

**EVALUATING FARMERS' PERCEPTIONS AND THE IMPACT OF
BUSH ENCROACHMENT ON HERBACEOUS VEGETATION AND
SOIL NUTRIENTS IN SHESHEGU COMMUNAL RANGELANDS
OF THE EASTERN CAPE, SOUTH AFRICA**

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EVALUATING FARMERS' PERCEPTIONS AND THE IMPACT OF BUSH
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NUTRIENTS IN SHESHEGU COMMUNAL RANGELANDS OF THE
EASTERN CAPE, SOUTH AFRICA

BY

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2016

DECLARATION

I declare that “Evaluating farmers’ perceptions and the impact of bush encroachment on herbaceous vegetation and soil nutrient content in Sheshegu communal rangelands of the Eastern Cape, South Africa” is my research under the supervision of Dr K. Mopipi and Dr E.C. Timpong-Jones and it has not been submitted for any degree in any research institution. All the information sources used in this dissertation have been cited properly without any manipulations to the best of my knowledge.

Mr Tokozwayo Sive

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Approved as to style and content by:



Date: 22/04/2016

**Dr K. Mopipi (Supervisor) &
Dr E.C. Timpong-Jones (co-supervisor)**

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ABSTRACT

Communal rangelands occupy 13% of the agricultural land in South Africa, and these rangelands serve as a source of feed to livestock. These areas are threatened by bush encroachment due to poor rangeland management. This study was conducted in Alice (Sheshegu communal area) and the objective was to assess farmers' perceptions and the impact of bush encroachment on herbaceous vegetation and soil nutrients. Structured questionnaires were used to assess indigenous knowledge of communal farmers on the impact of bush encroachment on rangelands. Forty (40) respondents from households who owned livestock were randomly selected and interviewed at Sheshegu village. About 89% of communal farmers perceived that change of their grasslands to encroached savannas was caused by unreliable rainfall, prolonged drought, and poor rangeland management.

Rangeland assessment was performed at four sites (Scattered, Moderate, Mixed and Dense bushland). 100mx50m were demarcated per site, and four 100m transects were laid parallel to each other, 30m apart. The step point method was used to determine both species composition and basal cover. Biomass production was determined by harvesting forage within randomly-paced a 0.25m² quadrats. *Aristida congesta* and *Eragrostis obtuse* were the most dominating grass species in dense, mixed and moderate bushland. Scattered bushland was dominated by *Themeda triandra*. Biomass production increases with increase in bush density and basal cover improved from winter to summer season. Increaser grass species increase with the increase in bush density, this indicated that the rangeland was poorly managed and palatable species were being replaced by less palatable ones. Species composition of woody plants was determined within a 200m² belt transect in all sites. *Maytenus polycantha*, *Aloe ferox*, *Erehia rigida* and *lucas capensis* were the most dominant woody species in Mixed bushland while *Acacia karroo* was most dominated in Scattered, Moderate and Dense bushland. Woody density showed no significant differences ($P > 0.05$) between Dense, Mixed and Moderate bushland. Woody plant density in all these sites exceed 2500 plants/ha, which showed that the rangeland was encroached with woody plants. Soil nutrient content was determined for each site. Five samples of soil were collected per site to test the effect of bush encroachment on soil nutrient composition. The concentration of nitrogen and soil pH

increased with increase in bush density, while that of potassium, phosphorous, magnesium, sodium and sulphur showed no significant differences ($P>0.05$) across all homogenous vegetation units.

The study revealed that Sheshegu communal farmers are aware of both negative and positive effects of encroachment on their community, and also argue that the government is not willing to support communal farmers in the process of reducing the spread of bush encroachment. It was concluded that the concentration of nitrogen and soil pH increased with increasing bush density and that bush encroachment had negative effects on herbaceous species. It was recommended that communal farmers should be formulating rangeland rules and regulations to manage rangeland resources. Rangeland rules and regulations should be based on the management of livestock management during grazing and harvesting of rangeland resources. The harvesting of woody and good timing of application of fire can also reduce the spread of bush encroachment. Veld resting and rotational grazing can also improve fuel load which is required for burning of woody plants. Furthermore, Department of agriculture should also provide workshops or training to communal farmers use different approaches or cheap ways of reducing bush encroachment and conserving rangeland resources.

Key words Indigenous ecological knowledge, bush encroachment, species composition, soil nutrient content

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LIST OF ABBREVIATIONS

ICP	Inductively Coupled Plasma
OC	Organic Carbon
IK	Indigenous Knowledge
Ca	Calcium
Cu	Copper
Fe	Iron
K	Potassium
Mg	Magnesium
Mn	Manganese
Na	Sodium
P	Phosphorous
S	Sulphur
Zn	Zinc
N	Nitrogen
SE	Standard error
HVU	Homogenous vegetation units
SAS	Statistical Analysis of System
GLM	General Linear Model
LBM	Lowest browseable Material
SPSS	Statistical Package for Social Science
TE	Tree Equivalents
BU	Browsing Unit
CEC	Cation Exchangeable Capacity

CHAPTER 1 INTRODUCTION

1.1. Background

Rangelands can be defined as land on which the indigenous vegetation is mostly dominated by grasses, grass-like plants, forbs or shrubs and is managed as a natural ecosystem for grazing and browsing animals (Allen *et al.*, 2011). The suppression of herbaceous components by woody plants is continuously threatening livestock production and challenging the sustainability of the farming system in communal rangelands of South Africa. This suppression occurs due to the speedy establishment of woody plants in communal rangelands, leading to the phenomenon called bush encroachment. According to Oba *et al.* (2000), progressive establishment of unwanted woody plant species is an indicator of land degradation. Bush encroachment is still considered as the extensive form of land degradation in both arid and semi-arid regions of South Africa (De Klerk, 2004; Joubert *et al.*, 2009; Schroter *et al.*, 2010).

Communal rangelands of South Africa and their surrounding homesteads occupy about 13% of agricultural land surface in South Africa whereas 4.8% was identified as degraded land with 12.7 million people residing in these areas (Vetter *et al.*, 2006; Bennett and Barrett, 2007; Bennett *et al.*, 2012). Livestock production is a foundation stone for rural livelihood, and livestock rely on these rangelands for their feed. The trend of livestock population in communal rangelands is currently expected to be significantly higher due to exponential growth of human population (Palmer and Ainslie, 2006). However, the transformations of grasslands and savannas to woodlands a phenomenon known as bush encroachment have a negative impact on livestock production.

Bush encroachment was defined as a suppression of palatable grasses and herbs by encroaching woody plants (Lampry, 1983; Scholes and Archer, 1996; Ward, 2005). The causes of bush encroachment in any vegetation cover were found to be more diverse and complex (Smit, 2004). Many hypotheses have been proposed to explain the causes of bush encroachment, but none of them have been found to be applicable to address this problem (Dougill and Cox, 2007). Grazing management practices and precipitation determine the structure and function of grazing land or rangeland from season to season (Scholes and Archer, 1996). Transformation of botanical composition of the rangeland can be influenced by the high stocking rate as a result of overgrazing or prolonged grazing (Tainton *et al.*, 1999). According to Valone *et al.* (2002), poor management practices such as overgrazing, exclusion of fire, absence of browsers

species, prolonged drought and climate change are the most common driving factors of bush encroachment. Heavy grazing has a negative impact on the quantity of fuel load, which is essential for fire ignition. The decrease of grazing capacity in savanna communal rangelands is linked to rapid increase of woody. According Oba *et al.* (2000), the transformation of grasslands to bush climax is associated with climate change, but there is no clear evidence which support that. According to Ward (2005), about 10-20 million hectares of biodiversity and agricultural productivity have been affected by bush encroachment in South Africa. The suppressive effect of encroaching woody species tend to reduce forage production which is valuable to livestock and also lead to the decline of profitability of rangeland in many communal rangelands of South Africa (Jacobs, 2000; Smit, 2004; Britz and Ward, 2007). The reduction in agricultural productivity is linked to low value of encroaching woody plants to livestock in terms of nutrient content and its palatability. On the other hand, reduced biodiversity occurs due to the fact that multi-grass species sward is replaced with single tree species (Ward, 2005). Communal farmers' perceptions and indigenous knowledge of vegetation changes are often ignored by researchers in communal rangelands of the Eastern Cape in Southern Africa. Communal farmers are known to have extensive indigenous knowledge which could complement scientific research (Barkes *et al.*, 2000; Oba and Kolite, 2001; Ladio and Lozada, 2009) and contribute to improved understanding and sustainable management of savanna ecosystems (Reed *et al.*, 2011).

Communal farmers are known to have rich ecological information about vegetation trends and factors that influence the change of livestock and vegetation species composition; these factors include unreliable precipitation, prolonged drought and grazing pressure (Davis, 2005; Oba and Kaitira, 2006). Therefore, it is essential to understand how communal farmers perceive rangeland conditions when conducting rangeland condition assessments in communal areas. The common understanding of range dynamics by both researchers and communal farmers is very crucial because it improves livestock production through good quality forage production of the rangelands (Kessler and Stroosnij der, 2010). Rangelands are the most important source of nutrition for livestock in South Africa, and herbaceous vegetation is the only cheapest source of nutrients for both browsing and grazing animals in communal areas. However, forage from natural rangelands rarely meets all the essential mineral requirements of livestock throughout the year (Espinoza *et al.*, 1991). Deficit of nutrients from the soil can lead to poor performance of livestock in terms of milk production, wool quality and meat quality. Moreover, shortage

of soil nutrients can also influence the quality of forage production because soil nutrients determine the quality of herbaceous vegetation (Espinoza *et al.*, 1991). Moreover, Gwaze *et al.* (2009) argued that livestock in communal rangelands can also be influenced by the seasonal fluctuation in forage quality and quantity in arid and semi-arid regions.

Deficiency of both macro and micro-nutrients from the soil such as nitrogen, potassium and phosphorous might have a negative impact on forage yield, which is a prerequisite of livestock production. It has been reported that in some instances, the type of encroaching woody plant has an impact on soil nutrient availability, for example, leguminous species such as *Acacia karoo* may contain more soil nitrogen than non-leguminous trees such as *Lycioides pyroides* (Archer *et al.*, 1988). Belsky (1996) also reported that nitrogen tends to be in abundance under leguminous trees compared to non-leguminous trees because leguminous trees have the ability to fix nitrogen. Wiengand *et al.* (2005) hypothesized that any form of disturbance such as grazing or fire can create space, thus making water and nutrients available for tree germination. Under low soil nitrogen conditions, nitrogen fixing trees have a competitive advantage over other plants, and where the rainfall is not a limiting factor these can grow very fast in such conditions. Britz and Ward (2007) reported that soil texture is a crucial determinant of the tree-grass ratio because of its effects on plant growth, soil moisture and nutrient availability. According to Kraaij and Ward (2006), nutrients, moisture, fire and herbivores play an important role in the tree-grass inter-relation in the savannas.

1.2. Problem Statement

Bush encroachment is regarded as an environmental and economic problem that affects livestock production by its suppressive effect on herbaceous vegetation in communal rangelands (Oba *et al.*, 2000). A rapid increase of bush density can lead to replacement or a complete disappearance of nutritious forage. Bush encroachment has ability to reduce forage production, thus reducing grazing capacity. However, in Eastern Cape Province bush encroachment reduces grazing capacity of grazers and this has resulted in the decline of grazing animals more especially in communal areas. There are a few documented studies that have been conducted on the impact of bush encroachment on herbaceous vegetation, soil nutrient status and the perceptions of communal farmer. Communal farmers are recognized to have extensive indigenous ecological knowledge of vegetation change (Barkes *et al.*, 2000; Ladio and Lozada, 2009), but the indigenous knowledge of communal farmers is often ignored by

researchers (Roba and Oba, 2009) however, communal farmers are ones that utilizes rangeland resources. Indigenous knowledge from communal farmers can be used by researchers to complement their research and contribute to improve communal rangelands and livestock production.

1.3. Justification for the study

There is insufficient documented scientific information on range assessment conditions in the savanna communal rangelands of the Eastern Cape in South Africa. This study was meant to provide information on the impact of bush encroachment on herbaceous forage production, soil nutrient status and also evaluate the indigenous knowledge of communal farmers toward bush encroachment in the Sheshegu communal rangeland. This study was also meant to provide information that would assist communal farmers to apply appropriate rangeland management practices to improve the production of good forage. The results of this study will inform policy makers in the planning of restoration programmes to improve forage production to boost livestock numbers in the Savanna communal rangelands of Sheshegu in the Eastern Cape in South Africa.

1.4. Objectives

1.4.1. General objective

- To evaluate farmers' perceptions and assess the impact of bush encroachment on herbaceous vegetation and soil nutrient content at Sheshegu communal rangelands.

1.4.2. Specific objectives

- To determine the impact of bush encroachment on herbaceous species composition, basal cover and dry matter production.
- To assess the impact of woody plants on soil nutrient content.
- To evaluate farmers' perceptions on the impact of bush encroachment on communal rangelands of the Eastern Cape of South Africa.

1.5. Hypothesis

It is hypothesized that bush encroachment has no impact on the biomass production, basal cover, herbaceous species composition and soil nutrient content at Sheshegu communal rangelands.

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CHAPTER 2 LITERATURE REVIEW

2.1. Overview of communal rangelands in South Africa

Rangeland is defined as land on which the native vegetation is dominated by trees, shrubs, grasses, grass-like plants and forbs, which are suitable for grazing or browsing animals (Allen *et al.*, 2011). Rangelands threatened by numerous drivers of change are considered to be difficult to evaluate (Thompson *et al.*, 2009). However, communal farmers are still depending on rangelands for their livelihood. In South Africa, land degradation and bush encroachment have been reported to be the most common factors threatening livestock production in communal rangelands. Bush encroachment and land degradation is threatening both the resilience of communal rangelands and the livelihoods of those who depend on them (Seymour and Desmet, 2009; Archer *et al.*, 2011).

Hahn *et al.* (2005) defined land degradation as the loss or reduction of biological or economic productivity arising from inappropriate land use practices; Ward (2005) defined bush encroachment as the suppression of palatable herbaceous plants by undesirable woody plants often unpalatable to livestock. In South Africa, there are two popular livestock production systems, namely, communal and commercial systems, but both systems have their challenges. The major challenge for the communal livestock systems is the complexity of rangeland resource management due to multi-ownership of the resource. In this system, all communal members have an equal access to rangeland or have equal right to keep their livestock on the communal rangeland (Mapekula, 2009).

Multi-ownership makes it very difficult for communal farmers to make decisions on which rangeland management practice to use (Hardin, 1968). Improper management of rangeland could lead to rangeland deterioration such as an establishment of undesirable woody plants (Smet and Ward, 2005). Poor norms concerning rangeland administration and absence of proper fences of grazing land have resulted in bush encroachment in many communal rangelands. This poor management of rangelands has also resulted into uncontrolled grazing which promotes under or over-grazing. Under- and over-grazing leads to the disappearance of palatable herbaceous vegetation (Smet and Ward, 2005). Frequently evaluation of communal rangelands is very important for quantifying the range resource and to estimate the extent of bush encroachment or land degradation. Solomon *et al.* (2007) proposed a three tier system of rangeland

assessment. This technique involves consideration of the herbaceous and woody vegetation as well as the soil component.

2.2. The perceptions of communal farmers on the impact of bush encroachment

Communal farmers are knowledgeable about the degree and time frames of deterioration of their rangelands (Ngulube, 2003). Rangeland deterioration includes bush encroachment, shifts in species composition and the reduction of forage production. Bush encroachment has been observed by communal farmers to be the major problem that deteriorates the condition of rangelands. Communal farmers in a study by Angassa and Oba (2008) noticed the decline of forage production and change in species composition and correctly attributed it to the rapid increase of woody plants (bush encroachment). Results of another study indicated that communal farmers perceived that some encroaching woody species have the tendency of suppressing growth of palatable herbaceous plants and creating conditions for the growth of unpalatable ones.

