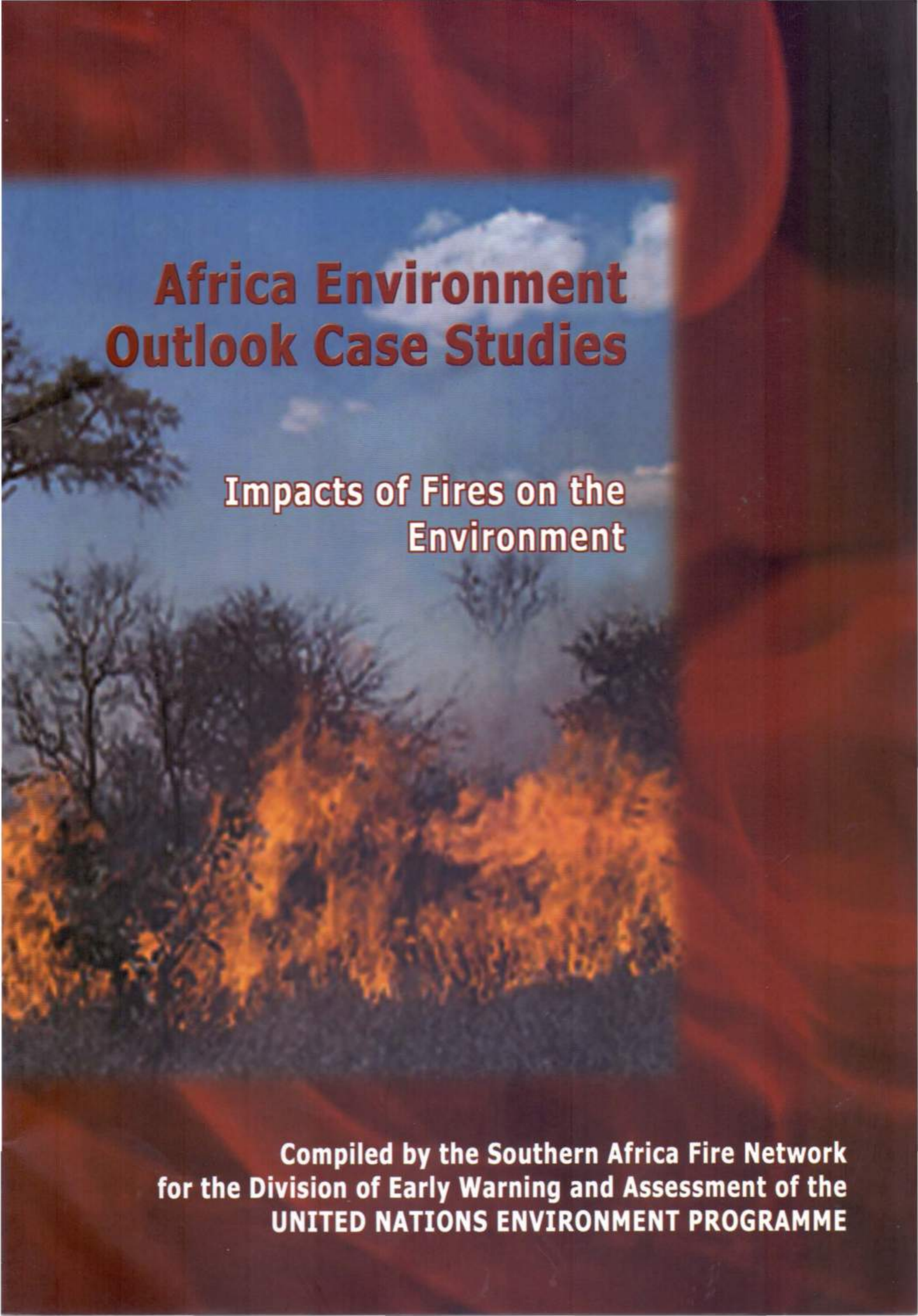

Africa Environment Outlook Case Studies

Impacts of Fires on the Environment

Compiled by the Southern Africa Fire Network
for the Division of Early Warning and Assessment of the
UNITED NATIONS ENVIRONMENT PROGRAMME

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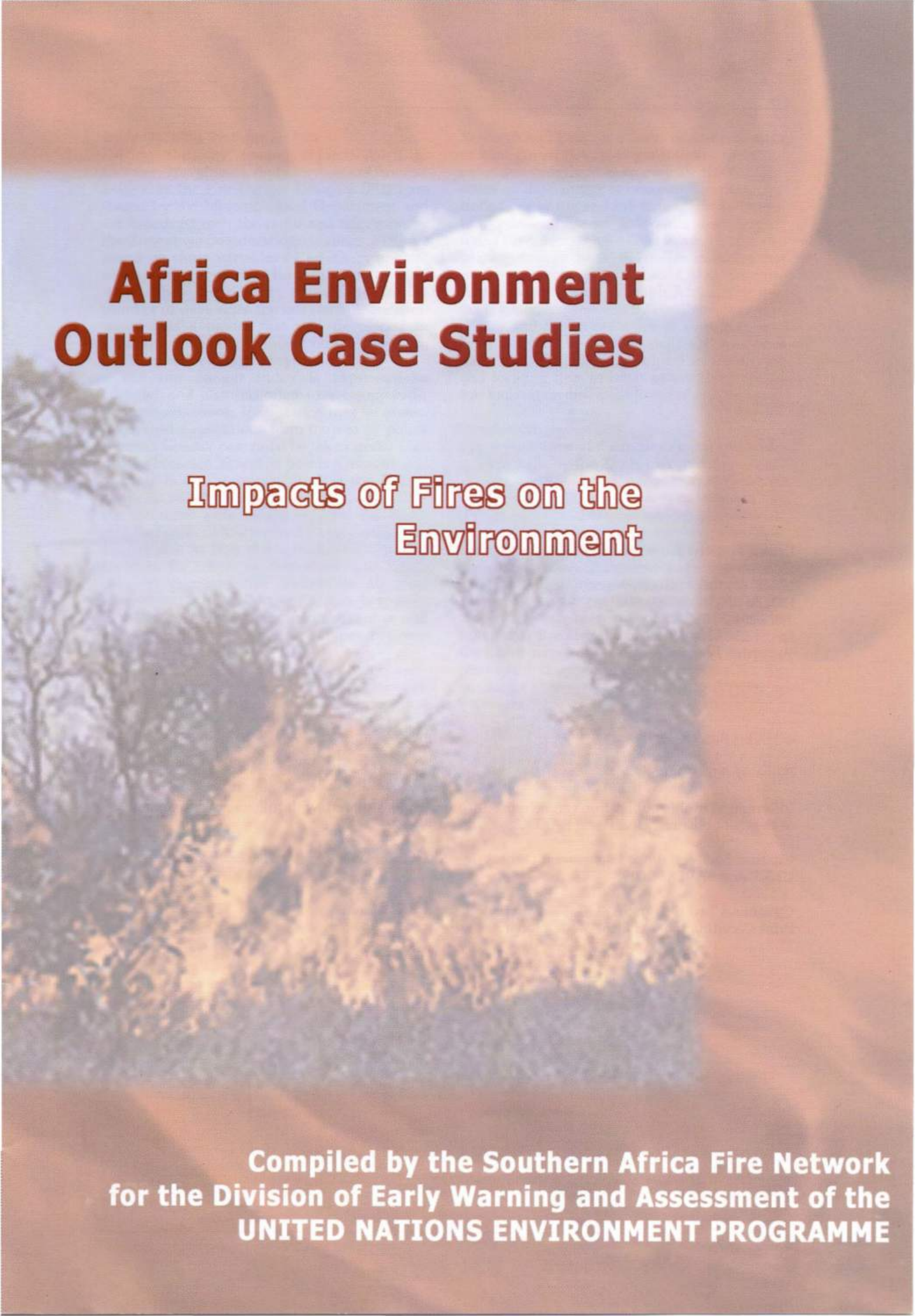

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CONTENTS

List of Boxes

List of Figures

List of Graphs

List of Maps

List of Tables

Background to the Case Studies

The 8th Session of the African Ministerial Conference on Environment (AMCEN) endorsed the preparation of an Africa Environment Outlook (AEO) report with the assistance of UNEP, to provide a comprehensive scientific assessment of the environment, policies and environmental management programmes in Africa. The report was launched at the 9th Session of the AMCEN, which adopted the AEO as a tool for monitoring sustainable environmental management in Africa and also to act as the environmental reporting framework at national levels.

The first AEO report (AEO-1) was published in 2002. The second AEO report (AEO-2) was launched in 2006. AEO-2 aims to:

Profile Africa's environmental resources as an asset for the continent's development. It highlights the potential of the region's natural resource base to support the development agenda of NEPAD and the opportunity cost of its misuse. AEO also serves as a monitoring and evaluation tool for the implementation of the programmes and activities contained in the Action Plan on the Environment Initiative of NEPAD.

Fire was not considered a major environmental issue in Africa in both AEO-1 and AEO-2 reports. However, SAFNet was invited to participate in the AEO-2 and GEO-4 Regional Consultative Meeting in April 2004, Nairobi, Kenya and this provided the opportunity to introduce fire in the AEO reporting process.

The frequency of fires and total surface area burnt annually has increased over Africa. The timing of fires has also changed. These new fire regimes have a potential to cause significant negative impacts on ecosystems goods and services and ultimately affect livelihoods, reducing the potential to take advantage of environmental opportunities.

Fires contribute green house gases and have a role in climate change processes. African Governments have limited capacity to address fire issues.

Widespread poverty and other stresses continue to make fire an integral part of land use management for the rural based African communities. Under natural conditions, fires have a positive role in ecosystem processes. As a result fire needs to be included in all environmental assessments to facilitate the development of guided policies on fire as an environmental asset and reduce its potential to constrain development.

It was behind this background that UNEP Division of Early Warning and Assessment (UNEP/DEWA) engaged the Southern Africa Fire Network (SAFNet) to facilitate the preparation of focused information on fire and a network of fire experts in the continent to guide the process of incorporating fire issues in the AEO process.

SAFNet facilitated the production of five case studies over Africa on:

Veld fires and their impacts on the environment and human vulnerability, the different policy responses and institutional frameworks. The case studies use satellite imagery to highlight environmental change due to fire and its impact on human vulnerability.

SAFNet organize a planning workshop that reviewed the case studies, determined a strategy for contributing in the AEO process, fire early warning and policy issues.

These case studies covering Botswana, Namibia, Zimbabwe, Tanzania and Senegal were presented at the Fifth SAFNet workshop: "Towards Meeting Fire Management Challenges in southern Africa" held in Mangochi, Malawi, 9-13 August 2004. The workshop was sponsored by UNEP/DEWA, the governments of Belgium, Ireland, Norway and the Netherlands, and UNEP Environment Fund. Technical support and satellite images were provided by NASA Land Cover Land Use Change and NASA Application Programmes START.

The case studies in this report provide a profile of the fire issues across Africa. Taken together they provide good comparison between major sub-regions of Africa in terms of use, causes, effects and human vulnerability to fire, technologies for monitoring fires, current and historical policy and institutional frameworks used to address the issue of fire.

The case studies were edited and designed by the Southern African Research and Documentation Centre (SARDC). SARDC also coordinated the printing of the book.

Fire Case Study Countries

BOTSWANA

Opha P. Dube[1] and J.G. Mafoko[2]

Abstract

Fires are common in Botswana and are considered part of the evolution of the savanna vegetation type found in the country. Different land use systems in Botswana have also evolved with fire.

The extent of burning in the country is not only closely linked to rainfall, which determines the amount of fuel load, but also land use, which results in most fire outbreaks.

The rise in population coupled with changes in land use management, poverty and other stresses such as HIV and AIDS have led to greater reliance on fire as a land management tool. This increases the risk of fire outbreaks, which contributes to human vulnerability. Frequent fires result in changes in the vegetation cover density, species and structural composition that ultimately influence hydrological processes, wildlife habitats and the supply of veld products.

A large section of the population relies on veld products for food and as a source of income. The tourism and livestock industries are directly dependent on the supply of natural resources, which are susceptible to frequent burning. It is for this reason that the fire management strategy in Botswana is focused on fire suppression. However, the leading agency in fire management, the Agricultural Resources Board (ARB) in the Ministry of Environment, Wildlife and Tourism has limited resources to effectively monitor and manage fire. The Herbage Preservation Act of 1977 guides fire management but there is no fire policy.

Most fires are not recorded and information on the area burnt and the frequency of fire is based on rough estimates. It is difficult to assess trends in fire history and the implication of this on natural resources and human livelihoods. Incorporating geo-spatial technologies in fire management in Botswana could greatly improve this situation. Satellite data is valuable in assessing the risk of fire danger, monitoring active fires, determining extent of burn scars, and in assessing post fire recovery.

Botswana's role in the Southern Africa Fire Network (SAFNet) is to facilitate access to information on the use of satellite based products in fire management and to help raise the profile of fire in the country and in the region given that fire is a potential trans-boundary problem.

Introduction

Fire, as part of natural processes, has a positive role in the vegetation structure and composition, and helps recycle nutrients contained in old and dead trees. There is, however, concern that the frequency, extent and pattern of burning are increasing due to human activity. For example, fires burnt about 20-30 per cent of Botswana between 1996 and 1997 (Central Statistics Office, 2000). It is believed that the damage from these fires has grown to outweigh the benefits of fire on the ecosystem.

Botswana is semi-arid, and there are several instances when rains fail following burning. This leaves the ground exposed for long periods which exacerbates land degradation and deprives livestock, wildlife and people of livelihood resources especially during periods when demand for these resources exceeds supply. Fires destroy soil microbia, timber and non-timber products, including forest-based services such as recreation, and cultural heritage sites. In addition, infrastructure and property are lost while uncontrolled fires also threaten lives of people, livestock and wildlife. Uncontrolled fires have negative impacts on the economy although so far there are no studies that have attempted to quantify the cost and benefits of fires in the country.

It is, however, worth noting the importance of fire as a management tool in the regeneration of natural and pasture vegetation. Not only is it important in the regeneration of vegetation but it also reduces levels of unwanted pests. Fire as a cheap management tool should not be used without enough knowledge of the season outlook that gives the likely rainfall amounts, wind speed and its direction.

Socio-economic Profile of Botswana

Botswana has a population of 1.7 million people, 70 per cent of whom live in rural areas (Kalabamu, 1994; Republic of Botswana, 2003). With a per capita GDP of US$3 135 in 2001, the country fell under the middle-income developing country category (Ministry of Works,

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Transport and Communication, 2001; Botswana National Agenda 21 Coordinating Committee, 2002). Despite growth in the economy, about 48 per cent of households in 1985/6, and 38 per cent in 1993/4 were below the poverty datum line (Buchanan-Smith, 1998; Botswana National Agenda 21 Coordinating Committee, 2002).

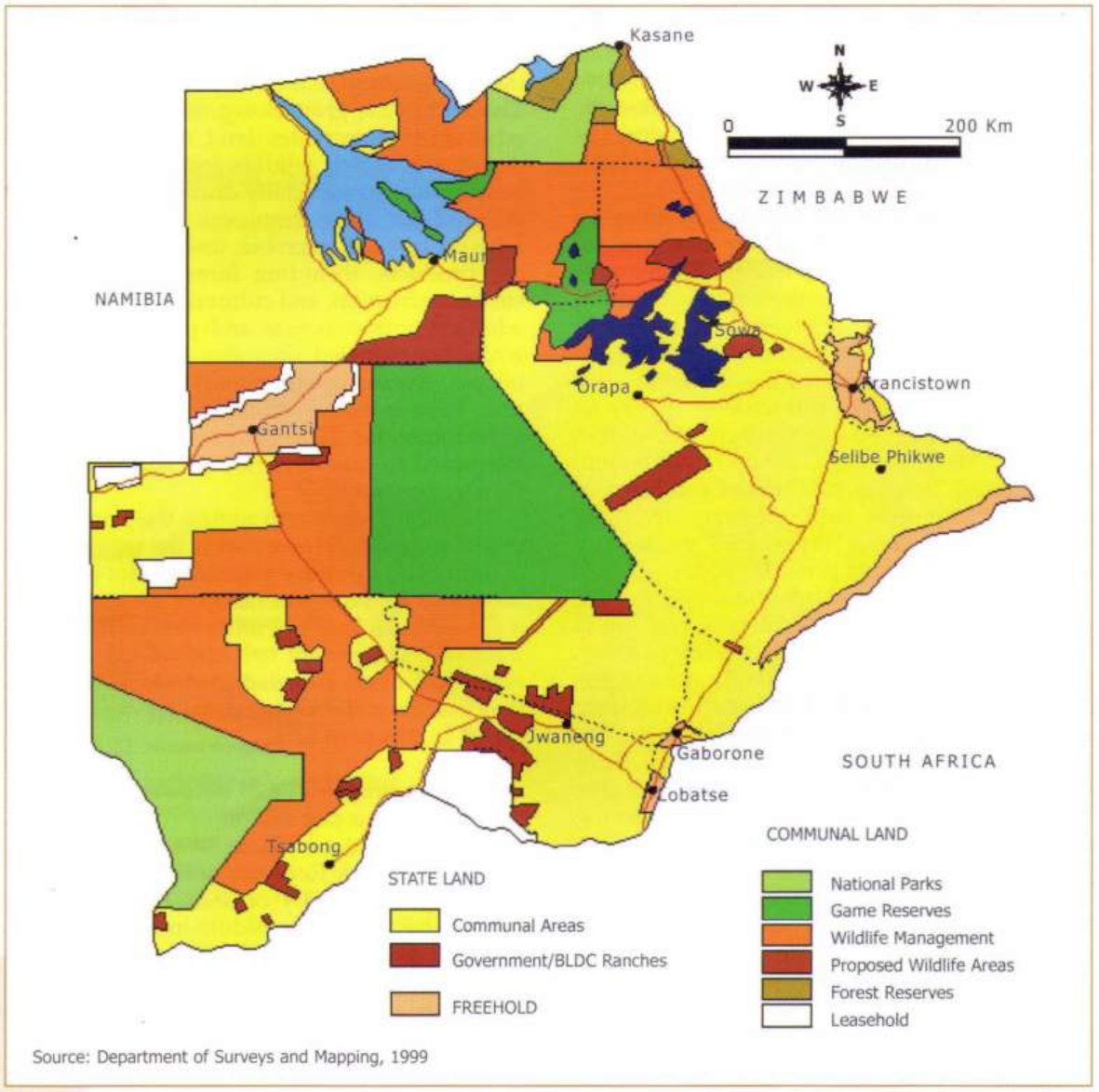
Most of the poor households are female-headed and found in rural areas where they are mainly engaged in subsistence mixed farming (livestock rearing, arable farming and gathering veld products). Fire is the cheapest and easiest tool to use for these households to meet different needs such as clearing fields.

The communal land tenure system where most of the subsistence farming is practiced is makes up about 70 per cent of the country (Map 1). Protected areas account for 17 per cent of the country's total surface area, while 13 per cent is made up of freehold and Government farms (Moyo et al., 1993; Ministry of Works, Transport and Communication, 2001). A significant number of fires are lit in communal areas but eventually spread into other land tenure systems.

