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The long-term effects of fire frequency and season on the woody vegetation in the Pretoriuskop Sourveld of The Kruger National Park

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6 RESULTS

6.1 A CRITICAL ANALYSIS OF THE HISTORY OF THE KRUGER NATIONAL PARK EXPERIMENTAL BURN PLOTS EXPERIMENT

The value of any historical analysis lies in its elucidation of how present situations have come into being.

Jane Carruthers – The Kruger National Park: A social and political history

The Kruger National Park (KNP) is a 1.9 million hectare nature reserve located in the north-eastern corner of South Africa. The vegetation of the KNP is dominated by arid savanna veld. A large controlled fire experiment was set up in the KNP in 1954 called the Experimental Burn Plot (EBP) experiment. The EBP experiment has been maintained for 50 years, it currently comprises 208 plots and covers approximately 1456 hectares.

6.1.1 A brief history of fire management in the Kruger National Park

The KNP had its tangible beginnings on March 26 1898, when the area between the Crocodile and Sabie Rivers was proclaimed as the Sabie Game Reserve (Stokes 1942). In 1902, Lieutenant-Colonel James Stevenson-Hamilton was appointed as the third warden in charge of the Sabie Game Reserve (Stokes 1942; Carruthers 1995). In 1903 and 1904, land acquisitions and the proclamation of the Shingwedzi Game Reserve extended Hamilton's wardenship up to the Luvuvu River excluding the area between the Letaba and Olifants Rivers (Stokes 1942; Carruthers 1995). In 1926, the National Parks Act was passed, and the boundaries of the KNP were formalised. Only a few minor changes have been made to the boundary of the KNP since 1926.

Little is known of the fire regime of the KNP before 1898. Before human settlement, lightning would have been the main ignition source for wildfires (Komarek 1968, Komarek 1971, Goldhammer 1997). By inference from historical and current anthropogenic use of fire, it is presumed that after human settlement anthropogenic ignition sources contributed significantly to the pool of ignition sources for wildfires before 1898 (West 1965, Goldhammer 1997). Hominids are believed to have domesticated fire more than 1,000,000 years ago, but the greatest influences by man on the ecosystem using fire are believed to have occurred in the last 10,000 to 20,000 years (West 1971, Kayll 1974, Brain and Sillen 1988). The anthropogenic use of fire varied, and included religious, domestic, agricultural, pastoral, and even industrial applications (West 1965). For example, wildfires were lit during religious ceremonies to bring on rain, agriculturalists used wildfire in slash and burn techniques to clear land for agricultural purposes, fire was used by pastoralists and hunter gatherers to create green post-fire pastures for game and stock, and fire was used extensively in ironsmith industries (Burbridge 1938, Bartlett 1956, and West 1965). Regardless of the ignition sources though, the fire regime in the KNP before 1898 was likely to have been determined by the patterns of rainfall. This is because the fire regime in the KNP is strongly correlated to rainfall (Van Wilgen *et al.* 2000).

The primary management objective of the area that was to become the KNP between 1898 and 1926 was the preservation of large herbivorous mammals (Stokes 1942; Carruthers 1995). This objective did not exclude the area being used as a grazing resource for stock farmers, and grazing rights within the boundaries of the game reserve were granted to stock farmers up until 1924 (Brynard 1964). Furthermore, the fire regime during this period was not governed by any management principles, and the veld was burnt regularly in autumn by hunters and stock farmers, mainly to remove old grass, which prevented large uncontrolled fires and improved grazing for the winter months (Brynard 1964, Brynard 1971). In the Pretoriuskop region, which is a mesic-savanna and has a rapid post-fire recovery, the vegetation was burnt

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almost annually (Brynard 1964, Brynard 1971). Woods *et al.* (2002) described the fire policy between 1912 and 1926 as haphazard and indecisive, and that the perception of fire was that it was bad for the environment.

6.1.1.1 The proclamation of the Kruger National Park (1926)

With the passing of the National Parks Act, the objectives of a National Park were changed from preserving large herbivorous mammals only, to the preservation of the flora, fauna, and the environment within the National Park (Carruthers 1995). While ecological thinking had not yet developed within the KNP, the management objectives in 1926 had a much broader focus than previously.

Between 1926 and 1934, no strict fire policy was pursued, mainly because there was a drought in the Lowveld. Any grass that had escaped accidental fires was burnt annually in autumn to provide grazing during the winter and to prevent uncontrolled wildfires burning through the KNP (Brynard 1964, Brynard 1971). Controlled burning of the veld in the KNP between 1926 and 1939 was difficult because there were no firebreaks that could be used to control runaway fires. In 1934, firebreaks were prepared and between 1934 and 1946, which was the end of Stevenson-Hamilton's term as warden, the policy regarding fire management was to burn biennially in autumn (Brynard 1964, Brynard 1971). The general focus in the management of the KNP during this period was still fauna-centric, and Stevenson-Hamilton stated that burning long old grass regularly was necessary, because long grass did not provide nourishment for animals. Furthermore, long grass was a danger to animals as it provided sites for ambush of grazers by predators and it harboured ticks (Brynard 1964, Brynard 1971).

In 1946, Col. JAB Sandenberg succeeded Stevenson-Hamilton as the warden of the KNP. He took over at a time of drought and so large areas of the vegetation did not burn for a number of years. In 1949 and 1950, uncontrolled fires burnt large areas in the park (Annual report 1951). This occurred at a time when the National Parks Board had just passed a resolution “that no veld shall be burnt more than once every five years”, primarily because Col. Sandenberg believed that deliberately burning the veld in the KNP upset the natural balance (Brynard 1964, Brynard 1971).

6.1.1.2 A new era – Management by intervention

The early 1950’s were a major inflection point concerning the management of the KNP, in which human intervention in the management of the ecology of the system increased. This period marked a transition in philosophy from a romanticised notion of man’s subservience to “Mother Nature” to a dominant ideological stance in which scientists and administrators worked together to manage KNP (Carruthers 1995). The change in management philosophy at this is aptly described as being “command-and-control"-centred with the main floral focus being on maintaining the KNP in a “pristine state” (Mentis and Bailey 1990, Holling and Meffe 1996).

In 1950, a research department was established in the KNP (Annual Report 1951). In October 1950, Dr TG Nel was appointed as the first research biologist in Skukuza, and HP Van Der Schijff was appointed as the research assistant based in Pretoriuskop in June 1951 (Annual report 1951). The role of the research department was to classify, quantify, categorise, and describe the area that is the KNP and to guide its management. The first task was to create animal and plant species lists, and to get a better understanding of the floral and faunal distributions in the KNP (Annual Report 1951).

