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The effect of a prescribed burn, followed up with browsing pressure, on rangeland condition in the Mountain savanna and Karstveld of Namibia

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Abstract

Measurements were taken before and after the application of a prescribed burn, aimed at controlling bush thickening, on a commercial farm in the Mountain savanna and Karstveld of Namibia. The high fuel load, due to high rainfall during the previous season, resulted in an intense fire that caused considerable top kill of bushes. However, the bushes, dominated by Dichrostachys cinerea, *resprouted at varying time intervals after the fire, mostly from ground level. The occasional goat browsing pressure that was subsequently applied was insufficient to keep the majority of bushes under control. Hence browsing pressure would need to be applied more frequently and over a longer time period after a fire, in order to keep more of the bush regrowth under control. The goats also grazed significantly on the regrowth from perennial grasses. Therefore the browsing pressure should not be excessive, as the goats also threaten the perennial grasses.*

Keywords: Bush thickening; fire; goats; *Dichrostachys cinerea;* Mountain savanna and Karstveld; Namibia

Introduction

Bush thickening is a serious problem affecting large parts of Namibia (Bester 1999). It is a symptom of range degradation, which lowers the biodiversity and productivity of the land. Methods used to combat the symptom include arboricides, manual chopping, stem burning and mechanical clearing. Methods used to combat the causes of bush thickening include grazing management, browsing pressure, and prescribed burning after exceptionally high rains. Prescribed burning has been followed up with browsing pressure to control post-burning regrowth of bushes in South Africa (Trollope 1980) and Botswana (Sweet & Mphinyane 1986). These areas generally receive sufficient rain, so that they can attain a fuel load of at least 4 t/ha, considered by Trollope *et al.* (2000) to be required for effective control of bushes. However, there are occasions when a sufficiently high fuel load also occurs in some parts of Namibia.

Namibian farmers who have applied various management treatments to their rangeland possess a lot of useful experience and knowledge. However this has rarely been quantified and validified, so the knowledge is not in a form that can be easily convincing to other farmers and extension workers. Yet, the application of management treatments by farmers provides a useful opportunity to measure the impacts, when farmers are willing to allow it.

Unusually high rainfall during the 1999/2000 season resulted in the accumulation of a high grass biomass in most of the beef producing areas of Namibia. Apart from causing an increase in the occurrence and spread of unwanted fires, this high fuel load prompted some farmers to apply prescribed burning as one of the means to combat bush encroachment. A commercial farmer near Otavi, Mr. Peter Zensi, was about to apply a prescribed burn to an area of about 1 000 ha, as a follow-up treatment to selective application of arboricides five years previously. This provided a good opportunity to conduct 'before' and 'after' measurements. The intention was for the prescribed burn to be followed up with browsing pressure by Boer goats.

Methods

Mr Zensi's farm, Hamburg, lies in the vegetation type described by (Geiss 1971) as Mountain savanna and Karstveld, and in the agro-ecological zone described by De Pauw *et al.* (1999) as Central Plateau, red Kalkveld. The area selected for the study was in one corner of the large paddock that was destined to be burnt. This area was selected due to the sandy nature of the soil, which responds better to burning (Zensi, *pers comm.*). The rainfall during the 1999/2000 season had been about 800 mm. This must be compared with a long-term mean annual rainfall for the area of about 580 mm, and a mean over the previous 10 years of about 410 mm. Cattle had not grazed in the paddock during the 2000 dry season, although game did have access to it.

The 'before' measurements were taken on 26 September 2000. The measurements were made at 100 sampling points, which were located by uniformly spaced GPS readings combined with a randomly thrown dart. The points were roughly 20 m apart, along four transects that were roughly 80 m apart. A turn was made to another transect whenever the vegetation appeared to change significantly due to soil conditions.

The species of bush closest to each sampling point was recorded, regardless of whether it was alive or dead, as long as it was still identifiable to species level. The distance was measured from the nearest stem of the bush at ground level to the sampling point. Similarly, the species and distance of the nearest perennial grass was also recorded at each point. If a canopy of a woody plant, taller than 0.5 m, occurred directly above the point, then its species was recorded, in order to estimate canopy cover from points.

