Euryops floribundus Encroachment in Eastern Cape Communal Rangelands: Indigenous and Scientific Understanding of Effects on Range Ecology, and Food Security

A dissertation submitted in partial fulfilment of the requirements of the Degree of Master of Science in Agriculture (Pasture Science)

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BY

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Declaration

I declare that ***Euryops floribundus*** **Encroachment in Eastern Cape communal Rangelands: Indigenous and Scientific Understandings of Effects on Range Ecology, Food Security** is my own work, that it has not been submitted for any degree or examination in any other university, and that all the sources I have used or quoted have been indicated and acknowledged by complete reference.

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Abstract

Euryops floribundus **Encroachment in Eastern Cape communal Rangelands: Indigenous and Scientific Understanding of Effects on Range Ecology, and Food Security**

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The study was conducted in Eastern Cape Province to 1) investigate local people's knowledge and perceptions on *Euryops floribundus* and 2) landscape distribution and effect of *Euryops floribundus* on herbaceous vegetation and soil. A total of 90 households who own livestock were randomly selected from the three communal areas, namely; Tsengiwe, Upper Mnxe and Manzimdaka for household surveys and group discussions. For landscape study, a total of about 5 ha of land were selected at Upper Mnxe communal area. Selection criteria included the presence of *E. floribundus* and different landscape gradients. A total of four 50mx50 plots were marked along the landscape gradients: Bottom, Middle, and Upper Slope and upland positions. To study the effect of *E. floribundus* invasion on the herbaceous vegetation and soil, a total of 4 ha communal land was selected in an accessible area which had a largely flat terrain. The area was selected to have adjacent sites with no invasion (< 5% shrub cover), light (5-15% shrub cover), moderate (>15-35) and heavy invasions (>35% shrub cover) of *E. floribundus*. The average household size in the study area was 6.8± 0.7. All people in the three communal areas unanimously ranked sheep as the most important species for their livelihood, but the ranking of cattle and goat varied among the communal areas. All elder groups agreed that *Europs floribundus* decreases both the quantity and quality of herbaceous forage as well as livestock production. Moreover, invaded patches create more bare areas which are responsible for the loss of top fertile soils and the formation of rills and gullies. The result showed that the total density of *E. floribundus* significantly increased from the topland (2301 plants ha^{-1}) moving to the bottomland (4888 plants ha^{-1}). Canopy cover was significantly lowest in the topland (17.9%), but the remaining gradients had similar cover. Grass dry matter yield was higher in the bottomlands and sloppy gradients than the toplands. Soil organic carbon was significantly higher ($P<0.05$) in the flat than the sloppy terrain. Soils from higher elevations (toplands and upper sloppy) had significantly higher N than the lower elevations (bottomlands and Middle sloppy). The lowest dry matter was observed at low invasion and non-invaded sites. Soil chemical properties were generally different from all density levels. In conclusion, *E. floribundus* encroachment was found to be major cause of decline in the peoples' livelihood because as this reduces the vegetation diversity and livestock production, both of which are the major of their livelihoods.

Key words: Local knowledge, *Euryops floribundus* (Lapesi), Communal areas

Dedication

This dissertation is dedicated to my parents, late father (Makhosi William Gxasheka), my dearest mother (Nomangesi Kunjuzwa) and the rest of the Gxasheka family.

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List of abbreviations

GLM- General Linear Model

SAS- statistical analysis system

ANOVA- Analysis of variance

CANOCO- Canonical correspondence analysis

SE- Standard Error

Total N-Total Nitrogen

C- Carbon

P- Phosphorus

Ca-calcium

SPSS –Statistical package for social sciences

Ha-hectare

List of scientific terms in vernacular language (Xhosa)

Basal cover- bubuninzi bengca egquma kungabonakali mhlaba

Bottomland- Emazantsi entaba

Bush encroachment-Ukugcwala kwethithi emadlelweni

Canopy Cover-Yindawo egqunywe ngamasebe emithi

Canopy diameter- Ubukhulu bamasebe omthi

Density level- Bubungakanani bemithi kulondawo

Dry cow dung- Ilongwe

Ecology- Lufundo lwezinto eziphilayo nedlela ezihleli ngayo nobunjani bendawo ezihleli kuyo

Euryops floribundus- Lapesi

Forage- Kukutya kwezilwanya okanye imfuyo

Forage yield- Ngumongo wokutya

Forbs- Likhula okanye yimifino kunye nayo yonke into engeyongca kodwa ekhula ilingane nengca okanye ngaphantsi kwengca

Height Class- Ubude nobufutshane bemithi

Herbaceous vegetation- Yiyonke into ekhula edlelweni ngaphadle kwemithi

Herbivory- Zizilwanyana ezitya ingca nemithi

Landscape gradient- Intaba

Livestock- Imfuyo

Overgrazing- Lidlelo eli nengca encinci okanye amabala emva kokuba inkomo okanye igusha zityile

Rangeland- Idlelo

Saplings-Yimithi emini ncinci okanye ebityileyo

Seed dispersal- Ukuhlayeleka kwembewo

Shrub Invasion- Ukukhula kwemithi kwindawo ibingekho kuyo

Soil fertility- Ukutshuma komhlaba

Soil moisture- Amanzi afumaneka emhlabeni

Sourveld-Ngamadlelo akwindawo efumana imvula eninzi ngexesha lemvula

Species composition- Yingca emfumanekayo kulo ndawo

Tuft diameter- Ubungakanani besikhondo sengca

Tuft distance- Umngama phaka kwezi khondo zengca

Upland/topland- Phezu kwentaba

Young shrubs- Imithi esakhulayo

CHAPTER1. INTRODUCTION

1.1. Background

Environmental changes demonstrated by a progressive growth in woody plant invasion and/or bush encroachment, are the common causes of herbaceous vegetation loss in many rangelands and are accountable for a decline in range condition (Angassa, 2005). Woody plant invasion can be defined as the increase in density, cover and biomass of woody or shrubby plants (Van Auken, 2009). Some of the encroaching woody plants are indigenous species which occur in their natural environment (Smit, 2004), while others are foreign to the local environments and South Africa is widely encroached by *Acacia* species (Scogings and Mopipi, 2008). O'Connor and Crow (1999) reported that woody plant encroachment had been taking place in the Eastern Cape over 49 years and this trend is likely to continue. Bush encroachment has reduced the grazing capacity of large areas of the southern African savannas to such an extent that many previously economic livestock farming areas are now no longer economically viable (Smit, 2004). Encroaching woody plants suppress the available grass species through competition for soil water as the primary determinant of production. Smit (2004) reported that the roots of woody plants are fundamental in their competitive interactions with grass species and other woody plants. Bush encroachment not only reduces the carrying capacity of rangelands for livestock but in addition may lead to habitat loss and fragmentation (Scogings and Mopipi, 2008). Tews and Jeltsch (2004) mentioned that climate change has altered rainfall pattern and distribution in Southern Africa savannas, and this was believed to be one of the environmental drivers of woody plants invasion.

Global climate change may have an impact in the increase of woody plant cover in the rangelands, associated with elevated carbon dioxide (Polley, 1997). Moreover, there are also several factors that appear to influence the distribution and structure of shrub plants in savanna and grassland ecosystems. These factors fall into two main categories, namely anthropogenic and environmentally related factors. It is widely accepted that the use of savannas for domestic livestock has facilitated shrub invasion through associated overgrazing combined with changes in fire regimes (Aucamp, 1976; Walker *et al.,* 1981; Van Vegten, 1983; Archer, 1995; Milton and Dean, 1995).Woody plant encroachment has an effect on the livestock production, to such extent that it threatens the global food security.

The majority of people do not understand the current cause of reduction of livestock as compared to earlier days. Ward (2005) indicated that agricultural productivity and biodiversity of 10-20 million ha of South Africa has been affected by bush encroachment. This therefore, shows that appropriate management practice should be in place to prevent further rangeland degradation. Lesoli (2008) reported that some parts of the communal rangelands of South Africa are encroached by *Euryops floribundus* species. The species is not browsed by animals even during periods of feed scarcity; however, people use the bush as insect repellent and source of firewood. One of the challenges is that once the plant establishes its seeds tend to spread by natural means into new areas (Scholes and Archer, 1997). Therefore, that makes it even more difficult to control the bush.

1.2. Problem statement

Encroachment by *Euryops floribundus* is a problem in some communal rangelands of South Africa. *Euryops floribundus* is spreading fast in some communal rangeland of the Eastern Cape. This species may directly compete with the palatable grass species for soil moisture, soil fertility and space, or may have allelopathic effects, that lead to reduction of forage production and that subsequently reduces livestock productivity of the encroached areas. As a result the encroachment of this species may threaten the food security of the communal people due to its effect on forage/browse production and/ or availability and livestock production. However, characterization of this species and its impact on forage productivity, soil protection and livestock production and its subsequent effects on food security in communal areas has not been investigated. Moreover, whether the spread of this species is influenced by climate change or not is not documented.

1.3. Justification

Generally, the study generated baseline information on the distribution ecology of *Euryops floribundus* and its effects on the grass and soil productivity. Therefore, this approach provides sufficient information which will lead to development of management practices, and therefore improve forage production in the rangelands, and in turn, improve animal production within encroached areas. Furthermore, it will promote a better understanding by communal farmers about severity of encroachment and implication on livestock production, and further it will improve their perception about the major causes of its invasion.