At this time, controversy surrounded the issue of veld burning in the KNP. Pretoriuskop featured prominently in that there was disagreement over the successional path the lowveld sourveld was likely to follow in the absence of fire, namely bush encroachment, or a more desirable sweetveld (Annual report 1951). These dichotomous views highlighted the need for a better understanding of the role of fire in the KNP. By 1953, sufficient progress in the floral and faunal investigations had been made, and a proposal to research the

effect of fire on the vegetation in the KNP was presented to the National Parks Board Advisory Committee (Annual report 1953). The fire research proposal was accepted in the same year (Annual report 1953).

During 1954, the fire experiment was set up and started. In December 1954, the National Parks Board amended the then current fire policy and instated an interim policy, which was as follows (Minutes 1962):

> "…… until it is proved to be wrong, it be laid down by the Board as an interim policy that the whole of the Kruger National Park be divided into sections separated by properly constructed fire breaks, 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 the spring after the first rains."

Practically, sections were burnt in spring after the first 50ml of rain had fallen (Gertenbach 1980b). The rational behind burning every three years in spring was that these fires were low intensity fires that would cause the least amount damage to the vegetation while removing moribund biomass (Govender 2003). Furthermore, these low intensity fires in spring posed little threat to the fauna of the KNP (Govender 2003).

Extensive firebreaks were created and the amended interim fire policy was started (Brynard 1964, Brynard 1971). Data from the EBP experiment was to be used to guide KNP management in the further formulation and implementation of fire policies that were in keeping with the spirit and purpose of a National Park (Annual report 1951). So began a new era of "management by intervention" in the KNP (Carruthers 1995).

In 1962, because of severe drought conditions prevailing in the KNP, it was necessary to revisit the fire management policy (Minutes 1961). The fire policy was amended as follows (Brynard 1971):

- Certain areas might be temporarily withdrawn or permanently withdrawn from the programme.
- The ideal size of discrete sections to be burnt at one time was about 60 km^2.
- No burning should be done before mid October.
- Fifty millimetres of rain had to have fallen in an area before it could be burnt.

Between 1962 and 1975, other minor changes were made to the 3-year rotation schedule. In 1975 in response again to drought conditions, the fire management policy was amended to allow for longer periods between fires in drier areas and season varied from between late winter to mid-summer to autumn (Van Wilgen *et al.* 2000). This policy built upon on the previous rotation burning policy, and instead of the frequency and timing of the prescribed burns being fixed, they were made more flexible. The timing and frequency of prescribed burns was determined by post fire age of the vegetation, fuel loads, and rainfall (Van Wilgen *et al.* in press). The application of fire over longer periods and at different times of the year spread the workload easing the intensity of the burden of prescribed burning (Van Wilgen 2002). Furthermore, it was felt that the diversity in timing and frequency resulted in "better utilisation" of post fire grazing (Van Wilgen 2002).

6.1.1.3 Abandoning prescribed burning – The wilderness years

In the early 1990's came another inflection point in the management philosophy of the KNP. There was a shift in attitude from managing by intervention toward a non-interventionist wilderness approach. This shift was reflected in a decision to abandon prescribed burning in 1992 in favour of a more natural lightning driven fire policy (Trollope *et al.* 1995; Biggs and Potgieter 1999). This policy became dubbed the *laissez-faire* approach to controlled burning (Trollope *et al.* 1995). This change in policy was once again in response to a drought in which the prescribed rotational burning policy appeared to be excessive (Biggs and Potgieter 1999; Van Wilgen *et al.* 2000). Effectively this policy prescribed that, within reason, lightning fires should be allowed to burn freely to their complete extent, and fires from all "non-natural" ignition sources (especially anthropogenic) should be extinguished. The network of firebreaks in the KNP was reduced by half to reduce the number of manmade barriers in the landscape that could hinder the spread of a fire (Van Wilgen *et al.* in

press). In 1997, a few refinements to the policy were made regarding the maximum percentage of a landscape unit that was permitted to bum during one season and rules stipulating facilitating the spread of fire across manmade barriers by KNP management (Potgieter 1997). This policy was difficult to implement. Controlling, “non-natural” fires with the reduced network of firebreaks proved to be difficult. Spatial analysis revealed that the boundaries of most fire scars during this period were either tourist roads or management roads (Govender 2003). Furthermore, it was found that after 10 years of the policy being in effect approximately 24% of the KNP had burnt in lighting ignited fires, and most fires had in effect been anthropogenic in origin (Van Wilgen *et al.* in press).

In April 2002, the wilderness or *laissez-faire* approach to controlled burning in the KNP was abandoned (Van Wilgen *et al.* in press). A new adaptive fire management policy was formulated, in which rainfall and the biomass of grass are used to prescribe fire quotas for specific landscapes at different times of the year (Brockett *et al.* 2001, Van Wilgen *et al.* in press, Trollope *et al.* 2003). This new approach is known as the Integrated Fire Management System (Trollope *et al.* 2003). The Integrated Fire Management System incorporates the application of point ignitions similar to that used in the patch mosaic burning system used in the Pilansberg National Park, while areas to be burnt are selected based on the condition of the vegetation (Trollope *et al.* 2003). The fire quotas for a landscape comprise the percentage of the area to burn, the time of the year the percentage should burn by, and the number of fires in which the area should be burnt. The prescribed percentage of an area to be burnt is a function of the fuel load in that area, and the numbers of fires that make up that percent are a function of the percentage of the area burnt in each fire (Brockett *et al.* 2001, Trollope *et al.* 2003). It is believed that this adaptive fire management policy is more aligned to the current mission of the KNP, which is to “To maintain biodiversity in all its natural facets and fluxes …” (Braack 1997), than previous fire management policies.

One detail that is glaringly obvious when looking at the history of fire management in the KNP is how little data from the EBP experiment has been used to guiding the formulation of fire management policies over past five decades.

6.1.2 The KNP experimental burn plots

In this section, the history of the KNP Experimental Burn Plots (EBPs) is examined, and changes in attitude toward the EBP experiment and its credible standing within the research community over time are exposed. Furthermore, the role the experiment has played in the understanding of fire in the KNP from a management perspective is explored.

Many issues have been controversial during the history of the management of the KNP. So the question begs asking, why set up such a large experiment and why fire?

The answer lies in the fact that the dominant vegetation type of the KNP is a tropical savanna with varying mixes of grasses and trees. Fire is a dominant feature of tropical savannas, and is recognised as playing an integral role in the dynamic relationship between the grasses and trees (Bond and Van Wilgen 1996). Furthermore, the early 1950s marked a transition from management by custodianship to management by intervention. Science, research, and empirical data were the means toward a rational and objective approach to the ecological management of the KNP.

6.1.2.1 Why set up such a large experiment in the early 1950s, and why fire?

There is no such thing as a savanna that does not burn (Scholes and Walker 1993). Therefore, when it comes to the management of fire in savanna ecosystems there are only two choices, planned fires and unplanned fires (Scholes and Walker 1993). In the early 1950s, the managing body of the KNP was faced with fire as a powerful ecological force, and a powerful management tool. Management philosophy had changed since the proclamation of KNP in 1926, from the preservation of a select few animals to the

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preservation of the ecosystem in its entirety. The key word here being preservation, and management focus was on preserving the state of the system.

