# Veld Burnings in the Kruger National Park, An Interim Report of Some Aspects of Research

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## INTRODUCTION

THE area under discussion is situated in the north-eastern corner of South Africa, forms part of the Transvaal Lowveld and is approximately 7,400 square miles or 4¾ million acres in extent.

### Ecological Factors

Various ecological factors in the area were instrumental in creating numerous and clearly defined plant communities. The most important of these factors are:

**Topography:**—The area slopes gradually from an undulating western section to the flat Lebombo plains in the east (altitude about 600 feet). With the exception of the Lebombo range, its foothills and some isolated koppies, only the area in the extreme southwest and the relatively small area north of Punda Milia rest camp may be called mountainous. A number of perennial rivers and numerous large and small seasonal streams, all flowing eastward, drain the area.

**Geology:**—Various geological formations are differentiated. Under the influence of environmental factors these formations were converted into a variety of soil types, and it is very clear that subject to local conditions there is a very close connection between soil type and the distribution of plant species.

With the possible exception of the sandy soils east of Punda Milia, the rest were formed residually and therefore follow the geological formations very closely. In the west the undulating hills are of granitic origin and extend from the Crocodile River in the south to Punda Milia in the north. The corresponding area in the east is covered by the basaltic Lebombo plains. Dolorite intrusions appear in the granitic block, from as far south as Pretoriuskop, up to the near vicinity of Punda Milia. The Lebombo mountains are of rhyolitic origin.

Within this general framework some anomalous types, caused by local factors and characterized by divergent plant associations, may be found.

**Climate:**—The normal rainy season lasts from October–November until March–April and the rainfall varies from $\pm$ 28 inches in the southwest to $\pm$ 16 inches in the lowlying northeastern areas with a very uncertain overall average of 22 inches per annum. Summer temperatures often reach, and sometimes surpass, 100 F (maximum 118 F) but in winter it rarely drops below zero. Phillips (1965) includes the area in what is termed subarid to arid wooded savanna.

**Biotic Factors:**—Animal life strongly influences the development of plant associations. Elephants, of which there are at present about 8,700 in the Park, particularly effect the upper strata and are capable of changing the entire physiognomy of an area. The general effect of grazers and other browsers, of which the numbers are estimated to be $\pm$ 240,000 at present, on the smaller plants is well known.

Under this heading must also be included Man, who exerts an influence on all factors which can be manipulated, especially fire.

## Plant Communities

Although the vegetation of this area is usually described in ecological parlance as savanna woodland the laymans' term "Bushveld" is more descriptive and fitting. With minor exceptions it consists of a mixture of small to medium sized trees, shrubs, grasses and herbs. Subject to local ecological conditions, these elements occur in varying proportions to one another resulting in open grassy plains with scattered large trees or grassy plains bearing small shrubs; fairly thick stands where trees and shrubs are the most important feature, and finally, dense bush communities where grass is completely subordinate.

Although more than 20 different plant communities are recognised at present, they may, for management purposes, be classified in the following major veld types.

1). Terminalia–Dichrostachys savanna woodland
2). Combretum–Acacia woodland
3). Acacia–Sclerocarya savanna woodland
4). Shrub Mopane savanna
5). Combretum–Mopane woodland
6). Sandveld communities

**Terminalia–Dichrostachys Savanna Woodland:**—This plant community is encountered on brownish, sandy loam soils of granitic origin. It has developed, from approximately 1880 to 1945 in the presence of annual autumn (early) burns. The area is exceptionally rolling and is traversed by countless streams and ravines. The watersheds are represented by fairly open bushveld while the lower–lying parts are usually well covered with trees and shrubby growth.

The dominant tree species in the area are *Dichrostachys cinerea* subsp. *nyassana* and *Terminalia sericea* which together constitute more than 50 percent of the upper stratum. Both species tend to encroach. Other very important trees are *Sclerocarys caffra*, *Parinari curatellifolia*, *Strychnos madagascarensis*, etc.

The shrub layer consists of a large variety of species which form local dense thickets in the protected, low-lying areas but are generally of minor importance. Of these the best known are *Maytenus senegalensis*, *Cassia petersiana* and *Xeromphis obovata.*

The grass cover consists of a mixture of sour and sweet grasses. On the whole, the community is characterized by the presence of a particularly robust sour grass, *Hyperthelia dissoluta*, over large areas. Other inferior and unpalatable species include *Elyonurus argenteus*, *Schizachyrium semiberbe*, *Loudetia simplex*, etc. Palatable species such as *Setaria flabellata*, *Heteropogon contortus*, *Digitaria* sp., and a number of *Eragrotis* spp. are also abundant and even dominant in some areas. *Panicum maximum* forms dense and almost homogenous stands under trees.

The region harbours a rich variety of herbs and amongst others various legumes. *Tephrosia indigofera*, *Crotolaria* sp., *Lantana salvifolia*, *Lippia asperifolia*, *Veronia kraussii*, and *Solanum* sp. are abundant.

Several of these species are inclined to intrude or to form conspicuous communities in early summer.

**Combretum–Acacia Woodland:**—On the remaining brownish to red granitic soils south of the Olifants River the vegetation is mostly rather dense and dominated by medium-sized *Combretum apiculatum* and big *Acacia nigrescens* (Fig. 1) trees on the higher and low-lying areas respectively. Shrubs are more conspicuous and more important in this community. The grazing is predominantly sweet and includes

FIG. 1. *Satara flabellata:* control, as of 10/6/71, *Acacia nigrescens* veld after 16 years protection against fire.

species such as *Setaria flabellata*, *Panicum maximum*, *Brachiaria* spp., *Eragrostis* spp., *Themeda triandra*, and *Digitaria eriantha*.