Climate

Botswana falls within the centre of the southern Africa landmass extending over an area of about 582 000 square kilometres (Ministry of Works, Transport and Communication, 2001; Botswana National Agenda 21 Coordinating Committee, 2002). The country has a semi-arid climate characterised by extreme events particularly, drought which reduces the risk of fire. Periods of above average rainfall also occur and these are usually followed by widespread fire events due to abundant fuel load. Rainfall declines towards the west of the country and the average annual rainfall

Land Use in Botswana Map 1



Source: Department of Surveys and Mapping, 1999

ranges from 200mm in the southwest to 650mm in the northeast (Ministry of Works, Transport and Communication, 2001).

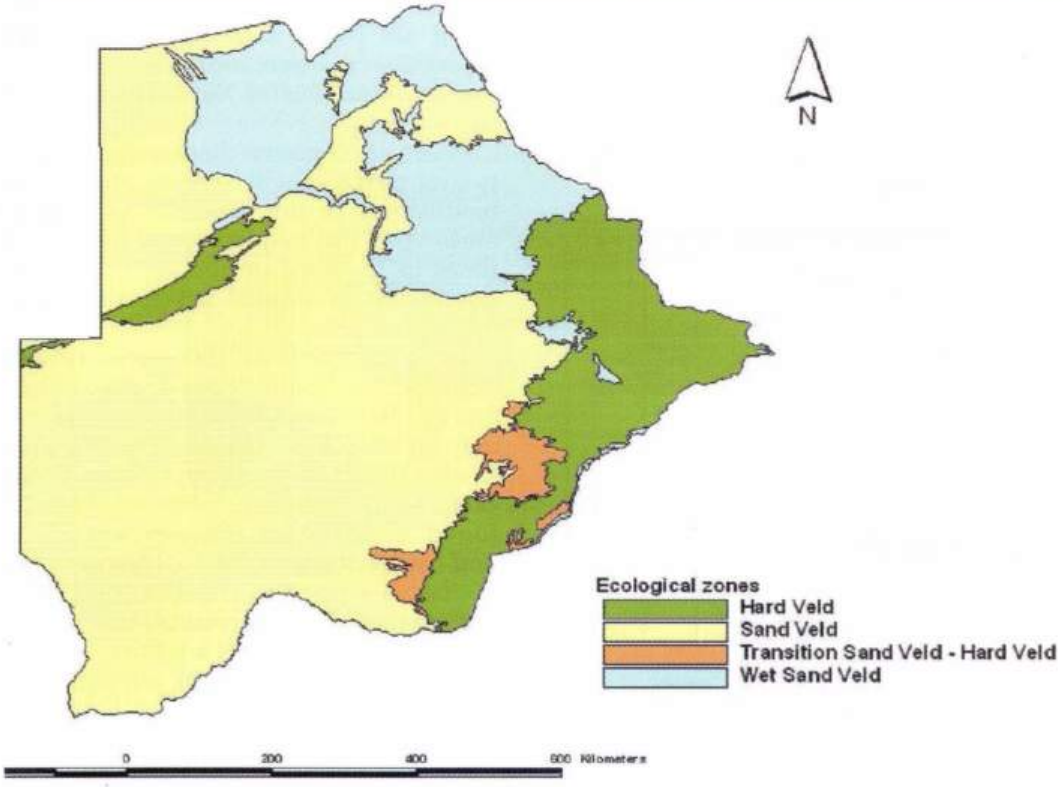
The mean monthly maximum temperature ranges from 20 - 29°C in winter to 30 - 35°C in summer. Due to low humidity night time mean temperatures regularly drop to near zero in winter (Ministry of Works, Transport and Communication, 2001). The long dry season spanning from around May to October provides favourable fire conditions particularly after sufficient rainfall has been experienced. Conditions are generally windy with low humidity and hot temperatures after July. The peak of the fire season is September, but most natural fires occur between October and November when thunderstorms are experienced. This was probably the peak of the natural fire season before human induced fires became widespread.

Land Use Systems and Patterns of Fire

In general, there are three major land use systems, the hardveld, the dry sandveld and the wet sandveld (Map 2). Most of the population and development infrastructure is found in the eastern part of the country, the hardveld, which has loamy soils that are more suitable for cultivation. The hardveld supports more palatable pastures and as a result has a longer history of human settlements and livestock production. For this reason it generally has lower fuel loads to sustain large fires (Map 3 and Figure 1). Most fire scars in the hardveld tend to be small because fires can be spotted and put out quickly or infrastructure such as roads acts as barriers preventing the fire from spreading. This is in contrast to the Kalahari sands, known as the sandveld, covering about 80 percent of the country (Thomas and Show, 1991; Botswana National Agenda 21 Coordinating Committee. 2002.) (Map 2, Map 3 and Figure 1).

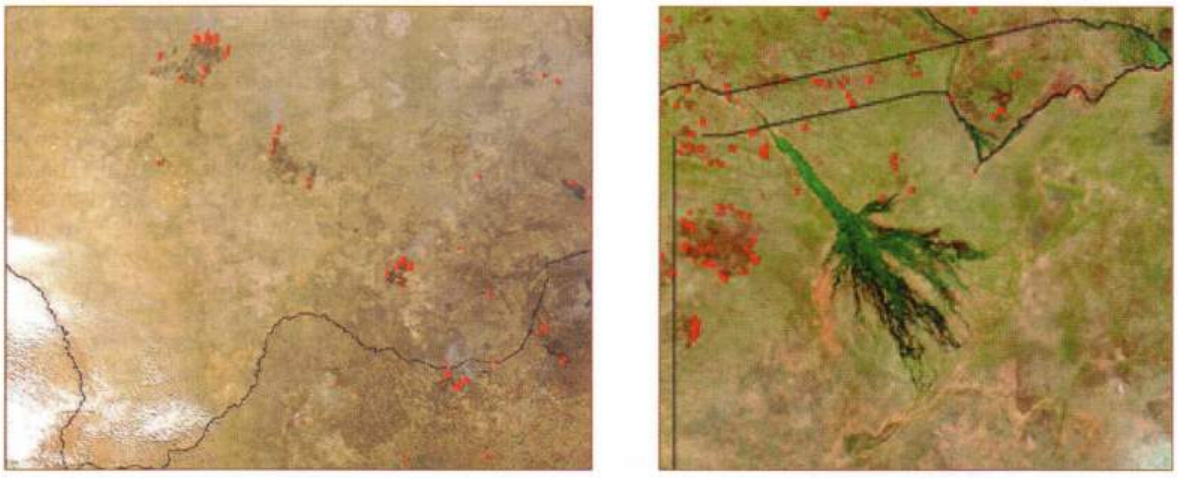
The dry sandveld found in the central and western parts of the country is dominated by shrubland with a dense, generally unpalatable grass layer and this combined with the dry hot weather results in high risk of fire (Maps 2 and 3). The far south-western corner where rainfall is below 200 mm has a more desert environment (Thomas and Shaw, 1991), and as a result there are limited fire incidents. Although the cattle industry expanded into the sandveld from the 1930s, areas of intensive grazing are localised due to limited availability of freshwater. Further, a large section of the sandveld comprises protected areas such as the Central Kalahari Game Reserve (CKGR) and these accumulate large fuel load which when ignited

Botswana Ecological Zones Map 2



Source: Ministry of Agriculture, 2003.

Active Forest Fires in Botswana Figure 1

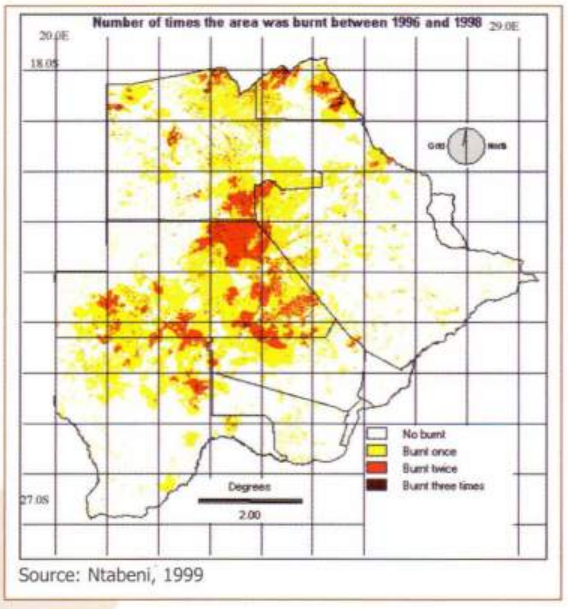


Active Fires (shown as red dots) captured on MODIS 1 km spatial resolution fire product. On the left are active fires in the dry sandveld - central to west and on the hardveld south-eastern parts of Botswana: 29th July 2002. On the right, the image shows active fires on the wet sandveld north-western part of the country (on the border with Namibia) with a lager fire west of the Okavango Delta: July 2001 (http://rapidfire.sci.gsfc.nasa.gov.).

results in large fires. Map 2, shows that most of the areas that burnt twice in the central parts of the country between 1996 and 1998 fall under the CKGR. Most of the sandveld is still not easily accessible which makes it difficult to detect fires in their early stages, resulting in large areas being burnt in each fire incident in contrast to the hardveld.

The wet sandveld in the northern part of the country is dominated by the lacustrine systems (Lake Ngami, Mababe and Makgadikgadi pans) and the alluvial systems such as the Chobe-Linyanti and the Okavango Delta in Ngamiland District, a classified wetland which is protected under the Ramsar Wetlands Convention (Thomas and Shaw, 19991). The wet sandveld is the most attractive to tourists due to availability of water and abundant wildlife. Because these areas generally have higher moisture content, large protected areas in the form of Game, Forest Reserves and National Parks, and are sparsely populated, they support more dense vegetation and as a result are prone to annual burning (Fig. 1). About 110 fires were reported between January and April in 1981 in Ngamiland District only (ARB, 1981).

Fire Frequency over Botswana from 1996 to 1998 Map 3



Source: Ntabeni, 1999

There are concerns that increased fire activity over the Delta will have negative impacts on biodiversity of this wetland. In Map 3 most areas with fire frequencies of between 4 – 10 times in 15 years are found in the Okavango floodplains grasslands which are flooded frequently.

In some parts of the wet sandveld, for instance the Chobe District, vegetation damage by elephants contributes to availability of dry material that can be ignited easily. The Chobe District is home to at least 60 000 elephants out of a large population of 130 000 found in Botswana (Department of Wildlife and National Parks, 2003). However, this part of the country also experiences the highest annual rainfall in the country (650 mm) and as a result miombo forests are supported. Fires in this area generally burn slowly, are more intense and exhibit crown torching on windy days. This is in contrast to the rest of the country where limited wood fuel results in faster and less intense fires.

Causes and Effects of Uncontrolled Fires

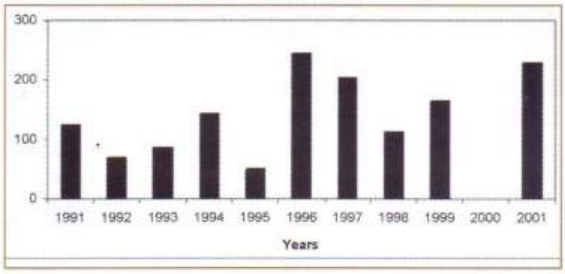
Causes of Fires

The Agricultural Resource Board (ARB) field reports (unpublished material) attribute 90 per cent of all fires to human causes. Most causes of wildfires in Botswana are related to land use. For the rural population fire is a cheap and easily available alternative to expensive human labour or modern equipment (Table 1). Although the use of fire has a long history, widespread poverty and other socio-economic challenges such as migration to urban areas and diseases such as HIV and AIDS, result in shortage of labour in rural areas, causing an increase in reliance on fire. Female-headed households constitute the majority of the poor and are more likely to suffer shortage of labour making the use of fire a necessity for this group (Buchanan Smith, 1998). Unfortunately it is during these positive uses of fire that uncontrolled fire outbreaks occur and because the users are already resource poor they are less likely to deploy adequate resources to suppress an active fire (Graph 1). Ironically it is also the same group that is most affected by fire damage.

The number of fire outbreaks is related to rainfall and as a result few outbreaks were reported over the drought years; 1992, 1993, 1995 and 1998 due to limited fuel load (Ministry Of Environment Wildlife And Tourism – ARB, 2003).

Indications are that farmers, hunters and gatherers of veld products cause the majority of fires (Table 1 and Graph1). There are few cases where wildfires are caused by lightning. It is estimated that lightning accounts for about 10 per cent of the fires in the country (Ministry of Works, Transport and Communication, 2001; Botswana National Agenda 21 Coordinating Committee. 2002). This is due to the fact that thunderstorms seldom occur in the period between May and October, when dry fuel load is abundant but occur mostly from November to April.

Fire Outbreaks in Botswana (1991 to 2001) Graph 1



Effects of Fires

Used properly, fire is a very essential management tool in Botswana as in the rest of Africa (Table 1) (Frost, 1998). For most rural communities controlled use of fire is a necessity and is part of sustainable livelihoods.

If the frequency is within the required threshold wildfires have a positive role in the vegetation structure and composition, and help to recycle nutrients. The ecological benefits of fire on the savanna ecosystem in general have been documented (Bond et al., 2004) but there are no

Potential Sources of Fire Outbreaks in Botswana Table 1

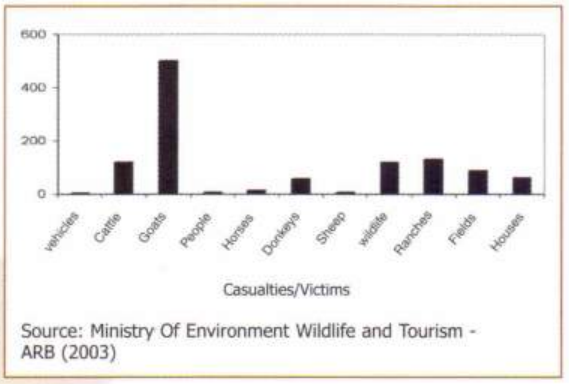
Type of user	Description of fire use
Livestock farmers	Fire lit towards end of the dry season to remove litter and stimulate growth of new grass. Other uses include controlling pests such as ticks and tsetse-fly.
Arable farmers	To remove unwanted biomass while clearing lands
Hunters (Also poachers)	Hunters use fires to open up dense forest to ease their movement and detection of wild animals.
Fishers	In the Okavango Delta floodplain fires are set just before flooding to open the area for fishing and increase production of phytoplankton.
Safari companies	Burning is done to attract wildlife to the new re-growth and hence increase chances for tourists to view and photograph game.
Road maintenance	Fire is used to assist in clearing vegetation that obstructs visibility along roads and attract animals to roads resulting in accidents.
Smoking	Accidental fires: These result from burning cigarette stumps and are visible along railways and major roads.
Domestic uses	Fires resulting from use of fire for warming, cooking and for security by hunters, herders, and gatherers of veld products such as thatching grass. Some of these may start by the roadside where campsites are usually located.

studies focused specifically on Botswana. Understanding the ecological benefits of fire will enhance the benefit of fire in land use management. For example, fire can kill emerging bush species, which helps to control bush encroachment and maintain open grasslands that are more appropriate for livestock production. Strategic application of fire could prove very useful for livestock managers in Botswana under future climate change when woody vegetation will be more supported due to a combination of warmer and drier climate conditions and elevated carbon dioxide (Bond and Archibald, 2003). Others believe that the current widespread bush encroachment in the country is partly due to fire suppression strategies that have been applied since the colonial period (Sporton and Thomas, 2002).

The problem associated with using fire as a management tool is that most of the uses occur over the dry season when dry flammable fuel load is abundant and weather conditions favour quick spreading of fire. As a result it is common for such fires to go out of control and extend beyond the original area planned for. Frequent occurrence of fires result in several negative ecological and economic consequences. People may die or get injured from the fire, lose property or they may be displaced from their homes (Dipholo, 1985). For the poor without insurance, loss of property due to fires contributes directly to poverty. Further, during an outbreak of fire many government officials and equipment are diverted from their normal duties to assist with suppression.

Graph 2, shows large losses in small stock such as goats and this is a concern because these normally contribute significantly to the well-being of the family, providing milk and meat, and are used to generate income for other household needs. Women usually have greater access to goats hence the important role of goats in the well being of the family. Because small stock is important for the poor households, fires have a potential to impoverish further those who are already poor.

Fire Damage Botswana 1991-2001 Graph 2



Source: Ministry Of Environment Wildlife and Tourism - ARB (2003)

The estimated losses shown in Graph 2 do not represent the full extent of the loss caused by fire, leaving out such resources as timber in Forestry Reserves, pasture and veld products in communal areas. For wildlife, fire results in changes in vegetation structure, which gives rise to changes in wildlife habitat structure. Predators such as lions, leopards, and cheetahs are attracted to burnt areas because of the availability and vulnerability of prey attracted to emerging green fodder in burnt areas but with no hiding places. A burning fire coinciding with animal migration periods will change the annual migration pattern of wild animals with implications on their survival as their migration routes will be impassable during the fires. However, Wright and Bailey (1982) have noted that, death of large animals directly due to fire is rare. Death is usually due to suffocation and primarily affects species with small home ranges (Chew et al., 1958).

There are a number of Community Based Natural Resources Management (CBNRM) projects in the country that rely on wildlife to generate income (Botswana National Agenda 21 Coordinating Committee, 2002).

Fires that occur in the early part of the dry season (June/July) result in cattle losing feed for the whole dry season and if rains are late or do not come, this will have a devastating long-term effect on farmers. After losing grazing pasture to fire, farmers are forced to divert resources to either buying livestock feed or moving animals to other places where they may cause congestion resulting in long-term loss of productivity due to land degradation processes. In a semi-arid climate post burn recovery is generally slow, and if rains fail, burnt areas are left exposed to agents of soil erosion such as heat and wind for long periods. Some of the off site consequences of veld fires include sedimentation of streams and rivers and reduction of the capacity of water reservoirs. However, research is required to assess how fire contributes to land degradation in Botswana relative to other activities such as overgrazing (Dube and Kwerepe, 2000).

Evolution of Fire Management

There are no studies on the history of fire management in Botswana. However, from general history traditional institutions and culture played a significant role (Tlou, 1985). Most of the current uses of fire were practiced in the past but the role of fire for security purposes, communication, hunting and disease control was probably more important than is the case now.

The *Basarwa* used fire, as part of hunting but it is not known exactly when fire was lit and what precautions were taken before burning. *Basarwa* lived in small nomadic groups, and as a result it is less likely that they neither engaged

in organised fire suppression expeditions nor was this necessary for their lifestyle (Dube, 1992).