The communal farmers are also capable of identifying invasive and non-invasive species that threaten their rangelands (Angassa and Oba, 2008). Communal farmers are known to have rich indigenous knowledge with regards to rangeland management (Ngulube, 2003) and therefore, it is useful to consider their ecological knowledge regarding their livestock development, rangeland management strategies and planning programmes. Communal farmers interact with their rangelands and they could share their ecological knowledge with the researchers. In so doing they could provide long term ecological viewpoint of bush encroachment or vegetation changes and the primary causes which is lacking in previous studies (Bart, 2006; Roba and Oba, 2009). Davis (2005) stated that communal farmers are known to have very useful knowledge of vegetation trends, species richness and acceptability to grazing animals. They are also very knowledgeable about factors that influence vegetation change such as rainfall availability, fire and grazing pressure (Oba and Kaitira, 2006). Therefore it is very crucial to understand how communal farmers perceive rangeland conditions and the extent of bush encroachment in communal areas.

2.3. Vegetation structure of Rangelands

2.3.1. Herbaceous species composition

Species composition is very vital for range condition assessment because of the variation in species palatability and acceptability to herbivores (Solomon *et al.*, 2007). Species composition is a reflection of how successful previous rangeland management strategies have been (Whalley and Hardy, 2000). Any change in rangeland management practices can lead to a change in herbaceous vegetation structure

(Hayes and Holl, 2003). Species composition and productivity are more influenced by heavy grazing or grazing pressure (Oztas *et al.*, 2003; Maki *et al.*, 2007). Laughlin and Abella (2007) reported that precipitation also plays a vital role in the determination of species composition. Good condition of the rangeland is characterized by dominance of perennial and other acceptable herbaceous plants. Improper grazing regimes promote the replacement or complete disappearance of palatable species by less acceptable ones such as Increaser II species (Tessema *et al.*, 2011). In heavy grazed areas, Decreaser species tend to disappear in favour of Increaser I and II species and/or invader species (Sisay and Baars, 2002). Milchunas *et al.* (1989) reported that structural characteristics of the community, such as greater cover, could affect productivities of water usage and complement physiological response to defoliation.

Herbivores physically damage plants by debarking and bruising. In the process of cutting forages, herbivores sometimes uproot plants and completely destroy them. Physical damage of growing points promotes retardation to the plant growth Lesoli (2011). Grazing or browsing animals directly affect range condition through trampling and defoliation of vegetation. Trampling causes a change in species composition, and animal mobility affects soil properties through mechanical breakdown of soil aggregates and compaction Lesoli (2011). Browsing and grazing animals also have a positive impact on the vegetation by promotion of seed germination, facilitation of seed dispersal and also through soil nutrient cycling (Schuman *et al.*, 2002).

Rapidly increase of woody plant population density in rangelands has made it difficult for communal farmers to plan effective range resource management and utilization approaches. Rangeland vegetation changes are established through continuous growth of phenomenon called bush encroachment. However bush encroachment is unknown as a cause of herbaceous vegetation loss in communal areas. Bush encroachment also responsible for a decline of rangeland condition (Smith, 1988; Scholes and Walker, 1993; Oba *et al.*, 2000). Bush encroachment ability to out complete herbaceous vegetation (negative effect) and this result to a reduction or complete disappearance of more palatable grass sward (Stoddart *et al.*, 1975). Rapidly increase of bush density has a negative effect on herbaceous vegetation because these woody plants have ability to suppress grasses through competition of soil resources. This suppression also impact livestock due to the fact that increase of woody plants in an area reduce the rangeland grazing capacity (Ward, 2005).

2.3.2. Biomass production

Biomass production determines the quantity of forage available for grazing animals, and it is used to quantify the effects of grazing management system on herbaceous vegetation through rangeland condition assessment (Abule *et al.*, 2007). High forage production and dominance of palatable herbaceous species is a good indication of properly managed rangeland (Sisay and Baars, 2002). Forage production range is described in terms of biomass yield and quality of dominating grass species (Peden *et al.*, 2007). The quality of forage production is influenced by several factors such as soil nutrient composition and moisture content availability. Acceptable perennials species such as *Themeda triandra* and *Digitaria eriantha* tend to be dominant under properly managed rangeland but decreases if the rangeland is over-utilized (Morris and Kotze, 2006). This occurs because of the fact that perennials tend to have more biomass production as compared to annual species (Morris and Kotze, 2006).

Constant drainage of nutrient reserves and frequent removal of plant leaves through overgrazing lead to loss of grass vigour (Malan and Van Niekerk, 2005). If the plant is unable to replace the lost nutrient reserves because of grazing pressure, the plant fails to establish new leaves, and the rate of photosynthesis decreases (Morris and Kotze, 2006). The reduction of photosynthesis rate reduces the competitive ability of herbaceous vegetation and therefore, results in a reduction of rangeland productivity (Tomlinson and O'Connor, 2005). However, the shift of vegetation from grass dominated ecosystem to bush climax is influenced by three factors namely: rainfall availability, intensity of grazing and fire (Scholes and Archer, 1996).

Bush encroachment accelerates the reduction of soil cover whereas heavy grazing reduces the fuel load which is vital for fire to burn bush cover (Scholes and Archer, 1996; Oba *et al.*, 2000). The decline of biomass or grass cover has a negative impact on livestock production because in communal areas livestock rely on grasses for their nutrition. An increase of grazing pressure and reduction grass cover result in the deterioration of rangeland resources (Assefa *et al.*, 1986). Bush encroachment has ability to out complete herbaceous vegetation for soil resources and reduces rangeland grazing capacity more especial under overgrazed rangeland. Hence, the proper rangeland management and conservation of range resources are essential (Coppock, 1994).

2.3.3. Basal cover

Savadojo *et al.* (2006) defined basal cover as an estimate of the area covered by vegetation to protect soil against erosion and is determined by the intensity of grazing, fire and other environmental factors. The heavy grazing has dramatic influence on herbaceous vegetation due to the fact that it reduces vegetation cover, on the other hand promotes the replacement of perennial species by annuals species (Todd and Hoffman, 1999). Perennial species provide a good soil cover and once the rangeland loss these species the land tend to be more susceptible to bush encroachment (Oztas *et al.*, 2003). The reduction of basal cover by heavy grazing therefore such soils becomes more prone wind and water erosion (Oztas *et al.*, 2003).

Bare spaces between herbaceous vegetation increases as grass species lose its vigour. This result in a reduction of water absorption and encourages water run-off. Hence, the lack of dense basal cover creates a good condition for encroaching woody plants (Stuart–Hill and Tainton, 1989). Poor application of range management practices can easily promote complete disappearance of palatable perennial species, which leads to the increase of annual species. Annual grass species are known to have less biomass production (or smaller tufts) with poor soil cover or basal cover compared to long-lived plants (Peden *et al.*, 2007). Perennial grasses have more ability to protect soil against soil erosion due to their extensive root structure compared to annual species (Maki *et al.*, 2007).

The shift of rangeland from perennial to annual species also results in a gradual increase of Increaser species such as *Aristida congesta*. The disappearance of perennials due to heavy grazing leaves soil surface uncovered. Therefore, such soils are more prone to the establishment of woody plants and land degradation (Malan and Van Niekerk, 2005). Basal cover under properly managed rangeland is always above 12%, which reduces the impact of raindrops on soil cover. Poor basal cover or bare patches is a good indicator of rangeland deterioration (Baars *et al.*, 1997; Sisay and Baars, 2002; Abule *et al.*, 2007). Once the soil cover reduces through heavy grazing it result in the decline of photosynthesis rate. Encroaching woody plants capitalizes on decline of photosynthesis rate of grazing material, and make a use all soil resource with no time and becomes well established.

Bush encroachment accelerates the reduction of soil cover whereas heavy grazing reduces the fuel load which is vital for fire to burn bush cover (Scholes and Archer, 1996; Oba *et al.*, 2000). The decline of biomass or grass cover has a negative impact on livestock production because in communal areas livestock rely on grasses for their nutrition. An increase of grazing pressure and reduction grass cover result in the deterioration of rangeland resources (Assefa *et al.*, 1986).

2.3.4. Woody species composition and density in Sheshegu communal rangeland

The rapid shift of former grassland to savanna vegetation in communal areas is a dramatic problem to livestock production. The increase of woody plants in rangelands results in the decline of grazing capacity due to inaccessibility of forage by grazing animals (Dube *et al.*, 2009; Angassa and Oba, 2010). An increase of bush density in communal rangelands is known to have a suppressive effect on the herbaceous vegetation due to their competitive ability for water and soil nutrients (soil resources); shading effect of woody plants also has an influence on herbaceous vegetation. The reduction of carrying capacity is of great importance due to the fact that savannas in Africa contain a huge and fast growing human population whose livelihood is dependent on their range resources (Lampry, 1983; Scholes and Archer, 1996; Ward, 2005).

The occurrence of woody plants in former grasslands is linked to disturbances of ecosystem regimes such as overgrazing, fire and seasonal precipitation (Smit, 2004; Tews and Jeltsch, 2004). Overgrazing can promote the establishment of woody plants where there are bare patches due to the fact that frequent grazing favours the percolation of water from the soil top layer (passes the grass root zone) to sub-soil layer (water in sub- soil layer is accessed by woody plants more significantly compared to grasses) (Kraaij and Ward, 2006; Solomon *et al.*, 2007).

Birds and herbivores promote the spreading of woody plants through ingestion of seeds of already existing encroaching species (Roques *et al.*, 2001) and spreading them through their droppings. The digestive system of herbivores has an ability of loosening the seed coat, thereby stimulating rapid germination and seedling development in rangelands. The digestive enzymes serve as seed coat treatment for seeds of some encroaching woody species, thus facilitating early establishment (Roques *et al.*, 2001; Abebe *et al.*, 2010). Fire is considered a rangeland management tool which could be used to minimize undesirable woody plants. At the same time, fire breaks down seed dormancy, thus stimulating seedling growth of woody plants (Kraaij and Ward, 2006). Fire exclusion and the absence of browsers tend to

allow the spread of woody species such as *Acacia* species in savannas (Titshall *et al.*, 2000; Western and Maitumo, 2004). During the land tenure system, communal rangelands were managed properly, but following the land tenure system, communal rangelands are not properly managed as communal rangelands are characterized by uncontrolled grazing due to vandalized fences from grazing camps (Vetter *et al.*, 2006). This has resulted to deterioration of rangeland which is characterized by reduction of biomass production and basal cover.

2.5. Soil nutrient composition

Soil pH is defined as a measure of alkalinity and acidity of the soil. Soil pH influences microbial activities and other soil properties. Knowledge of soil pH standards is very important for sustaining biological productivity and in promoting plant production in an ecosystem (Corwin *et al.*, 2003). Extreme high or low soil pH can have a great impact on the solubility of soil nutrients, which are essential for plant growth (Rezaei and Gilkes, 2005). Alkaline soils are commonly caused by high concentration of salts in the soil (Moyo *et al.*, 2010). Moyo *et al.* (2010) observed that soil pH tends to be acidic in an over-grazed rangeland whereas alkalinity is linked with under-utilized rangelands. High levels of manganese, aluminum and iron in the soil, are known to be indicators of soil acidity (Moyo *et al.*, 2010). Frequent application of fire was also reported as one of the causes of soil acidity that promotes the reduction of soil carbon and nitrogen (O'Connor *et al.*, 2004).

High population of woody plants can also lead to high concentrations of soil nutrients in the top soil due to the fact that woody plants have the ability to pump soil nutrients upwards from the deeper soil profiles better than grasses (Keilman, 1979; Scholes, 1990). Savanna woody plants play a vital role in creating shade for herbaceous vegetation and also drawing water from deeper soil profiles which are not accessible to grasses (Ludwing *et al.*, 2001). Soil nutrients can be inhibited by other soil nutrients in the soil. However, calcium carbonate, magnesium and iron oxides tend to bind with phosphorous, thereby masking its availability and potential to plants (Belnap *et al.*, 2003). Knapp *et al.* (2008) and Eldridge *et al.* (2011) reported that most of the encroaching woody plants are nitrogen fixers and therefore, these woody species have the ability to bring additional nitrogen in an ecosystem (Cech *et al.*, 2010). The influence of bush encroachment on herbaceous vegetation is globally documented, but there is lack of data clarifying the trends of bush encroachment on herbaceous vegetation on Sheshegu communal

rangelands, whether the encroachment of *Acacia karroo* and mixed bush have a positive or negative effect on herbaceous vegetation and soil nutrient status.

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CHAPTER 3 COMMUNAL FARMERS' PERCEPTIONS ON THE IMPACT OF BUSH ENCROACHMENT IN SHESHEGU COMMUNAL AREA

Abstract

Communal farmers' perceptions were investigated at Sheshegu community in Alice, Eastern Cape Province, South Africa, under Nkonkobe local Municipality found Amatole District. The objective of the study was to assess the perceptions of communal farmers on the impact of bush encroachment on herbaceous vegetation and soil nutrient content. Structured questionnaires were used to access the perceptions of farmers in relation to vegetation changes and livestock population trends. A total number of 40 communal farmers were selected randomly and interviewed. Respondents comprised 62% females and 38% males. Ages of the majority (40%) of the respondents ranged between 35-45 years. The farmers indicated that the previous 20 years had seen their grasslands being converted into savanna vegetation called Bisho thornveld. About 89% of respondents indicated that vegetation change was attributed to unreliable rainfall, prolonged drought, poor grazing management system and fire exclusion due to insufficient fuel load. Changes in vegetation and soil nutrient composition were perceived by the farmers as important indicators of the rangeland condition. *Acacia karroo* was perceived to be the most invasive woody species. The increase in woody species was perceived to be favourable to goat production at the detriment of cattle and sheep production because these species rely mostly on the grass cover which is suppressed by the dominance of the woody species. Thus, goat production was the most preferable livestock production system. Farmers had different views regarding the impact of bush encroachment on their livestock and herbaceous vegetation due to fact that those who were farming with goats were favoured by high bush density. However, those who were farming with cattle and sheep regarded their rangeland as encroached. Therefore, Sheshegu communal rangeland is more suitable for goat production (browsers) than sheep and cattle production, and this was supported by the increasing trend of goats as revealed in this study.

Key words: Indigenous ecological knowledge, livestock, bush encroachment, rangeland management.

3.1. Introduction

In South Africa, 75% of the rangelands are used for livestock production (Smet and Ward, 2006). These rangelands are poorly managed and, therefore, prone to land degradation and bush encroachment (FAO, 2009). Types of livestock production systems practiced in a community tend to have an impact on condition of communal rangelands. In communal areas, rangeland is usually shared by community members, and everyone within that community has an access to rangeland resources (FAO, 2005). Free access to grazing land and differences in the objectives in livestock ownership can result in poor rangeland condition (FAO, 2005). Communal farmers tend to keep their livestock for different purposes such as draught power, milk, meat, cash income, lobola (dowry/bride-price) and for other socio-cultural reasons.

Communal farmers have an equal right to access rangeland, even though their purposes for keeping livestock vary. Over-utilization of rangeland resources by grazing animals because of high stocking rate is a huge challenge in communal areas (FAO, 2005). Katjiuna and Ward (2007) defined over-utilization of rangeland resources as overgrazing of resources by livestock leading to an increase in undesirable plants. Loss of rangeland resources through overgrazing in communal areas has been linked with poor rangeland management because communal areas have unclear land tenure (Thomas, 2008). Grazing resources are poorly managed in communal areas because of communal ownership of the resource and free access of livestock to grazing and water points (Botswana Government, 1975). Due to the close attachment of communal farmers to their natural resources, subtle changes in these resources are noticed by them. This fact is sometimes ignored by researchers (Roba and Oba, 2009; Butt, 2010). However, communal farmers are known to have extensive ecological knowledge which could complement scientific knowledge and also contribute to improved understanding and sustainable management of rangelands (Berkes *et al.*, 2000; Oba and Kotile, 2001; Reed *et al.*, 2011). Even though communal rangelands are well researched (Thomas *et al.* 2000), there are still very few studies that have been documented on accessing the indigenous knowledge of communal farmers on the impact of bush encroachment. Most the farmers who are farming with grazers (cattle and sheep) across the Eastern Cape Province are facing the shortage of feed due to the fact herbaceous vegetation is being suppressed by rapidly increase of woody plant density. This situation is mostly common in communal rangelands and therefore this study is trying to assess the understanding communal farmers on the impact of bush encroachment of both vegetation and livestock production.