1.4. Objectives

1.4.1. General objectives

The objective of this research was to:

Improve livestock production in the communal rangelands of Eastern Cape, South Africa.

1.4.2. Specific objectives

The objectives of this research were to:

1) Investigate indigenous knowledge and perceptions of the communal land users on *E. floribundus* encroachment
2) To determine landscape distribution of *E .floribundus* and relation with herbaceous vegetation and soil properties.
3) To determine the effects of *E. floribundus* on herbaceous vegetation and soil chemical properties.

CHAPTER2. LITERATURE REVIEW

2.1. Introduction

Woody plant encroachment is commonly regarded as a major threat to livestock production and nature conservation in southern Africa because it alters habitat structure and decreases herbaceous vegetation production (O'Connor and Crow, 1999). This has occurred to an extent that many previously economically viable livestock areas are no longer productive. O'Connor and Crow, (1999) reported that woody plant encroachment had taken place in the Eastern Cape over past several years and that this trend is likely to continue. The causes for woody plant encroachment are diverse and complex (Tainton, 1999; Sharp *et al.,* 2012) and that makes it difficult to control. Among other factors, bush encroachment is often associated with long-term changes in grazing pattern, fire, flooding, forestry and soil disturbances, as well as more recent climatic changes (Sharp *et al.,* 2012).

The proximate causes of woody plant encroachment have been a controversial subject in rangeland ecosystems (Kassahun *et al.,* 2008). An increase in the biomass of already established plants and increase in tree density, mainly via the establishment of seedlings greatly influence woody plant encroachment (Smit, 2004). Angassa (2005) indicated that the shift from grassland to woody plant is influenced by the interactions between episodic rainfall, fire and heavy grazing. Overgrazing by livestock facilitates woody plant encroachment in the semi-arid savanna. Rainfall variability (Angassa and Oba, 2010) and fire (O'Connor and Crow, 1999) also influence the woody plant encroachment. Most communal livestock production systems in the world have been operating for several years via the use of their local knowledge to make decisions on livestock husbandry, rangeland resource utilisation and management. Communal livestock herders possess a detailed knowledge and perceptions of their natural resources (Oba and Kaitira, 2006; Marin, 2010).

2.2. Factors causing woody plant encroachment

Obliteration of grasses by overgrazing during drought provides an opportunity for the woody component because of reduced fire and competition (Kassahun *et al.,* 2008; O'Connor and Crow, 1999; Coetzee *et al.,* 2007; Meik *et al.,* 2002; Wiegand *et al.,* 2006). Improvement of livestock systems based almost entirely on selective grazers and decreased browsing pressure (Kassahun *et al.,* 2008) which results in overgrazing has an influence in the bush encroachment (Kraaij and Ward, 2006; Wiegand *et al.,*2006). Herbivores allow the spread of less palatable species by selectively removing the more palatable ones, thus reducing interplant competition (Kassahun *et al.,* 2008). However, grazers as well have indirect impact to tree seedling establishment by reducing the surrounding grass cover (Hagenah *et al.,* 2009; Roques *et al.,* 2001). Wiegand *et al.,* (2006) assumed that if grasses are removed through heavy grazing, grass roots extract less water from the top soil layer, allowing more water to percolate into the sub-soil, where it is available for woody plant growth.

Fire is believed as factor that influences the woody plant encroachment (O'Connor and Crow, 1999; Hudak *et al.*, 2003). Burning using hot fire can play a good role for controlling bush encroachment (Dalle *et al.*, 2006; Solomon *et al.*, 2007). However, long- term absence of fire will increase further the density of woody plants (Roques *et al.,*2001; Bond *et al.,* 2003; Hudak *et al.,* 2003; Solomon *et al.,* 2007; White *et al.*,2008). Indeed, the suppression of fire contributed to the expansion of bush encroachment (Angassa and Oba, 2008). Therefore, reintroducing of fire where is necessary will be useful to control the expansion of bush cover. This will improve pasture quality and facilitate livestock production Fuel loads are major determinants which influence fire frequency and intensity (Scholes and Archer, 1997).

Climate change in relation to rainfall variation also promotes bush encroachment because it tends to results on the less intense fires due to reduced fuel loads (Ward, 2005). Polley *et al*.,

(2002) also hypothesise that increase in the carbon dioxide concentration, increase soil water content sufficiently to improve seedling establishment.

2.3. Effect of woody plant encroachment on livestock production

Woody plant encroachment has a detrimental effect on livestock production and nature conservation in southern Africa for the reason that it decreases herbaceous production (O'Connor and Crow, 1999). Therefore, bush encroachment accelerates reduction in grass cover whilst the intensification of grazing pressure (Scholes and Archer, 1997) reduces the fuel load required for fire to burn the bushes. Cattle production in Eastern Cape entirely relies on grasses for their nutrition. The availability of grazing resources is extremely important because food security of the rural people solely depend on these resources. Angassa (2005) indicated that a rapid increase in woody plants population and degraded grazing resources badly affected cattle production.

O'Connor and Crow (1999) indicated that the Kei Road-Komga region has experienced from increases in the extent and abundance of *Acacia a karroo* and bush clump which markedly depresses herbaceous production to the extent that cattle production would be affected. Bush encroachment is not a problem only in South Africa but other countries are faced with the similar challenge. Thus, in Eastern Ethiopia Kassahun *et al.* (2008) reported that bush encroachment is the main reasons for Pastoralists to shift towards camels and goats, with a relatively lower preference for cattle and sheep due to the loss of grass cover. Dalle *et al.* (2006) reported that bush encroachment had an adverse influence on grass biomass production and leads to decreased potential grazing capacity. Therefore, it causes a decline in the grazing capacity of the herbaceous layer which severely affect livestock production worldwide (Smit, 2004; Solomon *et al.*, 2007).

However, some woody plants are considered to have some forage value since they provide leaves to browsers and to a lesser extent to sheep and cattle during the dry period (Solomon *et al.,* 2007). Bush encroachment has also been found to result in marked changes in the composition of grass species (Scholes and Archer, 1997). Furthermore, decreases in herbaceous and grass biomass production directly affects livestock production, on which the livelihoods of pastoralists depend because most of them cannot afford supplementation (Dalle *et al.,* 2006).

2.4. Encroaching woody plants in competition with grass cover

The botanical composition and productivity of any mature stand of vegetation is largely determined by competition. Therefore, competition is strongly influenced by root systems for encroaching woody plant. (Smit, 2004). Sankaran *et al*. (2004) assumed that water is a primary limiting factor for trees and grasses to access because of spatial differences in their rooting profiles. In fact, roots determine the spatial distribution of water and nutrient uptake and can cause an increase or a decrease in resource availability (Wu *et al*., 1985). However, grass can substantially reduce the growth of trees and strongly suppress saplings than larger trees in terms of growth (Cramer *et al.,* 2007) due to the fact that they have dense fibrous root systems tending to explore soil more intensively than tree roots for a nutrient supply where their roots occur together (Sankaran *et al.,* 2004).

But for survival of trees, they can go deeper in the soils to find high-resource patches not occupied by grasses. In addition, woody plant encroachment is limited by soil moisture availability and fire intensity rather than grass competition for soil moisture. However, grasses can control bush encroachment directly via competition for light, water, nutrients and indirectly as fuel loads which will influence fire frequency and intensity (Scholes and Archer, 1997). Cramer *et al.*, (2007) indicated that competition for light could limit the N2 fixation capacity of the tree seedlings.

2.5. Perceptions of farmers on causes and extent of woody plant encroachment in communal areas

Most communal farmers have different perceptions from each other towards the rangeland degradation (Ho and Azadi, 2010). According to (Lykke, 2000), farmers considered poor rainfall (Hudak,1999) and frequent and intensive fires as the main causes of the decline in forage production such that bush encroachment takes over. However, it is also scientifically perceived that intense grazing can lead to excessive removal of the most palatable species, which reduce ground cover and ultimately opens the way for less palatable and faster establishment of shrub and bush species to become dominant (Thomas and Twyman, 2004; Dalle *et al.*,2006; Britz and Ward, 2007). Furthermore, grazing is identified as an indirect cause bush encroachment due to the changes in grass abundance and vertical distribution of water in the soil (Cipriotti *et al.*, 2012). Causes of bush encroachment have been a contentious issue in rangeland ecology (Kassahun *et al.*, 2008) and they are rather diverse and complex (Abule *et al*., 2007; Sharp *et al.*, 2012).

Sharp *et al.*, (2012) also reported that drought, overgrazing, uncontrolled livestock movement, and lack of fire were perceived by farmers as factors that contribute to bush encroachment. Moreover, other farmers perceived that less use of indigenous knowledge in communal farming also contribute in bush encroachment (Dalle *et al.*, 2006). In addition, pastoralist in Ethiopia noted that ban on fire by government is a major cause of bush encroachment (Oba *et al.*, 2000; Solomon *et al.*, 2007). Angassa and Oba (2008) reported that farmers mentioned that the intensity of bush encroachment varied according to soil types. Olafsdottir and Juliusson (2000) noted that farmer's perceptions regarding environmental issues have attracted attention of scientist worldwide. Hence, communal farmer's suggestion such as rangeland burning, bush clearing, and herd diversification are taken note of by many scientists as they have a potential solutions to minimize impacts of woody plants encroachment (Oba *et al.*, 2000; Dalle *et al.*, 2006; Solomon *et al.*, 2007).

