VELD BURNING IN THE KRUGER NATIONAL PARK, SOUTH AFRICA—AN ADAPTIVE APPROACH

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SUMMARY

A rigid rotational burning programme was applied for at least 70 years in the Kruger National Park. Research results from the experimental plots for the last 35 years, as well as research into a natural fire regime, revealed a lack of flexibility in the programme to allow for change in frequency of veldfires based on accumulation of fuel. An adaptive approach was recommended to ensure that frequency of veldfires and season of burn should try to simulate a natural fire regime more closely.

INTRODUCTION

Site description

The Kruger National Park (KNP) is situated in the eastern Transvaal Lowveld of South Africa on the boundary of Mocambique. It covers an area of ± 2 million hectares. The KNP experiences a subtropical climate with warm wet summers, with temperatures of above 40 °C as a general phenomenon, and mild winters with frost as an exception. The annual rainfall ranges from 700 mm in the south to 450 mm in the northern section of the KNP.

The diversity of geological formations occurring in the KNP, together with diversity in climatic conditions and slopes, result in a variety of soil types. The variety of soil types support a variety of vegetation types, varying from open savanna to dense woodland. These differences in vegetation offer different habitats for animal species. The KNP can therefore be described as a diverse system of interdependent abiotic and biotic components functioning in a near-natural manner which was protected against human exploitation for the last 87 years.

The diverse nature of the KNP can be seen in the more than 2000 vascular plant species, 50 species of freshwater fish, 33 amphibian species, 112 reptile species, and 137 species of mammals ranging from small mammals like the fieldmouse (*Mastomys natalensis*) to large mammals like the African elephant (*Loxodonta africana*) and 490 species of birds. The 2000 vascular plant species consist of 325 species of grasses, 200 species of trees, 500 shrub species, 900 species of forbs, and a few species of creepers and ferns.

History of veldfires

Fire played a role in the development and migration of plant communities in South Africa long before human settlement (West 1965). Because of this age-old influence of fire on the ecosystems, it, like climate, must be regarded as a natural phenomenon which contributed toward the establishment of a climax vegetation. Fire occurring under such circumstances in the absence of man and initiated by lightning can be regarded as a natural fire regime (Trollope 1987). In the conservation and management of natural areas like KNP knowledge of a natural fire regime is of utmost importance and it will be highlighted later in this paper. Such a natural fire regime prevailed in the area currently known as KNP for centuries before any human settlement (Brynard 1971).

When man migrated to different parts of the world, he took with him the ability to manipulate his environment. West (1965) puts it as follows: "Fires resulting from such causes (lightning) probably played their part in moulding the earth's vegetation and animal life long before the advent of Man, but the full potency of fire in its ability to affect vegetation by producing and maintaining fire sub-climax types was probably not reached until Man discovered how to make fire and to use it in furthering his activities." Proof of the first people that used fire is scarce but Maggs (1976) claims that it was during the Middle Stone Age (150,000-180,000 BC). Manmade fires in the area of the present KNP date back for at least 100,000 years (Meyer 1986).

The fire regime during early black occupation can be divided into two eras. Firstly, the period between 100,000 BC to 1500 AD was characterized by sporadic occupation by primitive peaceful people of the hunter/gatherer type which lived in harmony with their environment also as far as a fire regime is concerned. Secondly, the shorter period from 1500 AD to 1800 AD was characterized by more permanent occupation by aggressive stock farmers, hunters, and agriculturalists who also used fire in warfare. They had a greater influence on their environment also as far as the fire regime is concerned. With the migration of white men to the Lowveld the status quo was almost the same as with the black stock farmers except for the period 1896-97 when almost all the game and domestic stock in the Lowveld was destroyed in a runderpest outbreak, grazing pressure diminished and more frequent fires occurred.

With the proclamation of the Sabie Game Reserve (later to be KNP) in 1902 a policy of annual burning during autumn was adopted (Brynard 1964). The period from 1926 to 1934 was characterized by the absence of any fire because of severe drought (Stevenson-Hamilton 1943). After 1934 a policy of biennial burns in autumn was adopted. Colonel Sandenberg became Warden of KNP in 1946 and immediately changed the policy to a burn every five years and in spring. This change of the burning season to spring was a change toward a more natural fire regime.