3.2. Methods and materials

3.2.1. Description of the study site

The study was conducted at Sheshegu communal rangeland in Alice under Nkonkobe Municipality, Eastern Cape Province, South Africa. Sheshegu is located in the South Western part of Alice, with coordinates of 32°53 '47"58S and 26°47'8"E. It is 544m above sea level with a humid climate (>0.65 p/pet). Annual rainfall ranges between 450-600mm, with February being the warmest month (with an average of 25°C) and July being the coldest with an average temperature of 6.3°C (Gwelo, 2012). The vegetation consists predominantly of False Thornveld savannah with its landscape dominated by *Acacia karroo*. The dominant grass species are *Themeda triandra*, *Panicum maximum* and *Digitaria eriantha* (Mapekula, 2009). The soil type consists of both mudstone and sandstone (lithology) with low Cation Exchange Capacity (CEC) and high saturation of bases (World Atlas, 2012). The inhabitants are mainly IsiXhosa speaking people who rely on animal farming.

3.2.2. The selection of communal farmers

Prior to selection of the farmers for interviews, a meeting was held with Extension officers and community leaders to brief them about the purpose of the study and solicit their support for the study. A total of 40 communal farmers (i.e. from the age of 35years and above) were randomly selected and interviewed at household level. There was no gender restriction as both male and female farmers who owned livestock were included.

3.2.4. Data collection

A total number of 40 communal farmers were interviewed using structured questionnaires (i.e open and closed-ended). The questionnaires were divided into five sections, namely: demographic information, livestock population, grazing management systems, and rangeland condition and bush encroachment.

3.2.5. Statistical Analysis

The data collected through the questionnaire were analyzed using Statistical Package of Social Science (SPSS). Descriptive statistics such as frequencies, means, and percentages were employed

3.4. Results

3.4.1. Demographic profile of communal farmers

The respondents were characteristically small scale livestock farmers. Some were not formally employed while others relied on livestock and social grants for livelihood. In addition, 65 % of them depended on livestock production for their livelihood while 35% were dependent on social grants and other formal employment for their livelihood. There were more female respondents (62%) than male (38%) as shown in Figure 3.4.1. The majority of the respondents (40%) were between the ages of 34 to 45 years, while 38% ranged from 56 to 75 years as indicated in (Table 3.4.1). Most of the communal farmers had some form of formal education, with only 8% of them being illiterate. Furthermore, 31% of household members were adults (from the ages of 21 years and above) while 69% were children (less than 21years).

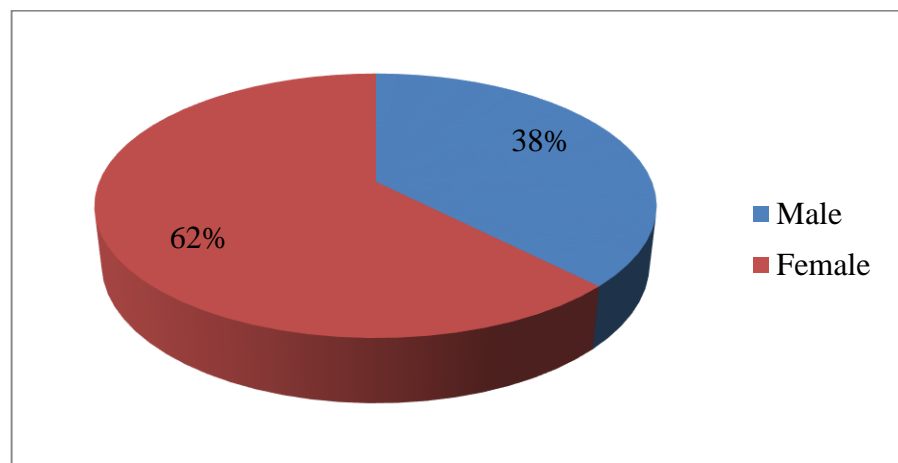


Figure 3.4.1: Proportion (%) of male and female livestock owners at Sheshegu communal area.

Table 3.4.1: Respondents' age distribution, educational status, primary source of income and household size (n=40)

Age	Frequency	Percentage (%)
35-45	16	40
46-55	9	22
56-65	8	20
66-75	7	18
Educational status		
Primary school	17	42
Uneducated	3	8
Secondary school	20	50
Primary source of income		
Livestock production	26	65
Work & social grant	14	35
Household size		
Adults (above 21 years old)	97	31
Child (less than 21 years old)	214	69

3.4.2. Livestock population

Goats (62%) were the most preferred livestock species followed by cattle (25%) and sheep (13%) respectively (Table 3.4.2). Bucks and wethers, doe and young females and kids showed no significant difference while bulls and oxen, cows and heifers and calves also indicated no significant difference, as shown in (Table 3.4.2). Rams and wethers, ewes and lambs also showed no significant difference while there was a significant difference between calves and ewes (Table 3.4.2).

Table 3.4.2: Mean (SE) composition of livestock species at Sheshegu communal area.

Livestock species	Mean (\pmSE)
Cattle	
Bulls & Oxen	0.9(0.2) ^a
Cows & Heifers	9.6(2.2) ^b
Calves	4.4(0.9) ^{ce}
Sheep	
Rams & Wethers	0.6(0.2) ^d
Ewes	4.4(1.2) ^e
Lambs	3.0(0.8) ^f
Goats	
Bucks & Wethers	2.7(0.4) ^g
Doe	18.5(2.0) ^h
Kids	13.7(1.4) ⁱ

Different superscripts (column) denote significant differences ($P < 0.05$) among the causes of shortage feed.

3.4.3. Socio-economic importance of livestock and challenges of communal farmers at Sheshegu communal area.

The reasons for keeping livestock varied, the most important reason for keeping livestock was with and status being the least important as shown in (Table 3.4.3). Lack of water points was perceived as the main challenge facing communal farmers while stock theft was identified as a least challenge faced by Sheshegu communal farmers as shown (Table 3.4.3).

Table 3.4.3: Mean ranks of the perceived reasons for keeping livestock and challenges faced by farmers at Sheshegu communal area (n=40)

Purpose	Mean Rank (\pmSE)	Rank
Sale	1.2(0.64) ^a	1
Meat	3.0(0.11) ^{bf}	2
Lobolo	4.8 (0.13) ^{cd}	3
Milk	4.7(0.14) ^{de}	4
Traction	4.3(0.24) ^e	5
Status	3.0(0.17) ^f	6
Challenges		
Lack of water points	1.4 (0.12) ^a	1
Shortage of forage	2.2 (0.15) ^b	2
Predators	4.7(0.09) ^c	3
Diseases	3.9(0.12) ^d	4
Stock theft	2.8(0.14) ^e	5

Different superscripts (column) denotes significant different among reasons and challenges at (P<0.05)

3.4.4. Perceived veld condition and bush encroachment at Sheshegu communal rangeland

Lack of rainfall (1.5) was considered as most important factor mentioned to cause forage scarcity particularly during winter season (Table 3.4.4). The change in herbaceous species composition was regarded as the consequence of the interaction between lack of precipitation and overgrazing. Bush encroachment (2.0) was perceived as second most cause of veld deterioration in Sheshegu communal rangeland (Table 3.4.4). Respondents reported that *Acacia karroo* was the most encroaching woody species and also mentioned that encroachment of *Acacia karroo* led to a reduction of grazing capacity, wool quality and forage accessibility. About 67% of communal farmers were aware of the effects of over-utilization of the veld on herbaceous vegetation. They indicated that their rangeland which was formerly dominated by high quality species (10-20 year ago) had been replaced by inferior hardy-like *Sporobolus fimbriatus*, *Cymbopogon plurinodis* as an indicator of overgrazing.

Table 3.4.4: Mean ranks of perceived causes of shortage of feed at Sheshegu (n=40)

Causes	Mean Rank	Rank
Lack of rainfall	1.5(0.13) ^a	1
Overgrazing	4.2(0.67) ^b	3
Burning	4.8(0.67) ^c	4
Bush encroachment	2.0(0.00) ^e	2

Different superscripts (column) denote significant differences (P<0.05) among the causes of shortage feed.

Timing of fire (Table 3.4.5) was perceived as the main cause of rangeland deterioration (bush encroachment) in Sheshegu communal rangeland. Communal farmers reported that their failure to set fire to rangeland at the right time was perceived to favour an increase in woody plant species, particularly *Acacia karroo*. However, encroachment of the rangeland by *Acacia karroo* was considered as a threat to livestock. Goat can be used to control bush density, however Sheshegu communal farmers perceived that number of goats in that village is still few as results their goats are falling to control bush encroachment. These farmers also perceived that if they were having large numbers of goats *Acacia*

karroo can be controlled through browsing and use of fire, even though absence of browsers were regarded as least cause of bush encroachment (Table 3.4.5). Climate change (3.4) and drought (1.4) were also perceived by the farmers to have a positive impact on the abundance of woody plants. The farmers perceived that overgrazing (1.7) was second the most cause of bush encroachment. There were no significant differences ($P>0.05$) between overgrazing and drought as well as climate change, timing of fire and absence of browsers. Furthermore Sheshegu communal farmers perceived that the correct application of fire (veld burning) and an increase of both browsers and grazers can be a solution in controlling bush encroachment.

Table 3.4.5: Mean ranks of perceived causes of bush encroachment and possible solutions to control bush encroachment at Sheshegu communal rangeland (n=40)

Causes	Mean Rank	Rank
Overgrazing	1.7 (0.75) ^{ab}	2
Drought	1.4(0.39) ^b	1
Burning	4.6(0.85) ^{ce} .	4
Climate change	3.4(0.78) ^{de}	3
Absence of Browsers	4.0(0.72) ^e	5
Possible solution		
Veld burning	2.8(0.08) ^a	3
Destocking	5.5(0.06) ^b	5
Increasing browsers	2.2(0.16) ^{de}	1
Increasing grazing	2.3(0.25) ^e	2
Use of mechanical technique	3.3(0.25) ^f	4

Different superscripts denote significant differences ($P<0.05$) between the causes and between possible solutions.

3.5. Discussion

3.5.1. Farmers' socio-economic background and livestock population dynamics

In this study, the majority of farmers interviewed were females compared to males (Figure 3.4.1). This was due to the fact that most of the men were at work during survey (Figure 3.4.1). These findings were in contrast with the study conducted by Admasu *et al.* (2010) in Southern Ethiopia who reported that males were interested in farming compared to females. This study also revealed that young people (62%) are engaged in Agricultural activities, and this disagrees with the study conducted by Lesoli (2011), who demonstrated that youth in communal areas showed low interest in livestock production. This study showed that 50% of farmers have reached secondary school; 42% primary school and 8% recorded as an uneducated (Table 3.4.1). This suggests that the level of education may be improving gradually in communal areas.

Farmers with secondary school qualifications owned larger numbers of goats than cattle and sheep as revealed by this study (Table 3.4.1). This showed that the level of exposure to sources of information has an effect on the selection of livestock production system because the majority of goats were owned by farmers with secondary school. Therefore, such results could be caused by access to information about goat production and their suitability to the rangeland conditions. Moyo *et al.* (2008) reported that literacy levels are a very important determinant of livestock production particularly on accepting new interventions of rangeland management.

This indicated that gradual improvement of levels of education also reduces poverty through farming in communal societies. Gwelo (2012) reported similar results that levels of education in communal areas of the Eastern Cape Province are improving gradually. According to Beck and Nesmith (2001), Eastern Cape Province is mainly dominated by rural areas, therefore, livestock production plays a vital role in the reduction of poverty in communal areas. This confirmed that livestock production in communal areas is regarded as a major source of food and livelihood for those who trade/sell) because goats, sheep and cattle are usually slaughtered during traditional ceremonies, funerals, weddings and rituals for sacrificial purposes. Similar findings were reported by Solomon *et al.* (2014) in the Eastern Cape Province of South Africa. On other hand, communal farmers generate income by selling their livestock in order to send their children to school. According to Stroebel *et al.* (2011), communal farmers in Southern Africa generate their income from livestock production. Communal farmers also perceived that the gradual

increase of woody plants in their rangeland favours the production of browsers such as goats. There was a slight decline in the production of sheep and cattle for past 20 years, as revealed by this study (Table 3.4.2). This was suspected to be caused by the decrease of grazing capacity which is reduced by the expansion of woody plants.

The expansion of bushes in Sheshegu communal area was linked to poor grazing management which was reported to be caused by vandalized fences from the grazing camps. Older communal farmers in Sheshegu have perceived that the spread of woody plants in their rangeland could be related to erratic rainfall and prolonged drought. Similar findings were observed in studies conducted by Mapiye *et al.* (2009) and Mngomezulu (2010) in savannas of the Eastern Cape Province. Solomon *et al.* (2014) also reported that livestock species composition can be easily influenced by land degradation and reduction of grazing capacity. How in this study livestock species composition was influenced by the reduction of grazing capacity because of rapidly spread of bush encroachment. Communal farmers perceived that lack of water points, decrease of grazing capacity and continuous grazing due to poor grazing camps are the major challenges in their communal rangeland (Table 3.4.3). The average livestock ownership in Sheshegu communal area was 12 goats, 8 cattle and 5 sheep as revealed by this study. This is in agreement with studies conducted by Mapiye *et al.* (2009) and Mwale and Masika (2009). However, these findings different from that of Solomon *et al.* (2014) which were conducted in savanna communal rangeland of the Eastern Cape Province. Solomon *et al.* (2014) presented high average number of sheep followed by sheep and goats were least species in terms of mean livestock ownership.

3.5.2 Perceptions on rangeland condition, resource management and bush encroachment

Most farmers (89%) perceived that grazing material availability is plenty during summer scarce winter season. Insufficient grazing material during winter was ascribed to low precipitation experienced in the dry season and low temperature. Farmers perception that forage availability is low during winter is in agreement with a study conducted by Goqwana *et al.* (2008) who stated that winter season always have a shortage of feed for livestock and this forces farmers to buy supplements during this season. According to Solomon *et al.* (2014), seasonal instability of forage quality is a main challenge to communal farmers of the Eastern Cape during dry season. Sheshegu communal farmers indicated that they do not supplement their animals even though there is need of supplementation during winter season. This could be attributed to low income generated from livestock and their products sale. Similar findings were

reported in the study conducted by Lesoli (2011) in the same province. At Sheshegu communal area, grazing animals rely on native forage only. This promotes poor quality and low biomass production of grazing material according to Raats (1999). Farmers that farm with cattle reported that cattle were not kraaled. This showed that cattle spent more time in the grazing lands, and their grazing camps were also not fenced. Therefore, this promotes overgrazing, selective grazing and continuous grazing (Lesoli, 2011). On the other hand, animals that are kraaled are more prone to stock theft and predators.

The fact that the cattle at Sheshegu were not kraaled contradicts the findings of Moyo *et al.* (2008) who reported that in most villages, animals are kraaled daily; this was caused by fear of stock theft and predators. Uncontrolled movement of grazing livestock at Sheshegu rangeland was perceived as a factor which promotes overgrazing. Similar results were presented by Lesoli (2011) at Amakhuze Tribal Authority in the Eastern Cape Province. Different findings were reported by Allsopp *et al.* (2007) who stated that communal farmers at Namaqualand control livestock movement through herding wherein herders daily select a certain portion for grazing. Sheshegu communal farmers also observe that grazing camps were well demarcated by the previous apartheid government, but now camps are not fenced. Therefore, this makes it difficult to control livestock movement or applying proper veld management practices. Scarcity of water, especially in winter, was indicated as a main challenge that affects all livestock. This suggests that animals can search for water for more than 1km distances; which was also mentioned during data collection. Dams are the only source of water for livestock.

