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THE EFFECTS OF BRUSH CONTROL ON GRASS SPECIES ABUNDANCE AT SEMONKONG, LESOTHO

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ABSTRACT

Shrub encroachment is one of the major threats to Lesotho's degraded rangelands. The main drivers of rangeland degradation include prolonged droughts, overgrazing and frequent burning of rangelands. The Ministry of Forestry, Range and Soil Conservation, through the Department of Range Resources Management, has engaged in brush control activities for removal of shrub species from the rangelands. The encroaching shrub species include *Chrysocoma ciliata, Helichrysum trilineatum, Relhania dieterlenii, Seriphium plumosum, Felicia filifolia, Erica dominans* and *Pentzia cooperi*. The shrubs are usually less than 1.5 m in height, and they are referred to as brush species. This study aimed at investigating the abundance of different grass species on shrub-cleared areas in 2016, 2017 and 2018 as compared to the uncleared brush area in the Semonkong grazing area, and to determine the relative abundance of palatable and less palatable grass species on shrub-controlled areas and an area with brush species. The study was conducted at the Semonkong grazing area in Maseru District, Lesotho. The species composition of the grass community significantly changed in response to the clearance, which was mainly due to changes in the abundance of four species, *Merxmuellera disticha*, *Festuca caprina, Eragrostis curvula* and *Helictotricon longifolia*. The area cleared three years before had the highest abundance of highly palatable grass species and the lowest abundance of less palatable species. However, there was a noticeable regrowth of shrubs and introduction of new shrub species such as *Erica dominans* and *Pentzia cooperi* three years after removal of shrubs. The results strongly suggest that brush control activity is a successful rangeland management tool in improving productivity of rangelands in Lesotho due to an increase in the abundance of highly palatable grass species and decreased abundance of less palatable species.

Keywords: brush control, palatability, species abundance

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ABBREVIATIONS

ANOVA	Analysis of variance
ArcGIS	Aeronautical Reconnaissance Coverage Geographic Information System
DRRM	Department of Range Resources Management
GPS	Global Positioning System
MFLR	Ministry of Forestry and Land Reclamation
NMDS	Non-metric Multidimensional Scaling
ORASCOM	Orange Senqu River Commission
SPSS	Statistical Package for Social Sciences

1. INTRODUCTION

Rangelands play a prominent role in providing and supporting ecological, social and economic services throughout the world (Sala et al. 2017). In Lesotho, a mountainous landlocked country entirely bounded by South Africa, the services include carbon sequestration, water storage and purification, provision of food and habitat to people and animals, aesthetic values and recreation. The country is estimated to be 30,355 km^2 in total area, and the rangelands encompass about 60% of the country's total area. The climate is temperate with hot summers and cold winters (DRRM [Department of Range Resources Management] 2014).

Livestock supports socio-economic life within the country. For instance, horses and donkeys are used for transport, cattle are used for tillage of cropland, and farmers earn money through exporting quality wool and mohair from Merino sheep and Angora goats to South Africa and other countries (ORASCOM [Orange-Senqu River Commission] 2011). The productivity of livestock depends on the rangeland forage quality and quantity available for animal consumption (DRRM 2014). Furthermore, Lesotho exports clean natural water from wetlands within highland rangelands to South Africa through the Lesotho Highland Water Project. However, decades of improper grazing management with overstocking and excessive burning of rangelands along with prolonged droughts has led to severe deterioration of rangelands (Hudak 1999).

Shrub encroachment commonly occurs in the world's arid and semi-arid regions. Thirteen million hectares of the South African area is reported to be encroached on by shrubs (Eldridge et al. 2011). This is associated with land-use trends such as increased grazing pressure and reduced rangeland burning (Roques et al. 2001). Burning is proven to be a major shrub disturbance and may have played a role in maintaining low shrub densities in many arid and semi-arid biomes (D'Odorico et al. 2012).

Rangeland shrub encroachment also occurs in more temperate conditions of Lesotho. Unpalatable shrub species take advantage of the bare ground of the degraded rangelands and eventually dominate the rangeland vegetation. The unpalatable shrub species that encroach degraded rangelands include *Chrysocoma ciliata*, *Helichrysum splendidum*, *Relhania dieterlenii*, *Seriphium plumosum* and *Felicia filifolia (*ORASCOM 2011; Hae 2016). These shrub species are usually less than 1.5 m in height and grow in dense populations and are called "brush species" in Lesotho. The words "brush" and "shrub" are used interchangeably and treated as synonyms in this study.

Chrysocoma ciliata in particular poses a more serious threat to the rangeland in the highlands than in the lowland regions because the highlands are traditionally used as summer grazing, leading to overstocking around the cattle-post areas. Rangeland degradation in Lesotho presents a tremendous depletion of biodiversity and high loss of the fertile soil layer as a result of improper rangeland management practices (Moshoeshoe & Sekantsi 2013).

The Ministry of Forestry, Range and Soil Conservation through the Department of Range Resources Management took an initiative in rangeland rehabilitation from 2006 by engaging labour to clear encroaching brush species on rangelands every year in every constituency within the country. The shrub control activity involves manual uprooting of encroaching and unpalatable brush species using simple hand equipment such as mattock, pick, hoe or spade (MFLR [Ministry of Forestry and Land Reclamation] 2014). Uprooted plants are packed in line across the slope to retard runoff velocity. According to Lesoli et al. (2013) the removal of encroaching bush in neighbouring South Africa can restore herbaceous plant productivity in degraded rangelands. However, the success of such management action in rangeland districts in Lesotho remains to be assessed.