**Acacia–Sclerocarya Savanna Woodland:** This community covers almost the entire eastern half of the Kruger Park (basaltic soils) south of the Olifants River and extends westward in the central region up to the western boundary where it occurs in a mosaic pattern in conjunction with combretum veld.

It consists mainly of fairly open plains with scattered, large *Acacia nigrescens* and *Sclerocarya caffra* trees as the dominant species. The shrubby undergrowth is represented by several *Grewia* spp., *Securinega virosa*, *Dichrostachys cinerea* subsp. *cinerea*, etc.

The excellent grazing potential of this veld type is manifested by the profusion of sweet grasses of which the more important genera include *Themeda*, *Panicum*, *Digitaria*, and *Eragrostis*. In the central area an undesirable grass species, *Bothriobhloa insculpta*, is firmly established, a condition allegedly attributable to excessive burning, probably coupled with selective grazing.

**Shrub Mopane Savanna Plains:**—From the Olifants River to the extreme northern limits of the Park, on the basalt flats along the eastern boundary *Colophospermum mopane* is the dominant woody plant. With the exception of the ridges in the south and the mountainous parts in the north, this area is covered with the coppice growth form of the species (Fig. 2).

In rocky situations with skeletal soils *Bothriochloa insculpta* is inclined to intrude, but in general the grass cover is excellent and consists of a wide variety of good grazing species such as *Themeda triandra*, *Cenchrus ciliaris*, *Panicum coloratum*, *Setaria woodii*, *Digitaria* spp., etc.

**Combretum–Mopane Woodland:**—From a point immediately south of the Olifants River in the western half of the Park, northwards to the Punda Milia area, the most important plants in the tree stratum are *Combretum apiculatum* on the crests of the undulations and *Colophospermum mopane* in the lower lying areas. Mopane also occurs widespread in its shrub form and dominates other shrubs such as *Dalbergia* sp., *Securinega* sp. and *Grewia* spp. The grass cover varies from poor on the shallow soils to exceptionally good with climax types as the outstanding elements. *Panicum maximum*, *Cenhrus*

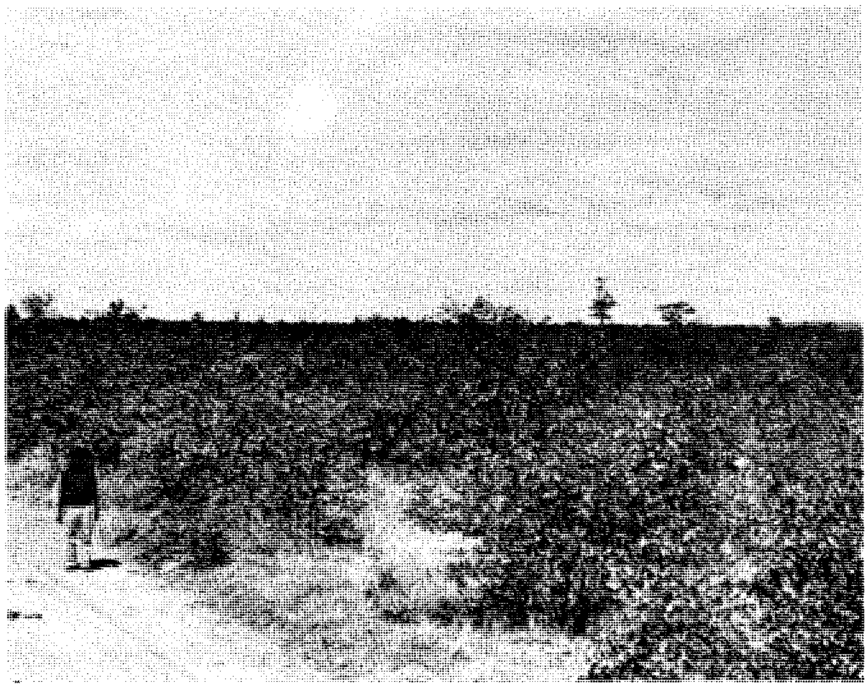

FIG. 2. Shrub mopane after about 20 fire-free years, Kruger National Park. Note stunted growth.

*ciliaris*, *Themeda triandra*, *Eragrostis* spp., *Aristida* spp. and several *Digitaria* spp. are usually conspicuous.

**Sandveld Communities:**—A fairly dense to extremely dense vegetation type with forest elements occurs on the sandy substratum in the vicinity of Punda Milia. Two separate areas with distinct floristic features are involved. To the north of Punda Milia the ridges and fairly deep valleys are mostly overgrown with a large variety of woody species with no definite dominants and to which justice can not be done in a short dissertation such as this. The grasses are predominantly sweet and include *Panicum* sp., *Digitaria* spp., *Setaria* sp., etc.

On the deep, red, loose Kalahari-like sands of the Wambiya area a unique plant association, harbouring a variety of exotic species, has become established. Many areas in this community are devoid of grasses, thereby signifying the extreme denseness of the woody species.

## VELDBURNING AS AN ECOLOGICAL FACTOR IN THE KRUGER PARK

Plant communities which developed under absolute natural conditions in all cases reached a climax stage under the influence of the previous situation and therefore contain elements adapted to each of the factors involved. With the advent of Man, changes were inevitable. For obvious reasons, fire was most probably the factor on which the greatest influence was exercised, for both the frequency and the season(s) in which it occurred. Sudden changes in a decisive factor such as this, could not but influence plant associations, provided the changes were drastic enough.

Existing evidence proved conclusively that fire is a natural factor. Our task then is to determine when and how often it should be applied to simulate natural conditions, and if possible, to improve the condition.