According to Lesoli (2011), accessibility, availability and distribution of water points could lead to low livestock mobility and higher concentration around water points. Everyone at Sheshegu communal area has access to rangeland, and access is not controlled. They gain access to rangeland resources because they are residents in the village. This indicated that there are no rules or policies used to control access to rangeland resources and therefore, this encourages over-utilization of rangeland resources. Similar findings were also reported by Solomon *et al.* (2014) in Cala communal rangeland of the Eastern Cape. Lesoli (2011) reported that vandalized fences from grazing camps were noted as the main challenge in rangeland management; communal farmers stated that government must intervene in this regard, in order to ensure sustainability use of rangeland resources. Vandalized fences from grazing camps were reported as the main cause of continuous grazing and selective grazing at Sheshegu rangeland. Sheshegu communal farmers have different views regarding their rangeland condition; as a result, 60% of them

perceived that an encroachment of *Acacia karroo* favours goat production. This implies that farmers who are farming goats regard Sheshegu rangeland as in a good condition.

However, those who are farming sheep and cattle regard it as being in poor a condition. At Sheshegu communal, rangeland *Acacia karroo* is the most dominant encroacher woody species which favours goat production, as perceived in this study. In addition to the benefit of goats from *Acacia karroo*, Sheshegu communal farmers reported that they also harvest *Acacia karroo* for cooking, building kraals, building houses and medicinal purposes. This suggests that *Acacia karroo* can be reduced through the use of browsers and harvesting for household uses. This was opposed by Bille and Assefa (1983) in Ethiopia, these authors reported that harvesting alone of woody for cooking, building kraals cannot be recommended as control measures of bush encroachment. Farmers who are farming cattle and sheep at Sheshegu perceived that the poor state of their rangeland was attributed to prolonged drought and poor grazing practices, and these were main causes of vegetation change. This is in agreement with the study conducted by Baars and Aptidon (2002) on the farmers' perceptions of rangeland degradation in Ethiopia. These authors reported that herbaceous species composition can be easily influenced by poor grazing management and prolonged drought. Bush encroachment at Sheshegu communal rangeland has resulted in a decrease in the grazing capacity, as revealed in this study. According Smit (2004), there is enough evidence in literature that bush encroachment reduces rangeland. Bush encroachment was also reported as the main cause of vegetation change (Angassa and Beyene, 2003; Kgosikoma *et al.*, 2012). Sheshegu communal farmers reported that they are very clear about the measures that can be used to control bush encroachment in their rangeland, but money is a challenge or limiting factor because it is needed to compensate someone who clearing bush. Therefore, they highlighted that they will not attempt to control bush encroachment until government intervenes.

3.6. Conclusions

Sheshegu communal farmers do not have adequate rangeland management skills to handle the current situation, and there are no policies for rangeland access and utilization of rangeland resources. Uncontrolled livestock movement has resulted in the spread of bush encroachment within Sheshegu communal rangeland. Government must introduce rangeland management training to communal farmers; in so doing scientific research can complement indigenous knowledge. If Sheshegu communal farmers had rangeland management skills, they would understand the impact of poor rangeland management practices and bush encroachment. This concludes that Sheshegu communal farmers have a poor understanding of the impact of bush encroachment on herbaceous vegetation. Farmers have different views regarding the impact of bush encroachment at Sheshegu communal rangeland, and this makes it difficult to evaluate the effects of bush encroachment. Therefore, more studies are still needed to evaluate the understanding of communal farmers regarding the impact of bush encroachment on soil components and herbaceous layers.

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CHAPTER 4 HERBACEOUS VEGETATION, WOODY PLANTS COMPOSITION AND PRODUCTION IN SHESHEGU COMMUNAL RANGELAND

Abstract

Herbaceous vegetation and woody plants are very important components of the rangeland and also plays a vital role in livestock production. This study was conducted at Sheshegu communal rangeland and the objective of this study was to assess the impact of bush encroachment on species composition, biomass production and basal cover. Four study sites were demarcated which were Scattered, Moderate, Mixed and Dense bushland. Step point method was used to estimate herbaceous species composition and basal cover. A 0.25m² quadrat was used to harvest herbaceous plant material from randomly-selected quadrats and harvested samples were oven-dried to determine dry matter production. A two- meter rod was used to measure the lowest browseable material (LBM), tree canopy diameter (TCD) and the height (H) of the tree. Woody plant density, tree equivalents and browsing units were estimated from measured H, LBM and (TCD). Nineteen herbaceous species were identified and recorded. These species comprised 68.4% Increaser II species, 5.3% Increaser I species and 26.3% Decreaser species. Out of the nineteen species, 57.9% had a low grazing value, and 42.1% had high grazing value. Among the nineteen species, 15 were perennials (78.9%), 1 annual species (5.3%) and 3 were unknown species (15.8%). *Digitaria eriantha* was significantly ($P<0.05$) higher in the sites and biomass production increased from Scattered bushland (379-194 kg ha⁻¹ i.e summer and winter, respectively) to Dense bushland (473- 277 kg ha⁻¹ i.e summer and winter, respectively). Basal cover showed no significant difference ($P>0.05$) between moderate, dense, mixed bushland (in summer) and dense, mixed bushland (in winter). *Acacia karroo* was the most dominant woody plant with mean abundance of 43.2% in all sites. Scattered bushland had low biomass, poor basal cover but dominated by Decreaser species. While moderate mixed and dense bushland had good soil cover and high biomass production but dominated by Increaser species. Plant density (Plant/ha) and tree equivalents (TE/ha) of dense and mixed bushland showed that these sites were encroached, because Plant/ha and TE/ha of these sites exceeded 2400 plant/ha and 2500 TE/ha. The study showed that Sheshegu rangeland is gradually being encroached, and this has resulted in the replacement of Decreaser with Increaser species, clearly indicating the negative effect of bush encroachment on herbaceous species

Key words: species composition, biomass production, basal cover, woody plant density.

4.1. Introduction

High woody plants population and heavy grazing tend to reduce grass cover and fuel load for effective bush burning (Scholes and Archer, 1996; Oba *et al.*, 2000). Ecological changes or rapid spread of woody plants in former grasslands in communal rangelands have made it difficult for communal farmers to plan and manage range resources effectively (Stoddart *et al.*, 1975). The change of rangeland vegetation is manifested by the progressive growth of woody plants in former grasslands in communal areas, and this is reported to be the main cause of loss or complete disappearance of palatable herbaceous species (Stoddart *et al.*, 1975). However, White (1980) reported that the presence of woody species in a savanna ecosystem may have some positive effect on that ecosystem, but when density exceeds 30%, herbaceous cover begins to deteriorate. Fire regimes, grazing management and rainfall play significant roles in vegetation transformation (Scholes and Archer, 1996).

Proper management of rangeland resources is very vital in communal rangelands due to the fact that communal farmers are mainly dependent on the native grass for livestock feeding. The evaluation and monitoring of rangeland resources is very crucial and diverse and involves three rangeland components, viz; soil nutrient composition, herbaceous vegetation and woody vegetation. Solomon *et al.* (2010) reported that there are few documented studies conducted on the impact of woody plants species on herbaceous layer and soil properties. The objective of this study therefore was to evaluate the impact of woody plants on herbaceous vegetation in Sheshegu communal rangeland.

4.2. Site description

The study was conducted at Sheshegu communal rangeland in Alice. Alice is situated 80km inland from the coastline of the Eastern Cape in South Africa. The veld type is characterized by False Thorn veld which is known as Bisho Thornveld. This savanna is mostly used for livestock grazing. *Acacia Karoo* is the most dominant woody plant (Dziba *et al.*, 2003) whereas *Themeda triandra*, *Panicum maximum*, *Digitaria eriantha* and *Sporobolus africanus* species are the most dominant grass species (Gwelo, 2012). Sheshegu communal rangeland is located at S32°54' 063" and E 026°47' 128" and receives about 580-800mm rainfall per year; 70% of this rainfall occurs between October and March and 30% between April and September (Gwelo, 2012). Average temperatures vary from season to season ranging between 16-27 °C in summer and between 6.5-18°C in winter (Gwelo, 2012). Soil is derived from shale and mudstone parent materials (Hester *et al.*, 2006).

4.3. Experimental layout and sampling

A survey was conducted at Sheshegu communal rangeland in Alice. Four homogenous vegetation units (HVU) were identified, namely: Scattered, Moderate, and Dense bushland. In each HVU, four sample sites of 100m x 50m were permanently demarcated (Trollope, 1989). At each sample site, four parallel 100m x 2m transects (Vetter *et al.*, 2006) were laid, and these were 15m apart with an open area of 5m left on each side to eliminate edge effect. The three tier system of range assessment was employed in the assessment of Sheshegu communal rangeland (Abule *et al.*, 2007).

4.4 Research techniques

4.4.1 Experimental design

A completely randomized design (CRD) was employed for field data collection. Each of the four HVU's were replicated four times.

4.4.2. Determination of herbaceous species composition

The step point technique was employed to determine herbaceous species (Evans and Love, 2006). The nearest species and basal strikes were estimated at 100 points along the 100m transect per sample site (Vetter *et al.*, 2006). In every 1m interval, a metal rod was dropped, and any herbaceous vegetation species on which the rod struck (basal strikes) was identified and assessed using the approach by Trollope (1986). Grasses were identified to species level, whereas other herbaceous plants belonging to other

families were categorized as forbs, sedges, rushes, and karoo species. Grasses were also classified according to their ecological status into Decreasers, Increasesers I and II. The plant life form was also included as another classification criterion into annuals and perennials (Solomon *et al.*, 2010). Grass species were categorized into grazing value as High, Moderate and Low grazing value.

4.4.3. Determination of basal cover

Basal cover was determined by using a point to tuft distance (Trollope, 1989). The mean point to tuft distance provides an estimate of basal cover and also provides an indication of vulnerability to soil erosion (Trollope, 1989). Basal cover was estimated from the number of direct strikes on a species as a proportion of the total number of points.

4.4.4. Determination of biomass production

The above-ground biomass production was determined by harvesting herbaceous vegetation. A 0.5m x 0.5m quadrat was placed 6 times along the 100m transects and the distance between two quadrats was 20m. A sickle was used to harvest the herbaceous species within the quadrat and samples were placed in paper bags. A total of 24 samples were harvested in each HVU. Samples were dried in the oven at 60°C for 48 hours. Dry weight was estimated in kg/ha.

4.4.5. Determination of woody species composition

Woody species composition was determined within the 2 x 100m All woody species within the transect were identified and recorded. Lowest browseable material (LBM), height and diameter of woody species were measured and recorded.

4.6. Statistical analysis

The following statistical model was used for data on species composition, biomass production and basal cover: $Y_{ij}(k) = \mu + \alpha_{i(K)} + \varepsilon_{ij(K)}$

Where $Y_{ij}(k)$ = Response variables (species composition, biomass production and basal cover).

μ = overall mean

$\alpha_{i(K)}$ = effect of the i^{th} HVU(scattered, moderate, dense and mixed bushland).

$\varepsilon_{ij}(K)$ = effect of a Random error.

A Fischer least test and Analysis of Variance were conducted and analysed using the General Linear Model (GLM) procedure of SAS (1999) to compare means at ($P < 0.05$) on woody and grass species composition, biomass production, basal cover, density, tree equivalents and browsing units among different HVUs of the rangeland. The interactions between HVU and season on species composition, basal cover and biomass production were also tested. The post hoc analysis was also conducted for pairwise mean comparison in species composition.

4.6. Results

4.6.1. Grass species composition in Sheshegu communal rangeland.

A total of nineteen herbaceous species were found in Sheshegu communal rangeland. Sixteen of these species were grass species while three were classified as 'Others' (forb, sedge, and karoo species), Species composition of grasses comprised of 68.4% Increaser II species, 5.3% Increaser I species and 26.3% Decreaser species. Out of the nineteen species, 57.9% had a low grazing value and 42.1% had high grazing value. 78.9% of the identified species were perennials (15 spp) 5.3% (1 spp) was annual and 15.3% (3 spp) were classified as 'others' (Forb, sedge and Karoo) (Table 4.1).

Table 4.1:Classification and relative abundance of herbaceous species in Sheshegu communal rangeland.

Species	Ecological status	Grazing value	Life form	%Abundance
<i>Aristida congesta</i>	Increaser II	Low	Perennial	6.7
<i>Cynodon dactylon</i>	Increaser II	High	Perennial	2.2
<i>Cymbopogon plurinodis</i>	Increaser II	Low	Perennial	0.5
<i>Digitaria eriantha</i>	Decreaser	High	Perennial	39.5
<i>Eragrostis obtuse</i>	Increaser II	Low	Perennial	13.5
<i>Eragrostis capensis</i>	Increaser II	Moderate	Perennial	0.6
<i>Eragrostis chloromelas</i>	Increaser II	Low	Perennial	5.2
<i>Eustachys paspaloides</i>	Decreaser	High	Perennial	0.5
<i>Forbs</i>	Increaser II	Low	Unknown	2.4
<i>Karoo</i>	Increaser II	Low	Unknown	3.5
<i>Karoochloa curva</i>	Increaser I	Low	Annual	1.2
<i>Microchloa cafra</i>	Increaser II	Low	Perennial	0.9
<i>Panicum maximum</i>	Decreaser	High	Perennial	1.5
<i>Panicum stapfianum</i>	Decreaser	High	Perennial	1.3
<i>Sporobolus africanus</i>	Increaser II	Low	Perennial	2.4
<i>Sporobolus fimbriatus</i>	Increaser II	High	Perennial	10
<i>Sedge</i>	Increaser II	Low	Unknown	1.4
<i>Setaria neglecta</i>	Increaser II	Low	Perennial	1.4
<i>Themeda triandra</i>	Decreaser	High	Perennial	5.3

4.6.2. Effect of season on abundance of herbaceous vegetation in Sheshegu rangeland

Seven grass species were found in the four HVUs (Scattered, Moderate, Dense and Mixed bushland) in the Sheshegu communal rangeland. These species were *Aristida congesta*, *Digitaria ariantha*, *Eragrostis chloromelas*, *Eragrostis obuse*, *Sporobolus fimbriatus*, *Sporobolus africanus* and *Themeda triandra*. Forbs were put together and not separated into species. The percentage abundance of *Aristida congesta* was significantly different ($P < 0.05$) across seasons for all HVU except for scattered bushland. *Eragrostis chloromelas* was significantly different ($P < 0.05$) across seasons for Scattered and Mixed bushlands while Moderate and Dense bushlands. *Digitaria ariantha* and *Themeda triandra* showed no significant difference ($P > 0.05$) across seasons but *Themeda triandra* and *Digitaria ariantha* showed significant difference ($P < 0.05$) in all HVU. The percentage abundance of *Sporobolus fimbriatus* was significantly different ($P < 0.05$) across seasons in all other HVU except Scattered bushland while *Sporobolus fimbriatus* was significantly different ($P < 0.05$) in both winter and summer. *Sporobolus africanus* and *Eragrostis obtuse* displayed no significant difference ($P > 0.05$) across HVUs in winter and summer (Table 4.2).

Table 4.2: Mean (\pm S. E) % abundance of 8 common grass species in homogenous vegetation units in Sheshegu community rangeland.