The shrub control activity is carried out on a large scale at the Mots'eremeli and Semonkong grazing areas found in Thaba-Tseka and Maseru Districts, respectively. The aim of this study was to assess how successful the rangeland rehabilitation efforts have been in terms of improved rangeland quality at the Semonkong grazing area. There were two specific objectives:

- To investigate the abundance of different grass species on shrub-cleared areas in 2016, 2017 and 2018 as compared to uncleared brush area.
- To determine the abundance of palatable and less palatable grass species on shrub-controlled areas and on area with brush.

By assuming that the conditions at the four study areas were otherwise comparable, the objectives addressed two research questions:

- What is the response of different grass species abundance after one, two and three years of shrub clearance on rangelands?
- Can shrub control affect the relative abundance of palatable grass species?

The hypothesis was that shrub control increases forage yield by increasing the abundance of palatable grass species on rangelands, and the abundance continues to rise with time from brush clearance.

2. METHODS

2.1 Site description

The Semonkong village is situated in the highland mountainous ecological zone of Maseru District. The village is a popular tourist destination because of the close by Maletsunyane Falls which is the highest single-dropping waterfall in Southern Africa. The main livestock farmed in the village's rangelands are sheep because of the high demand for its meat by tourists visiting the falls. The average temperature in Semonkong in 2018 was 18.5°C from September to April and 10°C from May to August. The 2018 monthly average rainfall was 62 mm from September to April and 9 mm from May to August (Semonkong climate n.d.).

The study was conducted at the grazing area of Matsatsaneng sub-village from 30 June to 3 July 2018 by range resources management staff members. The area was divided into four sections, 0, 1, 2 and 3. Section 0 had not been cleared from shrubs while sections 1, 2 and 3 were cleared from shrubs in 2018, 2017, 2016, respectively (Fig. 1). The total area of these sections was 91.4 ha, and the elevation ranges from 2238 m to 2583 m above sea level. Section 0 was about 10 ha, section 1 about 20.7 ha, section 2 about 25.9 ha and section 3, which was cleared in 2016, about 22 ha.

Figure 1. The study area at Semonkong, Matsatsaneng, Lesotho; **0** (blue) is the section uncleared from shrubs, **1** (green) was cleared in 2018, **2** (red) was cleared in 2017, and **3** (yellow) was cleared in 2016.

2.2 Data collection

At each sampling section, 15 sampling points were randomly selected using ArcGIS 10.5 such that every sampling point in each section was independent of the others (Fig 2.). In total 60 points were sampled.

Figure 2. Randomized sampling points at the Semonkong study area

GPS devices were used to locate the sampling points. The centre of each 1 m^2 sampling quadrat was placed at each GPS point. The percentage area occupied by each grass species within the quadrat was estimated visually and recorded. The regrowth of shrub species found in each quadrat was recorded in the same way.

2.3 Data analysis

The collected data was analysed using the R-software. First, the differences in grass community composition in the four sections were explored by ordinating the plots using NMDS. To test for the effects of shrub clearance over different years on grass species community composition, the difference between the groups was tested with a multivariate analysis of variances (permutational MANOVA) by using the adonis function in R (response variables: abundance of each grass species; predictor: year since shrub clearance (0, 1, 2 and 3 years)) (Anderson 2001). A linear model in R was used to test differences between sections in total grass cover and for seven individual grass species (*Eragrostis caesia, Eragrostis curvula, Festuca caprina, Ficinia filiformis, Helictotricon longifolia, Merxmuellera disticha and Themeda triandra*) that fulfilled the assumption of the parametric test.

Second, based on literature and expert knowledge, the grass species were classified into three palatability classes: palatable, intermediate and unpalatable. After checking that assumptions for parametric testing were fulfilled, the differences between sections (years since clearance) were tested for each palatability class by re-levelling, using linear model function in R statistics.

3. RESULTS

3.1 Grass species community composition

The grass species communities of the four sections partly overlapped along the first two NMDS ordination axes (Fig. 3). However, there was a significant difference in arrangement of grass species abundance in relation to the year of shrub removal ($F_{3,56}$ =5.284, P = 0.001).

