

# The estimation of herbage yields under fire and grazing treatments in the Mountain Zebra National Park

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The application of fire as a management tool is often used to change the species composition of the vegetation and its cover to maintain plant communities in a specific successional stage. This study investigates the influence of two fire treatments (a head and a back fire) on the plateau grassland communities in the Mountain Zebra National Park (MZNP). The production of herbage yield on grazed areas and areas protected from grazing which were subjected to two fire treatments, were compared with that of an unburnt control area subjected to grazing in the same homogenous grassland over two growing seasons. No differences were found in herbage production between the two fire treatment areas. After the burn the grazing exclosures achieved the same herbage yield as the control area within two growing seasons. In comparison, the grazed areas could after the burn only achieve a herbage yield equal to 55.7 % of that of the control area. The results indicate that fire stimulates active vegetation growth on the plateau grasslands in MZNP leading to a higher production rate and better utilisation by game.

Key words: vegetation production, controlled burning, Mountain Zebra National Park, head fire, back fire.

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## Introduction

Fire is widely accepted as an important and often essential veld management tool in both agricultural and conservation areas (Tainton & Mentis 1984; Trollope 1984; Trollope 1992). According to Cutler (1979) it can be used to change the species composition of the vegetation and its cover to maintain plant communities in a specific successional stage. The application of fire as a management tool often depends on the management objectives set for the area (Bond & Van Wilgen 1996).

Tainton & Mentis (1984) assumed that fire should be excluded from semi-arid grasslands and also found very little information on the effect of fire on plant production in these areas. Trollope (1978) has examined the role of fire in arid grasslands in the Eastern Cape and has suggested that it could be

used in conjunction with browsers to reduce the density or prevent encroachment of woody species and Karoo pioneers.

The results of a veld condition assessment of the plateau grasslands in Mountain Zebra National Park (MZNP) (Novellie 1998), indicated that the *Cymbopogon plurinodes* and *Eragrostis curvula* plant communities belonging to the *Eragrostis obtusa-Eragrostis curvula* plant community (Van der Walt 1980) in the northwest section (Rooiplaat) of the park were under-utilised by game as these communities were beginning to show signs of becoming moribund. However, to date there has been no fire management plan implemented in the MZNP despite the fact that this area has been highly favoured by game since the early 1960s and Novellie (1998) recommended that a controlled burn be undertaken to study the

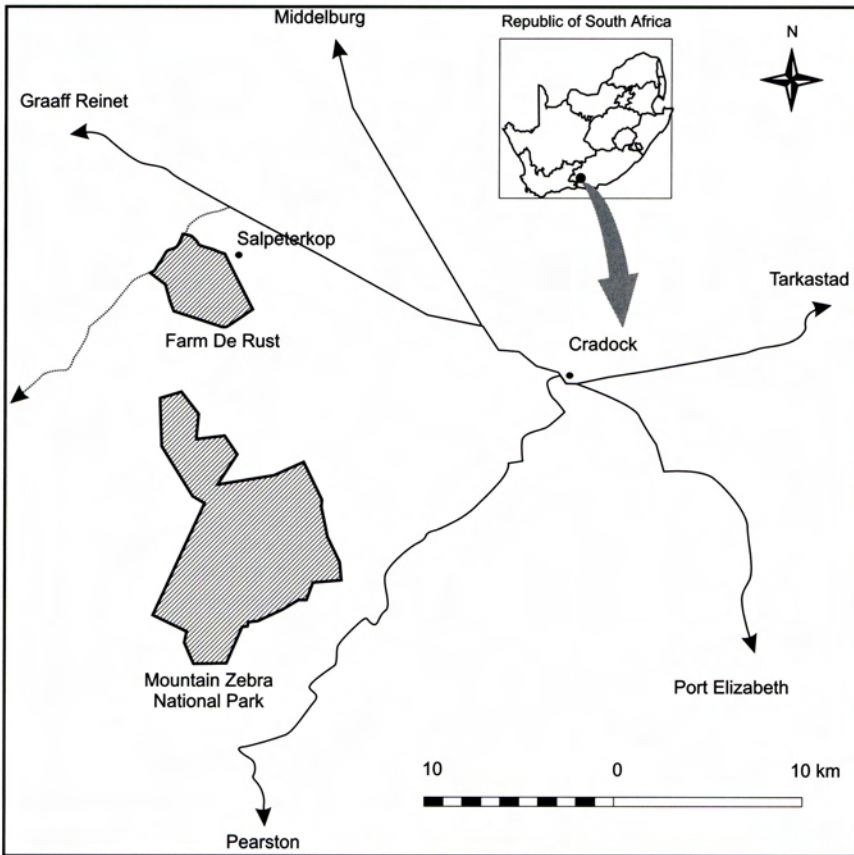


Fig. 1. Location of the study area.

impact of fire on floral and faunal diversity as a possible management tool.

