Proceedings

ROUND TABLE CONFERENCE ON INTEGRATED FOREST FIRE MANAGEMENT IN ETHIOPIA

19-20 September 2000
Addis Ababa, Ethiopia

MINISTRY OF AGRICULTURE
with
GTZ & GFMC

ADDIS ABABA, ETHIOPIA, 2000

MoA

The Natural Resources Management and Regulatory Department of the Ministry of Agriculture is responsible for formulating policy and legislation on Management, Conservation and Sustainable Development of the country's natural resources (Soil, Land, Forest and Wildlife). It has the mandate of monitoring and regulating the use and development of the natural resource base of the country and contributes to the successful rehabilitation and restoration of the natural environment. It also undertakes other conservation-related activities including, land use land cover assessment, soil erosion assessment and preparation of guidelines for resource management.

The Global Fire Monitoring Center (GFMC) was established in 1998 at the Fire Ecology and Biomass Burning Research Group of the Max Planck Institute of Chemistry, Germany. The GFMC also serves as a co-ordination unit of the Biomass Burning Experiment (BIBEX) of the International Geosphere-Biosphere Programme (IGBP), International Global Atmospheric Chemistry (IGAC) Project, and is a member of the UN-FAO/ECE/ ILO Team of Specialists on Forest Fire. The GFMC was initially supported financially by the Government of Germany, Ministry of Foreign Affairs, Office for the Co-ordination of Humanitarian Assistance, as a German contribution to the UN International Decade of Natural Disaster Reduction. This was in line with the objectives of the UN International Decade of Natural Disaster Reduction, and the recommendations of the Tropical Timber Organizations, the World Health Organization and various scientific and policy-oriented conferences.

GFMC is currently co-sponsored by the United Nations Educational and Scientific Organization, the World Bank Disaster Management Facility, and the World Conservation Union (IUCN).

GFMC and the Fire Ecology and Biomass Burning Research Group are located in Freiburg University (Germany). The expertise of the Institute goes back to the mid-1970s when scientific research and development in fire ecology, cultural history and the socio-economics of vegetation fires with a global focus was started at Freiburg University. At the same time, the Max Planck Institute for Chemistry, located in Mainz (Germany) took the lead in investigated the role of vegetation fires in global bio-geochemical cycles and atmospheric chemistry. The two institutions merged in 1990 to create the first interdisciplinary fire research institute. Since 1999, the GFMC has been part of the German Research Network for Natural Disasters, and is a member of and closely co-operates with the German Committee for Disaster Reduction.

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Published by

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Natural Resources Management & Regulatory Department
Addis Ababa, Ethiopia
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Cover photograph: The Harenna Forest area showing burnt patches and still burning areas in March 2000. Photo by Günther Haase.

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PREFACE

These Proceedings are the result of an Ethiopian ***Round Table Conference on Integrated Forest Fire Management***, held on 19–20 September 2000. The major objectives of the workshop were to:

- provide all stakeholders with comprehensive information on the present status and problems about forest fires;
- share experiences in forest fire management with other developing countries;
- identify and define components of an integrated forest fire management programme for Ethiopia;
- provide an opportunity for potential international partners to express their interests and ideas with respect to a co-operation in the development and implementation of a forest fire management system in Ethiopia

The natural resources of Ethiopia, and forests in particular, are under severe pressure arising from a combination of factors, including excessive harvesting, forest clearing for the expansion of agricultural lands, settlement, development projects, conflicts between the different user groups, etc. Although the cycle of events that leads to the destruction of forest resources involves many varying factors, those initiated by humans using fire to access and remove forest resources is the most severe.

The dangers from fire were experienced most recently during the forest fires that burnt between February and April 2000. These were the worst fires of the last one hundred years, and destroyed more than 90 thousand hectares of the country's moist evergreen forest. There are continuing concerns at the national level about possible reoccurrences of fires at the onset of future dry seasons in Ethiopia, particularly if the rains fail as they did for the two years preceding 2000 in southern Ethiopia. This workshop was, therefore, a step forward in the establishment of an institution responsible for the prevention and suppression of fires. The results of the workshop could also help develop policies, guidelines and other relevant strategies to combat fire in order to save the remaining forests of the country, and gain from lessons learnt from other countries.

In the past, forest fires were not given much priority and combating them was carried out in a disorganized way, mainly through the mobilization of the local communities, without any organised responsibility. As a result, wildfires have been scourging the country's forest resources and were only extinguished naturally. Now there is a growing concern from national and international communities that adequate attention be given to fires and especially to those forest types sensitive to fire. The Ministry of Agriculture (MoA) of the Federal Democratic Republic of Ethiopia, understanding the seriousness of fire hazards and the significance of both national and international experience in forging an appropriate strategy for integrated forest fire management (IFFM) in the country, has organised this historic workshop.

These Proceedings have seven papers and a section that summarizes the findings of the three working groups and the plenary discussion at the end of the workshop. The first paper reviews the vegetation types and forest management in Ethiopia. The second paper describes the role of vegetation fires in global processes in Africa and other continents. The third paper presents the effects and use of fire in southern Africa savannah. The fourth paper presents experience in Namibia with community-based forest fire management. The fifth paper deals with the significance of remote sensing of vegetation fires and its contribution to national fire information. The sixth paper provides an overview of integrated forest management (IFFM) concepts, lessons learnt and opportunities for Ethiopian conditions. The seventh paper delivers the results of a case study on survival strategies and ecological performance of plants in regularly burnt savannah woodlands and grasslands of western Ethiopia, Gambella National Regional State.

The final section presents the results of the group discussions, plenary session and recommendations. The group work addressed three major issues: fire ecology and fire impact, identification of key stakeholders, and an integrated fire management programme for Ethiopia. This is followed by the Annexes with the welcoming address, the opening address, the program, and the list of participants. It also includes a paper on the application of remote sensing and GIS in managing forest fires.

ACKNOWLEDGEMENT

The Natural Resources Management and Regulatory Department of the Ministry of Agriculture (MoA), on behalf of the Ministry, extends its heartfelt appreciation to the German Technical Co-operation (GTZ) and the technical assistance to the forest administration project in particular, for its technical and financial assistance, without which the workshop as well as the finalization of these Proceedings, would have not been possible.

ACRONYMS

AVHRR – Advanced Very High Resolution Radiometer

BIBEX – Biomass Burning Experiment

BLM – US Bureau of Land Management

BoA – Bureau of Agriculture

CACA – Caprivi Arts and Cultural Association

CBOs – Community Based Organizations

CIDA – Canadian International Development Agency

CSE – Conservation Strategy of Ethiopia

DfiD – Department for International Development (in UK)

DMF – Disaster Management Facility

DMSP – US Air Force Defence Meteorological Satellite Program

DPPC – Disaster Prevention and Preparedness Commission

DRM – World Institute for Disaster Risk Management

EARO – Ethiopian Agricultural Research organization

ECE – Economic Commission for Europe

ECMWF – European Centre for Medium Range Weather Forecasts

EFAP – Ethiopian Forestry Action Programme

EIA – Environmental Impact Assessment

ENSO – El Niño-Southern Oscillation

EPA – Environmental Protection Authority

ERRA – Ethiopian Rural Road Authority

ESTC – Ethiopian Science and Technology Commission

EU – European Union

EWCO – Ethiopian Wildlife Conservation Organization

EWNHS – Ethiopian Wildlife and Natural History Society

FAO – Food and Agriculture Organization of the UN

FDR – Fire Danger Rating System

FFA – South African Fire Fighting Association

FTSCU – Forestry Sector Technical Coordination Unit

GFMC – Global Fire Monitoring Center

GIS – Geographical Information System

GOs – Government Organizations

GTZ – Deutsche Gesellschaft für Technische Zusammenarbeit mbH (German Agency for Technical Cooperation)

IATF – Inter-Agency Task Force

IBCR – Institute of Bio-diversity Conservation and Research

ICS – Incident Command System

IDNDR – International Decade of Natural Disaster Reduction of the UN

IFFM – Integrated Forest Fire Management

IFFN – International Forest Fire News

IGAC – International Global Atmospheric Chemistry

IGBP – International Geosphere-Biosphere Programme

ILO – International Labour Organization of the UN

INSARAG –International Search and Rescue Advisory Group of the UN

ISDR – International Strategy for Disaster Reduction

ITTO – International Tropical Timber Organization

IUCN – World Conservation Union

KfW – German Development Bank

LAC – Local Area Coverage

LBS – Lightning Burning System

LIFE – Living In a Finite Environment Program

MoA – Ministry of Agriculture

MoD – Ministry of Defence

MoE – Ministry of Education

MoFEC – Ministry of Forestry and Estate Crops

MoI – Ministry of Information

MoWUD – Ministry of Works and Urban Development

MWS – Ministry of Water Resources

NASA – National Aeronautics and Space Administration (US)

NESDIS – National Environmental Satellite, Data, and Information Service (US)

NFFP – Namibia-Finland Forestry Programme

NFPA – National Forest Priority Areas

NFSP – Namibia Forestry Strategic Plan

NGOs – Non-government organizations

NMSA – National Meteorological Services Agency

NOAA – US National Oceanic and Atmospheric Administration

NRI – Natural Resources Institute

PMBS – Patch Mosaic Burning System

PMF – Participatory Management Forests

RCBS – Range Condition Burning System

RSA – Republic of South Africa

SADC – Southern Africa Development Co-operation

STC – Science and Technology Commission

TACIS – Technical Assistance to the Commonwealth of Independent States

UKMO – United Kingdom Meteorological Office

UN – United Nations

UNEP – United Nations Environment Programme

UNESCO – United Nations Educational and Scientific Organization

US - United States

USA – United States of America

USDA – United States Department of Agriculture

WHO – World Health Organization

VEGETATION TYPES AND FOREST FIRE MANAGEMENT IN ETHIOPIA

by Demel Teketay, PhD*

SUMMARY

This paper is a compilation of nine different vegetation types, and a synthesis of forest fire management practices in Ethiopia, beginning with a general background. It describes the salient features and effects of fire, i.e. types and occurrence of fire, factors that influence the behaviour of fire, effect of fire on soils, plants, animals and ecosystem processes. Fire behaviour in different ecological zones of Ethiopia and the causes and impacts of forest fires are discussed, as are actual forest fire management practices, and the problems related to a weak fire management system in the country. Community participation in controlling fires and the need for public awareness at all levels are emphasized. Suggestions made by various authors that could help prevent fires, and different fire prevention/control measures, are summarized. The very few research papers on fire in Ethiopia are mentioned and the need for more research on all aspects of fire is stressed.

1. INTRODUCTION

1.1. Physiography and Population

Ethiopia occupies the interior of the Eastern Horn of Africa stretching between 3° N and 15° N latitude and 33° E and 48° E, with a total area of 1.13 million km^2 (Anonymous, 1988). It is the ninth largest country in Africa, while its population of 55 million (Anonymous, 1996), with about three percent annual growth, makes it the third most populated country in the continent. Of the total population, 46.7 million live in rural areas while 8.2 million live in urban areas. The average population density in Ethiopia is about 34 persons/km^2, and this ranges between 8 and 95 persons/km^2 (Anonymous, 1988).

Ethiopia is a country of great geographical diversity with high and rugged mountains, flat-topped plateaux, deep gorges of incised river valleys and rolling plains. Over time, erosion, volcanic eruptions, tectonic movements and subsidence have occurred and continued throughout millennia to accentuate the unevenness of the

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surface (Anonymous, 1988). Altitudes range from the highest peak, Ras Dejen (4620 m), down to the depression of the Kobat Sink (Afar Depression), about 110 m below sea level. Most of the country consists of high plateaux and mountain ranges with precipitous edges dissected by numerous streams, which are tributaries of the major rivers. The Rift Valley separates the western and south-eastern highlands, and the highlands on each side give way to vast semi-arid lowland areas in the east and west, especially in the south of the country. The physical conditions and variations in altitudes have resulted in a great diversity of climate, soil and vegetation.

1.2. Geology and Soils

Geologically, Ethiopia is part of the structural unit referred to as the Horn of Africa, which connects with Arabia through the Red Sea area and the Gulf of Aden. The base of this region consists of intensively folded and faulted Precambrian rocks, which are overlain by Mesozoic marine strata and Tertiary basalt traps. This complex was uplifted in the Upper Eocene as part of the Arabo-Ethiopian swell, across which rifting later gave rise to the Rift System (Mohr, 1971; Westphal, 1975). The Precambrian rocks, the oldest rocks in Ethiopia dating back to more than 600 million years, contain a wide variety of sedimentary, volcanic and intrusive rocks, which have been metamorphosed to varying degrees (Anonymous, 1988). More recent Mesozoic rocks, mainly sandstone and limestone, overlie them. Where the younger overlying rocks have eroded, they have exposed these older rocks mainly around the periphery of the plateau. Tertiary volcanic rocks in turn overlie the Mesozoic rocks. The volcanic rocks include rhyolites, trachytes, tuffs, ignimbrites, agglomerates and basalt. These rocks form the substrata of most types of Afromontane forests (Friis, 1992). A detail account of the geology of Ethiopia can be found in Mohr (1971).

Detailed descriptions and classification of the soils of Ethiopia are still lacking. The older information has been summarized by Westphal (1975), and only an account of the soils of the Ethiopian highlands is included here. In the Gonder-Welo-Gojam-Shewa region Alfisols, mainly belonging to the suborder Ustalfs, Vertisols and Inceptisols dominate. The shallow soils among them are red to light red-brown on the mountains and hillsides, red-brown on the slopes, brown to dark in the rolling country, to nearly black in the lower parts. The red-brown to dark-brown soils are excellent for agriculture, particularly for grain crops, which are found all over the highlands. Stony mountain slopes and lower areas are used for grazing. The major soil problems are erosion on slopes, lack of drainage in lower parts, too high acidity and, therefore, a lack of phosphorous throughout. In the Lake Tana Plain, Entisols are found in association with Vertisols.

The south-western part is dominated by Oxisols, Ultisols and Vertisols. In the Eastern Highlands, shallow Inceptisols are found. In the Chercher region of these highlands, soils range from grey to brown and are often stony. Their good fertility makes extensive farming possible, particularly on the slopes and in those valleys where drainage is sufficient. Erosion is serious here, and cuts deep gullies in the steep slopes. In West Tigray and North Gonder, soils are stony, shallow and low in productivity. They belong to the orders Ultisols and Alfisols, which are even more rocky and shallow in the extreme north, whereas dry Vertisols and Inceptisols are found to the west. In south-western Welega, soils are deep and belong to the orders Oxisols and Ultisols. In South Sidamo, mainly Aridosols occur. The most common forest soils in Ethiopia are red or brownish Ferrisols derived from volcanic parent material (Friis, 1992).

1.3. Climate

The climate of Ethiopia is classified into three types based on the annual and monthly mean temperature and rainfall as well as on seasonal changes in rainfall and types of native vegetation associated with them. These are the dry, tropical, and temperate rainy climate types. These are further subdivided into three each, together making a total of nine principal climate types (Anonymous, 1988). They range from equatorial desert to hot and cool steppe, and from tropical savannah and rain forest to warm temperate and cool highland.

The south-west is the wettest region receiving the heaviest rainfall in Ethiopia with only two to four dry months in a year. The mean annual rainfall for the region is about 1500 mm, although some areas receive as much as 2800 mm. Mean annual rainfall decreases gradually towards the north-east and east. In central and north-central Ethiopia the mean annual rainfall is about 1100 mm, although there are some pockets with more than 2000 mm. In south-eastern Ethiopia, the mean annual rainfall is about 700 mm, but it varies from 400 mm in the lowest areas towards the south up to 2000 mm in some higher pockets where local orographic features and forest cover give rise to orographic rainfall. The mean annual rainfall in the north of the country is about 500 mm (Anonymous, 1988).

In Ethiopia, rainfall is seasonal, varying in amount, space and time. The long heavy rainy season is known locally as the 'big rains' or 'kremt' (June–September), and the short and moderate rainy periods are known as 'little rains' or 'belg' (March–May). However, south-western Ethiopia receives rain over eight to ten months while other regions, e.g. south-eastern Ethiopia, get rain twice a year at six-month intervals (April-May and September-October-November).

Temperature conditions in Ethiopia are influenced by latitude, altitude, winds and humidity, although with a varying magnitude (Anonymous, 1988). Although Ethiopia occupies a zone of maximum insolation, tropical temperatures are not experienced everywhere as it is a highland country. The highlands form the heartland of the country while the lowlands are limited to the peripheries. Temperature decreases from the peripheries towards the interior, with a mean annual temperature of 30°C in the lowlands to less than 10°C at very high altitudes. The variation in the amount of solar radiation received daily is small throughout the year. Temperature is high during the day, over 40°C in some places, and is considerably reduced at night causing the daily range of temperature to be large (up to 30°C). Ethiopia is, therefore, a country where two extremes of temperatures are experienced, altitude being the most important controlling factor.

1.4. Flora and Fauna

The flora of Ethiopia is very heterogeneous and has a rich endemic element. It is estimated to contain between 6,500–7000 species of higher plants, of which about 12 percent are endemic. Endemism is particularly high in the high mountains and in the Ogaden and Borena. Ethiopia is said to have the fifth largest flora in Africa (Anonymous, 1997).

The diversity of fauna in Ethiopia is also high owing to the diversity in climate, vegetation and terrain. There are 240 species of mammals and 845 species of birds of which 22 species of mammals (Anonymous, 1997) and 16 species of birds are endemic (EWNHS, 1996). This makes Ethiopia the richest in avifauna in mainland Africa. Although very little study has been done, six reptile and 33 amphibian species are known to be endemic. Even less is known about insects and the other groups of invertebrates, but they are likely to contain at least the same proportion of endemic species as the other animal groups.

2. Vegetation Types in Ethiopia

The vegetation of Ethiopia, including forest and woody vegetation resources, has been studied by many scholars (Logan, 1946; Pichi-Sermolli, 1957; von Breitenbach, 1961, 1963; Friis *et al.*, 1982; Friis, 1986; Friis & Mesfin Tadesse, 1988; Anonymous, 1988; Friis, 1992; EFAP, 1994), who have employed various methods of vegetation classification. The Conservation Strategy of Ethiopia has grouped the different vegetation types into nine categories basing its work on these authors. For the purpose of the present paper, I have adopted the CSE categories. The different vegetation types are discussed below. Nomenclature of plant names follows Cufodontis, 1953–1972; Hedberg & Edwards, 1989 & 1995; Edwards *et al.*, 1995 & 1996; Friis, 1992.

2.1. Afroalpine and Sub-Afroalpine Vegetation

The characteristic plant species in this vegetation type include small trees, giant herbs, shrubs, suffrutescents and herbs: *Erica arborea*, *E. trimera*, *Kniphofia* spp., *Helichrysum* spp., *Bartsia petitiana*, *Alchemilla* spp., *Crassula* spp., and giant *Lobelia* spp.; grasses are mainly species of *Festuca*, *Poa* and *Agrostis*.

This vegetation type occurs on the tops and slopes of mountains that are, on average, higher than 3,200 m. The rocks are volcanic being mostly basalt and trachyte. Moisture is not high since even though the mountains attract much rain the basaltic and trachyte bedrock has poor internal drainage. The temperature is low, falling below freezing at night, and this also makes water unavailable to plants. The soil is shallow but very rich in partly decomposed organic matter owing to the low temperatures. Livestock grazing and cultivation, usually involving fire, are the main human activities, which threatens the vegetation. *Erica* shrubs are often destroyed by human-induced fire, but they can regenerate soon afterwards. Uncontrolled grazing by livestock is becoming more serious and barley cultivation has encroached on the steeper and better drained lower parts of this zone. The Afroalpine vegetation of the north-eastern mountains has been more affected than that in the south-east.

This vegetation type occurs in a fragile environment with its unique climate of 'summer every day and winter every night'. It provides the upper catchment for many important rivers. Destruction of the vegetation would result in the extinction of many endemic plants and animals.

Two of the most famous parks of Ethiopia – The Simen Mountains National Park in the north and the Bale Mountains National Park in the south – are located here. The Simen Mountains were designated as a World Heritage Site in 1978 and contain the endemic Walia Ibex, Ethiopian Wolf and Gelada Baboon; also leopard, caracal, wild cat, bushbuck and 137 bird species. The Bale Mountains contain 46 mammals including the endemic Mountain Nyala, Ethiopian Wolf, Menelik's Bushbuck, and Giant Mole Rat, and others including leopard and olive baboon, more than 265 species of birds including 6 of the 16 endemics.

2.2. Dry Evergreen Montane Forest and Montane Grassland

The characteristic plant species in this vegetation type include *Olea europaea* subsp. *cuspidata*, *Juniperus procera*, *Celtis africana*, *Euphorbia ampliphylla*, *Dracaena* spp., *Carissa edulis*, *Rosa abyssinica*, *Mimusops kummel*, *Ekebergia capensis*. In some places, this vegetation type is associated with highland bamboo, *Arundinaria alpina*. There are extensive areas of grassland rich in species including legumes in the valleys and on areas with Vertisols. The most important genera are the grasses *Hyparrhenia*, *Eragrostis*, *Panicum*, *Sporobolus*, *Eleusine*, and *Pennisetum*, and the legumes *Trifolium*, *Eriosaema*, and *Crotalaria*. There are many endemics, particularly in the grasslands.

This vegetation type is found between 1500 and 3400 m and has an average annual temperature of 14–25°C and annual rainfall of 500–1500 mm. Most of the Ethiopian population lives here and this is a centuries-old zone of sedentary cereal-based mixed agriculture. Forests have diminished greatly throughout these areas because of human activity. They have been replaced by evergreen bushland in many places. Soils have become very shallow and infertile as a result of soil erosion.

Forests have virtually disappeared in northern Ethiopia exposing bare rocks with the consequence that springs and streams dry out during the dry season, or have disappeared altogether. Southern and eastern parts of the country are following suit.

Many of the larger mammals (elephants, buffalo, bushpig, klipspringer, etc.) occurred here but have been eliminated by human activities. More than half of the over 800 birds recorded for the country are found associated with this vegetation complex.

2.3. Evergreen Scrub

This vegetation type can be divided into two sub-types: montane evergreen thicket and montane evergreen scrub.

2.3.1. Montane Evergreen Thicket

Montane evergreen thicket consists of a dense growth of small evergreen shrubs, lianas and thinly spaced small trees, many of them spiny. Shrubs, 2–3 m tall, form the dominant part of the vegetation. Suffrutescents and perennial grasses are found tangled with shrubs.

2.3.2. Montane Evergreen Scrub

Montane evergreen scrub consists of a shrub stratum dominated by evergreen plants and climbers, 3–5 m tall. Trees project out of this shrub layer and there are usually passage ways among the clumps of woody plants. Suffrutescents, herbs and perennial grasses grow in and between the shrubs. The climate associated with this vegetation type has very variable annual rainfall and temperature regimes as it usually occurs on steeply sloping scarps.

These two vegetation types often form a mosaic on the plateau slopes with scrub usually occurring at lower altitudes and in moister areas. Small trees and shrubs occurring in this vegetation type include *Acokanthera schimperi*, *Carissa edulis*, *Euclea schimperi*, *Rhamnus staddo*, *Myrsine africana*, *Dodonaea angustifolia*, *Rhus* spp., *Calpurnia aurea*, *Jasminum abyssinicum*, *Osyris quartipartita*, *Ximenia americana*, *Protea gaguedi*. The larger trees include *Teclea nobilis*, *Croton macrostachyus*, *Bersama abyssinica*, *Olea europaea* subsp. *cuspidata*, *Juniperus procera*, *Ficus* spp., *Euphorbia abyssinica*, *E. candelabrum*, and *Dracaena* spp. The dominant liana is *Pterolobium stellatum*. The scrub differs from the thicket in having more and larger trees usually occurring in small clumps, and more space between the clumps.

Although evergreen thicket and scrub have been expanding at the expense forest, it is now disappearing from around towns because of the high demand for firewood. Wild animals associated with these areas include leopard, olive baboon, duiker and klipspringer.

2.4. *Acacia-Commiphora* or Small Leaved Deciduous Woodland

The characteristic plant species in this vegetation type include drought tolerant trees and shrubs: *Acacia tortilis*, *A. mellifera*, *Balanites aegyptiaca*, and species of

Acalypha, *Aerva*, *Barleria*, *Capparis*, *Combretum*, *Terminalia*, etc. The large wild animals include oryx, zebra, hartebeest, kudu and gazelle.

This vegetation type occurs mainly in southern and eastern parts of the country and the Rift Valley with an altitudinal range of 900–1900 m. Traditionally it is a grazing area, but it is sensitive to overgrazing since it is dry for as long as 10 months at a time. The increasing of rain-fed agriculture supplemented by irrigation in these areas is adding to its vulnerability. Deforestation is increasing, particularly in recent years, due to intensification of agriculture and cutting of woody plants for fuel wood and charcoal production.

2.5. Moist Evergreen Forest

The characteristic plant species in this vegetation type include the largest and commercially most important trees in Ethiopia: *Aningeria adolfi-friedericii*, *Podocarpus falcatus*, *Trilepisium madagascariense*, *Albizia gummifera*, *Celtis africana*, *Polyscias fulva*, *Schefflera abyssinica*, *Bersama abyssinica*. The under-storey contains coffee trees (*Coffea arabica*), including wild populations. Wild animals include monkeys, elephants, bushbucks, giant forest hogs and wild pigs.

This vegetation type occurs mainly in the south-western parts of the country with altitudinal range of 800–2500 m, average annual temperature of 18–25°C, annual rainfall of more than 1200 mm with rain all the year round except in December and January. The parts of the country with abundant moisture and warm temperatures have a high potential for timber production but uncontrolled exploitation has been reducing the existing areas of forest through complete deforestation for plantations and degradation through selected felling of high quality trees. The huge potential for growing coffee and tea has resulted in vast areas of forests either being thinned or cleared for coffee and tea plantations.

2.6. Lowland Semi-Evergreen Forest

The plant species in this vegetation type include a more-or-less continuous canopy of *Baphia abyssinica* (endemic to southwestern Ethiopia and adjacent areas of the Sudan), mixed with less common species: *Celtis toka, Diospyros abyssinica, Lecaniodiscus fraxinifolius, Malacantha alnifolia, Trichilia prieureana, Zanha golungensis* and *Zanthoxylum leprieurii*. Trees that emerge high above the canopy include *Alstonia boonei, Antiaris toxicaria, Celtis gomphophylla* and *Milicia excelsa*; and the small trees include *Acalypha neptunica, Erythroxylem fischeri, Tapura fischeri, Zizyphus pubesence* and *Xylopia parviflora*. Shrubs include *Alchornea laxiflora, Argomuellera macrophylla, Mimulopsis solmsii, Oncoba spinosa, Oxyanthus speciosus, Rinorea ilicifolia* and *Whitfieldia elongata:* and there are also a few grasses.

There is no information on the status of the forest and the presence of animals inhabiting the area. However, the adjacent Gambella National Park contains many wild animals, e.g. white-eared kob, rhinoceros, elephant, giraffe, lion, cheetah and over 150 species of birds.

The vegetation type was first described by Friis in 1984 and occurs only in Gambella, mainly on well drained sandy soils, with altitudinal range of 450 and 600 m, mean annual maximum temperature of 35–38°C, mean annual temperature of 28–30°C and annual rainfall range of 1300–1800 mm.

2.7. *Combretum-Terminalia* or Broad-Leaved Deciduous Woodland

The characteristic plant species in this vegetation type include small trees with fairly large deciduous leaves, particularly from Combretaceae. This woodland is often associated with the lowland bamboo (*Oxythenatera abyssinica*). Apart from species of *Combretum* and *Terminalia*, other important species found in this vegetation type are *Boswellia papyrifera*, *Lannea schimperi*, *Anogeissus leiocarpa*, and *Stereospermum kunthianum*. The understorey is a combination of herbs and grasses while in some of the shallow valleys extensive areas of very tall grasses dominated by species of *Cymbopogon*, *Hyparrhenia*, *Echinochloa*, *Sorghum*, *Pennisetum*, are found. Wild animals include elephant, buffalo, eland, greater and lesser kudu, hartebeest, gazelle and De Brazza's monkey.

This vegetation type occurs in the north-western, western and south-western parts of the country with an altitudinal range of 500–1900 m. The vegetation has developed under the influence of fire, which has strongly influenced both the types of vegetation and the species composition (Minassie, 2000). The rugged topography makes ploughing very destructive since the erosion rate is very high at the onset of the rains following the dry season. The north-western parts of the country categorized under this vegetation type traditionally grow sorghum, sesame and cotton. Here, agriculture is increasingly being intensified. As a result combined with the demand from urban centres for fuelwood and charcoal, deforestation is increasing. However, it has been indicated that this vegetation type is perhaps the least affected of the wooded vegetation types.

2.8. Desert and Semi-Desert Scrubland

The characteristic plant species in this vegetation type include highly drought-tolerant shrubs, some succulents and grasses. The woody plants include species of *Acacia*, *Boscia*, *Cadaba*, *Commiphora*, *Maerua*, *Zizyphus*, *Aloe*, *Commelina*, *Dactyloctenium*, *Euphorbia*, etc. The wild animals that are known to inhabit this area include Somali Wild Ass, Sömmering's gazelle, Beisa oryx, Grevy's zebra (large mammals); ostrich, bustards, secretary bird (large birds); carmine bee eater, Abyssinian roller and pygmy falcon (small but striking birds).

The areas in which this vegetation type occurs are very dry, and vulnerable to wind and water erosion. The alluvial soils have a poor structure because of salinity, and this makes these areas even more vulnerable. Irrigated agriculture can also cause saline conditions. A good example is the Amibara Project where, by 1988/89, 4,700 ha of land had been lost through salinity. Overgrazing by wild animals in areas around water points is common.

This vegetation type is most likely to be converted into bare desert if human activities continue unabated and the climate becomes even drier. However, deterioration can be reversed because of the low human population and the nomadic mode of life. This can be achieved if adequate research and investment is made to properly integrate irrigated agriculture, pastoralism and wildlife management.

2.9. Riparian and Swamp Vegetation

The characteristic plant species in riparian vegetation include *Celtis africana*, *Ficus sycamorus*, *Mimusops kummel*, *Tamarindus indica*, *Maytenus senegalensis*, *Acacia* spp., *Kigelia aethiopum*, *Syzygium guineense*, etc. The trees are associated with a wide range of shrubs, herbs and grasses.

Swamps are dominated by sedges, grasses and other herbs. Only specialized woody plants, like *Aeschynome elaphroxylon*, are able to grow in such water-logged conditions.

3. THE SALIENT FEATURES AND EFFECTS OF FIRE

In view of the recent outbreak of fire in many forested areas in Ethiopia, it is timely to present the salient features of fire so that both scientific and non-scientific personnel can have a common understanding about its positive and negative impacts. Most of the following account is based on the chapter on fire by Kimmins (1997).

Fire is a pervasive and powerful natural ecological factor that is as important as wind or precipitation in determining the structure and function of many of the world's ecosystems. Except in the very wettest, very hottest and very coldest environments (there is nothing to burn in the latter two!), fire has played a role virtually everywhere on Earth.

Fire was ecologically important long before it was used by humans, as evidenced by the presence of charcoal buried deeply in ancient sedimentary deposits. Such fires were the result of volcanic activity, spontaneous combustion or lightening, the latter being the most important. It was perhaps the first major force employed by humans to alter their surroundings. In addition to heating and cooking, it was employed to drive game, to improve grazing, to remove vegetation in order to facilitate travel, to clear land for agriculture and in both aggressive and defensive encounters with other humans.

The ecological effects of fire vary enormously according to the time of year, quantity, condition and distribution of the fuel, prevailing climatic conditions, severity and intensity of the fire, slope, aspect and elevation, type of vegetation and soil, etc. Generalisations on fire are dangerous and discussion of fire should always specify the type of fire and environment.

3.1. Types and Occurrence of Fire

Fire can be divided into three major types, *viz*:

- ground fires — largely flame-less fires which burn slowly through thick surface accumulations of organic matter;
- surface fires — rapidly burning fires that sweep quickly over an area consuming litter and the aboveground portions of herbs and shrubs; and
- crown fires — that burn through the crowns of woody vegetation, frequently leaving most of the stem and the forest floor relatively untouched.

The three types of fire can occur in any combination. Sometimes, a crown fire will be accompanied by both surface and ground fires resulting in the total consumption of all organic matter above the mineral soil. Even roots deep in the mineral soil may be burned. Alternatively, crown fires driven by strong winds may race through the tree tops consuming foliage and twigs only, leaving stems and forest floor virtually intact. Such fires leave most of the biomass and almost all of the minor vegetation intact. They have high intensity but low severity. Some trees are killed by having their crowns burnt, but others are able to regenerate branches and foliage.

Surface fires generally burn off just the litter layer and the aboveground parts of herbs and shrubs. These plants are often able to re-sprout from underground organs, depending on the depth of heat penetration into the soil and the depth of the lowest perennating organ of the plant. Trees may or may not be killed, depending on their bark thickness.

Ground fires tend to be more destructive, since they kill and consume all the roots below the forest floor, which generally prevents re-sprouting from underground organs. Ground fires can kill large tees by this means even when the stems and crowns remain untouched. Consumption of forest floor may eliminate most of the dormant seeds in the site, slowing re-vegetation of the area. However, viable seeds are sometimes found buried in the mineral soil, where they may escape destruction by ground fires and contribute to re-vegetation. The loss of forest floor exacerbates the ecological consequences of loosing all living vegetation, but the subsequent fall of dead but unburned shrub and tree materials contributes to a rebuilding of this layer.

Fire occurs mainly in the dry season, which happen at different times of the year (beginning, middle or end of the dry season) in different parts of the world, with markedly different ecological effects.

Information on the causes of fire is of some interest because it permits a comparison of the importance of humans as a cause of ignition with that of other causes.

3.2. Factors That Influence The Behaviour of Fire

The characteristics and behaviour of fire are determined by three environmental factors — fuel, topography and weather.

3.2.1. Fuel

Fuel is defined here as a complicated association of living and dead plant materials of various sizes and shapes that extend from the mineral soil to the top of the vegetation. The behaviour and spread of forest fire is governed by a number of fuel characteristics (de Vletter, 1986). These include:

- chemical composition of the fuel (that either enhance or retard fire);
- moisture content of the fuel;
- total quantity of material that can potentially be consumed by fire;
- size distribution of various parts of the vegetation (small branches burn better than thick stems);
- compactness of the vegetative materials ; and
- horizontal and vertical continuity of the vegetation.

The fuels can be classified as:

- ground fuels — roots, decaying wood, peat or muck directly below the fresh litter;
- surface fuels — fresh litter, grasses, shrubs and dead or green branches below 1.2 m height; and
- aerial fuels — stems, dead and green branches, green crown leaves above 1.2 m height.

3.2.2. Topography

Topography, which can be expressed in terms of slope, aspect and terrain, is an important factor determining forest fire hazard. It controls the rate and spread of fire. Fire is more threatening on sloping rather than level areas. Fire always 'climbs uphill' and mountainous winds can intensify this tendency. Fire travelling uphill is faster than a running man, a factor that makes suppressing operations a complicated and dangerous task. A large fire burning uphill may spread at a rate of 2000 m per hour while on level ground the normal speed is below 500 m per hour (Kinfe Abebe, 1993).

The southern-facing slope has higher temperature, more wind, lower fuel moisture content and lower relative humidity, and thus is more prone to fire hazard than a northern or western-facing slope, which tends to retain more moisture.

The terrain largely influences the direction of fire advance. Terrain also influences the amount of rainfall and cloudiness. It is also well established that as altitude increases average temperature and amount of combustible fuels decline. The combined effects of low temperature, more rains and low combustible fuels make risk of fire on mountains minimal. Nevertheless, if fuel is available when fire breaks out, the speed at which the fire travels uphill will be much faster than in the lowlands.

3.2.3. Weather

Weather factors that influence fire behaviour are rainfall, temperature, relative humidity and wind. Rainfall makes fuel wet, thereby reducing its combustibility and extinguishing fire. Relative humidity of the air also affects moisture in fuel.

Wind has a great influence on the rate of spread and direction of fire by drying forest fuel, increasing oxygen supply, bringing the flames towards unburned fuels and carrying spot fires to new areas.

Fire hazard increases with increasing length of the dry season.

3.3. Effects of Fire on Soils

Soil properties are strongly influenced by living vegetation and accumulated organic matter, both of which are removed to a variable degree by fire. Consequently, fire has the potential to induce major changes in soils. Such changes are sometimes deleterious, but in those ecosystems in which fire is a frequent and natural component, the effects of fire may be benign or even desirable.

The degree to which soil properties are altered by fire depends upon the fire intensity and the amount of organic matter consumed. These, in turn, are influenced by the amount of organic fuel available, its distribution and moisture content, and the prevailing weather conditions. A low-intensity surface fire may have very little effect on the soil, and a rapidly moving crown fire may also have little effect if the vegetation re-sprouts rapidly. Conversely, fire may have a great effect if all the vegetation is killed because the resulting losses of shade, root strength, and transpiration can lead to significant changes in soil temperature, stability and moisture. Ground fires generally have a marked effect by removing the surface accumulation of organic matter, while high-intensity ground-surface-crown fires during the dry season in Ethiopia can result in a massive alteration or the total loss of soil.

The effects of fire on soils can be categorized into three: physical, chemical and biological.

3.3.1. Physical Changes

Organic Matter: Loss of organic matter is one of the most important effects of fire on soils. Fire speeds up the normal process of mineralization of organic matter; it would otherwise take many years for the full decomposition of dead foliage, fine roots and logs. The loss of organic matter depends upon fire duration and intensity, fuel moisture, and how much organic matter is in the mineral soil.

Structure and Porosity: Burning exposes soil minerals and removes soil cover. It also alters the structure and porosity of the soil.

Moisture: Fire reduces transpiration from plants and interception losses in proportion to the reduction in foliage. It increases evaporation losses from the soil surface and reduces the infiltration of water.

Temperature: Fire affects soil temperatures over both the long- and short-term. Long-term effects generally involve an increase in soil temperatures by darkening the soil surface. This promotes the absorption of solar energy by reducing the depth of the surface organic accumulation and transfers heat to the mineral soil. The removal of shade trees also increases soil temperature.

3.3.2 Chemical Changes

pH: When fire oxidizes organic compounds, elements that form anions (e.g. N, P and Cl) are lost in much greater quantities than elements that form cations (e.g. Ca, K, and Mg). The ash left by the fire consists largely of soluble oxides of these alkali earths. These oxides are rapidly changed to carbonates, which have an alkaline reaction and tend to neutralize acidity in the soil. Consequently, soil pH generally increases following a fire.

The extent and duration of the increase will depend on the intensity of the fire, the amount of organic matter consumed, and the buffering capacity of the soil. An increase of 2–3 pH units has been reported in the forest floor following burning in Finland, only returning to the original levels after 50 years.

Site Nutrient Capital and Nutrient Availability: Fire induces a variety of chemical changes in the soil. As organic matter is burned, carbon is released as gaseous oxygen and nitrogen is lost increasingly as temperature rises.