Moreover, farmers indicated that abandonment of fields or cropping areas are also observed as cause of bush encroachment which eventually results in the loss of biodiversity and forage resources of the encroached areas (Pontes *et al.*, 2012). In addition, perceptions of farmers together with their historical evidence suggest that the direction of environmental change especially in bush encroachment is the combination of outcome of interaction between natural and human factors (Hamandawana *et al.*, 2007). Pastoralists' perceptions and ecological knowledge of vegetation changes are often ignored (Roba and Oba, 2009). Perception of farmers has significant influence on the management strategies adopted to exploit a particular ecosystem. Hence, it is essential to understand how communal farmers perceive rangeland conditions and the extent of degradation in communal grazing land (Kgosikoma *et al.*, 2012).

Kgosikoma *et al.* (2012) reported that communal farmers indicated that the increase in bush encroachment in rangelands suppresses grass productivity which reduces grazing area for livestock. The extent of bush encroachment threatens the livelihoods of communal farmers. However, bush encroachment is negatively perceived in the rangelands but some farmers also indicated its beneficial where it serves as fodder that support livestock (Moleele, 1998; Kgosikoma *et al.*, 2012). The bushes increase livestock predators, also leads to difficulties for livestock mustering and herding which became a home for harmful wildlife and prevented access to the available grass (Dalle *et al.*, 2006). Moreover, animal numbers quite dependent on the response of the rangelands to the extent of bush encroachment (Gillson and Hoffman, 2007). Generally, involving affected people by bush encroachment it triggers the importance of their perception towards bush encroachment (Thomas and Twyman, 2004).

2.6. Woody plant encroachment along landscape gradient

Altitudinal gradients are among the most important topographical factors which have been used to test ecological responses of woody plants to geographical influences. Altitudinal gradients exhibit strong environmental changes over short distances and therefore can significantly influence plant occurrence more than any other geographical factors (Kakembo *et al.*, 2007; Argaw *et al.*, 1999). Kakembo *et al.* (2007) also noted the impact of topographic position in the invasion of hillslopes by *Pteronia incana*.

The abundance of woody plants along landscape positions was also observed by Shackleton (2000) at the bottomland. O'Connor and Crow (1999) also stated that valleys were consistently two to three times more encroached than other landscape position. However, this abundance of woody plants in bottomlands is associated with overgrazing. Rezaei *et al.* (2005) observed that overgrazing is common in bottomlands due to other factors including the presence of animal watering points (rivers). In addition, movement of woody plant seeds from topland and the middle slopes into the bottomland (Argaw *et al.*, 1999) may increase the recruiting seed population and hence the abundance of woody plant. The influence of landscape position was also observed on the species diversity, productivity and composition of grass species (Schade *et al.*, 2003). Venter *et al.* (1989) reported also that landscape position has a greater influence on diversity than grazing intensity.

2.7. Woody plants encroachment on communal rangelands

Roques *et al.* (2001) point out that what determines the abundance of woody plants in savanna is of global interest. In South Africa it has been estimated that 13 million hectares (ha) of savanna have been subject to thorn bush encroachment (Trollope *et al.*, 1989).

However, despite the wide extent of this occurrence, little is known about the dynamics and causes of encroachment (Archer, 1995). The encroachment of woody plants into grassland and savanna can alter soil moisture, nutrient and microclimate conditions, and can suppress grass productivity (Stuart-Hill and Tainton, 1989). Consequently, it reduces carrying capacity for grazing animals (Dean and Macdonald, 1994), thereby threatening the livelihood of commercial and communal game and livestock ranchers.

Woody plant encroachment is of serious socioeconomic concern in southern Africa, where other forms of agriculture are not feasible on account of the low rainfall. The effect of woody plant encroachment is considered to be particularly acute in the communal rangelands of South Africa where human and livestock population densities are very high and consequently heavy grazing is common (Walker *et al.*, 1981). However, woody plant encroachment is considered to be far higher today compared to earlier days and it is not only the extent of woody encroachment, but also the rate at which it occurs, that is of great concern. Forbes and Trollope (1991) observed emerging of bush encroachment on the rangelands of Eastern Cape (Ciskei) after introduction of rotational grazing and resting systems. Therefore, overstocking has resulted in serious soil erosion and in the invasion of undesirable plant species such as *Euryops Spp* and *Pteronia incana* due to the fact farmers were using the recommended stocking rate of 1955 which were higher than current carrying capacity of the rangeland.
The encroachment of communal rangeland is an environmental predicament in the Eastern Cape Province due unpalatable *Euryops pyriodes* (Lesoli, 2008) and *Pteronia incana* (Kakembo *et al.,* 2007). Removal of some or all of the woody plants will normally result in an increase of grass production and thus also in the grazing capacity. However, the results of woody plant removal may differ between vegetation types, with the outcome determined by both negative and positive responses to tree removal (Teague and Smit, 1992).

CHAPTER 3. EVALUATION OF FARMERS' PERCEPTIONS OF LIVESTOCK HUSBANDRY, RANGELAND CONDITION AND INVASION OF *EURYOPS FLORIBUNDUS* IN THREE COMMUNAL AREAS OF THE EASTERN CAPE, SOUTH AFRICA

Abstract

The study was conducted to investigate the local knowledge and perceptions of the communal farmers on *Europs floribudus* and its relationship with climate and food security. This information is vital to develop participatory based interventions to control the invasion of this species, and establish development programs for sustainable livestock production. Three communal areas, namely Tsengiwe, Upper Mnxe and Manzimdaka were selected in Cala community located in the north of Eastern Cape Province, South Africa. The communal areas were selected mainly because the grazing lands are invaded by *E. floribundus.* From each communal area, 30 households and two elder groups (8 individuals per group) were selected on the basis of owning livestock, but among livestock owners randomly selection was conducted. Data were analysed using SPSS statistical software. The average household size in the study area was 6.8 ± 0.7. All the people in the three communal areas unanimously ranked sheep as the most important species for their livelihood, but the ranking of cattle and goats varied among the villages. Traditional ceremonies were ranked as the most important reason for keeping cattle by Tsengiwe and Manzimdaka. Elders from Tsengiwe indicated that their rangeland conditions were poor to very poor and suggested poor grass cover, the occurrence of high selective grazing and heavy *E. floribundus* as indicators. The other two communal areas described the rangeland as fair or good and used good animal body condition and the absence of *E. floribundus* as indicators. Elder groups suggested corrective measures to restore poor rangelands and these included fencing, proper stocking rate, and clearing of *E.*

floribundus. Elders from all communal areas perceived the advancement of *E. floribundus* over time. All elder groups agreed that *E. floribundus* decreases both the quantity and quality of herbaceous forages as well as livestock production. Moreover, invaded patches create more bare areas which are responsible for the loss of fertile top soils and the formation of rills and gullies. Elder respondents from Tsengiwe and Upper Mnxe associated *E. floribundus* invasion with climate change by relating mainly to rainfall increases. In conclusion, *E. floribundus* encroachment was found to be a major cause of decline in the peoples' livelihood because this reduces the vegetation diversity and livestock production, both of which are the major sources of their livelihoods Therefore, possible intervention in controlling the species to improve the productivity and sustainable use of rangelands are proposed.

Key words: Household, livestock production, opinion of local people

3.1. Introduction

Rangelands (landscapes dominated by native plant communities) account for around 70% of the global land surface (Fuhlendorf and Engle, 2001). There are three main types of animal production systems on South African extensive rangeland ecosystems, namely; communal livestock, commercial livestock, and wildlife (game ranching and nature conservation) production systems. These production systems vary in production goals, animal diversity, and management of natural resources (Smet and Ward, 2006). Communal people maintain diverse livestock species that support their livelihood and provide social and cultural values (Smet and Ward, 2005). Most communal livestock owners do not intend to sell their live animals. Animal products are mainly used for household consumption and only surpluses are sold on local market (Tomlinson *et al.*, 2002).

The grazing resource of communal areas is accessible to all community members, but animal management decisions are dependent either on the community or individual livestock owners. Most communal livestock production systems in the world have been operating for centuries via the use of their local knowledge to make decisions on livestock husbandry, rangeland resource utilisation and management. Communal livestock herders possess a detailed knowledge and perceptions of their natural resources, the environment in which they exist as well as their interactions and of land assessment methods suitable at a local scale (Oba and Kaitira, 2006; Marin, 2010). For example, Matlebyane *et al.* (2010) reported in Limpopo province of South Africa that communal farmers' local knowledge has been used to identify potential grass and shrubs which can be used to improve forage production for year round livestock feeding. In the Kalahari of Botswana, pastoralists identified prescribed land management practices suitable for use in the arid rangeland ecosystems (Reed *et al.*, 2007).

In China, Xu *et al.* (2006) concluded that local people's perceptions play vital roles in the conservation of natural resources. Following the 1992 United Nations Conference on

Environment and Development, it was acknowledged that sustainable development in the communal grazing lands should primarily focus on community-based natural resource management (Leach *et al.,* 1999; Helen *et al.,* 2012). The Eastern Cape Province of South Africa has about 3.1 million beef cattle, comprising nearly a quarter of the total cattle population in South Africa (National Department of Agriculture, 2008). Livestock farming is a major livelihood base for majority of the population in the province.