For the pastoral Batswana ethnic groups living in large communities the Chief *(Kgosi)*, was the head of the group and he/she managed resources on behalf of the community with the aid of his/her uncles or juniors (*Dikgosana*), and with labour organised in the form of regiments (*Mephato*) (Schapera, 1951; Dube, 1995). All fires had to be reported to the chief so as not to mistake them for communication fires. Where a fire was a threat to property and people, *Mephato* must have been engaged to suppress the fire as was the case with other dangers such as an attack by wildlife or another ethnic group. Judging from other activities such as setting dates for ploughing, the Chief with the aid of *Dikgosana* had a role on the use of fire in terms of permission to burn, where and when to burn for common land uses such as hunting and regeneration of pasture. There were measures taken against those failing to comply (Schapera, 1951). The chief also had the power to punish those who refused to help in fire fighting. As a result it can be inferred from the historical period that:

- Since the population was sparse, large fires were supported as fuel loads were generally high. It must have been common for fires that were not a danger to people and property to be left to burn until natural barriers such as rivers or rain stopped them as large areas were unoccupied and there were limited resources to handle large fierce fires. It is likely that people and wildlife died from some of these fires.
- The frequency of fire was low since the population was sparse and there was a coordinated system on when to burn for various uses resulting in a more predictable fire pattern. Fires due to lightning dominated some areas.
- Cooperation to suppress fires was achieved, as orders from the chief were obeyed.

The colonial period leading to the introduction of western model systems of governance marked the beginning of a process that eventually weakened chieftainship and changed lifestyles of groups such as the *Basarwa* resulting in different fire regimes. Colonial records show that a fire suppression approach was more favoured primarily due to the unpredictable rainfall (Zimmerman, 1985). However, Chiefs continued to have a role in mobilising labour to suppress burning fires.

The introduction of technologies to drill boreholes and improvements in road transport facilitated the expansion of the cattle industry into the Kalahari sandveld and this increased the frequency of fires (Dube, 1992). Due to problems of accessibility such fires burnt for days. Expansion into the sandveld and other socio-economic changes introduced dispersed settlements making it difficult for the Chiefs to maintain coordinated management and use of land resources including management of fire (Dube, 1995). These changes gave birth to different fire regimes as different users set fire for their own needs and at their own time without consulting other parties. Such practices resulted in conflicting periods of burning and change in the timing of fires, a problem that is widespread today.

The removal of the administration of land from the Chiefs after independence and the introduction of different land tenure systems such as communal land, National Parks, Game and Forestry Reserves, freehold and state land further weakened the role of traditional institutions in fire management and also changed fire patterns in the country. In general, in communal areas there are no clear individual responsibilities to land resources and as a result uncoordinated burning has continued and there is growing reluctance to assist in fire suppression. Fire is prohibited in protected areas while in freehold areas the owners are at liberty to burn as planned. However, fires have no respect for boundaries, and as a result fires from communal areas often spread into protected areas and into freehold land, where large fuel exists resulting in greater damage. It is partly against this background that the Agricultural Resources Conservation Act of 1974, which provides for the conservation of all natural resources in Botswana from any damage, be it natural (fire, floods) or artificial was put in place. The same Act also provided for the establishment of the Agricultural Resources Board to implement provisions of the Act.

Later the Herbage Preservation Act also known as Fire Prevention Act of 1977 was enacted and this provides for regulations governing the use and control of fires as follows:

- The issuing of burning permits to carry out prescribed fires.
- The power to request assistance in putting out fires.
- The protection of life, person or property by counter-firing.
- Construction of fire breaks to reduce wildfires and their impacts.

The division of the ARB, which recently, moved to the Ministry of Environment, Wildlife and Tourism is the custodian of this act. While ARB has the overall responsibility to manage fire, the Department of Wildlife and National Parks has a similar mandate but restricted to protected areas such as National Parks and Game Reserves. This can be a problem as most fires in protected areas spread from the communal lands adjacent to these areas.

Current Status of Fire Monitoring and Management

Fire Prevention

ARB has applied different approaches over the years to implement the Fire Prevention Act of 1977, including:

Firebreaks: ARB has over the past years embarked on the construction of firebreaks throughout the country. A network of firebreaks up to a total of 10 000 km has been constructed countrywide and is repaired every year to reduce the risk of spreading fires (ARB Secretary's Report, 2000).

The Agricultural Resources Conservation Act of 1974 requires construction and maintenance of firebreaks. As a result the ARB can be sued for failure to maintain firebreaks. In some cases private companies have been engaged to construct firebreaks (ARB Secretary's Report, 2000).

The construction and maintenance of firebreaks has proved to be very expensive. By the end of 2003, only 45 per cent of the total 10 000 km firebreaks were maintained due to financial constraints and lack of equipment. Furthermore, there are no indications that firebreaks have helped to reduce fire outbreaks judging by the incidents of fire noted above. However, firebreaks have reduced cases where fires from one land tenure system spreads to another, in particular from communal areas to other land tenure such as Game Reserves.

Public education: ARB also provides education through public gatherings, radio, national television, and other educational materials in order to enlighten people about wildfires. Signboards bearing messages such as "Se Tshube Naga" and "Somarela Matlotlo A Tlholego" Interpreted As "Do Not Burn the Forest" and "Conserve Natural Resources" are common throughout the country. In addition Conservation Committees are formed in different villages to assist in engaging communities in natural resource conservation and control of fire. It is not clear if these education campaigns have changed attitudes on fire.

It has been shown in Ghanzi in the western part of the country that communities did not take ARB education efforts seriously and they felt that the campaigns were inadequate (Mosweu, 2004). There is need to evaluate the education strategies used including the message signboards to formulate more effective approaches.

Under the Fire Act it is an offense punishable by law to cause a fire and anybody using fire needs to seek permission and also inform neighbours of their intention before doing so. Most people find it cumbersome to apply for a fire permit and there is no information to indicate how people may apply for fire permits, and how long it takes to get one. As such the ARB finds it difficult to take measures against those breaking laws.

First there are no resources for policing and secondly the public is reluctant to come forward with information on fire outbreaks. Since fire is widely used, individuals realise that there is always a chance that they too could cause an uncontrolled fire by accident and get reported.

As a result most fires are never reported and therefore, suspects are never arrested and it is difficult to analyse trends in causes of fire. This is one of the negative consequences of a stringent fire suppression approach. A more participatory approach to fire management needs to be considered.

Fire Monitoring

Fire detection relies on patrols by the ARB, but this Department is generally understaffed and poorly resourced. Reports by villagers, civil servants, lodge owners as well as small aircraft Safari pilots complement the ARB effort. Members of the public are likely to be the first to detect a fire.

As noted above there is general unwillingness by members of the public to report fire outbreaks as people fear that they may end up helping with investigation on causes of the fire. However, in other cases failure to report is due to ignorance on the wider impacts of fire on the environment and on the productivity of natural resources, which sustain their livelihoods. There is generally a tendency not to be concerned if the fire is not a direct threat to one's property.

Another form of detection is by use of fire towers, which is common in Chobe District. Deploying field assistants to work on fire lookout towers is costly as this is a 24-hour task during the fire season. Delayed deployment results in greater expenses because if a fire escapes its initial stages it becomes difficult to suppress. At present the posts are under utilised.

The current fire detection methods used in Botswana are therefore not systematic and are generally unreliable (Monageng, 1985). Further, where a fire is detected it is not always possible to deploy fire control forces early enough to suppress it before it spreads over large areas.

In order to improve fire monitoring, attempts have been made to incorporate information from satellite data.

Initial attempts in the late 1980s used hardcopies of Landsat MSS data to map fire scars but this was constrained by the cost of the data.

In 1996 the Department of Meteorological Services (DMS) acquired a PC-based NOAA receiver to provide data from the NOAA Advanced Very High Resolution Radiometer

(AVHRR) sensor. AVHRR data was used to map fire scars and vegetation cover. For early warning purposes DMS issued two reports each day – the Pilot Active Fire Action Report (PAFAR) and the Active Fire Impact Report (AFIR). The objective of the PAFAR was to alert fire management agencies (ARB) of possible fire, with a target time of 1100 hrs each day. The AFIR was issued with a target time of 1600 hrs each day but in contrast to PAFAR also included information on communities, land use and infrastructure that could have been affected by the fires. These products were evaluated under the Range Inventory and Monitoring Project (BRIMP) carried out by the Range Ecology Division of the Ministry of Agriculture in collaboration with ARB (Graph 2) (BRIMP, 1998).

However, the use of NOAA AVHRR data in fire monitoring was short lived due high incidents of false fire and fire scar detection. Limited skills in image processing also compounded this problem (Flasse, 1998). Nevertheless the development of the MODerate Resolution, Imaging Spectoradiometre (MODIS) that has special fire channels designed to saturate at about 500K and 400K, respectively has significantly reduced the potential of false fire detection experienced with AVHRR data.

Botswana participated in the validation of the MODIS fire products under the University of Maryland and NASA project facilitated through SAFNet (Roy et al, 2005). MODIS active fire products are available in the public domain on a website hosted by the Geography Department of the University of Maryland, USA (Website: http://maps.geog.umd.edu). However, these products remain inaccessible for use in operational fire monitoring in the country due to a number of constraints some of which include, insufficient Internet services to access the data and limited human resources in ARB.

Towards Reducing Vulnerability to Fire Outbreaks

In order to effectively control fire there is need to take into account different land use needs for fire so as to incorporate these into fire control strategies. This will improve coordination of burning by different users and facilitate focused education on how to prevent unplanned fire outbreaks.

Education on preventing fire outbreaks needs to be carried out through existing community based organisations and NGOs that are already dealing with natural resources. As a result there is need to review the current management approaches to clearly reflect the fire needs of different land uses because fire is integral to maintaining sustainable rural livelihoods while at the same time land use is the major source of unwanted fires.

A national fire danger rating system should also be developed and communicated to land use managers. Information on the major land systems and land use types of Botswana is available as baseline data from the Department of Meteorological Services (DMS) to assess fire risks relative to rainfall variability and other weather parameters.

Annual change in fuel load can be provided from satellite data products such as NOAA AVHRR, MODIS and more recently the Meteosat Second Generation data which is also being received by DMS. However, resources to access, process and use these different data types for fire early warning needs to be put in place in different institutions concerned with fire management. Without this structure in operational form the country remains vulnerable to fires particularly after very wet periods.

Fire management should incorporate the ecological role of fire. This requires information on the interactions between fire and different vegetation types found in the country. This will help to determine if current fire frequencies are a danger to the ecosystem.

Such knowledge is important for planning prescribed burning. So far there are limited studies focusing on the ecological role of fire in the country and there is limited prescribed burning practiced. Total exclusion of fire particularly in protected or sparsely populated areas promotes conditions for increased vulnerability to fire danger resulting from accumulation of fuel load.

Archiving and easy retrieval of information to assess fire history and trends is an important part of effective fire management. All satellite products need to be validated and the availability of both current and past ground based fire records is important in this process. Currently there is no fire database in Botswana. Lack of historical records constrains attempts to construct fire frequency records, to make predictions and to assess future vulnerability to fire.

On a regional scale fires have a role in greenhouse gas emissions. Botswana is a signatory of the United Nations Framework Convention on Climate Change and is therefore expected to provide a national inventory of sources and sinks of greenhouse gases. So far it is difficult to accomplish this requirement for fire because of the limitations noted above on fire monitoring. An ineffective fire management system increases the vulnerability of the country to climate change in future as studies have shown that fierce fires are likely to occur in future following very wet periods (Rutherford et al., 1999; Dube, 2003).

Botswana has taken a lead in building the Southern Africa Fire Network (SAFNet) prima-

rily aimed at providing motivation to address the fire problem. SAFNet facilitates more exposure to the use of geo-spatial data in fire management, issues of cross border fires, debates on engaging communities in fire control and appropriate institutional frameworks and fire policy requirements.

Conclusion

Although the frequency of fire in Botswana is low compared to areas of higher rainfall such as Angola and the Democratic Republic of Congo, the country remains vulnerable to fire outbreaks. This is because rainfall is unpredictable and a large section of the population depends on resources that rely on rainfall. As a result, loss of these resources due to fire is a concern, as supply may not be realised after a long time due to drought.

Fire occurs mostly over the dry season when the demand for most natural resources is very high. However, vulnerability to fire is partly linked to the fact that fire is part of land use management and as a result fire outbreaks are inevitable, particularly after wet periods. Added to this, is that although the country has a Fire Prevention Act, the implementation of this Act has not been effective. For instance there is no fire early warning system and the management of fire is not guided by scientific understanding of the role of fire in ecological processes and in land use management.

The use of geo-spatial technology could help improve fire management but the institutional capacity to incorporate this data operationally is limited. This is a major concern as initial climate change assessment shows that the country will experience more fire incidents in future.

The most vulnerable groups are the poor who rely on veld products for food and income generation. However, fire is also a threat to the country's livestock and tourism industries. There is need for studies to provide information on the cost and benefit of fires to assist in increasing awareness at all levels on the significance of fire in sustainable development.

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NAMIBIA

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Abstract

Namibia is a large semi arid country covering a surface area of 824,392 sq km with a small human population of 1.8 million people. The seasonality of the rainfall provides dry plant material that burns between April and November, with a peak during August and September. Lower rainfall in the southern and western parts of the country means less fuel and consequently fewer fires. However, sufficient biomass may accumulate over several seasons to sustain large but infrequent fires.

The predominance of fires during the cloudless dry season is indicative of anthropogenic fires that burn approximately five per cent or 40,000 sq km of the country every year. The most fire prone area is in the Kavango and Caprivi region where the rainfall is higher. Between 25 and 50 per cent of this area burns every year, possibly affecting as many as 280, 000 people. Fires are lit for reasons which are closely related to land use, including land clearing for cultivation, application of natural fertilisers, hunting and pasture rejuvenation. Frequent fires are seen as detrimental to the indigenous timber industry in particular, and may also have direct and indirect adverse affects on humans, livestock and wildlife. Local communities are actively involved in fire management, and the process of developing national fire policies is under way.

Socio-Economic Characteristics

Namibia is a large, arid, sparsely populated southern African country, bordering Angola, Zambia, Botswana, South Africa and Zimbabwe, and the Atlantic Ocean in the west. Human population density is about 2 people per square kilometre, but settlement is not uniformly distributed across the country (Mendelsohn et al. 2002). Less than 40 per cent of the country's population of 1.8 million people live in urban areas (Mendelsohn et al. 2002; Republic of Namibia, 2004; University of Namibia, 2005), while the majority of the rural communities live near perennial rivers in the northern parts of the country. More than 50 per cent of the population is under the age of 20 years and have yet to enter the labour market. Only about 50 per cent of the country's workforce receives a cash income (African Development Bank, 2002). Those who do not earn wages are not necessarily jobless since many are involved in subsistence farming at or near their homesteads.

Climate, Land Cover and Land Use

Namibia's rainfall is largely derived from the moist Inter-Tropical Convergence Zone (ITCZ), which moves from the equator southwards. However, in some seasons the ITCZ is kept north by a dry cold air mass of the Subtropical High Pressure Zone. Namibia has a pronounced rainy season from about November to March. The country has a steep rainfall gradient from the north-east to the south-west, with median annual figures of 550 mm and less than 50 mm respectively (Mendelsohn et al. 2002). As expected, these rainfall patterns give rise to a land cover gradient from tall moist woodlands in the north-east, to short dry scrub in the south-west of the country.

Land use in Namibia is dominated by agriculture. About 80 per cent of the country is reserved for farming on either freehold or communally owned land. Eco-tourism and mining activities are interspersed with farming in these areas. About 14 per cent of the country consists of state owned protected areas. Livestock farming is the main agricultural pursuit, but large areas are cleared for dryland (rain fed) crop cultivation, particularly in the northern, communally owned areas (Mendelsohn et al. 2002).

Fire

Namibia is not fire-prone due to low biomass load. Much of the country receives too little rain to generate sufficient amounts of combustible plant material. Nevertheless, in those areas that receive enough rain every year, fire is a regular and widespread phenomenon. The most frequent, intense and extensive fires occur in the north-east, while in the south and west fires are rare. The fire season is generally restricted to the dry season (April to October), pointing to people rather than lightning as the main source of ignition. Most of these fires spread through the grass and shrub layer as surface fires, while crown and subterranean (peat) fires are either rare or confined to small areas.

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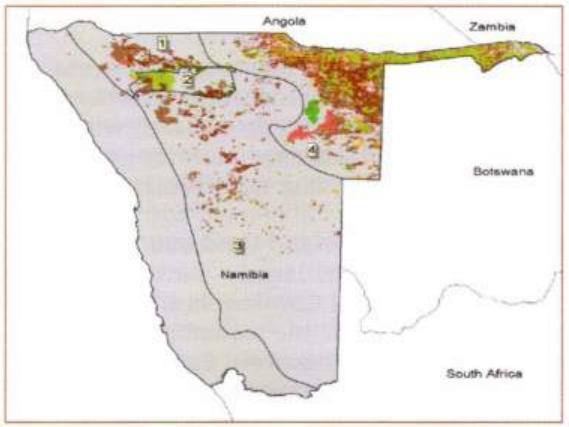
The issue of fire in Namibia can be discussed in relation to the four broad geographic regions shown in Map 4 below.

Fire Regions in Namibia Map 4



The coloured areas represent burned areas from five fire seasons. Adapted from Trigg and le Roux, 2001.

Region 1 is situated in the densely populated north-central part of the country. The vegetation consists mainly of mixed grassland and savanna woodland. The land use is predominantly small-scale farming on communally owned land where fires are ignited for land clearing and for grazing rejuvenation. Region 2 also in north-central but located immediately south of Region 1, comprises the Etosha National Park, an area of more than 22,000 sq km where large areas are burned annually as part of the Park's fire management strategy. Region 3 extends immediately south of Region 2 but covers a large area up to the borders of Botswana and South Africa. Region 3 consists of sparsely populated freehold farmland where the vegetation is predominantly mixed tree and shrub savanna. In this region every effort is made to prevent and combat fires. Region 4 is situated in the high rainfall north-eastern part of the country and covers all of the Caprivi and Kavango regions, as well as the northern part of the Otjozondjupa region where the vegetation is a mixture of grassland, savanna woodland and dry forest. This is the most fire prone area in the country, with fires being lit mainly for land clearing, grazing rejuvenation and hunting.

Causes and Effects of Fires

In regions 1 and 4, fires are lit to stimulate the growth of fresh grass for cattle, to attract game, to flush out game that can then be hunted, to clear vegetation around waterholes and honey-gathering areas, to clear land for cultivation, or to promote the regeneration of grasses used for thatching. Large areas are sometimes burned accidentally through the uncontrolled spread of fires deliberately lit to clear new fields. In region 3 fires are a result of lightning strikes, and accidental due to poorly supervised charcoal making and careless discarding of cigarettes.

Landscape Characteristics and Fire Regimes

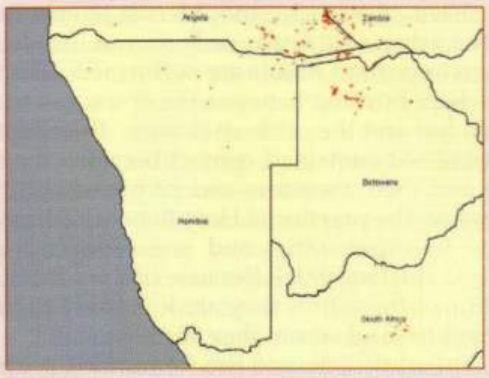
The progression of fires during the 2003 burning season is shown in Figure 2. The scarcity of detected fires in the images for April and November is due to a combination of cloud cover that block the satellite sensors' view of the earth's surface, and actual absence of fires at that time. Fire occurrences peak in August and September. Given that several fires occur over such large areas between the months of May and October, it is not surprising that there is such a dramatic drop in active fires in November, as much of the combustible fuel would have been consumed either by fire or livestock.