This study investigates the herbage yield and recovery rate achieved in two fire treatments compared with control areas over two growing seasons and forms part of a long-term study to determine the effects of controlled burning on vegetation composition and production, ungulate movement, small mammal and invertebrate communities.

### Study area

The MZNP is situated 25 km southwest from the town of Cradock in the Eastern Cape Province of South Africa extending from 32°05'S–32°20'S to 25°23'E–25°32'E (Fig. 1). The geological formations consist

mainly of sandstone, mudstone and shale with intrusions of dolerite from the Balfour Formation, Beaufort Group of the Karoo Supergroup (Toerien 1972). This study concentrated its efforts on the plateau grasslands of the Rooiplaat area in the northwest of the Park. The Rooiplaat plateau is situated on a Da98b landtype (Land Type Survey Staff 1999) with underlying mudstone, shale and sandstone. Acocks (1988) classified this area as False Karroid Broken Veld (37) while Hoffman (1996) classified it as Eastern Mixed Nama Karoo (52).

The MZNP is situated in the summer rainfall region with a long-term average measured between 1962 to 1998 of 381.9 mm. The average maximum temperatures vary between 23.1–28.4 °C in summer (September–March)

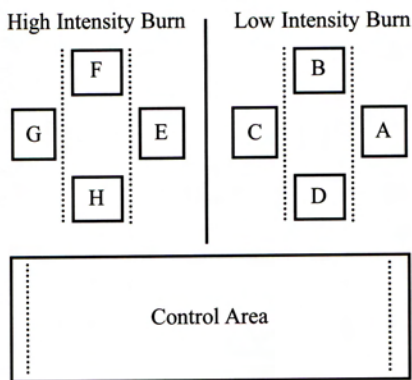


and 16.3–22.7 °C in winter (April–August), while the average minimum temperatures vary between 5.6–13.6 °C in summer and 0.05–7.8 °C in winter (Fig. 2) (Brown & Bezuidenhout 2000). Snowfall on the higher mountainous areas and frost in the valleys, occur frequently during the winter. Thunderstorms with heavy showers are characteristic for summer periods.

## Methods

A homogenous grassland community on the Rooiplateau plateau of approximately 100 ha in size, bounded by a tourist road along the northern, eastern and western borders and a firebreak along the southern border was chosen as the study area. The control area, where no burning was applied, was selected immediately to the south of the study area. A controlled burn by means of a back fire and a head fire was applied to the study area during October 1998. Wind speed and temperature were noted during the burn. The head and back fires, were ignited along a centreline through the study site. Although the fuel load was measured at 3594.9 kgDM/ha before burning, no formal attempt was made to determine fire intensity. However, a total of 25 Thermindex 'Temp Teller' Colour change crayons and thermal melt crayons, applied to aluminium plates, were used in each of the treatments to determine the mean temperature at ground level.

Four enclosure plots of 25 m<sup>2</sup> were erected within each of the two different fire treatment areas.



A–H = Enclosure plots (25 m<sup>2</sup>) each      ..... = Transect lines

Fig. 3. Layout of the monitoring areas of the experiment.

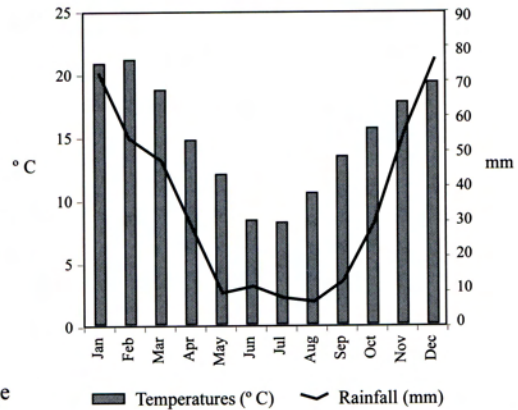


Fig. 2. The average monthly rainfall and the mean average temperatures as recorded at the Mountain Zebra National Park weather station for the period 1985–1999.

A disc pasture meter (Bransby & Tainton 1977) was used to determine the herbage yield before and after the fire treatments. The calibration was based on the method applied by Trollope & Potgieter (1986) in the Kruger National Park. In this study a total of 90 disk meter readings for the different grass heights were taken to determine a linear regression relationship between mean disk meter reading and herbage yield. Trollope & Potgieter (1986) recommended a minimum of 75 readings but found that there is no statistical advantage in taking more than 100 readings to determine the linear regression coefficient/relationship.