Communal land ownership and use form the principal land use practice in livestock production and over 65% of the livestock is produced in the communal areas (Eastern Cape Development Corporation, 2003). Like in the rest of Africa, communal farmers throughout Eastern Cape use their indigenous knowledge and perceptions to make decisions on livestock husbandry, rangeland resource utilisation and management. This has allowed them to maintain livestock for generations with little support from the government or non-governmental organisations. Nevertheless, deterioration of rangelands and encroachment by invasive species has been taking over many grazing lands threatening this sector of the agriculture. Some interventions and development efforts have been made, but showed little success due to the failure to obtain farmer's participation in providing information, as well as limiting their involvement in decision making and planning processes. A fundamental understanding of the perceptions of the communal livestock-rangeland management practices of the Eastern Cape was also lacking. The objectives of this study were therefore to investigate 1) local people's knowledge and perceptions on livestock husbandry in three communal areas, 2) and their perceptions of rangeland condition and invasion by *Euryops floribundus.*

3.2. Materials and methods

3.2.1. Description of the study area

The study was conducted in three communal areas around Cala community located in the northern Eastern Cape Province, South Africa. The three communal areas are Tsengiwe (31°34’S, 27°39’E and elevation is 1164 m) Upper Mnxe (31°33’S, 27°36’E and elevation is 144) and Manzimdaka (31° 34 ‘S, 27° 42’E and elevation is 1358). The vegetation type of the study area is Tsomo grassland (Mucina and Rutherford, 2006). The average summer rainfall (November to April) is 600 mm, while in winter (May to October), the rainfall is 200 mm. The mean temperature in January and July is 22ºC and 12ºC, respectively. The primary livelihood activities in the study areas are crop farming, animal farming and extraction of natural resources such as building material, wood for fuel, and fruits. Moreover, community directly derived benefits from *Euryops floribundus* such as drinking cooked leaves to relieve flue, use it broom to swipe in front of their houses and wood for fuel.

3.2.2. Sampling and survey approach

From each village, 30 households who own livestock were randomly selected giving a total of 90 households from the three villages. Two elder groups (8 elders per group) were selected in each communal area to conduct group discussions.

3.2.3. Data collection

In the first day of data collection, an introductory workshop with extension officers and all households and elders was held to discuss and give clarity about the survey and make appointment for the interview. Consent form was provided prior to interviews for all households’ interviews and elders to request their authorization. Individual households were interviewed using structured, semi structured, and open ended questionnaire. Both male and female adults of the selected households participated in the interview. The household interview was conducted to gather information on household demography, livestock species, feed and feedings, importance of raising cattle, constraints of livestock and rangeland practices. Open ended group discussions were also conducted with two elder groups per communal area (8 elders per group). The group discussion was conducted in an open-ended manner with sufficient time to gather details from the respondents. Questions were asked concerning rangeland condition and trends; perceptions of long-term vegetation change; and rangeland deterioration associated with *E. floribundus*, its causes and consequences. Both household and elders interviews were conducted from April to June 2012.

3.2.4. Statistical analysis

Data were analysed using the SPSS statistical software program version 20 (SPSS, 2011). For ranked data, Friedman's Chi square test (Steel and Torrie, 1980) was used. When Friedman's test revealed significant variation, a set of sign tests for multiple comparison of means were performed. Descriptive statistics such as means, standard deviations and percentages were used where appropriate.

3.3. Results

3.3.1. Household demography

A household is defined as a man and/or his wife, their children and any other person who is dependent for living and residing in the same house. The average household size in the survey area ranged from 5.1 (Tsengiwe village) to 8.1 (Upper Mnxe village) and showed significant ($P < 0.05$) differences between the three communal areas. Household members below 13 years did not vary greatly between the communal areas and generally accounted on average for 45%, 35% and 36% of the total household size in the Tsengiwe, Manzimdaka and Upper Mnxe, respectively (Table 3.1). The majority of the household respondents in the three communal areas received formal education at elementary (range: 20-53.3%) and secondary (33.3-66.7%) school levels (Table 3.1). The percentage of household respondents who received employment ranged from 3.3% (Upper Mnxe) to 10% (Tsengiwe). The percentage household respondents who received social grant also ranged from 30 % (Manzimdaka) to 33.3% (Tsengiwe).

Table 3. 1 Age distribution and mean household size in the three studied Communal areas (n = 30 per communal area)

Age	**Tsengiwe**	**Manzimdaka**	**Upper Mnxe**
≤13 years old	2.3^{a}(0.4)	2.5^{a}(0.4)	2.9^{a}(0.4)
>13 years old	2.9^{b}(0.2)	4.7^{a}(0.5)	5.2^{a}(0.9)
Total household size	5.1^{b}(0.4)	7.2^{ab}(0.7)	8.1^{a}(1.1)

*Standard error is indicated in brackets.

*Means with different superscripts within the same row (between villages) are significantly different (P < 0.05).

3.4.2. Livestock ownership

Table 3.2 presents the mean livestock holdings in the study areas. The mean cattle number did not vary significantly between the three communal areas and generally ranged from 5.2 ± 1.2 (Manzimdaka) to 7.2 ± 1.1 (Tsengiwe). Results on age distribution showed that cattle number at the age of ≥ 3 years did not show significant differences between the three communal areas. Female cattle at the age of < 3 years old were lowest at Manzimdaka and Upper Mnxe. Overall Adult cattle over 3 years of age contributed to 69%, 77% and 79% of the herd composition at Tsengiwe, Manzimdaka and Upper Mnxe communal areas, respectively. Cattle male contributed to 40%, 56% and 40% of the herd composition at Tsengiwe, Manzimdaka and Upper Mnxe communal areas, respectively.

The mean number of sheep was significantly higher at Tsengiwe (20.2 ± 4.8) than Upper Mnxe (12.5 ± 4.1) and Manzimdaka (9.6 ± 2.5). Results of age distribution showed that sheep number at the age of ≥ 2 years show significant differences between the three communal areas. Female sheep at the age of < 2 years old was lowest at Manzimdaka. Male sheep contributed to 36%, 50%, and 56% of herd composition at Tsengiwe, Manzimdaka and Upper Mnxe communal areas, respectively. Adult sheep over or equals to 2 years of age contributed to 70%, 53%, and 40% of the herd composition at Tsengiwe, Manzimdaka, and Upper Mnxe, respectively.

The mean number of goats was significantly higher at Manzimdaka (6.1 ± 1.3) than Upper Mnxe (4.7 ± 0.8) and Tsengiwe (1.9 ± 1.1). Goat numbers at the age of ≥ 2 years show significant differences between the three communal areas. Female goat at the age of < 2 years old was lowest at Manzimdaka. Overall, male goat contributed to 16%, 44%, and 30% of the herd composition at Tsengiwe, Manzimdaka and Upper Mnxe, respectively. Adult goats over 2 years contributed 79%, 74% and 70% of the herd composition at Tsengiwe, Manzimdaka and Upper Mnxe, respectively.

3.4.3. Relative importance of livestock and reason for raising cattle

All people in the three communal areas unanimously ranked sheep as the most important species for their livelihood (Table 3.3). However, the rankings of goat and cattle varied between the communal areas. Goat was as equally important as sheep at Tsengiwe and Manzimdaka communal areas, but at Upper Mnxe communal areas it was ranked as the second important species.

Cattle were ranked as equally important as sheep at Manzimdaka but at Tsengiwe and Upper mnxe, it was ranked as the second important species. Household respondents in the selected communal areas have special regard for cattle and keep them for various purposes. The purpose of keeping cattle varies among the communal areas. At Tsengiwe, lobola and rituals are the primary reasons followed by gift, sale and food.

Table 3. 2 Mean livestock holdings in the three studied communal areas (n = 30 per communal area)

Livestock	Tsengiwe	Manzimdaka	Upper Mnxe
Cattle			
< 3 years			
F	1.4 (0.4)^{a}	0.6 (0.2)^{b}	0.6 (0.3)^{b}
M	0.9 (0.3)^{a}	0.9 (0.2)^{a}	0.5 (0.2)^{a}
≥ 3 years			
F	2.9 (0.5)^{a}	3.1 (0.6)^{a}	2.4 (0.5)^{a}
M	2.0 (0.4)^{a}	1.8 (0.5)^{a}	1.7 (0.5)^{a}
Total cattle	7.2 (1.1)^{a}	6.4 (1.3)^{a}	5.2 (1.2)^{a}
Sheep			
< 2 years			
F	2.1 (0.7)^{b}	1.3 (0.5)^{b}	4.1(0.1)^{a}
M	3.1 (1.0)^{a}	3.3 (1.1)^{a}	3.4 (0.9)^{a}
≥ 2 years			
F	10.0 (2.6)^{a}	3.6 (0.9)^{b}	1.4 (1.1)^{c}
M	4.1 (1.0)^{a}	1.5 (0.5)^{b}	3.6 (0.9)^{a}
Total sheep	20.2 (4.8)^{a}	9.6 (2.5)^{b}	12.5 (4.1)^{b}
Goat			
< 2 years			
F	0.3 (0.2)^{b}	0.1 (0.2)^{b}	0.8 (0.2)^{a}
M	0.1 (0.01)^{a}	1.2 (0.3)^{b}	0.7(0.2)^{c}
≥ 2 years			
F	1.3 (0.8)^{b}	3.4(0.6)^{a}	2.6(0.2)^{b}
M	0.2 (0.1)^{c}	1.5(0.5)^{a}	0.7(0.2)^{b}
Total goat	1.9 (1.1)^{b}	6.1(1.3)^{a}	4.7(0.8)^{b}

- Standard error is indicated in brackets
- Means with different superscripts within the same row (between communal areas) are significantly different (P<0.05)

At Manzimdaka, rituals are the primary reasons for raising cattle followed by lobola, sale and food. At Upper Mnxe, sale, food and rituals are primary reasons followed by gift and lobola.