Even though the role of fire in African savannas was recognised as being ancient and pivotal (Van Der Schijff 1958), the vegetation state was seen as being a vulnerable sub-climax state between grassland and woodland, maintained by fire. This differs from current perceptions in which savanna ecosystems are not seen as unstable midpoints between grassland and woodland ecosystems. Rather savannas are seen as independent ecosystem entities in which the role of fire is one of mediating the coexistence of the tree-grass components. Savanna ecosystems are characterised by having grass and trees as main components, and the complex interaction between these components gives savanna ecosystems integrity of their own (Scholes and Walker 1993). Furthermore, the species composition of savannas does not often represent an intermediate vegetation state of locally occurring grassland or woodland ecosystems, and savannas are seldom geographically placed at a transition between grasslands and woodlands.

The role of fire in altering the structure and composition of the vegetation was well recognised in 1954. However, the practicalities of fire management were filtered through an agricultural mindset. In 1947, Scott gave four reasons for the use of fire in veld management (Scott 1947, West 1965):

1. To burn off the unpalatable growth left over from the previous season's growth which would not be touched by livestock and which, if not removed, would tend to become moribund and die out.
2. To stimulate growth during seasons when there is little green grazing and thus provide green food for stock at a time when it does not occur naturally.
3. To destroy parasites such as ticks which carry and transmit stock diseases.
4. To control the encroachment of undesirable plants in the veld.

In 1960, Campbell endorsed these reasons for using fire in veld management and contributed six additional reasons (Campbell 1960, West 1965):

5. To aid better distribution of animals on the range. Livestock tend to concentrate on favourite areas. Judicious burning of outlying areas attracts the herds and promotes an even distribution of grazing over the range as a whole.
6. To remove the fire hazard of accumulated old grass.
7. To establish fire breaks in developing a system of protection from fire.
8. To prepare a seedbed for natural or artificial seeding of desired forage species.
9. To stimulate range or pasture species to produce seed.
10. To encourage the growth of native legumes for forage and soil improvement.

While the use of fire in an agricultural environment seemed to be clear-cut, the use of fire within the ecosystem of the KNP, which had different objectives, was certainly not (Van Der Schijff 1958).

The debate surrounding fire management within the KNP was contentious. There were two main camps regarding the management of fire, there were those who believed that the vegetation should not be allowed to burn, and those that believed that fire was necessary (Van Der Schijff 1958). However, even those who believed that fire was necessary could not agree on the precise effects of fire applied at different times of the year or at different return periods.

Opinions differed so much, that the KNP experimental burn plots experiment was proposed in 1953 (Annual report 1953; Van Der Schijff 1958).

6.1.2.2 The objective of the experiment

The objective of this research was to study the effect of fire on the natural plant communities of the KNP under the grazing pressure of wild animals (Van Der Schijff 1958). This was in contrast to the fire research

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that had been undertaken by the Department of Agriculture at that time, which considered livestock and not wild animals (Van Der Schijff 1958).

In 1954, the experiment was laid out in four of the six major plant communities identified in the KNP by the assistant biologist HP Van Der Schijff (Annual Report 1954, Van Der Schijff 1958). The four major veld types were (Figure 6-1):

1. The broad leaf deciduous woodlands with long grass of Pretoriuskop.
2. The Combretum veld of Naphe.
3. The Knob thorn - Marula veld near Satara.
4. The Mopane woodlands between Shingwedzi and Letaba.

6.1.2.3 The experimental layout and design

The experiment was set-up in a randomised block design. Four replicates of treatments were placed in each of the four main plant communities defined within the KNP at the time by Van Der Schijff (1958) (Figure 6-1). In 1954, each replicate comprised seven plots to which seven fire treatments were randomly assigned (Annual report 1954, Van Der Schijff 1958). These treatments were no burning at all, annual fire in August, and biennial fire August, October, December, February, and April (Table 6-1).

In 1955, the Parks Board proposed expanding the experiment to incorporate treatments that were applied every three years (Annual Report 1955). In 1956, five more plots were added to each of the replicates, and five treatments were randomly assigned to these replicates, namely triennial burns in August, October, December, February, and April (Table 6-1) (Annual report 1955, Annual report 1956, Van Der Schijff 1958).

In total, there were twelve fire treatments, replicated four times each in each of the four major vegetation zones (Figure 6-1, Table 6-1). The experiment finally comprised 192 plots, each approximately 6.5 hectares in size, the whole experiment covering approximately 1248 hectares in the KNP. Biggs *et al*. (2003) have concluded that, because the treatments were not allocated to the replicates completely randomly, the EBP experiment cannot be considered a true randomised block design and can only be considered pseudo-randomised.

Table 6-1: The twelve treatments applied within each of the plant communities. The treatment code refers to the codes used in the database.

Year	Treatment code	Timing	Return period	Description
1954	Cont	None	0	No Burn – control
	Aug1	August	1	Annual burn in mid-winter
	Aug2	August	2	Biennial burn in mid-winter
	Oct	October	2	Biennial burn after the first rains
	Dec2	December	2	Biennial burn in mid-summer
	Feb2	February	2	Biennial burn in late summer
	Apr2	April	2	Biennial burn in Autumn
1956	Aug3	August	3	Triennial burn in mid-winter
	Oct3	October	3	Triennial burn after the first rains
	Dec3	December	3	Triennial burn in mid-summer
	Feb3	February	3	Triennial burn in late summer
	Apr3	April	3	Triennial burn in Autumn

