Sustainability in Environment
ISSN 2470-637X (Print) ISSN 2470-6388 (Online)
Vol. 4, No. 4, 2019
www.scholink.org/ojs/index.php/se

Original Paper

Assessment of Rangelands Around Molepolole Village of Botswana to Ascertain Its Potential to Support Free Range Beef Cattle Despite Its Long Term Use as a Grazing Area

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Received: September 22, 2019 Accepted: October 10, 2019 Online Published: October 14, 2019
doi:10.22158/se.v4n4p229 URL: http://dx.doi.org/10.22158/se.v4n4p229

Abstract

In Botswana, cattle rearing can either be in farms or in communal grazing areas. In communal grazing areas, carrying capacities are never adhered to, hence degradation sometimes occurs. This negatively impact on the livestock industry since cattle are mainly free ranging. This therefore calls for periodic checks of grass species to determine whether grazing areas still have potentials to sustain livestock production. A study was done to take stock of grass species and bush encroachment status around the biggest village of Botswana, known as Molepolole. The survey looked at species composition, distribution and production. The survey was done by using line transects, quadrats and plots in the northern and western direction of the village. In each quadrat, grass species were identified, counted by species, height measured and biomass determined by clipping. In plots, woody plants were counted for all species. The survey revealed that despite heavy grazing and periodic droughts the grazing area still has some grass species of good grazing value and the area is being threatened to being encroached by woody species. Thus there is still a potential for use of the area for grazing but at lower stocking rate. However, it was noted that the area needs some restoration by controlling bush encroachment and reintroduction of good grass species.

Keywords

communal grazing areas, diversity, herbivory, rangelands, similarity coefficient

1. Introduction

The cattle industry is of vital importance to Botswana's economy and the rangeland, sometimes called the "Green Gold of Botswana", provides the essential resources to support the cattle industry. Cattle in Botswana are mostly free ranging and are minimal supplemented. When the rains come, all kinds of grasses grow, some being valuable as food for livestock while others are not. About 70% of rural households in Botswana derive their livelihoods from agriculture. The agricultural share of the Gross Domestic Product (GDP) has declined from 40% at independence in 1966 to about 1.7% in 2013. Beef provides 80% of the sector's contribution to GDP.

In Botswana, cattle are reared under communal system where land is owned by the communities and stocking rates are not controlled. They are also reared in farms where cattle are grazed in paddocks with or without good management. About 80% of cattle slaughtered at the three export abattoirs being Maun, Francistown and Lobatse, are from the communal system. This is to say cattle are mostly dependent on the grasses of the rangelands. In 2012 cattle population was estimated to be three million.

The deterioration of rangelands in Botswana is a cause for concern because this comes about as a consequence of overgrazing and no resting of the land. One of the wonders of the grass species is that when it is disturbed (burned or cut), it is stimulated to regrow using reserved nutrients until the plant has enough leaves to photosynthesize and as the plant grows the reserve nutrients are sent back to the base of the stems and roots to be stored (McNaughton, 1984). Thus a grass plant need to rest after it has been grazed in order to build up the reserves again, whereby if it is not given enough time to rest overgrazing occurs. It should be noted that if the grass plant is not grazed or burnt, excess dead leaf material will accumulate and hinder new leaves, then the plant will suffocate and die off (van Oudtshoorn, 2002). Grasses can also be stressed by bush encroachment. Bush encroachment is the suppression of palatable grasses and herbs by encroaching woody species often unpalatable to domestic livestock (Ward, 2005; Makhabu, 2011). Areas are considered to be encroached by bushes if they have a density of woody plants equal or more than 2500 individuals per hectare (Dalle *et al.*, 2006).

In most cases there are numerous factors that affect the range condition, but knowledge of grass species compositions in a range or veld are best indicators to inform farmers whether the rangeland is degraded or still fine to support the livelihood of livestock. A farmer can therefore make informed decision in terms of stocking rates that has to be used without degrading the area. Molepolole village which is the biggest village in Botswana which had a population of 66 500 people in 2011 (CSO, 2014) has been supporting cattle around it since its inception in 1864. Whether the rangelands around Molepolole are still good for beef cattle production is not documented. In this regard, inventory of grass species, their forage value, basal cover, biomass estimation and their densities are essential so as to determine the suitability of the area for cattle production. The aim of this study was to assess whether the rangeland around Molepolole village still has the potential to support free ranging beef cattle. This was achieved by determining the grass species composition and bush encroachment status in different areas around the village. It was also determined whether the grass species composition was dominated by good, intermediate or poor grasses in terms of their grazing values. The grass species composition was checked whether they were similar in different sampled areas around the village. The study also determined the influence of grass diversity on the rangeland condition in the area of study. It was hypothesized that presence of perennial good grazing value grass species and low bush encroachment indicates that the area still has a potential to support beef cattle production. The results of this study might assist range managers and farmers in planning how best to manage grazing areas to avoid land degradation.