At each fourth point the overall canopy cover of trees and bushes taller than about 0.5 m was also measured by Bitterlich gauge (Friedel & Chewings 1988) using a half angle of 12°55′. The clumped distribution of some bushes made it difficult to determine where the canopy of one plant ended and another began. Therefore, in cases where canopies in a clump overlapped to form an approximate circle, the whole clump was counted as one individual, even if the canopy of each individual bush did not extend beyond the sighting pins of the Bitterlich gauge. Such a clump was therefore treated as if it were one large canopy instead of many smaller canopies. The resulting canopy cover estimate was therefore the % of ground covered by woody canopy, and not of the absolute canopy as in Friedel & Chewings (1988).

Measurements on the characteristics of individual live bushes closest to the sampling point were only made on the thickening species, these being mainly *Dichrostachys cinerea*, and a few bushes of *Acacia mellifera* subsp. *detinens*, *A. luederitzii* and *A. fleckii*. They were marked with a half brick and a GPS reading was taken, so as to facilitate their relocation after the fire.

At each individual bush of thickening species that was sampled, records were kept of the height of its highest living stem, the height of its highest dead stem, the maximum width of its canopy and the width at right angles to its maximum width. After the fire, before goats were brought in, the length of the longest shoot which had re-sprouted after the fire was measured from where it sprouted to its tip.

Canopy area of each sampled bush, in square meters, was estimated by using the formula:

$$A_c = \frac{\pi(W_m + W_r)^2}{160\,000}$$

where A_c = canopy area,
W_m = maximum width in cm, and
W_r = width in cm at right angles to maximum width

Fuel load was measured in September, by cutting the above-ground herbaceous layer in 10 quadrats of 1 m^2, followed by drying and weighing back at the Polytechnic.

The prescribed burn was applied on 30 October 2000. The 'after' measurements were made on 11 and 12 December 2000, and at the end of the growing season on 3 May 2001. Goats were first applied to the burnt area on 13 December 2000, by herding about 400 Boer goats over the area. One goat was conditioned to being followed for about ten minutes before the number of bites it took from different types of plants was recorded for two hours. A bite was defined as an audible jerk of the head, which tore off some of the forage from the plant. Subsequently the herder was instructed to herd the goats on every weekday over the paddock of ±900 ha that had been burnt. However this rarely happened in that part of the paddock where the measurements were taken, which was the furthest corner from the water point and kraal. So the goat pressure after 13 December 2000 is likely to have been only very light, if at all, in the measured area.

Results

The basic characteristics of the sampled area appear in Table 1. The most common bush species was *Dichrostachys cinerea,* while *Grewia* spp. made up the bulk of the non-thickening species. The majority of perennial grasses were broad leaved species, such as *Panicum maximum, Urochloa oligotricha* and *Cenchrus ciliaris*, while the main narrow-leaved species was *Stipagrostis uniplumis*.

Table 1: Basic characteristics of the areas sampled on farm Hamburg.

	Before burn (Sep '00)	After burn (Dec '00)	After season (May '01)
Mean distance to nearest bush (cm) [1]	85^{a}	92^{a}	96^{a}
Mean distance to nearest perennial grass (cm) [1]	102^{a}	$88^{a,b}$	66^{b}
Woody canopy cover by points (%)	55^{x}	36^{y}	29^{y}
Woody canopy cover by Bitterlich gauge (%)	38^{a}	31^{b}	30^{b}
Percent of thickening species amongst bush canopies, as determined by Bitterlich gauge	82^{x}	69^{y}	64^{y}
Percent of *Dichrostachys cinerea* amongst bush canopies, as determined by Bitterlich gauge	70^{x}	51^{y}	47^{y}
Percent of narrow-leaved grasses amongst perennial grasses	3^{x}	13^{y}	4^{x}

[1] after log normal transformation

[a, b] Values with different superscripts differ significantly ($p<0.05$) across rows, t-test.

[x, y] Values with different superscripts differ significantly ($p<0.05$) across rows, by chi-test.