At the time when a general policy for veld burning was instituted for the Park, it was realised that there was a frightening lack of information on the subject. Confronted with the controversial opinions of laymen and scientists and the lack of factual and experimental knowledge the National Parks Board in 1954 decided to undertake its own research into this vital problem.

### Experimental Plots

Although every block in the area serves as an experimental plot, formal burning plots for research purposes were laid out in four of the main veld types:

1) The Terminalia–Dichrostachys savanna woodland.
2) The Combretum–Acacia woodland.
3) The Acacia–Sclerocarya woodland.
4) The shrub Mopane savanna.

The plots are eight morgen (approximately 17 acres) each in extent and are situated in areas where the vegetation may be considered

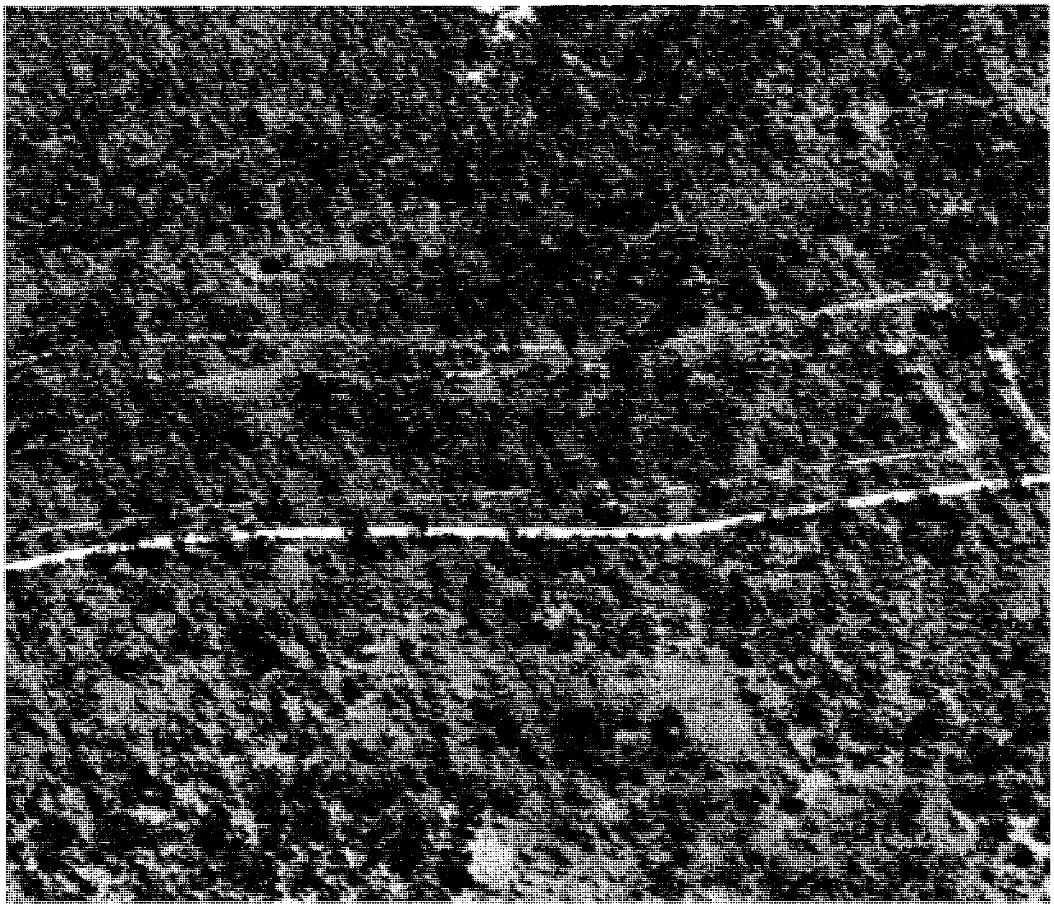

Fig. 3. Experimental plot in combretum veld in the Kruger National Park.

representative of the whole community (Fig. 3). Treatments are replicated four times and plots are separated from one another by wide firebreaks. Twelve different treatments are applied:

1) Control: Plots are not burnt at all.
2) Annual burn in August (late winter).
3) Biennial burns in August (late winter), October (early summer), December (summer), February (summer) and April (late summer/autumn).
4) Triennial burns (five) in the same seasons as the biennial burns.

## Collection of Data

Since the commencement of the research, records have been kept of the climatic conditions preceding treatments, the weather conditions, wind velocity and direction and the air temperature at the