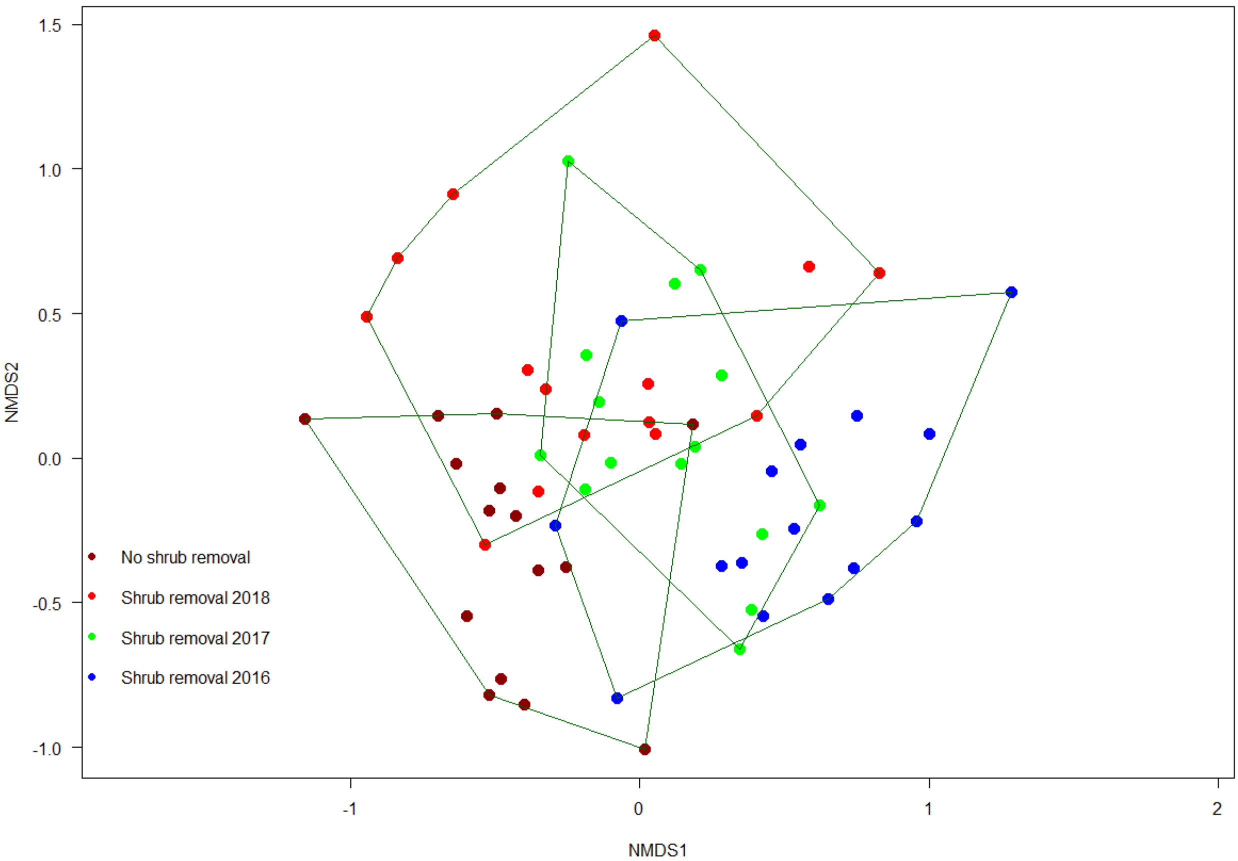

Figure 3. The ordination of the grass communities along the first two NMDS axes in the four sections.

In total, 18 grass species were registered in the area (Table 1; for descriptive statistics by section see A1). Eight species were only found in one of the sections while six species were found in all four sections although their abundance varied between sections. The total grass cover did not differ between sections (Fig. 4). However, when the difference in abundance between sections was considered for individual species, brush clearance and years after brush clearance had a significant effect only on four of the species, *Merxmuellera disticha*, *Festuca caprina*, *Eragrostis curvula* and *Helictotricon longifolia* (Table 1). The abundance of *Merxmuellera disticha* was significantly lower in the section cleared three years ago than in any of the other sections. *Festuca caprina* abundance was significantly lower in the sections cleared one and two years ago and was not found three years after brush control. *Eragrostis curvula* was found high in abundance every year after brush clearance and was significantly more abundant in the section cleared three years ago than in the uncleared section. The cover of *Helictotricon longifolia* was greater in the brush-controlled section than in the uncleared section and the difference was significant in the section cleared two years ago.

