

## **Savanna Fire Ignition Research Experiment (SavFIRE): Effects of point vs perimeter ignitions on the patchiness within the fire mosaic**

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### **ABSTRACT**

A recent development in the use of fire in large conservation areas like the Kruger National Park (KNP), is the hypothesis that the desired biodiversity of the overall ecosystem will be promoted by controlled burns applied as point ignitions instead of perimeter ignitions (block burns). At this stage benefits associated with controlled burns applied as point ignitions are untested hypotheses. An urgent necessity thus exists to determine whether point ignitions do in fact result in a greater patchiness within the fire mosaic (ie. different types and intensities of fires) compared to areas burnt as perimeter ignitions and at what scale. Preliminary results from treatments suggest that fire mosaic patterns are most strongly influenced by prevailing weather conditions and fuel characteristics at the time of ignition. This project attempts to determine the threshold area, weather conditions and fuel required for similar fire patterns and mosaics resulting from point ignition and perimeter ignitions. It is envisioned that such an investigation would promote the improved use of controlled burning in conservation areas, achieving their objective of promoting biodiversity in large national parks and smaller wild life areas in South Africa thereby benefiting ecotourism and its positive effects on poverty relief.

*Key-words:* fire danger index, fire intensity, fire weather, Kruger National Park, types of fire

### **INTRODUCTION**

African savannas are fire-prone, and the importance of fire in determining the composition, structure and function of these ecosystems (Anderson et. al., 2003; Bond and van Wilgen, 1996) is probably the oldest issue in savanna ecology that remains contentious (Scholes and Walker, 1993).

Savannas are tropical grasslands with scattered trees that occupy about 20% of the land surface of the Earth and 40% of Africa. These ecosystems are dynamic in their structure and composition, which changes in response to fluctuations in rainfall, levels of herbivory and occasional fires. Without fire, considerable areas of African savannas could potentially develop into closed woodlands under the current climate and the occurrence of fires over the past *c.* 8 million years has also seen the evolution of a fire-tolerant and fire-dependant flora (Bond et. al., 2005). The appropriate use of fire in savannas is therefore an important consideration for managing these ecosystems and the maintenance of biodiversity.

In African savannas, active fire management has been practiced for many decades (van Wilgen et. al., 1990). Fire policies, practices and implementation have changed as new evidence pertaining to the role of fire emerged (Mentis and Bailey, 1990; Bond and Archibald, 2003). Reasons for changes to policies and practices are often driven by philosophical debates, namely, (i). is fire necessary? (a protection (no fire) versus a active burning policy), (ii). are ecosystems stable? (a fixed versus a variable burning policy and (iii). should we interfere? (a natural fire versus a prescribed burning program).

### **KNP fire history**

The Kruger National Park (KNP) in South Africa is no exception to these influences. Since the proclamation of the park, fire management has passed through a number of phases (Wilgen et. al. 2004).

From 1926 – 1947, occasional and limited deliberate burning was conducted. Fires were ignited to consume old grass that escaped other fires in the area, mainly to provide new growth for grazing.

From 1948 – 1956, attempts were made to reduce the impacts of fire, by ensuring, wherever possible, that no area burned more often than once every 5 years.

From 1957 – 1980, regular prescribed burning was conducted every 3 years, in spring after the first rains on fixed areas of around 4000 ha (“burning blocks”).

From 1981 – 1991, a flexible prescribed burning programme was conducted, in which fires in burning blocks were timed to take fuel loads, post-fire age and mean annual rainfall into account. The seasonal distribution of fires was attempted. However the policy states these conditions but this was not actually implemented on the ground.

From 1992 – 2001, a “natural” fire policy was in place, in which all lightning-ignited fires were allowed to burn freely, while at the same time attempts were made to prevent, suppress or contain all other fires.

From 2002 – present, point ignitions are used to start fires in areas where fire is deemed necessary. Grass sward composition and grass fuel loads and rainfall in the preceding two years are used to identify the location of fires and amount to burn. Fires are ignited early in the fire season in order to allow for a dominance of low intensity fires.