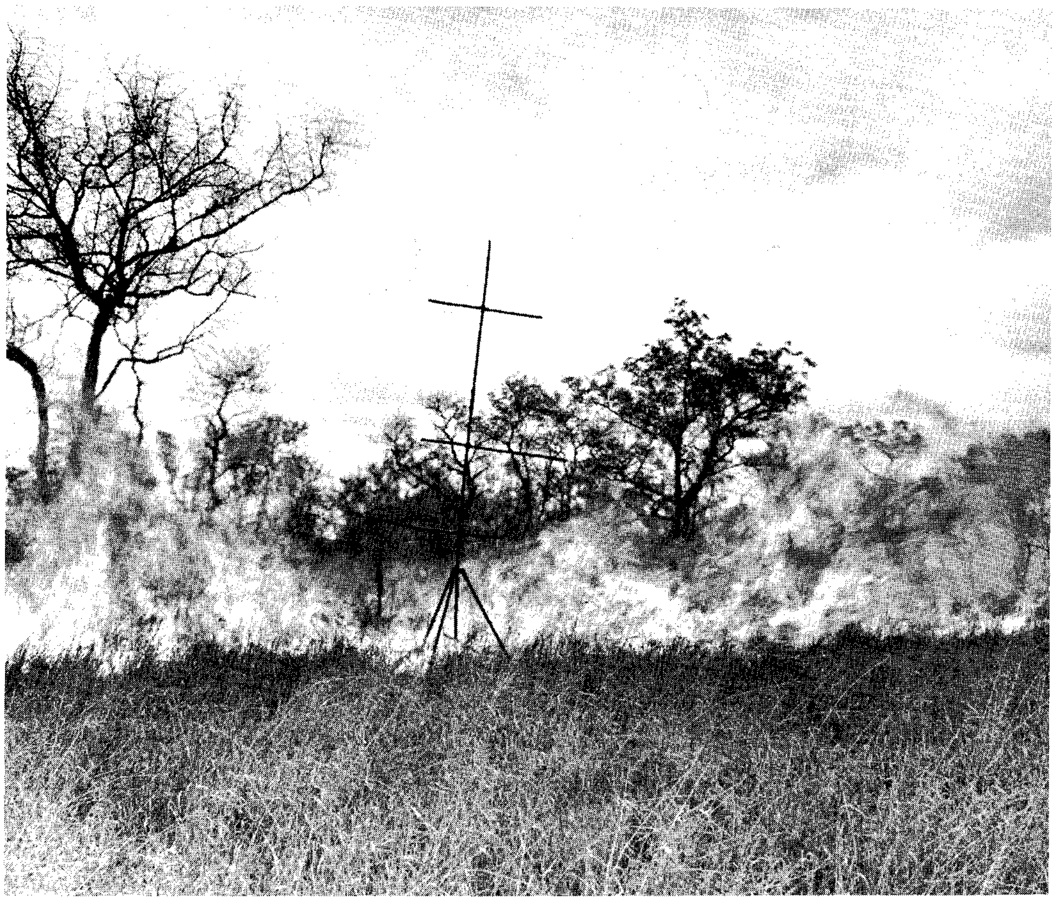

FIG. 4. Apparatus used for the measurement of fire temperatures.

time of a treatment, as well as of the moisture contents of the soil, the amount of green and dry material and the physical condition of the plants at the specific time. Observations with respect to the intensity and speed of the fire and of all visible effects on the vegetation are also recorded. The temperatures of the fires are measured at heights of 18 inches, three feet, six feet, and 12 feet above the ground level, by means of temperature pellets (Fig. 4). Regular inspections are carried out after the treatments to assess the direct effect on specific species, the rate of recovery and also to determine possible grazing intensities or preferences.

At the commencement of the experiment the composition of the vegetation was determined by means of the point–quadrat method for grasses and herbs and the belt–transect method for trees and shrubs. In the recent surveys the grass composition was measured by means of the wheel-point method of Tidmarsh and Havinga. For the trees and shrubs the quadrant method of Cottam and Curtis was used. Currently the grass yield is measured by sampling, thereby replacing a mere estimate of the yield. Soil samples have been taken and are being analysed. Photographs of the plots have been taken from fixed points and are still taken at intervals.

It has been considered advisable that surveys of the birds, insects, small mammals, reptiles, etc. be made. It is hoped to pay more attention to this project in the near future.

DISCUSSION OF RESULTS:

**General:**—Bearing in mind that the bushveld vegetation as we know it at present has been influenced by fire to such an extent that it is described by ecologists as a pyrophilous climax, it is unrealistic, especially in a arid or semi-arid region, to expect highly significant floristic changes within a few years of the readjustment of the burning programme.

Various uncontrollable factors influence the reactions of the plants to the fire-factor and complicate the interpretation of the results in such a way that cause and result are later indistinguishable.

Overgrazing of the grass stratum has already become an actual problem on many of the plots and threatens to jeopardise the research. In most areas it seems as if some animals have become conditioned to such an extent by the ready availability of short palatable burnt veld that they do not leave the area at all. Consequently it has become impossible to burn some plots in the acacia–sclerocarya savanna woodland during the last 10 years. The idea of burning large areas in the immediate vicinity of the plots is impractical. The same applies to the use of plant protection cages in the presence of big game species.

During the last number of years, drought has had a marked effect on the vegetation. In the Pretoriuskop area (terminalia–dichrostachys veld) where the rainfall is not only higher than the rest of the Park, but also more consistent, no deterioration attributable to drought conditions has ever been discernible, though in other areas, especially the acacia–sclerocarya and mopane communities, the effect is most obvious and alarming. In these areas the drought conditions probably caused such severe damage that the cumulative effect of fire on the grass stratum over the years was cancelled out completely.

Abnormally low temperatures in the Lowveld (— 4.2 C) were experienced during the winter of 1964. Although it is almost impossible to determine the exact cause of a plant's death, the sudden death of large numbers of young *Parinari curatellifolia* trees at Pretoriuskop as well as branches of several other species during the same period all indicate the drop in temperature as the most probable cause.

**Results:**—The rate of change in floristic composition under the influence of fire, or its absence all over the world, was shown to be much higher under moist conditions. Under prevailing local conditions the first definite trends must therefore be expected in the terminalia–dichrostachys savanna woodland. The following discussion therefore mainly reflects the results obtained in this area with only casual references to other areas where it is deemed necessary.

In the Lowveld, wind is not really an important factor and it has been impossible to correlate changes in wind velocity or direction with the different seasons. The prevailing winds are from the northeast to northwest and the average wind velocity during treatments varied between 2.5 and 4.5 miles/hour. The air temperature differs by 14°F in the different seasons (71–86°F) with the lowest in late winter (August) and the highest in mid summer (December). In summer the soil and fuel is mostly damp and in winter usually dry. Varying rainfall conditions, however, sometimes cause radical deviations.