2. Methods and Materials

2.1 Study Area

The study was conducted around Molepolole village in Kweneng district of Botswana. Molepolole is about 40 km on the western side of Botswana's capital Gaborone. It lies at latitude 24^0 25' South and longitude 25^0 32' East. The climate is semi-arid with summer rainfall, which rains during the period of October to March. The mean annual rainfall varies from 500 mm to 600 mm. The mean daily temperature in summer varies from 25-32.6^{0}C and in winter from 15-20^{0}C but at night it could go below 10^{0}C. The vegetation consists of bush and tree savanna, with acacia (syn. Vashellia & Senegalia) shrubs formations in southern, eastern and northern areas. The soils are loamy to clay either of petric luvisols and regosols on hills and rock exposures or vertisols on flood plains.

2.2 Data Collection

Field data were collected in 2013 using line transects. Two transects were set, one on the northern direction and the other on the western direction from the village. Along each transect, starting at one kilometre away from the last household in the village, five plots measuring 20 m by 20 m and being one kilometre apart were set. Where arable fields were encountered the distance between plots was altered. In each plot, a 1 m^2 quadrat was randomly thrown to assess grasses within it. The data were collected during the wet season after the grasses were fully mature. This period offered better grass identification because most grasses features were present.

In each quadrat, grass species were identified and the nomenclature is according to Van Oudtshoorn (2002) and Field (1976). Density of each grass species in the quadrat was assessed by counting individual grasses of each species in the quadrat and recorded, while grass heights and grass canopy/basal cover or width of each grass covering the soil or ground underneath were measured with a measuring tape. Percentage grass cover of the area was visually estimated.

For estimation of biomass, grass in the quadrat was clipped or cut at about 2 cm above ground level using sharp secateurs. Cut grasses were put on sampling bags (paper), separated according to their grazing value and whether they were annuals or perennial grasses and were weighed using a spring balance to obtain the fresh or wet weight. Some of the clipped grass samples were taken for drying at the labs in sample paper bags where they were oven dried for 48 hrs at a controlled temperature of 60^0 C within 25 hours of collection. The samples were then weighed. The biomass production of each grass species according to their grazing values were extrapolated for each quadrat or area (1 m^2 or 0.0001 hectare) using the dry weight.

Count of individuals of each woody species were done in the whole 20 m x 20 m plots. The counts were used to calculate densities of woody species to determine the status of bush encroachment. Nomenclature of woody species was according to Coates Palgrave (Coates Palgrave, 2002).

2.3 Statistical Analysis

The grass species diversity was determined by calculating the Shannon Diversity Index also sometimes called Shannon-Wiener Index (Kent & Coker, 1992). The formula used was as follows:

Where H' Shannon Diversity Index, s = the number of species, p_i = the proportion of individuals or the abundance of the ith species expressed as a proportion of total abundance

ln = log $base_n$

Similarity of grass species composition of the two transects was calculated by the use of Czekanowski coefficient (Kent & Coker, 1992).

S_c =

where *Xi* and *Yi* are the abundances of species I is the sum of the lesser scores of species *i* where it occurs in both quadrats m is the number of species.

The coefficient values range from 0 (complete dissimilarity) to 1 (total similarity).

Microsoft excel and IBM SPSS statistics for windows 23 (IBM Corp., 2015) were used to analyse the data.

3. Result

3.1 Grass Species Composition

There were 16 grass species present in the study area (Table 1). The noted grass species differed in terms of forage value and perenniality (Table 1). The percentage species compositions for each species are presented in Figure 1. The dominant species were *Urochloa trichopus* (Hochst.) Stapt*, Urochloa mosambicensis* (Hack.) Dandy and *Megaloprotachne albescens* (Figure 1). *Urochloa trichopus* (Hochst.) Stapt and *M. albescens* are annual grass species whereas *U. mosambicensis* is a perennial species and was present in Transect 2 only (Figure 1). The most diverse genus was Eragrostis (3 species) followed by Aristida (2 species). Other genera were represented by one species. The diversity and evenness of grass species were 1.33 and 0.46 respectively in western transect. In the northern transect the diversity and evenness were 1.45 and 0.50 respectively. The Czekanowski's Similarity Coefficient was 0.19 (19%) for grass species composition between the two transects.

