pp.- E)
34. Bibliografía comentada. Cambios en la cobertura forestal: Nicaragua (51 pp. – S)
35. Bibliografía comentada. Cambios en la cobertura forestal: México (35 pp. – S)
36. Bibliografía comentada. Cambios en la cobertura forestal: Costa Rica (55 pp. – S)
37. Bibliografía comentada. Cambios en la cobertura forestal: El Salvador (35 pp. – S)
38. Bibliografia comentada. Cambios en la cobertura forestal: Ecuador (47 pp. – S)
39. Bibliografia comentada. Cambios en la cobertura forestal: Venezuela (32 pp. – S)
40. Annotated bibliography. Forest Cover Change: Belize (36 pp. – E)
41. Bibliografia comentada. Cambios en la cobertura forestal: Panamà (32 pp. – S)
42. Proceedings of the FAO Expert consultation to review the FRA 2000 methodology for Regional and Global Forest Change Assessment (54 pp. – E)

43 Bibliografia comentada. Cambios en la cobertura forestal: Colombia (32 pp. – E)
44 Bibliografia comentada. Cambios en la cobertura forestal: Honduras (42 pp. – E)
45 Proceedings of the South-Asian Regional Workshop on Planning, Database & Networking for Sustainable Forest Management (254 pp. – E)
46 Under preparation
47 Proceedings of the Regional workshop on forestry information services, Stellenbosch, South Africa, february 2001
48-49 Under preparation
50 Global Forest Cover Mapping – Final Report (29 pp. – E)
51-54 Under preparation

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