Burnt areas that were mapped at the national level for five years (Map 4), show that about four million hectares burn every year. This amounts to a mere 4.8 per cent of Namibia's total area. The picture changes dramatically however, when one focuses on the north-eastern part of Namibia where between 25 and 50 per cent of the area burns every year. For regions 1, 2 and 3 where rainfall is more variable and lower, fires usually occur after a wet year. The unpredictability of rainfall has potential to lead to land degradation processes because vegetation regeneration may not be supported following the burning due to lack of moisture.

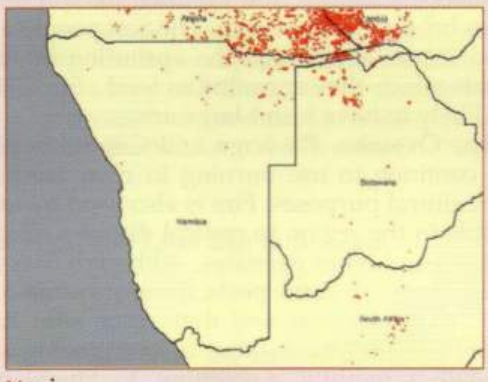
The fact that the burning season peaks towards the second half of the dry season indicates that management fires that could reduce the fuel load are not widely used. This is perhaps not surprising in a semi-arid country like Namibia, where livestock owners are often reluctant to burn fodder that will not be replaced if the rains fail and consider the potential effect of this on land degradation processes. The extent to which grazing acts as a substitute for management fires is not known, but judging by the size of the area that burns every year, this form of fuel reduction is ineffective at regional scales.

The frequent burning of large parts of north-western Namibia is responsible for damage to large areas of woodland, with a significant reduction in commercial and non-commercial timber resources, loss of habitat, reduction in woodland biodiversity, and loss of wood resources for domestic use. The high fire frequencies also promote the establishment of fire-resistant, but often less useful woody species such as *Dichrostachys cinerea*. All these processes

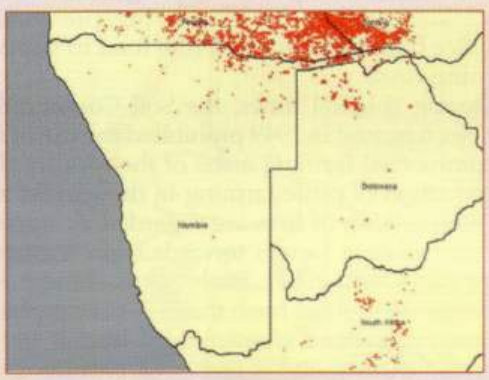
Monthly Time Series of Active Fires Map 5



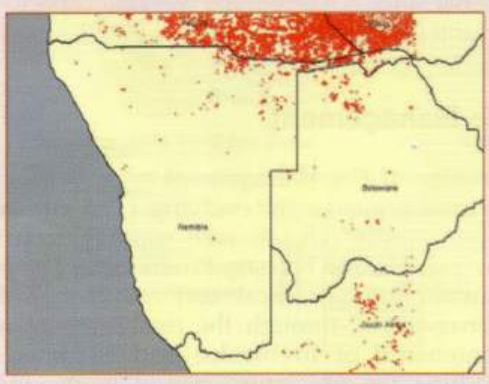
April



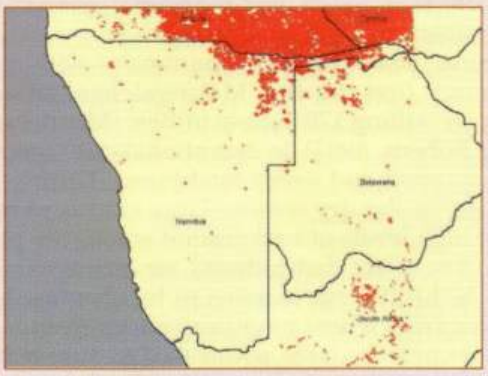
May



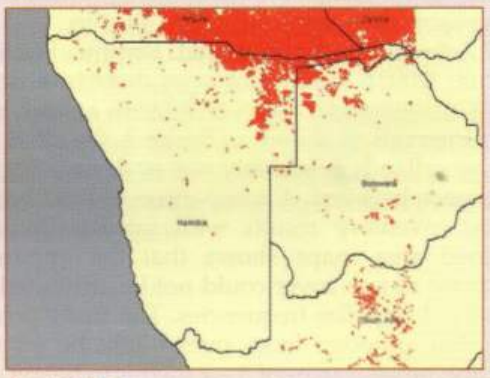
June



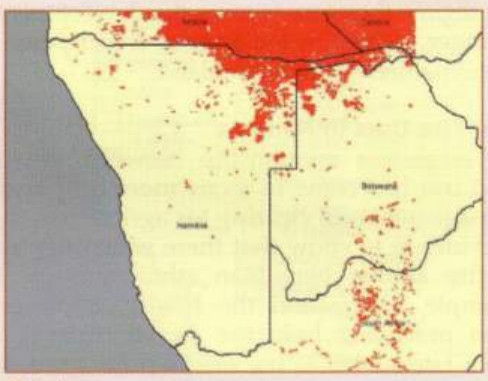
July



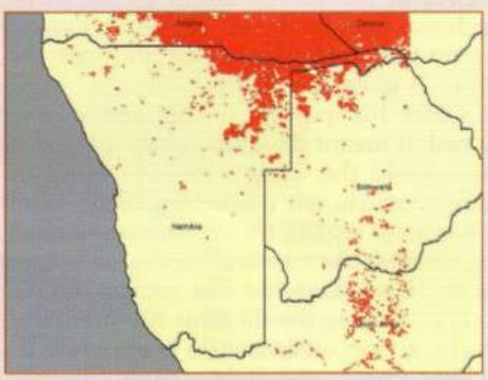
August



September



October



November

Source http://maps.geog.umd.edu/

eventually contribute to land degradation which is a major environmental concern in Namibia.

Fires also kill large mammals, with peat ground fires in the Malangalenga area of Caprivi killing 170 buffalo in 1996 (Mendelsohn and Roberts, 1997). In exceptional cases, people are trapped and suffer fatal burns. During the height of the dry season, large smoke plumes and high levels of background smoke are present. The effect that reduced air quality has on public health still remains to be quantified. In many areas where migratory pastoralism is no longer practiced, the removal of pasture by fire is highly undesirable as it threatens the survival of livestock. This situation is compounded during years when rains fail after burning.

A study by the National Remote Sensing Centre (2002), found that even though most of the Kavango and Caprivi area burns at very regular intervals as shown in figure 3, the effect on the woodlands is possibly not as devastating as was once believed. A comparison of field based forest inventory results with satellite derived burned area maps shows that the apparent decrease in tree cover could not be attributed to observed high fire frequencies. The study points out that although large trees might be on the decline, smaller trees of 3 – 4 metres in height are on the increase. The overall result of the current fire regime therefore favours the development of younger, denser woodland, at the expense of more mature wooded grassland.

Past Fire Uses in Namibia

Although the relationship between fire and land use has come to focus more on pastures management and clearing for agriculture, there is evidence to show that there were other uses of fire among Namibian ethnic groups. For example, *Herero* and the *Himba* people have been practicing holy fire for centuries. The Holy Fire serves as the medium for communicating with the ancestral spirits (Malan, 1995). All fires in the village are lit by the holy fire which was kept by the village-head. Among the *Ovambo* fire symbolised hope and luck for the nation. It gave the group existence, and gave the Chief his power. If this fire got extinguished, it meant the decay of the nation and it also foretold the Chief's loss of power or his death by witchcraft (Hiltunen, 1986). While in the Kavango region, the *Ovambukushu* used fire to symbolise the sun and moon, as helpers of *Nyambi* (God) to guide and protect the people on earth. During the day this fire (sun) burned fiercely, giving off immense heat, while it was just kept alive to give light at night (moon), and this allowed people to rest (Hiltunen, 1986). Although not documented it is likely that under favourable conditions such fires escaped and burnt large areas.

Another use of fire was in ritual ceremonies (Malan, 1995). The ritual fire was generated by means of ritual fire sticks called *'ozondume'*, of which each lineage kept a special set. This fire consisted of a single smouldering stump lying in the ashes and it was only stirred into flame when important rituals are performed. The fire was kept burning between the entrances to the main hut and the cattle enclosure. Burning fire symbolised sustained contact between the living and their ancestors and provided spiritual security. The practice of Holy Fires was discouraged by missionaries and is no longer widespread (Malan, 1995). Because of the controlled nature of these fires they are less likely to have spread beyond where they were lit.

The San people used fire for hunting purposes (Malan, 1995). The use of fire, cut the long distances travelled for hunting as sprouting grass brought game closer. The San people also used fire to encourage the sprouting of tube plants which they consume as food. Such fires are likely to have burnt large areas.

The Ovambo, Kavango and Caprivian people continue to use burning to clear land for agricultural purposes. Fire is also used by local people in the region to control diseases caused by ticks and other parasites. Although fires are easily started at cattle posts, these are often confined to small areas and they come after long intervals (fire returns) due to overgrazing and rainfall variability. According to Sheuyange (2002) the regions with adequate grass cover are those subjected to heavy grazing pressure, a practice that leaves limited fuel load to support burning fires.

During colonial times, the Soil Conservation Act No. 6 passed in 1949 prohibited the use of fire in commercial farming areas of the country. The introduction of cattle farming in these areas and the suppression of fires are regarded as some of the contributing factors towards bush encroachment (de Klerk, 2004). Bush encroachment is a phenomenon where bush thickets have replaced savanna woodland characterised by tall trees , scattered bushes and a carpet of pasture. Bush encroachment has a major impact on livestock farming since it reduces the carrying capacity of the land (Mendelson and O'beid, 2005).

Fire Management

Evolution of Fire Management

Fire management is still evolving, primarily driven by Forestry officials with support from the Namibia/Finland Forestry Programme. The programme involves local communities in fire "management" through the establishment and maintenance of firebreaks, and is aimed at stretching the fire return period in the forest reserves and other wooded areas of East Caprivi.

Current Policy Status

The formulation of policy and regulations concerning fire is also an ongoing process. Some of the recent efforts include the National Fire Policy and Guidelines on Fire Management in Namibia developed by the Directorate of Forestry (Goldammer, 1998). The policy and guidelines build on the Namibia Forestry Strategic Plan, which provided the basis for fire policy and management planning. The Strategic plan recognises many of the complexities of fire, including:

- The need to reduce the occurrence and severity of uncontrolled and accidental forest fire while allowing controlled fire under specific circumstances;
- The need for community participation in the protection of forest resources; and
- The need for different policies for different parts of the country.

Other fire policy development efforts include the Round Table Meeting on Fire held in 1999 with the aim of defining the country's fire policy and coordinating responsibility for fire management (Goldammer, 1999). Draft proposals for regulations on bush fire management have also been prepared (Piepmeyer, 2000), and the country ratified the UN Framework Convention on Climate Change, which requires it to provide quantitative assessments of free-burning vegetation fires (Goldammer, 1998).

Human Vulnerability to Fire

According to Kamminga (2001), the risk of wild fires is strongly related to the prevailing land use system and tenure. Traditional extensive systems have built-in strategies such as migratory pastoralism and crop cultivation, which reduce the community's vulnerability to fire and the absence of rainfall. Intensive grazing is another common if inadvertent means of reducing wildfire risk by reducing fuel loads. The combined effect of trampling and grazing around settlements is very effective as a means of protecting highly combustible wood and thatch houses.

About 280,000 people live in the fire prone north-western part of Namibia (Mendelsohn et al., 2002). While all of them are affected by the annual fires in some way, most live in a narrow strip along the banks of the Okavango River, where a combination of dense settlement and heavy grazing has virtually eliminated fire. In the extreme eastern part, between the Zambezi and Chobe/Linyanti rivers, about 80,000 people live in much closer proximity to these fire events. This amounts to approximately four per cent of the country's population.

The great majority of these fires are human-caused. It is therefore reasonable to expect that if enough people were adversely and directly affected by fires, they would stop igniting them. Judging by the extent and frequency of the burning in this part of the country, the benefits of the use of fire that has been going on for centuries, still outweighs the disadvantages.

Conclusion

It can be concluded that fire, although widespread, frequent and harmful to humans and the environment, affects rather small proportions of the country and its human population, and not always in a detrimental way.

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SENEGAL

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Abstract

West African savannas are characterised by permanent burning associated with several land management and natural resource extraction activities. The use of fire is seen as a necessary tool in agro-pastoral activities, national parks and game reserve management, and in forest product collection. Several fires occur annually in the savanna grasslands where a continuous grass layer prompts extensive burning every dry season. Uncontrolled burning is common, mainly when the herbaceous layer is very dry.

There are both biophysical and socio-economic negative impacts of fire in West Africa, including loss of biodiversity, vegetation fragmentation, loss of soil fertility, degradation of fodder, and reduction of rural incomes. There are also some positive impacts of fire such as the promotion of herbaceous re-growth for livestock, pest control, release of organic matter for soil fertility, and the opening up of land for crop farming. As such several attempts that have been made in the past to ban or mitigate fires have not been successful. In the colonial era the commonest management strategy was to ban fire mainly in the forest reserves.

The failure of the total ban along with positive scientific outputs on the use of fires drew an acceptance of early fires to achieve some management objectives. During the cyclic drought of the seventies and eighties, the West African governments adopted an extensive strategy for fire fighting. The lack of sustainability of this approach led to a shift from coercive to persuasive strategies. The new fire management regime gives responsibility to local communities to manage their natural resources. In order to support the new fire management approaches, which also include early warning systems, satellite data are required to document the temporal and spatial distribution of burning.

This case study is a summary of the state of bushfires in West Africa, focusing mainly on the historical background of fire, the main causes of fire, the fire regime in relation to landscape diversity, the timing of fire, the impact of fire, and fire management options.

Introduction

Bush fires have been a common occurrence in West Africa since pre-historic times (Goldammer and de Ronde, 2004). Although the overall consequences as well as the extent of the damage by fire are difficult to assess, it is generally agreed that the propagation and occurrence of bush fires is closely associated with several triggers linking the bio-physical and social environments.

Biomass production through the rainy season limits the extent of fires since fuel-loads have to be high enough for fires to spread (Nielsen and Rasmussen, 2001). In addition, the moisture content of the biomass strongly influences the propagation of fire (Saarnak et al, 2003; Mbow, 2000).

Fires are used for religious purposes by some communities. The same communities are also dependent on the use of fire to clear land for agriculture or to promote fodder production for their cattle. The majority of fires occurring in West African savannas are therefore human-caused and occur as part of an integral land and natural resource management regime (Goldammer, 1993; Schmitz, 1996; Hough, 1993).

Whereas fires have been endemic in the savanna regions, acting as a major factor shaping ecosystem productivity and functionality, it is clear that without regular, targeted fires, the savanna environment will have denser vegetation preventing the development of major agro-pastoral activities (Orgle, 1998).

Due to the high fire frequency in West Africa, several attempts to ban or fight fires have been introduced in the past with little success. The fire mitigation strategy should be oriented towards changing rural practices rather than investing in substantial logistics and heavy equipment to fight fires, as has been the case during the last 30 years.

Landscape Characteristics and Fire Regimes

Maps 6 and 7, derived from MODIS and NOAA AVHRR respectively, reveal a fairly consistent picture of the location of fires across West Africa. To the north, a low fuel load limits the occurrence of fires, while in the south fires are limited by humid conditions.

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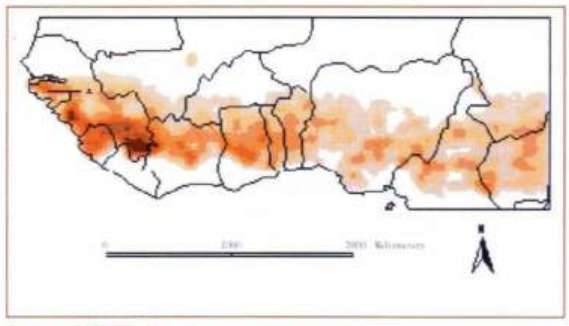
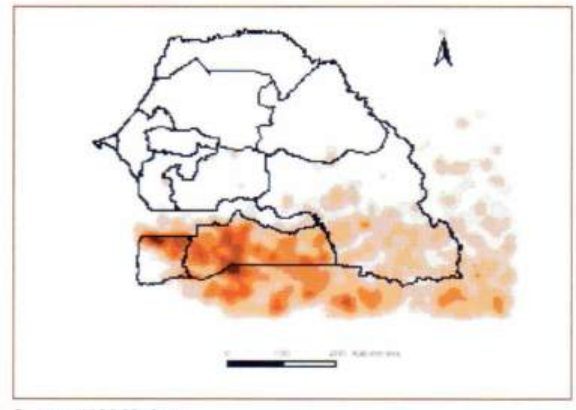
Use of Bush Fires in West Africa	Table 2
Source of burning	**Reasons for burning**
Agricultural	Shifting cultivation, field preparation, fertility improvement, residues removal, pest control
Forest management	Early fires to minimise late burning, forest accessibility, improvement of animal visibility for tourists in national parks, control of bush encroachment, stimulate the flowering of some plants
Rangeland management	Early burning for grass re-growth, counter season fire to remove 'bad grass'
Forest product extraction	Honey collection, hunting game, gum extraction, charcoal making, firewood collection, fruit collection
Crime	Elimination of grass to keep away nomads, avoid clashes between communities, track livestock raiders
Accidents Other sources	Non extinguished firewood, cigarettes, transportation of embers Clearing around villages to prevent house-burning, clearing along rail and roads to prevent animal accidents, traditional festivities in some ethnic groups, etc.
Source: Mbow et al. (2000)	

Fire Frequency in West Africa (dry season 2003-2004) Map 6



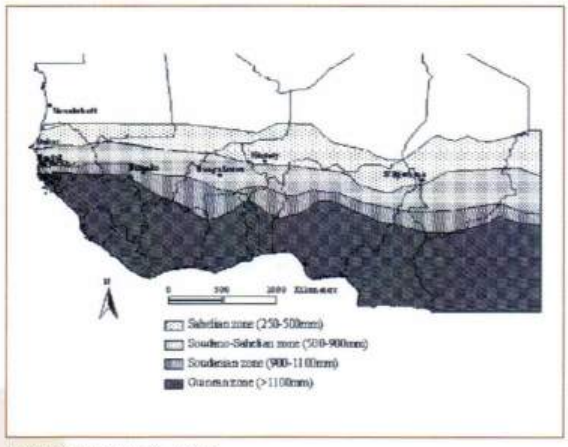
Source: MODIS data

Fire Frequency in Senegal (dry season 2003-2004) Map 7



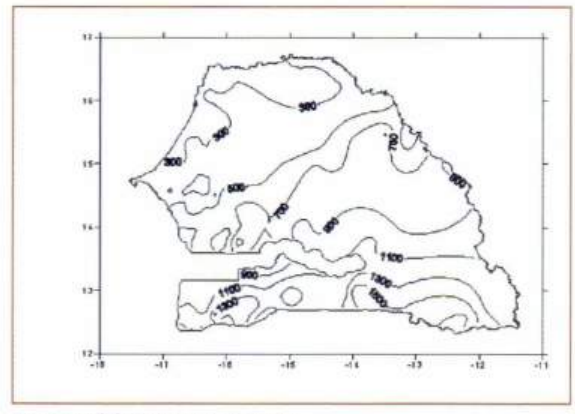
Source: MODIS data

Inter Annual Rainfall, 1961 to 1990 Map 8



Source: SDRN-FAO, Roma

Senegal: Isohyets of of the Rainy Season 2003 Map 9



Source: Météo-Nationale, Senegal

The temporal distribution of fires can be assessed by the same methods. In Map 6 and Figure 3 the total number of detected fires in the same data window Map 6 and 7 is illustrated as a function of the time of year. A pronounced fire-season corresponding to the onset of the dry season can be identified. Studies have shown that the fire season in West Africa sets in to the north as soon as the biomass dries up and moves southwards along a precipitation gradient (Nielsen and Rasmussen, 1997).