3.3.3. Biological Changes

Fire adversely affects both the fauna and flora in the soil. Nevertheless, its effect is most pronounced on micro-fauna (invertebrates) and micro-flora (fungi and bacteria).

3.4. Effect of Fire on Plants

Because fire has been such a characteristic feature in many ecosystems, a wide variety of plant adaptations have evolved. Fire may affect any stage in a plants development (vegetative, flowering, fruiting or dormant) and there is a corresponding variety of adaptive features.

3.4.1. Adaptations to Fire in the Vegetative Stage

Fire-resistant bark is one of the more common adaptations to surface and ground fires. Plants either quickly replace the burned bark or they grow very thick bark. Reduced flammability of tissues reduces the spread and intensity of a fire, thus reducing the risk of fire damage. For example, plants with none of the following or only a low content of resin, gums and moisture are less prone to burning than those with these flammable materials. Protected buds give plants the ability to continue to grow and recover from the loss of branches, foliage or even the entire aerial shoot.

Plants that have woody tubers are able to produce new shoots more rapidly than those lacking this adaptation because of the food reserves provided by the tuber. Plants that have rhizomes are also able to sprout rapidly following fire and are highly resistant to damage by fire.

3.4.2. Adaptation to Fire in the Reproductive Phase

Precocious flowering reduces the time from germination to seed production in perennial plants, and species such as pine. Fire has been shown to cause a stimulation of flowering in some plants after its occurrence. Seed dispersal is influenced by fire in some species. For example, seed heads of *Protea* are stimulated to open and shed their seeds after fire. (Attenborough, The Private Life of Plants)

3.4.3. Effects of Fire on Germination

The seeds of many species lie dormant in the soil until the area is burned. Many trees and shrubs like *Acacia* and *Rhus* produce large quantities of hard-coated seeds that germinate only when they have been heated. This may be achieved by exposure to full sun as well as to fire, but fire is generally the agent that removes the shade and is therefore either directly or indirectly responsible for the heating.

Many plants germinate better on mineral soil than on a loose surface with organic accumulation. This can be explained in terms of better moisture and temperature conditions on the mineral soils, and/or the removal of chemicals that may serve to inhibit germination (allelopathy). Some species are known to release a variety of terpenes, phenols, alkaloids, and other organic chemicals that inhibit the germination and growth of competing species. These allelochemicals accumulate in the surface soil, from which they can be removed by fire, permitting the invasion of previously excluded species.

3.4.4. Evolution of Increased Inflammability

Some fire-adapted species have apparently evolved along a totally different line. Rather than evolving resistance to fire, they have evolved an increased susceptibility of the vegetative stage to fire, coupled with seed adaptations. It is intriguing that, rather than being fire-resistant, many plant species in fire environments actually burn more readily and destructively than plants of environments in which fire is uncommon. It has been suggested that this represents a successful adaptation, which increases the fitness of the species. For example, jack pine (a species with precocious flowering and protected seeds) forms stands that under natural conditions burn with monotonous regularity. Fire eliminates the light demanding pine, but it also kills the competing tree species that would replace it in the absence of fire. Continued occupancy of the area by jack pine is thus ensured because the precociously produced seeds protected in their serotinous cones promptly reforest the burned area.

Similar examples are provided by fireweed (*Epilobium*) and bracken fern, which produce highly inflammable litter that accumulates because of slow decomposition. This increases the chance of fire, which benefits these rhizomatous species while eliminating the woody species that would shade them out.

3.4.5. Other Adaptations

Another adaptation to fire that is found in some fire-adapted species is very rapid early growth. This undoubtedly benefits the plants in other ways as well, but rapid elevation of the terminal bud and foliage out of reach of surface fires, and rapid development of thick bark are undoubtedly of advantage in a fire-dominated ecosystem. An interesting and well-known example of this type of adaptation is provided by longleaf pine (*Pinus palustris*). The terminal bud remains close to the ground for about 5 years after germination, while the seedling develops a large root system. During this period, the bud is protected from frequent surface fires by long fire-resistant needles that form a dense circle around the bud (the so-called grass stage of the tree). Many 1- and 2-year-old seedlings are killed by fire, but for those that survive the first 2 years, the fires merely scorch the ends of the needles. The grass stage ends when the well-rooted seedling begins a period of rapid height growth, which carries the fire-sensitive bud well above the reach of surface fires.

Longleaf pine is not only extremely resistant to fire damage; it also depends upon fire. This species is very susceptible to a foliage fungus (brown spot disease, *Septaria acicola*) which is eliminated or reduced by fire, and long-leaf pine stands are deliberately burned in the grass stage to control the disease. The species is also unable to compete with the under-storey hardwood species that would invade the site in the absence of fire.

Because of the variable degree of fire adaptation in different plant species, fire plays a major role in determining the structure and composition of many of the world's plant communities. Fire has been implicated in the maintenance of grassland around the world (although some grasslands are climatically or edaphically determined), and the extensive heathlands in Europe were created by deforestation followed by frequent fires. Much of the vast area of pine, Douglas-fir, and eucalypts in the world are of fire origin, and extensive areas of oak in Europe and eastern United States owe their existence to a history of forest fires. Without it, these species would be partially or completely replaced by others as fire is important in also controlling populations of parasites and diseases of trees. For example, fire has historically been important in regulating the infection in lodgepole pine (*Pinus contorta*) forests in the interior of British Columbia by the parasitic dwarf mistletoe (*Arceuthobium* sp.). Mistletoe infections of western hemlock (*Tsuga heterophylla*) in some coastal forests have similarly been controlled by fire. It should be noted, however, that only intense fires that kill all the infected trees have this effect. Lower severity fires that leave scattered infected trees alive will not prevent the next generation of trees from becoming infected. In many cases, a relatively low frequency of fire is all that is necessary to control the mistletoe.

3.4.6. Effect of Fire on Animals

Fire affects animals in two major ways: the direct effects during the burn, and the indirect effects that result from changes in the animal's environment.

The literature suggests that many small animals are able to avoid adverse effects of fire by moving into burrows, or to islands of vegetation that are not affected by the fire, or into lakes or rivers. Obviously, fire will have adverse effects on animals with low mobility such as young, eggs and fledglings of birds, as well as old, maimed and sick birds and other animals. These are animals that are normally subject to above-average mortality rates. In very large and intense fires, smoke and/or lack of oxygen may cause more harm to animals than the direct effects of heat.

The indirect effects of fire on animals are of much greater importance than the direct effects. Most animals are highly habitat specific. For reasons of food, cover, microclimate and competition from other species, each type of animal tends to be associated with one or a few specific vegetation types in a specific type of landscape. As fire changes the environment, there is normally a change in the abundance, distribution, productivity, and species of animal occupying an area. When a fire burns erratically through an area, it produces a mosaic of old and young vegetation types, each with its own characteristic fauna. Such fires serve to increase both the diversity and the abundance of fauna. In contrast, many species of birds and animals are absent in either continuous, dense old growth forest or an extensive, completely burned area. Many animals use different types of vegetation for different stages of their life cycle and therefore require a mosaic of vegetation.

Fire plays an important role in maintaining grasslands against invasion by woody plants. It has been suggested that herbivores contribute to this role of fire by feeding more on the fire-sensitive, less flammable species. By leaving the most flammable species, the animals contribute to the future re-burning of the area and the maintenance of habitat suitable to them. Examples to the contrary can also be found.

Animals living in fire-affected environments have evolved various adaptations. These include high dispersal rates and the ability to respond to the new found opportunities created by fire by having a high and variable birth rate. Such species must be able to tolerate rapid changes in their environment. Animals of fire areas tend to be larger and of the browser and grazer types, whereas animals of relatively fire-free forests generally tend to be smaller.

3.5. Effect of Fire on Ecosystem Processes

By influencing plants, soil and animals, fire induces several changes in ecosystem processes: energy flow and biogeochemistry.

3.5.1. Energy Flow

Energy flow out of the system is greatly increased during a fire, and decomposition following fire may also be accelerated. The reduction or elimination of plants decreases primary production, and where a fire has reduced the moisture and fertility status of the soil, primary production may be depressed for a long time. Alternatively, primary production may be increased by fire because of the change in species composition and more favourable soil conditions. Secondary productivity in grazing food chains is generally increased by fire except where severe soil damage has occurred. Much of the effect of fire on energy flow is the result of change in the bio-geochemistry of the ecosystem.

3.5.2. Forest Bio-geochemistry

Forest biogeochemistry is considerably altered by fire. The output of nutrients in smoke and ash has been mentioned. Reduced infiltration leads to overland flow, which may wash the ash directly into watercourses. Even where such overland flow is relatively short distance, there may be a significant redistribution of chemicals within the soil profile. The effects of fire on nutrient cycling are so great, and our knowledge of these effects is so inadequate that quantitative prediction concerning the long-term effects of fire on forest biogeochemistry has proved difficult.

3.5.3. Effects of Fire on Carbon Storage in Forests

A severe forest fire can release large amounts of energy and carbon dioxide back to the atmosphere. Forests that historically had a high fire frequency tend to have little surface accumulation of carbon on the forest floor in the form of decaying branches and logs as well as standing dead trees. Such forests are also generally rather open with few trees per hectare. In contrast, forests in humid climates that experience fire only every few hundred years may accumulate large quantities of organic matter in live and dead trees, decaying logs, and, depending on climate and site, a thick forest floor.

According to fire severity, a highly variable portion of this aboveground carbon accumulation may be returned to the atmosphere by the fire, and in some forests much of the organic matter that is not consumed will decompose over the subsequent decades. These forests are characterized by large accumulations of organic matter and carbon between fires, and large releases during and after a fire.

Climate change could cause large fluctuations in carbon storage over extensive areas of forest by its effects on forest fires. This has important implications for our understanding of the role of forests in regulating atmospheric CO_2 concentrations.

3.6. Effects of Fire Exclusion

Because fire is a natural factor of the environment, fire-affected ecosystems have been adapted to a particular frequency and intensity of fire and will remain in their natural condition only if this frequency and intensity remains the same. Human activities have often altered these. Fire has been introduced to ecosystems in which it has historically been rare, and the occurrence of fire has been greatly reduced in some ecosystems in which it was almost an annual event. In the former case, fire-resistant communities have replaced fire-sensitive communities. In the latter case, conditions have been created in which the relatively benign natural fire has gained the potential to produce widespread destruction.

In fire-adapted forests with natural fire frequency, fuel accumulation is prevented and regeneration is limited, so that surface fires tend to be of low intensity and do not turn into crown fires. Such low-intensity surface fires generally have a net beneficial effect on ecosystem functions. When fire is excluded from this type of forest, ground fuels accumulate, eventually resulting in intense ground and surface fires. Dense regeneration of trees provides a fire ladder by which a crown fire can be created from a surface fire. In fact, the net result of 50 years of successful fire suppression in fire-adapted forests has been the creation of a greatly increased risk of fire with greatly increased destructiveness. This problem has attracted a lot of attention recently and attempts are being made to introduce fire to fire-adapted forests.

An interesting example of the effect of fire on the interaction among organisms is the case of dieback of jarrah (*Eucalyptus marginata*) in Australia. This large tree is susceptible to an introduced root pathogen, *Phytophthora cinnamomi*, which can cause extensive tree mortality. Severe wildfire promotes the growth of legumes, which increase site nitrogen status through symbiotic nitrogen fixation, thereby increasing the vigour of jarrah and its resistance to *Phytophthora cinnamomi*. Severe fires also remove *Banksia grandis*, another tree species that is highly susceptible *Phytophthora*. Dieback of jarrah forest is particularly severe where there is an understory of *Banksia* because the fungal infection builds up in the *Banksia* and spreads to the jarrah. Low intensity prescribed fire, therefore, promotes the growth of *Banksia* and the subsequent dieback of jarrah. Control of wildfires and their replacement by prescribed burning has rendered the jarrah forest far more susceptible to this root pathogen.

3.7. Fire and Forest Management

Uncontrolled wildfire and intensive forest management have traditionally been considered incompatible. The forester wants to harvest much of the biomass that is consumed in a wildfire and does not want the undesirable changes to soil and the hydrological cycle that are the frequent aftermath of an intense summer wildfire. On the other hand, fire does have some uses in forestry. It can be used to manipulate the depth, chemistry, and decomposition of the forest floor and the temperature of the mineral soil. It can be used to sanitize an area of diseases, parasites and insect pests. It can remove unwanted biomass (post-harvest logging residues or slash), thus reducing the problem of fuel accumulation, improving regeneration possibilities, and improving access for wildlife. Brush problems can be temporarily reduced by fire, and established stands can be fireproofed by periodic prescribed burning.

There can be little doubt that managed or prescribed fire has an important role to play in forest management, especially during the conversion of over-mature virgin forests into second-growth forests. There can also be little doubt that we will continue to suppress many wildfires. To be useful to the forester, prescribed fire must be applied at the time of year where there is a reasonable chance of achieving given objectives. The important difference between managed fires and wildfires must be made clear to the public so that they will accept what may to a layperson appear to be an extraordinary policy.

4. Forest Fires and Their Management in Ethiopia

Fire is reported to have been responsible for the disappearance of forests in northern Ethiopia (Kinfe Abebe, 1993). The feudal lords in medieval times set fire to the highland forests in order to construct their settlements on the top of the mountains. These positions enabled the feudal lords to watch their enemies advancing from long distances. Their followers and defence force had to settle around the feudal domain; hence, more area had to be put under fire to acquire more land for settlement. Since then, the culture of setting fire to forests has become a tradition, especially when additional land is required for crop cultivation.

Experience and casual observation show that the occurrence and behaviour of fire varies among the traditionally recognized ecological zones of Ethiopia (Anonymous, 1988; Kinfe Abeba, 1993), although we lack empirical data on the risk of fire hazard in these zones.

4.1. Fire Behaviour in Different Ecological Zones of Ethiopia

4.1.1. The Coldest Highlands — 'Wurch' or 'Kur'

This zone is found above 3,300 m with temperatures between 0 and 10°C and annual rainfall of 1000–2000 mm. It is above the upper tree line, with *Erica arborea* in the lower reaches and alpine grasses above. Sometimes, this zone may be covered with temporary snow and ice.

The very cold temperature makes permanent human settlement difficult. Because of the low temperature, high rainfall with some snow and ice and the relatively low fuel load, the risk of fire hazard is very low or completely absent.

4.1.2. The Cool Highlands — 'Dega'

This zone is found from 2,300 m to 3,300 m and is characterized by temperatures of 10–15°C, annual rainfall of 1000–2000 mm and strong winds. The trees commonly found in this zone include, among others, *Hagenia abyssinica, Juniperus procera, Prunus africana* and *Arundinaria alpina* (mountain bamboo). Other fire features of this zone include the accumulation of forest fuel and sloping terrain.

Although the high elevation, which is associated with cool temperatures and a more or less even distribution of rainfall, reduces the risk of fire hazard in this zone, the spread of fire can be rapid in the event of its outbreak. This can be attributed to the ample fuel accumulation and strong winds. Once a fire is set going, the wind carries it quickly to unburned areas, particularly uphill when the areas are mountainous and sloping. Spot fires can also be carried to adjacent areas. At times fire in this zone can be continuous and become uncontrollable.

4.1.3. The Warm Highlands — 'Woina Dega'

This zone is found from 1,500 m to 2,500 m and is characterized by temperatures of 15–20°C and rainfall ranges between 800 and 2400 mm. It is also zone with the only two conifers in the country, *Juniperus procera* and *Podocarpus falcatus*. The colder and drier parts are dominated by *Juniperus* while the moist and humid parts support *Podocarpus, Albizia* spp., *Ekebergia capensis, Hagenia abyssinica, Ocotea kenyensis, Olea europaea* subsp. *cuspidata, Schefflera* spp., *Syzygium guineense*, etc.

Two fire potentials are recognized in this area. In the cold dry parts of the mountain escarpments, where *Juniperus* dominates, fire hazard may be high owing to the dryness of the area, discontinuous canopy that allows the growth of grasses and other plants, as well as strong winds. Assisted by wind, which also dries the fuel and spreads fire, the grass and other biomass can burn fast.

The moist and humid part of this zone has a lower risk of fire ignition because of the more frequent cloud cover and rain. Even if fire breaks out, the chances are high that the rain will put it out.

However, the high forests in this zone are, characteristically, found on areas of medium to high slopes making the risk of fire spread a big threat. Fire outbreak during dry seasons, associated with high temperature, low moisture and ample dry fuel, can be devastating in this zone

4.1.4. Hot and Relatively Low Lying Land — 'Kolla'

This zone is found from 400 m to 1500 m, and is characterized by annual temperatures of 20–25°C and rainfall varying from 400 mm to 1600 mm. Two distinct sub-zones have been recognized, namely the moist and dry sub-zones.

In the moist sub-zone, the characteristic trees include *Antiaris toxicaria*, *Celtis toka*, *Cordia africana*, *Milicia* (*Chlorophora*) *excelsa*, *Pouteria* (*Aningeria*) *adolphi-friederici*, etc. The drier sub-zone is composed of various species of *Acacia*, *Combretum* and *Commiphora*, *Brucea antidysenterica*, *Tamarindus indica*, etc.

Both sub-zones are prone to fire every year because of high temperatures and evapo-transpiration, accumulation of dry fuel and strong winds. However, the dry sub-zone experiences higher fire occurrence and spread compared with the moist sub-zone since the latter receives more rainfall than the former. Since most of the areas in this zone are level or have gentle slopes, the role of topography in the spread of fire is significant. Nevertheless, in areas with sloping terrain, the spread of fire could be very rapid, and at times difficult to control.

4.1.5. The Hottest Lowlands — 'Harror' or 'Berha'

This zone is found below 500 m, and is characterized by temperatures of more than 25°C and annual rainfall less than 400 mm. It is dominated by various species of *Acacia* and *Commiphora*. As a result of high temperatures, little or no moisture and strong wind, this zone experiences frequent fire outbreaks.

4.2. Causes of Forest Fires in Ethiopia

Owing to the lack of systematic studies on fire in the past, there are no statistical data on fires which are amenable to analysis of causes, risk and extent of damage. However, general information has accumulated over many years as a result of casual observation and experience that can be used to deduce the major causes of fire.

It has been long established that fire can be man-made, natural or both. According to an unpublished report from the Ministry of Agriculture (Anonymous, undated), the fire incidents that are known to have occurred between 1990 and 2000 have been started by people (Tables 1 & 2). However, it has to be noted that natural causes of fire, such as lightning, cannot be overlooked, particularly in lowland areas where species seem to have developed adaptive mechanisms.

As we have seen earlier, the potential occurrence, extent and behaviour of fire varies among the different zones. In addition, the underlying or root causes of fires started by people in Ethiopia have also been reported to differ in the lowland and highland areas (Ermias Bekele, 1984: Kinfe Abebe, 1993). In general, humans set fires deliberately to clear land for crop cultivation, encourage new growth of grass for grazing animals, get rid of insects pests and wild animals, fumigate traditional beehives placed on the branches of trees to collect honey and make charcoal. In the latter two examples, fire can escape and get out of control.

For instance, according to the preliminary results of our informal survey, factors that are believed to have caused the fires in the Bale Zone in 2000 include:

- expansion of coffee plantations associated with emerging markets in the surrounding areas;
- commercial utilization of timber that has raised issues of equity with the local people;
- immigration into and the subsequent settlement of people inside forests;
- social conflict and competition over forest land;
- careless use of fire during fumigation of beehives to harvest honey;
- un-extinguished cigarettes left behind by people passing through the forest;
- fires started to scare wild animals that eat crops, or attack domestic animals or people; and
- unfavourable policy and institutional matters.

4.3. Impact of Fire in Ethiopia

The impact of fires can be either positive or negative. Although there are no specific studies made, fire favours the regeneration of some species like species of *Acacia*, *Entada*, and *Piliostigma*. On the other hand, fire can be a real hazard to plants, animals, micro-organisms and human beings, in the general ecosystem.

There is no mechanism in place to monitor the occurrence, extent and risk of fire in Ethiopia. The limited records available in the Ministry of Agriculture provide some facts about the occurrence, extent and risk of fire in early 1984 (Table 1) and between 1990 and 2000 (Table 2). In 1984, about 308,198 ha were burnt, the largest impact being on high forests (Table 1).

Table 1. Vegetation resources affected by fire in 1984.

Vegetation	Total area affected (ha)
High Forests	209,913
Bushlands	41,785
Bamboo Forest	33,316
Woodlands	20,584
Plantations	2,600
Total	308,198

Source: Ministry of Agriculture (Anonymous, undated & unpublished)

Table 2. Occurrences of fire and total area of forests burned in Ethiopia between 1990 and 2000.

Year	Occurrence of fire (total number)	Area of forest burned (ha)
1990	4	1072
1991	2	153
1992	1	32
1993	20	3159
1994	1	1550
1995	-	-
1996	-	-
1997	-	-
1998	-	-
1999	-	-
2000	> 120	150,000
Total	> 148	155,966

Source: Ministry of Agriculture (Anonymous, undated & unpublished)

The number of fires and the area of forests burned between 1990 and 2000 ranged from 0–120 to 0–150,000 ha, respectively (Table 2). However, as can be expected, these figures seem to have underestimated the actual figures because there were no detailed surveys. The largest impact from these fires occurred in 2000, a year which had very high fire. In the Bale and Borena zones, over 150,000 ha of forests were destroyed which included natural forest and natural coffee stands, wild and domestic animals, traditional beehives, harvested coffee and maize, local houses and traditional grain storage facilities.

It has to be emphasized here that what is lost as a result of burned forests is not only the timber and non-timber forest products but also several ecological services: soil, water and biodiversity conservation; carbon sequestration and manufacture of oxygen; cultural and aesthetic factors, etc. In addition, the burning of our forests has released carbon dioxide (contributing to global warming), and consumed atmospheric oxygen (contributing to ozone layer depletion), disrupted energy flows and cycling of nutrients (upsetting the ecosystem functions), and polluted the atmosphere and water bodies (contributing to impaired health of organisms), etc.

Mr Shane, the South African expert in fire fighting, used a Spotter Helicopter, brought from South Africa to map the extent of damage as a result of controlled and uncontrolled fires and clearing for cultivating crops.

4.3.1. Fighting Recent Forest Fires in Ethiopia

The outbreaks of fire in the different parts of the country were devastating, particularly those in Borena and Bale Zones. The fires assumed the three major forms, i.e. ground, surface and crown fires, making fire-fighting efforts very difficult, at times impossible. Several thousand people were deployed, including German and South African experts highly experienced in fighting forest fires, and considerable financial and material resources. In this national and demanding obligation, more than 50 forestry researchers, technical and support staff from the Forestry Research Center and the Headquarters of EARO, with logistical support from EARO, participated and made a considerable contribution to stop the fires. Even though the fires were so strong, they finally disappeared completely after a heavy shower of rain.

4.4. Forest Fire Management in Ethiopia

The major activities involved in forest fire management are either prescribed burning to improve rangelands or prevention / control of forest fires.

4.4.1. Prescribed Burning

Prescribed burning is a community-based fire management practice used by pastoralists and semi-pastoralists in the lowland areas of Ethiopia to improve rangelands by stimulating vegetative growth of grasses as well as many trees and shrubs during the dry seasons. It is also used to control bush encroachment (particularly *Acacia drepanolobium* in Borena zone), ticks, tsetse flies and vectors of animal diseases, which pose serious problems, directly or indirectly, to the livestock herds.

4.4.2. Fire Management System

The managing of forest fires in Ethiopia has, until recently, been poorly organized and unco-ordinated, both at the Federal and Regional levels. There is neither any formal unit nor body specifically responsible for forest fire management nor an effective and efficient system that could co-ordinate fire management efforts or initiatives among any of the different administrative levels.

The management of forest fires is just one of the several responsibilities of the Forestry and Wildlife Regulatory Teams within MoA at the Federal level and Bureaux of Agriculture at the regional level. It is, therefore, only activated when there are emergency fire outbreaks. In such cases, both rural and urban communities are mobilized to control forest fires. For instance, to control the forest fire outbreaks in Bale and Borena Zones in 2000 as well as in several other areas, there was an urgent need to establish an emergency national committee at the federal level and similar committees at different levels of all zones. However, there were no such permanent functional and effective committees or units, except for the nominal 'Forest Protection Committee' established at each administrative zone. The human (estimated at over 76,500 people), financial and physical resources required to fight the fires had to be organized on an *ad hoc* basis. Although strenuous efforts were made both by the Government and the people at large, it was not possible to completely extinguish the fires, particularly in Bale and Borena Zones (where 50,000 people participated) until it rained. As a result, very large areas of intact forest were destroyed.

That the fire got out of hand before the necessary steps could be taken suggests that forest fires could be managed successfully (with no or very little damage) if permanent functional and effective standby units were established throughout the administrative structure. For controlling fire, specially trained personnel, equipment (including vehicles) and considerable financial resources are required. All of these were, and still are very limited in Ethiopia. Of the 58 Forest Priority Areas in the country, only two are well organized for fire protection.

Some of the reasons contributing to the weak forest fire management system, which makes fire prevention and control difficult, include:

- lack of awareness about the consequences of forest fire at all levels;
- lack of appropriate land use and forest policies with functional legislation;
- frequent organizational re-structuring of the forestry sub-sector;
- weak institutional arrangements in the sub-sector (federal & regional), i.e. inappropriate and ineffective structure as well as shortage of physical, human and financial resources;
- lack of an organized system, federal and regional, for preventing and controlling fire;
- lack of, or insufficient, law enforcement against arson;
- suspicion by and disincentives for farmers in relation to state-owned forests and other protected areas;
- lack of cost and benefit sharing mechanisms;
- insufficient or lack of appropriate fire prevention and control measures, e.g. demarcation of forest areas, preparation of management plans, including construction of roads, water sources, fire and fuel breaks, etc.
- insufficient research on forest fire leading to a lack of appropriate knowledge and technologies for fire prevention and control, or rehabilitation of forest areas affected by fire;
- lack of mechanisms to monitor forests and forecast possible fire risks;

- lack of a fire information system, i.e. the acquisition, management and dissemination of appropriate information;
- lack of linkages and networking (national, regional and international) to prevent and control fire;
- absence of a fire bonus system;
- insufficient control of the ever-increasing human population;
- poor overall economic performance; and
- poverty.

4.4.3. Community Participation

The fact that over 76,500 people participated in the countrywide fight against fire in 2000 is a good indication that they are concerned to involve themselves in forest fire management. In fact, the most effective forces to control fires in Ethiopia are local communities provided that they are organized, equipped and co-ordinated.

4.4.4. Public Awareness Creation

Professionals in the Government, NGOs, and higher learning institutions, and the mass media were involved in one or the other in creating awareness among rural and urban communities about forest resources, their importance and the impact of fire. This effort is encouraging and should continue in a more co-ordinated way at all levels until the goal is achieved.

5. Fire Prevention

Although fire prevention is better than fire suppression, it is not easy to prevent forest fires, especially those that are deliberately made by people. The possible solutions have to be sought from different angles. If a radical solution is required a to prevent fires, the following points have to be addressed.

- Put an appropriate land-use and forest policy with functional legislation as soon as possible.
- Improve the present organization of the forestry sector, both at Federal and Regional levels, to include adequate trained manpower, financial and physical resources.
- Demarcate forests owned by the state and prepare appropriate management plans in which fire breaks within the forests are included.
- Involve local people in the preparation and implementation of management plans as well as sharing benefits from income generated from forest products.

- Organize well-trained, well-equipped and financially viable Fire Brigades at both Federal and Regional levels.
- Be alert during dry seasons and follow carefully the movements of local people in the forests, especially those that have put their traditional beehives in the forests.
- Stop new settlement of people in forests, and find a viable solution for those that have already settled, including them in the decision making.
- Prevent people from occupying forest sites that have been damaged by fire and start rehabilitation work in those places.
- Suspend bidding for commercial timber from forests until an appropriate benefit sharing mechanism for the local people has been drawn up and agreed. (We are convinced that the selectively targeted burning of hundreds of big 'Kerero' trees around Kumbi, Mena Angetu (Bale Zone) stemmed from desperate local people.)
- Create awareness about forest fire at all levels starting from elementary schools all the way up to policy makers.
- Undertake research on positive or negative impacts of forest fires and appropriate control measures.
- Encourage measures that could help to control human population growth, which is the major driving force of deforestation in this country.

5.1. Fire Prevention Measures

The various fire prevention measures suggested by different authors are summarized below.

Awareness Creation: It is essential to create awareness about the important roles that forests play and the impact of fire on these resources at all levels, from the grassroots through schools to policy makers. Awareness creation is a pre-requisite for preventing human-made forest fires.

Availability Water: Water is one of the best ways in which fires can be prevented from spreading. It reduces the temperature, decreases the oxygen availability and, therefore, makes ignition more difficult. Artificial water stores within the forest should be maintained.

One of the major constraints in the fight against forest fires in 2000, both on the ground and from the air, in the Bale and Borena Zones, was lack of water.

Road Construction: A well-developed road system is always a precondition for proper forest management and is, therefore, also the basis for effective fire prevention and suppression.

The majority of forests in Ethiopia have no roads, and the roads that have been constructed in a few forests are generally of low density (number of running meters per ha), with sharp curves, steep slopes and narrowness. It means only high-quality all-terrain vehicles have access to these forests. De Vletter (1986) has made some guidelines for forest road construction within Ethiopia.

Fire and Fuel Breaks: Firebreaks are strips of exposed mineral soil to keep the fire from spreading to unburned parts of a forest. Although firebreaks can be kept relatively small, they are expensive to construct since a lot of vegetative material has to be removed either manually or mechanically. Other disadvantages include the need for clearing them at least once a year, and their inability to provide a very effective barrier against a full or spotting fire.

De Vletter (1986) has suggested that the construction and maintenance of extensive system of firebreaks might not be either realistic or affordable. Instead, it is better to concentrate on constructing networks of roads within forests.

Another option is the use of fuel breaks, in which low fuel volume/low inflammable vegetation is nurtured. Here, no attempt is made to maintain a mineral soil line. Fuel breaks need to be wider than fire breaks since permanent type conversion requires sufficient separation. Measures required to construct fuel breaks include heavy thinning, more extensive than elsewhere in the forest, pruning of stems up to 4 m height and the removal of all inflammable lower storey materials. Only a low grass or herb cover would be left. Maintenance of these fuel breaks is important, and can be done with machines (not feasible in Ethiopia), manually, with herbicides, by prescribed burning or controlled grazing.

A third barrier against fire is the artificial planting of strips of less inflammable species. Vegetation with the right chemical composition in its wood (high percentage of certain salts) or high water content. This requires research into the identification of fire resistant species.

Even without research, it is known that, in Ethiopia, species of *Opuntia*, *Euphorbia* and possibly *Acacia mearnsii* have some effect on preventing fire spread.

Controlled Burning: Controlled or prescribed burning has become a useful tool in fuel management in many countries. Fuel volume can be decreased by burning to the extent that fires no longer form a serious hazard and can be suppressed easily. However, prescribed burning requires trained personnel, extensive knowledge about fire behaviour, insight into the moisture content of the vegetation at that particular moment, weather expectations, etc. In general, since these preconditions are not met, this system of fuel management is not recommended in Ethiopia.

Controlled Grazing: Controlled grazing aims to reduce fuel volume within the forest or create fuel breaks. But it can damage the forest by trampling the soil, leading to soil compaction by the grazing animals and subsequent erosion, as well as excessive browsing that damages trees.

This method should be tested on a large scale under a number of different conditions. It requires the presence of trained guards, the exclusion of goats and avoidance of very steep slopes.

5.2. Forest Management for Fire Prevention

Proper forest management practices would help to prevent fires by:

- selecting tree species to avoid mortality of unsuitable trees causing inflammable fuel accumulation (e.g. *Cupressus lusitanica* stands on heavily eroded sites);
- selection of species with a fast early growth and the ability to reach stand closure quickly to suppress grasses and weeds;
- timely weeding and pruning operations;
- planting trees in narrower spaces along road and forest boundaries in order to prevent the build up of fuels there, and removing grasses and shrubs if they develop (or, allow a 'cut and carry' system for the local people);
- subdividing the forests into compartments; and
- systematic and continuous removal of fallen leaves, twigs, bark strips, etc.

5.3. Fire Detection

The early detection and exact location of forest fires, a reliable assessment of its direction and speed of travel, a speedy alarm system to the responsible persons and the immediate organization of suppressing crews, are the main conditions for a successfully fighting forest fires. The sooner suppression crews reach the fire, the smaller the burning area and the simpler its suppression.

The foregoing discussion implies that some kind of organized fire detection mechanisms are needed. This can be achieved through ground patrols, look-out towers or other posts, and additional observations from an aircraft.

5.4. Fire Suppression

5.4.1. Techniques

The combustion process is the interaction of three essential components, namely fuel, oxygen and heat. Combustion can proceed only when all the three components are linked together in a triangle. Therefore, fire suppression is aimed at removing any one of the three components.

Oxygen can be excluded by smothering the fuel with dirt or by diluting the combustible gases with water vapour. But forest fires have a virtually unlimited access to fresh air (oxygen supply). Hence, oxygen removal has only a very limited applicability in forest fire suppression.

Heat can be removed from fire by cooling the flames or the fuel surface. Water is the most common cooling agent.

Breaking the fuel side of the triangle is by far the most common method of suppressing forest fires. Usually, the fuel is simply removed from the front of the advancing flames, e.g. by scraping or bulldozing for low intensity fires, or by burning out when wider lines are needed to check high intensity fires.

There are three methods of bringing a forest fire under control:

- direct attack on the burning fire edge;
- parallel attack by constructing a fire line close by and parallel to the fire edge; and
- indirect attack by locating control lines at a considerable distance from the fire edge and burning out all intervening fuel (using a backfiring technique).

Defence measures are always carried out from fire lines, barriers constructed manually or mechanically (by bulldozers) during a suppression operation. Here the crews take up their positions and actively combat the fire with their equipment.

5.4.2. Equipment for Fire Fighting

Equipment required to fight forest fires includes:

- good shoes with strong, heat resistant soles and quality clothing for fire fighting crews;
- hand tools — cutting tools (motor saws, axes and brush cutters), beating tools (swatters or flaps and brooms), digging tools (e.g. shovels), raking tools (e.g. fire rake), etc.;
- backpack pump;
- vehicles for transporting water and equipment; and
- first aid kits, food and drinking water for safety and comfort of the fighters.

5.5. Organization of the Suppression Operation

There are no trained crews or organizations for fighting forest fires in Ethiopia. In emergency fire cases, local people, mostly without any training in fire fighting, are mobilized and deployed. Hence, the results are, in most cases, unsatisfactory.

6. RESEARCH ON FOREST FIRES IN ETHIOPIA

Research on fire in general, and forest fires in particular, is at its infancy in Ethiopia. There are only four research reports on forest fire (Tamene Yigezu, 1990; Woube, 1998; Eriksson, 2000; Minassie Gashaw, 2000) that the author is aware of.

Tamene Yigezu (1990) studied population dynamics of the problem shrubs *Acacia drepanolobium* and *A. brevispica* in the southern rangelands of Ethiopia. Although no particular experiment was carried out on the use of fire in this study, fire was cited as one of the ecological factors responsible for the invasion of woody plants in semi-arid grasslands. It was reported that prevention of regeneration in the two species could be assisted by grazing or burning, or by natural means. It was also noted that grazing would be unlikely to much reduce the seed pool. Burning or a combination of burning and grazing was more likely to reduce the seed pool.

Woube (1997) investigated the effect of fire on plant communities and soil in the humid tropical savannah of Gambella. Reports exist stating that fire has been and is being used by pastoralists and farmers in the Gambella Region (Baro-Akobo River Basin) to help the re-growth of young green shoots and food crops. The intensity, frequency and magnitude of fires in the region have been aggravated by a resettlement scheme and mechanized farming. As a result, useful plants and wild animals have been adversely affected. Fires have (i) changed the physiognomy of plants; (ii) reduced the number of essential plant species; (iii) pushed wild animals into neighbouring areas; and (iv) caused soil erosion. Based on these results, a warning message has been made that if the fire occurrences continue unabated, this region of rich biodiversity may become a desert.

Eriksson (2000) carried out a comparative study on fire ecology and plant community response to fire in *Acacia* woodland in the Ostrich Ranch of Abiata-Shalla Park and dry afromontane forest of Wondo Genet Forest in southern Ethiopia. The results from this study indicated that the total fuel quantity differed only slightly between the two vegetation types, but fuel composition differed substantially: The mass of litter fuels was two times greater in the *Acacia* woodland (673 g m^{-2}) than in dry afromontane forest (308 g m^{-2}). In contrast, the mass of woody fine fuels was four times greater in dry afromontane forest (300 g m^{-2}) than in *Acacia* woodland (76 g m^{-2}). The biomass of live fine fuels was also several times greater (110 g m^{-2}) in the dry afromontane forest compared with *Acacia* woodland (15 g m^{-2}). As expected, fuel moisture content in litter was lowest, 17 percent, at the *Acacia* woodland site compared with the dry afromontane forest, where it was 21 percent under closed canopy cover and 30 percent under open canopy cover.

During experimental fire, fuel consumption in *Acacia* woodland was 100 percent in all burned plots, but ranged between 10 percent and 40 percent of the available fuel within the plots in dry afromontane forest. The results from the soil seed bank study indicate little if any impact from fire. Bark thickness was measured as an indicator of fire resistance in tree species representing three vegetation types: *Acacia* woodland, woodland-forest transition zone and dry afromontane forest. There was a gradual increase in bark thickness of trees when going from the dry afromontane forest over the transition zone towards the *Acacia* woodland. Considering all species analyzed (26), bark thickness of trees 15 cm in diameter at one-meter height ranged from 2.4–15.4 mm.

Therefore, based on the differences in microclimate, fuels, fire behaviour and bark thickness, *Acacia* woodland was determined to be the most fire prone as well as most fire resilient ecosystem. In contrast, sustained combustion was unlikely at the dry afromontane forest plot. Fires would not spread because of the high fuel moisture content and poor fuel bed. Forest fragmentation and intentional burning of grasslands, followed by an altered microclimate would, however, increase the probability of fires penetrating dry afromontane forest.

Minassie Gashaw (2000) investigated the survival strategies and ecological performance of plants in regularly burnt savannah woodlands and grasslands of western Ethiopia. The investigation focussed on soil seed bank dynamics, post-fire regeneration strategies and tree-bark resistance to fire. Plant cover, leaf nutrient and condensed tannin concentration, following experimental burning, and seasonal variation in leaf condensed tannins in dominant trees, shrubs and grasses were also studied. The highlights from this study are published in these Proceedings.

Although the above studies have generated interesting and very important results, a lot more research remains to be carried out on forest fire. This has already been recognized in the development of the National Forestry Research Strategic Plan in the Ethiopian Agricultural Research Organization (EARO). This strategic plan has been approved by the Board of EARO and is in its first phase of implementation. Hence, it is hoped that major issues related to forest fire will be addressed by research along with other crucial problems of forestry in the country.