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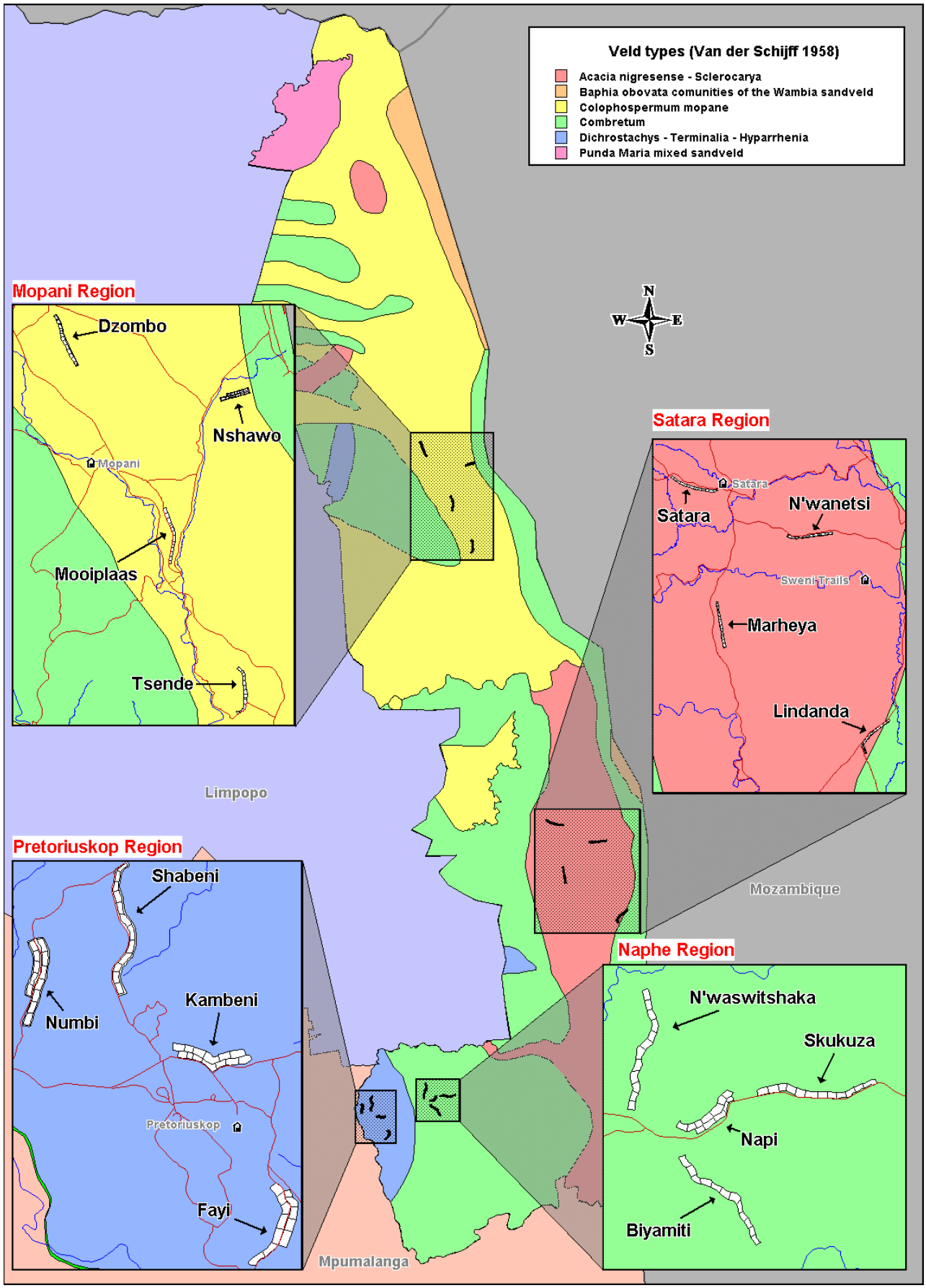


Figure 6-1: The layout of the Experimental Burn Plot experiment in the four vegetation communities in the Kruger National Park.

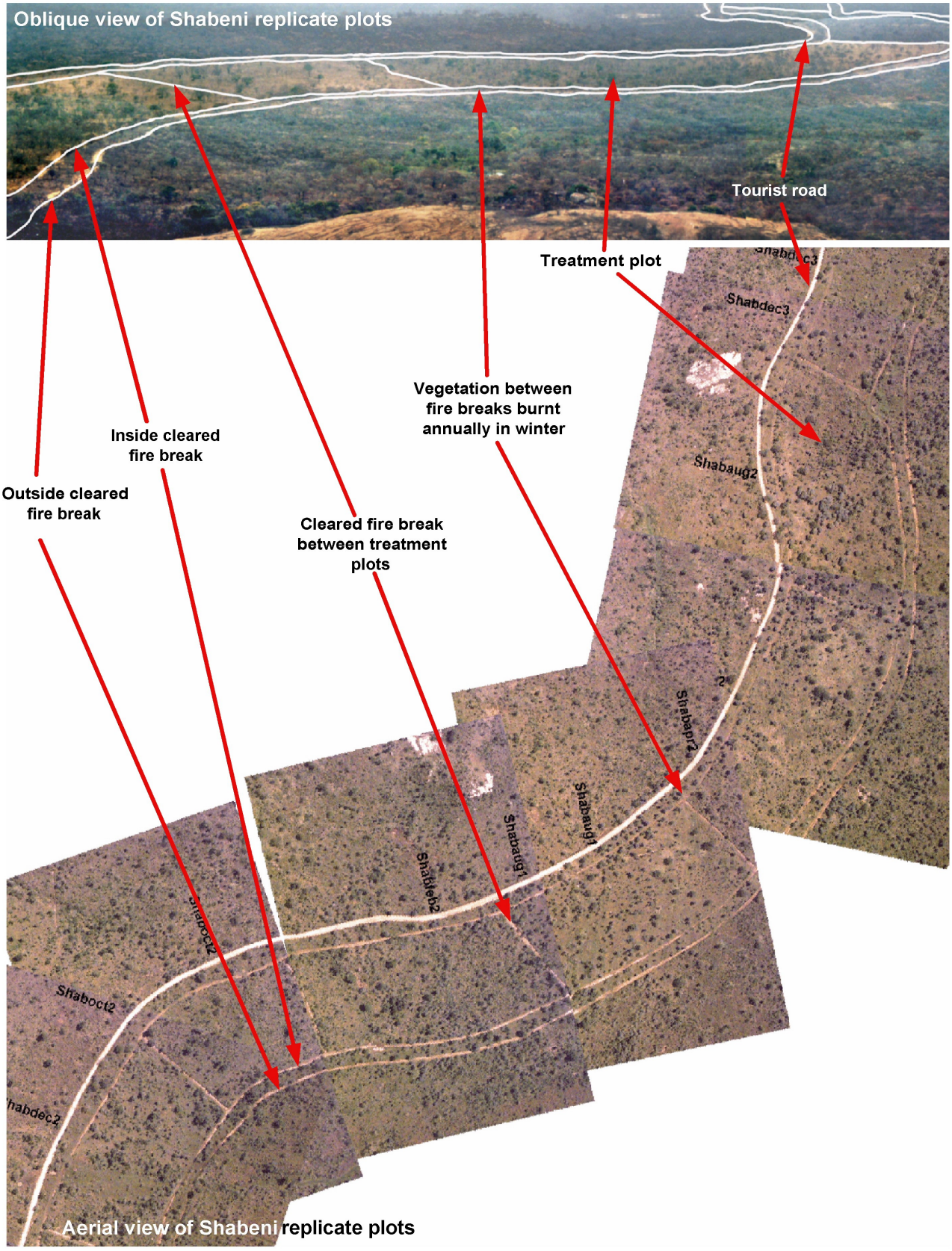


Figure 6-2: Oblique and aerial view of the Shabeni replicate, showing how the treatment plots were setup with the single cleared fire breaks between the plots and the two cleared fire breaks surrounding the replicate.