Considering all the factors already mentioned it was found that conditions were naturally most suitable for burning during late winter and early summer (August and October) with resultant very hot fires. Conditions are less suitable in summer (December and February) and sometimes even entirely unsuitable with burns normally much cooler and slower. Sometimes high temperatures are nevertheless registered near the ground. April burns are fairly slow, uneven and do not generate much heat. In the dry season the grass cover is removed completely, but in all other seasons stalks and larger or smaller unburned islands usually remain. The smaller trees and shrubs are burnt back to ground level at all seasons, provided the treatment has been successful, and the larger specimens are scorched.

**Recovery:**—After the late summer (April) and the late winter (August) burns the plants normally recover very slowly and the grass is moreover grazed fairly to quite heavily. After the treatments in other seasons the recovery is usually fair to good though dependent on the rainfall, and utilization is less intensive to negligible. Grazing even shows a definite ascending tendency on plots which are burnt later in the summer. Browsing is, except on the April burns, minimal and its omission justified. The influence of grazing is inevitably correlated with the rapidity of the burning rotation and hence the most apparent cumulative affects on the annual and to a lesser extent on the biennial burns.

**Herbs:**—Although retrogressive succession propensities have been noted on some plots, no treatment has as yet caused this phenomenon to reach the ebb, since weed-intrusion has not occurred as yet. Herbs are conspicuous on almost all plots and especially on those which are burnt in the dry season though this is merely a spring phase which endures until the onset of good summer rains. There is no ascending tendency in this aspect either.

**Grass:**—According to the results of the most recent botanical surveys, there have been no significant changes in the basal cover of grasses during the 15 years of treatment. However a few striking and interesting changes have been noted in the species composition.

1) The most important of these is a retrogressive succession propensity on the annually burnt plots and to a lesser extent also on those burnt biennially in April and August. Despite the fact that the basal cover does not differ markedly from that on other plots, there still are many more tufts per unit area than on the others. This fact points to either rejuvenation or a change in species composition. It seems likely that the latter is the case since the pioneer grass *Digitaria pentzii* var. *stolonifera*, which was encountered only once or twice on all plots in the original survey, abounds on all annually burnt areas, including April–May annual burns. It actually increased to such an extent that it is at present the most conspicuous and dominant grass species. Another pioneer, *Pogonarthria squarrosa* ranks very high and is conspicuously plentiful. Other annuals such as *Digitaria longiflora* and *Eragrostis rigidior* are also very obviously spreading.

Apart from the effect of fire itself, grazing also plays an important role in this phenomenon. This is substantiated by the fact that a greater number of tufts per unit area were also encountered on the more intensively grazed plots in both other rotations, viz. the August and April burns in the biennial and the April burns in the triennial rotation (Table 1). This may be due to the season in which the treatments were applied though it is doubtful.

2) *Hyperthelia dissoluta* which was the dominant grass species according to the original survey (18 strikes/2000 points compared with 9/2000 for the second) at present occupies only the sixth position in order of importance and is possibly giving way to pioneers under the severe onslaught of burning and grazing on the annual burns (Table 2). Conflicting with the opinion of other scientists, the species is, after 15 years, still one of the dominant grasses on the control plots.

TABLE 1. NUMBER OF GRASS TUFTS PER 3.3 SQUARE METERS

| Treatment* | Number of Tufts | Treatment | Number of Tufts |
|---|---|---|---|
| August —1 | 40.6 | Control | 22.7 |
| August —2 | 44.0 | August —3 | 25.8 |
| October —2 | 22.3 | October —3 | 24.5 |
| December —2 | 24.7 | December —3 | 26.4 |
| February —2 | 31.8 | February —3 | 28.3 |
| April —2 | 34.8 | April —3 | 33.4 |
| Average | *Annually (1) = 40.6 | *Biennially (2) = 31.5 | *Triennially (3) = 28.9 |

3) *Setaria flabellata,* one of the best fodder grasses in the area, has improved its position from 6th to 2nd place in order of importance (See Table 2). Unfortunately this species does not seem able to withstand a combination of burning and intensive grazing.

4) *Elyonurus argenteus* which initially was the subdominant grass species has probably become somewhat more subservient but this may be ascribed to the phenominal increase of *Digitaria pentzii.* Its present position as well as its reaction to different burning treatments, confirms once again its unpalatability since even under the most stringent grazing and burning tempo it shows no sign of deterioration (Table 2). The same characteristics are demonstrated by another unpalatable species, *Loudetia simplex.* Both these species display a tendency to decrease under protection.

5) Contrary to the above, tendencies have fortunately been observed (Table 2) which indicate that poor fodder grasses such as *Sporobolus schlechteri, Andropogon amplectens* and *Trachypogon*

TABLE 2. INFLUENCE OF DIFFERENT BURNING FREQUENCIES, AS WELL AS COMPLETE PROTECTION ON THE INCIDENCE OF CERTAIN GRASS SPECIES