The fuel load was found to be 4.9 ± 1.8 tons/ha (95% confidence limits), consisting primarily of annual grasses that were subjectively estimated to make up roughly 90% of the aboveground herbaceous dry matter. It resulted in an intense fire, despite lack of wind when the prescribed burn was applied.

The prescribed burn reduced the canopy cover of bushes, while changes in density, as reflected by the distance measurements, were not significant. The September and December measurements of canopy cover by Bitterlich angle gauge gave lower results than those obtained from the 100 points per survey, while in May the two methods gave similar results. It is likely that the Bitterlich angle gauge gave a more accurate measure, since 100 points are insufficient to obtain a very reliable estimate of canopy cover. The reduction in overall canopy cover due to the fire, as measured by Bitterlich gauge, was about 18%. No newly established bush seedlings were observed, either before the fire or thereafter.

Out of the 30 live bushes of thickening species, which were measured both before and after the fire, 27 were of *D. cinerea*. Their changes in height are shown in Figure 1, while mean results appear in Table 2. All of the 27 bushes eventually re-sprouted from ground level, some months after the fire. Strohbach (1996) found *D. cinerea* to be one of the toughest species of bush, even in its ability to survive stem burning. Trollope (1974) also found that most bushes suffered a kill of stems and branches after an intense fire in the Eastern Cape area of South Africa and then coppiced from the base of the stem.

Table 2: Mean changes in height and canopy area of the 27 bushes of *Dichrostachys cinerea*, as a result of the burning treatment at farm Hamburg.

	Before burn (Sep '00)	After burn (Dec '00)	After season (May '00)
Mean height of highest living stem (cm)	203^{a}	21^{b}	103^{c}
Mean height of highest dead stem (cm)	177^{a}	222^{a}	210^{a}
Mean height of highest stem, regardless of whether living or dead (cm)	235^{a}	$222^{a,b}$	211^{b}
Mean canopy area (m^2)	4.43^{a}	3.48^{b}	3.29^{b}

$^{a,\,b}$ Values with different superscripts differ significantly ($p<0.05$) across rows, by paired t-test.

By December, five weeks after the fire, there had been a highly significant overall 90% drop in height of the highest living stem in the 27 measured bushes of *D. cinerea.* In the case of the height of the highest dead stem, this decreased in some bushes that burnt down, while it increased in others due to live stems having been killed by the fire. The overall result was a 25% increase in height of the highest dead stem in the 27 measured bushes of *D. cinerea*, but this was only significant at $p = 0.073$. The net result was an overall decrease in height of the tallest stems per bush, whether live or dead, of 6%, which was not statistically significant. The overall canopy area of the 27 bushes of *D. cinerea* decreased by 22% as a result of the fire, which was significant at $p<0.05$.

By May, six months after the fire, there had been considerable regrowth from the bushes of *D. cinerea*, with the overall height of the highest living stem in the 27 measured bushes of *D. cinerea* shooting back to 51% of their living height before the fire, from 10% soon after the fire. In the case of the height of the highest dead stem, the overall result was a 19% increase in height of the highest dead stem in the 27 measured bushes of *D. cinerea* since before the fire, down from the 25% increase soon after the fire, probably due to some more of the dead stems breaking off. The net result was an overall decrease in height of the tallest stems per bush, whether live

