

# Fire Monitoring and Management in Namibia

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## Introduction

Namibia lies in the west of Southern Africa, bordering Botswana and South Africa to the east and the Atlantic Ocean to the west, and covers an area of approximately 824,000 km<sup>2</sup>. A gradient in average annual rainfall, from more than 750 mm in the extreme northeast to less than 100 mm in the west largely explains a predominance of woodland and savanna vegetation in the eastern and central regions and a transition to deserts in the west.

Large areas burn each year with a distribution relating to the rainfall gradient (and hence fuel loading) so that fires are most widespread and frequent in the north, and especially in the northeast. There is a perception that excessive, indiscriminate burning is having highly negative effects on some ecosystems, whilst in other areas, fire frequencies are more in equilibrium with requirements for long-term stability of existing vegetation communities (Goldammer 1999). The Namibia Forestry Strategic Plan consequently recognises the need for different regions in Namibia to be able to adopt different fire management policies as necessary.

Formulating national fire policy, and planning, monitoring and evaluating fire management programmes requires a wide range of information, including the timing, extent and frequency of fires. With such large areas involved, the only way to provide these parameters at a national level is to use satellite data.

Satellite-based monitoring of vegetation fires has been ongoing in Namibia since 1996 using data from the Advanced Very High Resolution Radiometer (AVHRR) onboard the NOAA (National Oceanic and Atmospheric Administration) satellite series. This data is downloaded daily by two PC-based receivers stationed in Namibia, at the National Weather Bureau, Windhoek and the Etosha Ecological Institute (EEI). Both receivers were established by projects funded by the UK-Department for International Development (DfID) and implemented by the UK - Natural Resources Institute (NRI) of the University of Greenwich.

Usually, the main fire information required is to delimit the areas burned, detected after the fire, rather than on the occurrence and distribution of active fires, which, while interesting, reveal little about the true fire extents. Burned areas are detected using a simple change detection technique applied to AVHRR thermal imagery. This identifies burns as pixels which increase significantly in brightness temperature between consecutive image dates as compared to background variation.

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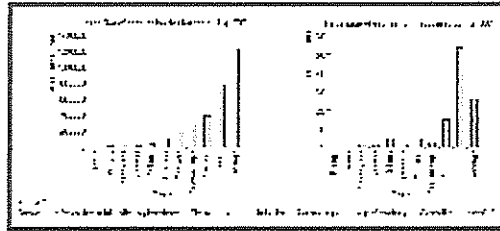
Examples of Namibian fire information and issues are given below.

## Super-Regional Fire Statistics

Figure 1 shows a area of northern Namibia which burned during 1997. Based on this map, it was calculated that 3,032,000 ha of vegetation burned during 1997. The bar chart in Figure 2a shows the area in hectares that burned within each administrative region. Figure 2b expresses these areas as percentages of the total area of each region. The Kavango region contains the largest area of burn, partly a function of its large size, whilst Caprivi was the region with the highest percentage its total area burned. This basic kind of information is valuable for identifying areas where fires may pose a sufficiently serious problem to require some form of action, especially if the burns are mapped over a number of years to derive fire frequency (Frost 1999).



**Fig.1.** Areas of northern Namibia which burned during 1997



**Fig.2.** Area of burn for each administrative region shown in Figure 1, expressed in hectares (2a) and in percentage of each regions area that burned (2b).

## Fire Information for Local Fire Management

Maps of burned areas are used more locally in the two areas of Namibia where fire is actively managed, namely, east Caprivi and the Etosha National Park.

### *Caprivi*

Caprivi forms the finger-like extension to the north east of Namibia and covers an area of approximately 22,000 km<sup>2</sup> and is vegetated predominantly by woodland, woodland savannah and floodplain grasses.

Rapidly increasing human population in Caprivi is resulting in fire being used more extensively than before, with approximately 60% of its vegetated area now burning annually (Trigg 1997, Mendelsohn and Roberts 1997, Trigg 1998). Although deliberate starting of fires is discouraged by government, it is still the main cause (Mendelsohn and Roberts 1997). The principal reasons for lighting fires are to convert wooded areas into croplands, to maintain grazing land and to assist (illegal) hunting of wild animals (Trollope and Trollope 1997). The increased frequency of burning is thought mainly responsible for a host of negative impacts, including economic losses through damage to valuable timber and non-timber resources, increased losses of grazing and consequent livestock mortalities, all of which are to the detriment of the local population. The Directorate of Forestry has therefore focused on fire suppression, via the implementation of the Integrated Forest Fire Management component of the Namibia-Finland Forestry Programme (NFFP). This programme has been highly successful at reducing areas burned in East Caprivi over the last three years, by both mobilising local communities to cut fire breaks, and educating the public about fire's detrimental effects. The success is however tempered by an ongoing necessity to set fires to maintain ecosystems in certain areas. For example, frequent fires are unlikely to have any adverse effects in floodplains, whilst fire exclusion prevents the regeneration of river grasses, an important raw material for thatching, and the socio-economy of the area (Trollope and Trollope 1999). Emphasis is therefore shifting towards continuing fire exclusion in areas where frequencies are clearly too high, whilst still allowing fires to be set under carefully controlled conditions in areas where impacts would be beneficial.