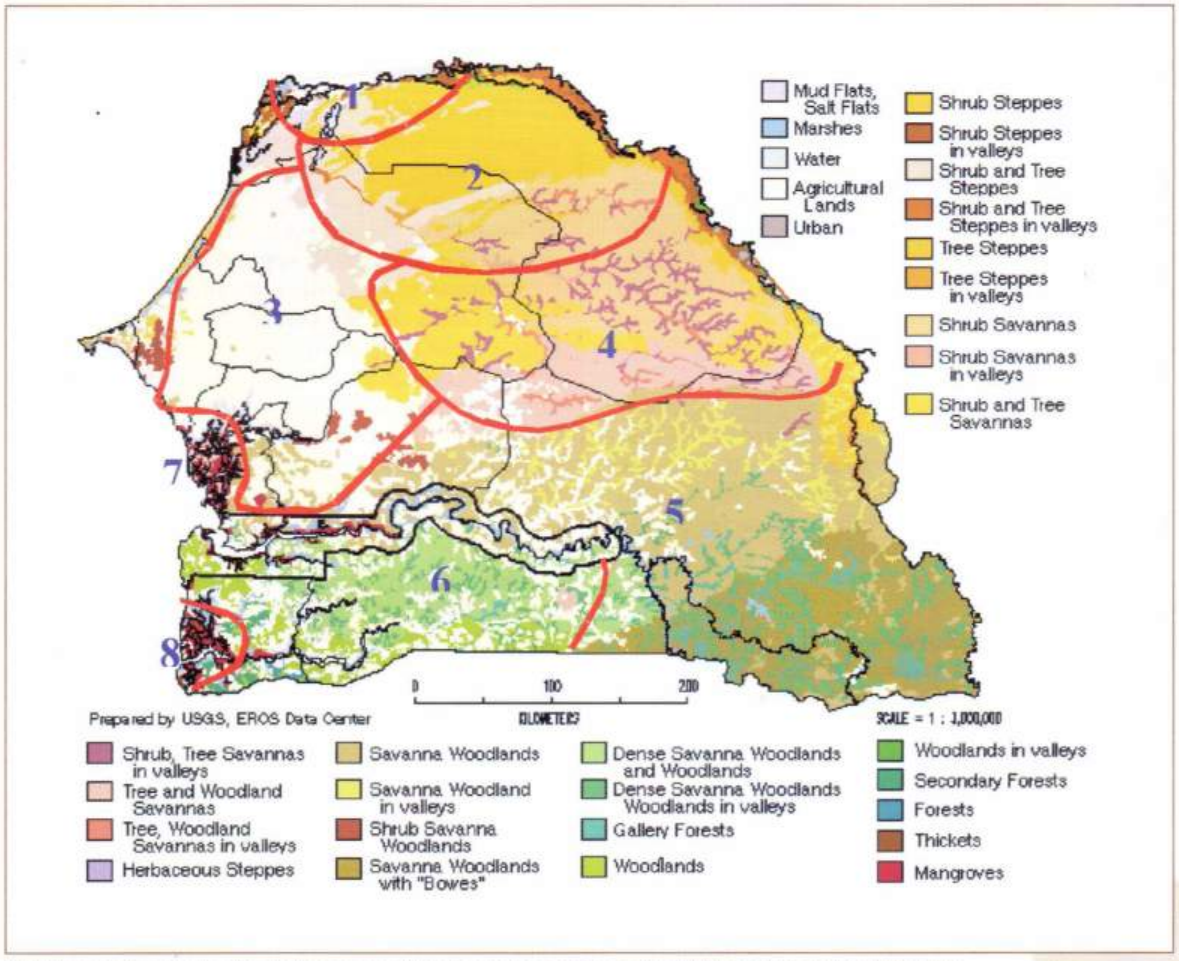
More detailed information can be obtained from the same data sources by analysing the detected fires on a more regional scale. In the present case, Senegal will be used as an example. Figure 2 illustrates the spatial density of detected fires. Here it is clearly seen that while the northern most regions of Senegal are seemingly unaffected by fires in the fire season of 2003-2004, a high density of fires is found in the south of the country. While these results were produced on the basis of MODIS data they still illustrate the results produced for Senegal for previous fire seasons based on data from the NOAA AVHRR sensor.

The key aspects of current fire trends are generally the same in the Sahelo-Sudanian zone of West Africa. The variation in the use of fire for management purposes depends on the status of the vegetation in a given area and the relationships between the local livelihood and natural resources. In Senegal one can identify a north-south variation with a gradual shift, in land cover types, rainfall, and agricultural/fire practices.

The fire regimes, causes, effects and fire management issues observed in Senegal are believed to be representative for most of the Sahel-Sudan region. In Maps 8 and 9 the pattern of fire occurrence in one particular dry season shows that a few fires occur where rainfall is below 800 mm. The same pattern is observed in other countries with slight difference in rainfall limit of fire occurrence.

A combination of the fire distribution and timing derived from several years of NOAA AVHRR and MODIS with the land cover map enable a stratification of Senegal into regions of uniform fire regime.

Vegetation and Land Use in Senegal Map 10



Red lines delineate the fire regime zones http://www.bcconline.org/wolof/Maps/VegetationMap.htm

Description of the Main Fire Regimes

1. The River Valley

The main land cover types in the Senegalese river valley are marshes (with dense invasive plants), agricultural land (rice, sugar cane, vegetables), and steeps (with grass and shrubs). Given the humidity and vegetation characteristics a few fires associated with the removal of crop residue in rice fields are noted every year. In addition, sugar cane extraction is done with extensive use of fire to facilitate cropping. Recently it has been noted that the fight against the encroachment into water bodies by *Phragmites australis*, necessitated extensive use of fire to remove the invasive plants hindering fishing and agricultural activities.

2. The Ferlo

The dominant land cover types are rangelands with a continuous grass layer. Although this is a fire prone zone, few accidental fires are noted early in the dry season (September, October and November). These fires can cover large areas because of extensive plateaux and continuous grass layer. In this area, fires are prevented by local people because of the scarcity of the herbaceous biomass (low fuel load) which is the main fodder for livestock. There is a deep commitment of local stakeholders to ban fires in order to preserve the main source of income, pastoralism.

3. The Peanut Basin

No fires have been noted in this area because of the absence of a continuous natural grass cover that could burn extensively. The land is mainly used for groundnut cultivation in along with millet and secondary crops like beans and maize. However, some small fires associated with field preparation can occur prior to the rainy season. These fires are dispersed and small such that only a few are observed by use of satellite images. As a result the satellite based fire regime characterisation describes the Peanut Basin as an area of low fire occurrence.

4. The Transition Zone

Trees and shrub savannas dominate the land cover of this area. This zone is characterised by a continuous grass layer and the presence of sparse trees. The use of fire is subject to great control because of its effects on the ecosystem and on the income of local people.

5. Eastern Senegal

The savanna woodland ecosystems in this zone are particularly favourable for fire propagation (Map 10). Rural activities are based on a mixture of crop and livestock production (Table 2). These two factors require the use of fire to prepare the land for new cultivation and to remove some patches of the herbaceous carpet to promote grass re-growth and destroy non-valuable grass. The Niokolo Koba National Park is located in this zone and fire is used as a management tool to promote tourist activities.

6. Central South

The high fire frequency in this area is associated with a relatively high human density and several activities causing fires are noted: agriculture, charcoal making, pastoralism, and hunting. Due to the high fire incidence in this area most of the past and current projects on bushfires have been implemented here. The population density is relatively high with a positive migration responsible for rapid spatial expansion of slash and burn agriculture for cash crops production (peanuts and cotton). The improved accessibility of this area with new roads made by the cotton company (SODEFITEX) could be one of the reasons why farming settlements are spreading through the region.

7-8. Mangrove

The main mangrove zone of Senegal is located in the western side of the country in the Delta valley of Casamance and Saloum rivers. These areas are characterised by the presence of moist vegetation with little grass. These ecosystems cannot catch fire except the low plateaus in between the salty depressions. Some few cases of fires have been reported in these plateaus where the terrestrial vegetation is dominated by savanna types with a consistent grass layer. In the Delta du Saloum (8) there is a National Park where fires are used at the onset of the dry season. The Casamance area is characterised by effective control of fires. There is a fear of setting fire in this area because of traditional/cultural censure associated with deliberate burning. Pasture land is mainly found on the small plateaus where livestock raising is an important activity.

The savanna ecosystem is quite heterogeneous in terms of fire regime. This difference is linked to the subtle variation of parameters such as the herbaceous layer continuity and the fuel load. Where the tree cover increases, the herbaceous carpet becomes patchy. It is noted from field observation that the highest biomass load is found in Trees and Woodland savannas, which are known to experience intensive fires (Mbow, 2000).

The analysis of the fire regimes clearly shows which areas have high risk and frequency of fire. This could form the basis on which to prioritise areas for the allocation of resources for bush fire management (Orgle, 1998).

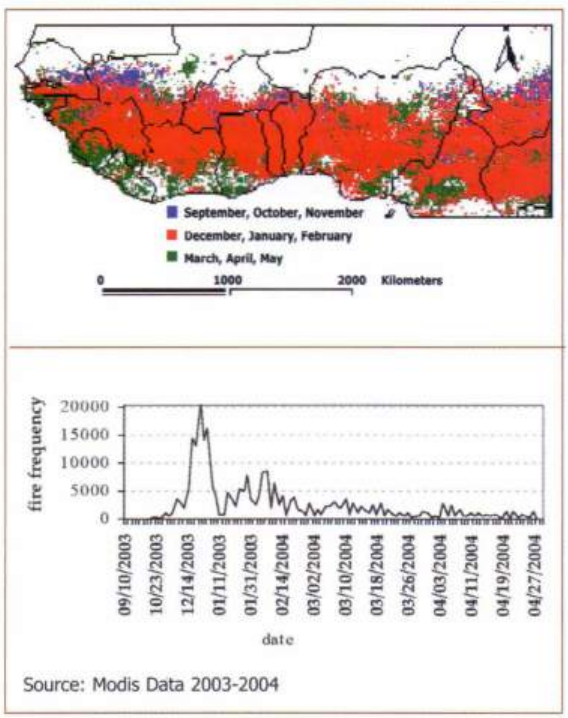
Temporal Distribution of Bushfires in West Africa

The temporal distribution of bushfires in West Africa can be divided into three main periods, each of which corresponds to the end of the dry season following a north-south trend. It appears from MODIS data analysis (November 2003 to March 2004) that fires appear first in the north (Sahelian zone) as the grass layer dries out earlier in this zone (September, October and November). The fire frequency is not very high during this period because of fuel scarcity and local fire prevention strategies to protect fodder for livestock. In the same period the fuel moisture content in the southern part is still relatively high to support ignition.

The second period corresponds to the peak of fire frequency in West Africa spanning the months of December, January, and February. Most of the management fires occur during this period. It corresponds to the end of the harvest and the start of non-agricultural activities – hunting, honey collection, charcoal making, management fires, among others – that require the extensive use of burning. This trend is clearly illustrated in Figure 2, which shows a rapid increase of fires and a slow decrease of burning as we go further into the dry season.

This trend of fire occurrence is very relevant to fire protection planning. Figure 2 shows that the most critical period for the occurrence of fire in West Africa is from December to February.

Temporal Distribution of Fires in West Africa Figure 2



Source: Modis Data 2003-2004

Fire Management

The fire management history in West Africa is difficult to address and differs according to colonial legacies of the former French colonies and English ones. In general terms there are two main periods in the fire management evolution in West Africa. The first period corresponds with the colonial time, while the second period is the post-colonial era.

During the pre-colonial era, fire was considered as a destructive phenomenon and was largely banned. Perceptions of, and attitudes to bushfires – and to the African environment in general – changed during the colonial era when new institutional responses emerged. Attempts to introduce repressive bushfire regimes as an integral part of forest reservation policies were challenged throughout the colonial period, particularly in terms of local struggles over land and access to woodland resources. Prominence was given to the perceived threats posed by bushfires even though some agricultural officers also questioned the wisdom of burning bans, and recognised the many economic and cultural uses of fire.

The use of fire as a land-clearing tool during the colonial era was meant to fill the labour gap created by slavery which left many agricultural areas (such as Haute Volta, Soudan Francais, Niger and the northern frontiers of the Gold Coast colony) with few, if any able-bodied men.

The total ban option did not give the expected results because of the role and importance of fire in achieving several land management objectives and in the promotion of social and economic activities. Thereafter, some scientific tests, such as those carried out by Aubreville and Chevalier (Brookman, Emissah, 1980; Louppe et. al., 1995; Schmitz et. al., 1996), on the role of fire in ecosystems showed that early burning, when performed correctly can be beneficial to the environment. The results of these tests carried out around 1950 showed, firstly, that early fires do not totally destroy the herbs but save part of the natural woody regeneration and, secondly, that these early fires are efficient in preventing late fire. Based on this evidence, legislation was modified to accept the use of early fires. This move led to a more flexible attitude with regard to use of fire, and this is clearly stated by Moor (1935) who stresses that "Complete protection is both impracticable and undesirable".

The application of the legislation promoting early fires faced some difficulties in its implementation. Forest Departments did not have the means to control the use of fires everywhere and the so-called early controlled burning became was not adequately controlled. Therefore, use of fire increased in all the West African countries. After the peak of fire occurrence during the drought of the seventies and in

the early eighties, some Forest Departments were provided with equipment and considerable budgetary allocations. In some countries such as Ghana, a National Fire Service was created to focus on fire fighting strategies and a Bushfire Prevention Law was promulgated in 1983 to address the problem of bushfires by enforcing measures aimed at curtailing the incidence and magnitude of burning (Ampadu-Agyei and Atsiatorme, 1998). At the same time the legislation for fire prevention was strengthened in other countries. For example, in Burkina Faso fire was considered a crime punishable by heavy penalties. In Benin and Mali, fire laws were enacted in 1982 and 1986, respectively, to formalise the fire policy at national level (Schmitz et al. 1996).

The concern about bushfires is one of the main interests of forest commissions as clearly stated in National Forest Action Plans. Through sensitisation, construction of firebreaks, early fires and formation of local fire committees and providing equipment, the Forest Departments aim to prevent drastic burning to mitigate forest loss due to fire. Sensitisation is becoming the major strategy to increase awareness of the environmental impacts of fire. Through Rural Radio, the local population has the opportunity to broadcast important information on bush fire control. This technology is widely used in most West African countries, including Senegal, Mali, Guinea, Niger, Burkina Faso and Benin. In parallel, active fire fighting is applied to stop active fires. This has been done since the drought of the 1970s. The active fight against fires is based on mobilisation of considerable personnel and logistics to stop fires.

Current efforts are shifting to management of fires, which depict both the acceptance of the importance of fires in rural activities and the requirement to control fire for better ecosystem renewal. This new approach is being hampered by a general perception of the forest resource as being owned by the State and that responsibility for its protection falls under official services. This situation results in the continued exclusion of local people from obtaining economic benefits from the use of natural forest resources, and consequently there is no local incentive to stop or minimise the use of fire since the forest resources will benefit only the "foreigners" (Mbow et al., 2001).

Current fire management strategies seek to promote the full commitment of local people in the fire management process. To achieve this goal, the decentralisation process taking place in most West African countries puts a great emphasis on allocation of forest resources to local stakeholders. The logic is to place the fire mitigation policy within the framework of the local agro-forestry activities, controlled by local people. The actual policy for fire management shows a conceptual shift from the coercive approach to a more persuasive one. This requires greater involvement of local people through key stakeholders with a clear and careful explanation of reasons of why the control of grass burning (limited use of fires) is relevant for the local context. In that respect, forest agents have been trained in participatory approaches to better facilitate the joint effort between the Forest Department and the local government in the context of decentralisation. Moreover, it is noted that while the legislation is clear about the responsibility of local government towards natural resources management there is not a clear back-up of the "community-based" fire management policies. There is a transfer of the decision making process and not a transfer of the means by which to apply the local decisions. In addition, local stakeholders have not yet achieved an effective transfer of managerial responsibilities, which requires budget transfer and planning skills.

The use of early fires for land management is clearly expressed in the forest legislation in most West African countries. Its application requires some caution, which is not always taken into account. It is noted at least in National Parks where this management burning takes place every year that the period of burning is far from optimal. Burning tends to take place when the level of fuel dryness is conducive to severe and uncontrolled burning. Outside the protected forests the local government, in consultation with the Forest Department, decides the use of early fires. The beginning of the early burning season does not, in most cases, take into account the variation and state of herbaceous layer.

For these reasons, better early burning policy should be based on monitoring of the herbaceous cover to set up a spatial and temporal plan for the use of fire for management purposes. This can be achieved by setting up a fire danger rating programme using up to date techniques for biological monitoring including satellite surveying of the fire prone areas. The Senegalese Laboratoire de Géomatique (LERG) and the Centre de Suivi Ecologique (CSE) are known to derive various environmental products from satellite data including fire monitoring and could therefore, play an important role in producing relevant information for the decision makers.

Conclusion

West African savannas are known to be fire prone because of regular burning that occurs every dry season. The complexity of the landscape (savanna mosaic) and the variability of local livelihoods towards natural resource management lead to different fire regimes.

Whatever the socio-economic motivations for the use of fire, the multiple consequences and side effects resulting from burning should be considered and should motivate a limited use of fire, given that for some purposes there is no alternative for land management.

One of the key challenges highlighted in this case study is the understanding of how and why fire is used in West African landscapes with a focus on Senegal. This will ultimately help to unravel the complex historical, ecological and socio-cultural realities and, ultimately, provide opportunities for State institutions to better harness the knowledge and skills of local resource managers.

The fire management constraints emanate from budgetary difficulties and sectoralism associated with the decentralisation process. This results in conflicting policies and limitations in community based natural resource management at the local level (Goldammer and De Ronde, 2004)

The use of fire should be included in the overall forestry programme and not considered in isolation. Controlled use of fire is a good pathway to promote: the renewal of degraded land, the reduction of greenhouse gases released into the atmosphere, the protection of soil against erosion and the improvement of the carbon storage possibilities in line with the Clean Development Mechanism initiative.