7. Conclusion

The foregoing discussions indicate that fire can be both beneficial and harmful to forest and woodland resources. To use fire beneficially, and prevent its harmful effects, knowledge about fire and its behaviour are prerequisites. Also needed are fire-fighting skills, an appropriate policy, legislative and institutional arrangements for forest fire management, an adequate budget, qualified personnel and equipment.

Good information about fire, its management and dissemination, including early warning mechanisms, as well as mechanisms for mobilizing and co-ordinating rural and urban communities in the management of forest fire, are also necessary. At present, most of these are not present in Ethiopia. Unless something can be done about them, it is highly probable that there will be a continuous risk of fire hazard in our forests and woodland resources. Ultimately, this in turn will have adverse effects on the welfare of plants, animals, micro-organisms and people. Therefore, let us act now to lay the foundation for either preventing or effectively controlling forest fires before it is too late.

ACKNOWLEDGEMENTS

I would like to thank the Round Table Conference Organizing Committee for inviting me to prepare and present this paper, Mr Million Bekele for providing me with valuable reference material, Mr Tadesse Woldemariam for his assistance in preparing the poster presented during the conference, Dr Yonas Yemshaw and Ato Deribe Gurmu for their assistance during the presentation of the paper and all the authors from whom I have freely quoted in compiling this paper.

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Discussion

Ensermu Kelbessa: In your classification of the vegetation of Ethiopia, category T5, moist evergreen forest should be 'moist broad-leaved evergreen montane forest' as there are two sub-types: Moist broad-leaved montane forest and moist mixed evergreen and broad-leaved deciduous forests. How do you comment?

Demel Teketay: I used the vegetation classification system of the National Conservation Strategy (NCS). There are different approaches to the Ethiopian vegetation classification and it raises the point that it might be good for us all to discuss the most suitable way of classifying the Ethiopian vegetation types since the same question is being repeated in many fora.

Gedion Asfaw: You have presented an excellent paper. Could we be told how the technical information might be used for planning, policy formulation and practical forest fire management?

Gunther Haase: The technical information provided in the presentations will be used as source documents for the planned group discussions.

Ensermu Kelbessa: We need to remember plant species whose seeds are assisted by fire for easy germination. It would also be helpful to have a note on the vulnerability of each of Dr Demel's nine vegetation types to fire.

Demel Teketay: Fire does not promote seed germination in all circumstances, but there is a clear indication that some morphological characteristics of tree seeds are adaptations to fire and still others require fire to activate germination, such as breaking seed dormancy. Generally, however, we should be cautious about the effect of fire on germination of seeds.

I understand vulnerability as a relative term. You can speak of vulnerability with respect to areas left to nature. Where resources, irrespective of where they are, are subjected to human pressure, the true meaning of vulnerability might not apply.

Winston Trollope: What is the current state of knowledge on grassland ecology and the effect of fire on grassland communities in Ethiopia?

Demel Teketay: The existing level of knowledge in this respect is limited. Perhaps Minassie Gashaw of EWCO, currently doing related research in the Gambella lowlands, might answer such questions in his paper?

Gedion Asfaw: What is the relationship between theoretical knowledge about the effect of fire on vegetation, and the practical need to formulate policy?

Demel Teketay: Not much has been done on that subject and it should be studied. But the fire damage has been hitherto so serious that our concern is to stop it by any means, be it through policy or any other legal measures.

REGIONAL TO GLOBAL FIRE ISSUES: THE ROLE OF VEGETATION FIRES IN AFRICA AND OTHER CONTINENTS IN GLOBAL PROCESSES

by Johann G. Goldammer*

SUMMARY

Fire is a phenomenon occurring in most vegetation zones of the world. Some vegetation types are adapted to the regular occurrence of natural and human-caused wildfires. Such ecosystems include African savannahs and also forest ecosystems in all continents. In many land-use systems, the application of prescribed fire in agriculture and pastoralism is often possible without negatively affecting the sustainability and productivity of these systems. In other ecosystems, fire may lead to the destruction of forests or to long-term site degradation. In most areas of the world, wildfires burning under extreme weather conditions will have detrimental impacts on economies, human health and safety, with consequences which are comparable in severity to other natural hazards.

Fires in forests and other vegetation produce gaseous and particle emissions that have impacts on the composition and functioning of the global atmosphere. These emissions interact with those from burning of fossil fuel and other technological sources that are the major cause for anthropogenic climate forcing. Smoke emissions from wildland fires also cause visibility problems that may result in accidents and economic losses. Smoke generated by wildland fires also affect human health and in some cases contributes to loss of human lives. Fire risk modelling in expected climate change scenarios indicates that within a relatively short period of the next three to four decades, the destructiveness of human-caused and natural wildfires will increase. Fire management strategies, which include preparedness and early warning, cannot be generalized due to the multi-dimensional effects of fire in different vegetation zones and ecosystems, and the manifold cultural, social, and economic factors involved.

Fire information systems that include early warning tools are essential components of fire and smoke management. Early warning systems rely on evaluation of vegetation dryness and weather; detection and monitoring of active fires; integrating and processing of these data in fire information systems with other relevant information, e.g. vegetation

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cover and values at risk; modelling capabilities of fire occurrence and behaviour; and dissemination of information.

Early warning of fire hazard may involve locally generated indicators, such as local fire-weather forecasts and assessment of vegetation dryness. Advanced technologies, however, which rely on remotely sensed data, evaluation of synoptic weather information and international communication systems (e.g., Internet) are now also available for remote locations.

This report reviews the global and the African fire situation and gives an overview about the tools that need to be created for the development of an Ethiopian fire management strategy.

1. INTRODUCTION

Fire is a dominant disturbance factor in almost all vegetation zones throughout the world. In many ecosystems, fire is an essential and ecologically significant force — organising physical and biological attributes, shaping landscape diversity, and influencing energy flows and biogeochemical cycles, particularly the global carbon cycle. In addition, the use of fire as a land-management tool is deeply embedded in the culture and traditions of many societies, particularly in agriculture and pastoralism in the developing world.

Conversely, in some ecosystems fire is an unnatural process that often leads to vegetation destruction and long-term site degradation. Yet, these regions, particularly in the humid tropics, are becoming increasingly vulnerable to fire due to growing population, economic, and land use pressures. Even in regions where fire is natural, e.g. the northern circumpolar boreal zone, more frequent weather conditions suitable for severe fires have created recurrent major fire problems in recent years. Extreme wildfire events are increasing throughout the world, with significant impacts on economies, and human health and safety comparable to those associated with other natural disasters, such as earthquakes, floods, droughts and volcanic eruptions. In many countries, rapidly changing social, economic and environmental conditions suggest that marked changes in fire regimes can be expected, with unknown local, regional, and global consequences.

Fires in forests and other vegetation produce gaseous and particle emissions that have impacts on the composition and functioning of the global atmosphere. These emissions combine with those from burning fossil fuels and other technological sources which are the major cause for anthropogenic climate warming. Fire risk modelling in expected climate change scenarios indicates that within a relatively short period, the next three to four decades, the destructiveness of human-caused and natural wildfires will increase. Fire management strategies, which include preparedness and early warning, cannot be generalized due to the multidirectional and multidimensional effects of fire in the different vegetation zones and ecosystems, as well as the manifold cultural, social, and economic factors involved.

2. Global Fire Occurrence

Reliable statistical data on occurrence of wildfires and land-use fires, areas burned and losses are available for only a limited number of nations and regions. Within the northern hemisphere the most complete data set on forest fires is periodically compiled and published for the member states of the Economic Commission for Europe (ECE). It includes all Western and Eastern European countries, countries of the former Soviet Union, the U.S.A. and Canada. The data set is restricted to forest fires and does not include land-use fires. Other countries from outside the ECE/EU region report fire statistics in the pages of the International Forest Fire News (IFFN) and other published and non-published reports. These statistical data are currently updated at the Global Fire Monitoring Center (GFMC) (see below).

A global inventory of fire events has been developed on the basis of active fires depicted by the space-borne NOAA AVHRR sensor. This data set provides the temporal and spatial distribution of vegetation fires throughout the year. However, it does not yet provide a quantitative database in terms of area burned, vegetative matter combusted, and gas and particle emissions generated. Space-borne sensors have been used in a large number of case studies to determine land areas affected and emissions produced by fires. Thus, potential tools for a quantitative inventory of fire effects using space-borne sensors are available.

2.1 Main Types of Vegetation Fires

Wildfires (uncontrolled fires) are common in all vegetation zones. They are mostly caused by negligence and are often associated with escaped land-use fires. Both wildfires and land-use fires can directly or indirectly cause immediate damage and/or have long-term environmental or humanitarian consequences. Despite the fact that many ecosystems are well adapted to fire and land-use fires often follow traditional and established practices, there is an increasing tendency for fire events to cause conflicts among the needs of the rapidly growing populations of the developing countries and to be at the interface with vulnerable structures of industrialized societies.

2.1.1 Wildfires (uncontrolled fires) in forests

In the temperate and northern boreal forests wildfires occur regularly during the dry northern summers. In North America and Eurasia, between 5 and 20 million hectares (ha) are burned annually. In the less populated high latitudes, the ignition sources are dominated by lightning, while in more frequently populated regions humans become the dominating fire lighters. In the Mediterranean region, an average of about 0.6 million ha of forest and other land is burned annually.

The equatorial rain forests are usually too moist to allow the propagation of wildfires. However, extreme droughts in association with forest exploitation periodically create conditions of flammability, fuel availability and fire spread in the equatorial rain forests. Such events regularly occur in the forests of tropical South Asia in association with cyclic climate variability caused by the El Niño-Southern Oscillation (ENSO) phenomenon. Some examples of large-scale (catastrophic) fire events are given below.

The largest areas affected by uncontrolled wildfires in tropical forests are in the seasonal forest biomes (deciduous and semi-deciduous forests, sometimes also referred to as 'monsoon' forests). Here, the fires burn in short-cycle intervals of 1 to 3 years. The tropical submontane coniferous forests are also subjected to regular fires.

The afro-montane forests of Ethiopia are examples of forest ecosystems that are not adapted to fires and which must be protected from any human-made fire activities.

2.1.2 Wildfires in tropical grass, brush and tree savannahs

Tropical savannahs cover an area of about 2.3-2.6 billion ha worldwide. Savannahs typically consist of a more or less continuous layer of grass with interspersed trees and shrubs. There are numerous transition types between savannahs and open forests. The surface fuels in these ecosystems are dominated by grasses and leaves which are shed during the dry season, and these are burned at intervals which may range from one to four years. This fire frequency has been increasing in some regions as a result of increasing population and more intensive use of rangeland. The area of savannahs potentially subjected to fire each year is up to several hundred millions of hectares.

The wildland fire scene in Southern and West Africa is dominated by fires burning in fire-adapted ecosystems. A recent research report of NASA indicated that about 130 million ha of savannahs and grasslands burn annually in Africa south of the equator (for comparison: South Africa covers an area of 122 million ha). The region's heaviest burning is concentrated in the moist subtropical belt that includes Angola, the southern Congo, Zambia, northern Mozambique and southern Tanzania. During the 2000 fire season the area burned south of the equator could have reached more than 200 million ha.

A case study from the Central African Republic in the second half of the 1990s showed that just the areas burnt was over 43% of Sudanian savannahs (equal to 8.6 million ha) and 58% of Guineo-Congolian/Sudanian savannahs (equal to ca. 62 million ha). The area of forest affected by fires is difficult to assess in the absence of a suitable forest database. However, in the 1994-95 dry season, 2486 cases of fires were detected in 'forested' areas. However, a close inspection of the data revealed that all these fires were on the edge of the forest domain and some were likely to be for the purposes of establishing coffee cultures. It was not, however, possible to quantify these in terms of area of forest burned.

As a result, savannah burning releases about three times as much gas and particle emissions to the atmosphere as deforestation burning. It has been estimated that more than 3 billion tons of vegetative matter are burned in tropical savannahs annually.

2.1.3 Conversion of forest and bushland to plantations, agricultural and pastoral systems

Two types of forest clearing for agricultural use are common, predominantly in the tropics: shifting agriculture, where the land is allowed to return to forest vegetation after a relatively short period of use, and permanent removal of forest to be converted to grazing or crop lands. In both instances, the clearing and burning follows initially the same pattern. First, trees are felled at the end of the wet season and, after extraction of marketable and otherwise usable trees, the vegetation is then left for some time to dry out in order to obtain better burning efficiency. In shifting agriculture, which is practised by several hundred million people worldwide, the cleared areas are used for agriculture for a few years until yields decline, then they are abandoned and new areas cleared. The generally observed shortening of shifting agriculture cycles is increasingly associated with site degradation making this traditional land-use technique one of the leading causes of global tropical deforestation.

The conversion of primary or secondary forest into permanent agriculture and grazing land, including tree plantations, is driven by expanding human populations that require additional food and living space, but also by large-scale resettlement programmes and land speculation by big business.

The net amount of plant biomass which is combusted in the process of vegetation clearing is in the range of 1 to 2 billion metric tons.

2.1.4 Burning of agricultural residues, control of bush and weeds, nutrient cycling on grazing and croplands

A substantial amount of agricultural residues, e.g. straw and stalks, is disposed off by burning. The magnitude of this practice is extremely difficult to quantify because of its dispersed nature. No statistics are available, mostly because no material of direct economic value is involved. It has been estimated that between 800 and 1,200 million tons of agricultural residuals are burned annually, making this practice a major source of atmospheric pollution.

By tradition fire is also a common practice to control bush and weed encroachment in both grazing and crop lands, mainly in the tropics.

2.2 Recent major fire episodes and losses

Comprehensive reports with final data on losses caused by forest and other vegetation fires (wildland fires), including impacts on human health, are only occasionally available. The main reason for the lack of reliable data is that the majority of both the benefits and losses from wildland fires involve intangible non-use values or non-market outputs which do not have a common base for comparison, i.e. biodiversity, ecosystem functioning, erosion, etc. Market values, particularly loss of timber or tourism revenue, have been calculated in some cases.

- The large wildfires in Borneo (Indonesia) during the ENSO drought of 1982-83 burned more than 5 million hectares of forest and agricultural lands. In East Kalimantan a fire damage inventory revealed total losses of about US$ 9 billion.
- First assessment of damage caused by the fire episode of 1997-98 in Indonesia on about 8-9 million ha resulted in:
  - losses of around US$ 10 billion
  - approximately 40 million people in SE Asia affected by smoke to various degrees (by increased morbidity and mortality — long-term health effects)
  - more than 250 fatalities due to aircraft and maritime accidents.
- The fires burning in Mexico during the 1998 episode forced the local government to shut down industrial production in order to decrease additional industrial pollution during the fire-generated smog. Daily production losses were around $US 8 million.
- Australia's *Ash Wednesday Fires* of 1983:
  - human death toll: 75
  - burned homes: 2539
  - burned domestic livestock: nearly 300,000
- Extended forest and savannah fires in Côte d'Ivoire 1982-83:
  - human death toll: more than 100
  - burned land area: 12 million ha
  - burned coffee plantations: 40,000 ha
  - burned cocoa plantations: 60,000 ha
- Forest fires in the Northeast of the People's Republic of China during the 1987 drought:
  - human death toll: 221
  - burned forest: 1.3 million ha
  - homeless population: 50,000
  - average annual human fatalities 1950-98 (all China): 92 dead, 551 wounded
- Same fire episode in the Soviet Union during the 1987 drought resulted in 14.5 million ha of burned forest and in 1998 7.1 million ha of burned forest.
- Mongolia steppe and forest fires 1996-97:
  - burned area 1996: 10.7 million ha
  - human death toll: 25
  - burned domestic animals: 7000

- burned stables/houses: 576/210
- damage assessment: US$ 2 billion
- burned area 1997: 12.4 million ha

Smoke pollution generated by wildland fires occasionally creates situations during which public health and local economies are affected seriously. The WHO *Health Guidelines on Vegetation Fire Events* deal with this problem and can be seen at their web site: http://www.who.int/peh/air/vegetation_fires/htm.

2.3 Hazard assessment as the basis of risk analysis

Early warning systems for fire and smoke management for local, regional, and global application require early warning information at various levels. Information on current weather conditions and vegetation dryness provides the starting point of any predictive assessment. From this information, the risk of wildfire starts and prediction of the possibility of current fire behaviour and fire impacts can be derived. Short- to long-range weather forecasts focused on fire hazards allow the assessment of fire risk and severity. These are carried out by advanced space-borne remote sensing technologies which make it possible to assess weather conditions and vegetation dryness covering large areas (local to global) at economic levels and with an accuracy that otherwise cannot be met by ground-based technologies. Remote sensing also provides capabilities for detecting new wildfire starts, monitoring ongoing active wildfires, and, in conjunction with fire-weather forecasts, providing an early warning tool for escalating extreme wildfire events.

2.4 Fire prevention and control: The role of communities

At the global scale, the majority (>90%) of all wildfires start in connection with land use. Negligence, ignorance, and lack of capacity (technologies and training) to control escaping fires are the main causative agents. Thus, fires represent a hazard that can be predicted and controlled, and also prevented. Fire prevention, however, must address different sectors of the society. Public policies which determine land use create the main underlying conditions for wildfire occurrence. Individuals and groups which use fire in forests, agriculture and pastoralism are the main causes for disastrous wildfires. At the same time, they are also threatened by wildfire.

Public education programmes for fire prevention have to address different target groups which vary from country to country. For example, urban people visiting as tourists are often the main starters of wildfires in industrial countries, and they have to be targeted by specific public awareness campaigns using mass media and targeted advertisements, e.g. in recreation areas, national parks etc. Education programmes for school children involve different media to transmit messages on environmental protection including forest fire prevention.

Most important in wildfire prevention is the involvement of rural communities. Experience in community-based fire management shows that incentive programmes create a positive atmosphere of collaboration and trust between land users and authorities.

3. Towards Global Programmes in Fire Management

Despite a high profile, current estimates of the extent and impact of vegetation fires globally are far from complete. Several hundred million hectares of forest and other vegetation burn annually throughout the world. However, a large percentage of these fires are not monitored or documented. Clearly, informed policy decision-making and emergency responses, including humanitarian assistance, require the timely quantification of fire activity and impacts nationally, regionally and globally. Primary policy considerations relate to concerns about the regional and global impacts of excessive and uncontrolled burning, broad-scale trends over time, and the options for instituting protocols that will lead to more efficient control. Key policy questions involve determining whether fire is a sufficiently serious problem to require action and, if so, what factors govern its incidence and impacts, and what are the relative costs and benefits of different options for reducing adverse impacts?

In order to answer the numerous open-ended questions, the Global Fire Monitoring Center (GFMC) was established in 1998. The Center is designed as an information and monitoring facility which national and international agencies involved in land-use planning, fire and other disaster management, scientists and policy makers can utilise for planning and decision making.

The GFMC is hosted by the *Fire Ecology and Biomass Burning Research Group* of the *Max Planck Institute of Chemistry, Biogeochemistry Department*, Germany, which also serves as a co-ordination unit of the *Biomass Burning Experiment* (BIBEX) of the *International Geosphere-Biosphere Programme* (IGBP), *International Global Atmospheric Chemistry* (IGAC) Project, and the *UN-FAO/ECE/ILO Team of Specialists on Forest Fire*. The GMFC was initially sponsored by the Government of Germany, Ministry of Foreign Affairs, Office for the Coordination of Humanitarian Affairs, as a German contribution to the UN *International Decade of Natural Disaster Reduction* (IDNDR). The creation of the GFMC in 1998 was in line with the policies of several international agencies and institutions which developed close partnerships, notably with

- the IDNDR and its successor arrangement, the *International Strategy for Disaster Reduction* (ISDR)
- the *World Conservation Union* (IUCN)
- the *Deutsche Gesellschaft für Technische Zusammenarbeit mbH* (GTZ)
- the *United Nations Economic Commission for Europe* (ECE)

- UN *International Search and Rescue Advisory Group* (INSARAG), Wildland Fire Group
- the *International Tropical Timber Organization* (ITTO)
- the *World Health Organization* (WHO)
- the *United Nations Educational and Scientific Organization* (UNESCO)
- the World Bank, *Disaster Management Facility* (DMF) and its associated *ProVention Consortium on Natural and Technological Catastrophes* and the *World Institute for Disaster Risk Management* (DRM)
- the Technical Assistance to the Commonwealth of Independent States (TACIS) programme in Russia
- the US *Bureau of Land Management* (BLM)

After the end of the IDNDR (1990-2000) the GFMC continues to support the IDNDR successor arrangement: the *International Strategy for Disaster Reduction* (ISDR) and the work of the ISDR *Inter-Agency Task Force* (IATF) which operates under the direct authority of the Under-Secretary-General for Humanitarian Affairs of the United Nations. In October 2000, the IATF *Working Group on Wildland Fire* was established at the 2nd IATF meeting. It is now being co-ordinated by the partners IUCN and GFMC.

The GFMC fire documentation, information and monitoring system is accessible through the Internet: <http://www.uni-freiburg.de/fireglobe/>.

The Fire Ecology and Biomass Burning Research Group and the GFMC are located at Freiburg University (Germany). The expertise of the Institute goes back to the mid-1970s when global scientific research and development work in the fields of fire ecology, cultural history and socio-economics of vegetation fires, with scientific findings being transferred into operational management systems and policy development began at Freiburg University. In the same time period, the Max Planck Institute for Chemistry, located in Mainz (Germany), took the lead in investigating the role of vegetation fires in global biogeochemical cycles and atmospheric chemistry. The two institutions merged in 1990 and created the first interdisciplinary global fire research facility. The information on the global fire research programmes of IGAC-BIBEX is accessible through the GFMC website. Since 1999, the GFMC has become part of the *German Research Network for Natural Disasters* <http://www.dfnk.gfz-potsdam.de> and is a member and closely co-operates with the national German Committee for Disaster Reduction.

The Fire Ecology Research Group/GFMC has provided advisory services for a broad range of bi- and multilateral scientific, technical fire management and fire policy development programmes in all continents. Co-operation with GTZ projects were implemented in Brazil (University of Paraná, Curitiba, 1980-82), Indonesia (Mulawarman University and IFFM, 1987-ongoing), Algeria (Projet Pilote de

Développement Forestier du massif de Collo, 1992), Argentina (CIEFAP, Esquel, 1991-97), Sudan (Jebel Marra Forest Circle, 1991) — see also Waldinfo No. 13 (1994). The GFMC has also contributed to a large number of projects of the FAO, the International Tropical Timber Organization (ITTO), the World Health Organization (WHO), and other international organizations.

Furthermore, the GFMC has assisted several countries to launch national fire management strategies. Main efforts have concentrated on Indonesia (1992) and Namibia (1999), and the process in Ethiopia (2000).

4. THE ETHIOPIA FIRE EMERGENCY IN 2000: AN EXAMPLE FOR INTERNATIONAL COOPERATION

Between late February and early April 2000, severe forest fires occurred in the mountain forests of Ethiopia. Following a request from the government of Ethiopia the very first and successful multi-national wildland fire fighting campaign in history was initiated in a tropical developing country. This summary provides a narrative of the events as they took place after the Global Fire Monitoring Center (GFMC) had been contacted on 18 February 2000.

The situation in the second half of February 2000: On 18 February, the Ethiopian Federal Ministry of Agriculture (MoA) received reports that uncontrolled forest fires had started in different parts of the country. On 20 February, the local GTZ forest advisor contacted the GFMC and described the situation. At this time, the extent of these fires was not yet known, but being at the end of the dry season the situation looked serious. Some of the fires had started in woodland areas in the lowlands, but had already encroached into the neighbouring afro-montane forest areas. The MoA was very concerned about the situation and launched two reconnaissance surveys on 18 February to more accurately assess the situation. Since local capacities for fire fighting were limited, possibilities for international assistance were being explored.

On 23 February, the MoA received more detailed reports on two large forest fires in Oromiya Regional State. Both fires had started in the transition zones between woodland and forest areas and had since encroached on the forest. One of the affected areas was located in the Borana Administrative Zone, near Shakiso town. Reportedly, about 10,000 ha of a total of 80,000 ha of a forested area had already burnt at that stage. There were three major fires in different locations. A task force consisting of forestry experts from all administrative levels and the local administration had been established to mobilise the local population for fire fighting activities. A mining company operating in the area joined the operation and provided heavy equipment. The MoA and the Regional Agricultural Bureau organised hand tools for fire fighting.

The other affected location was the Bale Massive in Bale Administrative Zone. The fire had encroached into one of the designated National Forest Priority Areas (NFPA) and reportedly burned 2,500 ha. There are four different NFPAs located in this area, totalling some 580,000 ha of forested land. The forests are in most parts disturbed or heavily disturbed increasing combustible biomass. They surround Bale Mountains National Park on three sides. By end of February 2000, 600 ha of the afroalpine vegetation in the Park had burnt but adjoining communities, environmental clubs and school students successfully extinguish the fire. As in the other area, there were scattered smaller fires constituting the fire threat. Apparently, in this area, fire does not expand much during daytime, but at night when the wind picks up.

When the international team arrived, the situation needed further assessment but it was hoped that the fire could eventually be controlled with local resources. However, it was found that the terrain was rugged and dissected, making access difficult, and fire fighters had to walk several hours to reach the fire fronts and were already exhausted by the time they arrived. There was also a shortage of fire fighting hand tools, but additional fire beaters had been ordered.

27 February 2000: The GFMC produced and distributed a fire situation report which called for the attention and assistance of fire specialists and government authorities in South Africa, Namibia, Zimbabwe and Ethiopia. At this stage, the government of Ethiopia also produced a request for assistance from South Africa. But, the South African helicopters could not come to support the fire fighting because they were already fully committed to rescuing people from the flood-stricken regions of Mozambique.

1-5 March 2000 — start of the international response: On 1 March, a fire specialist from the GFMC was dispatched to Ethiopia and on 2 March, a first situation analysis by GFMC-GTZ was submitted to the government of Ethiopia. It recommended immediate requests for international assistance. In addition, it recommended the acceptance of the Republic of South Africa's offer to deploy a team of three experts to assist in fighting the fires. The GTZ-GFMC team was also in close contact with institutions in the United States so that it could continuously receive medium- to high-resolution near-real time satellite maps (DMSP, NOAA AVHRR). It was proposed to transmit the maps directly to the US Embassy in Addis Ababa and the MoA so that the satellite data could be forwarded to the field to help direct the emergency measures.

Between Friday 3 and Sunday 5 March, an Ethiopian-German team was dispatched to the fire region south of Addis Ababa. It was joined by the South African team on 4 March.

6-9 March 2000 — Formation of an International Fire Emergency Advisory Group: On 6 March an International Fire Emergency Advisory Group was formed consisting of Ethiopian, GFMC, German, South African and US experts. The Group set up an Incident Command System (ICS), and the international community and the media were briefed on the situation.

Fire-weather forecasting for Ethiopia: The fire-weather forecast for Ethiopia during the Ethiopian fire crisis was generated on a daily basis by Net Forecasting. This independent weather forecast service from South Africa usually provides fire-weather forecasts for the South African Fire Fighting Association (FFA). The government of South Africa funded this special Ethiopian forecast under the umbrella of humanitarian aid.

Net Forecasting provided 6-day fire-weather forecasts twice daily for Addis Ababa and Goba regions respectively, and daily fire-weather forecast maps based on data from the European Centre for Medium Range Weather Forecasts (ECMWF) and the United Kingdom Meteorological Office (UKMO).

Satellite remote sensing of fires: The US National Oceanic and Atmospheric Administration (NOAA), National Environmental Satellite, Data and Information Service (NESDIS), International and Interagency Affairs Office, on the request of the Government of Ethiopia through the US Embassy in Addis Ababa, provide the following remote sensing information:

- **U.S. Air Force Defence Meteorological Satellite Program (DMSP)**: The DMSP Operational Linescan System detects fires at night in a light- intensified visible channel at a 2.7 km resolution for the East African region. A special survey of the area where the fires occurred (Goba and Shakiso Regions - 5-9°N, 38-42°E) were produced Monday through Friday.
- **NOAA Advanced Very High Resolution Radiometer (AVHRR)**: The NOAA AVHRR provides information for meteorological, hydrologic and oceanographic studies. POES AVHRR Local Area Coverage (LAC) 1 km resolution data recorded onto NOAA-14 spacecraft were processed from 8 to 10 March and occasionally later. Restrictions were due to the fact that the satellite's orbital track changed and the spacecraft did not image directly over Ethiopia due to other commitments.

The situation between 8 and 14 March 2000 — building up the field forces: Three crew leaders from the Republic of South Africa (RSA) arrive on 8 March. A South African and a US fire specialists left for Robe/Goba to carry out some training of ground crew leaders.

The spotter plane from South Africa arrived on Friday 10 March in the afternoon. Later that day, 15 forest fire fighters arrived from Johannesburg, South Africa. On 11 March, they were dispatched to Goba Base Camp where they were joined by 15 Ethiopian soldiers.

On Saturday morning (11 March), it was reported that students from an agricultural training centre, soldiers and community members from Bale Zone had succeeded in containing the fires in Kumbi Forest.

On 12 March, the South African pilot trainer, technician and additional four crew leaders arrived and on 13 March, the helicopter-based fire fighting crew became fully operational in Bale Zone. There were 38 fire fighters (18 South African and 20

Ethiopian) organised in four teams, who contained the fires extending over 25 hectares in the east of the National Park.

On 14 March, a shipment of 320 backpack water pumps from Germany arrived by special airfreight in the morning.

The situation between 15 and 28 March 2000: On 15 March, the Global Fire Monitoring Centre (GFMC) approached United Nations Environment Programme (UNEP) and suggested a cash donation to ensure the continuation of the South African fire fighters. On 17 March, the government of Ethiopia officially requested UNEP's assistance and on 21 March, UNEP handed over a donation of $US 20,000.

Parallel to the UNEP negotiations, the GFMC discussed the possibility of a contribution from the United Kingdom to upgrade the capabilities for fire detection of the Ethiopian Remote Sensing unit. In the meantime, 271 fire fighters (community members, militia men, etc.) were trained successfully in fire fighting techniques. The previously trained Ethiopian soldiers contributed effectively as trainers and, hence, to the success of the training.

As scheduled, on 21 March, 14 fire fighters from South Africa return to home. The remaining teams continued with training and fire fighting in the Shakiso area. Funding for this was covered by the UNEP contribution.

On 22 March, new fire outbreaks were reported in Nechisar (Southern Region, East of Arba Minch) and Awash (Afar Region) National Parks. The MoA had no detailed information on these fires, but believed that they were in woodland, bushland and grassland ecosystems. All of these vegetation types are adapted to fire and, hence, did not call for immediate fire fighting action. The fires presumably were started by pastoralists to encourage growth of fresh grass and to eliminate tick populations. The Ministry dispatched some of the reserve backpack water pumps from Germany to Nechisar Park to ensure that the fires did not spread into the unique ground water forest of Arba Minch.

On 24 March, the fire in Nechisar National Park was contained after burning 10 to 15% of the total Park area. The spotter plane continued to survey the area and found that there was still a serious fire around Amare Mountain, east of the National Park. Another fire was reported from Butajira Mountain (Gurarghe Mountain), approximately 100 km SSW of Addis Ababa.

The remaining South African fire fighters were deployed to combat a fire close to a microwave tower nearby the town of Shakiso. Winds were fairly strong on 24 March, but calmed down on 25 March. No rain was reported.

On 26 March, news was received of heavy showers that occurred on 24-25 March in Bale Zone around Dolo Mena. The efficiency of water bombing continued to improve, supporting the ground crews. On 31 March, heavy rainfall was reported in both Borana and Bale Zones for 29 and 30 March.

On 28 March, the South African Embassy organised a reception in honour of the South Africans and they all left on 29 March, with farewell presents from the Ethiopian Government.

Considerable capacity was built during the fire incident with the number of civilians and soldiers trained in fire fighting techniques totalling 755 by 30 March. The Incident Command Team continued to monitor the situation.

7 April 08:00 GMT — fires are under control: On 5 April, MoA Vice Minister, Mr. Belay Ejigu, held a press conference on the Forest Fires in Bale and Borana Zones to declare that the wildfires in these Zones were suppressed. The MoA experts were called back to Addis Ababa and asked to prepare their final reports. Except for continued monitoring of the situation by zonal experts, the fire fighting activities had been brought to an end.

5. RÉSUMÉ BY THE GFMC (7 APRIL 2000)

This fire fighting campaign — the very first multinational intervention successfully completed in history — had started in late February 2000. In answer to a request by the Government of Ethiopia, an immediate situation analysis and subsequent assistance were provided by a group of countries. The agencies involved through diplomatic channels and the individual fire specialists dispatched to Ethiopia or supporting the campaign from their home offices worked together in a very smooth and efficient way.

From the beginning, the GFMC, in close collaboration with the Government of Ethiopia and the German Agency for Technical Co-operation (GTZ), assessed, monitored and supported the campaign in which Germany, South Africa, the United States of America, and the UNEP successfully co-operated with the staff of the Ministry of Agriculture, the Armed Forces, the numerous villagers and enthusiastic students who provided voluntary help.

At the peak of the campaign, more than 70,000 people were involved in the fire-fighting. All worked together to save the ecologically and biodiversity-rich assets of the afro-montane forests of Ethiopia.

More challenges are ahead: The burning of forests and the escape of wildfires will continue. In order to address uncontrolled and destructive wildfires, a long-term prevention programme in fire management must be established. The National Round Table in Ethiopia is an important initiative in which all stakeholders involved in land-use and fire problems will initiate a process to find a consensus on how to address national fire issues.

DISCUSSION

Gedion Asfaw: Forest fires generate tropospheric ozone (O_3). Can tropospheric ozone be marshalled to stratospheric ozone layer? The implication being the probability of replenishing of the stratospheric ozone layer?

Johann Goldammer: If I could answer this, I assure you that I would have won the Nobel Price. Essentially, there is nothing we can do to protect the ozone layer. There is no way of balancing the ozone layer problem of the Southern and Northern Hemispheres either. The problem of the ozone layer in the Southern Hemisphere is different from that of the Northern Hemisphere. The ozone problem of the Northern Hemisphere is associated with the burning of fossil oils while that of the Southern Hemisphere emanates mainly from wildfires.

EFFECTS AND USE OF FIRE IN SOUTHERN AFRICAN SAVANNAHS

W.S.W. Trollope & L.A. Trollope*

ABSTRACT

Fire is the most widespread ecological disturbance in the world second to human activities related to urban living and agricultural production. Therefore it cannot, and should not, be ignored when considering the management of rangeland for both wildlife and domestic livestock systems. This is particularly pertinent to African savannahs where fire can have a very significant effect on the botanical composition and structure of savannah vegetation, particularly when combined with the impact of herbivores. The ability of African savannahs to support fire is because they are highly prone to lightning storms and have an ideal fire climate comprising a distinct wet season when plant materials can grow and accumulate, and a dry season when they become highly flammable plant fuels. The effect of fire on savannah vegetation depends upon the type and intensity of fire, and the season and frequency of burning i.e. fire regime.

The most common types of fire are surface fires, burning either as head or back-fires. Head fires have the least depressive effect on the recovery of grass sward, but cause the highest top-kill of stems and branches of trees and shrubs as compared to back-fires. Fire intensity has no significant effect on the recovery of the grass sward and the mortality of trees and shrubs. Generally, the main effect of fire on woody vegetation is to cause a top-kill of stems and branches forcing the plants to coppice from the collar region of the stem. This effect is positively correlated with fire intensity. The effect of seasonal burning is that fire causes the least damage to the grass sward if applied when the plants are dormant, while trees and shrubs are apparently insensitive as to when fires are applied. The frequency of burning has a marked effect on the botanical composition of the grass sward and on the physiognomic structure of trees and shrubs. Conversely, it generally has minimal effect on the density of woody vegetation.

When using fire as a range management practice the most important factors to consider are the reasons for burning and the appropriate fire regime to be applied. The basic reasons for burning rangeland in savannah areas are to remove moribund and/or unacceptable grass material and to eradicate and/or prevent the encroachment of undesirable plants. The fire regime to be applied with controlled burning will vary

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according to the aforementioned reasons for burning. Currently there is considerable controversy and debate in wildlife circles about the desirability of applying pro-active burning programs in conservation areas like national parks. This stems from the view that natural fire regimes in savannah areas were originally driven by lightning induced fires and not anthropogenic fires as is the case today. The opposing viewpoint is that it is both unrealistic and impractical to exclude anthropogenic fires from savannah ecosystems in Africa, which after all is the cradle of humanity. Nevertheless its use in the management of savannah areas for both domestic livestock and nature conservation is widely recognized and is best summed up by Phillips (1965) as being 'a bad master but a good servant'.

1. INTRODUCTION

Fire is the most widespread ecological disturbance in the world second to human activities related to urban living and agricultural production. From the arctic boreal forests to tropical grasslands and savannahs of the world, fire consumes enormous quantities of plant biomass. It is estimated that 2700–6800 million tons of plant carbon are consumed annually by the burning of savannah vegetation and through the use of fire in shifting agriculture. It is estimated that human beings have used fire for over a million years and, in Africa, fire has extended the grasslands and savannahs at the expense of evergreen forests. This emphasizes the fundamental conclusion that fire is a general and influential ecological phenomenon throughout the world (Bond & van Wilgen, 1996) and cannot be ignored when considering the management of rangeland ecosystems for both domestic livestock and wildlife purposes.

Africa is referred to as the Fire Continent (Komarek, 1971) because of the widespread occurrence of biomass burning in the savannah and grassland biomes. The capacity of Africa to support fire stems from the fact that it is highly prone to lightning storms and has an ideal fire climate comprising dry and wet periods. It also has the most extensive area of tropical savannah in the world (see Figure 1), which is characterized by a grassy under storey that becomes highly inflammable during the dry season.

As a result of these factors, fire is regarded as a natural ecological factor of the environment that has occurred since time immemorial in the savannah and grassland areas of Africa. Its use in the management of vegetation for both domestic livestock systems and in wildlife conservation is widely recognized (Tainton, 1981) and is best summed up by Phillips (1965) as being 'a bad master but a good servant'. However, before discussing the use of fire, it is necessary to consider the primary ignition sources and present an overview of research conducted on the fire ecology of African savannahs.

according to the aforementioned reasons for burning. Currently there is considerable controversy and debate in wildlife circles about the desirability of applying pro-active burning programs in conservation areas like national parks. This stems from the view that natural fire regimes in savannah areas were originally driven by lightning induced fires and not anthropogenic fires as is the case today. The opposing viewpoint is that it is both unrealistic and impractical to exclude anthropogenic fires from savannah ecosystems in Africa, which after all is the cradle of humanity. Nevertheless its use in the management of savannah areas for both domestic livestock and nature conservation is widely recognized and is best summed up by Phillips (1965) as being 'a bad master but a good servant'.

1. INTRODUCTION

Fire is the most widespread ecological disturbance in the world second to human activities related to urban living and agricultural production. From the arctic boreal forests to tropical grasslands and savannahs of the world, fire consumes enormous quantities of plant biomass. It is estimated that 2700–6800 million tons of plant carbon are consumed annually by the burning of savannah vegetation and through the use of fire in shifting agriculture. It is estimated that human beings have used fire for over a million years and, in Africa, fire has extended the grasslands and savannahs at the expense of evergreen forests. This emphasizes the fundamental conclusion that fire is a general and influential ecological phenomenon throughout the world (Bond & van Wilgen, 1996) and cannot be ignored when considering the management of rangeland ecosystems for both domestic livestock and wildlife purposes.