6.1.2.4 The construction of the experimental plots and replicates

Single cleared firebreaks separated each plot within a replicate from one another (Figure 6-2). Two cleared firebreaks protected each replicate on all sides from fires within the surrounding landscape (Figure 6-2). The vegetation between the firebreak roads was burnt annually towards the end of autumn, further protecting the replicates from untimely fires during the dry season (Annual Report 1954; Van Der Schijff 1958).

6.1.2.5 The application of the experimental treatments to the plots treatments

To contain the fire when applying a treatment to a plot, a back burn was burnt on the leeward (downwind) side of the plot before the fire front was lit on the upwind side of the plot (Figure 6-3). Furthermore, two lines of fire were ignited down the sides of the plot connecting the back burn and the head burn. The function of the back burn and two side burns was to prevent the head fire from escaping into adjacent areas. The size of the back burn was usually dependant on the strength of the prevailing wind, and the subjective estimation by the researcher of the likely intensity of the treatment. The stronger the wind and the more intense a treatment was likely to be the bigger the back burn was made.

The fire treatments were applied to the treatment plots regularly, and Biggs *et al*. (2003) found that less than twenty percent of the scheduled treatments between 1954 and 2001 were not applied. Some of these application errors were teething problems and occurred at the beginning of the experiment, and many others occurred at times of drought when the fuel levels on the plots were too low to sustain the fire treatments.

6.1.2.6 The application of the first fire treatments on the EBPs between 1954 and 1957

The first treatments (Table 6-1) were started in 1954, and the August Annual and Biennial, October Biennial, and the December Biennial treatments were applied in the Pretoriuskop and Naphe regions (Figure 6-1) (Annual Report 1954). The treatments were not applied to the EBPs in the Satara and Mopane regions (Figure 6-1) because the fuel levels were low and would not sustain a fire (Annual Report 1954). The treatments in the Satara and Mopane regions were rescheduled for 1955 (Annual Report 1954). During the application of the October Biennial treatments, in the Pretoriuskop region, the fire jumped in on the fourth replicate and burnt two adjacent treatment plots (Annual Report 1954). However, it is unclear which replicate (Fayi, Kambeni, Numbi, or Shabeni) the four replicate refers to, or which of the adjacent plots were burnt.

In 1955, the Annual and Biennial treatments were applied to the EBPs in the Pretoriuskop and Naphe regions without any mishaps (Annual Report 1955). The treatments in the Satara region were scheduled to be restarted in 1956, because many of the treatment plots were burnt out of schedule by fires in the Satara region in 1955 (Annual Report 1955). A photographic record of the plots was begun in 1955 (Annual Report 1955). These photographs included general photos showing veld condition and specific photos of research interest (Annual Report 1955). Unfortunately, these photographs were not catalogued and so they are of limited use (Annual Report 1957).

In 1956, the Biennial and Annual treatments were applied to the EBPs in the Pretoriuskop, Naphe, and Satara regions (Annual Report 1956). The treatments in the Mopane region were not started because some of the Dzombo replicate plots were burnt out of schedule when a firebreak fire accidentally burnt the plots (Annual Report 1956). The additional Triennial treatments were added to the existing replicates, but the treatments were not started because the vegetation surveys of these plots had not been completed (Annual Report 1956).

In 1957, the firebreaks roads around the EBP plots and replicates were made broader to approximately 7m (Annual Report 1957). This was done because of the spate of unscheduled fires on the treatment plots that had occurred between 1954 and 1957 (Annual Report 1957). The plots in each replicate were allocated numbers in 1957 to prevent plots from being burnt out of schedule by the application of the incorrect treatment (Annual Report 1957). The Annual and Biennial treatments were applied to the EBPs in the Pretoriuskop, Naphe, Satara and Mopane regions, and the triennial treatments were started in 1957 (Annual

Report 1957). A new photographic record was begun in which the photographs were catalogued (Annual Report 1957). The photographs were taken just before the application of each treatment. Furthermore, the data recorded before the application of each treatment was applied was systemised.

This marked the beginning of the Kruger National Park Experimental Burn Plots experiment.

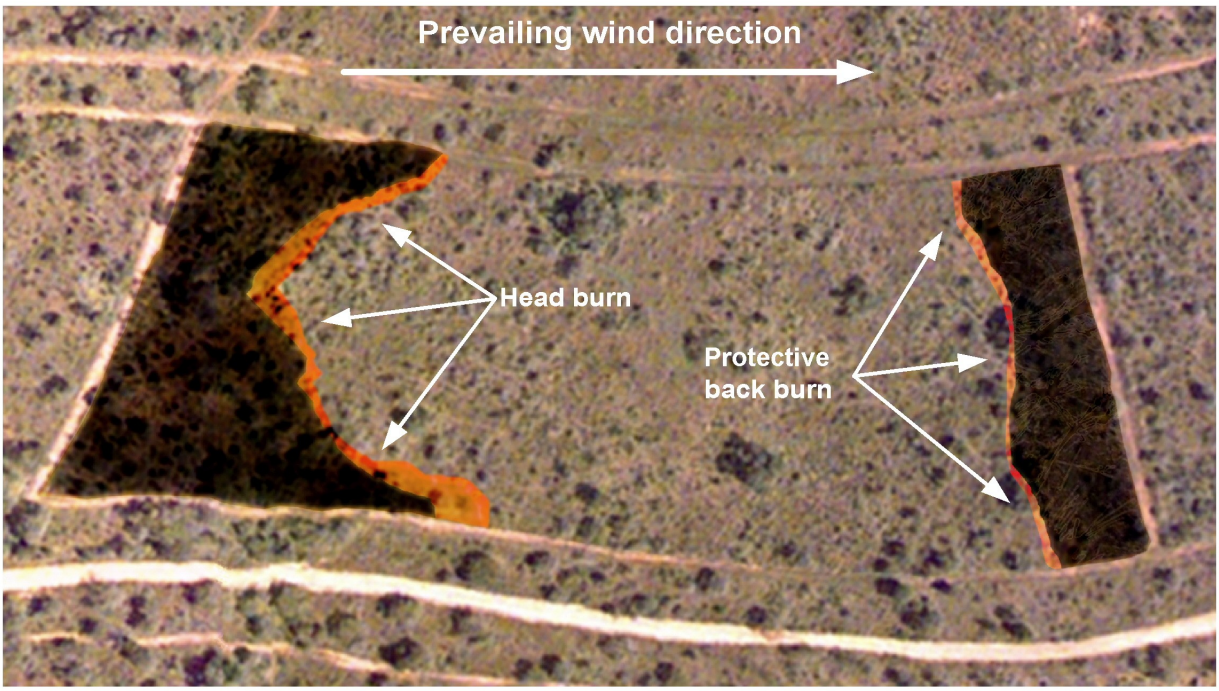


Figure 6-3: Showing the typical application of a fire treatment to an EBP, with a protective back burn to prevent the head burn from jumping the firebreak and burning the neighbouring plot or the surrounding landscape.