Table 1. Composition of Grass Species

No.	*Grass species*	English name	Setswana name	Forage value	Perenniality
1.	*Aristida congesta* Roem &	Tassel three awn grass	Seloka	Poor	Weak perennial

	Schult				
2.	*Aristida stipitata* Hack. *gracilliflora*	Long awned grass	Seloka	Poor	Perennial
3.	*Cynodon dactylon*	Couch grass	Motlhwa	Good	Perennial
4.	*Digitaria eriantha* Steud.	Common finger grass	Namele/moseka	Good	Perennial
5.	*Eragrostis lehmanniana* Nees	Lehmann's love grass	Rathathe	Intermediate	Perennial
6.	*Eragrostis pallens* Hack.	Broom love grass	Motshikiri	Poor	Perennial
7.	*Eragrostis pilosa*			Intermediate	Annual
8.	*Eragrostis regidor* Pilg.	(Broad) Curley leaf	Rathathe	Intermediate	Perennial
9.	*Heteropogon contortus* (L.) Roem. & Schult.	Spear grass	Seloka	Intermediate	Perennial
10.	*Megaloprotachne albescens*	-	Mohaha	Intermediate	Annual
11.	*Panicum coloratum* (L.)	Small buffalo grass		Good	Perennial
12.	*Schimidtia pappophroides* Steud.	Sand quick	Tshwang	Good	Perennial
13.	*Sporobolus ioclados* (Trin.) Nees	Pan dropseed		Good	Perennial
14.	*Tragus racemosa*	Carrot seed grass	Segwana	Poor	Annual
15.	*Urochloa mocambicensis* (Hack.) Dandy	Bushveld signal grass	Phoka	Good	Perennial
16.	*Urochloa trichopus* (Hochst.) Stapt	Signal grass	Phoka	Good	Annual

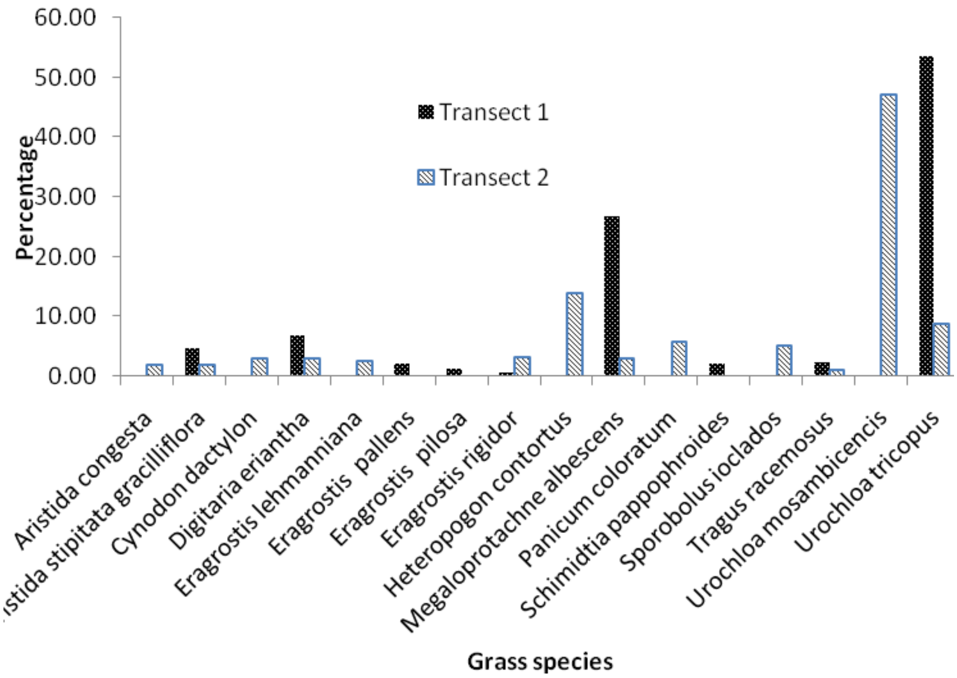

Figure 1. Composition of Grasses Found in Quadrates. Grass Species Names Are according to Van Oudtshoorn (2002) and Field (1976)

3.2 Biomass Production

Biomass of grasses within the three forage values did not significantly differ between transects (paired t-test, p = 0.23). On average more biomass was of good forage value grasses followed by the intermediate and the least was poor grasses (Table 2).