Rotational Burning Programme

In 1952 a fire ecologist was appointed to the staff of KNP and he initiated a series of experiments to test the influence of frequency and season of fire in different vegetation types. In 1954 the triennial rotational burning programme was implemented which stated: "Until it is proved to be wrong, it be laid down by the Board as an interim policy that the whole of the KNP be divided into sections, separated by properly constructed firebreaks and that all grass which has become long and rank be burnt every three years on the understanding that only one third of each section be burnt annually and as late as possible in spring after the first rains." Hundreds of kilometers of firebreaks were constructed and the area was divided into ±400 blocks. Each of these blocks was burnt every three years in spring in such a way that the burnt areas were scattered over the whole KNP. This triennial rotational burning programme lasted until 1975.

During 1975 the burning programme was slightly altered to accommodate burns before and after rains in spring and also in midsummer in cases where special habitat manipulation was necessary for specific game species (Van Wyk 1975).

FIRE RESEARCH

Methods

The fire experimental plots were laid out in 1954. The objective of the experiment was to provide knowledge on the most appropriate burning season and frequency to be applied in the dominant vegetation types in the KNP (Van der Schijff 1959). A series of twelve different treatments was applied to each of four replicates in four of the most dominant vegetation types. The treatments were: an annual burn in August; a biennial burn in August, October, December, February and April; a triennial burn in August, October, December, February and April; and a control plot with no burn at all.

The experimental plots were used to compare the effect of different fire treatments on the vegetation structure and composition, the composition of small mammal species, as well as the soil characteristics. Treatments were applied for the last 35 years.

Data on the frequency, season, and range of lightning fires and any other fires have been collected since 1946. This data can be useful in assessing the functioning of a natural fire regime for the area. Responses of the vegetation to the current triennial rotational burning programme were also carefully monitored using remote sensing techniques. An aerial survey of KNP is conducted every year during the dry season (Joubert 1983). Among other aspects, the surveys include the numbers and location of all larger game species, distribution of water, tree and shrub phenology, an estimate of grass cover, grass greenness, accumulated litter, and areas burned during the previous season. This data is stored in a computer for every burning block of KNP. When the survey is completed a map can be printed of all the areas in KNP with a high accumulation of litter. An annual veld condition assessment at the end of the growing season (Trollope et al. 1988) also focuses on the buildup of fuel in the veld. This data provides additional input to facilitate the decision to burn or not to burn during the next season.