Table 3.3 Importance of livestock species (mean rank) as perceived by household respondents in three communal areas (n = 30 per communal area).

Livestock species	Tsengiwe	Manzimdaka	Upper Mnxe
Sheep	1.6^{a}	1.83^{a}	1.5^{a}
Cattle	2.12^{b}	2.00^{a}	2.2^{b}
Goat	2.25^{a}	2.13^{a}	2.3^{b}

The reasons for rasining cattle

Purposes	Tsengiwe	Manzimdaka	Upper Mnxe
Sale	3.7^{b}	3.5^{b}	2.7^{a}
Lobola	2.9^{a}	3.2^{b}	4.0^{b}
Wealth Status	4.7^{c}	4.8^{c}	5.1^{c}
Food	3.9^{b}	3.4^{b}	2.5^{a}
Gift	3.5^{b}	4.3^{c}	3.9^{b}
Rituals	2.2^{a}	1.9^{a}	2.7^{a}

*Means with different superscripts within the same column (within village) are significantly different ($P < 0.05$)

*Attributes were listed and ranked from most important (1) to least important (6)

3.4.4. Crop production

A total of 12 different crops were cultivated in the survey area. Of these, nine are vegetables (beans, beetroot, cabbage, carrots, potatoes, pumpkin, spinach, onion, peas) and three (oats, maize, and sorghum**)** are cereals. The importance of these crops varies between households within each communal area and collectively between communal areas. At Tsengiwe communal area, the four most important crops included maize, beans, pumpkin and potatoes and these are cultivated by 86.7%, 36.7%, 30% and 26.7% of the households, respectively. At Manzimdaka communal area, the five most important crops included maize, cabbage, spinach, potatoes, and beans and these are cultivated by 74.2%, 45.2%, 38.7%, 32.3% and 29% the households, respectively. At Upper Mnxe communal area, the six most important crops included maize, potatoes, pumpkin, cabbage, spinach and beans and these are cultivated by 96.7%, 40%, 33.33%, 33.33%, 30%, and 26.7% the households, respectively.

3.4.5. Animal feed supplements

Table 3.4 presents the type of livestock feed supplements used in the study area. The supplements are in a form of cereal grains, residues or by products obtained from maize, cabbage, oats, spinach and pumpkins that are harvested in their back yards. Feed supplements offered varied greatly between household respondents from the three communal areas. For example, 46.7 and 13.3 % of the respondents from Tsengiwe provided their animals maize alone and maize and pumpkin, respectively as feed supplements. About 56.7% of the respondents from Manzimdaka provided maize stock alone. The percentage of household respondents from Upper Mnxe who provided maize stock alone was 90%. The percentage of household respondents who did not provide feed supplements was 20%, 20% and 3.3 % at Tsengiwe, Manzimdaka and Upper Mnxe, respectively.

3.4.6. Constraints of livestock production

Table 3.5 presents the major constrains of livestock production as perceived by elders groups from the three study areas. All elder respondents from the three communal areas agreed that encroachment of grazing lands by *E.floribundus* or other woody plants and low forage yields were the primary constraints of livestock production.

Table 3.4 Type of feed supplements used by household respondents (%) in the three communal areas (n = 30 per communal area).

Feed Supplements	Tsengiwe	Manzimdaka	Upper Mnxe	Period
Maize	46.7	3.3	3.3	June-August
Cabbage	3.3	3.3	0	July & Dec
Oats	6.7	0	0	July-Aug
Maize Stock	0	56.7	90	July-Sept
Maize stalk+ Cabbage	0	3.3	3.3	May-July
Cabbage+ Spinach	0	3.3	0	June-July
Maize + Pumpkin	13.3	0	0	July-Aug
Maize + Cab + Spinach	0	3.3	0	June-Sept
Maize Stalk + Pumpkin	6.7	6.7	0	May-Sept
Oats + Maize	3.3	0	0	June-July
No feeding	20	20	3.3	

The elderly group from the three communal areas agreed that recurrent drought and low quality were second constraints of livestock production and soil erosion with crop farming as regarded at the least constraints.

3.4.7. Rangeland condition assessment and indicators

This study showed that there is slight difference in the opinions of farmers about the importance of rangelands for their livelihood (Table3.6). All elder groups from the three communities agreed that rangelands are primarily used for grazing, but at Tsengiwe communal area, use of rangelands to harvest medicinal plants was ranked as equally important as the use for grazing.

Table 3.11 Constraints to livestock production as ranked by elders in the three communal areas (n =48)

Number	Mean rank	Attributes
1	1.83[a]	High bush density
2	2.17[a]	Low grass yield
3	3.00[ab]	Recurrent drought
4	3.67[bc]	Low forage quality
5	4.33[c]	Soil erosion
6	6.00[d]	Crop farming

*Attributes were listed and ranked from most important (1) to least important (6).

At Manzimdaka communal area, elders indicated that use of rangelands to harvest building material was ranked as equally important as the use for grazing. Other uses included collection of wood for firewood and collection of dry cow dung for cooking. About 50% of the elders from each communal area indicated that they used topography to classify their grazing lands. They divided their land into bottom land and upland. Upland is used during summer when enough rainfall is available, while bottomland is used during winter for easy livestock management such as providing supplementary feed and water for livestock.

Elders' perception of the present state of the rangelands varied within each community (Table 3.7). At Tsengiwe communal area, 50% of the elders agreed that the range is in poor condition, while the remaining respondents indicated that the rangeland is in very poor condition. At Manzimdaka and Upper Mnxe communal areas, 50 % of the elders agreed that the rangeland is in good condition, while the remaining respondents indicated that the rangelands is fair condition. Elders also listed the indicators of rangeland condition and mostly they relate it to the vegetation and animal body condition. Elder respondents relate poor range condition to low forage production and high woody plant encroachment (mainly *E.floribundus*); fair range condition to low woody plant encroachment and ability of rangeland to support livestock. Elders related good range condition to good body conformation of livestock, especially cattle.

Table 3. 12 Use of rangelands in order of importance as perceived by the elders in the three communal areas (n = 16 per communal area)

Activities	**Tsengiwe**	**Manzimdaka**	**Upper Mnxe**
Grazing	1.8^{a}	2.2^{a}	1.7^{a}
Firewood	3.1^{b}	3.4^{b}	3.1^{bc}
Building	3.1^{b}	2.8^{ab}	2.1^{b}
Medicine	2.3^{a}	3.3^{ab}	3.7^{d}
Cooking	3.9^{b}	3.4^{b}	3.6^{d}

*Means with different superscripts within the same column are significantly different (P<0.05)

*Attributes were listed and ranked from most important (1) to least important (5)

3.4.8. Elders' perceptions of vegetation change and rangeland deterioration

All elder respondents from the three communal areas unanimously agreed that the composition of woody and herbaceous vegetation had changed significantly since they settled in the communal areas. The opinions of all elders in the listing and ranking of the attributing factors to vegetation changes are also similar (Table 3.8). Drought and woody encroachment (*E. floribundus*) were ranked as the primary attributing factors followed by grazing. The third important attributing factor was human settlement. Other factors included water points, crop farming and lack of fencing in the grazing lands. Most interviewed elders stated that rangeland deterioration is more pronounced in the recent years (Table 3.9).

Table 3.13 Landscape classification, current range condition and indicators as perceived by elders in the three communal areas (n = 16 per communal area; 8 individuals per group).

Communal Areas	Land Classification	Classification Criteria	Range Condition	Indicators
Tsengiwwe				
Elder group-1	Yes	Topography	Poor	Poor grass, high selective grazing
Elder group-2	No		Very Poor	High bush encroachment
Manzimdaka				
Elder group-1	No		Good	Good body conformation of cattle
Elder group-2	Yes	Topography	Fair	Some *E. floribundus* free areas
Upper Mnxe				
Elder group-1	No		Good	Good body conformation of cattle
Elder group-2	Yes	Topography	Fair	Still able to support livesto production

The term degradation is used to explain losses in the productivity of rangelands, associated with a decline in grass productivity and soil erosion (Cossins and Upton, 1988) whilst vegetation change mainly refers to change in species richness, diversity and increase woody encroachment. Though elders from all the three communal areas agreed on the listing of the attributing factors, their views on the order of importance differed greatly. At Tsengiwe communal area, elders perceived that bush encroachment and absence of fencing were considered the most important factors that cause the deterioration of grazing lands. Secondly, they stated that topography as attributing factors to rangeland deterioration as grazing lands with different landscape positions have different resistance to degradation. Thirdly, overgrazing, rainfall and soil depth were equally ranked. The least important factors listed by the elders as attributing factor was the expansion of human settlement (some of the fenced rangeland were taken by settler, so they can no long keep animals around homesteads for weaning purposes and bull separation) and the concomitant reduction of the available grazing lands.