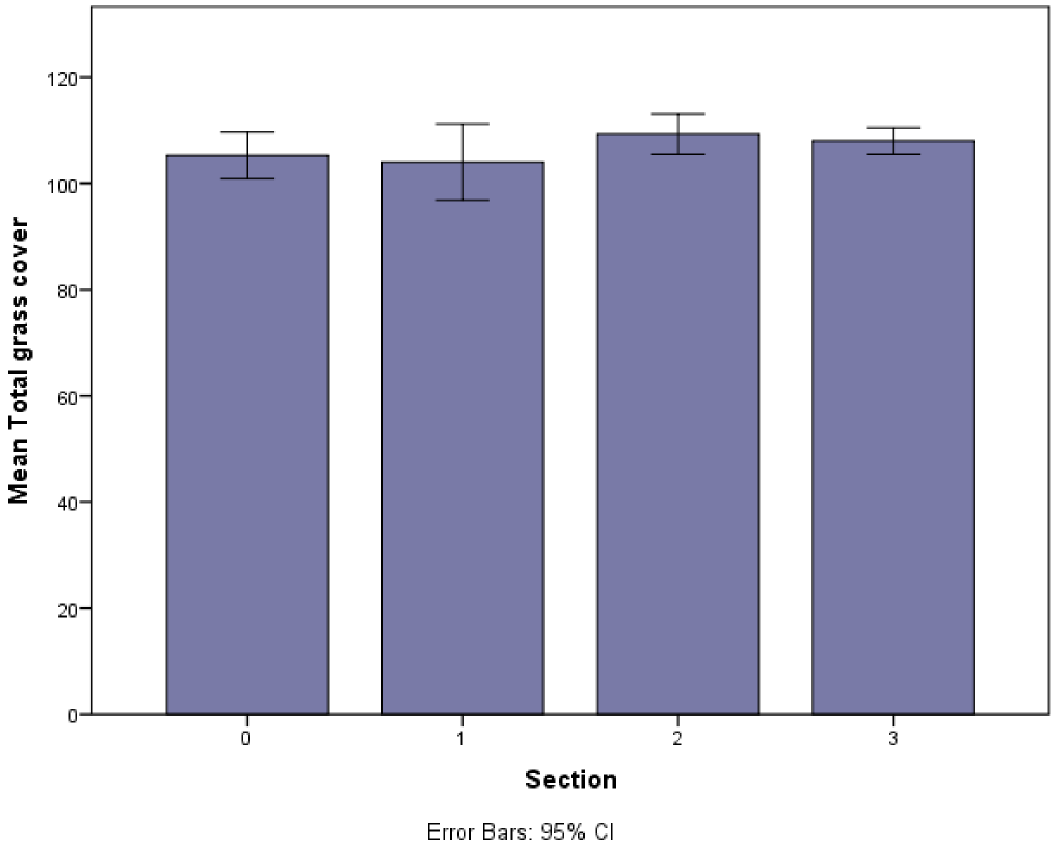

Figure 4. The mean total percentage grass cover ± 95% confidence intervals in the four sections (years since shrub removal).

Table 1. Means percentage cover and standard deviation of all grass species. Section refers to number of years since shrub clearance. The means in bold were significantly different and the letters (a and b) indicate which sections were different. Differences were assumed to be significant at probability (p-value) < 0.05. (see A2 for more information of ANOVA).

Species	Average cover mean ± standard deviation			
	0	1	2	3
Agrostis lachnantha	0.00 ± 0.00	3.00 ± 7.97	0.00 ± 0.00	0.00 ± 0.00
Aristida bipartita	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	1.33 ± 5.16
Bromus willdenowii	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	2.67 ± 4.95
Catalepis gracilis	0.00 ± 0.00	7.67 ± 16.35	0.00 ± 0.00	9.67 ± 20.22
Cyperus marginatus	0.00 ± 0.00	0.00 ± 0.00	0.33 ± 1.29	0.00 ± 0.00
Elionurus muticus	4.67 ± 13.56	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Eragrostis caesia	5.67 ± 9.42	2.67 ± 4.17	4.00 ± 10.56	3.00 ± 5.92
Eragrostis curvula	**2.00 ± 7.75 a**	**11.00 ± 15.61 ab**	**21.33 ± 17.16 ab**	**31.00 ± 25.93 b**
Festuca caprina	**20.00 ± 19.91 a**	**1.33 ± 3.99 b**	**1.00 ± 3.87 b**	**0.00 ± 0.00 b**
Ficinia filiformis	7.33 ± 11.48 a	8.33 ± 14.48 a	2.00 ± 7.75 a	1.33 ± 3.52 a
Harpochloa falx	4.33 ± 8.63	0.00 ± 0.00	1.67 ± 6.46	0.00 ± 0.00
Helictotricon longifolia	**0.33 ± 1.29 a**	**1.00 ± 2.80 ab**	**6.00 ± 7.84 b**	**4.67 ± 6.94 ab**
Koeleria capensis	0.00 ± 0.00	6.00 ± 7.84	3.67 ± 7.90	4.00 ± 10.56
Merxmuellera disticha	**16.67 ± 18.39 a**	**31.00 ± 20.63 a**	**21.67 ± 20.59 a**	**2.00 ± 5.61 b**
Pennisetum thunbergii	0.00 ± 0.00	1.67 ± 6.46	0.00 ± 0.00	0.00 ± 0.00
Pentaschistis oreodoxa	0.00 ± 0.00	2.67 ± 7.76	5.67 ± 13.21	0.00 ± 0.00
Setaria spacelata	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	2.33 ± 6.78
Themeda triandra	38.33 ± 20.76 a	24.00 ± 23.62 a	32.67 ± 22.75 a	38.00 ± 27.57 a

3.2 Grass species palatability

Six of the grass species were classified as highly palatable, five species as moderately palatable, and seven as less palatable (Table 2).

Table 2. The palatability classes of grass species and the references

Species names	Palatability	References
Agrostis lachnantha	Moderate	Van Oudtshoorn 2004
Aristida bipartita	Less	Van Oudtshoorn 2004
Bromus willdenowii	High	Killick 2012
Catalepis gracilis	Moderate	Van Oudtshoorn 2012
Cyperus marginatus	Less	Killick 2012
Elionurus muticus	Less	Van Oudtshoorn 2004
Eragrostis caesia	Moderate	Killick 2012
Eragrostis curvula	High	Van Oudtshoorn 2004
Festuca caprina	Less	Van Oudtshoorn 2012
Ficinia filiformis	High	Expect knowledge
Harpochloa falx	Moderate	Van Oudtshoorn 2004
Helictotricon longifolia	High	Killick 2012
Koeleria capensis	Less	Van Oudtshoorn 2004
Merxmuellera disticha	Less	Van Oudtshoorn 2004
Pennisetum thunbergii	Moderate	Van Oudtshoorn 2004
Pentaschistis oreodoxa	Less	Van Oudtshoorn 2012
Setaria spacelata	High	Van Oudtshoorn 2004
Themeda triandra	High	Van Oudtshoorn 2004