Africa is referred to as the Fire Continent (Komarek, 1971) because of the widespread occurrence of biomass burning in the savannah and grassland biomes. The capacity of Africa to support fire stems from the fact that it is highly prone to lightning storms and has an ideal fire climate comprising dry and wet periods. It also has the most extensive area of tropical savannah in the world (see Figure 1), which is characterized by a grassy under storey that becomes highly inflammable during the dry season.

As a result of these factors, fire is regarded as a natural ecological factor of the environment that has occurred since time immemorial in the savannah and grassland areas of Africa. Its use in the management of vegetation for both domestic livestock systems and in wildlife conservation is widely recognized (Tainton, 1981) and is best summed up by Phillips (1965) as being 'a bad master but a good servant'. However, before discussing the use of fire, it is necessary to consider the primary ignition sources and present an overview of research conducted on the fire ecology of African savannahs.

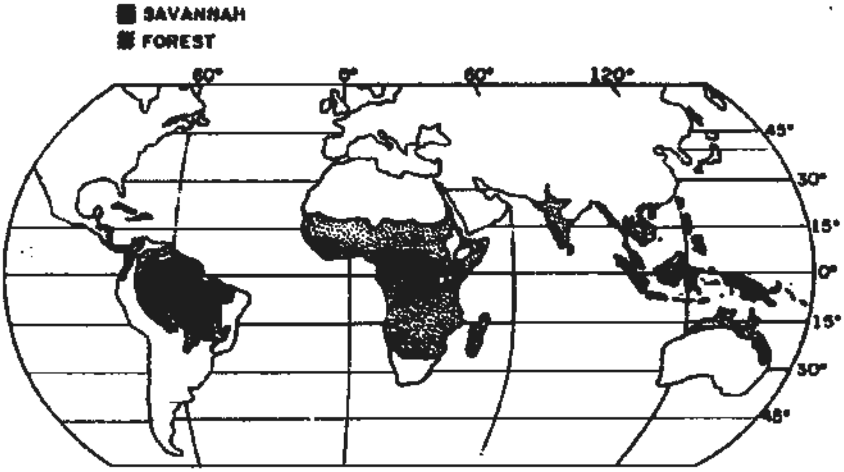


Figure 1: The distribution of tropical savannah and forest vegetation types in the world (adapted from Bartholomew, 1987)

2. IGNITION SOURCES OF FIRES IN AFRICAN SAVANNAHS

In considering lightning as a primary ignition source for natural vegetation fires, Komarek (1971) concluded that lightning is an expression of the earth's electrical field and a visual display of the universal force, electricity. The ingredients of weather that are necessary for the development of thunderstorms and lightning are a mix of hot, cold and humid masses of air. Most of these storms originate from the masses of air that circulate the globe from a westerly direction due to the earth's rotation.

Africa is one of the continents that is most prone to thunderstorms and lightning, and considerable evidence is available on the high frequency of thunderstorms and lightning throughout Africa (Komarek, 1971; West, 1965). This general circulation of air from the west is caused by the heavier cold air at the two polar regions flowing to the equator and, in turn, the hot air at the equator rising and flowing to the poles. In each case the direction of flow is deflected by the earth's rotation causing the air masses to move in an easterly direction. The intermixing of the resultant air masses gives rise to thunderstorms and lightning thus providing an ignition source for fires to occur (Pyne, 1982). Pyne (1982) claims that lightning fires occurred on earth as soon as the atmosphere evolved and vegetation appeared. The role of lightning is to balance the electrical equilibrium of the earth. The atmosphere is able to conduct electricity to a certain extent and there is a constant leakage of electricity from the earth to the atmosphere creating an electrical potential. When the potential is great enough, electricity discharges back to earth in the form of lightning.

It has been estimated that the earth would loose its electrical charge in less than an hour (48 minutes) unless it is replenished through lightning. Thunderstorms are therefore both a thermodynamic and electromagnetic necessity. It is estimated that thunderstorms produce more than 8 million lightning strokes per day globally which is equivalent to more than two thousand million kilowatt hours of electricity i.e. approximately 4.9 times the amount of electricity produced in South Africa in a year (Anonymous, 1992).

While recognising the primary ignition role of lightning in causing vegetation fires in the savannah areas of Africa, the stage has now been reached when, in most regions of the world, humans have become more important than lightning as sources of ignition (Goldammer & Crutzen, 1993). This is well illustrated in the savannah areas of the Kruger National Park in South Africa, where anthropogenic fires have now become the dominant ignition source of fires in that type of savannah community (Trollope, 1993).

3. Fire Ecology of African Savannahs with Particular Reference to Southern Africa

Fire ecology refers to the response of the biotic and abiotic components of the ecosystem to the fire regime i.e. the type and intensity of fire, and the season and frequency of burning (Trollope *et al.*, 1990). Research on the effects of fire has been conducted throughout the grassland and savannah areas of Africa since the early part of this century. West (1965) reviewed the topic and found that the first burning plots were established at Groenkloof, Pretoria, in South Africa in 1916, at Olokomeji in Nigeria in West Africa in 1929, at Ngong near Nairobi in Kenya in East Africa in 1931, at Ndola in Zambia in Central Africa in 1933 and at the Matopos in Zimbabwe in 1947.

An interesting feature about these early investigations and subsequent research up until 1971, was that it focussed on determining the effects of season and frequency of burning on the forage production potential of the grass sward and the ratio of grass to bush in savannah areas (West, 1965; Rose-Innes, 1971; Scott, 1971; Gill, 1981). This was undoubtedly in response to requests from mainly agricultural scientists and livestock farmers involved with range management who wanted to know when was the correct time to burn rangeland and how often should the rangeland be burnt in order to maintain its production potential and to control bush encroachment? Thus, until recently, fire research in Africa and South Africa in particular was conducted with an agricultural objective in mind rather than with the ecological objective of determining the effect of fire on all the biotic and abiotic components of the ecosystem. This was in contrast to fire research in other fire-prone habitats like the United States and Australia where the emphasis was on studying fire behaviour as a means of controlling wild fires.

However, in 1971, the Tall Timbers Research Station at Tallahassee in Florida convened a conference in the United States of America on the theme of 'Fire in Africa'. Fire ecologists from throughout Africa attended this congress. The major benefit that accrued from this conference was the realization that in Africa the study of fire behaviour and its effects on the ecosystem, as described by type and intensity of fire, had been largely ignored in all the fire research that had been conducted up until that time. In contrast, detailed knowledge on and models for predicting fire behaviour had been developed by the United States Forest Service (Byram, 1959; Rothermel, 1972; Brown & Davis, 1973) as a means for controlling wildfires in the extensive forested areas of the country. A similar situation existed in Australia where McArthur (1966), a forest fire researcher in New South Wales, had developed procedures based on fire behaviour for decreasing fire hazard in highly flammable *Eucalyptus* forests by reducing fuel loads through controlled burning.

The outcome of this congress proved to be a turning point in fire research in the savannah areas in South Africa, and a research programme was initiated to determine the effect of all the components of the fire regime on the vegetation, i.e. effects of type and intensity of fire, and season and frequency of burn. Unfortunately, as far as is known, similar research programmes were not initiated elsewhere in Africa. Nevertheless, this programme has gone a long way in describing the effects of the entire fire regime on the vegetation in the savannah areas of the continent. The overall effects of the different components of the fire regime on the grass and bush components of savannah vegetation have been dealt with separately, and have provided a sound scientific basis for formulating recommendations for controlled burning in southern African savannahs.

3.1. Type of Fire

The most common types of fire in savannah areas are surface fires (Trollope, 1983), burning either as head or backfires. Crown fires do occur, burning with the wind, but only under extreme atmospheric conditions characterized by high temperatures, low humidity and strong winds. The significance of the effect of type of fire on plants is that it determines the vertical level at which heat energy is released in relation to the location of meristematic sites, where buds develop when plants recover after burning.

Trollope (1978) investigated the effects of surface fires, either head or backfires, on the grass sward in the arid savannahs of the Eastern Cape of South Africa. The results showed that backfires significantly ($p=<0.01$) depressed the regrowth of grass in comparison to head fires because a critical threshold temperature of approximately 95°C was maintained for 20 seconds longer during backfires than during head fires. It was also found that more heat was released at ground level during backfires compared to head fires; therefore the shoot apices of the grass plants were more adversely affected during the backfires than during the head fires.

Bush is very sensitive to various types of fires because of differences in the vertical distribution of the release of heat energy. Field observations in the Kruger National Park and in the Eastern Cape indicate that crown and surface head fires cause the highest top-kill of stems and branches as compared to backfires. Unfortunately, there are only limited data to support these observations. Quantitative results were obtained from a burning trial at the University of Fort Hare in the False Thornveld of the Eastern Cape (Acocks, 1953) in South Africa, where a field scale burn was applied to an area of 62 hectares to control bush encroachment. The effect of head and backfires on the top-kill of stems and branches of bush was recorded in two-metre-wide belt transects, 940 metres and 560 metres long, in areas burnt as head and backfires respectively. The effect of the head and backfires is described as the reduction in the phytomass of bush recorded before and after the application of the fires, expressed in tree equivalents per hectare according to Teague et al (1981).

Table 1: The effect of surface head and backfires on the top-kill of bush in the False Thornveld of the Eastern Cape in South Africa expressed as the reduction in the number of tree equivalents per hectare.

Type of Fire	Bush Phytomass TE/ha		Reduction %
	Before Burning	After Burning	
Head Fire	3525	888	75
Backfire	3407	1991	42

TE = tree equivalent

The majority of the trial area was burnt as a head fire and the results in Table 1 indicate that the phytomass of bush was reduced by 75 percent in the area burnt as a head fire in comparison to 42 percent in the area burnt as a backfire. The explanation for this is that the flame height of head fires can be up to three times greater than for backfires resulting in higher temperatures being generated above ground level (Trollope, 1978). Therefore the above ground growing points of these plants, which are located in the canopies of the trees and shrubs, are subjected to greater heat loads and resultant damage during head fires than during backfires. This clearly illustrates the effects different types of fire have on tree and shrub vegetation.

3.2. Fire Intensity

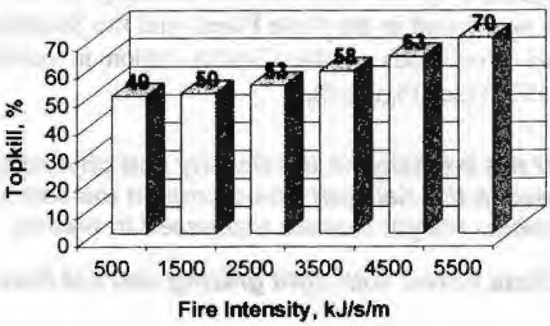
Fire intensity refers to the release of heat energy per unit time per unit length of fire front (kJ/s/m) (Byram, 1959). There have been very limited attempts in African savannahs at quantitatively measuring the intensity of fires and relating fire intensity to the response of herbaceous and woody plants in terms of mortality and changes in physical structure. Such research appears to be limited to studies conducted in the savannah areas of South Africa.

The effect of fire intensity on the recovery of the grass sward after burning was investigated in the arid savannahs of the Eastern Cape. After a series of fires ranging in intensity from 925 to 3,326 kJ/s/m (cool to extremely intense) there were no significant differences in the recovery of the grass sward at the end of the first or second growing seasons after the burns (Trollope & Tainton, 1986). The conclusion was that fire intensity had no significant effect on the recovery of the grass sward after a burn. This is a logical result as otherwise intense fires would not favour the development and maintenance of open savannah and grassland.

The effect of fire intensity on bush has been studied in the arid savannahs of the Eastern Cape (Trollope & Tainton, 1986) and the Kruger National Park (Trollope *et* *al.*, 1999) in South Africa. The mortality of plants and the total top-kill of stems and branches of bush of different heights were determined. The results indicated that bush is very resistant to fire alone and, in the Eastern Cape, the mortality of bush after a high intensity fire of 3,875 kJ/s/m was only 9.3 per cent. In the Kruger National Park the average mortality of 14 individuals of the most common bush species subjected to 43 fires ranging in fire intensity from 110 to 6,704 kJ/s/m was only 1.3 per cent. In both areas the majority of the trees that survived the fires recovered by coppicing from the collar region of the stem.

The overall effect of fire intensity on the top-kill of bush of all species was determined in the Kruger National Park and is illustrated in Figure 2 (Trollope *et al.*, 1999). The results are presented for the effect of different fire intensities on the top-kill of bush with a height of three metres and represents trees and shrubs that are becoming less available to a wide spectrum of wild and domestic ungulates.

Figure 2: The effect of fire intensity (kJ/s/m) on the top-kill of bush with a height of three metres in the Kruger National Park.

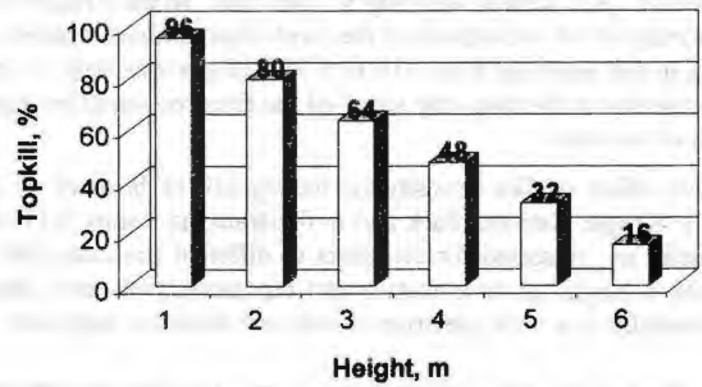


The results in Figure 2 indicate that the top-kill of bush increased with an increase in fire intensity but that a threshold is reached at approximately 3000 kJ/s/m below which the top-kill increased at a lower rate.

The effect of bush height on the top-kill of stems and branches with a fire intensity of 3000 kJ/s/m is illustrated in Figure 3 (Trollope et al, 1999).

The negative effect of bush height on the top-kill of stems and branches is clearly illustrated in Figure 3. The results suggest that above a height of three metres the bush becomes increasingly resistant to a top-kill (<50 percent) of stems and branches even when subjected to high intensity fires.

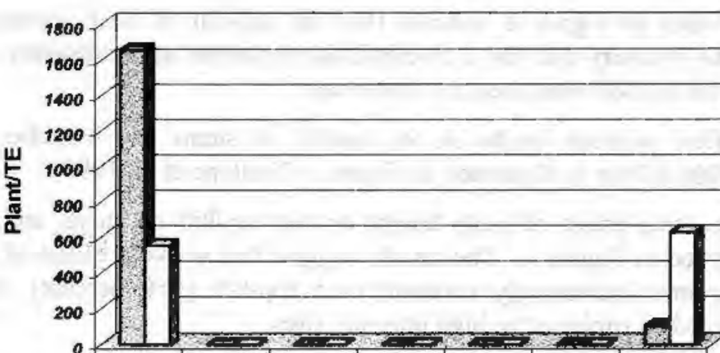
Figure 3: The effect of bush height on the top-kill of stems and branches with a fire intensity of 3000 kJ/s/m in the Kruger National Park.



An interesting example of the effect of fire intensity on the density, structure and phytomass of bush was found in the State Forest and the Sachinga Cattle Breeding Station in the Kalahari Woodlands of the Caprivi region in north-eastern Namibia (Trollope & Trollope, 1999) (see Figure 4).

Figure 4: Effect of fire intensity on the density and phytomass of bush in different height classes in the Kalahari Woodlands in the east Caprivi region of Namibia. Height classes expressed in metres.

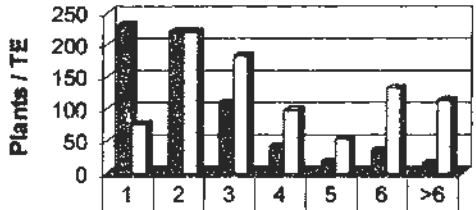
4a: State Forest with light grazing and hot fires



	1	2	3	4	5	6	>6
□ P/ha	1659	0	0	0	0	0	104
□ TE/ha	553	0	0	0	0	0	628

Height class

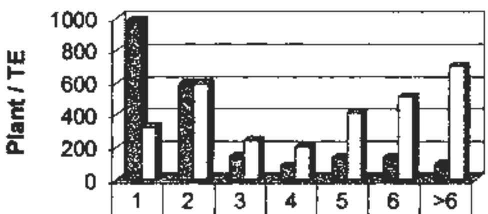
4b: State Forest with significant grazing and cool fires



Height class	1	2	3	4	5	6	>6
P/ha	232	220	110	42	18	36	16
TE/ha	77	220	183	98	53	132	113

Height class

4c: Sachinga Breeding Station with significant grazing and no fires



Height class	1	2	3	4	5	6	>6
P/ha	987	597	148	89	140	140	101
TE/ha	329	597	246	208	420	515	710

Height class

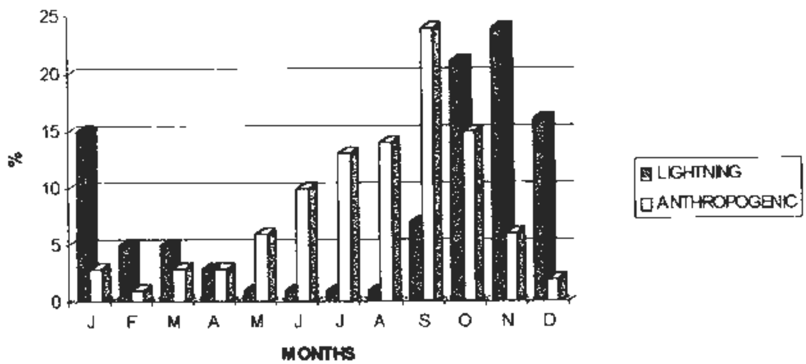
The three different structures of woody vegetation presented in Figure 4 are interpreted as being primarily the result of differences in fire intensity. Grass fuel loads of up to 4269 kg/ha were recorded in areas of the State Forest represented in Figure 4a. These were located away from human settlements and where clearly very light grazing occurred. Thus, intense fires occur in these areas resulting in a two-layered structure of woody vegetation characterized by a high plant density and phytomass (expressed as tree equivalents) of short coppicing shrubs with a scattering of a few large trees. Conversely grass fuel loads of as low as 177 kg/ha were recorded in areas of the State Forest represented in Figure 4b. These were located close to human settlements where there were physical signs of significant grazing by cattle. Thus fires would be much cooler in this type of situation and would result in a more equitable development of woody vegetation both in terms of density and size in all height classes. Finally, on the Sachinga Cattle Breeding Station, where fires have been actively suppressed since 1980 (Figure 4c), there is a significantly higher overall phytomass and density of woody plants (Trollope & Trollope, 1999).

3.3. Season of Burning

The temporal and spatial distribution of savannah fires in Africa has been studied by Cahoon, et al (1992) using night-time satellite imagery. The analysis of monthly satellite images for 1986 and 1987 indicated that January was the peak season for African savannah fires burning north of the equator, when all the savannahs in these areas receive less than 25 mm of rain. Rainfall then increases in both hemispheres and savannah burning is reduced to a minimum during April. After April the rainfall decreases in the southern hemisphere and the frequency of savannah fires increases initially to a maximum during June in the western regions of southern Africa. From July to October savannah burning increases in the eastern parts of southern Africa.

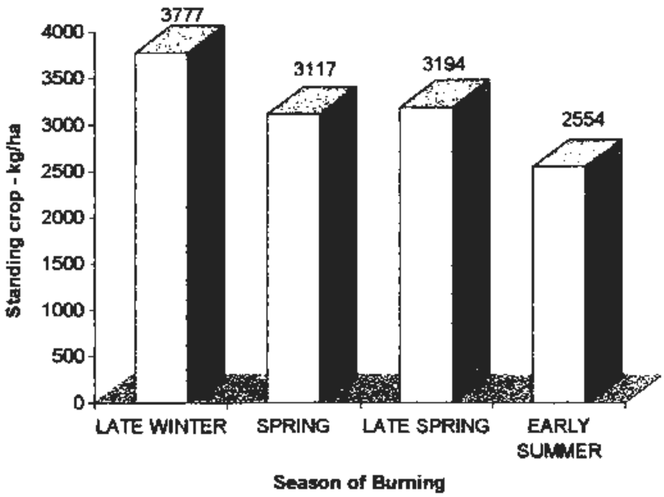
An interesting difference in seasonal burning exists between fires ignited by lightning and anthropogenic sources. Studies in the Kruger National Park in South Africa for the period 1980–1992 showed that lightning fires occurred most frequently during spring and summer (October to January) when thunderstorms are most frequent. Conversely anthropogenic fires occurred mainly during the mid-winter to early spring period (June to September) (Trollope, 1993). The results are illustrated in Figure 5.

Figure 5: The season of burning of lightning and anthropogenic ignited fires recorded in the Kruger National Park during the period 1980 to 1992.



Seasonal burning is one of the most controversial issues in the use of fire in range management. Very little quantitative information is available on the effect of seasonal burning on the productivity of the grass sward. Scott (1970) stated that burning in winter decreases the basal cover of the grass sward and recommended burning after the first spring rains for all forms of controlled burning. However, more recent research has led to the conclusion that, for all practical purposes, burning when the grasses are dormant in late winter or immediately after the first spring rains has very little difference in effect on the sward (Tainton, *et al.*, 1977; Dillon, 1980). This conclusion was investigated in the arid savannahs of the Eastern Cape and comprised determining the effect of burning on the recovery of the grass sward when applied in late winter, spring, late spring and early summer (Trollope, 1987) (see Figure 6).

Figure 6: Effect of season of burning on the recovery of the grass sward in the arid savannahs of the Eastern Cape.



The results in Figure 6 show that burning in late winter resulted in a significantly better recovery in the grass sward during the first growing season after the burn than the other treatments. Conversely, the early summer burns applied when the grass was actively growing had a significantly depressive effect on the regrowth of the grass sward in relation to the other treatments. This is explained by observations and measurements made at the time of the early summer burn that showed that the grass tillers were actively growing and the shoot apices were elevated and in a vulnerable position easily damaged by the fire. Furthermore the mean rate of spread for the early summer burns was 0.11 m/s compared to 0.31 m/s for the later winter burns. This would suggest that the slow moving early summer burn resulted in a longer duration of critical threshold temperatures compared to the fast moving winter burn and this had a greater damaging effect on the exposed shoot apices (Trollope, 1987). Subsequent investigations have confirmed this. It was found that rate of spread was significantly positively correlated ($r = 0.2669$; $DF = 54$; $P < 0.02$) with the recovery of the grass sward during the first growing season after the burn.

It is difficult to ascertain the effect of season of burning on woody vegetation because generally it is confounded with fire intensity. When the trees are dormant in winter the grass is dry and supports intense fires whereas when the trees are actively growing during summer the grass is green and the fires are much cooler. West (1965) postulated that trees and shrubs are probably more susceptible to fire at the end of the dry season when the plant reserves are depleted because of the new spring growth. However, the results of Trollope, Potgieter & Zambatis (1999) showed that the mortality of bush in the Kruger National Park was only 1.3 percent after fires that had been applied to bush ranging from dormant to actively growing plants. Therefore, it would appear that bush is not sensitive to seasonal burning.

3.4. Frequency of Burning

The effect of frequency of burning on vegetation is influenced by event-dependent and interval-dependent effects (Bond & van Wilgen, 1996). The event-dependent effects occur at the time of the fire and are influenced by the type and intensity of the burn and the physiological state of the vegetation at the time of the fire. The interval-dependent effects are influenced by the treatment and growing conditions during the interval between the burns. These two overall effects tend to confound the interpretation of the effect of frequency of burning and must be borne in mind when reporting on the effect of frequency of burning.

Frequency of burning has a marked effect on the botanical composition of the grass sward with species like *Themeda triandra* being favoured by frequent burning. In the arid savannahs of the Eastern Cape in South Africa it was found that frequent burning favours an increase in *Themeda triandra* and a decrease in *Cymbopogon plurinodis* (Robinson, et al. 1979; Forbes & Trollope, 1990). This is an interval-dependent effect because *Themeda* is sensitive to low light conditions that develop when the grass sward is not defoliated and this species rapidly becomes moribund during extended intervals between fires. Conversely, species like *C. plurinodis* are not as sensitive to low light conditions and survive extended periods of non-defoliation.

Conflicting results have been obtained on the effect of frequency of burning on bush. Kennan (1971) in Zimbabwe and van Wyk (1971) in the Kruger National Park in South Africa both found that there were no biologically meaningful changes in bush density in response to different burning frequencies. In the False Thornveld of the Eastern Cape in South Africa, Trollope (1983) found that after ten years of annual burning the density of bush increased by 41 per cent, the majority of which were in the form of short coppicing plants. Conversely, Sweet (1982) in Botswana and Boultwood & Rodel (1981) in Zimbabwe found that annual burning resulted in a significantly greater reduction in the density of bush than less frequent burning. It is difficult to draw any general conclusions from these contradictory results except to note that in all cases significant numbers of trees and shrubs/bushes were present even in the areas burnt annually, irrespective of whether they had decreased or increased after burning. These very variable results would suggest that the effect of frequency of burning on woody vegetation is more an event-dependent effect where factors like the type and intensity of fire have had highly significant individual effects overshadowing the effect of frequency of burning *per se*.

The effect of frequency of burning on forage production has not been intensively studied in South Africa and only limited quantitative data are available. The general conclusion is that the immediate effect of burning on the grass sward is to significantly reduce the yield of grass during the first growing season after burning but the depressive effect disappears during the second season (Tainton & Mentis, 1984; Trollope, 1984).

The effect of frequency of burning on the quality of forage is that generally frequent fires improve and maintain the nutritional quality of the grass sward particularly in high rainfall areas making it highly attractive to grazing animals. This phenomenon has been recorded throughout the savannah areas of Africa (West, 1965; Tainton et al. 1977; Moe et al., 1990; Munthali & Banda, 1992; Schackleton, 1990). West (1965) stated that the fresh green shoots of new growth on burnt grassland are very high in protein and quotes Plowes (1957) who found that the average crude protein content of 20 grasses after burning at the Matopos Research Station in Zimbabwe was 19 percent. This is approximately twice the protein content of mature grasses that have not been burnt at the end of the dry season.

There is apparently no information available on the effect of frequency of burning on the production and quality of browse by bush in the savannah areas.

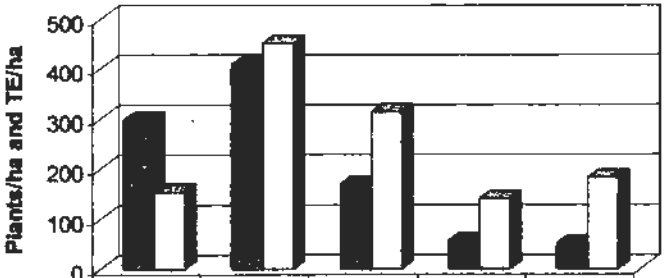
4. Effects of Interactions Between Fire and Herbivory on Vegetation

The use of vegetation by herbivores before or after burning can have a highly significant effect on the botanical composition and structure of the vegetation. To illustrate this phenomenon the effect of fire and elephants on trees and shrubs in the Kruger National Park will be considered.

The effect of elephants and fire on the density and structural diversity of woody vegetation in the Kruger National Park was determined by conducting bush surveys inside and outside of an exclosure located in the *Colophospermum mopane* Shrubveld on the basalt vegetation landscape described by Gertenbach (1983). The woody vegetation was dominated by *C. mopane* both inside and outside the exclosure, which was established in 1967 for conducting studies on roan antelope. The area of 309 ha is completely protected from elephants. Grazing by the small herd of roan antelope has had minimal impact on the grass sward. The exclosure is surrounded by an extensive area subjected to heavy utilization by elephants in particular and also by other wild ungulate species. The frequency of burning inside and outside the exclosure has been approximately every four years. The bush surveys recorded the presence of tree and shrub species rooted within a 2m wide transect located in stratified random transects. The height of each plant species was recorded and the data were expressed as plants per hectare (P/ha) for density and tree equivalents per hectare (TE/ha) for phytomass. Differences in the density and phytomass of bush occurring within the different exclosures were analysed using a Student t test (Trollope, *et al.*, 1998). The results of the bush surveys are presented in Figure 7.

Figure 7: The effect of fire and elephants on the density and structure of trees and shrubs in the* Colophospermum mopane *Shrubveld on a basalt vegetation landscape in the Kruger National Park (Trollope, et al., 1998). Height classes expressed in metres

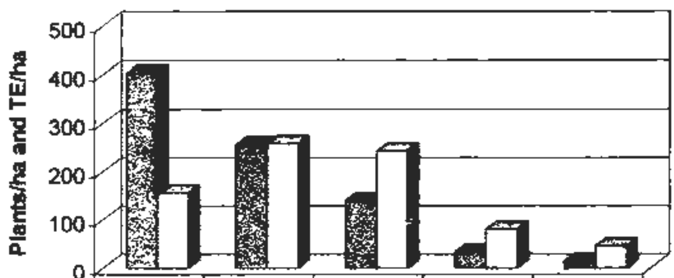
a) Inside exclosure: fire + no elephants



	1	2	3	4	5
Plants/ha	298	409	169	56	51
TE/ha	155	452	314	140	183

Height class, m

b) Outside exclosure: fire + elephants



	1	2	3	4	5
Plants/ha	404	256	140	33	14
TE/ha	157	259	243	81	46

Height class, m

A statistical analysis of the results presented in Figure 7 showed that there were no significant differences in the density (P/ha) of trees and shrubs inside and outside the exclosure. Conversely, the phytomass of bush (TE/ha) was significantly higher ($P< 0.05$) inside than outside the exclosure. These results are clearly illustrated in

Figures 7a and 7b where the main difference is that the majority of the trees and shrubs were taller (>2 m) inside the exclosure and shorter (<2 m) outside the exclosure. This difference also manifested itself in the phytomass of bush where there was a greater volume of bush in the taller height classes (>2 m) inside than outside the exclosure. The results provide a plausible explanation for the current shrub-like structure of the Mopane veld in northern Kruger National Park. They suggest that the mechanism involves elephants pushing over and ripping down the taller trees and shrubs (>2 m) which are then kept short by regular intense fires causing a significant top-kill of the recovering coppicing shrubs (<2 m).

This example of the interacting effects of fire and herbivores on savannah vegetation illustrates the importance of not considering fire in isolation when using it as a range management practice in the savannah areas of southern Africa.

5. Controlled Burning as a Range Management Practice

Fire is used for numerous reasons in southern African savannahs but this discussion is limited to its use as a range management practice in domestic livestock systems and in wildlife areas. The most important factors to consider when using fire as a range management practice are the reasons for burning and the appropriate fire regime.

5.1. Reasons For Burning

The current view amongst scientists, progressive livestock farmers and wildlife managers on the permissible reasons for burning rangeland in Africa are that fire can be used to:

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

These are the basic reasons for burning rangeland. An often quoted reason is to stimulate an out-of-season 'green bite' (Tainton, 1981). This is often practised during summer, late autumn or late winter to provide green grazing for domestic livestock. This practice is completely unacceptable because it:

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

This malpractice cannot be condemned enough as it has been responsible for the drastic deterioration in range condition over extensive areas and is still an important problem in numerous regions in southern Africa.

It has been suggested that fire can be used to control ticks (Scott, 1947; Pratt & Gwynne, 1977) but this reason is generally discounted because ticks persist in areas that are frequently burnt. Conversely Stampa (1959) showed that the Karroo Paralysis Tick, in the Karroid Merxmuellera Mountain Veld in South Africa, can be successfully combated by altering the micro-climate at soil level with controlled burning, thereby creating an unfavourable habitat resulting in its disappearance. It is, therefore, conceivable that using fire to manipulate habitats could be used to control ticks in savannah areas but no information is currently available.

Research results on the effect of frequency of burning on the botanical composition of the grass sward in savannah communities raises the possibility of using fire to improve range condition by increasing the abundance of valuable forage species e.g. *Themeda triandra*. Further research on the response of key grass species to fire could validate controlled burning for this reason in the future.

Finally the decision to burn or not should be based on the condition of the vegetation of the rangeland in question. Quantitative techniques for assessing range condition are becoming available in southern Africa. Research attention is being given to developing simplified techniques for assessing range condition that could assist land users to decide whether vegetation needs to be burnt or not in areas used for both livestock and nature conservation (Trollope *et al.*, 1991; Trollope & Trollope, 1999).

5.2. Fire Regime

The fire regime to be used in controlled burning refers to the type and intensity of fire, and the season and frequency of burning.

i) Type of fire

Based on the effect of fir types on savannah vegetation, head fires burning with the wind are recommended for controlled burning of rangeland used for domestic livestock. This is because this type of fire causes least damage to the grass sward but can cause maximum damage to woody vegetation if required. These fires are applied as perimeter ignitions (Trollope, 1989). In wildlife areas it is recommended that controlled burns be applied as point ignitions because this results in a wide range of types of fires thereby promoting species and habitat diversity in the vegetation to the benefit of different wild ungulate species (Trollope, *et al.*, 1995).

ii) Fire intensity

Research on fire behaviour in the Eastern Cape Province and Kruger National Park in South Africa has shown that fire can be classified into the following categories according to fire intensity (Trollope and Potgieter, 1985).

When burning to remove moribund and/or unacceptable grass material a cool or low intensity fire of <1000 kJ/s/m is recommended. This can be achieved by burning when the air temperature is <20°C and the relative humidity >50%. When burning to control undesirable plants like encroaching bush, a high intensity fire of >2000 kJ/s/m is necessary. This can be achieved when the grass fuel load is >4000 kg/ha, the air temperature is 25–30°C and the relative humidity <30%. This causes a significant top-kill of stems and branches of bush species up to a height of 3 m. In all cases the wind speed should not exceed 20 k/h (Trollope, 1989).

FIRE INTENSITY kJ/s/m	DESCRIPTION
<500	Very cool
501–1000	Cool
1001–2000	Moderately hot
2001–3000	Hot
> 3000	Extremely hot

iii) Season of burning

It is recommended that when burning to remove moribund and/or unacceptable grass material in livestock production systems, fires should preferably be applied after the first spring rains when the grass is still dormant and the fire hazard is low. Conversely when burning to control encroaching plants, a high intensity fire is necessary and burning should be applied at the end of winter before the first spring rains when the grass is dry and dormant (Trollope, 1989).

In wildlife areas, it is also recommended that fires be applied when the grass is dormant during the dry season. However, the burning window can be extended to include the entire dry season from early winter to late winter/ spring in order to maximize habitat diversity for different types of wildlife.

iv) Frequency of burning

When burning to remove moribund and/or unacceptable grass material the frequency of burning depends upon the accumulation rate of excess grass litter (Trollope, 1989). Field experience indicates that this should not exceed 4000 kg/ha and, therefore, the frequency of burning should be based on the rate at which this grass phytomass accumulates. This approach has the advantage that the frequency of burning is related to the stocking rate of grazers and to the amount of rainfall the area receives. Generally in moist savannahs this will result in the frequency of burning being every 2–4 years. In arid savannahs, it will be much lower and, in fact, this rule of thumb will exclude fire where the condition of the rangeland is so poor that excessive grass fuel loads never accumulate. The frequency of burning cannot be prescribed when using fire to control undesirable plants because it depends upon the plant species under consideration (Trollope, 1989) These recommendations apply to both domestic livestock systems and wildlife areas.

5.3. Range Management after Burning

It is recommended for systems involving domestic livestock that when burning is used to remove moribund and/or unacceptable grass material grazing can begin as soon as the rangeland has recovered to a grazeable condition. However, adequate recovery periods must be allowed between grazings. When burning to control undesirable plants, post-fire grazing management will depend upon the ecological characteristics of the encroaching plant (Trollope, 1989).

In wildlife areas, care must be taken to minimize the problem of excessively heavy, continuous grazing after burning. This can be avoided by ensuring that the area burnt exceeds the short term forage requirements of the game that will be attracted to it, i.e. relatively large areas must be burnt at any one time.

6. Alternative Burning Systems for Wildlife Areas

As of 2000, a major fire research project is being planned in the Kruger National Park to determine the effects of three potential fire management systems on natural biodiversity patterns within a context integrating the effects of other drivers such as herbivory, soils and water availability. The stimulus for the trial arose out of the need to provide comparative information on the effects of two alternative fire management systems to contrast with the data emanating from the Lightning Burning System (LBS) currently adopted by the Kruger National Park. This was believed to be essential because the decision to change to the LBS in 1992 was made in the absence of any comparative evidence being available from other alternative burning systems (Biggs & Potgieter, 1999). The three potential burning systems are:

- Lightning Burning System (LBS)
- Range Condition Burning System (RCBS)
- Patch Mosaic Burning System (PMBS)

6.1. Lightning Burning System (LBS)

The lightning burning system (LBS) is aimed at simulating a fire regime that would be similar to the one believed to have existed in the Park prior to the intervention of contemporary human beings. It is assumed that the biota in the Park is adapted to this fire regime. It is believed that in the LBS lightning was and is the dominant ignition source that moulded the present day savannah ecosystems. The system involves allowing all fires ignited by lightning to burn freely and to be assisted to do so if prevented by unnatural barriers like roads. All anthropogenic fires are suppressed as far as is possible. In the case of a small proportion of these fires not being extinguished it will be assumed that these fires represent the limited proportion of anthropogenic fires that would have occurred during those pre-historic times. This system has been followed since 1992 in the Kruger National Park, and has apparently resulted in a decline in the total area burnt but an increase in the burn sizes. There has also been a shift in the season of burning to later in the year (van Wilgen, *et al.*, 1998).

6.2. Range Condition Burning System (RCBS)

The range condition burning system (RCBS) is based on the view that ideally the fire regime in any area should be determined by the condition of the vegetation in relation to the management objectives of the system of land use. In the case of the Kruger National Park, a primary management objective is the development and/or maintenance of biodiversity. Research results from the Park suggest that this could be achieved by permitting or applying any form of point ignition source to rangeland where the grass sward is not dominated by pioneer grass species but is in an overgrown, moribund condition. This system was originally developed for the Kruger National Park in 1992 in response to the concern that excessively frequent burning and severe drought had contributed to a deterioration in the condition of the grass sward. However, the system was never applied in the Park.

6.3. Patch Mosaic Burning System (PMBS)

The patch mosaic burning system (PMBS) aims to maintain biodiversity through the application of a diverse fire regime. The system is based on the view that it simulates the pyrogenic activities of early human beings and should therefore be considered for the Kruger National Park. The system is based on studies of aboriginal burning practices in northern Australia. It involves the principle that the area burnt per year should be a function of the grass fuel load and that the number of fires per year should be determined by this potential. All types of point ignition sources are permitted. In the case of planned fires these are applied during the autumn, winter and spring period under a wide range of fuel and weather conditions and are allowed to burn out unattended. The fire parameters involving seasonality, extents of area burnt and fire intensity, are therefore spatially and temporally varied across a landscape that results in the creation of a fire mosaic. It is believed that this heterogeneity in time and space will promote and/or maintain biodiversity. The PMBS has been successfully applied in the Pilansberg National Park since 1989.