Species	Season	Scattered bushland	Moderate bushland	Dense bushland	Mixed bushland	\pm SE
<i>Aristida congesta</i>	Winter	(1.5) ^c	(20.3) ^a	(4.5) ^c	(8.0) ^b	2.2
	Summer	(1.5) ^c	(0.5) ^d	(3.5) ^b	(13.5) ^a	1.0
<i>Digitaria eriantha</i>	Winter	(36.0) ^a	(29.0) ^a	(47.8) ^a	(17.0) ^a	9.2
	Summer	(47.0) ^b	(48.3) ^b	(60.3) ^b	(30.3) ^b	4.1
<i>Eragrostis chloromelas</i>	Winter	(3.5) ^b	(6.0) ^{bc}	(1.8) ^{bc}	(23.8) ^a	2.5
	Summer	(3.5) ^a	(2.3) ^b	(0.3) ^b	(0.3) ^b	1.0
<i>Eragrostis obtuse</i>	Winter	(12.5) ^a	(6.8) ^a	(12.3) ^a	(15.3) ^a	3.0
	Summer	(18.0) ^a	(18.0) ^a	(6.3) ^a	(18.5) ^a	4.9
<i>Forbs</i>	Winter	(1.3) ^a	(3.5) ^a	(0.8) ^a	(4.5) ^a	1.8
	Summer	(1.0) ^a	(2.5) ^b	(1.8) ^b	(3.3) ^b	1.0
<i>Sporobolus africanus</i>	Winter	(2.0) ^a	(4.3) ^a	(3.0) ^a	(2.3) ^a	1.2
	Summer	(0.0) ^a	(4.5) ^a	(2.5) ^a	(0.5) ^a	1.2
<i>Sporobolus fimbriatus</i>	Winter	(6.8) ^a	(10.3) ^a	(14.5) ^a	(21.5) ^a	4.2
	Summer	(4.3) ^b	(4.0) ^b	(4.3) ^b	(14.3) ^a	1.8
<i>Themeda triandra</i>	Winter	(19.5) ^a	(1.3) ^b	(0.5) ^{bc}	(1.0) ^{dc}	2.4
	Summer	(14.5) ^a	(6.5) ^b	(1.8) ^{bc}	(0.0) ^{dc}	2.3

^{ab}Different superscripts for each species in a column denote significant differences at ($P < 0.05$) between season.

4.6.4. Biomass production at Sheshegu communal rangeland

Scattered, Moderate, Dense and Mixed bushlands (in summer) and scattered, dense and mixed bushlands (in winter) showed no significant difference in biomass production ($P > 0.05$). In both winter and summer seasons, Mixed and Scattered bushlands were significantly different from one another ($P < 0.05$). Summer season had more biomass production compared to winter season in three HVUs (Scattered, Dense and Mixed bushland), however, Moderate bushland had more biomass production in the dry season compared to the wet season (Figure. 4.1).

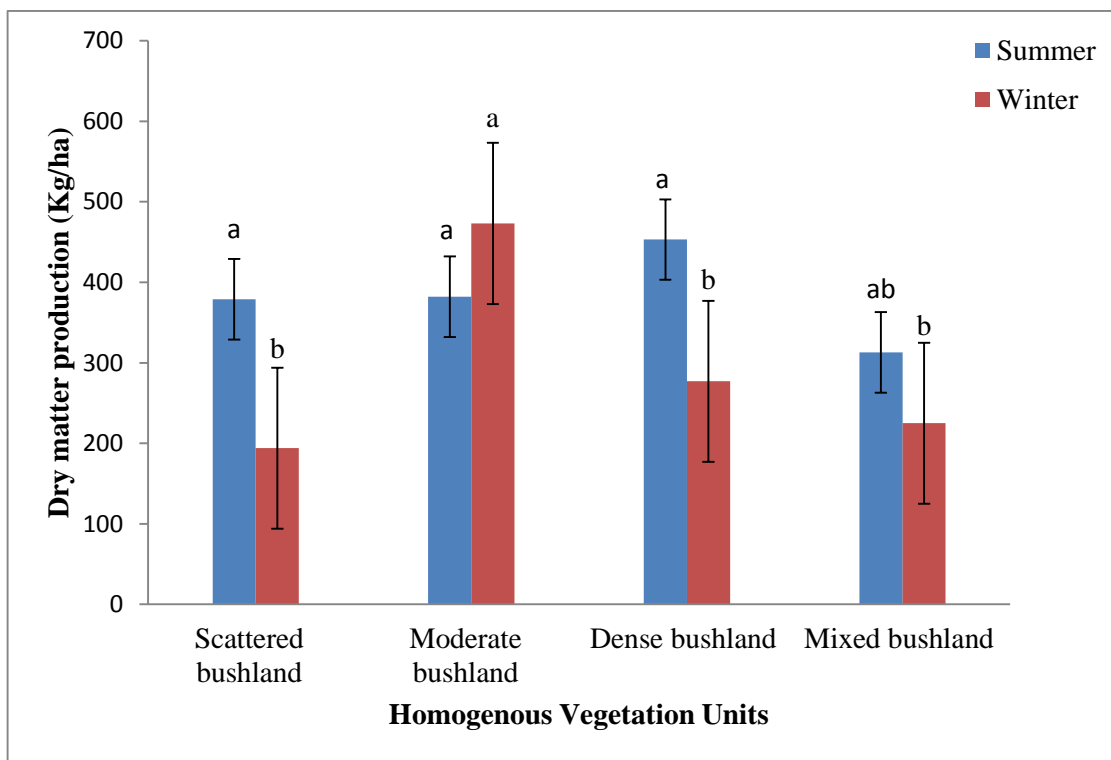


Figure 4.1: Seasonal dry matter production (kg ha^{-1}) in four homogenous vegetation units of Sheshegu communal rangeland. Dry matter production in the various Homogenous Vegetation Units with different superscripts are significantly different ($P < 0.05$).

4.6.5 Basal cover in four homogenous vegetation units of Sheshegu communal rangeland

There was no significant difference ($P>0.05$) in the mean basal cover of Moderate, Dense, Mixed bushland (in summer) and Dense, Mixed bushland (in winter). In both summer and winter scattered, dense and mixed bushland showed significant differences ($P<0.05$). Summer had more basal cover than the winter season. Basal cover increased across seasons from winter to summer (Figure 4.2).

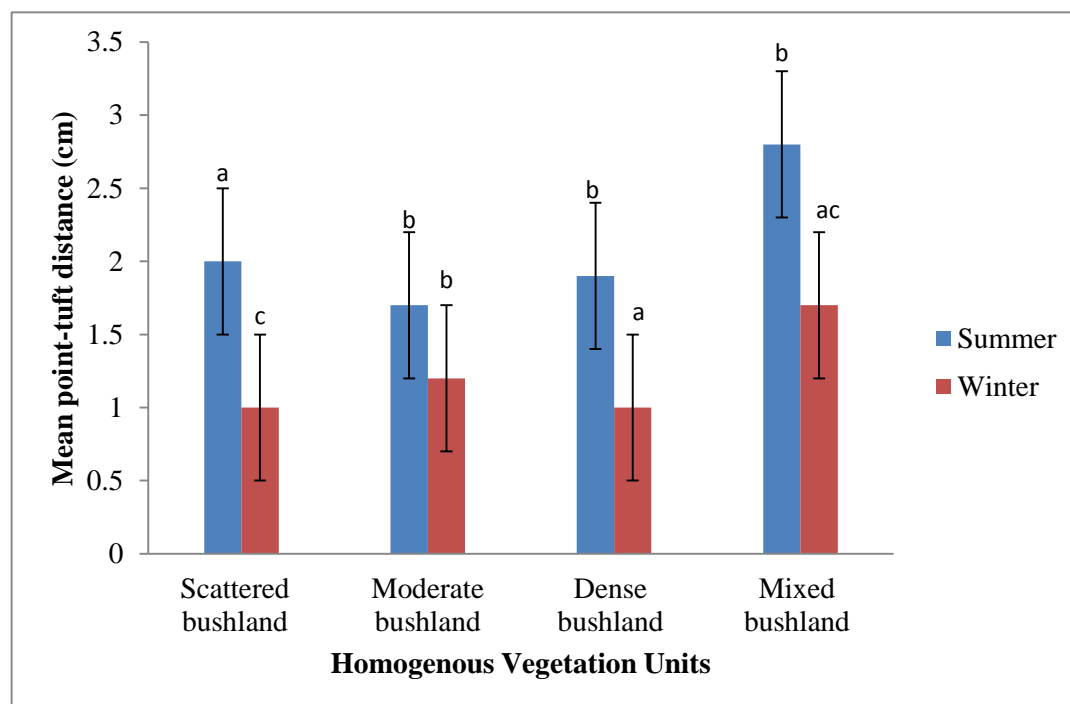


Figure 4.2: Mean basal cover (cm) in scattered, moderate, dense and mixed bushlands of Sheshegu communal rangeland.

4.6.6. Browsing units, woody plant density and tree equivalents of Sheshegu communal rangeland.

The browsing unit of mixed and dense bushland showed no significant difference ($P>0.05$) in both dry and wet seasons. Scattered and Moderate bushland were significantly different among the HVUs. Scattered and moderate bushlands displayed no significant difference ($P>0.05$) (i.e browsing units, plant

density and tree equivalents) while dense and mixed bushlands showed no significant difference ($P>0.05$) (i.e browsing unit, plant density and tree equivalents). Scattered bushland was significantly different ($P<0.05$) (i.e browsing unit, plant density and tree equivalents) among the HVUs. Tree equivalent in all HVU were significantly different ($P<0.05$) in the winter season. However, Moderate and Dense bushland showed no significant difference ($P>0.05$).

Table 4.3: Browsing units, woody plant density and tree equivalents in Scattered, Moderate, Dense and Mixed bushland of Sheshegu communal rangeland.

Species	Season	Scattered bushland	Moderate bushland	Dense bushland	Mixed bushland	±SE	P-value
Browsing units (BU/ha)	Winter	1424 ^b	2284 ^b	3294 ^a	3307 ^a	110	0.001
	Summer	1447 ^b	2745 ^a	3281 ^a	3332 ^a	310	0.003
Density (Plant/ha)	Winter	1425 ^b	2288 ^a	3300 ^a	3313 ^a	111	0.001
	Summer	1475 ^b	3025 ^a	3284 ^a	3335 ^a	302	0.003
Tree equivalents (TE/ha)	Winter	696 ^b	1432 ^a	2528 ^a	2668 ^a	133	0.002
	Summer	718 ^b	1503 ^a	2517 ^a	2685 ^a	94	0.002

Different superscripts across the row denote significant differences ($P<0.05$) between HVUs

4.6.8. Woody species composition in Sheshegu communal rangelands

There were 21 different woody species found in Sheshegu rangeland. These species were classified into two groups i.e. Acceptable (48%) and unacceptable (52%) (Table 4.3.). 43% of these woody plants were identified as thorn species, while 57% were thornless. *Acacia karroo*, *Coddia rudis*, *Maytenus polycantha*, *Aloe ferox*, *Erehia rigida* and *Lucas capensis* were among the six dominant woody species found in the HVU. However, *Acacia Karoo* was the most dominant species (43.2%) with *Diospyros lycioides* (1.1%) and *Scutia myrtina* (1.1%) being the least abundant species.

Table 4.4: Overall mean abundances (%) of herbaceous species composition in Sheshegu communal rangeland. A plus (+) sign indicates acceptability and thorns/spikes of the woody plant, a minus (-) denotes unacceptability of woody species and the absence of spikes on the woody plant.

Species	Acceptability	Thorns/spines	%Abundance
<i>Acacia karoo</i>	+	+	43.2
<i>Azima tetracantha</i>	-	+	3.4
<i>Aloe ferox</i>	-	+	3.7
<i>Brachylaena elliptica</i>	-	-	1.3
<i>Carissa haematocarpa</i>	-	-	2.5
<i>Coddia rudis</i>	-	-	7
<i>Diospyrosis lycioides</i>	-	-	1.1
<i>Erehia rigida</i>	+	-	3.5
<i>Grewia occidentalis</i>	+	-	2.1
<i>Lucas capensis</i>	-	-	7.2
<i>Lycium ferocissimum</i>	-	+	1.4
<i>Maytenus heterophylla</i>	+	+	5.4
<i>Maytenus capitata</i>	+	+	2.3
<i>Maytenus polycantha</i>	+	+	5.6
<i>Opantia ficus- indica</i>	-	+	1.2
<i>Pappea capensis</i>	-	-	1.3
<i>Phyllanthus verrucosus</i>	+	-	1.7
<i>Rhus longispina</i>	+	-	2.0
<i>Rhus refracta</i>	+	-	2.1
<i>Schotia Afra</i>	-	-	0.9
<i>Scutia Myrtina</i>	+	+	1.1

In winter season, all the woody species were significantly different across all the HVUs except *Acacia karoo* ($P>0.05$). In summer, there were significant differences in the abundance of *Maytenus polycantha*, *Erebia rigida* and *Lucas capensis* across all HVUs while *Coddia rudis* and *Aloe ferox* showed no significant differences ($P>0.05$) in the Moderate and Scattered bushlands. *Acacia karoo* showed no significant difference in Dense and Scattered HVUs in the summer season ($P>0.05$).

Table 4.5: Mean (\pm S.E) abundances of 6 common woody species in homogenous vegetation units.

Species	Season	Scattered bushland	Moderate bushland	Dense bushland	Mixed bushland
<i>Acacia karoo</i>	Winter	63.8(3.3) ^a	62.2(3.3) ^a	46.0(3.3) ^b	5.5(3.3) ^c
	Summer	87.8(5.1) ^a	78.0(5.1) ^b	95(5.1) ^a	7.5(5.1) ^c
<i>Aloe ferox</i>	Winter	6.0(1.4) ^b	1.5(1.4) ^d	3.3(1.4) ^c	13.5(1.4) ^a
	Summer	0.0(2.1) ^a	4.0(2.4) ^a	0.0(2.1) ^a	5.5(2.1) ^a
<i>Coddia.rudis</i>	Winter	4.3(1.4) ^b	2.0(1.4) ^d	4.5(1.4) ^c	13.5(1.4) ^a
	Summer	6.5(2.2) ^b	6.3(2.6) ^b	1.0(2.2) ^c	15.5(2.2) ^a
<i>Lucas capensis</i>	Winter	4.5(1.0) ^b	2.7(1.0) ^c	2.5(1.0) ^d	14.2(1.0) ^a
	Summer	1.5(1.1) ^b	0.7(1.3) ^d	1.0(2.2) ^c	5.5(2.2) ^a
<i>Erebia rigida</i>	Winter	3.3(1.3) ^c	1.0(1.3) ^d	4.0(1.3) ^b	4.2(1.3) ^a
	Summer	2.8(1.6) ^c	3.0(1.8) ^b	0.0(1.6) ^d	12.8(1.6) ^a
<i>Maytenus polycantha</i>	Winter	2.2(2.4) ^b	3.0(2.4) ^a	2.0(2.4) ^b	8.0(2.4) ^c
	Summer	0.0(1.3) ^d	3.0(1.5) ^b	0.5(1.3) ^c	14.3(1.3) ^a

^{ab}Different superscripts for each species in a column denote significant differences at ($P< 0.05$) between seasons.

4.7. Discussion

4.7.1. Herbaceous species composition

In this study, nineteen herbaceous species were recorded in Sheshegu communal rangeland, and this rangeland comprised 68.4% Increaser II species (*Eragrostis obtuse*, *Eragrostis congesta* and *Sporobolus fimbriatus*), 26.3% Decreaser species (*Digitaria eriantha* and *Themeda triandra*), 5.3% Increaser I and 5.3% karoo and forbs as shown in (Table 4.1). Scattered bushland was dominated by a decreaser species (*Themeda triandra*) while Moderate bushland, Mixed bushland and Dense bushland were dominated mostly by increaser species. Higgins *et al.* (2000) reported that interaction between woody plants and herbaceous vegetation in rangeland ecosystems is always controlled by very complex interactions such as disturbance regimes (Fire suppression and overutilization of range resources), climate change (drought, amount and seasonality of the precipitation) and soil (depth, pH, texture). A change of one or more of these factors could result in a change in tree-grass ratio. Scholes and Archer (1996) reported that the balance between woody plants and herbaceous vegetation can be easily influenced by rainfall availability, which determines the quantity of biomass production in an ecosystem. According to Fuhlendorf *et al.* (1996), heavy grazing and exclusion of both fire and browsers can accelerate the change of herbaceous species composition to woodland,

Low biomass production on Scattered bushland (573 kg/ha) indicated that the rangeland had undergone some over-utilization. This over-utilization can also be attributed to the fact that the Scattered bushland was dominated by decreaser species. On the other hand, Moderate, Mixed and Dense bushlands were dominated by increaser species. The Dense and Moderate bushlands showed no significant difference ($P>0.05$) in biomass production irrespective of the season (Figure 4.1). Abundance of decreaser species in Scattered bushland indicated that the rangeland condition was good in previous years but, decreaser species tend to decrease if the range is overutilised or underutilized (Botha, 1999). On the other hand, species like *Eragrostis obtuse* and *Aristida congesta* (Increaser II species) increased with increase in bush density in Mixed and Dense bushlands. Loss of palatable species in Sheshegu communal rangeland is an indication of poor range management. This left unchecked can lead to a gradual increase in woody species at the detriment of herbaceous species (Ward, 2005). The loss of highly acceptable grass species and the reduction of forage production also indicates veld deterioration (Ward, 2005).