6.1.2.7 The collection of the baseline data

Before applying the treatments to the plots, a survey of the woody vegetation and grasses was conducted on each plot, and a photographic survey of the plots was conducted (Van Der Schijff 1958).

6.1.2.7.1 The woody vegetation survey - methodology and data

Using a surveyor cable laid along the diagonals of each plot, a 5-foot wide (1.5m) transect was surveyed for 1000 feet (305m) along each diagonal (Figure 6-4). All woody vegetation was identified and recorded. The basal diameter of single-stem individuals was recorded in one of five stem diameter classes, namely 0-1 inches (0-2.5 cm), 1-3 inches (2.5-7.6 cm), 3-5 inches (7.6-12.7 cm), 5-7 inches (12.7-17.8 cm) and greater than 7 inches (17.8 cm) (Van Der Schijff 1953). The coppice diameter of multi-stem individuals (i.e. coppicing individuals) was recorded in one of three classes: 0-1 feet (0-30 cm), 1-3 feet (30-91 cm) and greater than 3 feet (91 cm) (Van Der Schijff 1953).

6.1.2.7.2 The grass and herb survey - methodology and data

A Levy bridge with ten points, 5 cm (2 inches) apart, was used to survey the grasses on the plots. The bridge was placed approximately at 6 m (20 feet) intervals along each diagonal. Fifty placements, and not 100 as reported by Van Der Schijff (1958), were made per diagonal and a total of 1000 survey points were recorded for each plot.

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The data for these surveys was tabulated and the raw data no longer exists. It was proposed that these surveys should be conducted once every ten years (Van Der Schijff 1958).

By 1959, the experiment was set-up and people began to review the methods and methodology. The first to be assessed were the baseline surveys of the woody vegetation.

6.1.2.8 Assessment of the belt transect baseline survey

In 1959 a calibration of the belt transect method was done on the Naphe plots of the Combretum veld (Brynard *et al.* 1960, Davidson *et al.* 1961). It was concluded that the belt transect survey was adequate for floristic studies and for the determination of the general structure of the vegetation on the plots. However, at the species level whether this method was adequate depended on the number of individuals surveyed in each transect. Furthermore, in an area where the vegetation diversity and woody species richness was high this method may prove to be poor.

It was concluded that the baseline survey should not be used as a direct comparison to subsequent surveys, and that subsequent surveys should be analysed using Analysis of Variance (ANOVA) by randomised blocking. Davidson *et al.* (1961) suggested that, depending on the needs of the experiment, either the area sampled on each plot could be increased (i.e. 3 x 310 m (10 x 1000 ft) transects), or a different survey method could be used, or a fixed transect or plot survey could be used. It was also suggested that a more meaningful measure of importance other than coppice diameter classes be used for the survey of the shrub forms (Brynard *et al.* 1960, Davidson *et al.* 1961).

The control plots in both the Pretoriuskop and Naphe regions were also resurveyed in 1959 using the same methodology as in 1954 (Annual Report 1959).

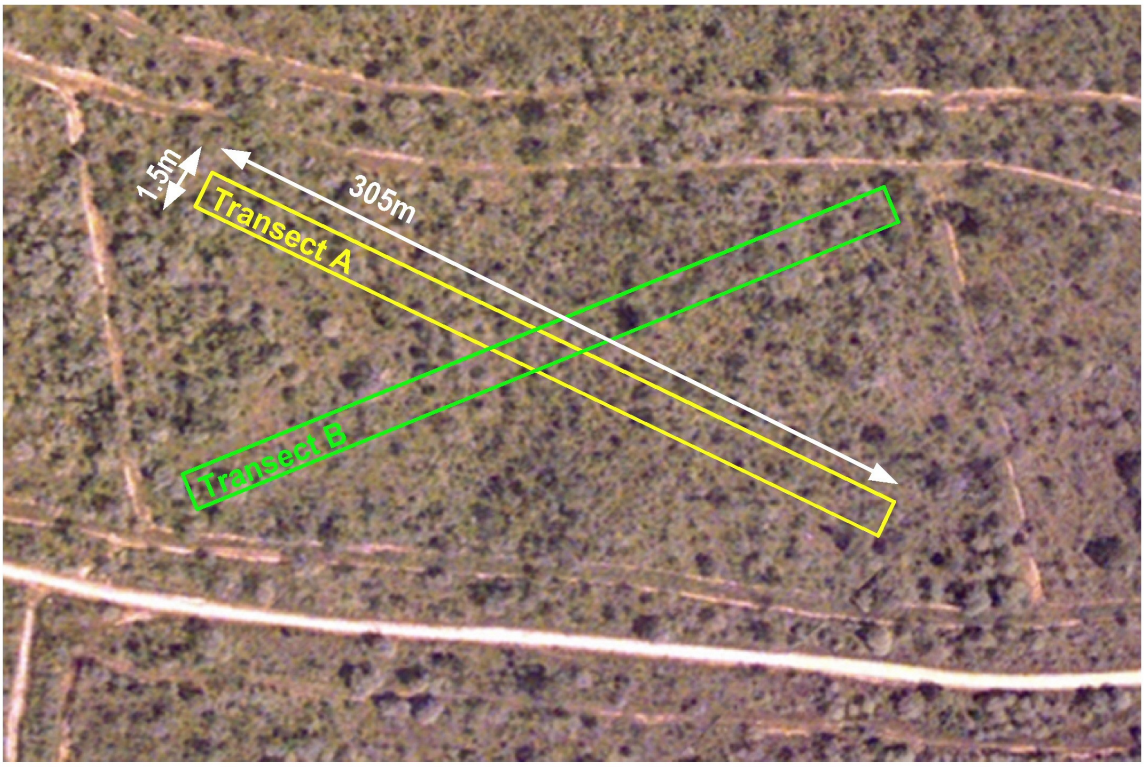


Figure 6-4: Showing the placement of the two transects along the diagonals of a treatment plot in the baseline woody vegetation survey of the EBPs in 1954.

This evaluation of the baseline data started a trend of criticism of the KNP EBP experiment that ultimately led to the credibility and perceived worth of the experiment being compromised. Follow up surveys (proposed every 10 years) were not conducted with any regularity or consistency. Furthermore, none of the follow up survey methodologies was the same as the baseline survey or the same as any of the other follow up surveys on the plots. This has made comparison and trend analysis over time challenging. However, regardless of the criticism aimed at the experiment, the same integrity of the experiment was maintained and treatments were faithfully applied.

Outside the daily maintenance of the experiment, research work and data collection continued on the plots, and in 1960 aerial photographs were taken of all the plots. Unfortunately, many of the photographs either were of poor quality or were not successfully processed, and the photographic material is no longer available (Annual Report 1960).