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Discussion

Tadesse Woldemariam: In cases where an ecosystem is similar in neighbouring countries with similar traditions etc., how can fire management in one country be extended to include other countries?

Winston Trollope: Collaboration by neighbouring countries to combat forest fires provides maximum strength and efficiency for controlling them. However, if a well-organized and co-ordinated command system does not exist in one country, regional integration is by no means sure of success. Therefore, each country must first build its own capacity in all aspects of forest fire prevention.

Azene Bekele: Will the response to frequency and time of burning presented here for savannah woodlands hold true for the wet high latitudinal zones of Ethiopia?

Winston Trollope: There are similar agro-ecological zones in Ethiopia and I believe that it would work under such similar conditions.

Ensermu Kelbessa: Regarding the vulnerability of species, I would like to comment that the basic classification of the vegetation of Ethiopia has helped us compare the vulnerability of species, especially trees, in different vegetation mixes. A good example is that tall trees in the savannah woodland are less affected than the trees in montane forests, which are as vulnerable as the shrubs and low trees, because the montane species are not fire adapted.

COMMUNITY-BASED FOREST FIRE MANAGEMENT IN NAMIBIA

*by Harri Seppanen**

1. INTRODUCTION

It is estimated that 3–5 million hectares of forest, bush and grassland are burned every year in Namibia. Traditionally, burning in Namibia is considered necessary before each rainy season to renew grass for grazing purposes and also to prepare land for cultivation. This habit began in the 1940s when all the land was set on fire. Some even believed that new rains would only come after a total burn. In Caprivi, north-eastern Namibia, this indiscriminate total burning of all grasslands and forest areas resulted in the fast degradation of the environment and the negative effects became visible to all the community leaders. In some communities, starvation and death of many cattle resulted from the burning of land.

Colonial fire laws and guidelines did not consider the prevailing land tenure system and agricultural practice on communal lands. Local skills and knowledge on how to prevent, control and suppress forest fires were, therefore, practically eliminated during the colonial years. In 1884, the supervision and control of burning was transferred from the traditional authorities to the Government, resulting in an erosion of traditional authority for controlling fires. Daily supervision ceased and large scale uncontrolled shifting cultivation, as well as hunting, using fires began in Northern Namibia.

Post-independent forest fire controls in the Caprivi Region were confined to the State Forest of Caprivi where two fire towers were erected and fire lines cleared using an agricultural tractor and grader. No fire training was given to the staff of the Forestry Office. Fire suppression efforts were made by using branches from trees as swatters as no hand tools were available.

Namibia's forest policy of 1894 had clauses about fires and burning, but its directives were never enforced since it would have meant thousands of local farmers being prosecuted annually. In East-Caprivi alone 10,000–15,000 fires were started each year without permission as the Law prescribed. Even today, the fire laws are still outdated both socially and culturally. However, a new policy and legislation for forests that is being processed will address these issues.

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Uncontrolled burning is resulting in considerable economic loss through damage to both timber and non-timber resources, loss of grazing land, and consequent increased mortality of livestock and wildlife. The loss of natural resources is detrimental to both local and national economies. The indiscriminate total burning of all vegetation in the north-eastern parts of Namibia has already seriously damaged the forests in this area which receive the highest rainfall in the whole of Namibia. There has been no viable regeneration of forest trees for the last 20 years, except in some small isolated pockets.

Internationally, concern is mounting at the extensive burning of forests and grasslands, and its direct contribution to the anthropogenic greenhouse effect and its influence on global climate change. It is argued that widespread fires in the wooded areas are reducing the overall phytomass or vegetation, thereby causing a release of radioactive trace gases and aerosols into the regional and global atmosphere.

Before the launching of the pilot project on Forest Fire Control in Caprivi in 1996, no nationally recognised policy on fire management was available and, despite the alarming magnitude of fires, no systematic and nation-wide fire extension work on fire control had been carried out.

2. Intervention

Because of the local and global concerns discussed earlier, the Government of Namibia entered into an agreement with the Government of Finland in 1996 to implement a project that was initially known as the Fire Control Project. The pilot area selected for the project was East-Caprivi (1.1 million ha) with a population of 100,000. The total area burned in 1995, when the project was initiated, was estimated at 850,000 ha. In 1997, the project was incorporated into the comprehensive forest development project, Namibia-Finland Forestry Programme (NFFP), and renamed Integrated Forest Fire Management (IFFM) component of NFFP.

The IFFM is operating within a local context of high unemployment, and a predominantly labour-based agricultural system with increasing elements of commercialisation. In addition, the prevalent HIV/AIDS epidemic is putting an extra onus on the productivity of those in work. The East-Caprivi area suffered major political disturbances in 1998 when separatist rebels attacked government targets in Katima Mulilo. A state of emergency was then declared in Caprivi and, consequently, temporary evacuation of all Finnish development co-operation personnel from East Caprivi.

3. Approach and Strategy

The Namibia Forestry Strategic Plan (NFSP) (Directorate of Forestry, 1996) provides the framework for fire policy and management planning. The Strategic Plan is based on ecological, environmental, cultural, and socio-economic considerations and considers 'production, protection and participation' as the three imperatives of forest policy. The plan underscores the need to reduce the negative effects of fires by stating: '*The occurrence and severity of uncontrolled and accidental forest fires has to be reduced, and the policy of burning off patches of woodlands to improve hunting grounds, should be changed to one using fire only as a controlled tool under specific circumstances*'.

Furthermore, it is stated in the Strategic Plan that: '*Participation of local communities and the private sector is essential for the sustainable use of the forest resources. The active involvement of local communities in management and conservation of forest resources is desirable for the purposes of environmental protection and for significant increases in rural incomes and employment levels.*'

These statements open a way for the development of community-based strategies not only in forest management but also in the control and management of forest fires. Under the given demographic, socio-economic and cultural conditions of Namibia, the fire extension message was initially focussed on fire prevention and control. Based on the technical and socio-economic review of the project in 1998, the message was adjusted to also involve raising awareness on the ecologically acceptable use of fire with the realisation that fire is a legitimate land management tool, if carefully timed and used. Accordingly, IFFM gradually evolved from a fire prevention programme to a fire management programme in which controlled burning is recognised as being ecologically necessary under certain circumstances. Such a change in attitude is being achieved through local district forestry personnel attending training programs in fire ecology and controlled burning relevant to the different forms of land-use practised in East-Caprivi.

The public awareness programme was then adapted to differentiate between the harmful effects that indiscriminate fires have on the vegetation, and the ecological necessity of using controlled burning. Such a change in the public awareness programme will eventually help restore the credibility of traditional knowledge which recognised the right ecological balance in using fire in managing natural vegetation in East Caprivi. It was also considered important for Namibia as a nation to distinguish between the legitimate and organised use of fire, and the unintentional fires that often have destructive consequences.

From the beginning, the implementation strategy of IFFM has focussed on involving the rural population in fire prevention and management. The participatory (community-based) approach is in direct agreement with the aims of the NFSP. The overall implementation strategy is based on:

- organising a massive fire awareness campaign directed at all sectors of society;
- capacity building at community level through introduction of labour-intensive fire control and management technology; and

- community mobilisation for voluntary fire prevention and suppression using gender-sensitive approach.

A variety of new and innovative community extension methods and channels have been introduced with significant success. The IFFM has also implemented an innovative strategy in fire management using labour-intensive methods instead of capital-intensive technologies. The basic differences between the conventional and community-based fire management strategy are illustrated in Annex 1. The most visible results on the ground are the fuel-breaks, or cutlines, cleared by local communities with the help of subsidised payment from the Government. As a result, not only have important employment benefits been created for the rural population but also the overall costs have been kept to a minimum. The total cost of fire prevention/control in 1999 in Caprivi was US$ 140,000 (only US$ per 0.10/ha). It is important, however, that the communities themselves take the initiative in maintaining the initial cutlines. Sustainability through replication can only be achieved when a community no longer requests assistance in protecting their area against wild fires.

The awareness raising campaign has targeted almost all the resident population of Caprivi, as well as visitors. Traditionally, forestry activities centred only on men — although women carry out 80% of the agricultural burning. Women traditionally receive their information either from men or from their children. Therefore, school children have constituted a special target group for the awareness campaign, since they are believed to be an important cause of wild fires, though they also play an important role in transmitting messages to their family. Accordingly, the strategy has a gender-sensitive approach in information dissemination at community level.

4. Results and Activities

The objective of the Integrated Forest Fire Management component of NFFP is to develop *an applicable model for integrated forest fire management which is implemented by Namibians*. It hopes to benefit forestry by involving local communities in wise fire management for their own benefit, using Caprivi as the pilot region. The IFFM component is enhancing the capabilities of all stakeholders in forest fire control and teaching an ecologically acceptable use of fire; it also aims to change attitudes, cultural values and habits in relation to fire and burning. A variety of preventive fire-protection field works have been completed and a message delivered on forest fire control and management through a diverse traditional, as well as new channels. The continuous monitoring of the effect of the project has been facilitated through a GIS-based fire scar mapping procedure developed by the National Remote Sensing Centre at the Directorate of Forestry. The development of national fire policy and fire management guidelines is also underway. Some of the actions taken in forest fire management in Namibia with potential for application elsewhere are summarised in Annex 2. The four objectives of IFFM and its main achievements under each objective are described below:

4.1 Forest Fire Management Plan for Caprivi

The Forest Fire Management Plan for Caprivi was developed and endorsed by relevant stakeholder institutions, including traditional tribal authorities, through:

- Draft proposal for Caprivi Forest Fire Management Plan under preparation.
- Stakeholder institutions identified, dissemination process underway.
- Field-testing and assessment of guidelines for prescribed burning underway in pilot communities.
- National Round Table meeting organised.

4.2 Improved Capacity of Directorate of Forestry

The Directorate of Forestry improved the capacity of its personnel, men and women, to assist rural communities in north-eastern Namibia in Integrated Forest Fire Management practices through:

- Fire Control Unit in Caprivi being made operational
- Gender sensitisation among fire extensionists
- Process of changing forest fire staff from the role of forest police to facilitators underway
- Pilot communities assisted in trial of prescribed burning activities for improving areas covered by moribund grasses

4.3 Increased Participation

Increased participation among rural communities, NGOs and other stakeholders, especially women's groups in north-eastern Namibia, to implement Integrated Forest Fire Management was facilitated through:

- Area protected from fire — 400,000 ha
- Extent of area under fire management — 500,000 ha
- Extent of fire lines constructed — 1000 km/annum
- Number of communities involved — 60
- Women groups controlling fire — 3
- People educated in fire management — 40,000

4.4 Strategy for Public Awareness Raising

The strategy for raising the awareness of the public on the ecologically acceptable use of fire was developed, tested and successfully implemented by Direcotrate of Forestry staff members and other stakeholders, through:

- *Placing of billboards along main roads*: a total of 24 billboards are spreading the fire message over a road stretch of 800 km.
- *Distribution of posters in various languages*: Artists from the Caprivi Arts and Cultural Association (CACA) have produced the educational materials needed for the fire campaign. These activities and the network of CACA handicraft makers who control fires in areas where materials for handicrafts grow have created a linkage between local artists and the National Arts Gallery of Namibia. The fire arts include 60 different posters and 24 erected fire billboards. These campaign materials, produced in several languages, have made a strong impact in educating the rural population and school children. A total of 6,000 fire posters have also been distributed in the regions of Caprivi and Kavango.
- *Radio programs and fire video*: Regular radio programmes have been used to extend the fire message to a increasing audience in the rural population The IFFM has also produced a 26-minute video on community-based forest fire management called '*Let us not burn our future*' The video shows how the fire prevention and control work is undertaken by the local communities in Namibia.
- *Designing and distribution of a national fire logo*: for Namibia was developed in 1996. The aim was to link national fire management efforts with wildlife endangered by uncontrolled fires. The Fire Ostrich became a national symbol since the last ostrich was killed in East-Caprivi in 1988.
- *Production of car stickers, badges, key rings, etc*. Car stickers, badges, key rings, etc. with the Fire Ostrich logo have been produced and about 6000 vehicles are presently carrying the Ostrich with the accompanying text '*Do Not Burn Our Environment*'.
- *Production of comic books and school materials*: Two different booklets have been produced. The fire story (21 pictures in colour) tells a true fire story '*Who Started the Fire*?' which took place in a local community. The text is produced both in English and in local language Silozi with the initial edition of 5000 copies. The Fire Cartoon '*Never Play with Fire*' tells a story about potential environmental damage caused by wild fires. The characters in the cartoon are not related to any true story or any living persons but reflects how once fire was a friend, but then it became an enemy. The text is published in English and Silozi and the initial

edition was 5000 copies. This story has also been produced as a radio drama performed by the Caprivi Drama Group. An initial set of these booklets have been officially donated by the Government of Finland to the Ministry of Basic Education and Culture of the Government of Namibia.

- *Exhibits at art shows, trade fairs etc.* The IFFM message has been actively disseminated at a variety of local events, and the posters have also been displayed as well as in the premises of the local administration, educational institutions and private sector companies.
- *Educational programme in schools*: The key element in the success of teaching environmental protection to local people has been in the education of pupils in schools. The programme has involved 84 schools where 20,000 pupils and 700 teachers have had teaching about forest fires. In addition, about 40,000 people in rural areas have also received fire education through other media.
- *Drama performances by a self-help theatre group*: As an integral part of the fire campaign a fire drama has been performed by the Caprivi Drama Group (under the National Theatre of Namibia). Through the fire drama the new fire message has been relayed to illiterate people in rural areas. The drama has also been performed on radio and has been broadcast by the National Broadcasting Corporation over the local radio stations.

4.5 Satellite-based Fire Monitoring System

The burned surface has been monitored regularly by IFFM staff while patrolling the project area. In addition, the burned surface in the pilot project area is objectively monitored through a satellite-based system using NOAA AVHRR satellite imagery (*fire scar assessment*). The regular monitoring mechanism has now been fully institutionalised at the National Remote Sensing Centre of the Directorate of Forestry.

The latest assessment clearly illustrates the efficiency of the IFFM project in reducing wild fires in East-Caprivi. Since its inception the percentage of East-Caprivi burned regularly decreased until 1999 when the political problems mentioned earlier caused a slight increase (Table 1). The decrease took place in East-Caprivi while the burned area in the surrounding areas covering the entire Caprivi and parts of Kavango and neighbouring countries (Caprivi window), and in West-Caprivi in particular, remained as high as ever.

Table 1. Burned areas in the Caprivi Region 1996-1999

Year	East Caprivi (%)	Caprivi window (%)	West Caprivi (%)
1996	54	49	67
1997	47	51	75
1998	36	46	57
1999	46	57	67

4.6 National Forest Fire Round Table in Namibia

The National Namibian Round Table on Fire Management set up in 1999 represented the launching of a process to formulate a national fire management strategy and programme in which all relevant sectors of the society should actively participate. The recommendations arising from the breakout groups and the Round Table plenary, represent the opinions and visions of the most important Government and Non-Government institutions and stakeholders, and have been documented in the draft proceedings of the meeting (Goldammer 1999).

The next step in the Namibian process will be to prioritise the recommendations and initiate action accordingly. It is considered obvious that the highest priority lies in the establishment of a *national fire forum*, which would provide the continuation of the spirit of a round table in which all stakeholders would jointly share responsibility. The forest development policy and forestry legislation being developed will also produce a conducive environment for effective community-based fire management and the necessary inter-sectoral co-ordination mechanisms.

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Annex 1

Comparison of Key Issues between Conventional and Community-Based Forest Fire Control

Activity of Techniques	Conventional	Community-based
Decision making	100% Government	80% Community 20% Government
Fire suppression	85% of resources Remove heat using water Imported equipment Know-how with Government	5% of resources Removing oxygen Locally produced hand tools Know-how with communities
Fire detection	10% of resources By radio Reporting to Forest Office Patrolling by motorised equipment	5% of resources By people Reporting to village fire unit Patrolling on foot
Fire prevention	5% of resources Government officials informing public Bringing arsonists to Police	90% of resources By village meetings Bringing arsonists for community trial
Burning permission	Government Office	Village authorities
Responsibility to suppress fire	Government employees	Village fire control unit
Benefits from fire management	100% Government	95% local community 5% Government
Training of staff	100% Government 100% on fire suppression Use of fire discouraged	80% communities 20% Government 100% on controlling burning Use of fire encouraged
Forest fire budget	100% used by Government	30% used by communities 70% used by Government
Other benefits	Timber for commercial use Biodiversity Ecotourism Reduction of air pollution Healthy population	Grazing and fodder Wood products for energy and housing Non-wood products for food security Rural employment Understanding of role of forests Diversity of flora and fauna Reduction of local erosion Reduction of respiratory diseases

Source: Jurvelius 1999

Annex 2

Fire Management Actions Undertaken in Namibia With Potential for Application Elsewhere

1. Implement education, training, information/dissemination and other extension activities by:

- Personal contacts
- Interviews/discussions with target groups; Government agencies, traditional leaders, farmers, fishermen, cattle raisers, women's groups, conservation cadres, environmentalists, tourists, hunters, honey hunters, arsonists, school children, teachers, handicraft makers etc.
- Developing and establishing a National Fire Logo
- Use of printed and electronic media
- Using Theatre Drama and national radio to relay fire message to illiterate rural people
- Targeting primary and secondary schools and other training institutions
- Involving local artists in the production of educational materials, text writing, song writing, video production
- Participating in literary programs for adult learners (the majority of whom are usually women)
- Participating in national/local exhibitions, cultural festivals, parades, school competitions
- Participating in National Arbour or Environmental Day, Food Day
- Organising national Fire Campaign on Radio/TV with National Fire Logo displayed
- Producing National Fire Logo badges, key rings etc.
- Producing Fire Stories or Fire Cartoons for mass distribution in English and local languages
- Producing Fire Billboards in strategic areas in English as well as in local languages

2. Technical actions and regulatory measures:

- Patrol and control/guard fire risk areas
- Fuel treatment (fuel modification e.g. slashing for reduced flame height), fuel isolation, fuel reduction by grazing or by prescribed burning
- Construction and maintenance of fire breaks, fuel breaks, grazing corridors and or silvicultural treatment areas
- General weather expectancy for fire season like El-Niño oscillation
- Socialise and enforce laws, by-laws and customary law

3. Implement formal and informal education and training:

Involve local communities in grass cutting groups, game lodges, and rural schools in fire prevention activities including cutline (fuel break) construction, prescribed burning whether done jointly with the Government or by themselves.

DISCUSSION

Peter Lowe: Two elements of the Namibian project concern me: (i) community education should not simply be delivering an extension message, it must also use indigenous wisdom; (ii) it is a mistake to rely on project inputs, e.g. for firebreaks, as they would not be sustainable, and projects should demonstrate the benefits of better resource management.

Azene Bekele: What was the role and contribution of the GOs, NGOs, CBOs, etc. for endorsing the fire management programme by the stakeholders?

Harri Seppanen: The technology was developed based on local/traditional wisdom. Initially there was a remarkable community mobilization and corporate activity involving all stakeholders.

Ensermu Kelbessa: How did you manage to convince the communities to stop believing forest fires bring rain or facilitate rainfall? There is a similar belief in the south-western part of Ethiopia where people believe that felling trees or deforestation in dry seasons causes the rain to fall even in the dry season.

Harri Seppanen: It was done by awareness creation. Community members were made to know the important relationship between vegetation/forest moisture, water and rainfall. They were also made to understand the functions of nature around them and the changes observed resulting from fire-induced deforestation.

I would like to raise three points about the video:

(i) The emphasis of the government and the project was to focus on prevention rather than suppression. I emphasize that it saved a great deal of money.

(ii) All the materials that the local people used (rakes, etc.) were locally produced. By the way, this had been part of the reminder during project formulation.

(iii) Not revealed until later in the project's life was that the traditional authorities were not working with the people properly, perhaps because of a lack of propaganda. We have now found it necessary to supplement the normal programme activities with sufficient orientation, grass roots education and propaganda.

REMOTE SENSING OF VEGETATION FIRES AND ITS CONTRIBUTION TO A NATIONAL FIRE INFORMATION SYSTEM

*by Stéphane Flasse**

1. Introduction

Fire is one method used for clearance of vegetation for agriculture, logging access, settlement and hunting. When used inappropriately, fire events may adversely affect ecosystems, local revenue, habitations and atmospheric conditions. In developing countries, resources to monitor and manage fire activities are usually limited (e.g., staff, materials, budget), and little information on the scale of the problem is generally available at regional or national level. Earth observation and GIS (geographical information system) technologies are a practical and affordable means to monitor biomass burning events efficiently at national scale. The Fire Group of the Natural Resources Institute conducts research and operational work to support developing countries in building operational fire information systems to assist decision makers for timely integrated fire management.

The presentation at the Ethiopian Round Table on Forest Fire Management was aimed at sharing practical experiences in using remote sensing information to support decision making for integrated fire management, and provide illustrations mostly from projects funded by the UK-Department for International Development (DfiD) in Indonesia, Nicaragua, and Botswana. This paper provides an extended summary of the presentation.

2. Fire Management and Information Needs

Management of fire consists of activities designed to control the frequency, area, intensity or impact of fire within the economic, social and environmental context at local and national levels. Figure 1 illustrates a typical approach to fire management.

The first step to effective fire management is often simply to know and to understand the climatic, environmental, economic and social factors that influence fire and its impacts. In order to know and understand a fire issue in a country or in a specific region, one can build a Fire Information System including, for example:

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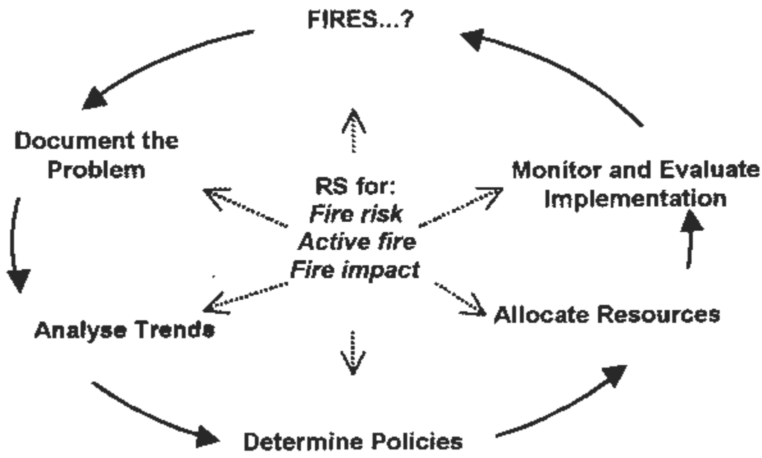

Figure 1. Typical approach to fire management

- fire events over the years (where and when do fires burn?)
- information that may be related to the fire events (e.g., what and how much is burned, why was fire set, attitude of different people towards fire and fire prevention, population density, meteorological data, vegetation status)
- ancillary information (e.g., roads and river networks, administrative boundaries, protected areas, concessions, villages, fire towers, fire fighting units).

Only comparison of fire occurrence, within a season, between seasons, and within their socio-economic and environmental 'contexts' allows resource managers to identify trends, to understand practices and needs, to prioritise problems, and to formulate fire management policies. In turn, the policies must be implemented by allocating the right resources, and their achievements must be monitored and evaluated. Then the question arises as to whether the fire problem is still there, and how it has evolved or changed. Fire management also consists in repeating the cycle many times to ensure that every iteration brings adjusted and improved policies. Therefore, updated information (on fires as well as all areas concerned) is essential at all stages of the management cycle.

While comprehensive analysis of fire data can only improve understanding and enable better management decisions to be made, such an approach may be a real challenge for a budget-constrained government in a developing country, especially one with more problems than capacity to intervene. Such governments are often constrained by outdated and ineffective institutions, and pressed by increasing rates of environmental change together with growing demands for accountability and competence through enhanced political and environmental awareness. They need assistance to help them improve management of their natural resources and environment. Decrepit observation networks, poor communications, underpaid and demoralised staff and urban-oriented political systems do not improve prospects. Under such circumstances, unless the need for fire control is inescapably obvious to all (and it very rarely is) then systematic, reliable data on fires over large remote areas are very unlikely to be collected, processed, assimilated, or utilised. As a consequence, even obtaining basic information is often a challenge.

The most practical, feasible, relatively objective and cost-effective means, by far, to quantify and monitor these fire events at national scales is to utilise Earth remote sensing technologies. Many studies have demonstrated the potential usefulness of remote sensing techniques for monitoring the Earth's surface and providing fire related information in particular (e.g., Kaufman et al., 1990; Pereira, 2000).

Remote sensing observation leads to environmental information such as vegetation (e.g. healthy vs. dead canopy, quantity of biomass, water content, etc.) and temperature (fires, water, cloud, rainfall, etc.), which can then, in turn, be related to specific biophysical processes. It works because each target on the earth (vegetation, bare soil and fire) reflects light and emits energy differently according to its type, status, quantity, etc. Since sensors on board satellite platforms have different 'channels' they can be sensitive to different targets. For example, a 'visible' channel will be sensitive to chlorophyll activity, a near infrared channel will be sensitive to leaf and canopy structure, and thermal channels to the actual temperature at the surface. Consequently, by combining observations from different channels, sensor observations can provide valuable information on the state of the Earth's surface and its atmosphere.

The technology gives the precise location of any point of an image, therefore allowing its combination with other geo-reference information such as roads, fire units, protected forest, plantations, villages, etc.

Finally, remote sensing data offer major benefits, essential to provide a coherent and useful information system in support of long term management. These include that:

- Observations are spatially comprehensive. They cover large areas of territory (e.g. the whole of Ethiopia at once), including areas that are remote and difficult to access by land.
- Observations are regular (e.g. daily), allowing for frequent update of the situations.
- Because the satellite is there, continuously orbiting around the earth, observations are reliable, systematic and objective (i.e. always done with the same sensor)

3. Remote Sensing and GIS for Fire Management

For the fire manager, remote sensing observations and their integration through a GIS into their local context can form the beginning of a structured fire information system. There are three main areas where they can assist fire management:

1. *Before the fire:* assessment of fire risk and fire danger,
2. *During the fire:* near real-time location of active fires, and
3. *After the fire:* assessment of burned areas.

The next paragraphs describe some examples where satellite observations were used operationally in some developing countries where we have been working.

3.1 Active Fires

Active fires can be detected from satellite data because fire fronts are very hot and emit large amounts of energy that can be observed by thermal sensors onboard satellites. The identification of fires in an image is now relatively well mastered (see Figure 2), and limitations are usually due to the sensor. Active fire information from satellite data can be used in two ways.

First, to prioritise resources for fire fighting in near-real time. Within minutes of the satellite overpass, the fire manager can know the locations of fires in his territory. Introduced into the fire information system, the importance of a fire can be

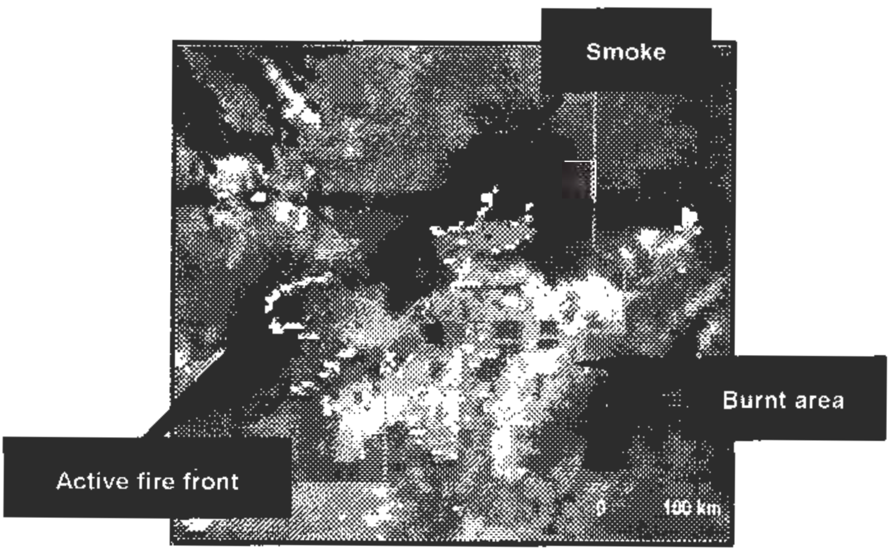

Figure 2. Thermal image from the AVHRR sensor, over North Botswana. White is hot, and black is cold.

considered. For example, a fire in an agricultural area at the time of land preparation probably means a *good* fire presenting no risk, whereas a fire near a coffee plantation may be more important to tackle. In Nicaragua, reports on fire locations as observed by the satellite, and organised by district (see Figure 3). These are faxed soon after the satellite overpass to each district centre where appropriate action is taken.

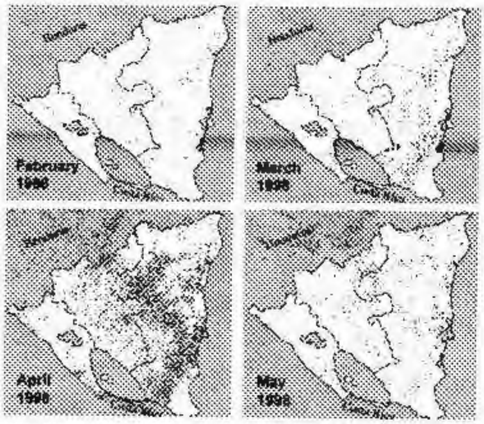

Figure 3. Nicaragua 1998 fire season

Secondly, as post fire information. In Nicaragua and Indonesia, active fire information has been used in different ways, to:

- **Document the trends over the years,**
- Document the type of fires according to the vegetation in which they occur,
- Identify areas of particular human pressure on the natural forest,
- To dissuade local farmers in the field.

Better informed decisions are, therefore, taken in the areas of forestry policies, land tenure, and policing strategies. In addition, the data are officially shared among Central American countries for international programmes, such as the Agricultural Frontier and the Biological Corridor.

3.2 Burned areas

Satellite observations can provide information on burned areas on a regular basis throughout the fire season. The detection is more complicated because the contrast between unburned and burned areas is not as sharp as for active fires. In addition, burned areas evolve a lot through time (from ash and charred ground, to bare ground, to regrowth). Their detection is often undertaken by looking at the changes from one date to the next, and algorithm design requires more sophisticated methods, as well as local adjustments for their efficient operational use.

When available however, burned area maps provide a better quantification of area burned than active fire, since the latter only indicates the presence of a fire at the time of the satellite observation. Burned area maps can be used as well as the active fire information for post fire decisions.

In Botswana, every year the burned areas are mapped and integrated into the national fire information system. Accumulated observations and archived data over the past few years have enabled interesting temporal analysis. In particular, the creation of a fire frequency product (see Figure 4) is proving of interest in two areas:

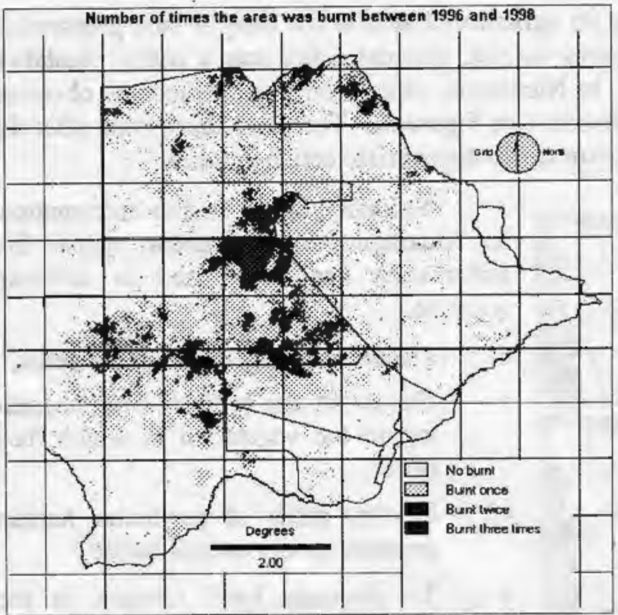

Figure 4. Fire frequency in Botswana

- for the fire manager, to prioritise fire break maintenance in areas where fire frequency has been low (accumulation of biomass) and where vegetation production has been high,
- for the rangeland manager to bring attention to potential area of bush encroachment (low frequency), as well as areas under high ecological pressure (high frequency).

In Namibia (see other paper in these proceedings) burned area mapping is playing an important role in monitoring and evaluating the impact of their integrated fire management programme.

3.3 Fire Risk

Fire risk assessment is a much more complex issue. Whilst information on active fire and burned areas can be used unsupported, here any remote sensing information must be combined with other information to provide a fire risk assessment. Actually, there are as many 'fire risk', 'fire danger' and 'fire threat' definitions as there are fire managers. Wording must therefore be used carefully and we here use 'fire risk' in a generic sense.

Fire risk information helps managers to prevent fires, as well as to prioritise action and focus resources (often scarce) in order to optimise results. We often consider two types of fire risk factors:

Physical factors, i.e. factors linked to the actual risk of having a fire, or fire occurrence risk. They include, for example: vegetation type, biomass quantity, vegetation status (live/dead, dry/wet), meteorological conditions, population (density, cultural customs, …), fire frequency.

Impact factors, i.e. factors which are linked to the type of fire impact, for example: impact on livelihood (threats to people's lives and essential belongings such as houses), impacts on the environment (biodiversity, protected areas, global change, …), economic impacts (reduced income due to damaged plantation, killed livestock, or destroyed forest; but also increased food for cattle due to regrowth).

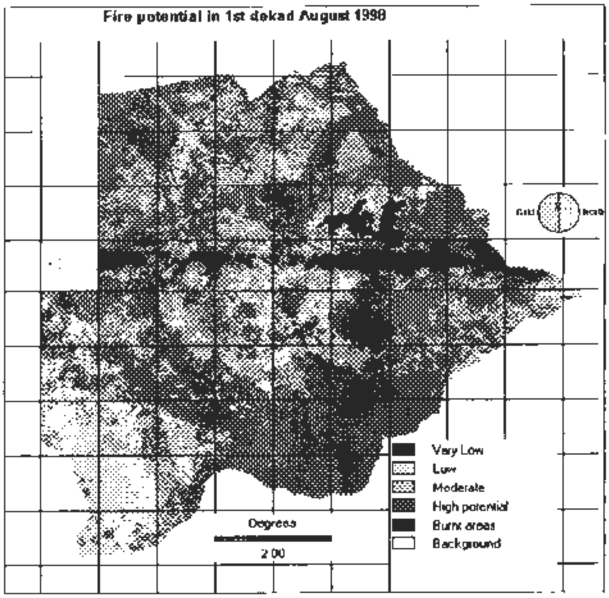

Figure 5. Botswana fire potential map for 1st dekad of August 1998

Managers rarely take all impact aspects into account, and the focus of a given fire risk map usually depends on what type of fire impact is considered. Remote sensing data can mostly contribute to the documentation of the *physical factors*, and therefore better inform managers of the risk of fire occurrence. Satellite observation can provide information on meteorological conditions (rainfall), vegetation status, fire frequency, and archives of fire occurrence, etc. Such information is often considered in relation to previous years, so to give relative information such as 'low rainfall' compared to the average for the same period, or 'very high' vegetation production compared to the average for the same month in previous years.

In developing countries, the creation of fire risk maps usually follows several years of remote sensing experience, as explained below. In Botswana, a new fire potential map (see Figure 5) to support rangeland managers was recently compiled. Its information included vegetation type, vegetation status, fuel quantity, villages and settlements.

3.4 Direct Access to Fire Information

In order for remote sensing data to be useful and for its use to be sustainable, it is essential that the data are available directly where they can best be used, and at a low cost. This is a challenge we are actively addressing as we seek to inform policy makers, planners, protected area managers, and forestry staff, as well as to work on awareness raising, fire prescription, prevention and extinction as required.

In order to achieve this, we promote the use of two meteorological satellites: NOAA-AVHRR (from the USA) and Meteosat (from Europe). Both are part of long term program, and are unlikely to be stopped or interrupted. In addition, their data are free as long as receiving equipment is in place, which is relatively cheap and easy to operate and maintain.

It is essential that appropriate information is available directly where it can readily best be used, i.e. in the hands of the manager. We have been using, for over 10 years, robust and low cost PC-based satellite data receivers. They are installed in the host country and operated by local, national or regional institutions to provide rapid and direct access to satellite data. Such receivers are operational in Namibia, Botswana, Nicaragua, Indonesia and many other countries, including Ethiopia, and have supported decision makers in forestry, fisheries, agriculture, pest management etc.

It is also important to note that these technologies have been used for many years now. New satellite programmes, as well as the globalisation process, are likely to bring, in the not-to-distant future, access to improved free remote sensing products. For example, they will be readily accessible through the internet.

3.5 Opportunities for Ethiopia

The use of remote sensing for addressing fire issues is increasing world-wide, within both global programmes (e.g., Global Observation of Forest Cover, International Geosphere Biosphere Programme), and individual countries, where the level of usage depends mainly on local resources (e.g., Australia, Brazil, Mexico, Mediterranean region, Senegal).

The National Meteorological Services Agency (NMSA) in Addis Ababa hosts receiving stations for the satellites indicated above. Initially implemented some 10 years ago to support drought preparedness (Tsegaye et al., 1995), the same data can be interpreted for fire management. NMSA already operates the systems and collects satellite data daily. The forest and fire community in Ethiopia only needs to build on this existing expertise to benefit from timely and national fire information from satellite data. An example is given in Figure 6.

From our experience, it is clear that the integration of remote sensing and GIS tools within local institutions is progressive, and requires a continuing ongoing commitment. It takes time for inexperienced local staff to appreciate fully the potential of the tools and to accept that they complement local methods rather than replace them. Time is also necessary to foster good understanding of the basic principles of remote sensing and GIS, to allow the users to get to grips with interpreting new types of information, and to relate it with knowledge in the field. Typically, this is an interactive learning process. Initially, one simply uses the tools to detect fires daily and observes their spatial distribution on a map. Through repeated use across several fire seasons, one becomes more familiar with the data, progressively realising the potential of the new information source. This leads to further analysis (e.g., proportion of fires within a forest, or forest types; correlation between fire occurrence and population density), the production of bulletins or creation of innovative products, such as fire risk maps.