Analysis by van Wilgen et. al., 2004, indicate that management had little if any effect on the extent of area burned (Figure 1) or on the variability in inter-fire intervals. These elements of the fire regime are strongly influenced by rainfall patterns, regardless of management approaches. However, managers are able to affect the spatial heterogeneity of fire patterns (van Wilgen et. al 2008) and the seasonal distribution of fires (Figure 2), thereby influencing the intensities that fires burn (Govender, et. al., 2006).

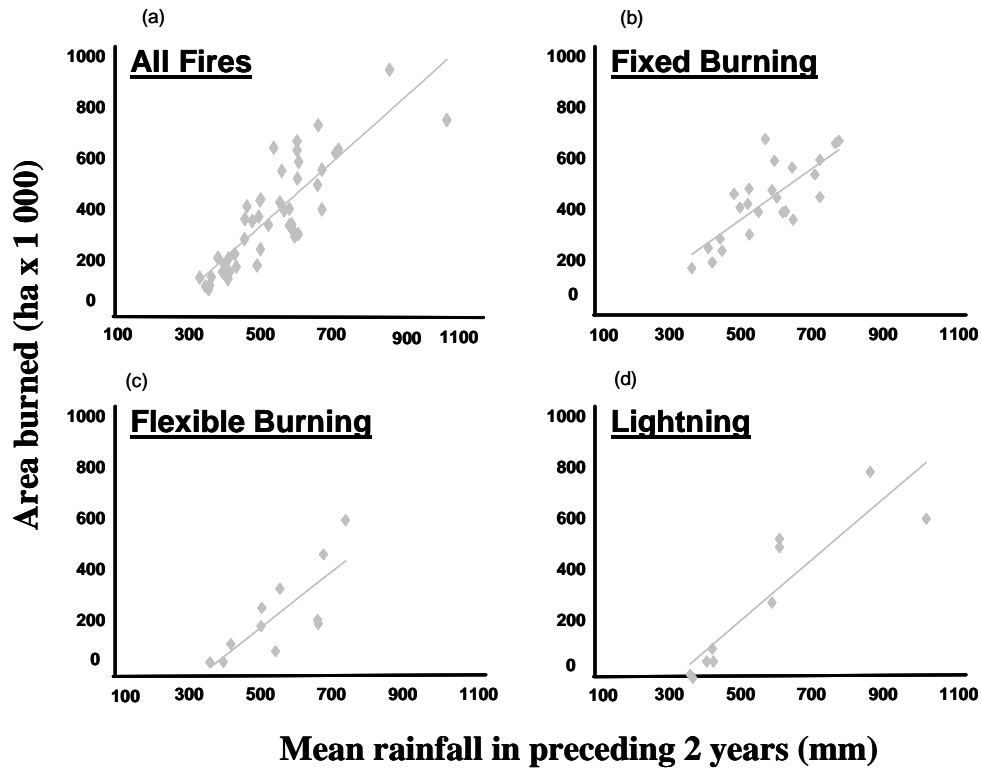


Figure 1: Relationship between the total area burnt (ha) and the mean of the preceding two years rainfall (mm) for (a) all years combined, (b) fixed burning period, (c) the flexible burning period and (d) the lightning era (van Wilgen et. al.2004).