At Manzimdaka communal area, elders perceived that bush encroachment and topography were primarily attributing to deterioration of grazing lands. Secondly, they consider overgrazing as a contributing factor to rangeland deterioration as severe overgrazing lead to poor basal cover. Thirdly, rainfall and soil depth were equally ranked. The least important factors listed by the elders as attributing factors were the human population and the presence of burning. At Upper Mnxe communal area, elders perceived that decrease of rainfall was considered as the most important fact that causes deterioration of grazing lands. Secondly, they stated that bush encroachment and burning as contributing factors to rangeland deterioration. Thirdly, overgrazing and topography were equally ranked. The least important factors listed by the elders as attributing factors were absence of fencing and soil depth.

3.4.9. Perception of *Euryops floribundus* invasion and its relation to climate change

The encroachment of *E. floribundus* as perceived by elders varies between communal areas (Table 3.10). All elders from Tsengiwe agreed that they did not observe *E. floribundus* plants in the grazing lands when they were teenagers. Elders also perceived that *E. floribundus* at low density became visible about 20 years ago, and this density turned to moderate level about 10 years ago and became high recently. All the elder respondents from Manzimdaka and Upper Mnxe communal areas had the same opinion that the population of *E. floribundus* was low when they were teenagers, and increased gradually to reach a high level recently. All elder respondents from the three villages agreed that the present annual rainfall is higher compared to 25 years and 15 years ago, and most perceived that the weather becomes hotter compared to some 25 and 15 years ago.

Table 3. 14 Attributing factors (mean rank) of vegetation change as ranked by elders in the three communal areas (n = 48)

Number	**Mean rank**	**Attributes**
1	1.8^{a}	Drought
2	2.00^{a}	Bush encroachment
3	3.92^{b}	Grazing
4	5.00^{c}	Human settlement
5	5.58^{c}	Land alienation
6	5.75^{cde}	Water points
7	5.75^{cde}	Crop farming
8	6.17^{e}	Absence of fence

* Means with different superscripts within the same column are significantly different (P<0.05). Attributes were listed and ranked from most important (1) to least important (8).

Table 3. 15 Attributing factors (mean rank) of rangeland deterioration as ranked by elders in three communal areas (n = 16 per communal area)

	Communal areas		
	Tsengiwe	**Manzimdaka**	**Upper Mnxe**
Frequent burning	8.0 ± 0.1^{d}	9.0 ± 0.0^{e}	3.5 ± 1.5^{b}
Bush encroachment	1.5 ± 0.5^{a}	2.0 ± 0.1^{a}	3.0 ± 0.0^{b}
Absence of fencing	2.0 ± 0.1^{a}	3.0 ± 0.1^{b}	7.0 ± 1.1^{e}
Increase in Human population	9.0 ± 0.0^{e}	9.0 ± 0.0^{e}	6.5 ± 0.5^{e}
Overgrazing	5.5 ± 2.9^{c}	4.5 ± 1.5^{c}	5.0 ± 1.1^{cd}
Rainfall	5.5 ± 2.5^{c}	5.5 ± 0.5^{c}	1.0 ± 0.0^{a}
Soil Depth	6.5 ± 2.5^{cd}	5.5 ± 1.5^{c}	9.0 ± 0.0^{f}
Topography	4.5 ± 0.5^{bc}	3.0 ± 1.1^{acb}	5.0 ± 2.1^{cd}
Water point development	7.5 ± 1.5^{d}	8.5 ± 0.5^{d}	6.5 ± 2.5^{de}

***** Means with different superscripts within the same column are significantly different (P<0.05**)**. Attributes were listed and ranked from most important (1) to least important (9).

Some elders from Manzimdaka and Upper Mnxe communal area also perceived that the winter season in particular receives more rain with frequent thunderstorm. About 50% of the elders at Tsengiwe and Upper Mnxe communities agreed that the increased population *E. floribundus* is promoted by increased rainfall but elders from Manzimdaka did not agree that *E. floribundus* is climate change related.

3.5. Discussion

3.5.1. Livestock ownership and importance

The results indicate that sheep population was higher than other livestock population. This suggests that sheep were the preferred livestock type in these communal areas. Farmers preference for sheep farming could attributed to the low buying power and easy maintenance and handling of sheep compared to cattle. Furthermore, this could be attributed to the shorter generation interval for sheep, also have a shorter gestation period, early maturing which in turn lead to provision of income where selling is the priority or provision of food. The fact that sheep could be converted into food earlier was also reported by (Valdivia, 2004). On other hand Mapiliyao (2010) reported in the similar study area that communal farmers keep sheep for income generation.

Moreover, local people tend to own small stock due to their lower purchasing power compared to owning large stock (Dovie *et al.,* 2006). Flock structure of sheep at Tsengiwe and Manzimdaka areas showed a slightly higher number of adult females; even so the herd composition may vary over seasons (Mapiliyao *et al.*, 2012). Total cattle population of this study was higher than the findings reported by Mapekula *et al*. (2010) and Gwelo (2012) in the same province, but slightly lower than Musemwa *et al*. (2007) who reported an average size of 16 cattle per farmer. In the current study, cattle herd structures comprise almost same number of adult females and adult males.

Table 3. 16 *Euryops floribundus* encroachment in the previous years as perceived by elders (n = 16 per communal area) in three communal areas

Communal areas	Teenager	20 years	10 years	5 years
Tsengiwe				
Elder group 1	No *E. floribundus*	Low density	Moderate density	High density
Elder group 2	No *E.floribundus*	Low density	Moderate density	High density
Manzimdaka				
Elder group-1	Low density	Low density	Moderate density	High density
Elder group-2	Low density	Moderate density	High density	High density
Upper Mnxe				
Elder group-1	No *E.floribundus*	Low density	Moderate density	High density
Elder group-2	Low density	Low density	Moderate density	High density

Against this study, Mapiye *et al.* (2009a) reported in the same province that the herd was dominated by adult females. The high adult male number may indicate the interest of local people to sell castrates which are commonly used during traditional ceremonies or draught power. Nevertheless, Solomon *et al.* (In Press) reported that large number of adult males may mean lower reproductive rate in the herd. The mean cattle number found in this study was higher than the values reported by Solomon *et al.* (In Press). However; Mapiye *et al*. (2009b) reported high number of cattle population as compared to the current study. The purpose of rearing cattle varied among the three communal areas, but generally the results were similar to the studies of Dovie *et al*. (2006); Nqeno (2008) and Mapiye *et al*. (2009). Even so, all elder respondents ranked traditional ceremonies as one of the most important reasons for keeping cattle.

The mean value of goat population found in this study was relatively lower than the report of Mapiye *et al.* (2009a); Mahanjana and Cronje (2000); Mapekula *et al*. (2009) and Gwase *et al*. (2010). This could be due to fact that the area is more of grassland and may not be more suitable for goat production. The dominance of female goats in Tsengiwe and Upper Mnxe herds is in agreement with the report of Gwaze *et al.* (2010) in the same province. Local people were mindful to keep adult breeding females of small stocks, and they sale male castrates for the reason that high proportion of adult female increases flock size via increased births (Gwaze *et al.*, 2010). The variation in the proportion of goats between communal areas may be attributed to differences in the number of goats slaughtered for rituals and many other traditional ceremonies. Masika and Mafu (2004) reported that slaughtering during rituals, and selling of live goats during the holiday seasons when most traditional ceremonies take place in the province are the main reason of keeping goats.

3.5.2. Crop production and animal feed supplements

The importance of crops varies between households within each communal area and collectively between communal areas. Most households grew maize, beans and potatoes. Maize was reported as major field crop grown for household consumption (Dovie *et al*., 2003; O'Neill *et al*., 1999) as much as crop residues for supplementary feed to animals (Mapiye *et al.*, 2009a; Mapekula *et al*., 2009). O'Neill *et al.* (1999) reported that maize stock was most commonly feed supplement during time of feed shortage (winter) in the same province. Type of feed supplements offered varied greatly between household respondents from the three communal areas. Generally, in this study, the communal farmers reported that feed shortage commonly occurred during May to September. The findings of the current study are similar to report of Mapiye *et al.* (2009a); Mapekula *et al*. (2009) and Mapiye *et al.* (2011). In particular, Mapiye *et al.* (2009a) reported that communal areas experienced feed shortage more than any other livestock systems and this has led farmers to utilize their limited feed on the lactating cows and calves than others (heifers, oxen and bulls) (O'Neill *et al*., 1999 ; Mapekula *et al*., 2009). More research is imperative to develop a supplementary feeding strategy using local available feed resources.

3.5.3. Constraint of livestock production

The results indicate that all elder respondents from the three communal areas agreed that encroachment of grazing lands by bushes and low forage yields were the primary constraints of livestock production. Although , the respondents did not suggest the reasons why bush encroachment is a problem, the constraint of bush encroachment could be explained by the fact that bush encroachment reduces forage yield and leads to reduction on livestock production. Progressive growth in bush encroachment is related to loss of herbaceous vegetation which cause low forage yields (Trollope, 1980; Meika *et al.,* 2002; Angassa, 2005). Similar findings about effects of bush encroachment on grazing lands were reported by Lesoli (2008). However, some other studies in the same province (Musemwa *et al*., 2008; Mapiye *et al.,* 2009a) reported different constraints such as feed shortage and diseases as major constraint of livestock production. In addition, elders during the study expressed that management practices such as bush clearing has been used by community to control *E.floribundus* in order to enhance livestock production. The results of bush clearing were ineffective as indicated by elder due increased density where the bush was cleared.