The monitoring of the herbage production in the head and back fire burns as well as the control area was then conducted during October 1998 (start of growing season), May 1999 (end of first growing season), October 1999 (start of second growing season) and April 2000 (end of second growing season):

- In both the head and back fire areas 25 disk meter readings (DMR) were taken per enclosure plot (i.e. a total of 100 DMR per fire treatment).
- Using a line transect, one hundred DMR were then taken outside the enclosure plots in the burnt areas (grazed).
- One hundred DMR were also taken along a line transect within the control area (Fig. 3).

A one way Analysis of Variance test (ANOVA) (Steyn *et al.* 1995) was used to determine if there

was any significant difference in herbage yield between the different treatments. A Tukey HSD (Honest Significant Difference) test was then used to determine where differences can be found and if it is really significant at a 95 % confidence limit (Steyn *et al.* 1995). The Tukey HSD test was also used to determine if there is any significant difference between herbage yield of the different growth periods. Comparisons were then drawn between herbage yield in each of the different monitoring plots (Fig. 3).

## Results

### 1. Calibration of the disk pasture meter.

Linear regression analysis indicated a strong positive linear regression between the dependant and independent variables, where fuel load was the dependant variable and disc height the independent variable ( $r = 0.940330$ ;  $P < 0.00005$ ). The intercept (a) value was 338.3 and the slope (b) 343.5, thus resulting in the regression equation;

$$y = 338.3 + 343.5 (x).$$

A mean confidence limit (95 %) of 380 kg/ha was calculated with a coefficient of determination ( $r^2$ ) of 0.884. The mean disc height was 16.8 cm with a minimum of 3.7 cm and a maximum of 46.05 cm. The mean fuel load was 6116 kg/ha with a minimum of 645 kg/ha and a maximum of 17 230 kg/ha.



Fig. 4. Herbage yield in the control area for the period October 1998 till April 2000.

### 2. Block burn

Although there were no significant differences in the recorded temperatures for the head and back fires (non parametric *t*-test; Mann-Whitney test  $U = 721$ ,  $df 48$ ,  $P = 0.107$ ) the mean temperatures recorded were 58 °C higher in the back fire (average = 374 °C; range 215–590 °C) than the head fire (average = 316 °C; range 215–525 °C). Both treatments were ignited at the same time (10:20) with the back fire taking 127 min to burn down while the head fire burn was completed within 60 min. Wind speed was measured between 5–15 km/h, while the humidity at ignition was 35 % decreasing to 20 % at the end of the burn. The ambient temperature ranged between 20–26 °C (MZNP Weather Station).

### 3. Monitoring of herbage yield.

Average rainfall was recorded during the first monitoring period (1998 = 385.6 mm) while above average rainfall fell during the second monitoring period (1999 = 439.2 mm).

The post burn herbage yield for October 1998 in the enclosure and grazed plots after the controlled burn was taken as 0 kg/ha as there had been no production immediately after the fire.

#### 3.1 Control plots (Fig. 4)

During the first growing period (October 1998–May 1999) a 0.3 % production was observed followed by a decrease of 0.3 % in the second growing period (October 1999–April 2000) resulting in an average of zero percent production for the entire study period (October 1998–April 2000). The average herbage yield for this area was 3594.90 kg/ha.

#### 3.2 Enclosure plots (Fig. 5)

The head fire enclosures had an average production of 59.2 % in the first growing period and a 36.4 % in the second growing period (expressed as a percentage of the average herbage yield of the control area namely 3594.9 kg/ha). Thus the head fire enclosures



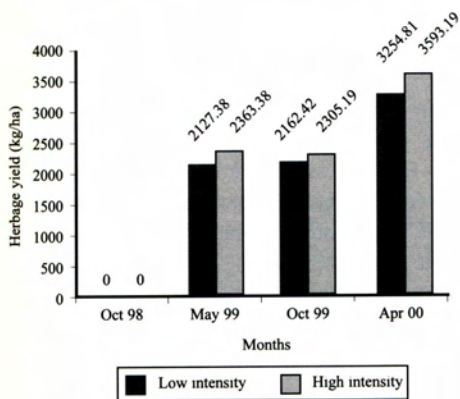


Fig. 5. Herbage yield in the exclosures in the high and low intensity ~~????????~~

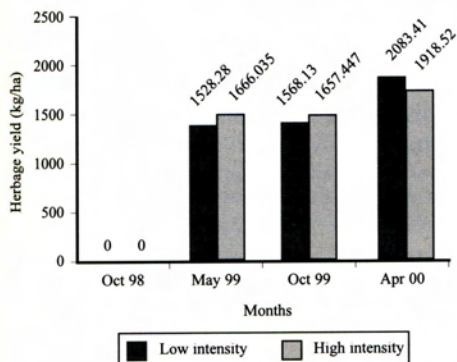


Fig. 6. Herbage yield in grazed areas in the high and low intensity fire.

achieved 90.5 % of the average herbage yield after the second growing period (3254.8 kg/ha).