Table 2. Biomass Production

Forage Value	Weight (g/m^2)
Good	45.4
Intermediate	28.6
Poor	8.4

3.3 Heights, Widths and Cover

The grass species heights were not significantly different between species ($F_{15,20} = 1.07$, $p = 0.44$) whereas widths of grass species differed between species ($F_{15,20} = 2.16$, $p = 0.05$). There was a strong positive correlation between heights and width ($r = 0.616$, $p = 0.001$). Only four species had a height above 60 cm (Figure 2). None of the grass species had a width exceeding 40 cm (Figure 2).

Grass ground cover in sampled areas ranged from 35 % to 80 %. On average it was estimated to be 54.5 %.

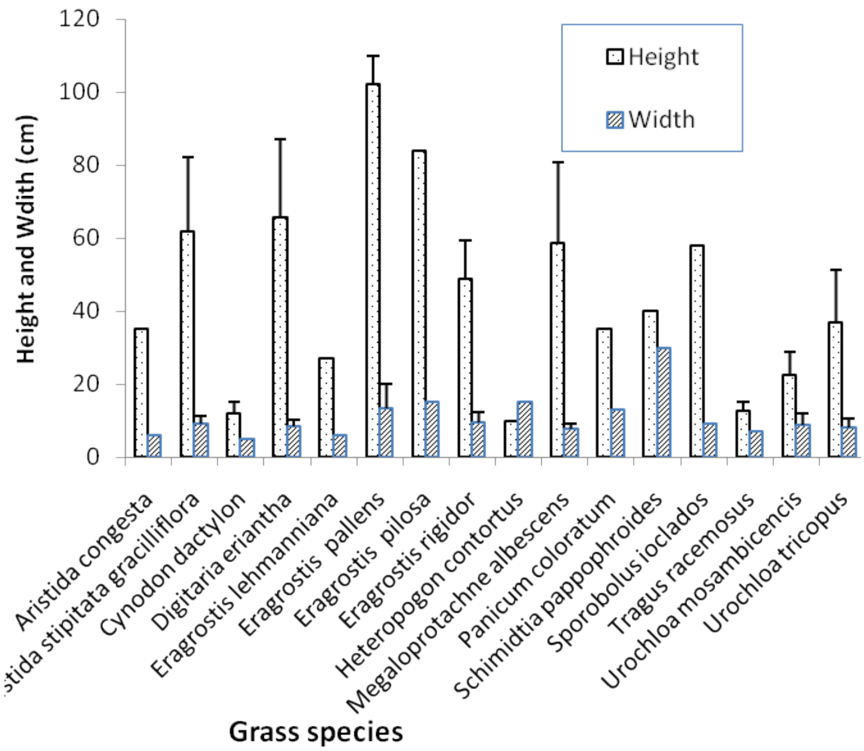

Figure 2. Average Heights and Widths of Grasses in the Study Area. Grass Species Names Are according to Van Oudtshoorn (2002) and Field (1976)

3.4 Bush Encroachment

The average density of woody plants of all species was 2035 ± 190 plants per hectare. Densities of each species varied with the maximum being 357 plants per hectare for *Grewia flava* DC. Species which had more than 100 plants per hectare were *Dichrostachys cinereal* (L.) Wight & Arn., *Grewia flavescens* Juss., *Euclea undulata* Thunb., *Tarchonanthus camphoratus* L., *Vachellia (*syn. *Acacia) tortilis* (Forssk.) Galasso & Banfi, *Croton gratissimus* Burch., *Gymnosporia senegalensis, Senegalia (*syn. *Acacia) mellifera* (Vahl) Seighler and Ebinger and *Grewia bicolor* Juss (Figure 3). Aloe and *Diospyros lycioides* Desf. species had about 80 plants per hectare (Figure 3). Species which had 10 to 30 plants per hectare were *Combretum heroroense* Schinz, *Boscia foetida* Schinz, *Vachellia (*syn. *Acacia) robusta* (Burch.) Kyal.& Boatwr., *Peltophorum africanum* Sonder, *Combretum zeyheri* Sonder, *Ziziphus mucronata* Willd., *Vachellia (*syn. *Acacia) erioloba, Gardenia volkensii* K. Schum. and *Azanza garckeana* (F. Hoffm.) Excell & Hillcoat. Other species had less than 10 plants per hectare and these were *Boscia albitrunca* (Burch.) Gilg and Benedict, *Combretum apiculatum* Sonder, *Terminalia sericea* Burch. Ex DC., *Ximmenia Americana* L., *Ximenia caffra* Sonder, *Vangueria infausta* Burch., *Mimusops zeyheri* Sonder and *Rhus lancea* L.