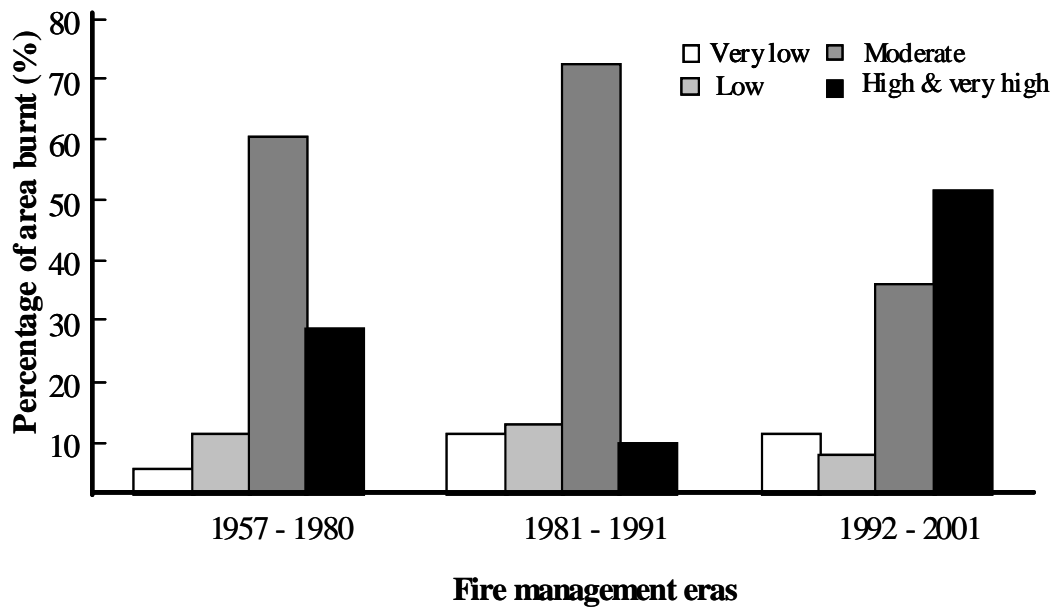


Figure 2: The proportion of area burnt in class of fire intensity during three distinct eras of fire management. The eras are (1) 1957-1980, regular prescribed burning; (2) 1981-1991, flexible prescribed burning; and (3) 1992-2001, “natural” fires. The areas burnt in each era were 7.8, 1.7 and 2.8 million ha respectively (Govender, et. al. 2006).

### **Reasons to influence the intensity of fires**

Study conducted by Higgins et al. 2007 on the effect of four decades of fire manipulation on woody vegetation demonstrated that savannas are demographically resilient to fire, but are structurally responsive. This is due to the high vulnerability of savanna trees to fire-induced stem mortality (topkill) combined with a high resilience to fire induced individual mortality. The resilience is due to the capacity of most savanna tree species to resprout after fire from root stocks (Higgins et al. 2000), hence, repeated fires can keep individuals small, but individuals rarely suffer mortality and large individuals are virtually immune from fire damage.

The tree species *Dichrostachy cinerea* is regarded as an encroaching species within the KNP. Burning in summer (lower intensity fires) can constrain *D. cinerea* population growth as summer burns negatively affect the fertility levels and re-growth levels of *D. cinerea* shrubs. This negative response is associated with seasonal fluctuations in the root carbon reserves of *D. cinerea* plants. Reserves are lowest in summer and therefore burning at this stage hampers the plants' ability to recover from the fire, which is expressed in lower re-growth rates and fertility levels and higher mortality rates (Schutz, 2006).

### **RATIONALE**

The major change from prescribed burning to lightning fires at the start of the 1990s came about in response to concerns about putative negative effects of fire on the vegetation (a decrease in large trees and a low diversity of grass species), the fire frequency was fixed and allowed for no variation and the high intensity fires associated with the practice of "ringburning" in which fires are ignited around the periphery of burning blocks towards the centre. Fires developing from lightning strikes were deemed "natural", and would spread out in all directions from a point, allowing the fire to develop a range of intensities as it spread.

When lightning is unable to contribute significantly to the area burnt, Patch Mosaic Burning (PMB) applied as point ignitions is thought to simulate lightning fires, thereby promoting habitat heterogeneity for the explicit objective of promoting conservation of biodiversity (Parr and Brockett, 1999). Point ignitions are thought to result in more varied fire behaviour patterns and fire severity than characteristic perimeter, ring or block ignitions (Cheney and Sullivan, 1997).