Complex ownership, free access to rangeland, uncontrolled grazing due to vandalized fences from camps and erratic rainfall were the most important reported challenges faced by Sheshegu communal farmers (Chapter 3: Farmers' perceptions). Similar findings were also reported by Goqwana and Trollope (2003), these authors reported that poor grazing management, and complex ownership can lead to poor rangeland conditions in communal areas.

Low biomass production in Scattered bushland could be attributed to heavy grazing due to low bush density of *Acacia karroo* that allows grazers access to forage material. On other hand, Mixed and Dense bushlands have high bush densities as compared to the Scattered and Moderate bushland, this makes access to forage materials by livestock more difficult. The assessment of rangeland species composition and other ecological changes are very crucial because species richness provide a clear image of previous rangeland management (Whalley and Hardy, 2000). Therefore the results from this study indicated that there was mismanagement of rangeland resources in Sheshegu communal due to changes in species composition from Decreaser to Increaser species. Tessema *et al.* (2011) presented similar findings that inappropriate grazing regimes may result in a replacement or complete disappearance of palatable species with less palatable ones. Savadogo *et al.* (2006) also reported that continuous grazing in communal rangelands changes the plant distribution and gradually reduce the proportion of palatable perennials with annual species such as *Aristida congesta*. Loss of perennial plants arises from the fact that perennial species are more sensitive to overgrazing. Furthermore, continuous grazing promotes soil compaction which results in poor soil water infiltration and removal of the apical meristems of plants which limit the regrowth of the plant. The recovery of plant from overutilization is always determined by time of grazing animal spent on grazing and frequency of grazing. Selective grazing by livestock also contributes to the shift in species composition. According to Oztas *et al.* (2003) and Maki *et al.* (2007), selective grazing is more common in communal rangelands due to the fact that in communal areas fences around grazing camps are not maintained allowing free entry of all types of livestock whose presence greatly influence changes in herbaceous species composition. This study has shown that Increaser species are more tolerance to woody plant suppression in comparison to Decreaser species (Table 4.1). This is in agreement with Angassa (2012) who reported that there were more Increaser species on bush encroached rangelands.

4.7.2. Biomass production and ground cover of Sheshegu communal rangeland

This study has shown that wet season had more forage production than the dry season as indicated in (Figure 4.1). This could be attributed to the variation of rainfall and temperatures between winter and summer seasons. Summer have high rainfall as compared to winter season. High rainfall and temperatures in summer usual promotes an increase of leaf surface area and leaf production which may result in high biomass production and good basal cover (Ward, 2005). Angassa and Oba (2010) reported that forage production varies from season to season but, under proper rangeland management, wet seasons usual have high biomass yield with good soil cover compared to dry season in communal rangelands of the Eastern Cape. Forage production and basal cover can be easily influenced by poor rangeland management practices.

Forage production of Scattered bushland (573 kg/ha) and Mixed bushland (538 kg/ha) showed no significant difference ($P>0.05$) while Moderate bushland (855kg/ha) and Dense bushland (730 kg/ha) showed significant differences ($P<0.05$). Basically, these findings showed that biomass production is increasing from interspacing trees to dense bush even though the quantity of biomass yield in all HVUs were less than the recommended standards. Teague *et al.* (2009) reported that if biomass yield falls below 1500kg/ha, rangeland is not in a good condition. This indicates that Sheshegu communal rangeland is not in good condition and cannot sustain grazers, unless control measures are put in place. These results were similar to that of Le Houero (1980) who reported that interspacing trees produce less forage than dense woody vegetation. This could be attributed to the fact that Dense and Mixed bushland have close trees cover making access to forage by grazers difficult

Furthermore, this study has shown that an increase of woody plants, particularly *Acacia karroo* (leguminous tree) has a positive impact on biomass production. The HVUs (i.e Moderate and Dense bushland) that were dominated by *Acacia karroo* had high biomass production compared to Scattered bush land (dominated by young trees of *Acacia karroo*) and Mixed bushland (dominated by *Coddia rudis*, *Aloe ferox*, *Lucas capensis*, *Erihia rigida*, *Maytenus polycantha* and *Acacia karroo*). High biomass production in these sites could be caused by the fact that woody plants have the ability to facilitate the forage production by shifting resource availability and microclimatic conditions through provision of grasses refuge from grazing animals. Abundance of woody plants can

also influence soil water redistribution in the landscape (Weltzin and McPherson, 1997). Many ecologists (Belsky *et al.*, 1989; Belsky, 1994; Ludwing *et al.*, 2001; Xu *et al.*, 2012) observed that woody plants have the ability to extract water from deeper soil layers through hydraulic lift process and also woody plants can produce shade to hamper the growth of grasses. However, the extent to which the positive effects of woody species offset the negative effects is unclear.

4.7.3. Woody plant species composition

Sheshegu communal rangeland is dominated by highly acceptable woody plant species such as *Acacia karroo*, *Coddia rudis*, *Maytenus polycantha*, *Aloe ferox*, *Erehia rigida* and *Lucas capensis*) as shown in Table 4.4. *Acacia karroo* is most dominant species in the communal rangeland of the Eastern Cape and this species becoming a threat to communal farmers due to the fact that it reduces grazing capacity. This was reported by Aucamp (1976), who observed that *Acacia karroo* is a big threat to communal rangeland across the Province of the Eastern Cape. Most ecologists have identified *Acacia karroo* as a threat to livestock production because of their negative impact on rangeland grazing capacity (Ward, 2005).

On the other hand, herbaceous species can benefit from the encroachment of leguminous trees such as *Acacia karroo* (Scholes and Archer, 1996). Leguminous species as *Acacia karroo* which is known as a nitrogen fixer (Stuart-Hill and Tainton, 1989) is capable of extracting water and soil nutrients from deeper soil layers making nutrients accessible to grasses through the decomposition of defoliated tree parts (Simmons *et al.*, 2008; Dube *et al.*, 2010). The replacement of palatable grass sward by less palatable ones is faster under high bush density than low bush density. Similar trend was observed by Oba and Kotile (2001), these authors observed that bush encroachment promotes changes in species richness.

4.7.4. Woody plant tree equivalent, browsing units and bush density

The mean bush density of Moderate bushland (2288 plant/ha in winter and 3025 plant/ha in summer), mixed bushland (3313 plant/ha in winter and 3335 plant/ha in summer) and Dense bushland (3300 plant/ha in winter and 3284 plant/ha in summer) showed no significant difference ($P > 0.05$), while Scattered bushland (1425 plant/ha in winter and 1475 plants/hectare in summer) was significantly different ($P < 0.05$) as compared to other HVUs in both winter and summer season (Table 4.3). This

indicates that, there was no seasonal effect on bush density (plant/ha), tree equivalent (TE/ha) and browsing unit. Moderate, Mixed and Dense bushlands are encroached according to set thresholds of some authors (Roques *et al.*, 2001; Gemedo *et al.*, 2006; Abate *et al.*, 2012). 2,400 woody plants per hectare have been reported by these authors to be the threshold between encroached and non-encroached areas. Richter *et al.* (2001) however indicated a threshold of 2500 trees equivalent (TE/ha). The mean tree equivalent of Dense bushland (2528 TE/ha in winter and 2517 TE/ha in summer) and Mixed bushland (2668 TE/ha in winter and 2685 TE/ha in summer) exceeded the 2500 TE/ha threshold, hence these two HVUs are encroached. On the hand, Scattered bushland (696 TE/ha in winter and 718 TE/ha in summer) and Moderate bushland (1432 TE/ha in winter and 1503 TE/ha in summer) had less than 2500 tree equivalent per hectare, therefore these areas were not encroached contrary to the report by Roques *et al.*(2001). Smit and Rethmann (1998) reported that rapid increase of woody plants beyond a critical limit lead to the decline of both grazing capacity and forage production because of the severe competition between woody plants and herbaceous vegetation for soil resources. The density of woody plants alone cannot be considered as solitary factor that can affect the competition of soil resources against herbaceous vegetation (Abule *et al.*, 2007).

Results of this study have shown that there is a negative relationship between the abundance of palatable grass species, forage production and woody plant density. This relationship is in sharp contrast with that of abundance and basal cover. The decline of palatable grasses and forage production can also be influenced by factors such as poor grazing management and climate viz; rainfall availability and drought. Aucamp *et al.* (1983) reported a different trend between tree density and forage production indicating that there is a positive relationship between tree density and forage production until it reaches a point where the woody species begin to suppress grass growth.

Uncontrolled grazing, lack of veld resting which leads to overgrazing, high selective grazing and communal veld ownership lead to fewer ownership of sheep and goats although livestock production plays a crucial role in supporting their livelihoods. Dziba *et al.* (2003) reported similar findings that livestock plays an important role across the Province of the Eastern Cape. The current state of Sheshegu communal rangeland forces farmers to keep goats due to the fact that goats can easily adjust under encroached areas. Goats can also adapt to different climatic conditions and have the ability to control coppices of *Acacia karroo* (Ward, 2005). Coppices usual grow after application of fire, however biomass

production of Sheshegu rangeland is not sufficient to support fire ignition. Fire can be applicable at Sheshegu communal rangeland only if the fuel load is sufficient to support fire ignition.

4.8. Conclusion

This study revealed the Sheshegu communal rangeland was encroached and was dominated by leguminous trees (*Acacia karoo*) and the increase of this species has resulted in the shift of herbeceous species composition. The shift of Decreaser species (*Themeda triandra*) to increaser species (*Aristida congesta*) were increasing with increase in the abundance of woody plants. However, the biomass production and soil cover increases with increase in bush density (Scattered had low biomass production compared to Mixed, Moderate and Dense bushland). The trend between biomass production and soil cover can easily be influenced by overgrazing and the defence mechanism of *Acacia karoo* against herbivores (*Acacia karoo*) can be restrict animals from grazing where there is high density of it). Therefore, it was concluded that the current state of veld condition of Sheshegu rangeland is not suitable for grazing animals due to the fact that the shift of herbaceous species has resulted in the replacement of palatable species by unpalatable ones. While goat production is favoured by abundance of *Acacia karoo* . it was recommended that government should intervene with appropriate rangeland recovery interventions to save the communal land from further decline.

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CHAPTER 5 SOIL NUTRIENT STATUS ACROSS HOMOGENOUS VEGETATION UNITS IN SHESHEGU

Abstract

Vegetation structure and its botanical composition of rangelands are determined by soil nutrients. The objective of this study was to determine the effects of bush encroachment on soil nutrient content. The effect of bush encroachment on soil nutrients was assessed in four levels of encroachment viz Scattered, Moderate, Mixed and Dense bushlands at Sheshegu communal rangeland. Five samples per site were sampled at 20cm using soil auger. Soil samples were analysed for macro-elements (nitrogen, phosphorous, potassium, magnesium, sulphur and sodium), micro-elements (copper, iron, manganese and Znic), soil organic carbon and soil pH. Macro-elements were analysed using ICP analysis of soil with 1% critic acid. N was analyzed using a standard Kjeldahl method. Micro-elements were determined through ICP in 0.02M DI-ammonium EDTA soil extracts. Organic Carbon was analyzed according to the Waltley-Black method, and soil pH was analyzed using 1M potassium chloride (kcl) 2.5 kcl: 1 soil. Higher concentration of nitrogen was observed in dense bushland (1.28%) and the lowest (1.11%) was observed in Mixed bushland; Scattered and Dense bushlands were significantly different ($P < 0.05$). Scattered and dense bushlands showed no significance different ($P > 0.05$) on the concentration of organic carbon content while Moderate and Mixed bushlands were significantly different ($P < 0.05$) compared to other sites. Potassium, phosphorous, magnesium, sodium and sulphur showed no significant differences ($P > 0.05$) across all sites. The concentrations of copper, magnesium, and zinc showed no significant differences ($P > 0.05$) in all sites. The concentrations iron were significantly different ($P < 0.05$) between mixed and dense bushland while other sites showed no significant differences ($P > 0.05$). Soil pH was higher in dense bushland (6.00) while in Scattered bushland, soil pH was lower (5.80). Soil pH, sodium and sulphur revealed that Sheshegu communal rangeland is lightly acidic, but soil pH increases with increase in bush density. On the other hand, iron concentration decreased with increase in bush density.

Key words: Soil macro-nutrients, micro-nutrients, soil pH and Homogenous Vegetation Units

5.1. Introduction

Soil nutrients play a vital role in tree-grass interaction, and these nutrients include trace, micro and macro elements cation exchange (CEC), nutrients and exchangeable bases, and these soil nutrients are known as determinants of vegetation productivity and species composition (Smit, 2004). Soil nutrients play a very crucial role in plant nutrition (Smit, 2004). Soil texture and soil moisture content are also known as determinants of tree-grass interaction due to their influence on soil nutrient composition (Britz and Ward, 2007). According to Kraaji and Ward (2006), soil nutrient content can be influenced by fire frequency and grass system in communal areas. Furthermore, soil plays a very crucial role in nutrient cycling, which improves soil properties such as physical, chemical and biological properties; these soil properties are known as soil indicators (Li *et al.*, 2007). Therefore, soil nutrient assessment is vital in order to understand the functional capacity of the soil. Under poor rangeland management, soil properties can be easily modified (Mojiri *et al.*, 2012). Soil organic matter (OM) has been recognized as an indicator of soil fertility because of its contribution to soil properties which influence soil quality (Hopmans *et al.*, 2005). According to Corwin *et al.* (2003), soil quality is the capability of the soil to function within an ecosystem in order to maintain a healthy environment and sustain biological productivity by promoting the growth and development of both plants and animals in ecosystem.

Soil pH can also influence the growth medium of plants; high or low levels of alkalinity or acidity could have a negative impact on the soil environment and can lead to poor vegetation production. Extremely low or high soil pH values can also influence the availability, solubility of soil nutrients and its absorption by plants. Deficiency of soil minerals or extremely low or high soil pH can result in changes in species composition (Rezaei and Gilkes, 2005). The deficiency of soil nutrient in forage tends to display the same shortage in animals feeding on that forage. This proves that there is a strong interaction between soil, animals and rangeland species diversity and conditions (Khan *et al.*, 2006). Many studies have been conducted on the influence of soil properties, but the influence of bush encroachment on soil nutrient content is poorly documented in communal rangelands. Soil nutrient content plays a vital role in tree-grass interaction within an ecosystem (Ward, 2005; Britz and Ward, 2007). Smit (2004) reported that soil nutrients, including nitrates, phosphorous, a series of anions and cations and other various trace elements, are very crucial for the growth and development of plants and determine the botanical composition and rangeland productivity. Therefore, there is a gap in literature which addresses the

impact of bush encroachment on soil nutrient status in communal rangelands of the Eastern Cape in South Africa.

5.2. Materials and methods

5.2.1. Soil sampling and chemical analysis

The study was conducted at Sheshegu communal rangeland in Alice Town. A total of five soil samples per site were collected at a depth of 20cm using a soil auger. The Completely Randomised Design (CRD) was used. Soil samples were oven-dried for 48 hours at 60⁰C and milled to pass through using a 2mm sieve. Soil samples were analyzed for soil pH, microelements zinc (Zn), manganese (Mn), copper (Cu), iron (Fe) and macroelements as nitrogen (N), magnesium (Mg), potassium (K), phosphorus (P) and soil organic carbon (OC). Soil pH was determined in 1M potassium chloride (kcl) 2.5 kcl: 1 soil (ALASA, 1998). Available Zn, Mn and Cu were determined by using Inductively Coupled Plasma (ICP) in 0.02M DI-ammonium EDTA soil extracts (ALASA, 1998). Available soil P, Mg and K were determined by the Inductively Coupled Plasma (ICP) analysis of soil with 1% critic acid (ALASA, 1998). Nitrogen was determined by using the standard Kjeldahl method using a block digester (Bremner and Breitenbeck, 1983). Organic carbon was analyzed using the Waltley-Black method (Nelson and Somers, 1982).