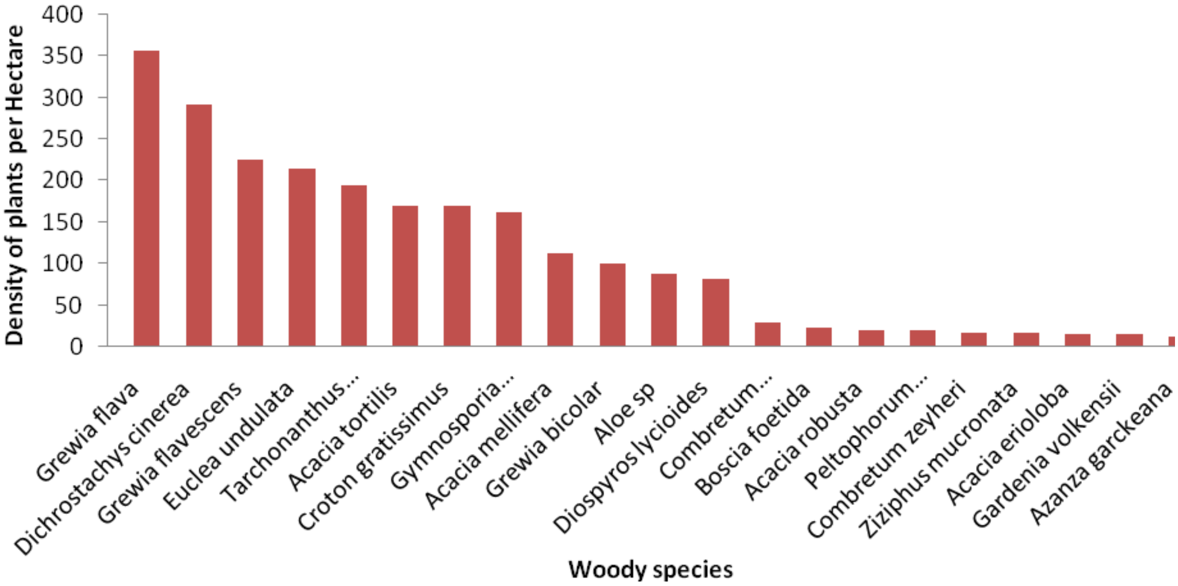

Figure 3. Densities of Woody Species in the Study Area

Plant species names are according to Coates Palgrave (2002). Note that synonyms are as follows; *Acacia tortilis* (syn. *Vachellia tortilis*), *Acacia mellifera* (syn. *Senegalia mellifera*), *Acacia robusta* (syn. *Vachellia robusta*).

4. Discussion

Grass species compositions in rangelands are mainly influenced by soil type, rainfall, temperature, herbivory, fire, landuse, competition and bush encroachment (Makhabu *et al*., 2002). These factors may act independently or interact to influence grass species composition, cover, biomass production and bush encroachment (Ward, 2005; Cook & Stubbendiek, 1986; Veenendaal *et al*., 1996; Schmidt *et al*., 2008; Makhabu & Marotsi, 2012). Some grass species only grow in specific soil types and rainfall amounts. Rainfall affects triggering seeds germination and subsequently survival of them. The amount of rain that triggers germination may be as little as 10 mm for the annual grass *Tragus berteronianus* Schultes in microsites where microtopography stimulated accumulation of water (Veenendaal *et al*., 1996). Some grass species grow well in disturbed areas affected by herbivory, fire, land use or bush encroachment. In this study most of the grass species recorded were those that are usually associated with disturbed or overgrazed areas (Van Oudtshoorn, 2002). The heights, width and basal covers of recorded grass species did not differ with those reported in the past (Van Oudtshoorn, 2002; Field, 1976). In addition, it still has average grass ground cover of more than 50 %. However, the area had a woody species density of 2035 ± 190 plants per hectare, which approaches 2500 plants per hectare, a level an area is regarded as encroached. The dominating woody species which include *D. cinerea, Grewia species, V. tortilis,* and *S. mellifera* are regarded as encroaching species (Moleele, 1998). The area could therefore be regarded as being threatened by being encroached by bushes.