Fire vulnerability in West African countries could only be mitigated if decision-making is based on an early warning system that gives information on fire risk and active fire distribution.

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UNITED REPUBLIC OF TANZANIA

Simon Mwansasu[1]

Abstract

Tanzania has a population of 34 million people. Forests and woodlands cover 38.8 million ha, constituting about 40 per cent of the country's total land area. The woodlands consist of secondary forest dominated by extensive savannahs that have developed as a result of frequent fires and overgrazing. Rainfall averages 400mm. Fire outbreaks are mainly attributed to preparation of farms, accounting to 35 per cent of all possible fire causes. Prescribed burning is practiced especially in protected areas like National Parks and Game Reserves. The use of remote sensed data is increasingly becoming important as demonstrated in the case of Tarangire National Park. Fire management falls under two different ministries – the Fire Services Force under the Ministry of Home Affairs and the Forest and Beekeeping Division under the Ministry of Natural Resources and Tourism. Each ministry is guided by different laws and regulations such as Fire and Rescue Services Force Act No. 3 of 1985 and the Forest Act No. 14 of 2002.

Introduction

Tanzania lies between Latitudes 1 and 12 degrees south and Longitudes 29 and 41 degrees east. It is bound by the Democratic Republic of Congo, Burundi and Rwanda to the west, Zambia to the southwest, Uganda to the northwest, Kenya to the northeast, Malawi and Mozambique to the south and the Indian Ocean to the east. Tanzania has a population of 34 million people (Census, 2002). About 51 per cent are women and 46 per cent of the total population is under 15 years of age. Around 70 per cent of the population lives in rural areas (United Republic of Tanzania, 2004). Agriculture is an important sector in rural areas contributing 45.1 per cent of the GDP in 2002 while other sectors had the following contribution: Transport (4.9 per cent), Commerce (12.4 per cent), Construction (5.2 per cent), Manufacturing (7.5 per cent) and others (24.9 percent). Tourism is increasingly becoming an important sector.

Physiographic Regions and Climate

The landscape of Tanzania consists of mainly three physiographic regions, namely, the islands and the coastal plains to the east; the inland saucer shaped plateau – forming the major part of the county; and the highlands. The Great Rift Valley cuts through the middle of the country, running north to south and splitting at Lake Nyasa/Niassa/Malawi.

The climate of Tanzania varies with altitude from the highest point on the continent, Mt. Kilimanjaro – which peaks at 5 895m – to sea level. The narrow lowland coastal region is consistently hot and humid, while the central regions are sufficiently elevated with cooler temperatures. In these two regions temperatures never fall below 20°C and the hottest period ranges from 25-31°C. In the highlands, temperatures range between 10 and 20°C. There are two rainfall regimes. One is unimodal (December – April) and the other is bimodal (October – December and March – May). The former is experienced in the southern, south-western, central and western parts of the country and the later is found to the north and northern coast. Average annual rainfall varies from 200 mm to 1,000 mm over most parts of the country. Higher rainfall, often over 2,000 mm, is commonly recorded in the highlands. Central Tanzania, comprising mostly the post fire secondary forests dominated by the savanna receives an annual average of 400 mm (http://statehouse.go.tz/abouttanzania/).

Land Use and Vegetation Types

Forests and woodlands cover 38.8 million ha, more than 40 per cent of the total land area in Tanzania. Woodland is the dominant vegetation type covering large areas in the western and southern parts of the country (Map 11). Other major land use types are presented in Graph 3. Most forests and woodland (in public land and to some extent in protected areas) are secondary forests having regenerated naturally after significant human and natural disturbances of the original forest vegetation. With fire playing a major role in these disturbances the forests display major differences in structure, canopy and species composition with respect to nearby primary forest on similar sites. There are at least five types of secondary forests:

- Post extraction secondary forest – these include miombo woodlands found almost throughout the country.
- Fallow secondary forest – these are generally woodland with scattered cropland. They are mainly found in the drier central plateau of the country.

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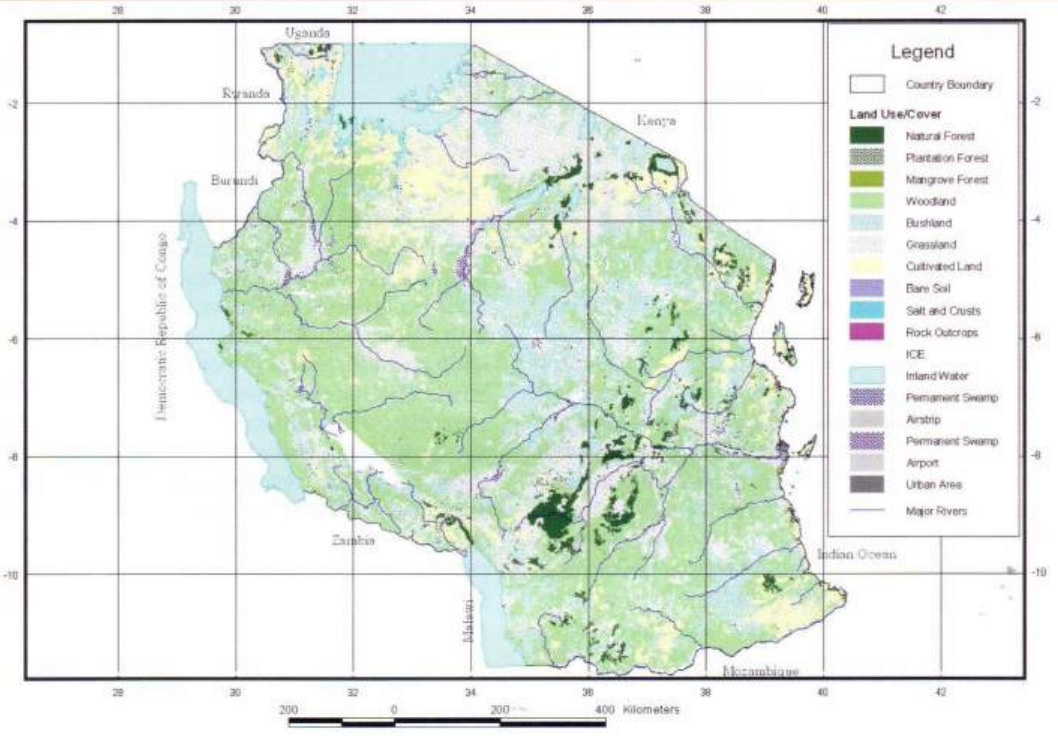
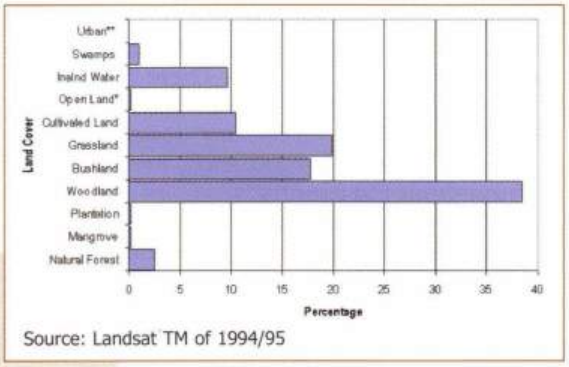
Major Land Use and Cover Types in Tanzania Map 11



Source: Based on Landsat TM 1994/95

- Rehabilitated secondary forest – these are largely degraded lands due to overgrazing and shifting cultivation.
- Post fire secondary forest – these forests cover large areas in Tanzania. They have developed as a result of frequent fires and overgrazing. The extensive savanna woodlands in the semi-arid central, western and southern parts of the country constitute a post fire secondary zone. Grazing is an important activity in this zone often regarded as rangelands.
- Post abandonment secondary forests – these are generally dry areas with low potential of regeneration.

Land Use/Cover Distribution for Tanzania Graph 3



Source: Landsat TM of 1994/95

Causes and Effects of Fires

There are frequent fire outbreaks or occurrences in both protected areas and public land that have resulted in the secondary forest types described above. The causes of fire in Tanzania have a lot to do with land tenure systems, especially where the land is protected (National Park, Game Reserve, Forest Reserve) or public. Public land is often viewed as belonging to no one and there is little incentive to protect it from fire.

Protected Areas and Forest Plantations

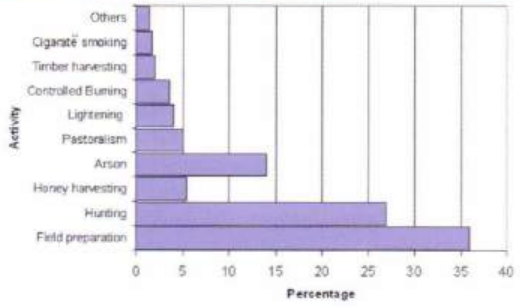
Fire is often used as an ecological management tool in many National Parks and Game Reserves. Fire is set in selected areas during the dry season in what is described as early burning. The aim is to induce the growth of grass at the beginning of the rainy season. Early burning is done under supervision to avoid fire spreading to other areas not intended for burning. Though done under supervision, controlled burning cannot exclude the possibility of fire being spread to adjacent areas, be it within the protected area or the adjacent public land, by various factors like wind. Between 1995 and 2000, there were 35 incidences of fire in Reserved Forests affecting 11,166 ha in Morogoro Region alone (Table 3).

Fire Incidences in Reserved Forests of Morogoro Region Table 3

Year	Fire incidences	Area affected (ha)
1995/96	7	3 495
1996/97	18	5 270
1997/98	4	1 202
1998/99	4	472
1999/00	2	727
Total	35	11 166

Source: Forest and Beekeeping Division, Ministry of Natural Resources and Tourism, 2001.

Causes of Fire Outbreak in Forest Plantations Graph 4



Source: Forest and Beekeeping Division

Public Land

There are a number of reasons for fire outbreaks in the public lands. Some of the main causes of fires are:

- Cattle herders set fire when the vegetation is dry during the dry season to induce regeneration of fresh grass. The herders usually do not have resources to control the extent of the area to be burnt.
- Subsistence farmers use fire during the dry season to prepare their plots. This process is often difficult to control and the possibility of a fire spreading to other areas is high. In those areas with inadequate rainfall, fire is used to clear the land before sowing the seeds.
- When new agricultural areas are opened as part of shifting cultivation, burning is almost inevitable.
- Fire is also used during hunting to drive out animals from their hideouts.
- In tsetse fly infected areas, fire is deliberately set during the dry season to reduce the menace of tsetse flies.
- Charcoal burning is always cited as another source of fires. There is some controversy to this as bush fires especially those with devastating effects are not in the interest of charcoal burners.
- Natural fires ignited by lightning.

According to Dallu (2003), records with the Forest and Beekeeping Division between 1990/91-1999/2000 show that the major causes of fire in Forest Plantations are field preparation (36 per cent), hunting (27 per cent) and arson (14 Per cent). Other causes for the same duration are indicated in Graph 4.

Fires started intentionally have in many cases been very destructive, reducing for example, the grazing potential of land and exposing it to soil erosion. The species composition of the post fire secondary forest is determined by fire. The forest is dominated by *Afromosia* and *Combretum* species. It has been argued that if these forests remain protected from fire for a number of years plant fuel accumulates on the ground and when a fire occurs the accumulated plant material fuels fierce burning which exposes the land to severe soil erosion making regeneration difficult (Box 1).

Community experience in effect of fire suppression in Mgori Forest Reserve Box 1

In Singida Region, Mgori Forest Reserve has been under community based management with each surrounding village managing a portion of it. Forest officials have been emphasizing the importance of eliminating fire to keep the forest intact, and the extent to which the villages could achieve this was regarded by those government officers to be a key measure of their success. Many village leaders accordingly pressed for control and instituted rules which resulted in a dramatic decline in grass fires during the early part of the dry season in both 1995 and 1996, only to lead however to much more widespread fires in the forest later in the dry season, given the greater amount of dry biomass on the ground. The heat from these late fires managed to damage standing trees, an effect that was not normally seen during earlier fires, when the grass was less dry. Villagers came to the conclusion that the traditional burning of Mgori by hunters, which without controls, tend to occur in earlier months, were in fact protecting the forest from later fires spreading and doing more damage.

Source: Wily, Liz (1996)

Though most fires occur in miombo woodlands and rangelands, they are not limited to those areas. For example, between 1997 and 1999 bush fires damaged 5,000 ha of forest and peat land on Mt. Kilimanjaro and Mt. Kenya in neighbouring Kenya (Global Forest Fire Assessment, 1999/2000).

Fire Management and Monitoring - Tarangire National Park

Tarangire National Park provides a good example of fire vulnerability assessment in Tanzania. Established in 1970, the park measures approximately 2,600 km^2, and is the fifth largest of the twelve national parks in Tanzania (Mchallo, 1994; Hjert, 2006). The park is named after the

Tarangire River which provides the only permanent water source for wildlife in the area. Tarangire River runs through the centre of the park passing through diverse habitats and varied topography, gentle rolling hills and seasonal swamps dominated by black cotton volcanic soils. The park is located in a wooded steppe with an arid acacia savanna belt that is dominated by *Acacia* and *Commiphora* species.

The various types of woodland include *Acacia – Commiphora* woodland, *Acacia drepanolobium* woodland, *Combretum – Dalbergia* woodland, Riparian woodland, and *Acacia tortilis* Parkland. Other vegetation types include wetlands and seasonal flood plains vegetation, riverine grassland, deep gully vegetation and grasslands with plenty of baobab trees (Map 12). Tarangire National Park has the highest concentration of wildlife during the dry season due to Tarangire River (Forey, 2002). The dry season occurs from July - September and temperatures range between 18 and 32 ^{O}C. The wet season occurs from mid-October to mid-May and temperatures are between 21 and 27^{O}C. Rainfall is usually in the region of 1,600 mm per annum and is heaviest from November through to April (Kahurananga and Silkiluwasha, 1997). During the rainy season, animals disperse to the greater Tarangire ecosystem.

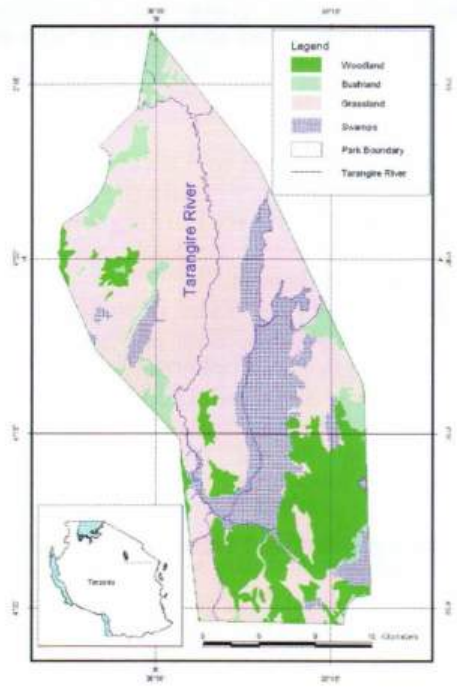
Fire Issues in Tarangire National Park

The park resembles an island surrounded by the pastoralist *Maasai* except on the eastern part bordering Babati District where farmers rely on cultivation although they may keep some livestock like cattle and goats. Fire is widely used in the preparation of farms. In recent years, the *Maasai* pastoralists have engaged in agricultural activities for subsistence. Fire has been part of the ecology for many years and is responsible for the Park's high biological diversity.

Observations mainly based on years of experience, show that the growth rate of new vegetation at the onset of the rains is very different on burnt areas compared to unburnt areas and this difference is evident throughout the park (Paul and Marc, 2003). After burning, soil is exposed to the drying effects of the sun and wind. The exposed soil may be colonised by other species that have better dispersal ability than the previous species. The exposure may also result in soil erosion and desertification if the rains are late or come as floods, which are a common phenomenon.

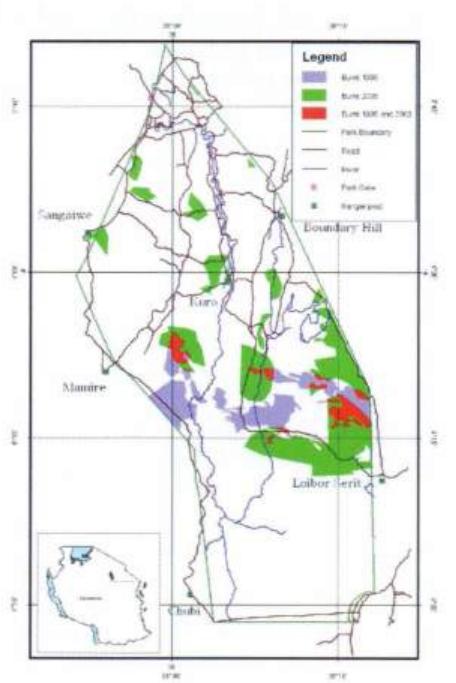
Recent research in the Ngorongoro Crater, where fire has been artificially suppressed, showed that tick numbers increase two-fold with every 0.5m increase in grass height and that it was the control of fire which resulted in the increase in parasites noted on Buffalos in 2001/2002 (Mills, et al, 2003) This 'parasite

Major Vegetation Types of Tarangire National Park Map 12



Mapped using Landsat TM 1994/95 data

Distribution of Burnt Areas in Tarangire National Park Map 13



Based on Landsat TM 1994/95 and GPS survey of 2003

load' along with late rains in 2002 resulted in the deaths of hundreds of Buffalo in the crater.

Prescribed burning is done in Tarangire National Park according to the ecological management of the park. However, most fires affecting the park are ignited outside and spread into the park burning considerable areas.

Spatial Distribution of Fires in Tarangire National Park

Data derived from the Landsat TM 1995 image shows that eight per cent of the park was burnt in that year (Map 13). The burnt areas comprised mainly of the grass plains. In 2003, the area burnt increased to 15 per cent and more than 80 per cent of these were grassland plains. The rest was bush land and very little wooded vegetation. Analysis of Maps 12 and 13, show that the area burnt in both 1995 and 2003 represented two per cent of the total park area.

Evolution of Fire Management in Tanzania

The evolution and management of fire issues in Tanzania falls under two categories. There is the evolution of fire management in urban areas, specifically in town councils, airports and sea ports and the evolution of fire management in forest areas (both protected and public land). There are, therefore, two Acts dealing with fire management. One under the Ministry of Home Affairs and another under the Ministry of Natural Resources and Tourism.

Evolution of Fire Management in Urban Areas

The first Police Fire Brigade was established in 1945. Between 1953 and 1981, the Police Fire Brigade was overwhelmed and a number of Fire Brigades were established. In 1972, the Police Fire Brigade was transferred from the Ministry of Home Affairs to the Ministry of Works and then back to Home Affairs in 1978. In response to the increasing number of fire incidents and the need to have organised services pertaining to fire hazard rescue operations, the "Fire and Rescue Services Force Act No.3 of 1985" was passed to provide for the better organisation, administration, discipline and operation of fire and rescue brigade services.