5.3. Statistical analysis

A Fischer least test and analysis of variance were employed using SAS (1999) to find significant differences on the mean concentrations of each nutrient between homogenous vegetation units. The significant differences between means were recognized at a confidence level of 90 % ($P < 0.05$).

5.4. Results

5.4.1 Soil macro nutrients in Sheshegu communal rangeland

Table 5.1 presents macro elements status of the Sheshegu communal rangeland. Higher concentration of nitrogen between the HVUs was observed in Dense bushland (1.28%), and the lowest (1.11%) concentration was observed in Mixed bushland. Nitrogen content in Dense bushland and Scattered bushland were significantly different ($P<0.05$). Soil C showed no significant difference ($P>0.05$) between Scattered and Dense bushlands while Moderate and Mixed bushlands were different compared to other HVUs. The C content between Moderate and Mixed bushland were also significantly different ($P<0.05$). The concentration of K, P, Mg, Na and S showed no significant differences ($P>0.05$) across all HVUs. The concentrations of S and Na increased with increasing bush density while other soil elements showed no clear trend across all HVUs.

Table 5.1: Soil macro elements across HVUs in Sheshegu communal rangeland

Minerals	Scattered bushland	Moderate bushland	Mixed bushland	Dense bushland	±SE
N (%)	0.17 ^a	0.23 ^{bd}	0.11 ^{bc}	1.28 ^a	0.03
OC (%)	1.20 ^a	1.03 ^b	0.89 ^c	1.27 ^a	0.04
K (mg/kg)	210.34 ^a	184.80 ^a	226.90 ^a	174.00 ^a	16.16
P (mg/kg)	24.00 ^a	22.20 ^a	21.95 ^a	17.70 ^a	12.89
Mg (cmol (+) /kg)	1.36 ^a	1.54 ^a	1.30 ^a	1.48 ^a	0.16
Na (mg/kg)	34.60 ^a	40.40 ^a	50.90 ^a	44.70 ^a	11.11
S (mg/kg)	17.52 ^a	18.69 ^a	20.02 ^a	24.50 ^a	16.12

Different superscripts across the row indicate significant differences ($P<0.05$) on each soil nutrient.

5.4.2. Soil micro nutrients in Sheshegu communal rangeland

Table 5.2 presents the micronutrient status and soil pH of Sheshegu communal rangeland. The concentrations of copper (Cu), manganese (Mn) and zinc (Zn) showed no significant difference ($P>0.05$) between all homogenous vegetation units. Iron (Fe) concentrations were significantly different ($P<0.05$) between Mixed and Dense bushland, while Scattered and Moderate bushland showed no significant difference ($P>0.05$). The concentration of manganese and iron were high while zinc (Zn) and copper (Cu) were lower. Soil pH showed no significant difference ($P>0.05$) in all HVUs. Soil pH concentration was higher in Dense bushland (6.00) while in Scattered bushland, soil pH was lower (5.80) (Table 5.2). The increase in soil pH with bush density indicates that there is a positive relationship between woody plant density and soil pH across all HVUs.

Table 5.2: Soil micro elements and soil pH across HVUs in Sheshegu communal rangeland.

Minerals	Scattered bushland	Moderate bushland	Mixed bushland	Dense bushland	±SE
Cu (mg/kg)	2.37 ^a	1.56 ^a	1.50 ^a	1.37 ^a	0.35
Fe (mg/kg)	123.16 ^a	117.85 ^a	86.55 ^b	8.98 ^c	9.76
Mn(mg/kg)	160.01 ^a	227.79 ^a	243.36 ^a	203.04 ^a	50.24
Zn (mg/kg)	0.85 ^a	0.99 ^a	0.78 ^a	0.82 ^a	0.13
pH(KCl)	5.80 ^a	5.95 ^a	5.90 ^a	6.00 ^a	0.20

Different superscripts across the row indicate significant differences ($P<0.05$) on each soil nutrient

5.5. Discussion

5.5.1. The effects of homogenous vegetation units on soil nutrient composition and pH.

Soil is composed of numerous nutrients such as micro and macro elements, and these nutrients play a very important role in both growth and development of plants. Soil nutrients also play a crucial role in determine the forage quality and the vegetation composition (Tiedemann and Lopez, 2004; Hagos and Smit, 2005). Gwelo (2012) indicated that soil minerals indirectly form the main source of nutrition for livestock in communal areas of Eastern Cape. Table 5.1 from this study shows a positive trend of soil carbon increases from Scattered to Dense bushlands. High levels of organic carbon could be attributed to the increase in microbial activities and high accumulation of dead material under tree canopies. This is in harmony with the report by Gemedo *et al.* (2006). Retallack (2001) also indicated that soil carbon increases from interspacing trees to dense bush due to the fact that under high density there is high soil moisture content and accumulation of dead materials. Therefore this suggests that soil carbon is determined by the rate of decomposition of plant litter and is also influenced by soil moisture content (Retallack, 2001; Gemedo *et al.*, 2006).

N concentration showed a similar trend as OC. This could be attributed to the fact that Sheshegu rangeland is dominated by leguminous (*Acacia karroo*). This species is also known to fix nitrogen, (Rasaei *et al.*, 2012). In so doing, *Acacia karroo* brings additional nitrogen into the soil ecosystem. However, Vitousek *et al.* (2002) reported that abundance *Acacia* species in an ecosystem tend to have a suppressive effect of P abundance. Concentration of P decreases with increasing bush density as shown in this study. This suggests that these results are similar with that of Vitousek *et al.* (2002). There was no definite observed trend between potassium and magnesium concentrations across HVUs. This can be attributable to the fact that these soil nutrients are soluble and can be easily leached under high precipitation. Schlesinger and Pilmanis (1998) reported that concentrations of potassium tend to be higher under encroached area in savannas while other authors have reported that the concentrations of soil carbon, nitrogen, phosphorus and other cations are higher under tree canopies (Belsky *et al.*, 1989; Scholes and Archer, 1997).

The accumulation of soil nutrients under dense tree canopies can be influenced by the age, size and the height of encroaching woody plants (Treydte *et al.*, 2008) and the abundance of N concentration is doubled under tree canopies (Belsky *et al.*, 1989; Scholes and Archer 1997). Na and S concentration increased with increasing bush density as recorded in this study. These findings were in line with that of Schlesinger and Pilmanis (1998) who reported that the concentrations of sodium (Na) and sulphur (S) increases from slightly encroached to densely encroached areas. Schlesinger and Pilmanis (1998) reported that in savanna communal rangelands, soil nutrient content increases rapidly under tree canopies as compared to open grasslands. Abdullah *et al.* (2008) observed that individual trees tend to have high abundances of N, P, K, Mg, and Na under dense bushes compared to open grasslands bushes.

High concentration of both Cu and iron was observed in Scattered bushland and Mn and Zn increases with increase in bush density. However Keilman (1979) reported similar trend and this author stated that this trend arise from the fact that woody plants have tap root which allows them to extract these elements from deeper soil profiles. However, the abundance of elements can be easy influenced by the soil alkalinity or acidity (Keilman, 1979; Scholes, 1990). In this study, all HVUs (Scattered, Moderate, Mixed and Dense bushland) showed no significant difference ($P>0.05$) in soil pH (Table 5.2). All HVUs reflected an acidic state due to the fact that all HVUs comprised soil pH ranging from 5.80 to 6.00. Acidic state of Sheshegu communal rangeland can be attributed to inadequate rainfall. Soil pH can be influenced by rainfall, soil organic matter and soil parent material (Craul, 1985; Harris, 1992). Soil fertility was also affected due to the fact that under woody plants, dominant soil pH tends to be lower because of leaching of volatile acids from the foliage of woody plants (Whitford, 1992). Therefore, this improves soil mobility and usually increases the abundance of soil C and N pool (Schlesinger and Pilmanis, 1998).

5.6. Conclusion

The results from this study have showed that soil pH and nitrogen increases with increase in bush density. However, this trend could be influenced by the fact that Sheshegu communal rangeland is dominated by *Acacia karoo* which has ability to fix nitrogen. Furthermore, this study revealed that there was no clear trend between other soil nutrients and difference the abundance of micro and macro elements and soil pH in rangeland ecosystems such as fire and availability of rainfall. The influence of bush encroachment on soil nutrient composition is complex. Therefore, it was recommended that more studies or long term trials are needed to explore the effect of bush density on soil nutrient status further.

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CHAPTER 6 GENERAL DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

6.1. General Discussion

This study has revealed that bush density is increasing gradually in Sheshegu rangeland, and this has resulted in bush encroachment. Increase of woody plants beyond 2500 plants/hectare has resulted in a reduction of forage production and gradual change of species composition. There is the replacement or complete disappearance of palatable herbaceous species such as *Digitaria eriantha* and *Themeda triandra*. This study has also revealed that Scattered bushland is dominated by palatable species, and these species decrease with increase in bush density. Farmers' perceptions from this study revealed that communal farmers have observed this shift of the vegetation. *Acacia karroo* was identified as the most encroaching woody plant species in Sheshegu rangeland. Similar findings were also presented by Moyo *et al.* (2013) in communal rangelands of the Eastern Cape Province in South Africa.

The results from this study showed that there is a positive relationship between woody plants and biomass production. Biomass increases with increase in bush density, but poor grazing management system might have an influence in this trend. The trend of biomass production, in relation to woody plants, was not expected due to the fact that Scattered bushland has less bush density compared to others sites. Furthermore, Scattered bushland consists of Decreaser species (palatable species) which are known as perennial species with big tuft diameters which provide good soil cover with high forage production, however, this was vice versa in Sheshegu rangeland. Sheshegu communal rangeland is more prone to land degradation because biomass production in all HVUs was below the recommended threshold (1500kg ha⁻¹) according to Teague *et al.* (2009). Biomass production in Sheshegu communal rangeland can be influenced by both poor grazing management and bush encroachment. Moreover, feed preference of grazers can also play a part in this regard. Dense and Mixed bushlands has more biomass compared to Scattered and Moderate due to fact that high bush density restricts grazers from grazing forage between the trees. Similar findings were reported by Moleele *et al.* (2002). Moleele *et al.* (2002) reported that some of the encroaching species are not acceptable to browsers because some of these species have ability to defend themselves against herbivores through chemical or physical mechanisms. Cattle and sheep producers reported that bush encroachment is the main threat to their rangeland because bush

encroachment reduces grazing capacity. However, goat producers reported that bush encroachment has no negative effect on their production because *Acacia karroo* encroachment favours goat production. Rangeland conditions at Sheshegu are driving grazer producers to change their production system to browser production system. This arises from the fact that goats have an ability to feed on woody plants. Goats also are capable of feeding on woody plants because they contain high concentrations of tannins and phenolic compounds (Aganga *et al.*, 1998). On the other hand, sheep farmers reported that bush encroachment has a negative impact on wool quality.

Prolonged drought and poor application of veld management practices such as veld resting and veld burning are highly recognized as the driving forces of the poor rangeland (Angasa, 2005; Ward, 2005). Most of the Sheshegu communal farmers reported that unreliable rainfall and long drought has resulted in veld deterioration and poor livestock performance. This was supported by Angassa (2005) who stated that erratic precipitation and anthropogenic factors such as heavy grazing and poor application of fire could increase woody plant density.

Repeated removal of herbaceous vegetation through heavy grazing in the Sheshegu communal rangeland may result in reduced competitive ability of grasses against woody plants. Therefore, reduced biomass production results in low fuel load which is required for fire ignition; under such a condition, fire alone cannot be able to control bush encroachment. These findings revealed that there is a common understanding between the communal farmers' perceptions and scientific knowledge, but in communal rangelands, there is very poor application of veld management practices due to complex ownership and multi-production systems. On the other hand, these findings showed that Sheshegu communal farmers have a poor understanding of the soil functional capacity of their rangeland. The effect of bush encroachment on both micro and macro nutrients varies, and there was no constant trend among these elements. However, soil pH increases from interspacing (Scattered) to Dense bushland.

6.2. Conclusions

Sheshegu communal farmers have a good understanding of vegetation and livestock dynamics. Farmers' perceptions, according to this study indicated that the Sheshegu rangeland was formerly grassland dominated by palatable grass species, but currently, this rangeland has changed to encroached savanna. Communal farmers further perceived that *Acacia karroo* is the most encroaching woody species. The

perceptions of rangeland conditions were different due to the fact that some communal farmers prefer to rear goats whereas others prefer cattle and sheep. Sheep and cattle were not favoured by the changing rangeland condition but goats farmers were content with the situation. It was hypothesized that there were no differences in herbaceous species composition, biomass production, soil cover and soil nutrient content between Scattered, Moderate, Mixed and Dense bushlands. This hypothesis has been rejected due to fact that there is a variation between homogenous vegetation units among the parameters that were quantified.

6.3. Recommendations

Due to multi-production systems and free access to rangelands of Sheshegu community, it was recommended that communal farmers should formulate rangeland rules and regulations to manage rangeland resources. Rangeland rules and regulations should be based on the management of livestock movements and harvesting of rangeland resources. The Department of Agriculture and Fisheries should also provide workshops or training to communal farmers on different approaches or cheap ways of reducing bush encroachment and conserving rangeland resources.

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APPENDICES

Appendix A: Questionnaire used to interview farmers at Sheshegu communal area

EVALUATING FARMER’S PERCEPTIONS AND ASSESSING IMPACT OF BUSH ENCROACHMENT ON HERBACEOUS VEGETATION AND SOIL NUTRIENT CONTENT IN COMMUNAL RANGELANDS OF THE EASTERN CAPE, SOUTH AFRICA



The objective of the survey is to investigate indigenous knowledge and farmer’s perceptions on the impact bush encroachment on their communal rangelands

Name of interviewer.....Date.....Village.....

Name of respondent.....Questionnaire reference number.....

INSTRUCTIONS: Fill in the relevant information and where possible mark with an X

DEMOGRAPHIC INFORMATION

A.1 Gender

Male		Female	
------	--	--------	--

A.2 Age

Age	15-30	30-40	40-50	Above 50
Mark with an X				

A.3 Marital status

Marital status	Single	Married	Widowed	Divorced
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Mark with an X				
-----------------------	--	--	--	--

A.4 Household size

Number of adults	Number of children (<21 years)

A.5 Level of education

Levels of education	Primary school	Secondary school	Tertiary education	Other
Mark with X				

A.6. Occupation

Occupation	House wife	Farming	employee	Pensioner	business	Other
Mark with X						

A.7. Primary source of income.

Sources of income	Mark with X
Livestock production	
Crop production	
Work	
Other	

LIVESTOCK POPULATION

B.1 Livestock types and numbers

Livestock type	Numbers			
Cattle	Bulls	Cows & heifers	Calves	total

Livestock type	Numbers			
Sheep	Ram	ewe	lambs	total

Livestock type	Numbers			
Goats	Buck	Boer	kids	total

B.2. What is your purpose for keeping livestock? (In order of importance 1= most important, 5=least important)

Purposes	mark with X	Rank
Meat		
Sale		
Lobola		
Milk		
Traction		
Status		

B.3 What trend did you observed on livestock population for the past 10-20 years?

Trend	Increasing	Decreasing	Remain same
Mark with X			

B.4 What challenges are you facing in raising livestock? (1= most important, 5= Least important).

Challenges	mark with X	Rank
Shortage of forage		
Lack of water points/dams		
Predators		
Animal diseases		

Stock theft		
-------------	--	--

B.5. Which type of livestock do you prefer to keep? Grazers [] or browsers [] and why?

.....