The cover of highly palatable grass species in section 0 (not yet cleared of brush) was not significantly different to sections 1 and 2, but significantly lower than in section 3, which was cleared three years ago (Fig. 5 A). Section 2 was not significantly different from any of the other sections. The cover of grass species of moderate palatability did not differ between sections (Fig. 4 B). The cover of less palatable grass species did not differ from sections 0, 1, and 2, but in section 3 their cover was significantly lower than in the other sections (Fig. 5 C). (For more information on statistical analysis see A3 and A4).

3.3 Shrubs

Only two shrub species (*Chrysocoma ciliata* and *Helichrysum trilineatum*) were identified in the section that was not cleared from shrubs (section 0). There was a noticeable regrowth of *Chrysocoma ciliata* and *Helichrysum trilineatum* in the section cleared of shrubs in 2017 (section 2). The results of the study further revealed that there was an introduction of new shrub species (*Erica dominans* and *Pentzia cooperi*) into the section that was cleared in 2016 (section 3) (Fig.6).

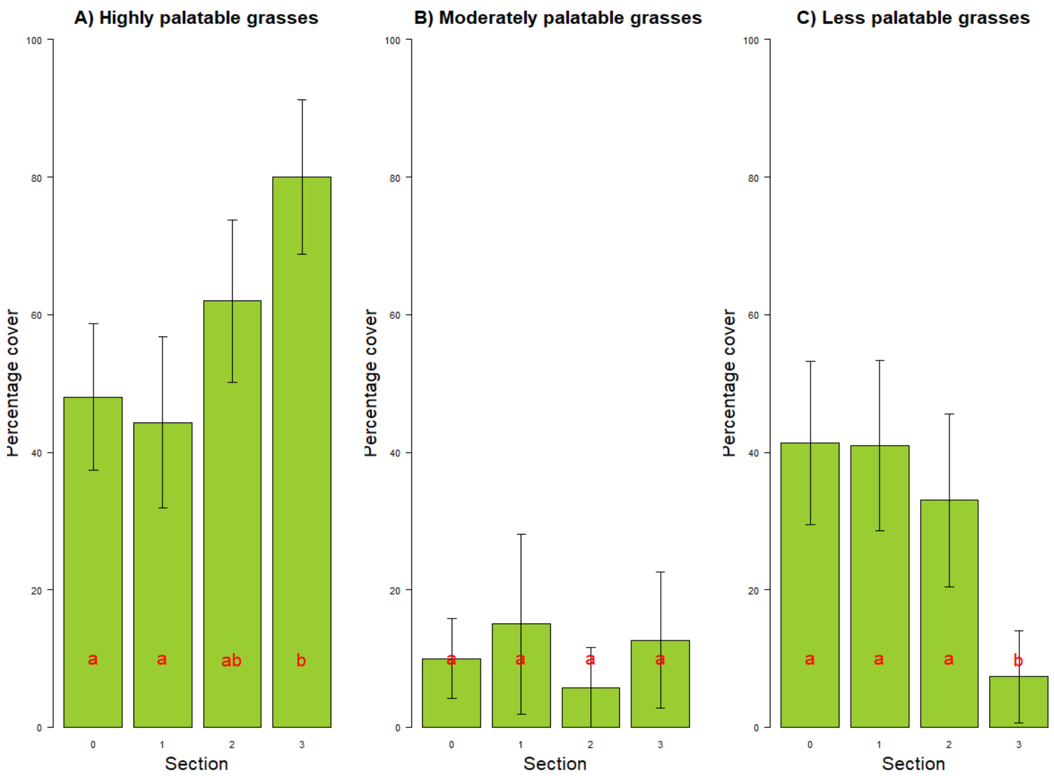

Figure 5. Mean percentage cover ± 95% confidence intervals for grass palatability classes in four sections (years since shrub removal); The sections per each palatability class with the same letters (red a and b) were not different, e.g. a was significantly different from b, ab was neither significantly different from a nor b.