Evolution of Fire Management in Forest Areas

In principle all forest areas, whether protected or not, were protected against fire under the Forest Ordinance Act of 1957 Cap 389 and the Grass Fires Control Ordinance Cap 135 of 1943. The aim of Cap 389 was to protect and manage forest areas under the central government and town councils in Tanzania. The Grass Fires Control Ordinance prohibited setting fire on natural vegetation although this could be done with permission of the District Commissioner. Once the permission was granted, the law also required the person to inform in writing, the District Administrative Officer and neighbours within half a kilometre of the area to be burnt, two days before actual setting of fire. The New Forest Act No. 14 of 2002 has merged the two ordinances to facilitate among other things, the management of fire in forest areas. Part IX sets conditions for preventing fires, procedures to follow for setting fire, measures to be taken once one is caught setting fire and outlines the responsibilities of each citizen to extinguish fire once there is a an outbreak. In principle there are no major differences with the Grass Fire Control Ordinance except that the latter emphasises enforcement.

Current Statutes

Currently, there are two statutes dealing with fire management in Tanzania. These are the Fire and Rescue Services Force Act No.3 of 1985 and the Forest Act No.14 of 2002 (Table 4).

Part IX of the Forest Act No.14 of 2002 deals with fires. This part has largely been inherited from the Grass Fires Control Ordinance Cap 135 of 1943. Under part XI (Penalties and Offences) of the Forest Act, any person found guilty shall be liable to a fine or to imprisonment for a term not exceeding one year or to both.

Details of the Fire and Rescue Services Force Act No. 3 of 1985 and the Forest Act No.14 of 2002 Table 4

Fire and Rescue Services Act, No.3 of 1985: - Duties of the Fire force under section 5 (1) of the Act.	**Part IX of the Forest Act No.14 of 2002:** Provisions.
Extinguish fires; Protecting life and property in case of fire or other calamities; Discharging such other duties as may be imposed on it by law or by any direction of the Minister.	70. Restriction on burning of vegetation. 71. Power to require persons to assist in extinguishing fire. 72. Orders in relation to firebreaks. 73. Fires kindled on land of another to be controlled and extinguished. 74. Saving of counter firing. 75. Saving of right to recover damages. 76. Definition of the words owner or occupier.

Source: Ntamuturano, 2003.

Limitations of the Fire Management Strategy

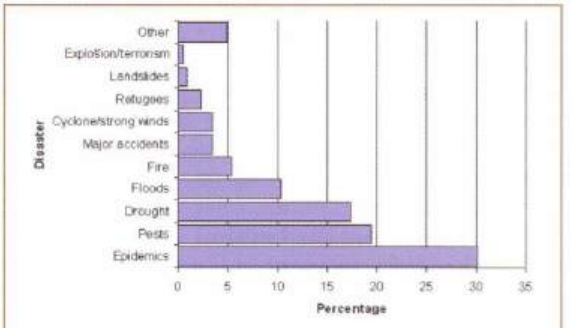
There are two organisations dealing with fire management in Tanzania. These are the Fire and Rescue Services and the Forestry Depart ment. The Fire and Rescue Services serves mostly the urban areas, covering industries, towns, air and seaports, while the Forestry Department covers forests in public and protected areas. There are no indications of coordinated efforts between the two organisations. In both cases, there is lack of proper equipment and sufficient trained human resources for fire management activities. Enforcement of the existing laws also appears to be a problem.

There are no early warning systems in place for both urban and rural areas. There are however, some preventive measures that include the construction of fire breaks and planting fire resistant species particularly in forest plantations. The Sao Hill forest plantation in Iringa has some observation towers for detection of fire outbreaks.

Human Vulnerability to Fire

Tanzania is prone to disasters. Most of the disasters are linked to its topography, climate, natural resources and human activities. According to the Disaster Vulnerability Analysis carried out by the Disaster Management Department in 2001 the most common disasters in over 57 Districts in mainland Tanzania were related to epidemics, pest infestation, drought/famine, floods, fire, major accidents, cyclone/strong winds, refugees, conflicts/Internally Displaced Persons (IDPs), landslides, explosions, earthquakes and technological disasters. Fire constitutes 5.4 per cent of the occurrences of disasters (Graph 5). Most fires that claim lives and property occur in urban areas. Most of the fire incidents are closely related to the nature of the location they occur. The common causes are electrical faults and industrial inflammable substances such as chemical and petroleum products.

Common Disaster Occurrences in Tanzania Graph 5



Source: Prime Minister's Office – Disaster Management Department (2001)

Conclusion

Fire is, and will continue to be an important ecological tool for the foreseeable future. The New Forest Act of 2002 has now incorporated aspects of community participation in the management of forest resources. Fire issues can no longer be ignored in those joint management endeavours. The Mgori experience has demonstrated this reality. What is required is sustainable use of fire. The use of remote sensed data can greatly assist in coming up with sustainable management plans and early warning systems. However, constraints such as a poor communication network, lack of software, hardware and skilled manpower continue to limit the use of geo-spatial data even where this data is available for free (http:/rapidfire.sci.gsfc.nasa.gov/). There is a need to tap into the local knowledge of fire management that is often disregarded by "experts". There is also need to harmonise fire management by having one fire act possibly under one body.

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ZIMBABWE

Kolethi C. Gumbo

Abstract

Fires play a natural and useful role in the life cycle of forests. However, fire can also have a devastating long-term effect on ecosystems that are not adapted to frequent burning. Frequent fires in tropical forests such as those found in Zimbabwe, alter forest species and structural composition, regeneration and recovery potential and also flammability. Frequent burning has implications on carbon stocks and emissions, wildlife habitat, human health and livelihoods. In a mature forest, a fire might burn only the forest floor and leave larger trees undamaged.

In Zimbabwe where there is a long dry season, dry plant debris in the miombo woodlands provide a lot of fuel on the ground and as a result fire flames are hot enough to reach the forest canopy and spread rapidly over large areas. Human activity is the major cause of fire. This includes burning to clear forests for the establishment of agricultural land, improvement of grazing, hunting and small fires used in livelihood activities such as honey gathering, cooking or to keep warm. Fires can burn out of control in areas where there are no incentives for fire protection and spread into protected areas, grazing land, forests, conservancies and national parks causing massive damage.

Although there are laws and regulations governing the use of fires, they are difficult to enforce. Fire management is done in protected areas such as national parks and forests, conservancies and commercial farms but not in the communal lands where more than 60 per cent of the country's population lives. This case study summarises the role of fire in land use management and environmental change; its impact on human vulnerability; and forest policy/institutional responses in Zimbabwe.

Introduction

Zimbabwe is a land-locked country in southern Africa, covering 39 million hectares (Ministry of Mines, Environment and Tourism, 1998), and surrounded by Zambia to the North, Mozambique to the East, South Africa to the South and Botswana to the West. The country has a population of about 12.6 million people according to the 2002 National Census. The soils in Zimbabwe vary from less fertile sandy granite-derived soils, which are found in 70 per cent of the country (Zimbabwe Geological map – Surveyor General Department), to the fertile clay igneous intrusion soils. The country has a sub-tropical climate with warm wet summers and cool dry winters. The maximum temperatures in summer can reach 40°C and the cold temperatures getting down to about 10°C.

Background Information about Zimbabwe

High fuel loads and a conducive climate render Zimbabwe prone to fires. The country experiences two distinct seasons: the wet season (summer/autumn), which facilitates the growth of grasses and other herbaceous vegetation, and the dry season (winter/spring) when temperatures are initially cold and then very hot, effectively drying the vegetation. The hot and dry season is ideal for fire, as there is enough dry fuel load, low humidity and the temperatures are high enough to sustain the ignition.

According to Goldammer and de Ronde (2004), the majority of wildfires in developing countries of the tropics and subtropics, and in temperate-boreal countries in transition, are caused by human activities usually associated with land use practices and changes. Many land use systems in these regions are vulnerable to wild fires. The property, health and welfare of people in these areas are negatively affected by direct and indirect consequences of fire such as air pollution. Active involvement of the local people is therefore, recognised as being necessary for the successful implementation of fire management programmes, especially at the interfaces between wild lands, managed systems and residential areas.

Land Use, Climate and Vegetation Cover

In order to understand the fire situation in Zimbabwe, it is necessary to look at the country's vegetation cover and land use, as the vegetation is the fuel for the fires and the land use provides the source of most of the fires. Uncontrolled fires are mostly associated with land uses such as farming and pasture management. Species diversity in Zimbabwe is described within the context of the five woodland types of the *Zambeziaca* phyto-region

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Estimates of the Extent of Land Cover Types of Zimbabwe		Table 5
Land cover	**Area (000 ha)**	**% of total area**
Afro-montane Rainforest	12	0.03
Exotic plantations	156	0.40
Indigenous woodlands	25 772	65.93
Grasslands	1 894	4.85
Cultivated land	10 783	27.56
Settlements	139	0.36
Other (water, rocky outcrops)	334	0.85
Total	39 090	100

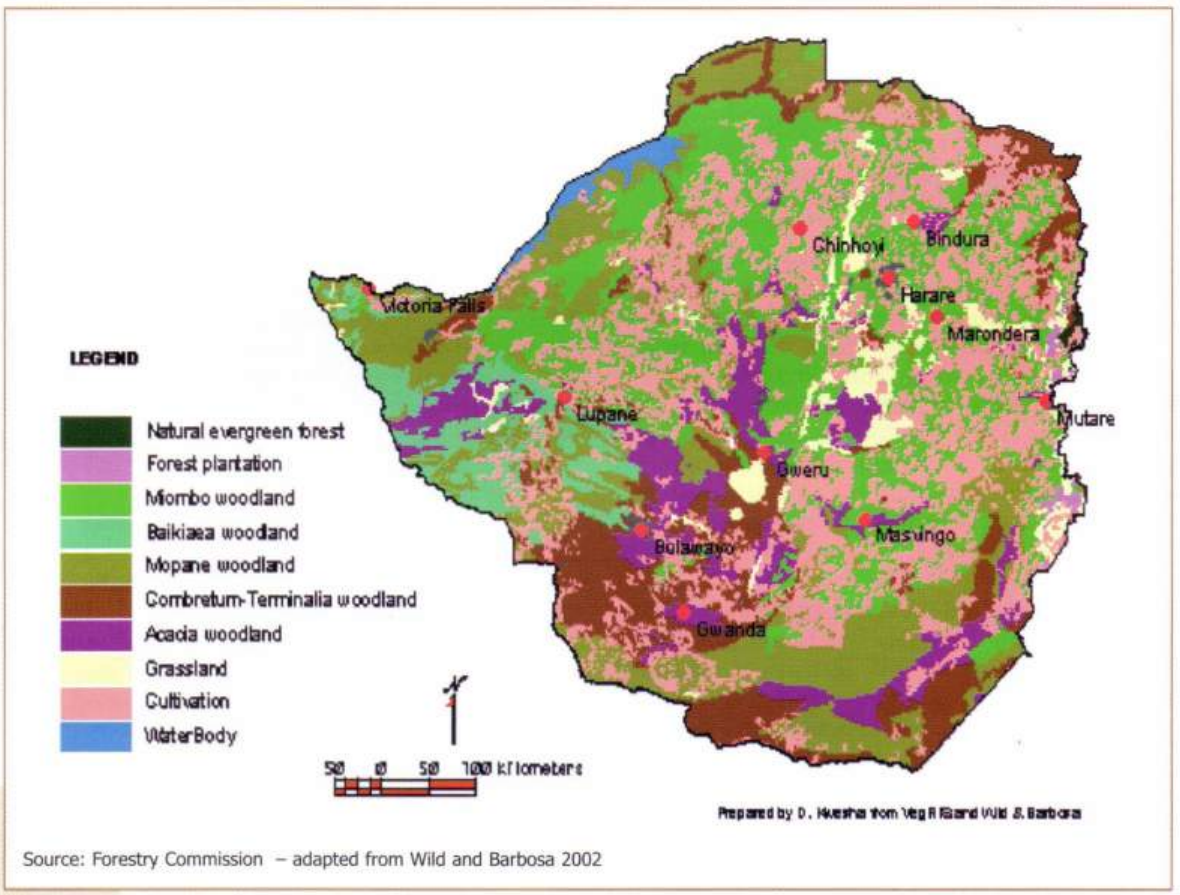
Source: Forestry Commission Report, 1996

These are Miombo, Mopane, Teak, Acacia and *Terminalia* (Ministry of Mines, Environment and Tourism, 1998). All these vegetation types are very prone to fire (Table 5).

Much of the country's forest cover, other than the *Mopane* woodland, is found in the gazetted state forests, National Parks, commercial farming areas and the Eastern Highlands part of the country. About 40 per cent of the country's natural forests and woodlands are found in the communal areas. These areas are the most exposed to frequent natural fires, indiscriminate tree cutting, and clearing for agriculture and construction purposes. Indigenous woodlands cover about 25.8 million ha – 66 per cent of the total land area. (VegRIS – Forestry Commission, 1996).

Land use in Zimbabwe is varied, ranging from agriculture (which includes crop farming and livestock ranching), forestry, wildlife, and settlements. Farming, which includes both communal and commercial agriculture, constitutes the major land use found throughout the country. The land use systems have a lot of influence on the occurrence of fires. Forestry and wildlife areas are strictly conservation areas, where there are fire prevention and monitoring systems. The investment in fire protection mechanisms such as fireguards in some commercial farming areas has lessened the spread of fire. However, the same cannot be said for the communal lands. Frost (2003) noted that as in the rest of Africa, where the land tenure in Zimbabwe is communal the responsibility for controlling the use of fires is a collective effort involving the whole community.

Zimbabwe Vegetation Cover Map 14



Source: Forestry Commission – adapted from Wild and Barbosa 2002

Climatic conditions in Zimbabwe are moderated by altitude, aspect, proximity to maritime influence and influence of the mid-continental high pressure. There are three seasons in Zimbabwe which are the hot dry season, warm to hot wet season and cool to warm dry season. Although the early dry season conditions in May/June are conducive to fire outbreaks most fires occur between August and October and sometimes November.

The exact time of the year at which fires start and finish depends mostly on the past rainy season and the start of the rains in the current season (WWF, 2001). Hot fires usually occur late in the dry season when the grass and trees are very dry. The hot dry season has more decayed humus content and dried up vegetation thereby increasing the risk of fire as land is mostly bare. Wind speed, high temperatures and high humidity contribute to erratic and uncontrollable fires in August, September and October. The weather conditions in winter and rainy seasons cause less extreme burning during these periods.

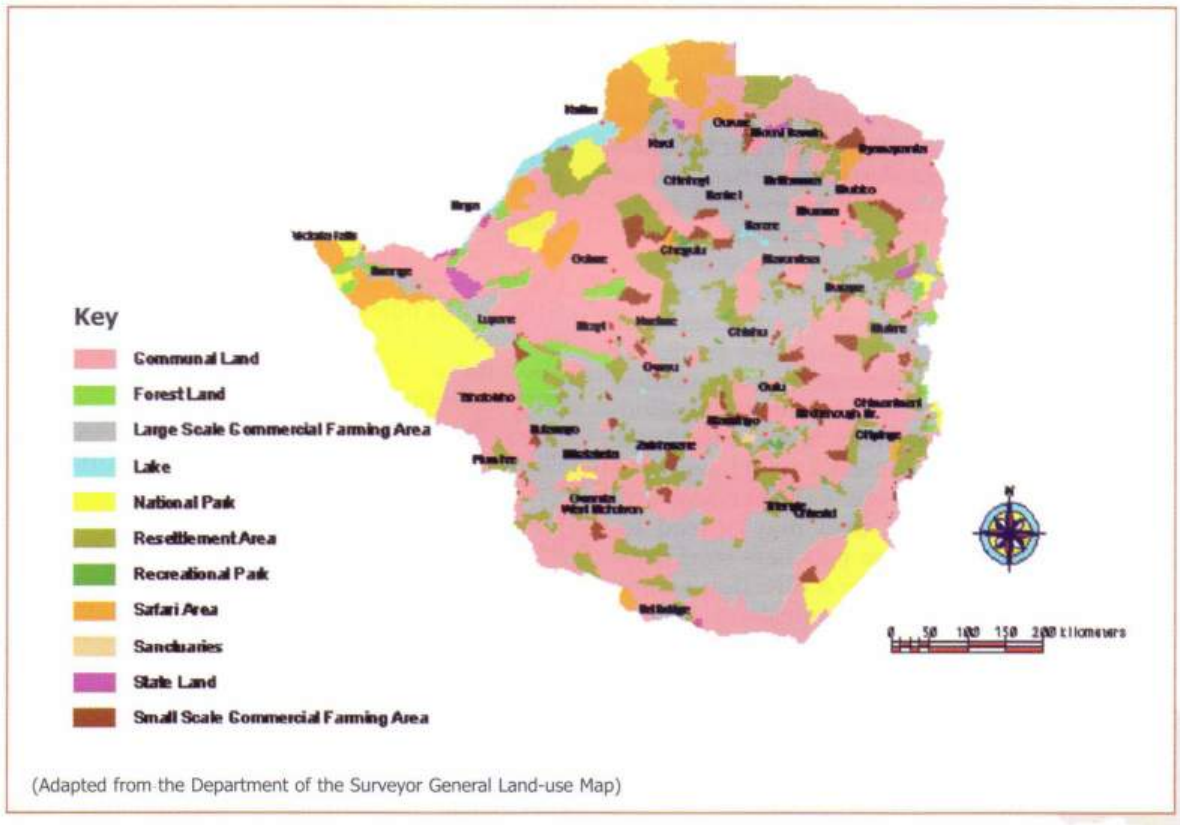
Fire

The Forestry Commission and the Institute of Environmental Studies (IES) of the University of Zimbabwe have carried out some research into wild fires and their effects. Frost (1992) states that miombo fires are fuelled largely by grass. Fire intensity therefore depends much on the recent grass production. Fires tend to be more frequent and intense in areas where canopy cover is low, mean annual rainfall high and grazing intensity low. In miombo forests, dry-season fires in the under-stories occur regularly and frequently. At a given site, there is variation in the seasonal timing of fires and in the interval between them.

The complete absence of fire is rare and probably limited to dense miombo forests with an evergreen under-storey and limited grass cover (Frost and Robertson, 1987). According to Frost (1992) fire-return intervals at any one location are likely to be more variable, depending on fuel accumulation and potential sources of ignition. Late dry-season fires are more intense and destructive than early dry season fires, (between June and July) and late wet season fires, (between April and May), which are less intense because the fuel material is still moist. However, if fires are excluded, litter accumulation increases the risk of accidental intensive fires.

Many of the woodlands are beginning to show signs of damage from frequent and intense fires. In Gambiza et al. (2000) it is stated

Zimbabwe Land Tenure Map 15



(Adapted from the Department of the Surveyor General Land-use Map)

that timber extraction exacerbates the risk of fire by opening up the woodland canopy and by allowing more light to reach the herbaceous layer as this promotes increased production of grass and fire-resistant shrubs that fuel fires. Fires kill the more fire-sensitive trees and suppress the re-growth of the fire resistant species. Calvert (1993), carried out burning trials for over 30 years and noted that forest fires do not eliminate the woody component of the vegetation but stimulate the development of an under ground community. Calvert further showed that there has been a shift in the proportion of individuals away from exploited timber species and in structure from single stems to coppice as well as a reduction of roughly 15 per cent in species biodiversity.