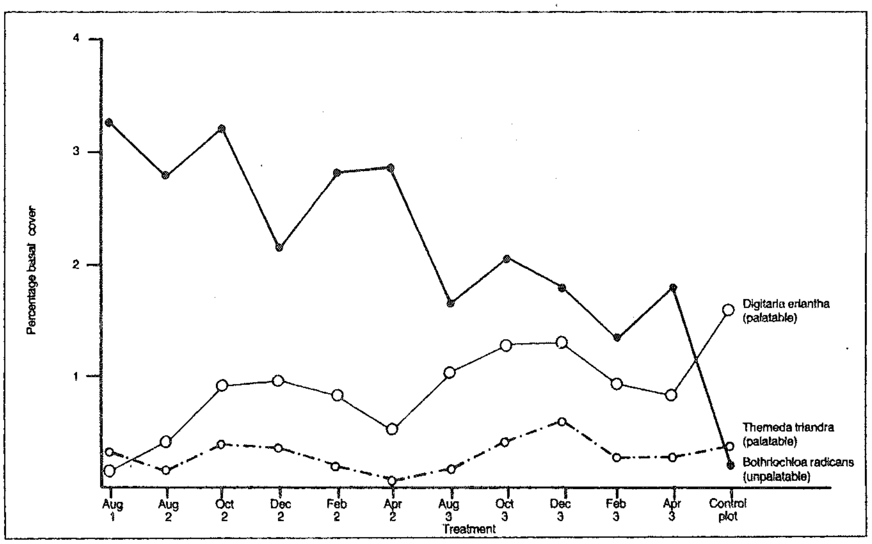
Results

Results of these surveys and trials have been published by several researchers (Van der Schijff 1958, Brynard & Pienaar 1960, Brynard 1964 & 1971, Van Wyk 1971 & 1975, Potgieter 1974, Gertenbach & Potgieter 1975 & 1979, Webber 1979, Fraser 1983, Kern 1981, Trollope & Potgieter 1985, Gertenbach 1987). A summary of the results obtained from the experimental plots is presented below for the herbaceous and woody layers.

The Herbaceous Layer

1. In unburnt veld, the grass layer becomes moribund and eventually dies out with a simultaneous increase in the occurrence of forbs (Gertenbach & Potgieter 1979).
2. Grass on an unburnt plot is essentially unutilized (Van Wyk 1971, Van der Schijff 1958).
3. Unpalatable grass material can be removed by regular burning.
4. Regular burning can be useful in preventing selective grazing (Van Wyk 1971).
5. Veld burnt too frequently shows signs of deterioration. There is an increase in unpalatable species and a simultaneous decrease in palatable species (Fig. 1).

Figure 1. Percentage basal cover of *Bothriochloa radicans, Digitaria eriantha,* and *Themeda triandra* on the fire experimental plots of Satara, Kruger National Park (Gertenbach & Potgieter 1975).



6. Veldfires in August and October result in an unnaturally high grazing pressure after the burn with detrimental effects to the herbaceous layer.
7. Fire during the dormant phase is less detrimental to the grass tuft than fires when the grass is actively growing (Trollope 1987).
8. The effect of grazing after a burn is as important as the effect of the burn itself.
9. The desired frequency of burning is very closely related to the rainfall and to the speed at which undecomposed litter accumulates. This depends on rainfall and utilization (Gertenbach & Potgieter 1979).

The Woody Vegetation

1. Unburnt veld becomes dense and unacceptable for most plains-loving game.
2. Too frequent burns can also result in bush encroachment. Better control of bush occurs with biennial and triennial burns.
3. Regular burns in August, October, and December are more capable of controlling bush encroachment than burns in February or April.
4. Most of the woody species in the KNP are adapted to and cannot be eradicated by fire. Regular fires only influence the horizontal structure of the woody vegetation.
5. Burning is more effective in regions of high rainfall than in more arid regions (West 1965, Scott 1971, Trollope 1987). Therefore lower burning frequency under higher rainfall.
6. The effect of burning on a specific vegetation type differs from wet to dry climatic cycles (Gertenbach 1980).
7. The effect of veldburning differs from one vegetation type to another (Brynard 1971, Gertenbach & Potgieter 1979).
8. No significant change in species composition of the woody layer occurred since the commencement of the experiment (Van Wyk 1971).

Because no sound conclusions could be drawn from the experimental plots and because the experimental plots only give account for four of the vegetation types in KNP, research efforts were directed towards an understanding of the functioning of a natural fire regime and the drafting of an adaptive burning programme to simulate a natural regime as far as possible. By adopting this approach the chances of making erroneous management decisions are minimized.

Research on the geological, climatological, pedological, vegetational, and zoological aspects of KNP advanced to such a point that it was possible to divide KNP into landscape units based on these different attributes (Gertenbach 1983). These landscapes are also used as management units for the purpose of a burning programme. Management objectives were drawn up for each of these landscapes and a new burning programme tried to meet the requirements of these objectives.

Analysis of the rainfall data for the KNP revealed a cyclic pattern which implies a period of about ten years of above average rainfall, succeeded by a period of about ten years of below average rainfall (Gertenbach 1980). A close relationship was also found between the accumulation of litter in the wet spells and the frequency of lightning fires (Fig. 2). This indicated that a regular burning frequency which does not consider the climatic cycles and therefore the accumulation of litter, is unnatural and that the frequency of veldfires should be adapted to correspond with the climatic cycles and the buildup of grass fuel in the veld.