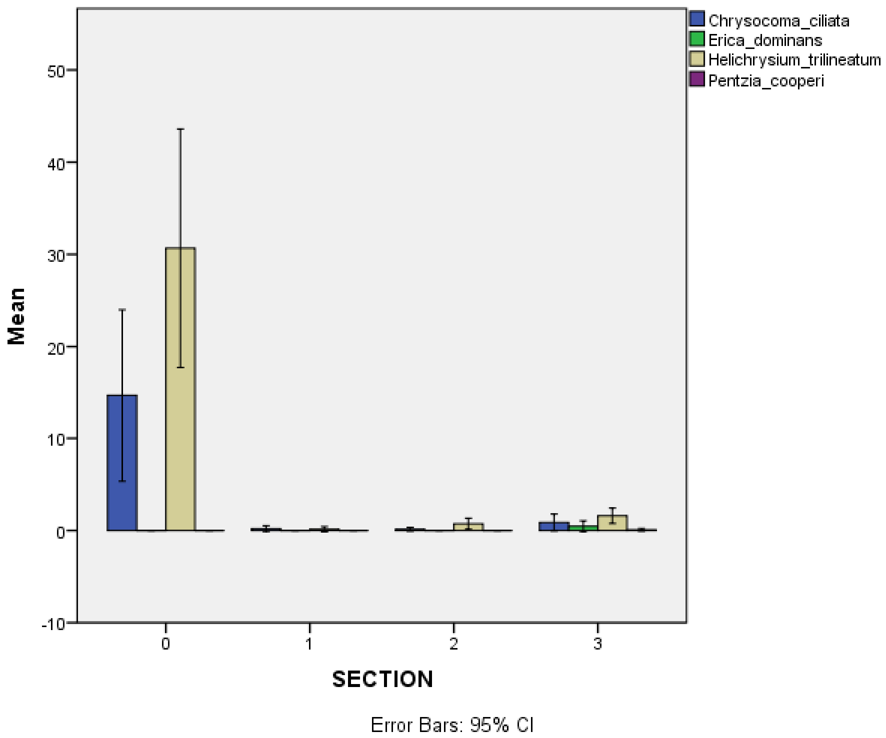

Figure 6. Mean percentage cover ± 95% confidence intervals for shrub species found in different sections.

4. DISCUSSION

The findings of this study indicate that clearance of shrub species (brush control) influenced the abundance of different grass species over some time after clearance. The results also revealed that brush control activity can improve rangeland condition by increasing the abundance of palatable grass species while decreasing less palatable grass species. The abundances and distributions of both grasses and shrubs were different in the four sections (Fig. 7). Therefore, the results support the hypothesis that shrub control increases forage yield by increasing the abundance of palatable grass species on rangelands, and that the abundance continues to rise with time from brush clearance.

Figure 7. Different states of the sections. A shows section 0 where there was no shrub removal, B shows section 1 where shrubs were removed in 2018, C is section 2 where shrubs were removed in 2017 and D is section 3 where shrub removal was in 2016.

4.1 Effects of brush control on grass species abundance

The significant change in the grass community composition in response to shrub clearance was consistent with the results of the study undertaken by ORASCOM (2013) on the effects of rangeland rehabilitation on rangeland conditions in terms of shift in individual species abundances, but different in terms of total grass cover. That study revealed that shrub clearance resulted in a significantly higher grass species abundance and grass cover at Mount Moorosi, which is in the lowlands part of Lesotho. In addition, there was an observation of a decrease in grass cover and grass species abundance in shrub encroached rangelands compared to the cleared rangelands of Borana in Ethiopia (Angassa 2002, 2014; Angassa et al 2006). This is because woody vegetation reduces grass cover by increasing competition for water, nutrients and sunlight, which resulted in reduction of relative abundance and occurrence of grass species in the Omo rangelands Ethiopia (Worku & T/Yohannes 2018). An increase in grass species abundance in a shrub-cleared area was also recorded in semi-arid regions of South Africa, Namibia and Ethiopia (Haussmann et al. 2015; Angassa et al. 2006; Scholes & Archer 1997).

In this study, 18 grass species were identified in different sections. Most of the species had a low abundance and were only present in one or two of the sections. The most abundant species, however, showed variable responses to shrub clearance, where they presumably either increased or decreased with time since brush clearance, while others increased and then decreased over time. The highly palatable species, *Eragrostis curvula,* seemingly continued to increase every year after shrub removal. This might be because *Eragrostis curvula* produces large quantities of seeds that readily spread and germinate in disturbed areas (Firn 2009; Parsons & Cuthbertson 2001).

The results of this study revealed that the less palatable species *Festuca caprina* seemed to favour growing in association with shrubs because its abundance decreased significantly after shrub clearance, and after three years it was almost completely outcompeted by other grass species. The possible cause of the absence of *Festuca caprina* may be that it grows well in association with shrubs. Angassa (2002) discovered that some herbaceous species have a mutual relationship with certain shrubs, and removal of such shrub species can lead to reduction of those herbaceous species. This reduction indicates a micro-environmental shift when ecologically important shrubs are removed, resulting in exposure of sensitive herbaceous species to high sunlight intensity (Lukomska et al. 2014; Pihlgren & Lennartsson 2008).

One of the most dominant grass species found in the study area, the highly palatable *Themeda triandra*, did not show a significant change in abundance with shrub removal and time after removal. This implies that *Themeda triandra* survives well both under a canopy of shrubs and in brush-controlled areas (Fig. 8 A and B). The reason for its dominance might be that soil and climatic conditions are conducive to *Themeda triandra* and hence it is able to survive in shrub encroached and open rangelands. This agrees with the study by Angassa et al. (2006) which indicated that there was no difference in the abundance of dominant grass species between shrub encroached and non-encroached areas in the Boranna rangelands in Ethiopia.

Figure 8. *Themeda triandra* dominating in both shrub encroached area (left) and shrub cleared area (right).