Use of fire in Zimbabwe

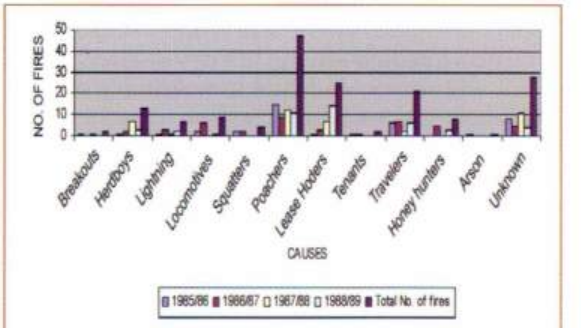
The use of fire as a tool for land use management in Zimbabwe is widespread and historical. Fire is used by farmers to clear land to plant agricultural crops and to improve grazing, and by hunters to drive out or later to attract animals to the re-growth on the burnt areas. Clearing of land for the next cropping season is done using fire in communal areas, as the use of fire is the cheapest method, Frost (2003). Fire is also used by honey-hunters to smoke out bees and by most people, especially in the rural areas, for cooking, lighting and warming. Farmers, conservationists and foresters use fire in the preparation of fireguards to protect their areas from wild fires. Fire is also used in the curing of tobacco.

Causes of Fire in Zimbabwe

Sources of fire in Zimbabwe are both natural and anthropogenic. Gumbo (2001) noted that although lightning causes natural fires, these are very few in Zimbabwe as in most cases they are put out by the rains that accompany the thunderstorms. The common anthropogenic causes of uncontrolled fires in public areas include, hunting practices, clearing land for farming, poachers, illegal gold panning, unattended fires and throwing away smouldering cigarettes. Fire is the cheapest method used by small-scale farmers to clear the land for the next cropping season.

Farmers burn the foliage in the evening and if left unattended such fires may spread to other areas. In some cases poachers start fires in order to drive animals in a direction where traps have been set. In Manicaland timber forests, honey hunters caused 14.8 per cent of the total fires with the 38 reported cases accounting for 274 hectares, according to the Timber Producers Federation. Border Timbers Limited reported that in the Chimanimani Estates 3,000 hectares were damaged by arson fires started by squatters in the estate.

Causes of Fire in Demarcated forests in Zimbabwe (1985 and 1989) Graph 6



Source: Forestry Commission

Machinery, including steam locomotives also causes fires as shown in Graph 6.

Impact of Fire

Fires as part of the natural process, has a positive role in vegetation structure and composition and helps recycle nutrients contained in old and dead trees. However, if frequency, extent and pattern of burning are not strategically planned they pose devastating effects. Fire impacts on both human and environmental processes. Strategic application of fires has proven to be very useful. If the frequency is within the required threshold wildfires have a positive role in vegetation structure and composition. They help to recycle nutrients and bring many benefits in land use management. The overall ecological benefit of fires is to kill emerging bush species and help with nutrient recycling. Further, they maintain open grasslands which is more appropriate for pasture production.

Uncontrolled fires have devastating effects on the vegetation ecosystem. Fires lead to changes in vegetation structure which gives rise to change in wildlife habitat structure. Predators such as lions, leopards, cheetahs are attracted to burnt areas because of availability and vulnerability of prey. Migration patterns also change due to fires (Ministry of Mines, Environment and Tourism, 1998).

Death of species occurs due to suffocation, however this mostly affect species with small home ranges as compared to large animals (Wright and Bailey 1982). Uncontrolled fires have devastating effects on the vegetation ecosystem.

Since 2002 there has been a massive increase of uncontrolled veld fires which have inflicted substantial damage to National Park areas, indigenous forests, commercial timber plantations, rangelands and grazing areas have been lost (Ministry of Mines, Environment and Tourism 2006). A study on the effect of fires in the Gwaai Forest Reserve showed that fires

have a depressive effect on teak woodlands as they shift species composition from Baikiaea and Guibourtia towards non-commercial species and from single to multi-stemmed rootstocks (Shaw and Timberlake 1994). Farquhar (1970) identified two shrubs namely Bauhina petersiana and Commiphora mossambicencis as indicative of the adverse effects of fires. Other species which tend to dominate after repeated fires are Terminalia sericea,Ochna pulcra and Combretum species. The complete protection of teak woodlands from fires favours the regeneration of fire tolerant species such as Pterocarpus angolensis and Burkea Africana (Farquhar 1970).

Although most people rely on fire for their livelihood, often such controlled fires break out and cause wild fires that lead to major destruction. Damage may constitute heavy financial losses and damage to humans, flora and fauna. Fires destroy grazing pastures contributing to loss of production in the livestock sector, which leads to poverty, as many rural communities are pastoral farmers.

Fires are known to have destroyed grazing pastures for livestock with animals having to be moved to other areas for relief grazing before the burnt areas recovered.

A case in point is the Save Conservancy, which in 2000 was destroyed by huge wild fires started by new farmers clearing their lands for agriculture. Moving the cattle was a very costly exercise and those that were not moved perished. The situation has been severe in resettlement areas and timber plantations. 2004 and 2005 were the worst years with an unprecedented 10,925,351 ha and 11,508,587 ha of land respectively being destroyed by uncontrolled fires.

The damage in 2005 alone is estimated at timber valued at over Z$1.5 trillion (Ministry of Mines, Environment and Tourism 2006). Properties are destroyed during fire outbreaks and in some cases, people have been killed in these fires. Frequent fires have a role in processes of land degradation, which leads to poor harvests causing famine and starvation that leads to malnutrition and diseases.

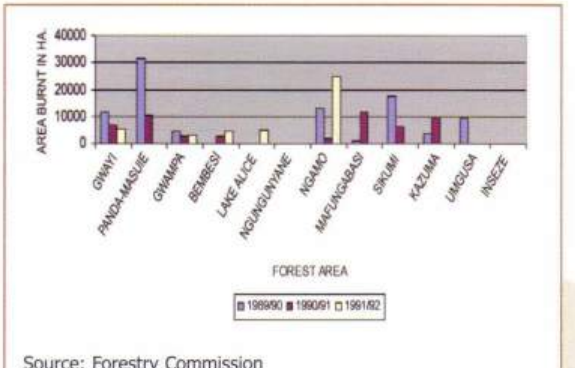
Forest Fire Management and Monitoring

Some of the indigenous forests of Zimbabwe are located in Matabeleland North Province and in Western Zimbabwe on loose Kalahari sands found in very fragile eco-systems. The forest areas, which cover about 800,000 ha, are managed by the Zimbabwe Forestry Commission under multiple use principles, which involve timber production, grazing, wildlife, watershed protection and conservation of biodiversity. Judge (1975) noted that most trees that are damaged by fires showed serious faults and blemishes that reduced their value. Forest fires that occur annually during the dry season are a major concern for sustainable management of these forests. As a result, fire protection is one of the major activities in these forests. Data on fire incidence, spatial distribution and effects are collected in order to develop strategies aimed at improving fire protection and prevention measures. This enables the zoning of the forests into fire protection zones classified according to the susceptibility of each area to fire.

During the fire season, which runs between July and November, fireguards are cleared and fire towers manned during the day and all fires occurring within the forest area reported. Active fires within the forest are put out and mapped. All the fires mapped are plotted onto a 1:250,000 map. At the end of the year a report summarising all the recorded fires is prepared giving statistics of the numbers of the fires by cause and the total area burnt (Fig. 4). As a result, there are several paper copy maps that have been produced over the years showing the number of fires by forest area, causes and area burnt each year. Mkosana (2000), proposed that this information could be used in a Geographic Information System (GIS) to identify "hot spots" or areas that burn regularly to help strategise on fire protection measures.

However, fire mapping in the forest areas is a rudimentary process whose accuracy cannot be verified. This usually results in unreliable estimates of the actual size of the fire as it is done manually by simply sketching the fire boundaries on the map. The documentation of the occurrence of fire dates back to the 1960s, although there has been no meaningful analysis of the data to come up with trends on fire occurrences. The collection of fire data is primarily aimed at improving fire protection strategies in the demarcated forests thereby reducing fire protection costs. Zoning of areas into fire susceptibility zones is the major goal of this exercise but this has not yet been achieved. As a

Areas Burnt in Demarcated Forest Areas in Zimbabwe (1989 and 1992) Graph 7



Source: Forestry Commission

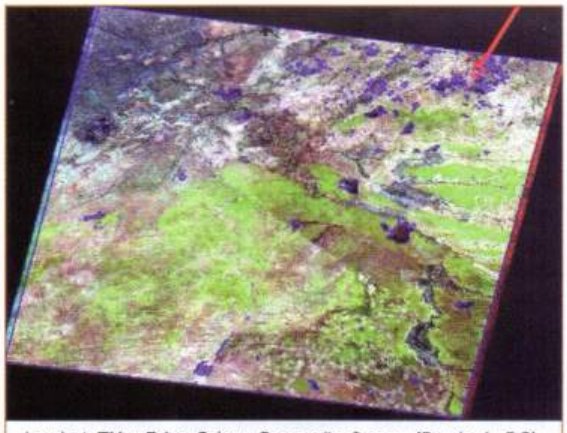
result despite the large investment that is put into fire protection, fires still occur within these forests. There is a need to improve and strategise on fire protection measures so that they can be more effective.

Use of Remote Sensing to Demonstrate Fire Distribution

As stated in Tacheba et. al. (2001) the use of remote sensing in monitoring fires provides opportunities of improving data handling, analysing and archiving the data through the use of new technologies such as Geographic Information Systems (GIS). Fire distribution data can be analysed in relation to other data sets like land cover, land use, soils and climate to develop effective fire monitoring and prediction strategies for forest fire management. New satellite data sources that can be used for fire studies such as Landsat ETM+, ASTER and the MODerate Resolution Imaging Spectoradiometre (MODIS) are now available. Apart from providing direct information on fire, such sensors also provide information on vegetation from which fuel loads can be determined and fire risk assessment made with the consideration of other factors such as land use.

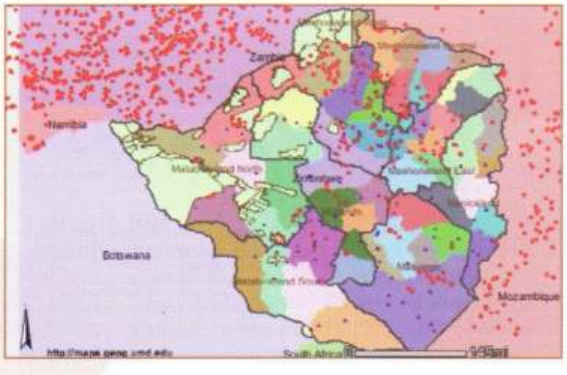
As indicated in Roy (2000), Zimbabwe participated in studies to find out how MODIS fire products could be actively integrated into forest fire mapping and monitoring programs. The Landsat-7 and comparative MODIS fire products were made available for validation following the SAFARI-2000 data policy. Figure 4 below is a Landsat TM False Colour image of North Western Zimbabwe showing burnt areas. Due to land use patterns in the Communal Lands fires are fragmented and very difficult to map

An Example of Landsat Burnt Area Mapping in North Western Matabeleland, Zimbabwe Figure 3



Landsat TM+ False Colour Composite Image (Bands 4, 5,3) Scene 171 –73, spatial resolution: 30m, dated 27 August, 2000 showing mapped fire scars (blue vectors) in Matabeleland North in Zimbabwe (Image courtesy of David Roy).

MODIS Active Fires Detected over Zimbabwe between 7 and 8 August, 2004 Map 16



Forest Fire Policy and Control in Zimbabwe

The use of fire in Zimbabwe is controlled by legislation under The Environmental Management Act of 2000 and The Forest Act, Chapter 19:05 of 1996 Sections 67–75 which cover:

- The control of fires and burning of vegetation;
- The creation and maintenance of fire guards;
- Measures to be taken when using controlled fires;
- Litigation in relation to damages caused by fire;
- Procedures in extinguishing fires and;
- Penalties for offences related to fires.

The laws are however, very difficult to enforce, especially in the Communal lands. As has been noted by Frost (2003), where central governments have attempted to regulate and control the amount of burning, it has been patently impossible to exercise the control. Matose (1997) cites the case of Mafungabusi where most fires are caused by honey hunters despite there being regulations to curb fire.

The solution to the problem could lie with devolving the authority to control and use fires to the communities themselves. Frost (2003) emphasises that by seeking to institutionalise the responsibility for burning within communities, more restrained and accountable patterns of fire use should emerge. In the government protected areas there are efforts to have resource sharing schemes with communities living in or bordering the forests. Communities get thatching grass, graze their livestock and are given part of the proceeds of revenue accrued from the resources by the authorities for community development projects like schools and clinics. Cases that can be cited are the Zimbabwean Communal Areas Management Programme for Indigenous Resources (Campfire) and the Mafungabusi Resource Sharing Scheme (Thomas 1993, Matose, 1997 and Mapedzae 2000).

Early Warning Systems on Fire

During the dry season (March/April to October/November), daily forecasts of fire risk known as the Fire Danger Estimate (FDE) are issued by the Meteorological Department and are broadcast over the radio and television by the Zimbabwe Broadcasting Holdings. FDE are based on three variables of weather: ambient temperature, relative humidity and wind speed. These components, plus a factor for the number of days since the last rainfall, are computed into a model that was developed in Chimanimani in 1964 (Elias 1992). This system has been refined in recent years.

The fire danger index is expressed in "points" and also indicated in a colour code. Prescribed burning, for instance, may be undertaken under conditions from 0 up to 39 points (Green). Greater care must be taken under conditions between 39 and 59 points (Orange), and burning is not permitted at all if the FDE is above 60 points (Red). Up to 1990 the fire danger estimates were issued only for the North and the South of Manicaland Province (Eastern Highlands). In 1991 this service was extended to cover the whole of Zimbabwe. This was a step to promote fire awareness all over Zimbabwe. The Fire Danger Estimate is applied equally to forested lands, open savannas and grasslands, and the transition types between forest and savanna.

In addition, the government through conservation agencies like the Forestry Commission, Department of Natural Resources, Agricultural Research and Extension Services and a number of Non-governmental Organisations, carry out extension programmes to educate the communities on the dangers of uncontrolled fires, controlled use of fire and fire management. In protected areas there are billboards discouraging forest fires. Through SAFNet Zimbabwe is also participating in the AFIS Fire-fax initiative that is being run from the CSIR Satellite Applications Centre in South Africa. The fire-fax is generated and sent by email together with a map and the co-ordinates of fires that have been detected by MODIS over the area on a daily basis. This is very helpful in identifying and locating fires in areas where there are no fire lookout facilities.

Conclusion

Fire remains one of the most integral and widely used tools by the Zimbabwean communities for various livelihood needs. It is therefore clear that the communities will continue to rely on the use of fire. What is needed is to educate the communities and encourage their participation in fire management so that fire remains their tool and not their master. There is a need for participatory fire management programmes that would enable communities to be part of the whole fire management process. It must be noted that fire also plays an important role in the maintenance of the ecosystem and therefore research into appropriate fire regimes for the sustained management of the eco-systems is necessary.

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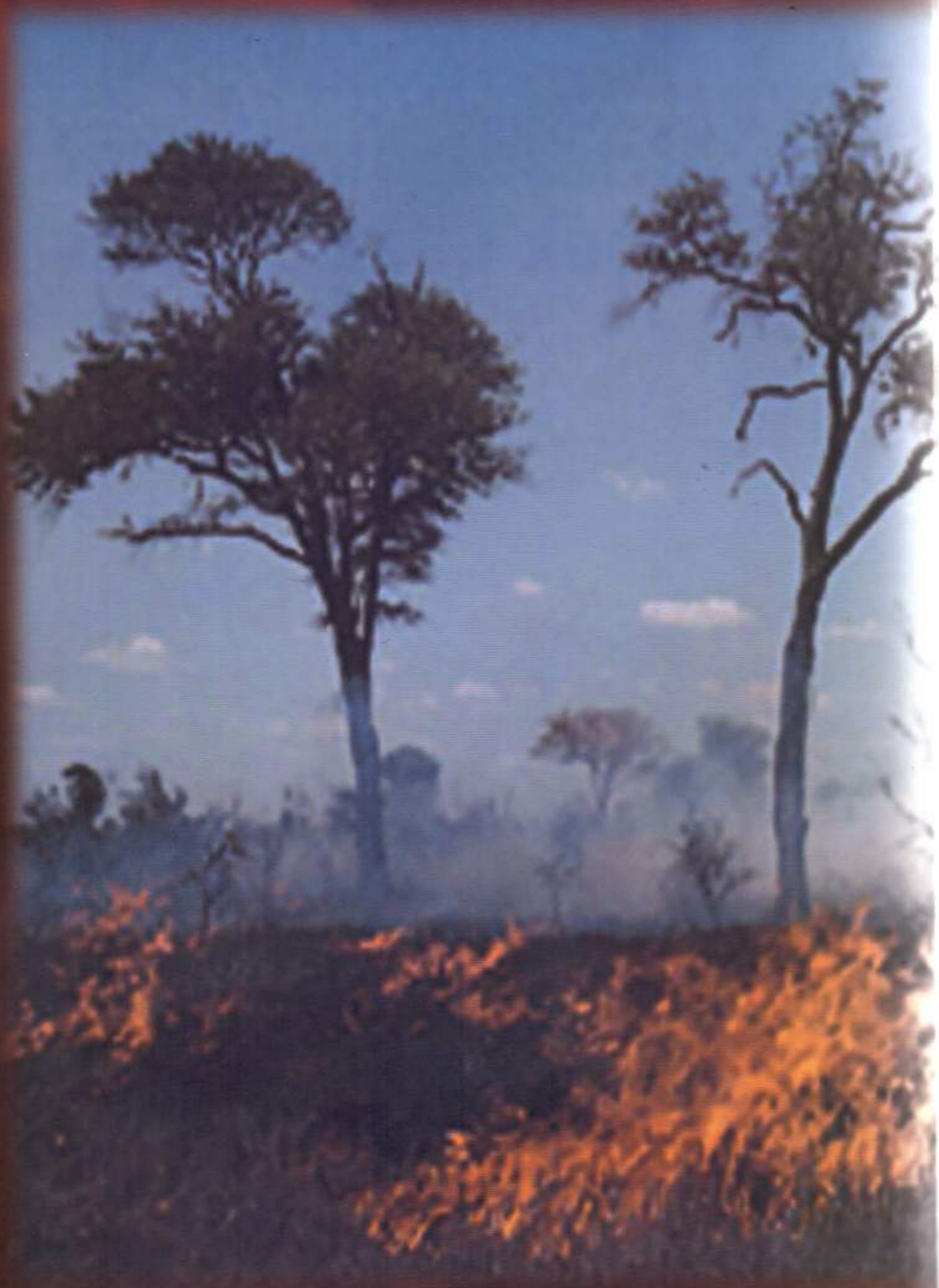

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