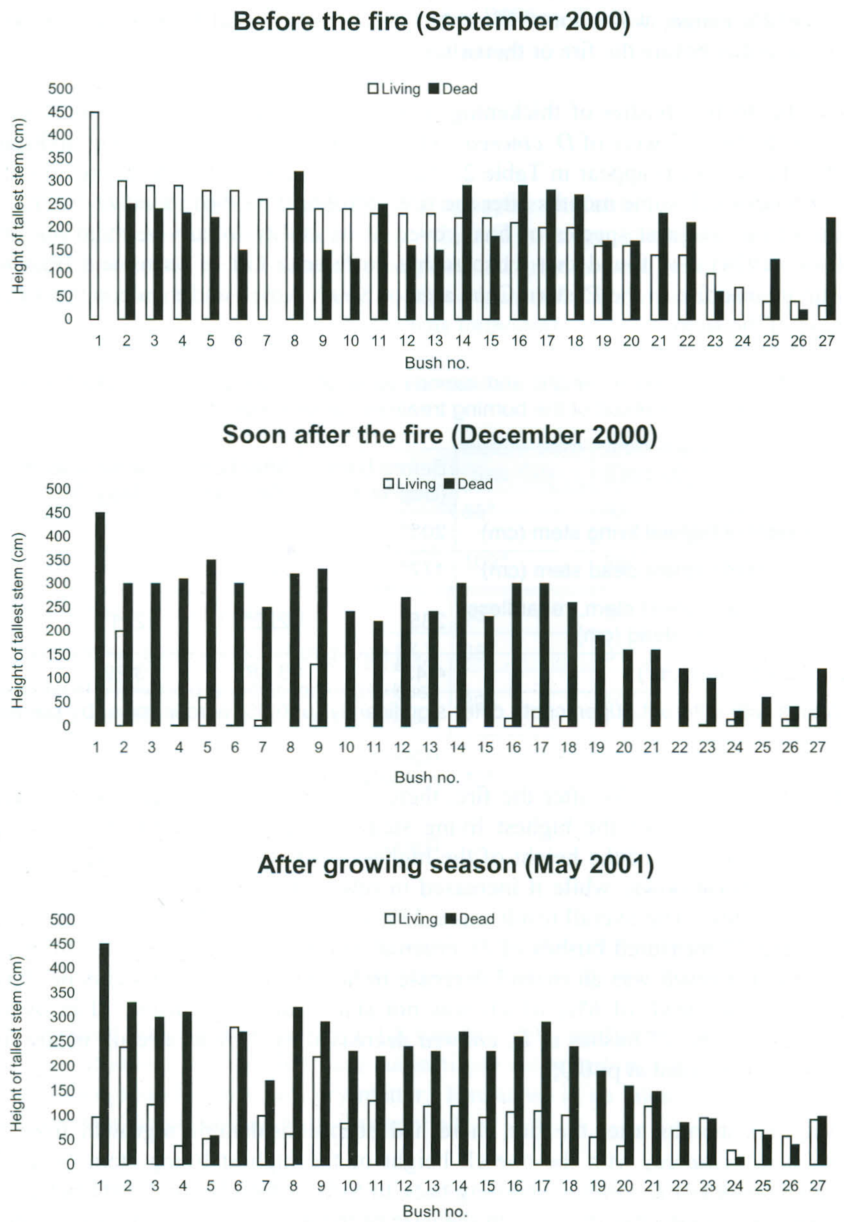

Figure 1: Changes in height of the tallest living and dead stems in each of the 27 bushes of *Dichrostachys cinerea* as a result of the burning treatment at farm Hamburg.

or dead, of 10% since before the fire, slightly lower than the 6% reduction soon after the fire, but the latter difference was not statistically significant. The overall canopy area of the 27 bushes of *D. cinerea* dropped down to 74% of its area before the fire, from 78% soon after the fire, probably as a result of some more of the dead branches breaking off.

There was great variability in the longest lengths of new shoots on the 27 bushes of *D. cinerea*, as can be seen in Figure 2. Five weeks after the fire there were still many bushes that had not yet sprouted their new shoots, while others had already grown shoots up to 60 cm in length. By this time game had already eaten some of the re-sprouted bushes and grasses.

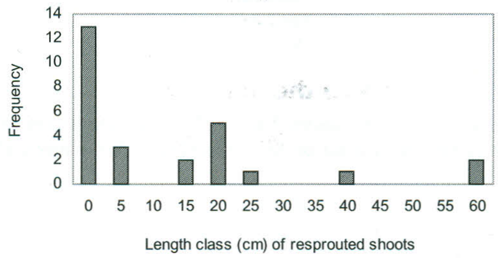

Figure 2: Frequency distribution of lengths of the longest resprouted shoots in each of the 27 bushes of *Dichrostachys cinerea* as measured in December, five weeks after the burning treatment at farm Hamburg.