4.2 Grass species palatability

The results of the study revealed that shrub control affected the relative abundance of palatable grass species on rangelands. Overall, removal of shrub species resulted in an increase in highly palatable grass species and a decrease in less palatable grass species. These results are consistent with results from a study in Borana Ethiopia, where unpalatable grass species were common in an uncleared area and certain palatable grass species increased in abundance in a shrub-controlled area (Angassa 2002).

4.3 Shrub regrowth

The study revealed that there is a high probability of shrub regrowth and re-encroachment a few years after clearance. The reason can be that some unseen young shrubs were accidentally left out when manually removing shrubs, or that the seeds of removed shrubs left on the surface or in the soil seed bank germinate after some time (Fig. 9). It might be necessary to repeat the shrub clearance activity or use fire instead of manual uprooting. Fire usually destroys the meristems of shrubs and kills their seeds on the surface (Van Auken 2000; Roquess et al. 2001; Eldridge et al. 2011).

Figure 9. Regrowth of shrub species in section 3 (cleared in 2016).

In addition, the results showed that there was an introduction of *Erica dominans* and *Pentzia cooperi* on the site three years after brush control (figure 8). This implies that these two shrub species may re-establish after soil disturbance while clearing shrubs and that they are eventually outcompeted by *Chrysocoma ciliata* and *Helichrysum trilineatum*.

5. CONCLUSIONS AND RECOMMENDATIONS

It was assumed that the four sections of the study area represent different lengths of time since shrub clearance, but that they were otherwise comparable in terms of ecological conditions. Based on this assumtion, the results strongly suggest that brush control activity is a successful rangeland management tool in improving productivity of rangelands in Lesotho due to an increase in the abundance of highly palatable grass species and decreased abundance of less palatable species. However, the removal of *Chrysocoma ciliata* and *Helichrysum trilineatum* can give an advantage to the introduction of new shrub species.

Although more research on the consequences of removal of shrubs on rangelands is required in the country, based on this study it can still be recommended that monitoring of shrub cleared areas should be carried out every two years in order to track changes in grass species and regrowth or introduction of shrub species. It is also recommended that other shrub clearing methods should be put to the test to see if they can be successful. Brush control has proven to be beneficial to the socio-economic livelihood of the Basotho people and can therefore be recommended at a larger scale throughout the country.

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APPENDICES

Appendix I: Grass species abundance

A1. Descriptive statistics of the percentage cover of individual grass species.

Descriptive						
					95% Confidence Interval for Mean	
Grass species	**Section**	**Mean**	**Std. Deviation**	**Std. Error**	**Lower Bound**	**Upper Bound**
Agrostis lachnantha	0	0.00	0.000	0.000	0.00	0.00
	1	3.00	7.973	2.059	-1.42	7.42
	2	0.00	0.000	0.000	0.00	0.00
	3	0.00	0.000	0.000	0.00	0.00
Aristida bipartita	0	0.00	0.000	0.000	0.00	0.00
	1	0.00	0.000	0.000	0.00	0.00
	2	0.00	0.000	0.000	0.00	0.00
	3	1.33	5.164	1.333	-1.53	4.19
Bromus willdenowii	0	0.00	0.000	0.000	0.00	0.00
	1	0.00	0.000	0.000	0.00	0.00
	2	0.00	0.000	0.000	0.00	0.00
	3	2.67	4.952	1.279	-0.08	5.41
Catalepis gracilis	0	0.00	0.000	0.000	0.00	0.00
	1	7.67	16.352	4.222	-1.39	16.72
	2	0.00	0.000	0.000	0.00	0.00
	3	9.67	20.219	5.221	-1.53	20.86
Cyperus marginatus	0	0.00	0.000	0.000	0.00	0.00
	1	0.00	0.000	0.000	0.00	0.00
	2	0.33	1.291	0.333	-0.38	1.05
	3	0.00	0.000	0.000	0.00	0.00
Elionurus muticus	0	4.67	13.558	3.501	-2.84	12.17
	1	0.00	0.000	0.000	0.00	0.00
	2	0.00	0.000	0.000	0.00	0.00
	3	0.00	0.000	0.000	0.00	0.00
Eragrostis caesia	0	5.67	9.424	2.433	0.45	10.89
	1	2.67	4.169	1.076	0.36	4.98
	2	4.00	10.556	2.726	-1.85	9.85
	3	3.00	5.916	1.528	-0.28	6.28
Eragrostis curvula	0	2.00	7.746	2.000	-2.29	6.29
	1	11.00	15.607	4.030	2.36	19.64
	2	21.33	17.162	4.431	11.83	30.84
	3	31.00	25.926	6.694	16.64	45.36
Festuca caprina	0	20.00	19.911	5.141	8.97	31.03
	1	1.33	3.994	1.031	-0.88	3.55
	2	1.00	3.873	1.000	-1.14	3.14
	3	0.00	0.000	0.000	0.00	0.00