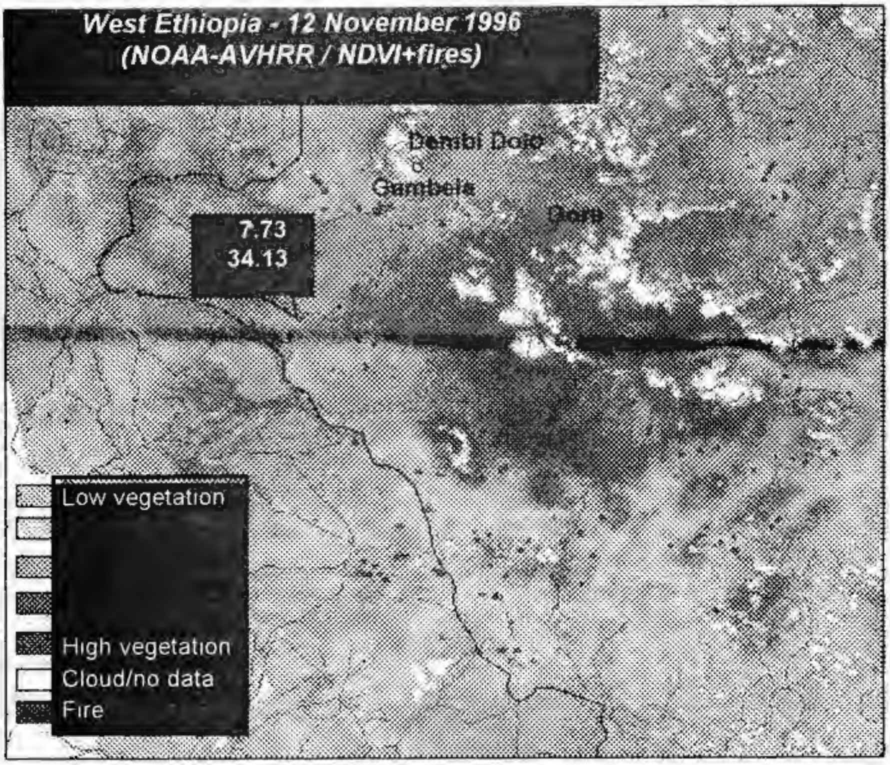

Figure 6. Vegetation and fire information from satellite data over Ethiopia, using NMSA technology.

For Ethiopia, part of the learning process has already been achieved through NMSA. Building on that expertise, development and training is further required to extract the appropriate fire-relevant information and to build the beginning of a fire information system that will answer specific requests.

4. ACKNOWLEDGEMENTS

The author is grateful to the Ministry of Agriculture of Ethiopia, the German Technical Co-operation and to the UK-Department for International Development who supported his participation in the Round Table. Many individual people have worked in research activities, developments and projects described here. Their contributions are warmly acknowledged

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Discussion

Tesfaye Gisela made the following observation. The 'bega' (dry) season and the first half of the 'belg' (small rains) season, which are called the forest fire seasons, can lead to very extended and wide spread forest fire if the moisture coming to the country is suppressed. This condition usually occurs if there is high activity in tropical cyclones over the Indian Ocean. This was the condition during the droughts and fires of 1984 and 2000. As to the global ENSO phenomenon, La Niña conditions tend to suppress rainfall during the 'belg' season, particularly the first half of the 'belg' season when there is an increased fire risk. On the other hand, El Niño conditions tend to suppress the rainfall during the 'kremt' (long rains) season. However, normally the 'kremt' season is not a forest fire season for Ethiopia.

Ensermu Kelbessa: I have difficulty reconciling the satellite image with the condition on the ground. For example, I am puzzled when I compare the existing south-western forest areas with those shown on the satellite pictures you showed. It is sometimes difficult to differentiate between forest cover and that of enset plantations. I have another example from my own experience of travelling to

Tigray where my colleagues have conducted studies on the relationship between the vegetation and people in the area. The area has been shown on the satellite imagery as deep green, while the original vegetation cover of this same area has been reduced to small shrubs because of grazing and browsing by cattle, and yet another area, which is actually more forested, is shown on the same satellite imagery as light green. Is there a way of reducing such problems in using satellite imagery?

Stéphane Flasse: I don't see much of a problem as we have various powerful sensors that can detect different levels of chlorophyll activity within a kilometre. For example, in young plantations you actually have more chlorophyll activity and, therefore, the image is greener. Whereas, the images of more mature forests, with reduced chlorophyll activity, are seen as less green. It is the level of chlorophyll activity that is very important and that is why I insisted that it is very important to combine the information from satellite imageries with local knowledge. I would go a bit further and mention that there are images that allow you to differentiate between old forests and young plantations. These images include fine details, which means they are expensive. What we often do is, for example, one year buy high-resolution imagery (i.e. with fine details) and do a map of land use, repeating this once every 3-5 years. Then you use the information to monitor the resolutions from the actual land use you have recorded.

THE INTEGRATED FOREST FIRE MANAGEMENT CONCEPT: LESSONS LEARNT FROM INDONESIA AND OPPORTUNITIES TO TRANSFER THE CONCEPT TO ETHIOPIA

by Johann G. Goldammer* and Hartmut Abbgerger

1. THE INTEGRATED FOREST FIRE MANAGEMENT PROJECT IN INDONESIA

The Integrated Forest Fire Management (IFFM) Project is a bilateral technical co-operation project between the governments of Indonesia and Germany. It is the responsibility of the Ministry of Forestry and Estate Crops (MoFEC) of Indonesia and is being implemented by the two provincial forestry agencies Kanwil Kehutanan and Dinas Kehutanan. The project began in 1994 and is scheduled to last nine years. With phase II (1997-2000), IFFM has become a co-operation project with the German Development Bank (KfW), which provides financial grant of 10 million DM for the purchasing of fire equipment. GTZ (German Agency for Technical Cooperation) is in overall charge and provides the necessary training and advice to set up a complete fire management system. Indonesia provides the premises, personnel and budget for operating fire management in East Kalimantan (on Borneo). This paper describes the project and briefly discusses the opportunities to transfer some of the experience gained to Ethiopia.

2. FRAME CONDITIONS AND BACKGROUND

The fires within the rural and wildland areas in East Kalimantan are virtually all human-induced. Only in very limited areas, burning coal seams, mostly ignited by previous fires, have some significance in causing wildfires. A large number of all ignitions result from activities in forest conversion for industrial plantations and from small-scale agricultural burns that have escaped. Fire is the cheapest tool to reduce vegetation cover, and for many smallholders the only one available.

After the disastrous fires of 1997/98, particularly in the province of East Kalimantan, it was obvious that approaches for the prevention of fires face a complex set of constraints, including:

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- A general lack of awareness and concern about forest and land fires at all levels of the society;
- Institutional constraints like lack of clear authority and responsibility, and law enforcement;
- Available budgets insufficient at the operational level;
- Overlapping claims to land and forest resources and tenure insecurity for both, large companies and smallholders, but particularly for smallholders in indigenous communities; and
- Human-induced changes in vegetation cover resulting in the rapid spread of fire-prone vegetation types, which create hazards for future fires over large areas in the province.

Such conditions make the prevention of wildfires a big challenge. Human-induced wildfires, however, are generally preventable. To reduce their occurrence, human resource and institutional development along with general awareness campaigns are the foremost tasks to target at the group level. Furthermore, in a province like East Kalimantan with limited and insufficient technical fire management capacities to reduce the spread of large-scale fire events, the prevention of wildfires from starting at all is possibly the most effective and efficient part of a fire management system.

3. Community-Based Forest Fire Management (CBFFM)

Grassroots approaches are the backbone of fire prevention concepts in East Kalimantan. Many of the local people are upland farmers and use fire as a tool for land clearing. On the other hand, many of them also have experienced damage and losses due to the fires in 1997/98. Therefore, fire management at village level is first of all a self-help-oriented approach.

Extension work, which includes village awareness campaigns and the distribution of information materials, is the first essential step to plant 'fire prevention seeds' at village level. This is followed by the provision of a basic training in fire management and fire fighting hand tools. The next step is to form volunteer village fire crews and to institutionalize the approach in planning workshops together with village fire crews, formal and informal community leaders and involved government agencies.

Besides these activities, nature camps for children and 'roadside campaigns' are additional activities developed and carried out by IFFM to support CBFFM.

For the success of the program, an incentive system has to be designed benefiting local people who participate in the CBFFM. This further enhances the sustainability of such a programme in general. The following incentives should to be part of a CBFFM system along with training and the provision of equipment:

Six Steps towards Community Based Forest Fire Management

Step 1: Orientation process/identification of villages

- 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.

Step 2: Fire prevention campaigns

- 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.

Step 3: Fire prevention and suppression training for volunteer village fire crews

- 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.).

Step 4: Institutionalizing of fire prevention work at village level

- 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".

Step 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.

Step 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.

- Village fire crews should have regular access to fire relevant information (early warning aspect, communication, co-ordination and co-operation in the field, etc.).

- Career opportunities in fire management within the forestry department but also job opportunities (volunteer fire crews, village trainers, etc.) have to be created;
- Government support for community development (e.g. income generating programs like the rehabilitation of burnt forest areas, etc.; provision of seedlings in the framework of community forestry; technical support like water supply facilities, further equipment, etc.).
- Awards for out-standing fire prevention performance during high fire danger events given to successful villages.

4. State of Implementation of the Program:

So far, about 80 villages in the six most fire-affected forestry districts and one national park (Kutai National Park) of East Kalimantan have been included in this program. Extension work, and fire prevention and suppression training have been successfully carried out and the villagers in more than 20 communities have established volunteer fire crews. IFFM is currently preparing participatory planning workshops to integrate the approach into the institutional framework of those villages. Main issues to be addressed are responsibilities and co-ordination, legal aspects, budgets, and communication. Fire fighting equipment (hand tools) has been purchased and distributed.

5. Public Relations Work as Part of Fire Prevention

Public awareness of forest fires is still small in Indonesia. Only during ENSO events, like in 1997/98, does fire become a 'hot' issue. Hence, continuous public relations work is indispensable in the efforts to prevent forest fires. IFFM has been very active in designing and carrying out fire prevention campaigns in East Kalimantan, often in co-operation with local TV and radio stations and a number of newspapers.

To promote the Indonesian fire prevention mascot, *Si Pongi*, various extension materials have been produced and events organized. For more than a year, the famous Indonesian TV Star *Kak Seto* and his *Mutiara Indonesia Foundation* have co-operated with IFFM to help raise the awareness of children about forests and forest fires. In April 1999, Kak Seto presented *Si Pongi* in a big show in Samarinda together with about 3000 children and adults. Since then, Kak Seto and IFFM have produced together a *Si Pongi* video clip for the national TV. The intention is to introduce the mascot to a broader audience and to promote a professionally produced *Si Pongi* music cassette. *Si Pongi* dolls and other items are very much liked by children and *Si Pongi* has the potential to become a successful figure on the toy market.

A 'nature camp' has been designed and carried out within the framework of the established environmental education (EE) working group together with local NGOs.

This programme may become another promising approach to address fire prevention with children in villages as part of the CBFFM program.

6. Opportunities to Transfer IFFM Experience to Ethiopia

All the above has been developed for Indonesia where the climatic, ecological and socio-cultural conditions are very different from Ethiopia. However, the approach of the IFFM project in Namibia (see the earlier contribution by Seppanen in these proceedings) and similar work in Mongolia has shown that the basic principles of IFFM are similar and transferable.

In order to create a national fire management strategy, a consensus must be reached among all the different stakeholders in the country. The participants in such a consensus-building approach will (or must) range from those who are using fire or being affected positively or negatively by fire, the agencies responsible for land-use planning and protection of natural resources, and all other governmental and non-governmental bodies that are practically and theoretically involved in any aspect of fire management.

The task of this first Ethiopian Round Table on Fire will be to identify a list of activities in which some fundamental questions must be answered, for example:

- Basics in fire ecology: fire-sensitive and fire-adapted ecosystems of the country
- Basics in the socio-culture of fire: traditional vs. modern applications of fire
- Contemporary demographic problems: population growth and food supply
- Conflicts between land-use systems and protected forest reserves
- Education: creation of public awareness
- Training: create national capabilities to deal with fire
- Co-operation with neighbours and international partners: building of coalitions in capacity building and sharing of fire management and training resources

We think that it will be possible to create synergism between the already existing IFFM projects in Indonesia and Namibia, and also include some experiences from the Integrated Fire Management project in Mongolia. All this has to be discussed during the First National Round Table on Fire in Ethiopia.

7. Further Information on IFFM in Indonesia and Elsewhere

The IFFM project homepage <http://www.iffm.or.id/> provides more details of the IFFM activities and operations, e.g. the IFFM Fire Information System with:

- the Fire Danger Rating System (FDR) which is used as an early warning system
- the fire zones of East Kalimantan
- maps showing fires detected by satellite
- a retrospective of the extreme fire situation in East Kalimantan during the El Niño of 1997-98
- the IFFM fire prevention activities
- link to the Global Fire Monitoring Center (GFMC) which supports the IFFM research and development concepts <http://www.ruf.uni-freiburg.de/fireglobe/>

Articles on IFFM published in International Forest Fire News (IFFN) which are available on the internet

Indonesia

Long-Term National Integrated Forest Fire Management Programme Initiated at Bandung (IFFN No. 8, January 1993)
http://www.ruf.uni-freiburg.de/fireglobe/iffn/country/id/id_1.htm

Integrated Forest Fire Management Project in East Kalimantan (IFFN No. 14, January 1996)
http://www.ruf.uni-freiburg.de/fireglobe/iffn/country/id/id_3.htm

Causes and Impacts of Forest Fires: A Case Study from East Kalimantan, Indonesia (IFFN No. 22, April 2000) http://www.ruf.uni-freiburg.de/fireglobe/iffn/country/id/id_24.htm

Namibia

30 % Reduction in Fire Incidents in three years (IFFN No. 19, October 1998)
http://www.ruf.uni-freiburg.de/fireglobe/iffn/country/na/na_1.htm

Reduction in Fire Incidents in East Caprivi (IFFN No. 21, September 1999)
http://www.ruf.uni-freiburg.de/fireglobe/iffn/country/na/na_2.htm

Fire Monitoring and Management in Namibia (IFFN No. 22, April 2000)
http://www.ruf.uni-freiburg.de/fireglobe/iffn/country/na/na_3.htm

Mongolia

Fire in Forest Ecosystems of Mongolia (IFFN No. 19, October 1998)
http://www.ruf.uni-freiburg.de/fireglobe/iffn/country/mn/mn_5.htm

The German–Mongolian Technical Co-operation, GTZ Integrated Fire Management Project (IFFN No. 19 - October 1998)

http://www.ruf.uni-freiburg.de/fireglobe/iffn/country/mn/mn_6.htm

Forest and Steppe Fire Monitoring in Mongolia Using Satellite Remote Sensing (IFFN No. 21, September 1999)
http://www.ruf.uni-freiburg.de/fireglobe/iffn/country/mn/mn_7.htm

The Social Conditions of Wildfire in Mongolia (IFFN No. 21, September 1999)
http://www.ruf.uni-freiburg.de/fireglobe/iffn/country/mn/mn_8.htm

Discussion

Yonas Yemeshaw asked: Is there international experience of integrating these variables into an index for which a map of sensitivity to forest fire can be made? If we had such a map, we could devise prescriptions for each component in the map.

If this is not available, are there any suggestions on how we could set about preparing such a map? This would provide a concrete proposal from this workshop for combating fire.

Günther Haase said that there would be group work the following day on these issues. Group one will deal with fire ecology and fire impact

Yonas Yemeshaw extended his appreciation for the two presentations. However, he had noted some imbalance in the presentations between biophysical issues and socio-economic ones. He had not heard much being said about the latter. His opinion was that socio-economics issues, such as demography, ethnic composition, resources competition, institutional arrangement, policy statements etc. are as important as biophysical parameters, if not more so. He asked if there was any way of regaining the balance during the remainder of the program?

Günther Haase said there was not space to integrate a paper presentation on socio-economic issues at this point in time. However, the comments were extremely valid and as much as possible the group assigned to carry out a stakeholder analysis during day 2 should try to address these issues

Ensermu Kelbessa commented that the situation found in Indonesia in the early 1990s was similar to what was now happening in Ethiopia. As far as he saw it, no one was taking care of the forests in Ethiopia. Fire was not the only problem; there were all sorts of problems concerning forest resources. One problem was duplication of effort. There was no single body mandated to mobilize the human and material resources for forest protection. Instead, there were several institutions sharing the meagre resources and probably contributing much less than what any single responsible institute could produce.

There was hardly any attention given to involving local communities in matters concerning forest conservation in this country. This has caused a lot of problems. We do not also look at the underlying causes of problems, which, in fact, are causing many of the problems, in this country, like the recent forest fires that destroyed over 90,000 ha of Natural High Forest.

There is a mention made of social problems, human migration for example, but we don't involve people, we do not discuss their problems. Unless we discuss these, for example, why people migrate, what if we allow migration or immigration of people of different social aspect/attitude towards the forest?

Johann Goldammer: The situation in Indonesia was terrible; they lost 10 million hectares of forest because, at the time when they should have recognized and when they should have taken action, they did not. So if it is really the case, as you said and as I think is mainly true, we are in a new phase of deforestation and burning of forests in Ethiopia. If we wait here, much bigger fires will come, so that the 2000 fires will be seen as relatively small. They have occurred as a warning signal for what could become major problems — forest resources are not so big in this country. The fire problem could be overcome in a relatively short time. But if we wait longer, there will be no forest left to protect.

Günther Haase thanked Dr Ensermu for putting the discussion into a wider picture. He had raised an important point, which was also touched on by Mr Lowe, the question of benefits for local communities, living in and around state forests, which are so called National Forest Priority Areas (NFPAs). It would seem that the disastrous fires that occurred in the Bale and Borena forests earlier in 2000 resulted as much from the alienation of local communities as from the inadequate land/forest management in, at least, the NFPAs. It was obviously a very crucial situation, and any discussion about policies should also include in-depth discussion on how to improve/amend the policies for active participation by the communities in the management of the country's forest resources.

Mr Haase also commented that after being in Ethiopia for the last four years, he had experienced a definite change of attitude concerning community participation in forest management. He observed much support on the part of the professionals and the decision-makers for participatory forest management, and one should not be so pessimistic. There was a pilot project underway in the Dodola-Adaba forests of Oromiya in Bale Zone, and, further more, quite recently a national working group for participatory forest management (PFM) had been established. He believed efforts were on the right track.

He also said he had heard the movement of the people being given as a problem, particularly the resettlement programme where people were moved from one region to another. The problem is that new settlers do not have any cultural attachment with the forest and this was presented as one of the reasons for starting most of the forest fires, also in Bale and Borana Zones. Migration is a natural phenomenon, resulting from the natural growth of the population in one region and the natural movement of people in search of land and livelihood. Planning should take account of these movements so that people's movement should be considered in its positive sense not otherwise. Provisions have to be made so that these settlers can live harmoniously with their new environment.

Johann Goldammer also commented on people's migration and forest fires. The Government of Indonesia initiated a transmigration program, with active support of the international community. This effectively imposed transmigration on families in local communities from the overcrowded islands of Indonesia, particularly Java, to Borneo and Sumatra that were more sparsely populated.

The people of Java were planting rice and living in a non-fire culture because Java has soils rich in volcanic ash. They had no need for shifting cultivation. But they were brought to an environment where fire was used to clear forest to do shifting cultivation. The migrants adopted shifting cultivation and this was one of the reasons why fire got out of control in Borneo/Kalimantan.

On the other hand, the indigenous people of Borneo have been living with fire for millions of years. They have been burning the forest all their lives, and they have always done this very carefully. These people are forest dwellers, moving throughout the forest and also having permanent villages. In their indigenous system, they had forest guards and knew how to use forest fires. They paid very much attention to ensure that none of the fires left the forest area to create uncontrolled wildfires.

The large masses of people from Java did not know any alternatives other than fire for converting all types of forest into agricultural land. They also started to burn the organic layers of the peat bog to make it suitable for rice plantation. All this huge clearing for rice plantation and conversion of peat bog into agricultural land produced huge smoke, which caused various health problems for the people. So the original smallholders and small shifting cultivators did not cause the big fire episode in the early 1990s. It was rather a big fire that went out of control due to the big programmes of forest conversion into various commercial land uses.

The issue then was what to do about it? The problem was brought to the attention of the government and the transmigration programme was reduced. The government recognized that it could not continue the transmigration. The other action taken was to investigate whether there were alternative ways of using the biomass instead of wastefully burning it. Whether it could be used for various products, such as charcoal energy briquettes and so on. But this is only part of the whole solution. It has finally been recognized that certain parts of the land should be excluded from the conversion process. That brings us back to the question: what are the interests and responsibilities for the central government?

And what are the interests of the local communities and their responsibility to do their share in protecting the forest. It is a very difficult process, reconciling the various interests. The government cannot just say: 'Ok, I give the whole of the existing national forest to you villagers.' 'Now you shoulder the responsibility to protect it.' The worst that would happen is that the villagers would cut down the forest immediately, thus making a good business out of it and then disappear from the area. If the intention is not carefully planned, it can develop into a very dangerous scenario and the underlying cause of all this is, of course, the population growth.

What are the alternatives for feeding the increasing population? Can this be done with the existing local resources in place? What other solutions should be sought so that the whole question becomes a national issue? It is a fact that natural resources are not equally distributed over the country and it becomes a national responsibility to take care of how they are used. May be in an overpopulated situation it cannot be solved simply by some local policies. But, really I can not give any advice in this situation. In Malaysia there is a now a new approach to family planning. If all populations grow as they did in the past, how can the existing land resources support this population growth? Where is the limit to carrying capacity? We must be very realistic about the carrying capacity for human populations. In some places it is already exhausted and that is why people are moving to the mountain forests. Land use planning and a national forest fire management strategy are only two elements of the overall national theme to cope with the future of our population growth and human security.

Ermias Bekele: What factors/enabling environments do you think have contributed to the positive effects recorded by your intervention? I am thinking of such interventions as '*living in a finite environment*' (LIFE) as well as the SADC (Southern Africa Development Community) strategy for Regional Integrated Forest Management.

Johann Goldammer: Encouraging achievements have and are being recorded by the Living in a Finite Environment Program (LIFE) of Namibia, especially when it comes to community-based natural resources management in communal areas. There are interesting experiences related to forest fire management in the LIFE encompassed communal areas. One of these is the Pilot Integrated Forest Fire Management Programme developed in northeastern Namibia, i.e., East Caprivi, between 1995 and 1998. The Directorate of Forestry of Namibia through the technical and financial assistance of the Finnish Government developed it. Since the community-based fire management model was so successful in reducing the fires by 54%, the project was expanded to include the west Caprivi and Kavarago areas, totalling some 7 million hectares. I believe one the participants from Namibia will be spending some time sharing their experiences in one of the presentations in this workshop. I also know that there is a video film taken on the same topic and I do hope he has and will show us.

It is also true that, since the early 1990s, SADC has been involved in developing a SADC wide and comprehensive forest fire management strategy. Accordingly, the Forestry Sector Technical Co-operation Unit (FSTCU) of SADC with the support of USDA (United States Department of Agriculture) Forest Services commissioned a SADC Regional Forest Fire Management System Review in 1994. Attended by the representatives of 11 of the then 12 SADC member countries and by the project team consisting of US and Canadian experts, the Situation Review Report was discussed at a Regional Workshop held in Lusaka in 1995 under the sponsorship of USDA Forest Service and CIDA. The delegates at the workshop reviewed the submission and agreed on the following four prioritized project proposals.

- Regional Wildfire Management Co-ordination
- Wildfire Personnel Training
- Wildfire Prevention and Public Education
- Operational Wildfire Research And Technology Transfer

Though these proposals, each with several modules, have in principle been accepted by each of the SADC member countries, it appears that the FSTCU is still seeking assistance for their implementation. Like most programs, its implementation has been very limited, if not almost absent, largely because of lack of funds. It is only lately that some capacity building related efforts have been initiated, particularly in Botswana and Malawi.

SURVIVAL STRATEGIES AND ECOLOGICAL PERFORMANCES OF PLANTS IN REGULARLY BURNT SAVANNAH WOODLANDS AND GRASSLANDS OF WESTERN ETHIOPIA

By Minassie Gashaw*

SUMMARY

The survival mechanisms of plants in responses to fire were investigated to see ecological performances of plants in frequently burnt plots of savannah woodlands and grassland of the Gambella area in western Ethiopia. These studies included:

Soil seed bank dynamics to determine the size and taxonomic composition of the soil seed bank. Even if the soil seed bank is one strategy to escape fire, it was found that only a few species, mainly grasses, used this pathway.

The amount of seeds in the soil and plant species composition of regularly burnt savannah woodland in western Ethiopia varied spatially and temporally. Most of the seeds in the soil seed bank came from annuals rather than perennial plants. The grass species, *Hyparrhenia confinis*, dominates the soil seed banks of frequently burnt sites, but is rare or absent in the soil seed banks of the rarely burned plots. In contrast, the species abundance and richness of the woody plants in the soil seed banks are relatively higher in unburned plots. Grass species largely survive mild fires by a high seed input to the soil, and the strong floristic similarity in composition between the soil seed bank and the standing vegetation of grasses shows that the soil seed bank has an important role in post fire regeneration and survival of fire by these grasses.

However, the soil seed bank for woody plants is low because these plants produce fewer seeds. There was little similarity in floristic composition between the soil seed bank and the standing vegetation. Therefore, soil seed banks of woody plants have less significance as a strategy to survive fire. The woody plants survive the fire by with seeds at deeper soil layers, and from resprouting.

The soil seed bank for graminoids is highest during the early dry period and lowest at the beginning of the wet season, whereas, for woody plants it is highest in the late dry season and lowest at the beginning of the dry season. For graminoids, seed dispersal and the input of seeds into the soil occurs ahead of the onset of the regular fire

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season. For woody species and herbs, some seeds may be killed by early fire prior to seed dispersal and incorporation into the soil. Late fires are detrimental to seeds of all – graminoids, herbs and woody plants – and could affect the present grass dominance or the vegetation composition in general. However, the current fire regime of the study sites i.e. high frequency and relatively low intensity seems to maintain the dominance of graminoids, particularly, *Hyparrhenia confinis* both as seeds in the soil and in herbaceous stratum of the vegetation as a whole.

Exposure of seeds to different levels of heat treatment was done to see the influence of heat (fire) on the germination of different plant species. Germination performance of 15 species were compared and discussed. Frequent and light burning of the savannah in the Gambella area seems to stimulate and enhance germination of most of the studied plant species.

The role of tree bark thickness to survival of tree species in fire-prone ecosystems was studied. Results indicate that tree bark resistance to fire varied among species and was related to bark thickness and age of the plant.

The responses to the different levels and duration of heat were species specific. Five of 15 germinating species showed higher germination following treatments at 60°C or 90°C than at 20°C, and hence, benefited from heating. However, a combination of high temperature and prolonged exposure significantly reduced seed viability in most plant species. Five of the 15 species showed two optima for germination, with peaks following both low and high temperature treatments. This mechanism ensures that at least some seeds germinate in the absence of fire, but also those viable seeds remain after late fires, which could have killed emerging seedlings. Four of 15 species resisted temperatures of 200°C, and those can be considered as highly pyrophytic. Among species, high seed sizes and seed weights were correlated with high tolerance to heating. However, seed resistance to high temperature alone may not assure the species survival in the fire environment.

Species with vegetative reproduction or with spatial and temporal fire escaping specializations may add to the species richness and the plant biomass in fire-prone ecosystems. Examples in western Ethiopian savannah are the dominant grass *Hyparrhenia confinis* and the dominant tree *Combretum collinum*, which rely on a large soil seed bank and resprouting, and cryptogeal germination and resprouting survival strategies, respectively. The present fire regime, i.e. frequent burning with relatively low intensity, seems to be within the seed heat resistance range of most of the species. However, if fires become less frequent and therefore more intense due to high fuel loads, a higher proportion of seeds may be killed in the less tolerant species, which will affect the plant species composition.

Generally, three reproductive strategies are important and coexist in forming the existing vegetation mosaic, which is determined by the various interacting factors of fire regime, means of survival, rate of recovery after fire disturbances and by the life-history or growth forms of plants. There were clear differences among the different plant growth forms in the strategy for regeneration after fire. Obligate seeding strategy was widely used by the short-lived broadleaved herbs, which relied on the short rains to recruit seedlings from the soil seed bank after fires. Trees/shrubs were largely obligate sprouters and were commonly sprouting immediately following fire in the dry season. Thick bark or cork layers further reinforced the survival of trees, once they reached adult size or when their reproductive tissues escaped the fire belt, whereas the thin barked trees might be susceptible to fire damage. The highest biomass production in the savannah woodlands and grasslands of the Gambella area was made up of a dominant grass species, *Hyparrhenia confinis*, which reproduced both by seeds and by resprouting.

Despite the fact that fire stimulates seed germination through direct heat and by removing litter or other inhibitors, the short fire cycle might impede seedling establishment, and hence low seedling density was recorded in all of our study sites. However, reduced fire frequency might constitute a high selection pressure for obligate-seeding strategy.

Regeneration mechanisms of vegetation were studied along transect lines by quantifying foliar cover and frequency of individual plant species regenerating either by resprouting or seedlings or both, during both the dry season and at the beginning of the wet season. Resprouting plants (both facultative and obligate sprouters) contributed significantly to post-fire recovery making up 98.5% of the total vegetation cover. The contribution of seedlings to cover and abundance immediately following fire was negligible but seedling density increased in the beginning of rainy season, 4 to 5 months after fire.

Effects of nutrient status and fire on floristic composition were studied through three treatments: fire, biomass additions (before burning) and ash fertilization (after burning) on plant cover, leaf nutrient (N, P, K) and condensed tannin concentrations were examined prior to the experimental burning and after 90 and 210 days. There was a main effect of fire on the cover of grasses and tree seedlings, whereas no main effect of fire and other treatments was found on the cover of broad-leaved plants and shrubs/trees. There was also a tendency towards a main effect of fire on the plant species diversity of the experimental plots after 90 days. Generally the concentrations of N, P, and K and leaf condensed tannins were higher in broad-leaved plants than in grasses. The changes observed in vegetation composition and herbage quality with fire, biomass and ash treatments were small compared to the changes observed between seasons. This indicates that the influence of fire is secondary in determining the vegetation pattern. Therefore, the relatively low intensity and annual burning in the Gambella area seems to maintain the present balance among the various plant forms.

The levels of leaf condensed tannin and the relative amount of tannin to nitrogen of 11 plant species were compared between seasons and between vegetation types exposed to different levels of fire severity. Mean condensed tannin concentrations varied between seasons, plant species and different plant growth forms, but seasonal variations and concentrations in single plant species were, in most cases, independent of vegetation type. Seasonal changes in tannin concentrations were much larger than differences caused by soil nutrient availability among vegetation types. Seasonal differences in condensed tannins are probably due to leaf phenology, i.e. with high concentrations in new leaves normally emerging right after the fire, and decreasing concentrations during leaf expansion. Total condensed tannins for individual species ranged from 2 to 400 mg catechin per gramme of leaf by dry weight. Trees generally contained higher amounts of condensed tannins and showed higher rates of tannins to nitrogen than grasses, with shrubs with intermediate concentrations. Facultative browsers may avoid tree foliage during the dry season when concentrations are high whereas concentrations in the different plant life forms are more similar in the rainy season. Fire disturbance results in nutrient mobilization and evolution of re-sprouting traits which enable rapid re-growth and hence, probably reduced selection pressure for the production of carbon-based defence chemicals by rapidly growing species.

There is a distinct relationship between fire, vegetation dynamics and leaf chemistry of plants. A strong promoting effect of fire on plant cover was observed for the grasses. This suggests that fire is maintaining ecosystem stability by promoting the dominant species (grasses) and by suppressing the less frequent, such as woody species. Fire is also playing a major role in controlling the level of plant nutrients and, in the grasses, the production of carbon-based defences against herbivory. For the less abundant broadleaved herbs the tendency towards a high production of condensed tannins might be a strategy or evolutionary response for survival in an ecosystem with severe competition.

Generally, the changes observed in vegetation composition and herbage quality with fire were small compared to the changes observed between seasons. This indicates that the influence of the current fire regime is secondary in determining the vegetation pattern. Therefore, fire seems to maintain the present balance between the various plant forms under the current fire regimes in the Gambella area i.e. with relatively low intensity and annual burning

Discussion

Ensermu Kelbessa: Is there a correlation between seed tolerance to heat and tree bark thickness? For example, does a thick barked tree like *Terminalia* have seeds that are also tolerant to high temperature?

Minassie Gashaw: Our expectation was that those species which do not have soil seed banks would have highly resistant bark or a hard seed coat to resist fire. Some species that were not found in the soil seed bank were found to escape fire by having a highly resistant seed coat. Other species use both strategies, i.e. having some seeds in the soil as well as producing seeds with hard coats, or even also having highly resistant thick bark. However, in most cases we found that the strategies compensated for one another.

Harri Sepannen: Could you give us some idea about the fuel loads involved and possibly also the fire intensities needed?

Minassie Gashaw: The sites were selected based on differences in the vegetation types, particularly in grass biomass. We found that the fuel load of an area that experienced fire every year was not uniformly distributed nor was it heavily loaded because of the frequent annual burning.

Ensermu Kelbessa: Is there a possibility of loosing a species or a proportion of a species permanently after a fire episode?

Minassie Gashaw: We measured the carbon 13 to carbon 14 ratio which showed that there has been vegetation change from dense forest to open wooded grassland. If this trend continues we might loose some plant species. The frequent fire favours the graminoides at the expense of woody plants and broadleaved herbaceous plants. We might have already lost some woody or herbaceous plant species. Carbon dating might tell us at what time a given site was densely forested and then turned to a wooded grassland area.

TOPICS FOR THE WORKING GROUP DISCUSSIONS

The Round Table broke into three working groups to discuss the topics listed below. During their deliberations the group members were asked to consider the points raised in the presentations and evaluate proposals made vis-à-vis the Ethiopian context.

Group 1: *Fire Ecology and Fire Impact*

The group will discuss the following topics:

- Fire ecology and major vegetation types, i.e. ecological rate of fire in Ethiopian ecosystems;
- Fire-sensitivity and fire-adaptiveness of different vegetation types and ecosystems of Ethiopia, and proposals for fire management restrictions;.
- Causes of forest fires by vegetation type;
- Advantages and disadvantages of fires: ecological and socio-economic impacts;
- Controlled burning:
  (i) assessment of vegetation for controlled burning,
  (ii) fire régime for different objectives for controlled burning
  (Note: this is also considered an integral part of the work of Group 3.);
- Implications of fires at national and global levels;
- Fire-related policy issues, rules and regulations at national and global levels.

Group 2: *Identification of Key Stakeholders and Supporters*

The group will identify important stakeholders from all areas of society, i.e. communities, governmental organisations and NGOs. The strengths, weaknesses and potentials of these stakeholders with regard to integrated forest fire management will be analysed and areas for capacity building identified. Finally, recommendations will be elaborated regarding the future roles and mandates of the respective stakeholders within an integrated fire management programme.

Group 3: *Integrated Forest Fire Management Programme for Ethiopia: Proposal of Approaches and Components*

Based on the experiences of previous fire incidents a gap analysis will be performed and the required elements / components for a system of integrated fire management will be identified. Special emphasis will be given to the following topics:

- Identification of essential fire fighting materials and equipment;
- Elements of a national fire information system;
- Need for revision of policies and legislation;
- Organisational structure for fire fighting and fire prevention (at federal, regional, zonal, woreda and community levels), in particular regarding the delineation of roles between the Federal Ministry of Agriculture and the Regional Bureaux of Agriculture, including proposals for fire incident command systems and related reporting systems;
- Fire prevention (awareness creation / extension, sylvicultural measures, etc.);
- Human resources development;
- Controlled burning (Note: this component will also be elaborated by Group 1)

The recommendations should consider available resources and opportunities (skilled manpower, available material and financial resources, policy and legal framework, etc.). Potential sources of financial resources (national and international) should be identified.

OUTPUTS FROM

WORKING GROUP DISCUSSIONS

GROUP 1: OUTPUT FROM FIRE ECOLOGY AND FIRE IMPACT

1. Categorization of Vegetation Types (based on Demel, 2000, and the paper in this proceedings)

Vegetation Type	Population density	Reasons/Causes of fire	Frequency	Sensitivity*
1a. Afroalpine	Low	Wild fires	Rare	Extremely sensitive (ES)
1b. Sub-Afro- Alpine	Low	Access, grazing, hunting, driving wild animals out	Annual / mosaic + 1-5 years (IF)	Non sensitive (NS) – adapted to fire
2a. Dry evergreen montane forest	Very High	Clearing for agriculture, wild honey extraction	Annual-Irregular (I), burnt annually for slash & burn.	N/A – forest destroyed S
2b. Montane grasslands	Moderately High	Agriculture, tick control	No fires	ES
3a. Montane evergreen thickets	Moderate	Grazing, agriculture, hunting, charcoal, honey, ticks	Annual (IF)	S
3b. Montane evergreen scrub	Moderate	-	Annual (F)	Low sensitivity (LS)
4. *Acacia-Commiphora,* small-leaved deciduous woodlands	Moderate	Agriculture/grazing, charcoal, ticks, honey, control of bush, hunting	Annual-5 year cycle	LS
5. Moist evergreen forest	High	Agriculture, wild honey	IF, >5 years	ES
6. Lowland semi-evergreen forest	Low-Moderate	Honey, hunting, access to fuel	Annual	LS
7. *Combretum-Terminalia*, broad-leaved deciduous woodlands	Low	Agriculture/grazing, ticks, honey, hunting, charcoal	Annual	LS - adapted to fire
8. Desert & semi-desert scrub lands	Low	Wild fires	IF/rare	S
9. Riparian & swamp vegetation	High	Accidental, agriculture on periphery	Rare	?

* refers to potential of vegetation to recover

Key: F = frequent, A = annual; IF = Infrequent, 2–5 years; I = Irregular, 5–20 years; ES = extremely sensitive; S = Sensitive; LS = Low sensitivity; NS = non sensitive; N/A= not applicable.

A Fire Risk Map should include vegetation sensitivity/vulnerability aspects

NB: Conflict/wars are also a cause of fire.

The table presented above already includes some amendments based on comments received during the plenary discussion

2. Ecological and Socio-Economic Advantages of Controlled Burning for each Vegetation Type

Vegetation Type	Advantages	Disadvantages
1a. Afroalpine	None	Destroys biodiversity
1b. Sub -Afroalpine	Controlled fire helps regeneration - promotes plant biodiversity	Excessive fire frequency destroys biodiversity, aggravates soil erosion
2 Dry evergreen montane forest	None	Excessive fire destroys forest, reduces biodiversity
3a. Montane evergreen thickets	Controlled fire improves forage quality	Excessive fire reduces biodiversity
3b. Montane evergreen scrub	None	Excessive fire reduces biodiversity
4. *Acacia-Commiphora*, small-leaved deciduous woodlands	Maintains forage quality, improves ground cover, weed, bush & tick control	Excessive fire reduces biodiversity
5. Moist evergreen forest	None	Excessive fire results in loss of biodiversity, soil erosion
6. Lowland semi-evergreen forest	Encourages germination of fire-dependant spp., promotes biodiversity	Excessive fire results in loss of biodiversity
7. *Combretum-Terminalia*, broad-leaved deciduous woodlands	Maintains balance between grass & shrubs, promotes forage production and enhances germination of pyrophytic species	Excessive fire results in loss of biodiversity
8. Desert & semi-desert scrublands	None	Excessive fire destroys sensitive communities and reduces biodiversity
9. Riparian & swamp vegetation	None	Excessive fire destroys ecosystem, affects water production & quality

3. Controlled Burning

The primary reasons for controlled burning in the management of natural vegetation for livestock farming and wildlife management are:

1. For the removal of moribund, unpalatable herbaceous material for livestock & wildlife; and
2. To control encroachment of undesirable plant species as determined by the system of land use, e.g. *Dodonea angustifolia* in evergreen scrub vegetation.