Satellite monitoring of burned areas in East Caprivi has been useful at different stages. A first assessment of burning (Trigg 1997, Mendelsohn and Roberts 1997) found that 60 % of the Caprivi region had burned during the course of 1996. The large area affected meant that it was highly probable that many areas would be burning every year, with certain detrimental effects to woodland biodiversity and its potential to regenerate.

A preliminary assessment was made of whether fire lines cut in 1997 had reduced the area subsequently burned compared to the area burned in 1996 (Trigg 1998). Maps of the areas burned both years are shown in Figure 3. It was found that seven percent less of East Caprivi burned in 1997 than burned in

1996, against a 8% increase in the area burned over the same two year period in west Caprivi. This supported the proposition that the fire lines had a positive effect in reducing fire extent. However, the assessment would be improved markedly by combining the maps in Figure 3 with an accurate map of the fire lines cut and by mapping burns over additional years to better understand normal variation. Additional work is planned to map susceptible areas with high fire frequencies by mapping additional burn years.



**Fig.3.** Areas which burned in East Caprivi during 1996 and 1997. Seven percent less was found to have burned in 1997, the year when most fire lines were cut by the community-based fire control project.

The utility of satellite-derived information on the actual fire situation would be enhanced greatly when used in combination with ecological information on desired fire regimes for each intended land use. A recent ecological survey (Trollope and Trollope 1999) stratified East Caprivi into areas where fires are desirable and those where fire should continue to be excluded (the latter class still accounting for the vast majority of the total area). The next step in improving the fire information will be to establish an integrated fire information system which combines the remotely sensed fire occurrence data with field-derived ecological information in a Geographic Information System. Using the GIS, it will then be possible to discriminate ecologically acceptable fires from ecologically unacceptable ones as an improved basis for planning, monitoring and evaluating fire management activities.

### ***Etosha***

The Etosha National Park (Etosha), covers an area of 22,915 km<sup>2</sup> and has been managed as a wildlife reserve since 1907. It is Namibia's best-known tourist attraction, with abundant large mammal and bird life. The vegetation is mostly semi-arid to arid savanna.

Official policy forbade intentional burning of vegetation within the boundaries of the Etosha National Park until 1980, when the beneficial effects of fire were officially recognised. Since 1981, fires have been prescribed by park management, to remove moribund grasses, control bush encroachment, recycle nutrients and to manipulate game movements, all in line with an overall aim of maintaining and in specific cases increasing biotic diversity (Du Plessis 1997). For the purpose of prescribed burning, the Park is divided into 25 blocks. Each block is burned periodically in an attempt to simulate natural fire frequencies derived from historical records.

The selection of areas to be burned each year depends on the mean seasonal rainfall in each burning block, the time since it last burned and the accumulation of herbaceous fuel (Du Plessis 1997). For this, EEI's AVHRR receiver is used to map burned areas during the current season, which are then compared with burned area records to derive the date of last burn. With blocks ranging in size from 68 to 1788 km<sup>2</sup>, the satellite-derived burned area maps are considered both more accurate (in terms of areal extent) and cost-effective than the previous method of driving block perimeters after fires. AVHRR data is also used to eliminate spurious rain gauge data by comparing interpolated rainfall maps with NDVI composites of the same period. Active fires, detected in near-real time using AVHRR thermal data have also been used to direct fighting teams to tackle unwanted fires.

### **Further Research and Development**

Forthcoming improvements to satellite sensors will allow burned areas to be mapped with improved accuracy and in more detail. For instance, the MODIS sensor, due to be online in early 2000, will provide data with excellent spectral discrimination (36 bands) and at a spatial resolution up to 19 times finer than the approximately 1.1 km spatial resolution of the AVHRR instrument.

Research has been conducted to characterise the spectral evolution of burned savanna and shrubland sites in Caprivi. This will form the basis of research aiming to design improved algorithms for detecting burned areas in northern Namibia using data from the new and improved satellites.

For the full potential to be realised, the burned areas detected should be integrated with field-derived knowledge on desired fire regimes (i.e. desired timing, intensity and frequency of fires), for each intended land use. Such information can be used to put detected fires into context, by indicating whether impacts are likely to be beneficial or detrimental, as part of an improved basis for action.

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