3.5.4. Elders' perceptions of rangeland conditions

The primary use of rangelands for grazing purposes has been reported by several researchers (Mapiye *et al*., 2009 b; Kassahun *et al*., 2008). This is because these rangelands are the major source of forage for resource limited farmers who keep livestock as main source of livelihood. At Tsengiwe, rangelands are used equally for harvesting medicinal plants because many traditional healers reside in this part of the communal areas. Moreover, use of ethno-veterinary can be also a factor was which reported by several researchers in Eastern Cape

Province (Dold and Cocks, 2001; Mwale and Masika, 2009; Moyo and Masika, 2009). Nevertheless, rangelands are also a source of cow dung. In other areas of South Africa, Dovie *et al*. (2003) reported that cow dung was accessed through purchasing.

Differences in elders' perception of rangeland condition between communities may be related to the variation in the location of their rangeland on the landscape gradient. Therefore, this variation could be attributed to variation on the size the rangeland, level of bush encroachment and average number of livestock grazing per each communal area. The finding of the current study is partially similar to the report of Bennett *et al.* (2010) that overall rangeland condition in same province was low. Elders also listed the indicators of rangeland condition and mostly they relate range condition to the vegetation and animal body condition. Bennett *et al.* (2010) also reported other rangeland indicators perceived by communal farmer including few species of good quality, dominating *Acacia karroo* and amounts of unpalatable karroid shrubs. In Botswana, Reed and Dougill (2002) related rangeland indicators to livestock body condition, grass cover and the abundance of key palatable forbs and grass species. Moreover, communal farmer make a direct link between the amount of rainfall and condition of their livestock as a reflection of the impact of rain on forage availability (Allop *et al*., 2007).

Drought and bush encroachment were ranked by elders as the primary attributing factors to vegetation change. Nel and Davies (1999) indicated that unreliable rainfall and recurrent drought still poses serious challenges in the communal areas of South Africa. Moreover, communal farmers are more prone to drought due to less potential of resources such supplementation, enough gazing land and divided camps (Ngaka, 2012). In Ethiopia, Kassahun *et al*. (2008) reported major constraints to pastoral production systems which includes drought as the major limiting factor to pastoralists' livelihoods.

Elders from three communities expressed their opinion that increased shrub or bush density suppresses growth of grass species which lead to low forage yield. Likewise, O'Connor and Crow (1999) stated dense bush encroachment markedly depress herbaceous production to such extent that cattle production would be affected. In South Africa, pronounced effect of bush encroachment on grass cover, especially on communal rangeland was also reported by Wigley *et al*. (2009). In Namibia, pastoralists perceived bush encroachment as beneficial because woody plants provide browse for livestock production and served as source of firewood and timber construction (Katjiua and Ward, 2007) and same opinion was also reported in South Africa (Wigley *et al*.2009). In Ethiopia, Solomon *et al.* (2007) reported that elders of Borana pastoralists in southern Ethopia stated that sheep and cattle are most negatively affected by increased bush encroachment.

Elders from Tsengiwe expressed that absence of camps in their communal rangeland leads to deterioration of rangeland because grazing management practices such as rotation are impractical. During the time of Lennox Sebe in Ciskei, Eastern Cape , communal rangelands were fenced but currently, there were no fences and this has made control of livestock movement very difficult (Bennett *et al*., 2010). The absence of fencing as a major constraint of livestock production and grazing management has been similarly reported by Samuels *et al*. (2007) and Nqeno (2008). Bennett *et al*. (2010) reported that several communal farmers stated that fencing of the rangeland is necessary to allow them to manage as well as restore degraded rangelands. Mapiye *et al*. (2009b) reported that communal farmer recommended provision of fence to reduce cattle theft.

Most elders in the current study perceived the gradual increment of *E. floribundus* density. Similar finding about the expansion of woody plants was reported by Wigley *et al*. (2009). Shackleton and Gambiza (2008) reported that *E. floribundus* was collected daily or few times per week for firewood and this promoted dispersal of the seeds over large areas. The encroachment can also be associated with physical removal of the *E. floribundus* with no proper strategy of utilizing rangeland after removal of the species which opens a window for more *E. floribundus* seedlings for survive

All elder respondents from the three villages agreed that the present annual rainfall is higher compared to 25 years and 15 years ago, and most perceived that the weather becomes hotter compared to some 25 and 15 years ago. Findings of the current study are in agreement with findings reported by Clarke *et al*. (2012) that farmers experienced a hotter dry season, increased rainfall irregularity and increased unpredictability of extreme events in the same province. In other areas of South Africa, Wigley *et al*. (2009) reported that majority of farmer's perceived rainfall to have decreased over time. Generally, climate change in South Africa has been observed in terms of significant variation in the amount of rainfall and change of temperatures (Meadows and Hoffman, 2002).

About 50% of the elders at Tsengiwe community and Upper Mnxe community agreed the increased population *E. floribundus* is promoted by increased rainfall but elders from Manzimdaka did not agree that *E. floribundus* is climate change related. Wigley *et al*. (2010) indicated that changes in rainfall and temperature are more likely to influence woody encroachment, especially extreme events such as prolonged droughts.

3.6. Conclusion

Local people's knowledge and perception on livestock production varied across the community areas. In this study, farmers are using strategic ways of surviving during dry season (winter) where they move their livestock to fields after harvesting and therefore, livestock population increases. Livestock population particularly sheep and cattle were higher than other studies in the same province. There are several constraints to livestock production but *E. floribundus* and drought were found to be more important in this study. Communal farmer in this study found to be using several traditional supplementary feed, especially maize stock during time of feed shortage. It is concluded that rangeland deterioration is more pronounced in the recent years. Encroachment of *E. floribundus* as perceived by local people was low during their teenage stage but became heavy since recently. Further research is required to focus on ways of improving supplementary feed during time of feed scarcity and development of specific management plan by researchers with government is required in order to remove *E. floribundus* with support and participation of local communities.

CHAPTER 4. ABUNDANCE OF *EURYOPS FLORIBUNDUS*, HERBACEOUS VEGETATION AND SOIL NUTRIENTS ALONG LANDSCAPE GRADIENTS AND THEIR RELATIONSHIPS

Abstract

The study investigated the effect of landscape on the distribution of *Euryops floribundus,* herbaceous vegetation and on soils and their relationships. A total of four 50 m x50 m plots were selected along the following landscape positions: bottomland, middle, upper slope and upland sites. Each landscape gradient was replicated in four different sites. A plot of 50 m x 50 m was marked in each site to collect vegetation and soil data. The field experiment was arranged in a non-randomized block design with each plot in the plot serving as blocks. The data was analysed using a General Linear Model (GLM) of SAS (2001). CANOCO software was used for multivariate analysis to investigate relationships between environmental and species variables. The result showed that the total density of *E.floribundus* significantly increased from the topland (2301 plants ha^{-1}) moving to the bottomland (4888 plants ha^{-1}). Canopy cover was significantly lowest in the topland (17.9%), but the remaining gradients had similar cover. Species that occurred as common or dominant species in at least on site included *Aristida diffusa, Elionurus muticus, Eragrostis chloromelas, E. plana, Heteropogon contortus, Sporobolus africanus,* and *Themeda triandra*. The average distance between grass tufts was significantly higher ($P<0.05$) at the bottomland and sloppy sites than at top lands. Grass dry matter yield was higher ($P<0.05$) at the bottomlands and sloppy gradients than the toplands. Soil organic carbon was generally higher ($P<0.05$) in the flat (bottom and toplands) than the sloppy terrain. Soils from higher elevations (toplands and upper sloppy) had significantly higher N than the lower elevations (bottomlands and Middle sloppy). Tuft diameter, mature shrubs and canopy cover were positively correlated with landscape altitude, and total density of *E. floribundus* was negatively correlated. This study concluded that landscape gradient influence the distribution of *E. floribundus* across all flat terrain and sloppiness in terms of density and height distribution. Therefore, this study motivate for other researchers to critical consider topographic position during control of this species.

Keywords: Tuft distance, herbaceous yield, diversity

4.1. Introduction

Shrub invasion has been widely reported to cause major changes in the herbaceous vegetation composition, diversity and cover in arid and semiarid regions of the world (Archer, 1995; Fensham *et al.,* 2005; van Auken 2000; Roques *et al.,* 2001; knap *et al.,* 2008; Beyene In press). Several factors appear to influence the distribution and structure of shrub plants in a savanna and grassland ecosystems. These factors fall into two main categories, namely anthropogenic and environmentally related factors. It is widely accepted that the use of savannas for domestic livestock has facilitated shrub invasion through associated overgrazing combined with changes in fire regimes (Aucamp, 1976; Walker *et al*., 1981; Van Vegten 1983; Archer, 1995; Milton and Dean, 1995). Overgrazing by livestock is responsible for opening up the grass sward, and enables woody plant species to have access to soil moisture that could otherwise have been utilized by the grasses. The reduction of grasses by overgrazing provides favourable conditions for woody plants recruitment because of reduced fuel load and competition (O'Connor and Crow, 1999; Meik *et al.,* 2002; Wiegand *et al.,* 2006; Coetzee *et al*., 2007; Kassahun *et al.,* 2008).