6.1.2.9 A second assessment of the baseline surveys and further recommendations

In 1962, the KNP research department began collaborating with HH Von Broembsen of the Agricultural Department of the University of Pretoria (Annual Report 1962). The aims of this collaboration were (Annual Report 1962):

1. To examine the vegetation of some of the plots in the EBP experiment in order to make recommendations about the analysis and assessment of data obtained from previous surveys.
2. To test various survey methods for the tree and shrub components of the EBPs.
3. Make recommendations regarding future sampling methods of the woody vegetation. The aim was to identify methods that were both easily repeatable and comparable to the baseline survey data.

Based on the collaboration it was decided that further surveys of the EBPs would be postponed until suitable survey methods had been decided upon (Annual Report 1962).

In 1963, HH Von Broembsen and P Muller submitted a report on their findings regarding the EBP experiment (Annual report 1963). They found that there was no way in which to examine the effect of fire on the vegetation pattern. Furthermore, it was doubtful whether the relative species contribution to the total population could be used in comparing the data between surveys. They concluded, "…that the sampling data derived from the two previous surveys [1954 and 1959] are useless as far as statistical evaluation is concerned" (Von Broembsen 1963).

Again, the validity of the experiment, or at least the validity of the assessment of the experiment, was challenged. This time the assessment was certainly more cutting, although Von Broembsen does hasten to clarify that "…the criticism expressed here is not intended to imply that this situation arose through negligence on the part of any officer of the National Parks Board" (Von Broembsen 1963).

Von Broembsen (1963) recommended the use of the wheel point method developed by Tidmarsh and Havenga (1955). This method of sampling could be used to survey both the tree-shrub and grass components. For the grasses and herbs, 2000 sampling points would be required, however for the trees and shrubs between 16000 and 32000 sample points were recommended for the different vegetation types (Von Broembsen 1963).

In contrast with the baseline surveys, this approach uses a point method to estimate the cover of vegetation and not the density of the vegetation. These two measures of vegetation abundance are difficult to compare.

In 1965, the Satara plots were surveyed following the recommendations of Von Broembsen and Muller (Annual report 1965). No clear pattern was found in the grass-herb data and it was thought that heavy grazing might be confounding the treatment effects on these plots (Annual report 1965). This was not the first time that concern had been expressed over the potential confounding effects of grazing. In the 1964

Annual report, P Van Wyk commented that grazing was certainly heavier on the experimental plots than in the surrounding areas (Annual report 1964).

By the mid 1960's the credibility of the EBP experiment especially within the KNP administration was in question. The experimental design appeared to be flawed, and so too was any attempt at assessing the experiment. However, despite the criticism aimed at the EBP experiment it had the inertia of ten years of operation that kept it going. Furthermore, it was recognised that the EBP experiment was a long-term experiment.

In 1966, the grasses and herbs on the Pretoriuskop plots were surveyed using the Tidmarsh wheel method. It was found that there was a remarkable decrease in *Hyparrhenia dissoluta* (Annual report 1966).

6.1.2.10 Quadrate middle-point surveys – another method

In 1967 and 1968 the woody vegetation on the plots in the Pretoriuskop and Mopane regions were surveyed using the quadrate middle point method developed by Cottam and Curtis (1956) (Annual report 1967, Van Wyk 1971). A 1000 plants were sampled on thirteen transects, per plot. Data recorded were the identity and distance of the nearest plant in each quadrate, stem diameter of single-stem trees, multi-stem individuals were recorded in one of four coppice diameter classes (0-15 cm (0-6"), 15-31 cm (7-12"), 31-91 cm (13-36") and greater than 91 cm (36")), and the height to which plants had been scorched in the previous treatment. A density estimate can be calculated from the data collected using this method (Brower and Zar 1977).

Findings from these surveys were presented at the 11th Annual Tall Timbers Fire and Ecology Conference in Florida, USA.

6.1.2.11 Step point method (1970)

In 1970, the woody vegetation of the Pretoriuskop region was surveyed by means of a step point method. Twelve transects, with points ten yards apart, were walked for each plot. The identity of the nearest plant on either side of the line transect was recorded. Single-stem individuals were classified into six height classes (0-1 m, 1-2 m, 2-4 m, 4-6 m, 6-9 m and 9-12 m), seven canopy diameter classes ("no leaves", 0-1 m, 1-2 m, 2-4 m, 4-6 m, 6-9 m and 9-12 m), and six stem diameter classes (0-5 cm, 5-10 cm, 10-15 cm, 15-20 cm, 20-30 cm and 30-40 cm). Multi-stem individuals were classified into the same height canopy diameter classes, but only four coppice basal diameters were defined (0-0.5 m, 0.5-1 m, 1-2 m, and >2 m).

Unfortunately, the distance from point to plant was not measured. Without the distance measures density cannot be estimated. Using this data for comparative analyses is limited.

6.1.2.12 Half hectare survey plot – a permanent monitoring plot

In 1971, permanent monitoring plots were placed on each EBP (Annual report 1971, Gertenbach and Potgieter 1975, Gertenbach and Potgieter 1979 a & b). These monitor plots were setup firstly because repeating the baseline survey was believed to be impractical, and secondly to address criticism that had been levelled the monitoring of the vegetation on the EBPs (Annual report 1971, Gertenbach and Potgieter 1975). Gertenbach and Potgieter (1975) report that the size of the monitor plots was 100m x 50m (½ hectare), while Gertenbach and Potgieter (1979a & b) report that the size of the monitor plots was 50m x 50 m (¼ hectare). These monitor plots were 100m x 50m and only half the data was used in the analyses reported in Gertenbach and Potgieter (1979a & b). The monitor plots comprised 20 transects of 5m wide and 50m long, and the following woody vegetation data were recorded on them: species, position, height, canopy diameter, number of stems and stem diameter (Gertenbach and Potgieter 1975, Gertenbach and Potgieter 1979 a & b). The herbaceous vegetation on these plots was surveyed using a Tidmarsh wheel, and one thousand points was recorded on each monitor plot (Gertenbach and Potgieter 1975, Gertenbach and Potgieter 1979 a & b).

While the monitor plot did not necessarily represent the whole experimental plot, it made up for this by enabling time series analysis on the effects of the treatments on the vegetation, accomplished by repeatedly surveying the exact same patch of vegetation (Annual report 1971). Furthermore, the measurement of the treatment effects on individuals could also be done since the location of individuals was recoded in 1m x 1m grids (Annual report 1971). It was also felt that this method would be quicker than the belt-transect method or the quadrate-middle-point method, which had been used to survey the vegetation previously.