The secondary benefits which results from the above are:

1. Control of livestock pests e.g. ticks & tsetse fly, though there is no scientific evidence for tick reduction (burning is for many reasons and tick reduction is a secondary benefit); and to
2. Improve range condition, indeed burning encourages particular forage species.

The acceptability of using fire in shifting cultivation as a means of promoting nutrient cycling needs to be evaluated. The use of fire for converting natural vegetation into cropland is ecologically acceptable provided that it results in a sustainable form of land use. Generally, however, burning for shifting cultivation is not an acceptable practice in the present Ethiopian conditions and needs to be discouraged.

3.1 Criteria for Controlled Burning

Recommendation – Well defined criteria that satisfy the various agro-ecological conditions of the country must be developed prior to prescribing any sort of controlled burning activities in the country.

3.2 Fire Regimes

Recommendation – A fire regime (including the type and intensity of fire, the season, and the frequency of burning), must be developed through research as well as tapping and testing the conventional wisdom that already exists in the country.

4. Implications of Fires at National and Global Levels

At national level the disadvantages are:

- Loss of biodiversity
- Environmental pollution of water and air
- Promotion of degradation of land, particularly soil erosion
- Loss of forage

- Cost implications due to loss of certain infrastructure e.g. telecommunications
- Loss of timber and forest products
- Loss of cultural resources

The advantages at national level are:

- Improves socio-economic status of pastoralists
- Improves biodiversity if controlled fires are allowed as the pyrophytic (fire-loving) plants benefit.

The implications at the global level are:

- The global climate is affected if fires result in biomass reduction e.g. conversion of forest to grassland
- Can have a positive or negative impact on biodiversity e.g. retention or loss of endemic plant and animal species

5. Fire-Related Policy and Other Issues, Rules & Regulations

The group strongly supports the formulation of an *Integrated Forest Fire Management Programme for Ethiopia*. The most vulnerable vegetation types can be seen from the first table.

Vegetation Type	Moisture	Land Use	Fire Ecology
1a. Afroalpine	arid	National Parks	fires rare
1b. Sub -Afroalpine	moist	National Parks	annual burn, fire sensitive
2 Dry evergreen montane forest	moist	National Parks, rangeland, agriculture	fire prone/sensitive, high priority area
3a. Montane evergreen thickets	moist	rangeland	fire prone
3b. Montane evergreen scrub	moist	rangeland	fire prone
4. *Acacia-Commiphora*, small-leaved deciduous woodlands	semi-arid	agriculture, rangeland	fire prone
5. Moist evergreen forest	moist	Protected National Forests, timber, plantation crops	should be no fire
6. Lowland semi-evergreen forest	moist	National Parks, plantation crops, rangeland	annual firest in grassland areas
7. *Combretum-Terminalia*, broad-leaved deciduous woodlands	semi-arid	rangeland, wildlife	fire prone
8. Desert & semi-desert scrublands	arid	rangelands, gums and resins, wildlife	no fire
9. Riparian & swamp vegetation	moist	rangelands, protected wetlands for biodiversity	buffer zone, no fire

DISCUSSION ON THE OUTPUTS OF GROUP 1

Harri Seppannen: Our experience from Namibia is to try to use traditional local techniques for fire prevention as far as possible, whereas you recommend using heavy machinery to make fire breaks. Would you consider trying that principle since it encourages the use of inexpensive local techniques?

Chairperson: that should be taken as a suggestion for future planning.

Günther Haase: Regarding the causes of fire in the *Combretum-Terminalia* woodlands, the group presented two causes of fires: one is to convert bushland into agricultural land and the other is to promote grazing. According to my experiences in North and South Omo Zones, causes of fire in the *Combretum-Terminalia* woodlands and the *Acacia-Commiphora* woodlands are identical. They also include honey gathering and hunting.

Ensermu Kelbessa: The Afroalpine zone has been divided for practical reasons. All the high mountains above 4000 m in Ethiopia are accessible to the top and vehicles can be driven to the top of the Bale Mountains. As a result, the Afroalpine zone is populated by people and domestic livestock, which causes over-grazing and soil compaction, but fire is not actually a problem in this vegetation. The sub-afroalpine zone is dominated by *Erica arborea* and *Erica trimera*. This is a fire resistant vegetation with the germination of its seeds being promoted by fire. Fire is frequent in the Bale Mountains. The most fire-adapted vegetation, however, are the woodlands: *Combretum-Terminalia* in the western lowlands and river valleys, and *Acacia-Commiphora* in the Rift Valley and in areas bordering Kenya, Somalia and Eritrea. Fire also aggravates erosion, because of the nature of the mountains. They are steep and because of the excessive destruction of natural vegetation cover, especially litter, there is an excessive exposure of the soil to rain and wind erosion. These combined effects are particularly prevalent on southern aspects.

It is interesting to note the altitudinal variations in the Afroalpine zone, which generally occurs between 3250–3800 m. In the north, the mountains reach up to 4620 m, while in the southeast they rise up to 4370 m. In the Bale Mountains, the tree line is at 3250m while on Menagesha it is found at 3000 m. Because of this, a range is given to the latitudinal variation on the mountains. Thus, evergreen woodlands or forests can be found as high as 3350 m or well above 3000 m, depending on the latitude and aspect of the mountain.

Azene Bekele: In the *Combretum-Terminalia* woodland area we should also include charcoal making as *Terminalia* makes good quality charcoal and this sometimes causes fires. My second comment is on your suggestion to remove undesirable plants in your strategy to control burning. In Ethiopia, species are very heterogeneous and, as no reliable studies have been done, I do not think we should talk in terms of desirable/undesirable species — what we think undesirable today might turn out to be desirable in future.

Ensermu Kelbessa: Farmers call some species undesirable. For example, in the highlands above 2000 m, there is a shrubland dominated by *Dodonaea angustifolia*, which people use only for fuel wood. This is burnt because the people prefer grass. Another example is from the lowlands of Borenna where people set fire to undesirable bush to encourage grass growth.

Concerning the causes of fire in *Acacia-Commiphora* woodland, shifting cultivation, previously known only from the wet forests of southwest Ethiopia, has now spread to the drier parts of the country like Borenna. This has happened over the last 20 years with the government trying to settle nomadic people and forcing them to cultivate. They clear some woodland, cultivate it for two years and then shift to another plot to do the same, as burning was not allowed. I asked them why they burnt, and they said that it was to control the bush on their grassland. As a result, in my view, this shifting cultivation is destroying the biodiversity of the area.

Yonas Yemeshaw: You made the point that shifting cultivation can legitimately be practised in this country. I remember reading that under a certain level of population, shifting cultivation can be part of a sustainable resource management system. But there has not been any study in this country to determine the threshold as per population per unit area where such a resource management system could legitimately be practised. As a forester I am horrified at the idea of shifting cultivation knowing that we are left with only 2.7% forest cover and a huge population. Probably my colleagues will agree with me that shifting cultivation is not for Ethiopia.

It is important that natural resources be managed at all levels of society at a sustainable level, with or without fire.

Gedion Asfaw: We have only a short time to put things right, so I think we have to be practical. I know for sure that we should start from the stem to the branches – work from the top downwards. I believe we need a separate policy for forest fires because it is a hot issue which concerns all levels, even the decision-makers.

Harri Seppanen: I do not know whether my question is premature, but we have been talking about a Draft Forest Policy, which may still be a confidential document, but I would like to know what are the basic principles. What is fundamental here is who is responsible for the forests. Is it the government; or is it the community? Or is there some kind of joint agreement, which should come in the first paragraph of the policy. Is there a way of including this point, because that would affect the management of forest fires. That is the most fundamental issue in any forest policy.

Peter Lowe: We have been talking very widely about what a forest is, what forest is left, what bushland is left and even about trees outside the forest. Classification is needed on whether the forest policy mandates the forestry role of the MoA to tackle all these separate areas and issues, or, in fact, only the title of this round table in its strict sense, meaning the management of forest fires. There is a danger of being very ambitious, putting every kind of fire in the country under forest fire.

GROUP 2: OUTPUT FROM STAKEHOLDER ANALYSIS

In order to accomplish the set task, the group undertook the following working steps:

1. Identification/Brainstorming of Key Stakeholders
2. Final Selection of Key Stakeholders
3. Assessment of strengths, opportunities, weaknesses and threats of the identified stakeholders
4. Identification of required action to strengthen key stakeholders and a proposal for the role or mandate for a given stakeholder within the framework of a future Programme on Integrated Forest Fire Management for Ethiopia.

The output of this working process is documented in Table 1. It should be noted that due to time constraints the analysis could not be completed. It should rather be viewed as a starting point for a more detailed analysis. The order of stakeholders should not be understood as an order of priority or importance.

During a more detailed analysis, special emphasis should be given to a differentiation of communities, which are seen by the group members as the most important stakeholder for integrated fire management. There was consensus amongst the group members that fire prevention and protection without the support of communities would be doomed to fail. The following variables and criteria were identified as being crucial for community differentiation: (i) ethnicity, (ii) religion, (iii) time of settlement, (iv) land holding and (v) livelihood system. The listed variables are known or expected to have a distinct impact on the relationship of farming communities to forest resources.

While the primary stakeholders are listed in Table 1, the group also compiled a list of secondary stakeholders. These are depicted in Table 2, organised in three groups according to the type of major role that they are anticipated to play for integrated fire management.

It was agreed to analyse NGO's and their potential in general terms, since all NGOs that are working in rural areas adjacent to high forest areas could be important collaborators in the effort for fire prevention and management. However, for the sake of completeness, the following NGOs were mentioned by name during group discussions due to their special commitment to sustainable forest and natural resources management: FARM Africa, Care Ethiopia, Ethiopian Wildlife and Natural History Society, Lem-Ethiopia, Red Cross Society for Ethiopia, IUCN, Worldwide Fund for Nature, and SOS Sahel.

While the analysis focussed on national stakeholders, it was understood by the group and the plenary that international stakeholders will have to play a crucial role in the development and implementation of an integrated forest fire management programme in Ethiopia

Table 1: Key Stakeholders for Integrated Forest Fire Management (IFFM) in Ethiopia

Stakeholder	Strengths / Opportunities	Weaknesses / Threats	Required Action	Role / mandate within IFFM
Ministry of Agriculture (MoA)	Organizational structure in place Manpower available	Low hierarchical level (of forestry team) Inadequate material and financial resources Poor linkage between federal MoA and regional BoA	More emphasis for forestry (in terms of resource allocation and organizational profile) Capacity building for fire management (training and equipment for fire monitoring and control)	Incident command for forest fires of national significance Formulation of forest policy/forest fire policy, legislation and forest fire prevention programme / strategy Forest fire monitoring and establishment of a national forest fire information system Preparation of forest fire prevention and control extension guidelines / manuals Preparation of press releases for wide dissemination through Min. of Information (more frequent than at present)
Bureau of Agriculture (regional BoA, zonal ZADD, woreda WADO)	Organizational structure in place Manpower available	As above: insufficient tools, logistics and finance Poor forest organization (low hierarchical level, in part no forest offices / officers at NFPA level)	Training of fire protection specialists Provision of appropriate fire fighting equipment Strengthen forest organization at all levels	Coordination of forest fire preventative measures/activities Coordination of forest fire prevention / suppression measures for forest fires of limited significance Training and Capacity Building for subsequent levels of BoA and community members
Administrations at different levels (Regional to	Authority/Mandate Structure, authority and manpower for law	Inadequate commitment to forest protection	Awareness creation for administration officers	Mobilization of resources/manpower Law enforcement

Stakeholder	Strengths / Opportunities	Weaknesses / Threats	Required Action	Role / mandate within IFFM
Ministry of Education (MoE)	Human resources for awareness creation Institutional network	Absence of forest fire topics in school curricula	Revise school curricula and integrate forest fire topics / issues	Awareness creation / dissemination of information on forest fire prevention and control
Ministry of Information (MoI)	Numerically strong in human resources Material resources for information dissemination (own media network)	Inaccurate reporting Poor professional standards of / for journalists	Improve coverage of forest news	Information dissemination on forest fire prevention control
Ministry of Defence (MoD)	Disciplined staff, easy / efficient to mobilize	Insufficient forest fire fighting skills Difficulty of integrating the military command into the fire incident command system	Training and exposure of staff assigned for fire fighting activities Prepare memorandum of understanding for integrating Defence Forces into the ICS	Participate in air-borne and ground forest fire suppression operations Training of communities in fire fighting techniques
Environmental Protection Authority (EPA)	Mandate to monitor compliance of investments with Environmental Policy	Limited outreach to the regions	Incorporate forest fire prevention / protection issues into EIA guidelines	Strengthen knowledge base on forest fire management
Ethiopian/Rural Road Authority (ERRA)	Heavy machinery for earthworks (graders, dozers, trucks, etc)	not analysed	Prepare Memorandum of Understanding, detailing the duties of ERRA in case of fire incidents	Provide heavy equipment for clearing fire breaks for preventive purposes
Ministry of Works and Urban Development (MoWUD)	Heavy machinery for earthworks (graders, dozers, trucks, etc)	not analysed	Prepare Memorandum of Understanding	Provide heavy equipment for clearing fire breaks for preventive purposes

Stakeholder	Strengths / Opportunities	Weaknesses / Threats	Required Action	Role / mandate within IFFM
Institute of Biodiversity Conservation and Research (IBCR)	Mandate for establishment and management of *in situ* conservation sites	Limited manpower at field level	Introduce fire prevention measures in the surroundings of *in situ* sites	Secure forest fire prevention / suppression in *in situ* conservation sites
National Meteorological Services Authority (NMSA)	Receiving station for NOAA satellite data (useful for forest fire monitoring) Knowhow on weather forecasting	Lack of specific skills and software for forest fire information management	Building capacities (training and equipment)	Satellite-based forest fire reconnaissance Preparation of fire weather forecasts / fire danger rating
Ethiopian Agricultural Research Organisaiton (EARO)	Availability of researchers	Shortage of resources	Conduct problem-oriented forest fire research	Research on forest fire issues Development of controlled burning guidelines for different vegetation types and burning objectives Assist in technology transfer and adoption by means of training
Ethiopian Wildlife Conservation Organization (EWCO)	Mandate for management of protected areas	Limited know-how on fire management Limited in staffing at field level	Basic training in fire management	Secure forest fire prevention/control measures in protected wildlife areas
Ethiopian Science and Technology Commission (ESTC)	Own Radio Programme Can assist with / facilitate the mobilization of research grants	not analysed	not determined	Contribute to awareness creation on forest fire prevention and control technologies Assist in securing funds for relevant forest fire research Assist in technology transfer and adoption

Stakeholder	Strengths / Opportunities	Weaknesses / Threats	Required Action	Role / mandate within IFFM
Disaster Prevention and Preparedness Commission (and regional organizational levels)	Mandate to coordinate activities of NGOs Capability to organize distribution of food aid in remote areas	Human disasters are accorded priority Limited resource mobilization for fire fighting	Awareness creation on long-term impacts of wildfires	Co-ordination of NGO's for fund raising Facilitate provision of material and food aid as incentives for forest fire fighting and prevention measures
NGOs and their umbrella organizations (Christian Relief Development Agency - CRDA)	Access to resources Access to communities High level of commitment	Inadequate forest fire management skills and level of coordination	not determined	Provision of inputs Facilitation of training / capacity building Awareness creation Community mobilisation
Cultural / traditional organizations (community or relative-based)	Strong influence / authority / legitimization amongst communities	Inadequate awareness and skills	Involve them as alternative institutions	Awareness creation Community mobilisation
Religious Institutions	Strong influence and authority	Inadequate awareness and skills	Involve them as alternative institutions	Awareness creation Community mobilisation
Communities	Traditional knowledge on (forest) fire management Manpower Detailed know-how of forest areas	Inadequate fire fighting skills Little at stake with NFPAs (state forests) Insufficient awareness on impacts of wildfires	Introduce Participatory Forest Mgt. to increase ownership for forest resources Training in fire fighting techniques Awareness creation	Should become custodians of forest resources through introduction of PFM Backbone for ground-based fire fighting activities

Table 2: Secondary Stakeholders in Integrated Forest Fire Management in Ethiopia

1. Awareness Creation / Information Dissemination	2. Information Providers*	3. Input Providers
Women's Associations Nature-clubs in schools Tourist Guide Associations Ministry of Trade and Industry (MoTI) Professional Associations Youth Associations	Ethiopian Mapping Authority (EMA) Ethiopian Statistics Authority Population Affairs Office	Ministry of Health Forest Industries Rehabilitation and Development Associations Ministry of Water Construction Service Cooperatives Private Companies Rural Technology Promotion Centers Addis Ababa Fire Brigade

DISCUSSION ON THE OUTPUT OF GROUP 2

Harri Seppennen: Whose responsibility is it to develop forest fire policy?

Million Bekele: The responsibility to develop policy related to forestry and agriculture in general lies with the Ministry of Agriculture.

In a country like ours, where we don't have a Forest policy or even a Land Use Policy, how can we really think of formulating forest fire policy and legislation in isolation from the other draft forest policy? Why don't we consider these two as one component?

My other point concerns the Environmental Protection Authority (EPA), I don't know how you can justify giving a lower credit to EPA as far as forest fires are concerned?

Günther Haase: The first question is clearly answered in the existing forest proclamation where it is clearly stated that it is the mandate of the MoA to formulate agricultural policies including a forest policy. I think forest fire policy would be one part of it. Whether it should be a separate policy or the existing draft should be supplemented by some paragraphs on forest fires is a separate issue. But it is generally agreed that it is within the mandate of the MoA.

Concerning your second point on EPA, perhaps my fellow group members can elaborate? We see the role of EPA mainly as monitoring or supervising whether ministries comply with the standards set by EPA. But the actual implementation is clearly the responsibility of the line ministries; and only if their activities are not complying with the Environmental Policy, the EPA should take action. That is how we understood the EPA's role. Therefore, we stressed that the main stakeholder is the MoA and, of course, the BoAs. However, both are under the overall monitoring of EPA.

Harri Seppannen: I would like to express my view regarding this formulation of forest fire policy. I was involved in forest policy development both in Namibia and Tanzania, and we felt in both cases that fire incidence in the forest should be included under forest policy. But, if it is necessary to make a separate kind of fire management policy, not only for the forest areas but also for agricultural or urban areas, that could also be done. But that should be treated as a separate kind of a policy development. In my view, forest fires as such can be incorporated in the overall Forest Policy. To be more precise, I think that the formulation of the strategy and objectives of the sector should immediately follow the policy development process, including the specific tasks and guidelines that would facilitate the implementation and follow up. Then action can be taken if they are not met. So I consider that policy development is an intermediate process which needs to be followed by the strategy and objectives of the sector in order to implement the work.

Johann Goldammer: In group 3, we also discussed this issue. We also agreed that it would be important first to develop Fire Management Guidelines as a base document, which would then lay the basis for the development of Fire Policy at a national level, which again should be a part of the Forest Policy. As we understand it, the situation at the moment on Forest Policy is still under discussion. So one can have two options at this stage. Firstly, the National Fire Committee could facilitate the drafting of the Forest Policy, so that it could be influenced by the ideas coming out of this National Fire Committee. The second option would be to wait until the Forest Policy is issued and then formulate the Forest Fire Policy.

However, I think the most important thing is that, as a consequence of this activity, the follow up steps will be taken first by all the stakeholders, as recommended by Group 2. This should be organized under a National Fire Committee where all of the stakeholders can bring their views on how the country should deal with forest fires. Nevertheless, this has to be followed by a strategic action plan, which I think should be developed simultaneously. I am not familiar with how it should run for this country, but concerning South Africa there is a regulation called the 'Forest Fire Act'. This is a law which governs the responsibilities in wildfire management. It does not really reflect any particular policy. Also, the Act in South Africa does not include the incidence command system as debated by Group 2. It only became clear after the severe fires in the South African Cape Region that there was no functional Fire Incidence Command System (IFCS) in place. What we need to learn from this is that we need to establish an Incidence Command System, at least at the Federal and Regional levels, and not less than that.

Harri Seppannen: I don't know why prescribed burning is omitted from this discussion? People from different communities in different vegetation types use fire very widely. We have also discussed these issues in Group I, and recognized that fire prevention and control were very important. We have to make sure that prescribed burning is equally important because people are going to carry on using fire activities, whether we like it or not. I think it is important to know why people use fire in specific ecosytems for specific purposes, knowing that fire could have advantages if applied sensibly.

Minassie Gashaw: Have you also included international stakeholders or supporters in the list of main stakeholders?

Günther Haase: We discussed this at the beginning and agreed to concentrate our attention on the national stakeholders, be they private or government. However, we fully ackknowledge the crucial role of international stakeholders in implementing a system of integrated forest fire management for Ethiopia.

Group 3: Output from an Integrated Forest Fire Management Programme For Ethiopia

Summary of current situation

The group first reviewed the current responsibilities and legal framework of fire management in Ethiopia.

Legal frameworks

- 1991: Decentralization declaration: all resources actually belong to the Regions
- 1994: Proclamation to conserve, develop and manage forest resources of the country. Under the proclamation, communities are expected to report fires to responsible bodies. Therefore, in a way all citizens are responsible for fighting fires. Other specific arrangements for fire controls do not exist.
- There is one general federal law indicated in Forest Proclamation No. 94/1994 that gives responsibilities to the Regions regarding their own protection of forests from damage, including insects, diseases, fire, etc.

- There is a draft Forest Policy currently being reviewed by the Ministry of Agriculture (first draft from 1998). This policy document would apparently not include fire issues

Responsibilities

In general, responsibilities for fire are covered within the forest protection responsibilities (including insects, disease, etc.), but there are no specific or separate responsibilities for fire issues, nor special arrangement as such.

At 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. However, the federal responsibilities do not include the supervision of the Regions' actions, but rather to develop policies which will give the framework under which Regions can develop their own regional policies based on the policy framework issued from the Federal government. Consequently, policies can vary among the Regions. The Federal Forestry and Wildlife Management and Regulatory Team of the Natural Resources Management and Regulatory Department of the Ministry of Agriculture can give technical assistance upon request

At the Regional level, it is the Regional Bureaus of Agriculture and Environmental Protection that are responsible for forest protection, and therefore, fire issues. However, there are no special arrangements for fire management, but it is at the regional level that actual operations for forest protection are undertaken. The Regions manage their own budgets, but there is also a Federal fund for emergencies.

There is currently an initiative at regional level for the drafting of acts that will include fire management issues. Currently, the Oromiya Region is in the process of restructuring. The establishment of an Environmental Protection and Natural Resources Management Authority is being proposed.

Fire issues may also be relevant in other areas of policy, particularly environmental protection and land use. Most Regions have developed their own conservation and environment strategies, but little has, as yet, been implemented and fire issues have generally not specifically been included.

In summary: there exists no real programme for forest management at either Regional or Federal levels. There is no power to force Regions to do more about fire management. Therefore, the suggestion is to focus on fire management at the Regional level, except for emergency situations when the Federal authority can take overall control.

Gap Analysis

The group then identified existing key gaps in the management of forest fires in Ethiopia.

- There is no policy specific for fire management in Ethiopia.
- There is no proper institutional structure to deal with fire issues (including a lack of clear authority in fire matters).
- There is poor linkage and communication between the Federal MoA and Regional Bureaus.
- There is a lack of capacity in terms of trained human resources at all levels.
- There is a very poor information system (if any).
- There is very poor community awareness on the benefits of fire management.

The Group felt that there could be many more gaps identified at various levels and in more detail (Group 2 did identify more), especially considering the fact that there is nothing in place for fire management as yet. The Group, therefore, concentrated on mechanisms for solutions.

Solutions and Suggestions

Since there is no fire management programme as yet, a complete definition of such a programme would not be in the scope of this Group's discussions. The group, therefore, focussed on mechanisms to be implemented for the development of such a programme.

Policy

Policies are important. It was recommended that the fire issues be included in relevant policies. However, there was no consensus as to whether there should be a completely separate policy for fire management or whether fire issues should be integrated into the existing policies. The most obvious one would be the Forest Policy, but it was underlined that fire issues cannot be considered in isolation. It is necessary to link all the components of the systems as they exist naturally (tree and land use, existing conditions, demography, people and land, etc.). It is, therefore, important to consider a fire programme as part of a holistic system. Consequently, fire policies should also be considered in the framework of other policies, such as environment, land use, etc.

National Forest Fire Management Committee

It was strongly felt that one cannot wait for policies to be written and implemented, since their development is very political and can take substantial time. This is why it was suggested that a Forest Fire Management Committee should be created.

The name of the committee was just a suggestion. Substantial debate took place on whether the committee should only deal with forest, or be more comprehensive. However, it also depended on the definition of forest used (FAO, UN, foresters, etc.). The 'transition zone' around forests is probably an important zone for fire management.

Because of the strong forestry background of the group, it was suggested that the committee would initially focus on forests.

General Mandate, Composition and Organisation

The general mandate of the committee would be to promote fire issues and management, to ensure that something is done about fire issues, and to advise on fire management accordingly.

The committee would include representatives from all levels, from communities, regional and federal government offices, NGOs, etc. The results from Group 2 discussion (identification of stakeholders) could be used as a starting point.

Since fire has to be considered as a holistic issue, it was suggested that the National Forest Fire Management Committee would be answerable to the Prime Minister's Office, while the Ministry of Agriculture would be the secretariat.

It was strongly recommended that FAO-TCP would work in harmony and in co-operation with the committee.

Key Roles

A first list of suggested key roles for the committee was drawn up: (NB: the rapporteur structured these roles in following three classes):

A. Policy and awareness

a) Ensure that fire management issues are **included into policies**. As a priority, the committee should push for some fire management issues to be integrated into the current draft Forestry Policy. Later, the committees will advise on other policies (environment, land-use, etc.) as well as the need for a separate fire management policy.

b) In order to help the development of policies, the committee should develop **Forest Fire Management Guidelines**. Inspiration could come from recent guidelines developed in Namibia and Indonesia, as well as WHO guidelines. The current draft Forest Policy should also be assessed accordingly.

c) Organize and facilitate national **fire campaign awareness**.

Organization

a) **Mobilize technical and financial resources** (as a permanent basis and not just for emergencies).

b) Advise and ensure the establishment of **fire management sub-committees** at all levels. The exact roles and types of role will depend on the level with the regions managing fire in their own way.

c) Facilitate the establishment of a **National Fire Information System**, ensuring a proper 2-way information flow to ensure that information arrives on time to the fire manager in the field, and that the latter provide feed-back and suggest improvements.

d) Promote **Inter-Regional Co-ordination** (within Ethiopia so that Regions can benefit from each others experience, but also with Ethiopia's neighbouring countries).

e) Ensure establishment of an **Incident Command System** at Federal level (to be ready for activation in disaster and other emergency situations).

f) Ensure that local traditions are kept when still appropriate (e.g. watch towers, local organisations, drums and church bells, etc. for fire alarms).

g) Ensure no-duplication of organization, i.e. ensure that the existing structures in Ethiopia are used if available (e.g. Disaster Prevention & Preparedness Commission (DPPC), Ministry of Information, Forest Fire Protection Committee, etc.)

Capacity building level

a) Facilitate the building of fire management capability at all levels (to support the sub-committees).

b) Identify training needs.

c) Advice on training at Federal and Regional level (those regions which cannot support themselves).

d) Identify and promote problem-oriented fire research (forest, social, economic, policy, etc.).

e) Ensure and promote appropriate Monitoring and Evaluation, at all levels.

f) Ensure basic fire fighting equipment (demonstration from other countries, adaptation for local use and local manufacturing be promoted)

g) Ensure the education of the young population.

DISCUSSION ON THE OUTPUT FROM GROUP 3

Deribe Gurmu: I think Group 3 was given a strenuous subject to deal with, which was not effectively handled, I am sorry to say. However, I am sure the Group touched on policy, forest regulation, the problems we are faced with and the experience we have already gathered. Indeed, we do know our problems. In view of the solutions, however, your conclusions seem to be a little bit soft. Perhaps you are looking forward to another workshop. I think the basic thing is that we know the problems. If so, do we really need to ignore our basic issues for the sake of policies? I don't think so because our resources have been depleted before the policies were put into effect. An example is the Forest Policy formulation, in which I have been involved for more than five years ago and which has still not yet come out. If one is expecting any forest fire policy to be drafted, I am sorry, I do not think it will. Rather it will remain wishful thinking. Perhaps a better idea, in view of the recurrent and acute problems, and the possibility that the coming years could be even worse, is to suggest an immediate institutionalization of Integrated Forest Fire Management (IFFM) within the Ministry, or outside as appropriate, without any need for a fire policy. One of the objectives of the IFFM would then be to struggle for a forest policy, at the same time producing fire management guidelines and procedures, and also examining the need for a forest fire policy.

I would also like to point out that although we talk about fires, I don't think that we really know their causes, as we haven't done much on the socio-economic part, which is the most sensitive part of the policy formulation process. The basic requirement of such a policy is the understanding of the many variables that affect policy formulation coming from the grassroots. It is not legitimate to produce policies that reflect only the interest of the technocrats. Rather, policy needs and their contents have to come from the people, and the technocrats are only an operational tool.

Therefore, as pointed out above, what we have to recommend *is the establishment of a fire incidence combat system or an integrated forest fire management unit within the MoA because of the urgency of the problem, and, at the same time, claim for both the fire and forest policies.*

The other thing which is not yet agreed upon is that there are two issues: one is a group suggesting a separate policy for forest fires, and another group claiming for its inclusion in forest policy as a whole. If we opt for its inclusion, we are then obliged to ask the MoA to give us back the Forest Policy, which is well on its way to being completed. This is, in a way, reversing the momentum, perhaps forcing a delay of another five years or more. At this point in time, it is my strong advice that we should not delude ourselves that policies are the panacea for everything. Even if they are, it is only in rare cases. Remember that we have a number of fine policies and good regulations, but, at the end of the day, if we evaluate and examine them using some indicators, we can see that all of them were only as good as their initiators. Because of this, I am of the opinion that we should not depend on policies as the only solution to the fire problems we are facing now. We can suggest that the exercise be done through a future responsible body. This also will give us the opportunity to decide on the content and the structure of the fire as well as the forest policy envisaged. Thank you.

Günther Haase: I would like to come back to two previous questions of Harri Seppanen and Peter Lowe. Peter has provided two different definitions of forest fires. Firstly, the ecological definition of a forest ecosystem, which, according to him, are forests with a cover of 100% or having an interlocking canopy of trees. However, the definition used in the Forest Proclamation, and also adopted for the draft Forest Policy, is actually wider in order to include other ecosystems. Woodlands and bushlands are also included in the Forest Policy. But, if we talk about forest in ecological terms, then we are limited to the formerly closed forests of the National Forest Protected Areas (NFPAs). Those are actually the forest types we are most concerned about. However, we cannot rule out the use of fire from all forest vegetation types in the country, as has been clearly pointed out by the group presentations and other deliberations. As Million also pointed out, wherever it is possible and proves beneficial to the community and/or to the ecosystem, I think we should allow or encourage the wise use of fires.

Regarding Harri Seppanen's question, there are three types of forest ownership in Ethiopia. When we consider the high forests, these are the ecosystems with natural vegetation types that are under the most serious pressure and where we are most concerned. These are all under the ownership of regional governments, except for Menagesha Forest which is owned by the federal government. This leads to the point already raised yesterday that the primary task is how to involve and bring benefits to local communities in the management and protection of the state-owned NFPAs That is a crucial task because all the forest fires have occurred in the state-owned NFPAs.

Harri Sepannen: It is quite risky for the state to retain sole control of these forests, even if they are very valuable forests, because effective control has to involve the local communities. Efforts would also be futile unless there are sufficient resources on hand to implement the prevention and suppression of fires. There are several, very good experiences outside Ethiopia of arrangements between local communities and the government that have made joint agreements between the two primary stakeholders, in which both of them have a stake in the shared benefit of protecting and managing forests. I think the system of protection solely by the central government involves quite a lot of risk to the forests and the other resources associated with them. So, I would recommend studying the modality of the joint Forest Management Agreements made between the local people and the government in India and Nepal as there are several good experiences there.

Media person: The recommendations of Group 3 were expected to indicate what should be done with respect to policies and institutional set up to fight forest fires. A lot of topics seem to have been raised and discussed, and that is good. But they have missed the main point. The fact remains that we are losing our forests to fires, which we have to stop by any of the ways mentioned during the last two days.

According to these deliberations, there are two approaches: One is the preventive and the other is the protective approach. As a developing country with meagre resources, obviously we cannot opt for the preventive method. Perhaps the relevant method for us is to choose the protective method? To this effect, we have to either teach the local people not to initiate forest fires, or to assign people who would conduct conventional forest management practices like silvicultural treatment, fire protection activities, controlled burning, and the like. What is expected from us, therefore, is to indicate whose responsibility should this be? As people from the media, we are expecting a responsible body that can end bush fires. What is expected of this workshop is to pinpoint every activity deemed necessary to combat fire. But you do not seem to agree on even what kind of an institution should be established? It also seems that you are waiting for a policy to come, no matter how long it is delayed, and wish to convene a forum to discuss it. Why don't you tell us the problem? I need some clarification on this. Thank you.

Ensermu Kelbessa: It seems as if no one is as concerned about the development of a Forest Fire Management Programme (FFMP) as compared with the Forest Policy. I think there must be courage to develop a FFMP even if there is no policy to support it, at least to tackle the problem, which is threatening the Ethiopian forests. Having said this, I would like to mention that I heard several people saying that there is no community awareness of fire hazards. I think that phrase must be replaced, because I am quite sure that the community is well aware of the danger, but it is the government machinery which is actually unaware. That is why the problem of forest fires could not be dealt with in time.

It is the government machinery which does not allow the communities to decide their own fate.

For example, if you go to the people and ask, do you set your house on fire? They would answer, 'No, we never do that!' because, living in the forest, they never do that, and they have never done that. The problem of forest fires resulted because of the interference of regional bureaux with the rights of the people. If enough participants from the regions, where the remaining forest areas in this country are located, were represented here they would have told us a lot about this fact. Otherwise, I assure you that the community is more than just aware. It is the government machinery which is not willing to address the problem. So I suggest replacing the phrase 'No community awareness' with 'No goodwill on the part of the government machinery to involve local people in all matters that affect their life'. Thank you.

OBJECTIVES, CONCLUSION AND RECOMMENDATIONS

1. Round Table Objectives

1) To provide all stakeholders with comprehensive information on the present state and problems in the field of forest fires:
2) To learn from the experiences in forest fire management from other developing countries:
3) To identify and define components of an Integrated Forest Fire Management Programme for Ethiopia;
4) To provide an opportunity for potential international partners to express their interests and ideas with respect to co-operation in the development and implementation of a forest fire management system.

2. Conclusion

The Ethiopian Round Table Conference on Forest Fires created a forum for presentation and sharing of experiences related to forest fire management. A number of issues were covered during the deliberations. During the first day, research papers were presented on (i) ecological impacts of forest fires in different vegetation types, (ii) the status of forest fire management in Ethiopia, (iii) fire issues at regional and global levels, (iv) fire information systems, and (v) experiences with integrated forest fire management in Eastern and Southern African countries as well as in South-East Asia.

Thorough discussions were made during the group work and plenary sessions on the second day. Based on the presented papers and group discussions short-term and long-term forest fire management approaches were recommended, which included the establishment of a comprehensive Integrated Forest Fire Management System (IFFMS) for the country.

3. Major Recommendations

1) The workshop participants analysed that forest fire issues were not adequately elucidated in the Draft Forest Policy of the country. Thus, it was recommended to include issues on Integrated Forest Fire Management into the Draft Forest Policy as well as other relevant policies like those on land use, population, investment and economic activities.
2) Forest fire management committees should be established at all administrative levels, i.e. from the federal down to woreda and community levels. These

committees should facilitate, monitor and evaluate the implementation of the Integrated Forest Fire Management Programme.

The National Forest Fire Management Committee should be subordinated to the Prime Minister's Office, with the Ministry of Agriculture serving as its secretary. Other relevant stakeholders should be assigned as members (member list to be defined at a later date).

3) The initiation and further development of an integrated forest management programme for the country should be pursued through the proposed FAO-TCP/ETH project. All efforts should be made to ensure the timely start of the project. The project should operate under the overall authority of the National Forest Fire Management Committee.

4) Types of fires, their intensity, season of burning, frequency and their causes differ depending on the vegetation type and agro-ecological characteristics. In certain ecosystems, fires are an important management tool to achieve both ecological and socio-economic objectives. These issues have to be further analysed and considered in the formulation of fire policy statements, regulations on use of fires, and fire management strategies. Prescribed burning schemes for suitable ecosystems/vegetation types have to be an integral part of the national fire management programme.

5) The participants acknowledged that the shortage of material and financial resources as well as the lack of trained manpower have all contributed much to the disastrous effects of forest fires in the first part of the year 2000 in Ethiopia. Therefore, it was suggested that the government should make adequate budget allocations and continue to seek international assistance in order to build and strengthen national capabilities for fire monitoring, fire prevention and fire control.

6) The Integrated Forest Fire Management System (IFFMS) needs to be developed with the active participation of all relevant stakeholders. Their needs and potentials have to be considered, explored and capitalised upon. Thus, it was recommended to involve the local communities, relevant government organizations, NGOs and other development partners in the planning and implementation of the IFFMS.

7) Participants in the workshop realized the effectiveness and efficiency of participatory forest fire management in Namibia and other countries. It was recommended to develop similar approaches for use in Ethiopia. Any successful IFFMS has to be based on strong communal participation. Consideration of the needs of communities and awareness creation will be key to successful implementation.

8) Forest fires in State Forests are an indirect result of the alienation of communities from the resource base. Therefore, the workshop strongly recommended efforts should continue to pioneer and implement schemes for participatory forest management in Ethiopia. This way, attitudes of ownership and feelings of involvement by local communities can be built up for the remaining high forests of the country. This should lead to the improved monitoring and protection of these forests from fires and other hazards.

More specific recommendations can be found in the outputs from the discussions following the outputs from each of the Working Groups, and in the final plenary session.

ANNEXES

ANNEX 1

WELCOME ADDRESS

by Tamiru Habte
Head, Natural Resources Management & Regulatory Department,
Ministry of Agriculture

Honourable Minister,

Honourable Members of the UN System and its Sister Organizations

Distinguished Representatives of Embassies in Ethiopia

Dear Participants

Ladies and Gentlemen.

On behalf of the Ministry of Agriculture, the Natural Resources Management & Regulatory Department and the GTZ Project Advisory Assistance to Forest Administration, it gives me a great pleasure and honour to welcome you all to this special event, the first of its kind in the country — even in the Horn of Africa — convened to discuss issues of Forest Fire Management in Ethiopia.

Following last February's forest fire incidence in the south and southeastern parts of the country, the Ministry of Agriculture and its partners at all levels have been working for the last several months for this workshop to come to light. This workshop has a paramount importance and significance for the conservation and sustainable utilization of the country's natural ecosystems, which include highland forests, savannah and bushland, fresh-water lakes, etc., which also have global values.