| Species | Number of Strikes Per 2000 Points for Different Frequencies | | | | | |
|---|---|---|---|---|---|---|
| | Initially | At Present | | | | |
| | | Annual | Biennial | Tri-ennial | Control | Average |
| *Digitaria pentzii* | 1.56 | 23.63 | 8.30 | 7.55 | 2.75 | 9.94 |
| *Setaria flabellata* | 5.15 | 4.88 | 8.95 | 8.45 | 7.00 | 7.98 |
| *Elyonurus argenteus* | 9.56 | 7.88 | 7.70 | 7.00 | 3.75 | 7.15 |
| *Heteropogon contortus* | 5.67 | 9.38 | 6.25 | 6.15 | 6.00 | 6.67 |
| *Loudetia simplex* | 8.92 | 5.38 | 6.05 | 4.50 | 4.00 | 5.19 |
| *Hyperthelia dissoluta* | 17.96 | 3.00 | 6.65 | 3.40 | 5.00 | 4.71 |
| *Panicum maximum* | 4.42 | 2.13 | 4.85 | 4.30 | 5.50 | 4.27 |
| *Schizachyrium semiberbe* | 6.96 | 3.88 | 4.00 | 3.25 | 4.50 | 3.73 |
| *Andropogon amplectens* | 5.45 | 1.00 | 1.70 | 2.50 | 5.50 | 2.19 |
| *Sporobolus schlechteri* | 0.73 (±0.40) | 1.63 | 1.75 | 2.00 | 5.00 | 2.08 |
| *Pogonarthria squarrosa* | 1.86 | 4.13 | 1.95 | 1.50 | 0.50 | 2.00 |
| *Trachypogon spicatus* | 1.90 | 0.38 | 1.70 | 1.90 | 3.00 | 1.67 |
| *Sporobolus stapfianus* | — | 5.75 | 1.45 | 0.85 | 0.50 | 1.81 |
| *Cynodon dactylon* | 1.52 | 1.88 | 1.70 | 0.80 | 0.75 | 1.31 |
| *Eragrostis racemosa* | (±0.67) | 0.50 | 0.90 | 0.70 | 2.75 | 0.90 |
| *Digitaria longiflora* | — | 0.88 | 1.40 | 0.20 | 0.50 | 0.79 |
| *Setaria sphacelata* | 0.08 | 0.13 | 0.25 | 0.05 | 1.25 | 0.23 |
| Total | 71.74 | 76.44 | 65.55 | 55.10 | 58.25 | 62.53 |
| Total—All Species | 95.31 | 87.00 | 73.95 | 62.05 | 67.50 | 70.88 |

*spicatus* which are all climax types, are showing signs of a decrease under the influence of burning and grazing, or conversely show tendencies to increase under protection.

6) On the protected areas utilisation of the vegetation is minimal and almost limited to browsing by species such as the kudu and duiker which favour dense thickets. As a source of nourishment the grass stratum on these is in a definite undesirable condition—a condition which would present an ideal setting for an accidental fire if it is allowed to develop on one of the bigger blocks.

With the exception of the obvious increase of pioneer grasses and the number of tufts on some plots, the present indications are that the changes in the grass stratum have been negligible on this series of plots despite the differential treatments.

**Trees and Shrubs:**—In all the various plant communities of the Park on blocks which have been protected from fire for periods of 15 to 25 years it has been found that there is an unmistakable tendency towards bush encroachment. The encroachment rate is closely correlated with rainfall as well as the presence, or absence, of intruding species. In the combretum–acacia woodland this tempo is, with the exception of the low–lying areas, rather slow and at present no obvious differences which merits mentioning are discernible between treatments. On those plots in the acacia–sclerocarya woodland and the shrub mopane savanna regions, encroachment is obviously taking place, but observations as well as botanical surveys indicate that the bushiness on protected areas must be ascribed to an increase in the size of the existing plants rather than to an actual increase in numbers. On burnt plots, which harbour about the same number of individual plants, the plants are stunted.

In the Pretoriuskop area (teminalia–dichrostachys savanna woodland) definite propensities are discernible at present. As a result of the vast initial differences between plots, the changes which took place in the woody vegetation can not be proved statistically at this stage. Some of these propensities are of such a nature however that they may surely be acceptable.

Because of the fact that different methods were in use, results obtained in the recent survey can also not be compared statistically with those of the initial. In order to detect possible tendencies the results were therefore compared on a general basis only.

According to the figures (Table 3a), the density of the woody vegetation on all the plots as a group, probably increased slightly (about 103). If control plots are not considered then this difference decreases to a point where it is absolutely negligible (about 15). Changes which seem to have developed due to the various treatments are generally not acceptable; the only exception being the very prominent increase on protected areas.

Mutual comparison of the present data (Table 3b) for the various treatments with regard to the woody stratum reveals interesting tendencies:

1) The foremost (and expected) tendency is the phenomenal increase in trees and shrubs on the protected areas. On these plots the population at present exceeds the general average for burnt plots by about 1000 individuals per morgen (500/acre) or roughly 30 percent (from 1900 to 3,000).

TABLE 3. CHANGES IN THE TREE AND SHRUB STRATUM IN THE TERMINALIA–DICHROSTACHYS VELD INDUCED BY DIFFERENT BURNING TREATMENTS OVER A 15 YEAR PERIOD

a.

| Treatments* | Number of Trees/Morgen Initially | At Present | Change |
|---|---|---|---|
| February —2 | 2367 | 2487 | + 120 |
| August —1 | 2320 | 1976 | — 344 |
| August —2 | 2223 | 2071 | — 152 |
| February —3 | 2138 | 2107 | — 31 |
| April —2 | 2095 | 1768 | — 327 |
| October —2 | 2084 | 1863 | — 221 |
| December —3 | 1964 | 1625 | — 339 |
| August —3 | 1620 | 1718 | + 98 |
| April —3 | 1600 | 1732 | + 132 |
| Control | 1589 | 3003 | +1414 |
| December —2 | 1474 | 1700 | + 226 |
| October —3 | 1121 | 1790 | + 669 |
| Average | 1883 | 1986 | + 103 |

b.

| Treatments* | Number of Trees/Morgen Initially | At Present | Change |
|---|---|---|---|
| Control | 1589 | 3003 | +1414 |
| February —2 | 2367 | 2487 | + 120 |
| February —3 | 2138 | 2107 | — 31 |
| August —2 | 2223 | 2071 | — 152 |
| August —1 | 2320 | 1976 | — 344 |
| October —2 | 2084 | 1863 | — 221 |
| October —3 | 1121 | 1790 | + 669 |
| April —2 | 2095 | 1768 | — 327 |
| April —3 | 1600 | 1732 | + 132 |
| August —3 | 1620 | 1718 | + 98 |
| December —2 | 1474 | 1700 | + 226 |
| December —3 | 1964 | 1625 | — 339 |
| Average | 1883 | 1986 | + 103 |

* 1—Annual; 2—Biennial; 3—Triennial; Control—protected.