The back fire exclosures achieved an average production of 65.7 % for the first growing period and 32.2 % in the second growing period. The total average herbage yield for the back fireburn exclosure was 99.9 % of the average herbage yield in the control area after two growing periods (3593.19 kg/ha).

### 3.3 Grazed plots (Fig. 6)

In the head fire (grazed) plots an average production of 42.5 % was measured in the

first growing period with a further 15.4 % in the second growing period. The resultant average herbage yield after the second growing period was 2083.41 kg/ha, which is 57.9% of the average herbage yield in the control area.

The back fire area had an average production of 42.3% and 11% in the first and second growing periods respectively. The total herbage yield after the second growing period was 1918.5 kg/ha, which represents 53.3% of average herbage yield measured in the control area.

### 3.4 Statistical analysis

The one way Analysis of Variance (ANOVA) test shows a statistical significant difference ( $P < 0.05$ ) between all the monitoring plots. This test, however, does not show where the differences between the experimental sites are.

The Tukey HSD test indicated no significant differences between the exclosures in the high and head fireburnt areas and also no significant differences between the high and head firegrazed areas ( $P > 0.05$ ).

This test also indicated no significant difference between the herbage yield in the exclosure as well as the grazed areas between May 1999 and October 1999 ( $P > 0.05$ ) but a significant difference between the surveys of October 1999 and April 2000 ( $P < 0.05$ ). No significant difference was indicated between the exclosure surveys in April 2000 and the control surveys in April 2000 ( $P > 0.05$ ).

### Discussion and conclusions

The DPM regression equation calculated for this study ( $y = 338.3 + 343.5 (x)$ ) corresponds well with the equation calculated by Trollope (1983) for the Eastern Cape ( $y = 340 + 338.3 (x)$ ).

The calibration of the disc pasture meter was considered to be successful as the correlation coefficient ( $r$ ) was 0.94 and the coefficient of determination ( $r^2$ ) was 0.884.

The mean disc height therefore accounted for 88.4 % of the variation in herbage yield over a wide range of grassland communities, indicating that this calibration equation can be used to determine herbage yield in a wide range of grassland communities within the Eastern Mixed Nama Karoo (Hoffman 1996), varying from those dominated by short grass species such as *Aristida* spp. to tall grass species like *Hyparrhenia hirta*.

The monitoring surveys in the control area indicated a zero percent production over the two growing seasons. This corresponds with the findings of Novellie (1998) who found this veld to be moribund and unacceptable to grazers. It is proposed that the control area might also be the start of a retrogressive successional phase as a result of under-grazing, which could lead to a decrease in herbage yield in future years. Continued monitoring will be required to substantiate this hypothesis.

Within two growing seasons the enclosure plots (high and low intensity) recorded similar amounts of dry matter to that measured in the moribund control area. The herbage yield in the enclosures can be ascribed to the lack of defoliation by grazers as well as an above average rainfall in the second year of monitoring. However this does not necessarily mean that the vegetation within the enclosures is also becoming moribund, because continued monitoring may indicate a higher production and therefore a higher yield than in the control area. Herbage yield measured after both the first and second growing periods indicated no difference between the two fire treatments.

The grazed areas produced only an average of 55.7 % of the herbage yield measured in the control area after two growing periods. The concentration of short grass grazers such as blesbok, springbok and black wildebeest on the study area after the burns (*pers. obs.*) could have contributed to this effect. This suggests that there is sustained herbage production after fire which is able to support the ungulate species while still contributing to vegetation regrowth.

Consequently the grazed areas might only reach the same herbage yield of the control area within an estimated four to five years under normal climatic and grazing conditions. Further monitoring is therefore necessary to determine whether the grazed areas will reach the same, or even higher, herbage yield as the control area (3594.9 kg/ha) within the next few years.

The controlled burns (head and back fires) not only eliminated the moribund grass tufts (Novellie 1990), but the results of this study also indicate that the application of fire to the plateau grasslands on MZNP stimulates active growth of the vegetation leading to a higher production rate of vegetation. However, before final management decisions on the implementation of a fire management plan for mountain plateau areas in MZNP are taken, it is important to combine these results with the current studies concentrating on floral and faunal species diversity in response to fire treatment, for this area.

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