However, fires ignited as point ignitions are more hazardous and difficult to control compared to perimeter ignitions which are applied to areas with prepared firebreaks or off existing roads. If the same diversity of fire mosaics and variation in fire intensities can be obtained by applying perimeter ignitions to areas above a certain threshold size, this would be an attractive ignition procedure for fire managers within conservation areas who are currently mandated to maintain and promote biodiversity.

Finally, Parr and Anderson, 2006 outlined 4 guidelines that should assist in formalising PMB policies for burning for conservation. These include (i) establishing the relationship between pyrodiversity and biodiversity, (ii) identifying the management interventions required, (iii) establishing clear operational guidelines and targets and (iv) implementing effective monitoring and feedbacks. This project attempts to link the relationship between pyrodiversity (variation in fire intensity) and the two ignition sources and provide an alternative ignition procedure (with clear implementation guidelines) to fire managers.

## **THE EXPERIMENT**

SavFIRE (Savanna Fire Ignition Research Experiment) is a large landscape burning trial that is being conducted in the KNP, South Africa. The primary objective of the trial is to test the hypothesis that the behaviour and resultant fire mosaic of controlled burns applied as point and perimeter ignitions, is significantly different when applied to small areas, but becomes increasingly similar as the areas being burnt increases in size, until a threshold area is reached and the fire behaviour, fire mosaics and patchiness within the respective fire scars are not significantly different

## **METHOD**

### **Field Site**

The Kruger National Park is one of the largest proclaimed and officially protected natural areas in the world. Established in 1926, the park is approximately 1 898 458 ha, occupying almost 2.5 percent of the total land surface area in South Africa (Figure 3). It is situated in the north-eastern region of South Africa and is separated from adjoining Mozambique by the Lebombo mountain range in the east and from Zimbabwe in the north by the Limpopo valley. Mean average rainfall for the entire park is approximately 500 mm, but varies around 350 mm in the north to around 750 mm in the south. The park is also distinctively divided in two by its geology, with granitic sandy soils on the western half of the park and basaltic clay soils on the eastern half. The vegetation of the park is dominated by trees from the *Acacia* Mill., *Combretum* Loefl., *Sclerocarya* Hochst. and *Colophospermum* J.Kirk ex J.Léonard genera. The flora of the park comprises +/- 2000 taxa, including over 400 tree and shrub species, and over 220 grasses. The fauna of the park includes 148 mammal and +/- 500 bird species.

### **Protocol**

Point & perimeter ignitions will be applied to paired areas ranging from 500, 1000, 2000 and 4000 hectares under similar plant fuel (> 4000 kg/ha), fuel moisture (fully cured, < 20%), weather conditions (air temperature, <25 °C, RH, <50 % and wind speed, ± 10 km/h) and fire danger index < 50. The point ignition will be a singular circular ignition with a circumference of 50 to 100m in the middle of the block. This experiment will be replicated in three of the four major landscapes in the KNP (Figure 3). Application of all fire treatment is undertaken by the Working on Fire Organization.

The first phase of SavFIRE was conducted as a “trial run” in savanna dominated by *Colophospermum* trees in October, 2006. The second phase was conducted in June 2007 in Pretoriuskop section. However due to a change in the point ignition procedure (from 3 ignitions to a single point) and additional vegetation surveys that were implemented in 2008, the treatments will be re-applied in the Pretoriuskop section in 2010.