Figure 2. Rainfall vs accidental/rotational burns 1975-1986 Kruger National Park

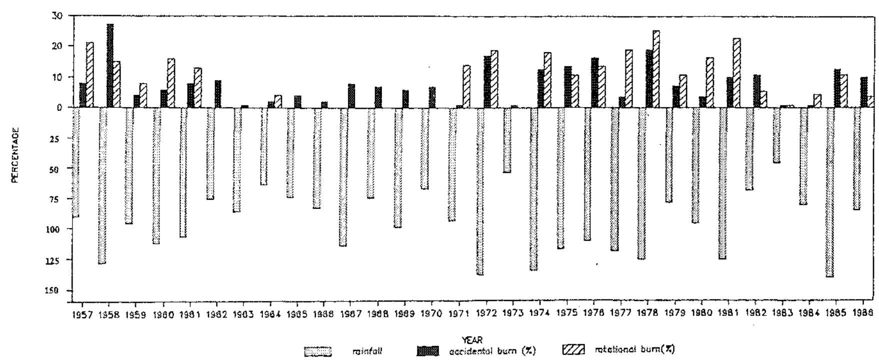


Figure 3. Fuel load vs rainfall cycle

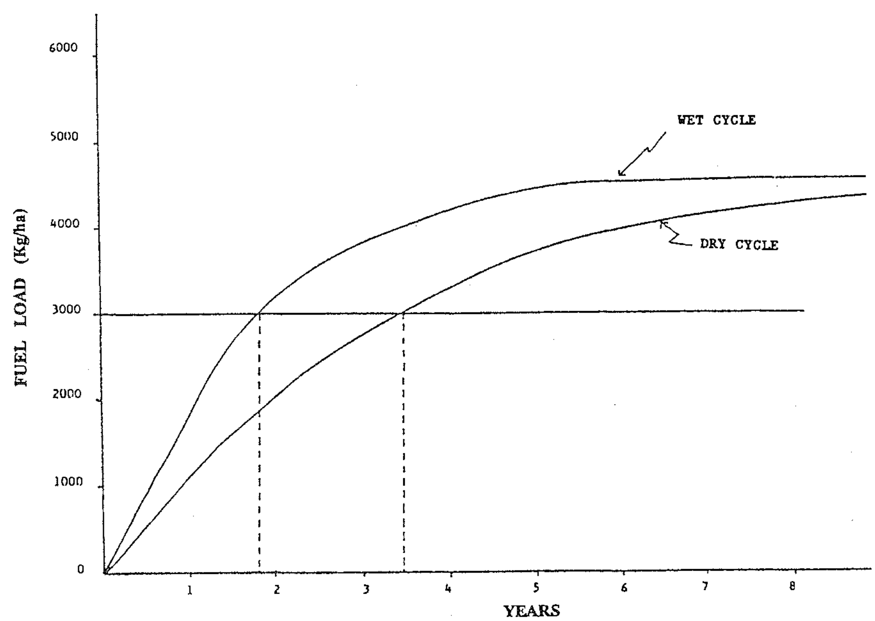
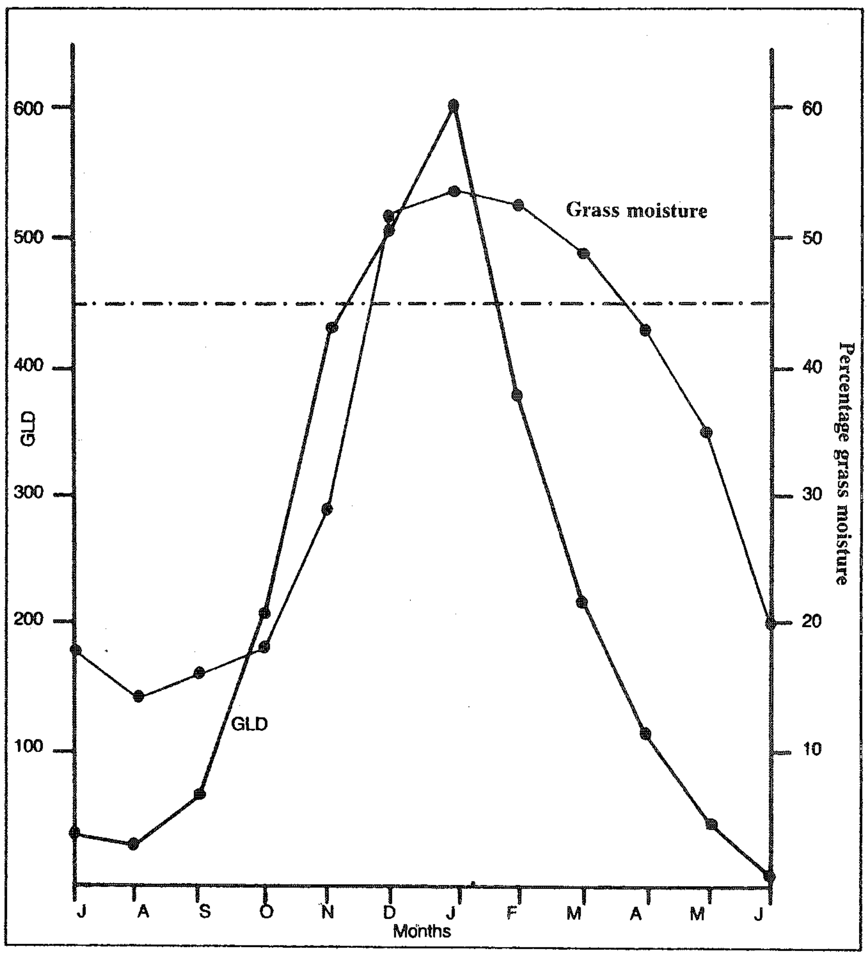