2) When the different treatments are arranged in order of importance, according to the population density, control plots naturally occupy the first place.

Next in the order are February burns (bi- and triennially (Fig. 5) followed by August burns (annual and biennial (Fig. 6), October burns (bi- and triennial) (Fig. 7), April burns (bi- and triennial), August burns (triennial), and in the last place December burns (bi- and triennial).

Although the differences are in some instances very small and statistically nonsignificant, the systematic succession of the bi- and

FIG. 5. *Pretoriuskop.* Burned February triennially as on 9/6/71. Terminalia-Dichrostachys veld.

triennial treatments, and the specific positions of the seasons, reflect the influence of the various treatments.

The February burns probably follow the control treatment because the burns at this time of the year are often ineffective and, at times, even unsuccessful. An explanation for the remainder of the succession pattern for the different seasons is rather difficult and rests upon speculation supported by observations on, amongst other things, the physical condition of the plants during the various seasons, as well as measurements of factors which influence the intensity of a fire. During summer the fires progress at a much slower rate than in the dry season, but, according to the results, reach rather high temperatures near the ground. The bases of the plants, which are the most important part, are therefore subjected to these high temperatures for a relatively prolonged period, in any case much longer than during the

FIG. 6. Pretoriuskop: Burned August annually, as on 9/6/71. Terminalia-Dichrostachys veld.

dry season. In summer, when all plants are in full leaf and actively growing, they are probably more vulnerable than during the resting period and the influence exerted by fire will therefore be much higher. Although the deciduous plants often start to cast their leaves in April they are often still actively growing at this time, depending on the rainfall. The arguments with regard to slower fires are therefore probably applicable in this case too. Provided these arguments are correct and acceptable then the positions of the very hot but fast annual and biennial August burns are explained automatically. The ostensible extreme damaging effect of the triennial burns in August seems to be, in the face of the foregoing, anomalous. In this case one probably is dealing with a general temperature which is so high as to be detrimental in spite of the tempo of the fire. The higher temperatures, due to an excess of combustible material on triennial burns,

FIG. 7. Pretoriuskop: Burned October biennially, as on 9/6/71. Terminalia-Dichrostachys veld.

probably explains the constant manner in which the bi- and triennial burns for each season succeed each other.

**Individual Species:**—According to figures (see Table 4), the woody stratum is absolutely dominated by two tree species, *Dichrostachys cinerea* subsp. *nyassana* and *Terminalia sericea*. Both species are to a certain extent fire resistant, although plants of up to about four feet are generally burnt back to ground level. Instances in which young *T. sericea* trees of up to 12 feet were burnt back have also been encountered. Depending on the rainfall these damaged plants usually sprout vigorously shortly after the burn. In a three year or shorter burning rotation plants once burnt back seldom escape the regular damage to reach maturity.

From a comparison of the results of the two surveys it seems as if the population originally contained a smaller number of these two

TABLE 4. INFLUENCE OF DIFFERENT BURNING TREATMENTS OVER A 15 YEAR PERIOD ON THE INCIDENCE OF *Dichrostachys cinerea* SUBSP. *nyassana* AND *Terminalia sericea*

a. *Number of plants/morgen.*

| Treatment | Dichrostachys | | Terminalia | |
|---|---|---|---|---|
| | Number of Plants | Average/ Rotation | Number of Plants | Average/ Rotation |
| Control | 766.5 | 1109.8 | 993.6 | 974.8 |
| Wolhuter circle | 1453.0 | | 956.0 | |
| August —1 | 726.8 | 726.8 | 460.0 | 460.0 |
| August —2 | 868.4 | | 540.4 | |
| October —2 | 478.0 | | 572.4 | |
| December —2 | 431.2 | 684.3 | 442.1 | 492.2 |
| February —2 | 915.3 | | 497.9 | |
| April —2 | 728.4 | | 408.2 | |
| August —3 | 692.8 | | 548.9 | |
| October —3 | 532.5 | | 623.7 | |
| December —3 | 709.5 | 623.5 | 328.2 | 604.7 |
| February —3 | 533.6 | | 910.8 | |
| April —3 | 649.2 | | 520.7 | |
| Average | 729.6 | 729.6 | 600.2 | 600.2 |

b. *Number of plants as a percentage of the tree and shrub population.*

| Treatment | Dichrostachys | | Terminalia | |
|---|---|---|---|---|
| | Percentage | Average/ Rotation | Percentage | Average/ Rotation |
| Control | 25.5 | 34.5 | 33.1 | 30.4 |
| Wolhuter circle | 43.4 | | 27.7 | |
| August —1 | 36.7 | 36.7 | 23.3 | 23.3 |
| August —2 | 41.9 | | 26.1 | |
| October —2 | 25.6 | | 30.7 | |
| December —2 | 25.4 | 34.2 | 26.0 | 25.2 |
| February —2 | 36.8 | | 20.0 | |
| April —2 | 41.2 | | 23.1 | |
| August —3 | 40.3 | | 31.9 | |
| October —3 | 29.7 | | 34.9 | |
| December —3 | 43.6 | 35.3 | 20.2 | 32.1 |
| February —3 | 25.3 | | 43.2 | |
| April —3 | 37.5 | | 30.1 | |
| Average | 34.8 | 34.8 | 28.5 | 28.5 |

species (46 percent) than at present (63 percent). Another survey conducted in the same area earlier on revealed a figure which corresponds with the present situation (84 percent). If it is taken into consideration that (1) the overall woody population on burned plots shows no increase in numbers, (2) the control plots show a very strong ascending propensity with regard to the overall population and (3) in spite of the preceding phenomena the two species together nevertheless occur in about the same ratio to the rest of the population on all treatments, then it must be accepted that neither of the two species increased on the burned plots.