Ficinia filiformis	0	7.33	11.475	2.963	0.98	13.69
	1	8.33	14.475	3.737	0.32	16.35
	2	2.00	7.746	2.000	-2.29	6.29
	3	1.33	3.519	.909	-0.62	3.28
Harpochloa falx	0	4.33	8.633	2.229	-0.45	9.11
	1	0.00	0.000	0.000	0.00	0.00
	2	1.67	6.455	1.667	-1.91	5.24
	3	0.00	0.000	0.000	0.00	0.00
Helictotricon longifolia	0	0.33	1.291	.333	-0.38	1.05
	1	1.00	2.803	.724	-0.55	2.55
	2	6.00	7.838	2.024	1.66	10.34
	3	4.67	6.935	1.791	0.83	8.51
Koeleria capensis	0	0.00	0.000	0.000	0.00	0.00
	1	6.00	7.838	2.024	1.66	10.34
	2	3.67	7.898	2.039	-0.71	8.04
	3	4.00	10.556	2.726	-1.85	9.85
Merxmuellera disticha	0	16.67	18.387	4.748	6.48	26.85
	1	31.00	20.633	5.327	19.57	42.43
	2	21.67	20.587	5.315	10.27	33.07
	3	2.00	5.606	1.447	-1.10	5.10
Pennisetum thunbergii	0	0.00	0.000	0.000	0.00	0.00
	1	1.67	6.455	1.667	-1.91	5.24
	2	0.00	0.000	0.000	0.00	0.00
	3	0.00	0.000	0.000	0.00	0.00
Pentaschistis oreodoxa	0	0.00	0.000	0.000	0.00	0.00
	1	2.67	7.761	2.004	-1.63	6.96
	2	5.67	13.211	3.411	-1.65	12.98
	3	0.00	0.000	0.000	0.00	0.00
Setaria sphacelata	0	0.00	0.000	0.000	0.00	0.00
	1	0.00	0.000	0.000	0.00	0.00
	2	0.00	0.000	0.000	0.00	0.00
	3	2.33	6.779	1.750	-1.42	6.09
Themeda triandra	0	38.33	20.759	5.360	26.84	49.83
	1	24.00	23.619	6.098	10.92	37.08
	2	32.67	22.746	5.873	20.07	45.26
	3	38.00	27.568	7.118	22.73	53.27

A2. ANOVA of the percentage cover of individual grass species between four sections.

ANOVA				
		df	F	p
Agrostis lachnantha	Between groups	3	2.124	0.107
	Within groups	56		
Aristida bipartita	Between groups	3	1.000	0.400
	Within groups	56		
Bromus willdenowii	Between groups	3	4.350	0.008
	Within groups	56		
Catalepis gracilis	Between groups	3	2.281	0.089
	Within groups	56		
Cyperus marginatus	Between groups	3	1.000	0.400
	Within groups	56		
Elionurus muticus	Between groups	3	1.777	0.162
	Within groups	56		
Eragrostis caesia	Between groups	3	0.431	0.732
	Within groups	56		
Eragrostis curvula	Between groups	3	7.463	0.000
	Within groups	56		
Festuca caprina	Between groups	3	13.013	0.000
	Within groups	56		
Ficinia filiformis	Between groups	3	1.874	0.144
	Within groups	56		
Harpochloa falx	Between groups	3	2.161	0.103
	Within groups	56		
Helictotricon longifolia	Between groups	3	3.845	0.014
	Within groups	56		
Koeleria capensis	Between groups	3	1.594	0.201
	Within groups	56		
Merxmuellera disticha	Between groups	3	7.221	0.000
	Within groups	56		
Pennisetum thunbergii	Between groups	3	1.000	0.400
	Within groups	56		
Pentaschistis oreodoxa	Between groups	3	1.862	0.146
	Within groups	56		
Setaria sphacelata	Between groups	3	1.777	0.162
	Within groups	56		
Themeda triandra	Between groups	3	1.185	0.324
	Within groups	56		

Appendix II: Grass species palatability

A3. Descriptive statistics of the percentage cover of palatability classes of grass species.

Descriptive						
					95% Confidence Interval for Mean	
		Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound
HIGLY PALATABLE GRASS SPECIES	0	48.00	21.027	5.429	36.36	59.64
	1	44.33	24.558	6.341	30.73	57.93
	2	62.00	23.361	6.032	49.06	74.94
	3	80.00	22.120	5.711	67.75	92.25
MODERATELY PALATABLE GRASS SPECIES	0	10.00	11.495	2.968	3.63	16.37
	1	15.00	25.774	6.655	0.73	29.27
	2	5.67	11.782	3.042	-0.86	12.19
	3	12.67	19.536	5.044	1.85	23.49
LESS PALATABLE GRASS SPECIES	0	41.33	23.563	6.084	28.28	54.38
	1	41.00	24.509	6.328	27.43	54.57
	2	33.00	24.842	6.414	19.24	46.76
	3	7.33	13.345	3.446	-0.06	14.72

A4. ANOVA of the percentage cover of palatability classes between four sections.

ANOVA

		Sum of Squares	df	Mean Square	F	p
HIGLY PALATABLE GRASS SPECIES	Between Groups	11781.250	3	3927.083	7.551	.000
	Within Groups	29123.333	56	520.060		
	Total	40904.583	59			
MODERATELY PALATABLE GRASS SPECIES	Between Groups	721.667	3	240.556	.731	.538
	Within Groups	18436.667	56	329.226		
	Total	19158.333	59			
LESS PALATABLE GRASS SPECIES	Between Groups	11556.667	3	3852.222	7.897	.000
	Within Groups	27316.667	56	487.798		
	Total	38873.333	59			