The density of perennial grasses increased significantly by the end of the growing season. This appears to have been through establishment of quite a lot of new perennial grass seedlings, especially of *P. maximum*, due to the fairly good rain. It appeared as though *S. uniplumis* flushed earlier than the broad-leaved grass species, since a higher proportion of *S. uniplumis* was found soon after the fire.

Some of the re-sprouted bushes and grasses had already been eaten by game when the 'after burning' measurements were taken in December. The goat took a total of 1 488 bites during the two hours of observation in the burnt area, five weeks after the fire. Almost all the bites were taken of re-sprouted forage. Only five bites were taken of dry leaves, those of *Lonchocarpus nelsii.* The results appear in Figure 3 as percentages, showing that almost half the feeding was by grazing on grasses. It was not easy to identify the species of every grass plant eaten, so they were all lumped together, but they were all broad-leaved species. *Grewia* species were the main bushes that were browsed on, especially *G. flavescens*, while *D. cinerea* was also much favoured. Only a small amount of *Acacia* species were browsed on, namely *A. luederitzii* and *A. mellifera*.

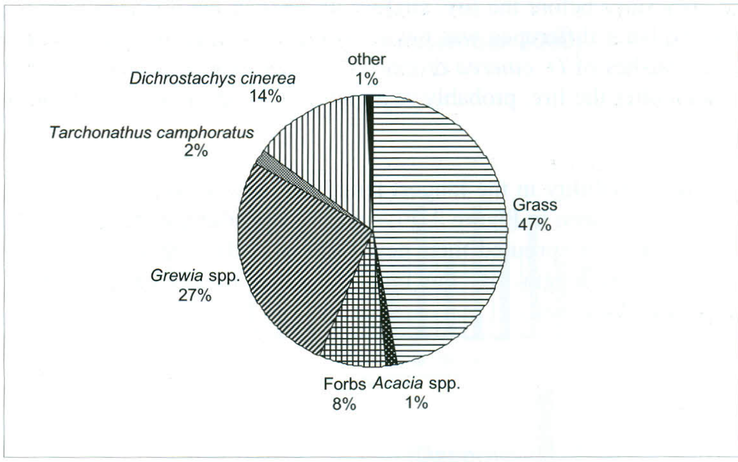

Figure 3: The percentage of bites taken from different categories of plants by the goat feeding for two hours in the burnt area on farm Hamburg, five weeks after the fire.

Conclusion

The goat pressure appears to have been insufficient to harm the bush thickening species in the measured area. The fire resulted in a considerable top kill of bushes of all species, thanks to the high fuel load resulting from the exceptionally high rainfall. The bushes subsequently re-sprouted from ground level. Although goats temporarily set back the regrowth on some of the bushes, their vigorous regrowth subsequently managed to escape the browsing pressure.

The longer-term influence of the fire on the bushes depends largely on the amount and timing of browsing pressure that is applied. However the goats and game also feed significantly on the re-sprouting grasses, which might lead to further weakening of the grasses.

The large variability in response of the bushes means that goat pressure would need to be applied repeatedly at short intervals, or continuously over a longer period after the fire, which may also lead to weakening of grasses that have their regrowth continuously grazed. Sweet & Mphinyane (1986) found adverse changes in herbaceous layer composition where a continuous high stocking rate of goats was applied after fire. Hence it seems as though a delicate balancing act will be needed to ensure that the goat pressure harms most bushes while allowing most perennial grasses to survive. Another drawback is that opportunities for applying high intensity fires are limited to those years that have experienced exceptionally high rainfall, to produce sufficient fuel.

Good rains also produce many bush seeds that, if followed up with another good rainy season, may result in the establishment of many bush seedlings. The fire itself is likely to destroy most of the fruits that are still on the bushes at the time of the fire, and any young seedlings that established themselves during the season before the fire.

In another, smaller paddock, where the goats were kept over weekends, their regular pressure appears to have resulted in more effective control of regrowth of *D. cinerea*. (Zensi, *pers comm.*). Regretfully no measurements were made in this small paddock.

Acknowledgements

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