Figure 3 shows a graph of the buildup of grass fuel during a wet and dry cycle. If 3000 kg/ha is the level at which a lightning fire would occur, then this level will be reached in two years in a wet cycle, but it may take up to four years to reach this level in a dry cycle. This once again implies that burning frequency must be adapted according to rainfall or climatic cycles and the buildup of grass fuel.

Research showed that the ground lightning density (GLD) (Fig. 4) increases during the summer months. The moisture content of the grass layer also increases during the summer months. The result is that the success of a lightning strike to set fire to veld decreases during the summer months and also decreases in the winter as a result of lack of thunderstorms and the associated

Figure 4. Average ground lightning density (GLD) and percentage grass moisture for Kruger National Park (Gertenbach 1989)



lightning. The only season of the year when the GLD is high enough and the grass moisture is low enough to start a fire is during early spring. In wet spells with a high buildup of fuel, lightning fires occurred almost any time of the year with a peak in early spring. The incidence of these fires in dry spells was restricted to early spring. These observations are substantiated by figures from the KNP and Etosha (Table 1). A burning programme should therefore be adaptive to accommodate such a phenomenon.

Conclusions

Results from the fire experimental plots as well as the research into a natural fire regime led to the following conclusions.

I) Fire is a natural factor in the development and maintenance of the vegetation of KNP.

II) The effect of veldfires on the vegetation differs for different vegetation types and KNP can therefore not be treated as one unit in fire management.

III) Veldburning on a rigid rotational frequency is unnatural and must be adapted to allow for periods of high and low buildup of grass fuel.

IV) Season of burning must be selected to coincide with the peak occurrence of lightning fires.

Table 1. Number of lightning fires in the Kruger National Park and Etosha.

MONTH	KNP (1982-84)	ETOSHA (1975-79)
January February	13	4
March April	3	0
May June	1	0
July August	1	3
September October	4	15
November December	32	19
TOTAL	54	41

PRESENT PROGRAMME

The objectives of veldburning in the KNP are to remove old unpalatable fuel and to stimulate new growth, to try to combat bush encroachment, to stimulate genetic diversity, and to simulate a natural fire regime.