From the onset of February 2000, the human induced forest fires, mainly in Bale and Borenna zones of Oromia Region, have consumed about 90,000 ha of forest land. The damage and its extent might have been considerably higher compared to our readiness and capability to suppress forest fires of that magnitude. However, thanks to the concerted efforts of National and International Organizations and the governments of South Africa, Germany and Canada, and, above all, the communities in the fire zones and the Oromia Regional Government, the situation has been brought under control without spreading further into the famous Bale Mountains National Park where many endemic wild animals, birds, etc. are residing.

Honourable Minister

Distinguished guests and participants,

We are proud and honoured to have among us Dr Johann Goldammer, the dedicated fire fighter and Director of the Global Fire Monitoring Center based in Freiburg, in the Federal Republic of Germany, whose organization without delay responded to the country's appeal for international assistance during the recent disaster.

The Global Fire Monitoring Center not only responded but the director himself flew immediately to Addis and to the fire zone, and led the international team (South African and USA) who joined him later. After an aerial survey, the team identified the type of assistance the country required and came up with a proposal for action. With your permission, allow me to welcome Dr Johann Goldammer once again to Ethiopia and to the workshop.

Dr Goldammer you are most welcome.

On behalf of the Ministry of Agriculture and the organizing committee, I would like also to welcome:

Professor Winston Trollope of South Africa,

Mr Harri Seppanen of Namibia, and

Dr Stéphane Flasse of the United Kingdom, who are here to share with us their knowledge, expertise and experiences in fighting wild fires, the establishment of early warning systems and the formulation of integrated fire management programmes with the active and sound participation of the community.

Your Excellency and Distinguished Guests,

Participants to the workshop are drawn from concerned:

Ministries & Authorities

Research organizations and higher learning institutions

Regional government offices and agricultural bureaus

Ethiopian Wildlife and Natural History Society

Biological Society of Ethiopia,

several relevant projects, and

Non-governmental organizations involved in the sustainable utilization of the country's only hope for its economic development, its natural resources.

Participants are:

Decision makers

Researchers

Scholars

Prominent conservationists

Front line foresters and

Senior experts in natural resources

At this juncture, with your recognition allow me also to welcome all participants who have been and still are catering for the betterment of the sector with all their capacities and available technical, institutional and legal arrangements in the country.

Dear Participants,

Ethiopia is a land of enormous geographical diversity and altitudinal variation. The flora of Ethiopia is very diverse; it is estimated that between 6500 and 7000 species of higher plant occur, of which 15% are endemic.

Endemism is particularly high in the Ogaden, the Afro-alpine vegetation zone and the dry mountain forest and grassland complex of the plateau, and to a lesser extent in the humid forests of the southwest.

The faunistic diversity of Ethiopia is also high due to the variations in climate, topography and vegetation, and also includes many endemic wild animals, birds and others.

Ethiopia, with a total area of 1.1 million sq. km., out of which forest cover accounts for only 2.7% of its territory, is experiencing a serious ecological and biodiversity degradation due to bad utilization and mismanagement of its land and forest resources. With the existing backward agricultural practices and rural population explosion, more forestland is cleared and put under fire to expand land for farming and support livelihoods in rural areas where 85% of the population is toiling.

The uncontrolled and unplanned burning of communal land for a variety of purposes and the escaping fires damaging adjacent forests and plantations is also becoming a repetitive scenario in different parts of the country. Traditional bee keeping, and negligence when harvesting from hives hanging in forest areas, and uncontrolled fire to manage grazing land are also causes among many for forest fire incidence in the country. Forest fires not only damage forests and valuable timber resources but also upset soil and water régimes, and decrease the productivity of the land and lower water tables.

With the dwindling of our resources and decline of production in the agricultural sector, frequent climate changes, and other phenomenon, conservation and sustainable utilization of our remaining forest resources should be given prime emphasis.

Dear Participants,

We all are here for the above underlined cause — to save our forests and their biodiversity. The following major task/objective is brought to this dynamic and august gathering who has at stake the conservation of the above.

Fire is destructive, but it can also be useful to stimulate disturbances for the renewal of ecosystems and to manage resource, if it is properly prescribed and controlled.

Therefore, you participants are expected to analyse the present status and problems of forest fire in Ethiopia, pick the good experiences of other countries in the region and elsewhere in the world from the days of deliberations and to assist in the formulation of a participatory, acceptable and appropriate fire management programme. The design mechanism and opportunities for external assistance, be they technical or financial, shall be sought for the realization of the Programme. We can foresee Ethiopia's contribution to global efforts in the protection of ecosystems and biodiversity by doing so.

Honourable Minister, Distinguished Guests,

It is my sincere hope that we meet our objectives and come up with an integrated fire management programme for the country.

With this brief remark and heartfelt welcome, with respect and honour, I would like to invite His Excellency, Dr. Mengistu Hulluka, Minister of the Ministry of Agriculture, to make the opening speech.

Thank you

ANNEX 2

OPENING ADDRESS

Dr. Mengistu Hulluka,
A/Minister, Ministry of Agriculture

Distingushed Participants,

Ladies and Gentlemen,

It is, indeed, a great pleasure to welcome you all to this National Round Table Workshop on Integrated Forest Fire Management in Ethiopia, which is aiming to address the major challenges of forest fire and to look into the possibilities of forest protection through a systematic forest fire management plan. Luckily enough, we are enjoying the presence of distingushed personalities from abroad with a broad knowledge on forest fire management in order to share their experiences in this workshop.

Ladies and Gentlemen,

There is no doubt that natural resources are the foundation of the economy of any nation. Being an agrarian country this is more reflected in our context, as the livelihood of the vast majority of the population is highly dependent on renewable natural resources.

'Renewable natural resources, i.e. land, water, forests and trees as well as other forms of biodiversity, which meet the basic needs for food, water, clothing, and shelter have now deteriorated to a low level productivity. In many areas of highland Ethiopia, the present consumption of wood is in excess of the unaided natural sustainable production.'

The current estimate of forest destruction, as presented in some fora, is disturbingly high. In Sub-Saharan Africa, on the average, for every 32 hectares deforested annually only one hectare is restocked or reforested, while the global rate is estimated as 5 to 1. Though statistics of such a nature have not been issued yet in this country, in view of the past trend, the likelihood of occurrence of such an estimate for Sub-Sahara Africa cannot be refuted.

As a nation, we must ensure that essential ecological processes and life support systems are sustained, biological diversity is preserved, and renewable natural resources are used in such a way that their regenerative and productive capabilities are maintained, and, where possible, also enhanced so that the satisfaction of the needs of future generations is not compromised.

In order to sustain such a system for long and continuously one has to counter the forces of destruction of natural resources, specially forests, which are more vulnerable to attack by several damaging agents – the most important of which is bush fire.

Fellow Participants,

It is clear that most activities after planting deal with forest protection. To our dismay, our involvement and preparedness in this aspect of forestry programmes is appalling low. We have got to do much more along this line to save our remaining forests and those being planted every year in some regions.

Among the many agents affecting tree growth and development, human interference is the most destructive to forests. Man destroys forests for settlement and engages in unsustainable exploitation of forest products. The consequences of which are beyond ones imagination in terms of soil erosion, the negative effects on the environment, on water quality, on catchment conservation, on bio-diversity and on all living organisms in the forested areas.

Except in a few instances, all forest fires, directly or indirectly, have been ignited by human interference in the forested area. Every year, larger and larger areas of our precious forests are exposed to fire hazards and the fires become rampant in some years when the dry season lingers on due to extended and unseasonal drought spells.

In the east and northeastern parts of the country, the natural vegetation ranges from grasslands to woodland formations with grazing as the dominant form of farming system. This vegetation is deliberately burnt every year in order to induce the sprouting of vegetation for fresh grazing. In addition, the use of fire as an aid to hunting and to control tsetse fly and tick populations are among the major causes of forest fires in the lowland areas.

On the other hand, in the highlands, where rapid population growth is demanding more land area, forest fire is used as the major tool to clear forestland in order to convert it to crop farming. The crude traditional practice of smoking out wild bees in order to gather honey and charcoal-making operations is also a factor contributing to fire outbreaks. The traditional practices of using fire as a means of land preparation and incendiary burning, i.e. as malicious acts or vandalism, with clear intention to cause harm to properties are some other causes of bush fires.

In general, the causes of forest deterioration by fire are rooted in poverty which is being constantly fuelled by the uncontrolled rate of population growth.

Respected Participants, Ladies and Gentlemen,

As important as they are in the national economy as well as for the welfare of the whole society and the environment, minimal attention has been given to foster an institutional framework for forest protection. Plantation forests and more so the natural forests are highly vulnerable to any kind of damage. Past history clearly shows this phenomenon as there is no clear evidence of any intervention in capacity building on this aspect of forestry.

There is no question that there is a need for a systematic and well-facilitated fire management organization with a greater share of responsibility solely to protect forests. At the outset there are two approaches in fire management: one is preventive measures i.e. action prior to fire outbreak, and the other is suppressive measures after the onset of fire. For both there are well developed techniques and technologies which can easily be adopted here with little modification.

Being a developing country with meagre resources, our option should be the preventive approach by mobilizing all available resources and community-oriented effort to prevent fire from occurring, or to combat the fire at the initial stage. I think we can easily build capacity to educate our people on the usefulness of protecting our forests by using different approaches. I also think we can construct preventive measures very easily if we are conscious of forest fire as part of forest management well ahead of time. Preventive practices such as timely pruning and weeding operations, controlled grazing and reduction of combustible materials in plantation forests, ground patrolling during the fire season, construction of fire-breaks and look-out towers, and educating and empowering the community in forest protection through a provision of incentives are some of the measures which can easily be implemented.

Once a fire out-break reaches to the tree canopy, any measures taken so far will have been a futile exercise. Even those countries with massive outlays on facilities to fight fires — aerial surveillance operations, networks of communications, efficient ground transportation systems, modern fire-fighting equipment, etc. — have had a hard time to suppress crown fires. Very good recent examples are the huge forest fires which devastated valuable timber in several States in the U.S.A. and in Borneo and Sumatra of Indonesia. However, owing to the fact that one preventive measure might fail, we have to position ourselves in combat readiness with all available means to deal with fire outbreaks.

The forest fires which raged in Bale and Borenna are cases in point. Had it not been for a well-organized effort by all concerned, including the local communities and students, much greater loss would have occurred.

Without dwelling too much on the legacy of past institutions, which have been accused with accelerating deforestation, we must commit ourselves to the future development of our forests. This requires a concerted action by all concerned and your involvement in formulating a viable system and programme which would hopefully bring our forests back to where they were earlier in the last century.

Distingushed Participants,

Ladies and Gentlemen,

The discussions in this National Round Table Workshop would hopefully address all issues pertinent to forest fire management, and exchange experiences on preventing and combating forest fire by providing a sound proposal which lays the ground work for future intervention.

We need your unreserved attention in this regard in order to stop this unabated destruction once and for all, and replenish the land, specially our mountains, with valuable vegetation and keep it sustained for the current and future generations.

Finally, *Ladies and Gentlemen,*

I would like to express my heartfelt appreciation to the German Technical Cooperation (GTZ) for sponsoring this useful workshop and for all the assistance rendered under the project, entitled Advisory Assistance to the Forest Administration at the Ministry of Agriculture.

I would also like to recognize the organizing Committee for fielding such an important event by inviting all stakeholders prior to the forthcoming fire season.

Hoping that the deliberations of the workshop would be fruitful, I declare this workshop open.

Thank you.

ANNEX 3

REMOTE SENSING AND GIS TOOLS TO SUPPORT VEGETATION FIRE MANAGEMENT IN DEVELOPING COUNTRIES

Stéphane P. Flasse*, Pietro Ceccato*, Ian D. Downey*, Jim B. Williams*, Pedro Navarro† and Mahmud A. Raimadoya‡

Abstract

Fire is involved to some extent in clearance of vegetation for agriculture, logging access, settlement and hunting. When used inappropriately, fire events may adversely affect ecosystems and alter atmospheric conditions. In developing countries resources to monitor and manage fire activities are usually limited (*e.g.*, staff, material, budget), and little information on the scale of the problem is generally available at regional and/or national level. Earth observation remote sensing and GIS technologies are the most practical and feasible means to monitor biomass burning events efficiently at regional and global scale. NRI is conducting research and operational work to provide developing countries with tools to assist with timely integrated management of vegetation fires. Vegetation status and active fires are monitored through direct reception of NOAA-AVHRR data, and production of thematic information is carried out by the integration of fire information with local environmental knowledge. This paper describes areas of research and current tools used in Indonesia and Nicaragua to support natural resources managers. It illustrates the usefulness of direct reception of satellite data to forestry departments and associated line agencies, and underlines the challenges that have to be overcome in developing countries if such information is to be used effectively.

1. INTRODUCTION

Though fire is a useful and efficient tool to perform environmental management such as forest clearance, field preparation, regrowth for livestock, reduction of fire hazard, its misuse can have adverse consequences (Bond and van Wilgen, 1996). Areas of concern vary from natural resource sustainability and biodiversity conservation to destruction of commercial wood and threats to village welfare. As a result, there is

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increasing pressure from international, national, regional and local communities to manage vegetation fires. However, developing countries are often challenged by a lack of means to monitor fire on a national scale. This paper describes NRI's experience in providing developing countries with local reception of satellite data and its integration into GIS in order to improve fire management effectiveness.

2. Fire Management in Developing Countries

In many of the more developed countries, fire management has been a common practice for years. In many other countries, though fires have occurred for millennia, concern has increased recently due to changes in fire patterns and the growing scarcity of natural vegetation. For example, the increasing number of large destructive forest fire events is believed to interfere with biodiversity and productivity (of both vegetation and fauna) or with sophisticated 20th century life as in the case of large smoke plumes disturbing aviation, (*e.g.*, Mueller-Dombois and Goldammer, 1990; Abensperg-Trau and Milewski, 1995; UN-ECE/FAO, 1996). In addition, recent studies on global climate change have also increased pressure on countries to control gas emissions to the atmosphere (*e.g.*, Lacaux *et al.*, 1993, Lashof, 1991). As a consequence, there is high pressure for fire management.

Management of fire consists of activities designed to control the frequency, area, intensity or impact of fire within a local or regional environment. A typical approach to fire management is illustrated in Figure 1.

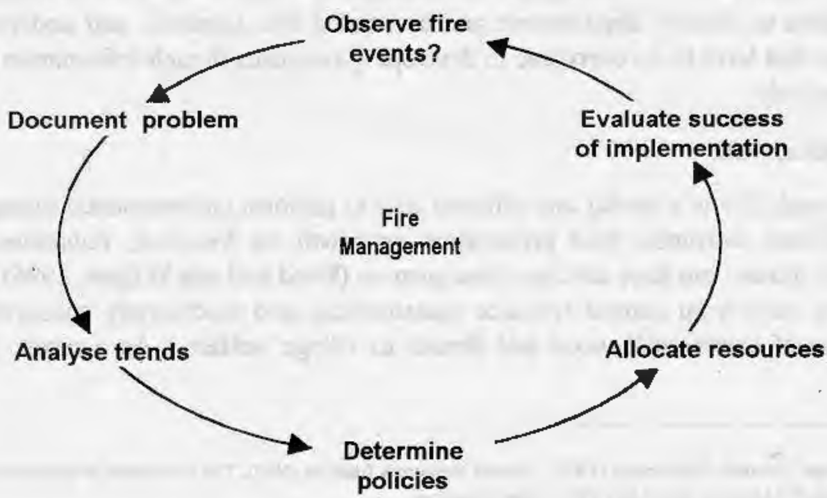

Figure 1: Typical approach to fire management

It is not rare to hear from forestry departments that fires constitute a huge problem, based on rumours or subjective information rather than understood facts. So is there, in fact, really a problem? The first step to effective fire management is, therefore, to know and to understand the climatic, environmental and social factors which influence fire and its impacts. In order to know and understand a fire issue in a country or in a specific region, one must:

- document the events (where and when does it burn?) over the years
- gather information that may be related to the fire events (e.g., what and how much is burned, why was fire set, attitude of different people towards fire and fire prevention, population density, meteorological data, vegetation status)
- gather ancillary information (e.g., roads and river network, administrative boundaries, protected areas, concessions, villages, fire towers, fire fighting units).

Only comparison of fire occurrence, within a season, between seasons, and within 'context' allows resource managers to identify trends, to understand practices and needs, to prioritise problems, and to formulate environmental management policies. In turn, the policies must be implemented by allocating the right resources, and their success must be evaluated. Fire management also consists in going many times around the loop, to ensure that each iteration brings refinement of policies, as well as allowing management to adapt to changes.

While comprehensive analysis of fire data can only improve understanding and enable better management decisions to be made, such an approach may be a real challenge for a budget constrained government in a developing country, especially one with more problems than capacity to intervene. Such governments, constrained by often outdated and ineffective institutions, and pressed by increasing rates of environmental change together with growing demands for accountability and competence through enhanced political and environmental awareness, need assistance to help them improve management of their natural resources and environment. Decrepit observation networks, poor communications, underpaid and demoralised staff and urban-oriented political systems do not improve prospects. Under such circumstances, unless the need for fire control is inescapably obvious to all (and it very rarely is) then systematic, reliable data on fires over large remote areas are most unlikely to be collected, processed, assimilated, or acted upon.

As a consequence, the basic information required to analyse the situation (*e.g.*, time and location of fires) is often the primary challenge: there is a need to find sustainable and reliable ways of documenting events to allow the scarce fire management resources to be used most efficiently.

3. Direct Access to Fire Information

The most practical, feasible and relatively objective and cost effective means, by far, to quantify and monitor these fire events at national to regional scales is to utilise Earth remote sensing and GIS technologies. Many studies have demonstrated the potential usefulness of remote sensing techniques to monitor the Earth's surface and fire related information in particular (*e.g.*, Kaufman *et al.*, 1990; Prevedel, 1995). Clearly, the major benefit of remote sensing is that it permits the observation of large areas of territory on a regular basis. Its monitoring capabilities can be used to aid in the identification of fire events and the ongoing observance to detect trends and evaluate efficiency of fire management practices. In addition, remote sensing can be used to observe vegetation status and land surface temperature which are useful in the assessment of fire risk (*e.g.*, Chuvieco and Martin, 1994; Burgan, 1995).

However, it is essential that appropriate information is available directly where it can best be used. This may appear obvious, but examples exist, even in industrialised countries, which suggest that it is not working (*e.g.*, Smith, 1994). This is a challenge NRI is actively addressing (see Box 1), seeking to inform policy makers, planners, protected area managers and forestry staff, as well as working on awareness raising, fire prescription, prevention and extinction as required.

Once environmental data are accessible at the local department or institute level (for example through direct reception of NOAA satellite data), regular and operational use must also be implemented. NRI provides training in the interpretation and use by non-experts of appropriate environmental data. From NRI's experience, it is clear that the integration of remote sensing and GIS tools within local institutions is progressive, and requires a steady and slow pace. Indeed, it takes time for inexperienced local staff to appreciate fully the potential of the tools and to accept that they complement local methods rather than replace them. Time is also necessary to foster good understanding of the basic principles of remote sensing and GIS, to get to grips with interpreting new types of information, and to relate it with knowledge in the field. Progressively one can see the potential of the new information source, and can then produce innovative ideas to use it efficiently.

Typically, this is an iterative learning process for fire management using remote sensing and GIS tools. Initially, one simply uses the tools to detect fires daily, and observe their spatial distribution on a map. Through repeated use across several fire seasons, one becomes more familiar with the data, and wants to analyse using statistics in more detail, such as:

BOX. 1. The Natural Resource Institute and LARST

The Natural Resource Institute (NRI) is a centre of expertise on the natural resources sector in developing countries. A major concern of the NRI is the provision of real-time access to environmental data in country, as it believes this to be key to efficient management of natural resources.

The Environmental Sciences Department at NRI has led the development of an approach known as Local Applications of Remote Sensing Techniques (LARST) (Williams and Rosenberg, 1993). One of the principal outputs of this approach has been the development of robust low-cost satellite data receivers for NOAA and METEOSAT satellites. The second principal output has been the adaptive development of tools specific to real operational needs in the field.

These receiving stations are installed in the host country and operated by local, national or regional institutions to provide rapid, direct access to Earth observation data in-country; thereby allowing the direct application of observations to improve natural resource monitoring and management. The LARST approach is based on simple principles that ensure sustainability and longevity of operation (robust hardware, easy-to-use software, low cost PC-based systems, low cost printing, free real time data, locally sustainable technology). The LARST approach utilises satellite observation of geophysical parameters such as cloud top temperature and sea surface temperature as well as information derived from the satellite orbital position. These observations can also be used to provide indications of other phenomena which cannot be measured directly from satellite observations such as pest habitats from vegetation status, potential fish stock in upwelling regions and agricultural encroachment from fire detection.

(adapted from Downey, 1994)

- proportion of fires within the forest
- correlation between fire occurrence and population density
- relation between fire occurrences and vegetation status
- relation between fire occurrences and meteorological conditions.

Progressively, the different possibilities motivate one. If at the beginning a simple approach to fire event documentation is established, increasingly more elaborate strategies can be developed to inform concessions, forestry departments, and ministries regularly, as the capacity of these institutions to absorb and act on this information increases over time. However, sustainable integration of new tools and information takes time. Can existing institutions actually cope?

4. Development and Uptake of Tools

In order to support the rapid uptake of new fire management tools and information, NRI works at two main levels: in-country projects and adaptive research. In-country projects usually lead the adaptive research. The latter consists of building methods and tools that can be used operationally without sophisticated inputs from the user. Usually new methods are developed and/or existing ones are adapted to match reality. Simple user interfaces are also implemented in the local language to allow technicians to run these tools operationally and to ease the training of new staff.

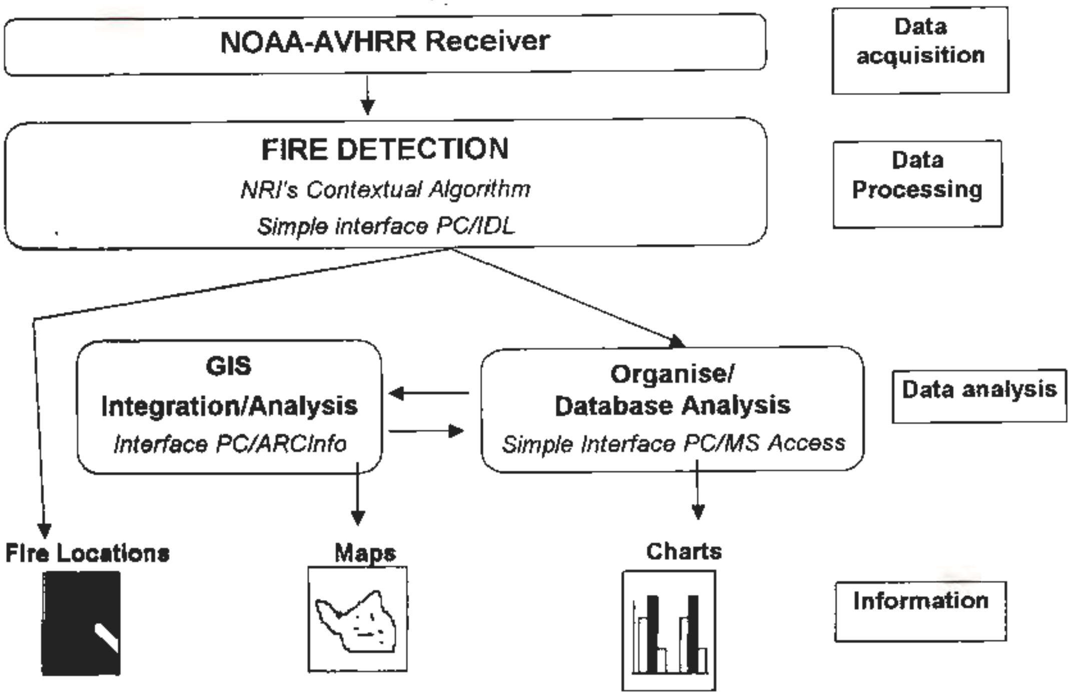

Figure 2: Operational Tools

In the area of fire monitoring, NRI has developed a contextual fire detection algorithm (Flasse and Ceccato, 1996) to improve the reliability of automated fire detection from NOAA AVHRR data. Compared to previous multiple threshold techniques, where thresholds need constant updates according to time and space, the contextual approach allows the automatic detection of fires with minimum input from the user (Eva and Flasse, 1996). The algorithm was developed in support of the IGBP-DIS Global Vegetation Fire Product and has been found to work reliably in Central African Republic, Madagascar, Indonesia, and Nicaragua. The algorithm forms the basis of operational detection projects in Indonesia and Nicaragua.

The remote sensing data processing tools are implemented under the IDL software package into customised stand-alone modules. Very straightforward interfaces are added, translated into local languages. They consist of a few buttons calling for the processing of images as well as the display of primary fire maps and the extraction of fire locations.

Iterative learning is progressing in Indonesia and Nicaragua, resulting in increased demand for development of additional tools to analyse the data. Though most sites now have various GIS packages, NRI develops and implements simple prototype tools and interfaces, based on standard database software (*i.e.* MS Access) to allow users to produce pre-defined charts and fire reports efficiently and operationally. Figure 2 shows the typical combination of remote sensing and GIS tools to deliver useful fire information products. Currently, some countries have reached enough experience to begin looking at the assessment of fire risk using remote sensing data. Following this evolution, NRI is currently working on the implementation of locally operational fire risk assessment tools. Examples of fire monitoring in Indonesia and Nicaragua are given below.

5. Examples

Indonesia

Operational fire monitoring over the Indonesian archipelago faces many challenges. Indonesia comprises an area of some 1.9 million km^2 and much is inaccessible and remote. Fire occurrence is highly variable, both spatially and temporally, but it is recognised officially that just for 1994, 5 million hectares of forest land have been destroyed by fires (Wildfire, June 1995). In 1994, media attention focused on the problem of smoke from forest and agricultural fires. The ensuing air pollution caused serious local health hazards and severe restrictions to air and marine traffic (ECE/FAO 1995). Fire issues are now addressed by the Indonesian *National Coordination Team on Land and Forest Fire Management.*

In 1993, a NOAA receiver was installed by NRI at the Overseas Development Administration's (ODA) Indonesia-UK Tropical Forest Management Programme (ITFMP) office in Palangkaraya, Central Kalimantan. The fire monitoring system routinely captures AVHRR data of Kalimantan from any of the NOAA satellites as they pass overhead. Maps of probable fire locations are produced within 30 minutes of satellite overpass, using NRI's contextual fire detection software and simple interface. Co-ordinates of suspected fires are also produced and transmitted to the Ministry of Forestry in Jakarta. Several projects in Indonesia are now co-ordinating their efforts to best manage wildfires over the whole country. So far four NOAA systems are working daily (Jakarta [2], Palembang and Palangkaraya), and several others have been planned in order to give most provinces direct access to fire information.

After several fire seasons, the NOAA fire information is beginning to be combined with supplementary information in a GIS. At the local scale, this provides an early-warning tool in fire suppression, and at the national scale, temporal fire maps combined with supplementary vegetation maps can locate possible deforestation fronts, helping to raise political awareness, or to direct extension programmes to promote alternative land use. Work is still needed to realise the potential fully. The most important aspect will be to improve the dissemination and uptake of the fire information and by forging better links with end-users.

Nicaragua

A collaborative project between ODA and the Ministerio del Ambiente Y Recursos Naturales (MARENA) in Nicaragua commenced in May 1995. Nicaragua has prepared a National Forest Action Plan and attaches high priority to fire prevention and control. Nevertheless, base data are often lacking. One objective of the project is to identify fires in forested areas and seasonal changes in forest cover as observed by satellite. Complex social, economic and institutional issues associated with fire and the use of real-time satellite information is being broached with a view towards sustainable monitoring and optimal utilisation of the information for better decision-making.

During the December 1995 to May 1996 fire season, for the first time, daily information and monthly summaries on fire activity for the whole of Nicaragua were produced by MARENA, and transmitted to provincial forestry offices. These were in the form of fire maps and lists of fire co-ordinates referenced to topographic map sheets. Even though daily reports could not be acted on immediately, the analysis of the fire season using this new type of information has clearly shed a completely new light on the problem, provoking surprise and encouraging motivation to utilise the information nationally and regionally. Initially, these powerful new data can be contentious as they highlight the existing under-capacity of institutions and resources. But progressively, as staff (from technicians to minister level) are informed, trained and involved, it is being recognised that the information offers the potential to make better decisions on fire policies and to increase awareness of the situation. Preparations for the operations in the next fire season are in hand including the design of new specialised local data reports to help operational management at local level.

6. Conclusions

Comprehensive information on the spatio-temporal dynamics of fire is essential, for both scientific studies of the impact of fire on the environment and formulation of fire management policies.

The methodology developed at NRI provides direct access to real-time data continually transmitted from NOAA satellites, via low-cost, robust satellite receiver stations, and appropriate information extracted by customised tools and automated analysis procedures. This directly contributes to the information necessary for the implementation of operational programmes for fire management at local, national and regional levels. Once actions to manage a fire problem have been taken, impact assessments can be performed through the same methodology to determine whether or not fire is still a problem. This in-country approach increases uptake of new tools and information, and improves local capacity to the benefit of fire managers and decision-makers.

Acknowledgement

This work is supported by the UK Overseas Development Administration.

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ANNEX 4

Workshop Programme
Ethiopian Round Table Workshop on Forest Fire Management
19–20 September 2000, Addis Ababa, Ethiopia

Date	Time	Activities	Responsible
Tuesday 19/09/00	8.30-9.00	Registration	Organisers
	9.00-9.15	Welcome Speech	Ato Tamiru Habite
	9.15-9.30	Opening speech	HE Dr Menglstu Hulluka A/Minister, MoA
	9.30-10.15	Vegetation Types and Forest Fire Manageent in Ethiopia	Dr Demel Teketay
	10.15-1045	Tea Break	
	10.45-11.45	Regional to Global Fire Issues: The Role of Vegetation Fires in Africa and other Continents in global Processes	Dr J.G. Goldammer
	11.45-12.30	Effects and Use of Fire in Southern African Savannas	Prof. W. Trollope
	12.30-13.30	Lunch	
	13.30-14.15	Community-based Forest Fire Management in Namibia	Mr Harri Seppanen
	14.15-14.45	Video Presentation on Integrated Fire Management in Namibia	Mr Harri Seppanen
	14.45-15.30	Remote Sensing of Vegetation Fires and its Contribution to National Fire Information	Dr Stéphane P. Flasse
	15.30-16.00	Tea Break	
	16.00-16.45	The Integrated Forest Fire Management (IFFM) concept: Lessons learnt and opportunities for the Ethiopian condition	Dr. J.G. Goldammer
	16.45-17.30	Case study: Ecological Performance and Survival Strategies of Savannah Woodland Plants to recurrent fires in Gambella Region	Ato Minassie Gashaw
Wednesday 20/09/00	8.30-10.00	Group Discussion	Participants
	10.00-10.30	Tea Break	
	10.30-12.30	Group Discussion	Participants
	12.30-14.00	Lunch Break	
	14.00-15.30	Group Presentation and Discussion	Participants
	15.30-16.00	Tea Break	
	16.00-17.00	Plenary Discussion	Participants
	17.00-17.30	Wrap-up Discussions	Participants

ANNEX 5

Participants
of the Ethiopia Round Table Workshop on Forest Fire Management
Addis Ababa, 19–20 September 2000

Name	Organization/Region	Position
Abaye Assefa	EWNHS	Executive Director
Abera Legesse	MoA	S.Agri. Engineer
Abreham Gelaw	Radio Ethiopia	Journalist
Adenew Feleke	ETV	Journalist
Adil Yusuf	Harrarege Region	Forestry Expert
Admassu Mamo	A.A Fire Brigade	Chief Fire Officer
Amare Worku	MoA	Forester
Andargachew Biru	Ethiopian News Agency (ENA)	Journalist
Argaw Beyene	MoA	Forestry Expert
Asfaw Gebreye	Dire Dawa Council	Forestry Expert
Assefa H/Mariam	Afar Region	Forestry team leader
Atnaf Agonafer	Benshangul Gumuz, BoA	Land use Expert
Azene Bekele	Ethio-Forest (NGO)	Director
Bateno Kabeto	MoA, Crop Production and Protection TRD	Dept. Head
Bekele Girma	AAU, Institute of Ethiopian Studies	Librarian
Belay Demisie	BoA, Amhara Nation Regional State	Dept. Head
Belete Geda	EPA	Expert
Belew Yenealem	Eth. Press	Journalist
Berhane G/Egziabehare	Eth. Press	Journalist
Berhanu Mengesha	GTZ / AAFA	Forest Mgt. Expert
Beyene Moges	ENA	Journalist
Birhanu Olana	ETV	Journalist
Bob Henson	Royal Netherlands Embassy	Diplomat
Bogalech Alemu	MoA, Women's Affairs Dept.	Dept. Head
Bruno Leclerc	AFD (French Development Cooperation Agency)	Representative A.A
Daniel Dana	SNNPRS	Forestry Expert
Dawit Berhanu	ENA	Journalist
Dawit Gezmu	NMSA	Junior Meteorologist
Dawit Girma	ENDA	Expert
Dawit Rebed	ETV	Journalist
Demel Teketay	EARO, Forestry Research Team	Director
Deribe Gurmu	Forestry Research Center / EARO	Head, Forestry Research
Dessie Tebekew	Amhara Region	Expert
Diro Bulbula	Oromiya Bureau of Agricultural Development	Dept. Head

Name	Organization/Region	Position
Edris Gudeta	Radio Fana	Journalist
Emiyayu Ejigsemahu	Menagesha Suba	Project Head
Ensermu Kelbessa	AAU, National Herbarium	Assoc. Professor
Ermias Bekele	World Wildlife Fund	Project Head
Feleke Alemu	MoA	Senior Expert
Flasse, Stéphane	Natural Resources Institute, UK	GIS expert
G/Kidan Teklu	MoA	Senior Expert
G/Medhin Hadera	Woody Biomass ISPP	Manager
Gedion Asfaw	Conservation Secretariat of Ethiopia / EPA	Technical Adviser
Getahun Bedane	MoA	PRS Expert
Getaneh Kassa	MoA	Computer expert
Gezahegn Tilahun	MoA	Forestry expert
Girum Tariku	Radio Eth. Eng. Program	Reporter
Goldammer, Johann	Global Fire Monitoring Centre, Germay	Director
H/Gebriel Yimer	Eletawe Addis	Journalist
H/Waregay	Bank pensioner	Veteran Banker
Habtamu Bogale	ETV	Journalist
Haymen Dagne	Ministry of Works	Sanitary Engineer
K/Mariam Jemberu	STC	Project Coordinator
Kassa Woyecha	SNNPRS	D/Head, BOA
Kasso Morka	Oromyyaa	D/Bureau, Head
Kifle Asfaw	MoA	Forestry expert
Kiflu Segu	WBISPP	Forest inventory
Kiros Kindaye	Ministry of Information	Journalist
Leykun Berhanu	MoA	Senior Expert
Mamushet Workneh	A.A. Fire Birgade	Training officer
Mateos Ersado	GTZ	Forestry Expert
Minassie Gashaw	AAU / Ethiopian Wildlife Conservation Organization	Student (Ph.D)
Million Bekele	MoA, Forest and Wildlife Team	Team Leader
Moges Worku	American Embassy	Reg. Env. Specialist
Mulugetta Hirpa	Ethiopian Heritage Trust	Forester
Muzemil Temam	Woreda 22	Adminstrator
Negusse Tefera	MoA	Head, Administration
Netsanet Tesfaye	MoA	PRS Expert
Peter Lowe	FAO, Accra	Regional Forest Officer
Seifu Mengistu	ETV	Camera Man
Seppanen, Harri	Namibia-Finland Forestry Programme	Consultant Team Leader
Seyoum G/Meskel	MoA	Forester
Sisaye G/Giorgis	EAO	Program Ass.
Tadasse Hailu	MoA	Senior Forest Expert
Tadesse W/Mariam	Bonn University	Forest Ecologist
Tamiru Habte	MoA	Dept. head
Tesfaye Gissela	NMSA	Team Leader

Name	Organization/Region	Position
Tewodros Abera	WIC	Journalist
Thao Uej	Chinese Embassy	Political Attache
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Tumicha Balguda	MoA	Forester
Johannson, Wesley	Embassy of South Africa	Ambassador
Worku Ayele	MEDAC	Team Leader
Yonas Yemeshaw	FRC/EARO	Senior Expert
Zerihun Bekele	Gambella BoA	Forestry Expert
Zerihun Tsgie	AA Agriculture Bureau	Head, Bureau
Zeynu Lema	IFMP, Adaba-Dodola	Forestry expert

Reporters: Deribe Gurmu

Mateos Ersado

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Editors: Sarah Howard-Sherlock and Sue Edwards

The GTZ and its Co-operation with Ethiopia

The Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH – German Technical Co-operation – in Eschborn near Frankfurt am Main, Germany, is one of the world's largest consultancy organizations for development co-operation. GTZ was established in 1975, is owned by the German government, and implements technical co-operation activities of the government.

In 130 countries of Africa, Asia and Latin America, and in the transition countries of Central Europe, more than 10,000 GTZ co-workers are helping to improve the living standards and opportunities for local people and preserve their natural basis of life within the framework of more than 2700 projects and programmes. GTZ's services focus on transferring technical, economic and organizational skills, and on support measures to upgrade the conditions for exercising these skills.

GTZ's main financing organization is the Federal Ministry for Economic Co-operation Development (BMZ). Increasingly, however, it is also. being commissioned by other German ministries, international institutions, and foreign governments to provide services. GTZ is a public-benefit company and primarily uses public funds for its operations. Any surplus which ensues is used exclusively for development co-operation projects.

Ethiopia and Germany can look back on a long-standing tradition of technical co-operation. It started over ninety years agi when, at the invitation of Emperor Menelik, the Royal Bavarian Government seconded a forestry advisor to Ethiopia who was instrumental in the planting of eucalyptus in the vicinities of towns and large settlements. This tradition of co-operation continued until a basic bilateral co-operation agreement between the two countries was concluded in 1964.

Following the bilateral agreement, a number of successful projects were undertaken. Among the early notable successful examples of the GTZ's involvement in Ethiopia were: the Felege Hiwot Hospital in Bahir Dar, the vocational training centre at Holetta, the Faculty of Engineering and Technology of Addis Ababa University, and the first years of the Institute for Biodiversity Conservation and Research (IBCR), then called the Gene Bank of Ethiopia.

It is, however, after the change in government in Ethiopia, in 1991, that the co-operation assumed a larger dimension and that GTZ's role as a development partner stands out clearly. GTZ projects are located in different parts of Ethiopia and are involved with various sectors that are particularly relevant to poverty alleviation: economic and social restructuring, support to setting up federal structures, water supplies and liquid waste disposal, agriculture and food security, environmental protection and natural resource management, family planning and primary education. This sectoral orientation matches the development priorities and potentials of Ethiopia.

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