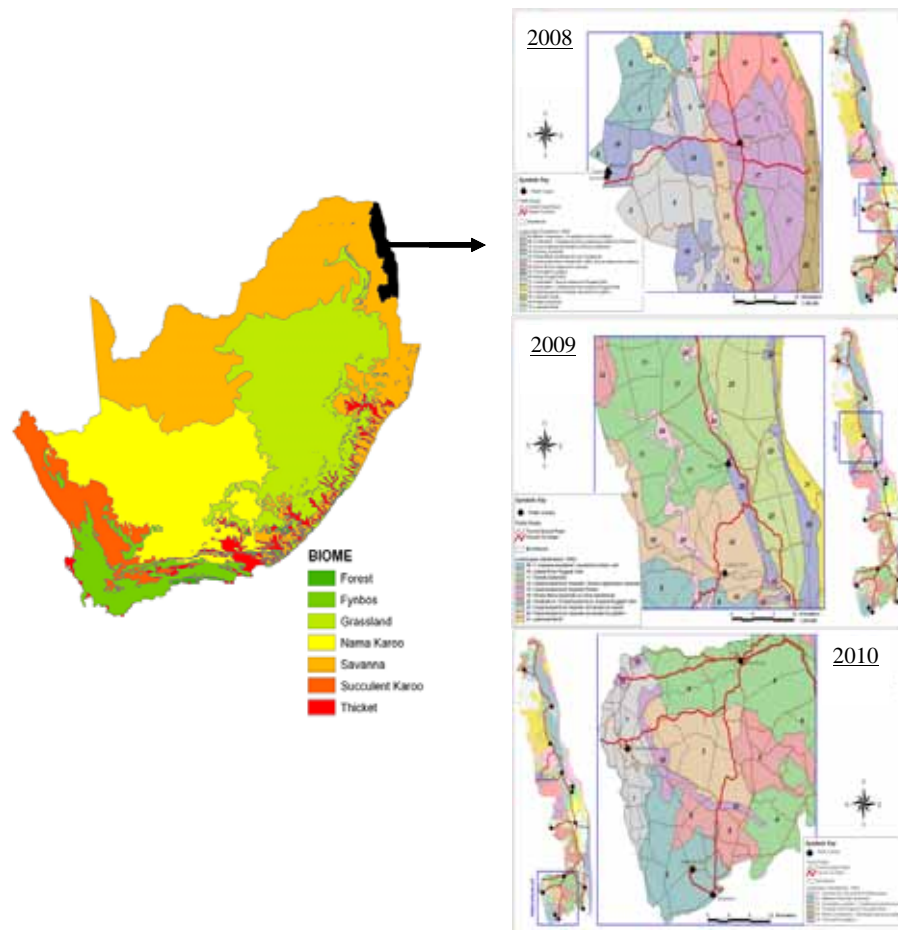


Figure 3: The position of Kruger National Park (KNP) within South Africa and the location of the 3 sites within the KNP that SavFIRE will be implemented in 2008, 2009 and 2010.

## RESULTS

There are currently no scientific results that can be discussed, but I would like to go through the data that we are collect, possible way of analysis the data and what we have leant over the past three years.

### Data that is being collected

Within a particular landscape blocks of the respective areas are selected. The blocks are protected from external fires by burning 80 to 100m firebreaks around them before the treatment is applied. Thereafter 3 transects per block in randomly drawn at 90 degrees to the river system within the area. With the use of a cyber-tracker program, pre-fire vegetation surveys (2 weeks before treatments), post-fire vegetation surveys (a week after the treatments) and re-growth vegetation surveys (after 30mm of rain) are conducted on each of the transects. All data points are GPSed. The pre-fire data is collected at 10m intervals include, a disc pasture meter, the terrain unit, grass species composition and the distance to the nearest tuft measurements. The post-fire data is sampled at 30m intervals and the data collected is disc pasture meter reading and if the site is burnt or un-burnt. Also included in the post fire surveys at 50m intervals are a set of tree measurements which includes the tree species, tree height, char height and the scorch height is recorded. This is done for trees < 2m, >2m and the largest

tree around the point. The re-growth data is sampled at 30m intervals and the data collected is disc pasture meter reading and the grass species. At every 50m interval a set of tree measurements which includes the tree species, tree height, if the tree is coppicing or shooting or both and the height of the re-growth are recorded. This is done for trees < 2m, >2m and the largest tree. Fuel moisture samples (12 per block) are collected at least two hours before the treatment is applied. Continuous (every 5 minutes) and detailed (air temperature, relative humidity, wind speed, wind direction, barometric pressure and rainfall) weather conditions are recorded by automatic weather stations that range between 2 – 15km from the experimental sites. On site weather conditions are also recorded every 30 minutes at various locations around the experimental sites by 3 to 4 observers, using a Kestrel.