The present survey further reveals that both species increased on protected plots. As far as I know *Terminalia* sp. has received no special attention from plant ecologists so far. On the other hand *Dichrostachys* spp., which occur over vast areas in South and South West Africa, and tend to encroach in every situation, have been studied by a number of research workers. The results obtained in the present experiment are not in agreement with the findings of any of these scientists. According to their observations, the species succumbs in areas protected against fire, and find the reason for this in the increased competition from a much denser grass cover. According to our own observations, this plant dies for no apparent reason, under all circumstances, protection or no protection, and even in absolutely overgrazed areas. What happens is that in regularly burnt areas the dead material is removed while, in protected areas, plants which possess a very hard and durable wood (able to withstand weathering for more than 40 years) may last for decades.

It is obvious that one is misled by the resultant progressive accumulation of dead plant material.

At this stage there are no other tendencies, apart from the previously mentioned, which reveal differences in damage due to the various seasonal treatments.

**Other Species:**—Compared to *Dichrostachys* spp. and *Terminalia* spp. the total contribution of the other species (35 percent) is relatively small. A few species such as *Cassia petersiana*, *Maytenus senegalensis*, *Strychnos madagascariensis*, *Xeromphis obovata* and *Parinari curatellifolia* are very promient and together comprise of 80 percent or more of this group.

In general the situation merits no long discussion. At least 10 of these species have, however, apparently increased to such an extent that they occur in greater abundance in protected areas than in unprotected areas. Amongst these are the first three species mentioned above as well as *Annona senegalensis*, *Rhus pyroides*, *Diospyros lycioides* subsp. *lycioides*, *Euclea divinorum* and *Ochna natalitia*. The last two species as well as *Maytenus senegalensis* are evergreen species.

It is obvious from the figures that a wide variety of species are involved. At present there is no indication of any change in species composition due to the burning treatments. Under protection on the other hand, no sign of an increase in the number of species is detectable.

## SUMMARY

The present situation in the Kruger National Park is the result of an experiment which commenced centuries ago, and in which, a large number of unstable factors and infinitely more living organisms participated.

Even under the most natural conditions this situation is never stable but, nevertheless, retains a varying balance.

When man pokes his nose into something, it not usually but always leads to fiasco. For this very reason we must be extremely careful of the manner in which we handle nature, especially in a sanctuary like the Kruger Park, which is, theoretically, supposed to remain completely natural and unchanged but which, due to circumstances, is in an unnatural state already.

The area is either fenced or surrounded by human activities and nature can no longer be allowed its own course. Historical facts, as well as the results of research, past and present, demand the regarding of fire as an integral part of the ecological complex. The tendencies which have appeared in the short time in which research has been conducted under local conditions, unquestionably suggest that the withdrawal of the fire factor initially leads to a deterioration of the grazing conditions and, eventually, to a victory of the woody stratum and the exclusion of the grasses. On the other hand, excessive burning ultimately leads to deterioration of the entire plant community. After 15 years of burning, the damage is apparently still limited to the grass stratum, in which definite retrogressive tendencies are obvious. In time, the tree and shrub stratum may also be affected in such a way that the entire physiognomy of the community will be changed, especially in the presence of browsing species like the elephant.

According to available data with regard to the influence of veldburning on the vegetation of the Kruger National Park there is no reason whatsoever for a change in the present general veldburning policy followed in the Park. Even on the relatively small burning

plots on which the grazing intensity is abnormally high there seems to be very little or no qualitative or quantitative changes in the grass-tratum in case of triennially burned plots. Advantageous tendencies with regard to the woody stratum of the vegetation are also more pronounced on the triennially burned plots. Although it seems as if midsummer treatments may eventually have the best results it would be infeasible when put to practice, as is even sometimes experienced in the present policy.

Preservation of all present floristic elements as well as the mosaic of plant communities, each of which supplies the needs of a variety of living organisms, is, above all else, essential for the survival of this unique sanctuary. As fire is one of the factors involved in retaining this status quo, it cannot be withdrawn.

I conclude this treatise with the well known phrase first used by a distinguished ecologist, presently in our midst: "Fire is a bad master but a good servant—but like all good servants it must be handled with understanding and firmness."

## LITERATURE CITED

Brynard, A. M. 1960. Annual report of the biologist 1958/59. Koedoe 3: 173-191.

———. 1964. The influence of veld burning on the vegetation and game of the Kruger National Park. Ecological studies in Southern Africa. Monographiae Biologicae 14:371–393.

Phillips, J. P. 1965. Fire–as master and servant: Its influence in the bioclimatic regions of Trans-Saharan Africa. Tall Timbers Ecology Conf. no. 4: 7—110.

Van der Schyff, H. P. 1959. Weidingsmoontlikhede en Weidingsprobleme in die Nasionale Krugerwildtuin Koedoe 2: 96-127.

Van Wyk, P. and Wager, V. A. 1968. Problems of fire in the Kruger National Park. African Wild Life 22 (4): 269-280.