To meet these objectives the following burning programme was introduced into KNP in 1982. A burning programme for KNP, with its 400 burning blocks and different biological variables, demands an efficient data storage and retrieval system. Computer facilities became available in KNP in 1978 and were immediately employed to facilitate a more flexible burning programme. The size, location, and fire history of each block as well as the corresponding landscape are stored in the computer. A list of all the blocks in a particular landscape arranged in chronological sequence of date of the previous burn, together with the percentage contribution toward the area of the landscape can thus be retrieved from the computer at any time of the year (Table 2).

With these data and computer maps showing accumulated litter, game distribution, grass cover (obtained from the aerial surveys and the veld evaluation), and rainfall distribution for the past few years, a panel of research and management personnel decides on the percentage area per landscape which can be burnt without damaging the habitat. This decision is also based on the management objective for each landscape or management unit. The percentage area per landscape is then transferred to the computer printout and the blocks due to be burnt can be read off. In order to verify the

Table 2: Example of a burning planning schedule for one management unit in the KNP.

Block no	Previous burn	Responsible ranger	Area of block	Percentage of management unit	Cumulative percentage
S68	09/12/75	9070	107.1	11.4	11.4
S62A	10/13/77	9072	33.5	3.6	15.0
S66A	05/29/78	9070	47.6	5.1	20.1
S60B	08/29/78	9068	95.2	10.1	30.2
S89	08/29/78	9068	58.4	6.2	36.4
S85	10/31/78	9068	68.7	7.3	43.7
S86	10/31/78	9069	48.7	5.2	48.9
S59A	10/31/78	9067	36.2	3.9	52.8
S59B	11/02/78	9068	31.3	3.3	56.1
S63A	09/14/79	9069	68.7	7.3	70.1
S34	03/31/80	9067	48.1	5.1	75.2
S60A	09/15/80	9072	59.5	6.3	81.5
S67	09/15/80	9070	18.9	2.0	83.5
S62	09/18/80	9072	94.6	10.1	93.6
S66	09/24/80	9070	58.9	6.3	100.0

computer selection an inspection of the blocks due for burning is done. The inspection includes a visual estimate of the density of the woody vegetation and a measurement of the available grass fuel using a disc pasture meter.

The time of burning for each block depends largely on the time it was burnt during the previous cycle and the management objectives for the landscape. Blocks burned during the early spring before the rain in the previous cycle, will preferably be burnt after the first rain in spring during the next cycle. The time of burning is also adapted according to the accumulation of litter and the prevailing climatic cycle. Lightning fires occurring in a block before the scheduled time can easily be incorporated in the programme.

By adapting the percentage area of a landscape which has to be burnt per year, the frequency of burning changes automatically. The burning programme can therefore be adapted from year to year to correspond with changes in fuel load, grazing pressure, climatic cycle, and management objectives.

Each fire is described in terms of the environmental conditions before, during, and after the burn. Fuel load, fire intensity, vegetation damage, animal damage, etc, and the success of the burn with regard to the objective for the management unit are carefully described using a computer sheet. This data is stored in a computer to facilitate the drafting of a fire model to be able to predict the effect of a fire in the future or to give guidelines for the selection of the appropriate environmental conditions under which circumstances to burn in order to achieve the desired management goal.

DISCUSSION

The success of the current programme is evaluated on a continuous basis. The most important shortcoming of the programme is not in the structure, but in the practical application of the fire itself. Blocks of up to 50 km^2 are burned upwind as a back-fire to create a firebreak. Afterwards fires are lighted around the whole block. The fire creates its own wind resulting in a very high intensity fire in the middle of the block. Game can be trapped in such a fire with severe results.

The suggestion has quite recently been made to use whole landscapes as burning blocks, to make use of a spot source of igniting instead of a ring source, to let the fire continue until the preferred percentage area has been burned and then to put it out, to shift the point of ignition during the next season, etc. In applying such a strategy the end result might be an annual mosaic of burnt and unburnt veld which would be more natural than a system of blocks burnt from four sides.

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