## METHODS TO QUANTIFY PYRODIVERSITY

### Direct

Quantifying (ratios of burnt and unburnt areas, heterogeneity indices and variation in the intensity classes), mapping and validating (measurements of fire intensity, fire intensity vegetation characteristics and re-growth responses) the pyrodiversity from the experimental sites using SPOT 5 images.

### Indirect

Using landscape features (soil, topography, drainage lines and slope), fuel characteristics (biomass, species composition, woody tree cover and fuel moisture content) and fire weather (air temperature, relative humidity, wind speed, wind direction and rainfall) to determine the variation in fire intensity and the resultant effect on the patchiness within the fire scar in each of the experimental sites (Figure 4).

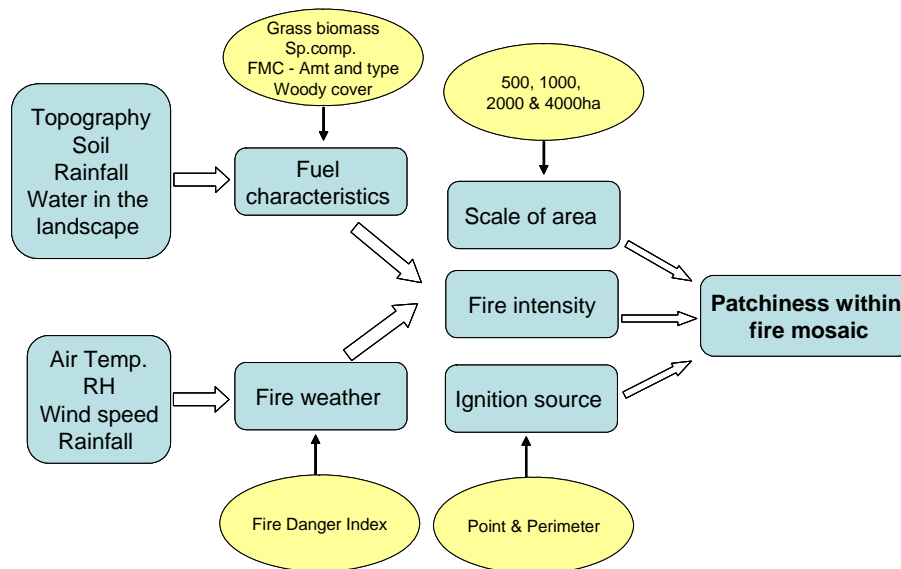


Figure 4: Diagram illustrating the indirect method to determine the patchiness within the fire mosaic and the factor that will be used to calculate fire intensity.

## **DISCUSSION**

Preliminary observations have indicated that prevailing weather conditions (air temperature, relative humidity and wind speed) during fires have a significant effect on the development of fire mosaics. By selecting weather conditions that are less extreme (lower air temperatures and higher relative humidity) one can successfully achieve the formation of a diverse range of fire mosaics, even at scales of only 2000ha. This is in contrast to the conclusion by Brockett et. al. (2001), who suggested that the PMB system involving the use of point ignitions, is best suited to large conservation areas of greater than 20000 ha. Results here indicate that the use of PMB can be used in significantly smaller wildlife conservation areas.

Despite widespread support for the PMB as a strategic goal for biodiversity conservation, conservation managers have struggled to implement it effectively. For example, management plans typically lack the details on the scale and distribution of patchiness that is considered desirable for biodiversity and how fire managers should achieve this patchiness within the fire scar. Without such detail it is unlikely that management aims will be achieved or that outcomes of management can even be effectively assessed (Andersen, 1999).

## **CONCLUSION AND THE WAY FORWARD**

Clearly there is much work that needs to be done to elucidate the intricacies of an effective PMB system. This project attempts through experimental research to develop methods for quantifying scales of achieving “pyrodiversity for biodiversity” by providing clear and detailed operational guidelines for fire managers, which is clearly needed for effective application of the PMB system (Parr and Andersen, 2006).

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