As it turned out the half-hectare survey was just as time consuming and it took three years, from 1971 to 1973 to survey all the plots. Furthermore, the control plots for the Pretoriuskop area were not surveyed, because the researcher surveying the plots "didn't have the heart" to go into those dense plots after surveying the EBPs for three years (Potgieter pers. com. 1998). From 1973 onward, no complete vegetation surveys were conducted on the EBPs. The main reason for this was the sheer size of the task.

In 1972, Prof JD Scott from the University of Natal assessed the EBP experiment and added further criticism (Scott 1972, Annual report 1972). He stated, "One very important fact that emerged was that differences in soils had a far greater effect on the vegetation than treatments". Furthermore, he felt that the timing of the treatments were not ecologically significant since the first rains of the wet season did not conform to the Gregorian calendar.

Now not only did grazing confound the treatment effects but so too did the underlying soil pattern.

In 1973 a series of plots were laid out in the Knob thorn veld near Crocodile Bridge. These plots were smaller than the existing EBPs, but were fenced in to control for the effects of post-fire grazing and trampling (Annual report 1973). It was proposed that three more "camps" were laid out in the Naphe, Satara, and Pretoriuskop regions. These plots, it was hoped, would help quantify the post-fire grazing and trampling effects on the EBPs.

In 1976, Prof AM Starfield, of the University of Witwatersrand, assisted the KNP Research Department in analysing some of the data collected in the ¼ hectare monitoring plots (Annual report 1976). They concluded that the experiment was "…. severely hampered by the fact that there was no proper base-line" (Sarnak *et al.* 1977). Furthermore, the broad trends that were evident from the analyses "…should have been obvious to the trained eye in the first place without going through the process of collecting and analysing the data" (Sarnak *et al.* 1977).

They recommended that the monitor plots should be surveyed regularly, and that game free enclosures be built to remove the confounding effects of post fire grazing (Sarnak *et al.* 1977).

It is not clear in the report to what extent the previous data collected on the plots was actually scrutinised. However, it now became "fact" that surveys prior to 1971 were of little use and might as well not exist. Furthermore, discounting 3 years of surveying the monitor plots was certain to demoralise those involved with the groundwork on the EBP experiment.

Some comments regarding the recommendations in the report give an idea of the feeling in the KNP at the time towards the EBP experiment. In response to the suggestion of using enclosures to mitigate the high post-fire grazing pressure on the EBPs, one researcher commented that the KNP should "Rather spend the effort and exploit better what we do have (than start another big circus)" (Comments on archived copy of Sarnak *et al.* 1977).

In 1978, the KNP was incorporated into the "Ecological effects of fire" Scientific Committee on Problems of the Environment project (SCOPE). The aim of the programme was to collate current research and understanding of the ecological effects of fire in South African Ecosystems (SCOPE 1978).

WISETD

During 1980, in response to the change in the prescribed burning policy, it was decided that two more frequencies should be added to the EBP experiment in the Mopane and Satara regions (Annual report 1980). This was done by dividing the February 2 and 3 year burn plots in half and applying an October 4 and 6 year burns respectively (Annual report 1980).

The year 1982 marked the beginning of a long-term collaboration between WSW Trollope and the KNP research department. Since 1982, there has been a concentrated focus on fire research using the EBPs and other areas in the KNP by Trollope and the KNP research. Research focus has ranged from calibrating grass fuel load assessments, to fire behaviour studies, to post fire mortality of trees under different fire conditions. This research improved the image of the EBPs. However, the fact that these studies were not the original objective of the experiment seemed to discount the value of the EBPs. Therefore, the negative perception of the EBP experiment persisted.

6.1.2.13 To continue with the EBPs, or not to continue with the EBPs?

In 1989, N Tainton conducted grass and tree surveys on a number of plots in the Pretoriuskop and Naphe regions (Annual report 1989). He concluded that to resurvey and analyse the data of the EBPs would be an enormous task (Annual report 1990).

The question was posed, whether it was worth resurveying the plots (Annual report 1990). This question was put forward in light of the effects of heavy post-fire grazing on the plots.

Tainton recommended that if the KNP Research Department did not intend to resurvey the plots then the continuation of the EBP experiment might not be justified (Annual report 1990). This was the first time that a recommendation mentioned terminating the experiment.

In 1992, the EBP experiment featured in the KNP portion of the South African Fire-Atmosphere Research Initiative (SAFARI). SAFARI 1992 provided a holistic approach to researching for the cause and effect relationships between changes in the earth's atmosphere and African savanna ecosystem structure and functioning, with particular reference to fire (Van Wilgen *et al.* 1997).

Between 1995 and 1997, the KNP undertook a reassessment of their vision, mission, and objectives as part of a greater transformation process within the South African National Parks. This required a complete review of research policy and current research activities in the Park (Trollope *et al.* 1998).

During this assessment, the future of the KNP EBPs came under scrutiny. The perception of the EBP experiment by this time was that it was fundamentally flawed (Van Wilgen *et al.* 1998). Rather than waste resources on maintaining an experiment with limited prospects for profit, "…it would seem sensible to terminate this experiment after an analysis of the data collected to date" (Van Wilgen *et al.* 1998).

It is interesting that a long-term experiment such as the EBP experiment should fall victim to such negativity at a time when "…the establishment of long-term research sites subjected to a range of carefully applied fire regimes is urgently required" (Whelan 1995). Since 1959, almost every external scientific assessment of the experiment created and added to a critical mass of negativity, which then surrounded EBP experiment. This long history of critical evaluation of the EBP experiment, which focused on the negative aspects, resulted in the EBP experiment by slow degrees becoming an embarrassment instead of a point of pride.

However, long-term ecological experiments that have been maintained rigorously are rare, and the EBP experiment is one such experiment. While many of the criticisms of the experiment are valid, modern computational power and analytical techniques make the early data very valuable. Furthermore, the computational power available currently makes readily useable many analytical techniques that provide the means this factoring and accounting for non-treatment variance on the EBP experiment such as grazing and

WISETD

soil substrate. Finally, regardless of the original objectives of the experiment the value of a +40-year database in light of global climate change research is immeasurable.

In February 1997, a fire workshop was held in Skukuza to discuss the future of the EBP experiment. The following recommendations were made (Trollope *et al.* 1998):

1. Complete a final woody and grass survey of the EBPs.
2. Analyse and interpret the findings, and digitise all existing survey data.
3. Collate existing published and unpublished information on the EBPs.
4. Make recommendations regarding the scaling down of the EBP experiment.

In a follow-up to this workshop, it was recommended that the experiment be continued until mid-2003 in its current form (Trollope *et al.* 1998). This period was to serve as a wrapping-up period of conducting final surveys, capturing data, and exploring further potential use for the EBP infrastructure (Trollope *et al.* 1998). Since the 1997 workshop, the future of the EBP experiment has become solidified. The 1997 workshop bought the EBP experiment into the scientific mainstream, and the value of this long-term experiment has become apparent to scientists locally and globally who are clamouring to get at the data and to become involved in the future of the EBP experiment.

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