B.6. Which type of livestock is currently increasing? Grazers [] or browsers [] and what could be the reason such an increase?

.....

B.7. Which type of livestock is currently decreasing? Grazers [] or browsers [] and what could be the reason for such a decrease?

.....

GRAZING MANAGEMENT

C.1 What type of grazing systems do you practice in your rangeland?

Types of grazing systems	Continuous grazing	Rational grazing	Other
Mark with X			

C.2 Where do your livestock animals start grazing or browsing?

Near homestead	Moderate distance from homestead	Far from homestead

C.3 What time of the year do you experience shortage of grazing material?

Seasons	Winter	Summer	Spring	Autumn
Mark with X				

C.4 What could be the possible reason for the shortage? (1=most important and 5= least important).

Possible reasons	Mark with X	Rank
Lack of rainfall		
Over stocking		
Incorrect application of fire		
Decrease of grazing capacity		
Bush encroachment		

C.5 how does your livestock perform in terms of production and reproduction? Good [], fair [], poor []

C.7 Do you use supplements to your livestock animals? Yes [] or No [] If yes which supplements do you normal use?

Supplements	Licks	Maize	Lucerne	Other
Mark with X				

C.8 Do you practice any veld management in your rangeland? Yes [] or No []

If yes fill the table below

Practices	How often?	In which season(s)
Veld burning		
Veld resting		
Rotational grazing		
Stocking rate		
Other (Specify)		

RANGELAND CONDITION

D.1 Which species were dominant in the past 10-20 years in your rangeland?

Name of grass species	Name of woody species

D.2 Which species are currently dominating in your rangeland?

Name of grass species	Name of woody species

D.3 Which species were mostly preferred by livestock animals in the past 10-20 years in your rangeland?

Name of grass species	Name of woody species

D.4 Which species are less palatable in your rangeland?

Name of grass species	Name of woody species

D.5 What trend did you observe in your rangeland in the past 10-20 years compared to the current condition?

Trends	Decrease	Increase	Remain same
Mark with X			

D.6 Is there any problem of land degradation in your rangeland? Yes [] or No [] If yes what could be the reason

.....

D.7 What other challenges are you facing regarding range management?

.....

D.8 How would you describe the condition of your rangeland?

Veld condition	Mark with X
Poor	
Very poor	
Fair	

Good	
Very Good	

D.9 What led to the current state of rangelands? (1=Most important and 5= least)

Causes	Mark with X	Rank
Grazing management		
Burning		
Soil Depth		
Lack of rainfall		
Human activities		
Other		

D.10 What do you utilize rangeland for? (1=most and 5-least important)

Purpose	Mark with X	Rank
Grazing/browsing of livestock		
Collecting fire wood		
Fencing and building houses		
Other (specify)		

D.11 Does your community have grazing camps? Yes [] or No [] If yes, what is the purpose of camps?

.....

BUSH ENCROACHMENT

E.1 When did you notice bush encroachment in your rangeland?

.....

.....

E.2 Which woody species is the most encroaching in your rangelands?

.....

.....

E.3 From your point of view, what should be done in order to eradicate/control encroaching species?
(1=most important and 5=least important).

Possible solution	Mark with X	Rank
Veld burning		
Destocking		
Overstocking		
Increasing browsers		
Increasing grazers		
Use of mechanical technique		
Veld resting		

E.4 What could be the causes of bush encroachment in your rangeland? (1= most and 5=least).

Reasons	Mark with X	Rank
Overgrazing		
Drought		
Timing of fire		
Climate change		
Absence of browsers		
Other		

E.5 Do you think bush encroachment affects grass production? Yes [] or No [] If yes what could be the reason?

.....

.....

E.6 Do you think bush encroachment has an effect on soil nutrient status? Yes [] or No [] If yes justify your answer

.....
.....

E.7. Is there any impact of bush encroachment on grass nutrient status? Yes [] or No [] If yes justify you answer

.....
.....

E.8. What are the pros and cons of bush encroachment in your rangeland?

Pros	Cons

Any comment:

.....
.....
.....
.....

Appendix B: ANOVA table for woody plants abundances

Acacia karoo

Source	DF	Type III SS	Mean Square	F Value	Pr > F
HVU (summer)	3	3579.687500	1193.229167	37.56	<.0001
HVU (winter)	3	19490.98333	6496.99444	62.54	<.0001

Azima tetraantha

Source	DF	Type I SS	Mean Square	F Value	Pr > F
HVU (summer)	3	4.68750000	1.56250000	2.78	0.0869
HVU (winter)	3	8.98333333	2.99444444	2.58	0.1063

Aloe ferox

Source	DF	Squares	Mean Square	F Value	Pr > F
HVU (summer)	3	42.18750000	14.06250000	3.77	0.0407
HVU (winter)	3	91.93333333	30.64444444	1.80	0.2049

Brachylaena Elliptica

Source	DF	Type I SS	Mean Square	F Value	Pr > F
HVU (summer)	3	3.00000000	1.00000000	6.00	0.0097
HVU (winter)	3	8.98333333	2.99444444	6.93	0.0069

Carissa heamotocarpa

Source	DF	Type I SS	Mean Square	F Value	Pr > F
HVU (summer)	3	1.68750000	0.56250000	2.45	0.1134
HVU (winter)	3	2.93333333	0.97777778	2.69	0.0978

Cordia rudis

Source	DF	Type I SS	Mean Square	F Value	Pr > F
HVU (summer)	3	223.2500000	74.4166667	20.07	<.0001
HVU (winter)	3	432.9333333	144.3111111	7.19	0.0061

Diospyros lycioides

Source	DF	Type III SS	Mean Square	F Value	Pr > F
HVU (summer)	3	0.75000000	0.25000000	3.00	0.072
HVU (winter)	3	2.93333333	0.97777778	2.69	0.0978

Erebia rigida

Source	DF	Type I SS	Mean Square	F Value	Pr > F
HVU (summer)	3	164.5000000	54.8333333	28.00	<.0001
HVU (winter)	3	371.4333333	123.8111111	12.44	0.0007

Grewia occidentalis

Source	DF	Type I SS	Mean Square	F Value	Pr > F
HVU	3	1.50000000	0.50000000	4.00	0.0346
HVU	3	5.73333333	1.91111111	3.50	0.0531

Lucas capensis

Source	DF	Type I SS	Mean Square	F Value	Pr > F
HVU	3	22.00000000	7.33333333	11.00	0.0009
HVU	3	58.26666667	19.42222222	4.06	0.0362

Lycium ferocissimum

Source	DF	Type I SS	Mean Square	F Value	Pr > F
HVU (summer)	3	2.18750000	0.72916667	1.52	0.2593

HVU (winter)	3	12.18333333	4.06111111	0.92	0.4647
<i>Maytenus heterophylla</i>					
Source	DF	Type I SS	Mean Square	F Value	Pr > F
HVU (summer)	3	188.1875000	62.7291667	28.14	<.0001
HVU (winter)	3	494.0000000	164.6666667	11.18	0.0011
<i>Maytenus capitata</i>					
Source	DF	Type I SS	Mean Square	F Value	Pr > F
HVU (summer)	3	154.2500000	51.4166667	11.98	0.0006
HVU (winter)	3	422.9833333	140.9944444	9.08	0.0026
<i>Maytenus polycantha</i>					
Source	DF	Type III SS	Mean Square	F Value	Pr > F
HVU (summer)	3	272.2500000	90.7500000	50.65	<.0001
HVU (winter)	3	531.9833333	177.3277778	25.09	<.0001
<i>Opantia ficus indica</i>					
Source	DF	Type I SS	Mean Square	F Value	Pr > F
HVU (summer)	3	0.25000000	0.08333333	0.67	0.5885
HVU (winter)	3	2.33333333	0.77777778	0.95	0.4497
<i>Pappia capensis</i>					
Source	DF	Type I SS	Mean Square	F Value	Pr > F
HVU (summer)	3	1.50000000	0.50000000	1.71	0.2170
HVU (winter)	3	2.93333333	0.97777778	2.69	0.0978
<i>Phyllanthus Verrucosus</i>					
Source	DF	Type I SS	Mean Square	F Value	Pr > F
HVU (summer)	3	0.68750000	0.22916667	0.73	0.5519
HVU (winter)	3	3.73333333	1.24444444	0.76	0.5394
<i>Rhus longispina</i>					
Source	DF	Type I SS	Mean Square	F Value	Pr > F
HVU (summer)	3	0.75000000	0.25000000	3.00	0.0728
HVU (winter)	3	2.93333333	0.97777778	2.69	0.0978
<i>Rhus refracta</i>					
Source	DF	Type I SS	Mean Square	F Value	Pr > F
HVU (summer)	3	0.25000000	0.08333333	0.67	0.5885
HVU (winter)	3	0.93333333	0.31111111	0.57	0.6460
<i>Schotia afra</i>					
Source	DF	Type I SS	Mean Square	F Value	Pr > F
HVU (summer)	3	0	0	.	.
HVU (winter)	3	1.06666667	0.35555556	1.47	0.2771

Appendix C: ANOVA table for Herbaceous species abundance

Dependent Variable: *Aristida congesta*

Source	DF	Type I SS	Mean Square	F Value	Pr > F
HVU (winter)	3	813.1875000	271.0625000	14.10	0.0003
HVU (summer)	3	427.0000000	142.3333333	35.58	<.0001

Dependent Variable: *Cynodon dactylon*

Source	DF	Type I SS	Mean Square	F Value	Pr > F
HVU(Winter)	3	126.5000000	42.1666667	1.63	0.2335
HVU (summer)	3	126.5000000	42.1666667	1.63	0.2335

Dependent Variable: *Cymbopogon plurinodis*

Source	DF	Type I SS	Mean Square	F Value	Pr > F
HVU (Winter)	3	0.68750000	0.22916667	0.58	0.6399
HVU (summer)	3	27.00000000	9.00000000	10.80	0.0010

Dependent Variable: *Digitaria eriantha*

Source	DF	Type I SS	Mean Square	F Value	Pr > F
HVU (Winter)	3	1989.187500	663.062500	1.97	0.1722
HVU (summer)	3	1825.687500	608.562500	8.95	0.0022

Dependent Variable: *Eragrostis obtuse*

Source	DF	Type I SS	Mean Square	F Value	Pr > F
HVU	3	6.18750000	2.06250000	2.54	0.1057
HVU	3	426.6875000	142.2291667	1.55	0.2521

Dependent Variable: *Eragrostis capensis*

Source	DF	Type I SS	Mean Square	F Value	Pr > F
HVU (Winter)	3	1236.500000	412.166667	16.03	0.0002
HVU (summer)	3	7.68750000	2.56250000	1.95	0.1751

Dependent Variable: *Eragrostis chloromelas*

Source	DF	Type I SS	Mean Square	F Value	Pr > F
HVU(Winter)	3	152.1875000	50.7291667	1.39	0.2928
HVU (summer)	3	30.68750000	10.22916667	2.40	0.1192

Dependent Variable: *E.paspaloides*

Source	DF	Type I SS	Mean Square	F Value	Pr > F
HVU (Winter)	3	2.68750000	0.89583333	2.26	0.1334
HVU (summer)	3	3.68750000	1.22916667	0.56	0.6503

Dependent Variable: **FORB**

Source	DF	Type I SS	Mean Square	F Value	Pr > F
HVU (Winter)	3	38.50000000	12.83333333	0.99	0.4302
HVU (summer)	3	11.25000000	3.75000000	0.97	0.4397

Dependent Variable: ***Karoochloa curva***

Source	DF	Type I SS	Mean Square	F Value	Pr > F
HVU (Winter)	3	0.18750000	0.06250000	1.00	0.4262
HVU (summer)	3	100.6875000	33.5625000	11.59	0.0007

Dependent Variable: **KARROO**

Source	DF	Type I SS	Mean Square	F Value	Pr > F
HVU (Winter)	3	84.68750000	28.22916667	1.27	0.3280
HVU (summer)	3	164.5000000	54.83333333	8.07	0.0033

Dependent Variable: ***Panicum maximum***

Source	DF	Type I SS	Mean Square	F Value	Pr > F
HVU (Winter)	3	63.18750000	21.06250000	3.84	0.0386
HVU (summer)	3	14.18750000	4.72916667	2.61	0.0997

Dependent Variable: ***Panicum stapfianum***

Source	DF	Type I SS	Mean Square	F Value	Pr > F
HVU (Winter)	3	72.50000000	24.16666667	4.00	0.0346
HVU (summer)	3	14.18750000	4.72916667	2.61	0.0997

Dependent Variable: ***Sporobolus africanus***

Source	DF	Type I SS	Mean Square	F Value	Pr > F
HVU (Winter)	3	12.25000000	4.08333333	0.67	0.5885
HVU (summer)	3	50.75000000	16.91666667	2.86	0.0814

Dependent Variable: ***Sporobolus fimbriatus***

Source	DF	Type I SS	Mean Square	F Value	Pr > F
HVU (Winter)	3	483.5000000	161.1666667	2.26	0.1343
HVU (summer)	3	305.1875000	101.7291667	7.43	0.0045

Dependent Variable: ***Setaria neglecta***

Source	DF	Type I SS	Mean Square	F Value	Pr > F
HVU (Winter)	3	8.18750000	2.72916667	1.16	0.3655
HVU (summer)	3	26.18750000	8.72916667	2.45	0.1138

Dependent Variable: ***Themeda triandra***

Source	DF	Type I SS	Mean Square	F Value	Pr > F
HVU (Winter)	3	1037.187500	345.729167	15.21	0.0002
HVU (summer)	3	504.6875000	168.2291667	7.74	0.0039

Appendix D: Biomass production

Source	DF	Type III SS	Mean Square	F Value	Pr > F
HVU (summer)	3	234345.3333	78115.1111	4.47	0.0057
HVU (winter)	3	1126659.420	375553.140	13.93	<.0001

Appendix E: Soil nutrients

Dependent Variable: soil pH

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	0.04375000	0.01458333	0.18	0.9051
Error	4	0.32500000	0.08125000		
Corrected Total	7	0.36875000			

Dependent Variable: Carbon

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	0.17030000	0.05676667	17.60	0.0091
Error	4	0.01290000	0.00322500		
Corrected Total	7	0.18320000			

Dependent Variable: Calcium

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	0.01060000	0.00353333	0.01	0.9992
Error	4	2.16640000	0.54160000		
Corrected Total	7	2.17700000			

Dependent Variable: Copper

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	1.22143750	0.40714583	1.65	0.3128
Error	4	0.98645000	0.24661250		
Corrected Total	7	2.20788750			

Dependent Variable: Iron

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	2118.151450	706.050483	3.70	0.1192
Error	4	762.695500	190.673875		
Corrected Total	7	2880.846950			

Dependent Variable: Potassium

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	3467.290400	1155.763467	2.21	0.2292
Error	4	2089.915200	522.478800		
Corrected Total	7	5557.205600			

Dependent Variable: Magnesium

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	0.07565000	0.02521667	0.51	0.6988
Error	4	0.19930000	0.04982500		
Corrected Total	7	0.27495000			

Dependent Variable: Nitrogen

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	0.03255000	0.01085000	8.68	0.0317
Error	4	0.00500000	0.00125000		
Corrected Total	7	0.03755000			

Dependent Variable: Manganese

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	7937.78164	2645.92721	0.52	0.6887
Error	4	20192.76305	5048.19076		
Corrected Total	7	28130.54469			

Dependent Variable: Sodium

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
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Model	3	284.260000	94.753333	0.38	0.7714
Error	4	988.040000	247.010000		
Corrected Total	7	1272.300000			

Dependent Variable: phosphorous

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	42.753750	14.251250	0.04	0.9865
Error	4	1329.225000	332.306250		
Corrected Total	7	1371.978750			

Dependent Variable: Sulphur

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	56.020637	18.673546	0.04	0.9896
Error	4	2080.555450	520.138863		
Corrected Total	7	2136.576088			

Dependent Variable: Zinc

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	0.04765000	0.01588333	0.45	0.7335
Error	4	0.14250000	0.03562500		
Corrected Total	7	0.190150			