According to Holechek *et al.* (2004) the greater the proportion of poor grass species (increasers or invaders) indicates the poorer condition while a greater proportion of good grasses (decreasers) indicate a better range condition. In this study, good grass species dominated in certain areas while poor species dominated in others. Similarity in grass species composition was low. An area dominated by low quality grasses plus high encroaching woody species is unlikely to support free ranging beef cattle because they will have low production and reproductive performance as well as slow growths.

The study area here is a communal grazing area where all members of the communities of nearby villages especially Molepolole have the right to graze their livestock. Continuous grazing system is practised whereby animals have access to the area throughout the year. Grasses are not given time to rest. This kind of grazing normally is characterized by the range dominated by increasers. Carrying capacities of communal areas in Botswana are normally exceeded since there is no limit to the number of livestock a farmer can keep (Peters, 1987). Every farmer wants to maximize production without due care to the environment (Abel & Blaikie, 1989). Grazing management should balance livestock demand with forage availability, promote rapid pasture regrowth during the grazing season and promote long-term pasture persistence. This means the art of grazing management is to ensure that there is sufficient pasture in a stage suitable to graze at all times throughout the grazing season and hence calls for proper management of rangelands.

Diversity of grass species in this study varied from one area to another and similarity of grass species between sites was low. This is likely the result of differing microhabitats, grazing pressure and interaction between plants. Some plants species like the legumes have the ability to fix nutrients hence plant growing next to them can do well by using the fixed nutrients as compared to those far from them. However, some plants have allelopathic effects which result in inhibiting other plants growing near them. Soil properties might vary within a habitat and this affect the composition, structure and productivity of vegetation (Abdallah et al., 2008; Abule et al., 2005). This is so because soil nutrients such as nitrates, phosphorus, series of anions, cations and various trace elements are essentials for plants growth and development. Soils of Botswana generally lack phosphorus. Some plants have the ability to trap soils and litters around them hence improve soil fertility and water holding capacity. This favour the establishment of desirable grass species (Amundson et al., 1995). Studies have shown that soils under tree canopies are more fertile than soils not under canopies (Abdallah et al., 2008, Abule et al., 2005; David & Venessa, 2005). The woody vegetation in our study area is open to dense, hence creates diverse microenvironment that might explain low similarity in grass species composition in different sites.

The dominancy of annuals as shown by this study is a source of concerns since it is not good for livestock and the environment. Annual grass species dry up in winter. Their nutritive value thus drops hence livestock feeding on them will not have sufficient nutrients. Drying of grass species exposes the ground to agents of soil erosion mainly wind and water runoff. This is likely to reduce the soil fertility hence ends up not supporting desirable species. The best option to avoid activities that might lead to desertification is to practice good range management. This involves stocking the range conservatively and restoring degraded areas. Therefore, reduction of grazing pressure around Molepolole area appears to be the best option to prevent degradation which might end up difficult to reverse.

5. Conclusions

A total of 16 grass species were recorded around Molepolole village. They differed in grazing value. Grasses of good grazing value dominated followed by those of intermediate grazing value then the poor ones. *Urochloea tricopus* was the predominant good grass species, with *Megaloprotachne albescens* as the predominant intermediate grass species while *Aristida stipitata var gracilliflora* was the predominant poor grass species. There were some signs of heavy grazing as grasses had stunted growths and hence low biomass production and less ground cover. There is a threat of the area being encroached by bushes. The area still has a potential to support livestock at low stocking rates. However, it was noted that the area needs introduction of some perennial grasses of good grazing value. It also needs bush encroachment controlled. The limitation is that since the area is a communal grazing area, no one will be willing to take responsibility to introduce the desired grass species and the control of bushes unless the government takes the initiatives.

6. Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper. The support mentioned in the Acknowledgement section below do not lead to any conflicts of interest regarding the publication of this manuscript.

7. Acknowledgments

This work was supported by the Department of Biological Sciences of Botswana University of Agriculture and Natural Resources, and the Department of Agricultural Research of the Ministry of Agriculture, Botswana. Many thanks go to Mr Andrew Moroka for the assistance he provided in identifying the grass species and field data collection. Thanks, are also due to Dr M Nsinamwa and Dr K Tshireletso for their valuable comments on earlier versions of this paper.

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