Environmental factors known to influence shrub encroachment include rainfall variability, topography and soil. The importance of rainfall for bush encroachment involves competition for resource (soil moisture) with herbaceous layer. This phenomenon is fundamental to Walter's (1971) two-layer hypothesis, which dominates the literature on tree-grass interaction in savannas. Moreover, Kraaij and Ward (2006) hypothesized that unusually high rainfall is critical for mass tree seedling recruitment, which will ultimately result in bush encroachment. The ability of leguminous trees and shrubs to fix N2 can greatly contribute to their success in poor environments (Dart *et al.,* 1991). However, Kraaij and Ward (2006) predict that an increase in soil nitrogen will enhance growth of herbaceous plants, which will then increase their negative effects on the early growth and establishment of tree seedlings. Altitudinal gradients and landscape terrain are among the most important topographical factors which have been used to test ecological responses of woody plants to geographical influences. Both anthropogenic and environmental factors vary from region to regions and often interact among each other to form distinct woody vegetation density and cover.

Euryops floribundus is spreading rapidly in the vast communal grazing lands of the Eastern Cape province of South Africa. This species is distributed in all landscape gradients ranging from bottomland to topland. *Euryops floribundus* could potentially expand its geographical ranges in future because of climate change, adaptation to wider elevation regimes, and production of small sized copious seeds which can be easily dispersed by wind, animals and water. As the population of this species increases, threats and impacts on the herbaceous vegetation, the soil and biodiversity may increase.

However, there are few studies that investigated the patterns of *Euryops floribundus* along elevation gradients. Altitudinal gradients exhibit strong environmental changes over short distances and therefore can significantly influence plant occurrence more than any other geographical factors (Wang *et al*., 2002). There are also limited studies that show the relationship between abundance of *Euryops floribundus*, soil and herbaceous vegetation across elevation gradients. *Euryops floribudus* invasion may be facilitated by several factors and their interactions still need to be understood in order to initiate sustainable restoration practices towards controlling this species. The aims of the study was therefore to examine 1) the distribution of *E. floribundus* along four elevation gradients (bottom, lower middle, upper middle and upland terrains), and 2) the relationship between elevation gradients, *E. floribundus*, herbaceous vegetation and soil nutrients.

4.2. Materials and Methods

4.2.1. Description of the study area

The study was conducted in Cala communal areas at Upper Mnxe located at 31º33´S, 27º36´E and altitudinal range of 1294 to 1441m a.s.l. The vegetation type of the study area is Tsomo grassland (Mucina and Rutherford, 2006). The average summer (November to April) is winter (May to October) rainfall are 600 mm and 200 mm, respectively. The mean temperature in January and July is 22ºC and 12ºC, respectively. Upper Mnxe is generally flat with some hills, gentle to steep slopes (12%) and wide valleys. The livestock types kept include cattle, sheep, and goats. The animals are not kraaled except during animal inspection and supplementary feeding (Lesoli *et al*., 2010).

4.2.2. Site selection and field layout

A total of about 5 ha land was selected for this study. Selection criteria included the presence of *E. floribundus* and different landscape gradients. A total of four 50 m x 50 m plots were marked along the landscape gradients: Bottom, middle slope, and upper slope and upland positions. This gives a total of 16 plots. Four belt transect of 50 m x2m were marked within each plot to record plant and soil data. The belt transects were vertical long and horizontal short.

4.2.3. Plant data collection

Density of all woody species were recorded within each belt transect and the height, and canopy diameter (long and short canopy diameters) of individual plants were measured. Canopy cover is calculated from canopy diameter using the formula:

$=\Pi\ (d_1 x d_2/4)^2$

d_1= the shortest diameter

d_2= the longest diameter perpendicular to the shortest diameter

Table 4. 1 Altitudes, latitudes and longitudes of landscape gradients in the study areas

Landscape	Altitude	Latitude	Longitude
Block 1			
Bottom	1294	31.5254	27.59272
Middle	1327	31.52507	27.92742
Upper slope	1337	31.52502	27.59483
Top	1391	31.52402	27.59602
Block 2			
Bottom	1298	31.51842	27.59903
Middle	1304	31.51842	27.59852
Upper slope	1323	31.51842	27.59785
Top	1410	31.52058	27.59785
Block 3			
Bottom	1276	31.51687	27.59933
Middle	1304	31.51697	27.59833
Upper slope	1320	31.51717	27.59782
Top	1392	31.51868	27.59632
Block 4			
Bottom	1279	31.51585	27.5932
Middle	1289	31.51642	27.59372
Upper slope	1298	31.51688	27.59437
Top	1404	31.51963	27.59562

Five 0.5 m x 0.5 m (0.25m^2) quadrants were also randomly laid within each belt transect. All herbaceous species within each quadrant were recorded and their tuft diameter measured

using 30 cm ruler. Distance between any two tufts was also measured using the ruler. Each species was then cut separately and placed in paper bags. Collected samples of herbaceous vegetation were taken to the laboratory and oven dried at 60°C for 48 hours to determine the dry matter biomass. Species diversity was estimated using Shannon-Wiener index (H) using the formula: $H' = -\sum [(n_i/N) \times \ln (n_i/N)]$

n_i= amount of biomass of each species

N= Total amount of biomass

Ln= the natural log of biomass

4.2.4. Soil sampling

A total of five soils were collected randomly from each corner and centre of the main plots at 5 cm and 20 cm depths. All soil samples were composite (mixed) based on depths (5cm and 20 cm).

4.2. 5. Experimental design and statistical analysis

This experiment was arranged in a non-randomized block design with each landscape gradient replicated in four major sites of 50 m x 50 m plots which served as blocks. Therefore, the total number of plots (replicates) per landscape gradient was four. Sampling transects and quadrants were nested within each block. Woody and herbaceous vegetation as well as soil data were analysed using a General Linear Model (GLM) of SAS (2001).

The canonical correspondence analysis (CCA) of CANOCO version 4.5 software (ter Braak and Šmilauer 2002) was used as a multivariate analysis tool to investigate the relationship between investigate relationships between environmental variables (altitude, pH, Carbon, phosphorus, nitrogen and resistance) and species variables (young shrubs, total density of *E.floribundus*, total density, seedling, diversity index, dry matter and total density of *E.floribundus*). In general, plant species exhibit unimodal response curves along distance gradients (Fensham *et al.*, 1999). Canonical correspondence analysis is an ordination method appropriate for direct degradation gradient analysis. Automatic forward selection was conducted stepwise to select environmental variables that could explain most of the species data variations. The Monto Carlo method was used to test the significance of the first canonical axis (ter Braak and Šmilauer, 2002).

4.3. Results

4.3.1. Density and height class distribution of *E. floribundus*

Table 4.2 presents the total density and canopy cover (%) of *E. floribundus* along landscape gradients. The result showed that the total density significantly increased from the topland (2301 plants ha^{-1}) moving to the bottomland (4888 plants ha^{-1}). Canopy cover was significantly lowest in the topland (17.9%), but the remaining gradients had similar cover. With regard to height class distribution, saplings (>0-1m) were more abundant in bottomlands, and young shrubs (>1-2 m) were more abundant in the upper and middle slopes. Mature shrubs (>2 m) had the lowest proportion of all sizes and were denser in the upper slope followed by topland.

Table 4.2 Total density (no ha^{-1}) and cover (%) of *Euryops floribuduns* along landscape gradient

Landscape position	Total density	Canopy cover
Bottom	4888^a	28.8^a
Middle	3813^b	33.7^a
Upper	3131.6^b	31.9^a
Top	2300.6^c	17.9^b
SE	273.5	2.9

*Means with different superscript letters vary significantly (P <0.05).

4.3.2. Species composition of grasses and diversity along landscape gradients

A total of 26 grass species were identified in all the study plots. Species that occurred as common or dominant species in at least on site included *Aristida diffusa, Elionurus muticus, Eragrostis chloromelas, E. plana, Heteropogon contortus, Sporobolus africanus, Themeda triandra*.

Table 4.3 Height class distribution (%) of *Europs floribuduns* along landscape gradient

Landscape Position	>0-1m	>1-2m	>2m
Bottom	57	38	5
Middle	32	65	4
Upper	29	63	8
Top	51	44	6
SE	1.6	1.1	0.4

*Means with different superscript letters vary significantly (P <0.05)

*SE: Standard Error

All these species accounted for 68%, 75%, 70%, 72.3% of the total species abundance in the bottom, middle and upper slopes and toplands, respectively. *Themeda triandra* recorded as dominant species (>10%) throughout the landscape gradients. *Eragrostis chloromelas* was recorded as the dominant species only in the bottom and topland sites. *Eragrostis plana* dominated (12.6%) the bottomland. The dominance of *A. diffusa* was restricted to sloppy areas. Similarly, *H. contortus* occurred more abundantly in the sloppy areas than any other sites. *Sporobolus africanus* occurred more frequently in the plateau landscapes (bottom and toplands). Results on species diversity are presented in Figure 4.1. The highest diversity index (1) occurred at bottom terrain. Middle slope and toplands had similar diversity index (0.9) and lowest diversity index (0.8) occurred at Upper slope.

4.3.3. Tuft distance, diameter and basal cover

Grasses at the bottomlands and sloppy sites had similar and significantly greater ($P < 0.05$) tuft diameter than grasses at the toplands (Figure 4.2). Similarly, the average distance between grass tufts was significantly higher at the bottomland and sloppy sites than at top lands (Figure 4.3).

Table 4.4 Life forms and abundance (%) of grass species along landscape gradient

Species	Grazing Value	Bottom	Middle	Upper	Top
Andropogon appendiculatus	High	1.6	2.1	3.5	5.2
Aristida congesta	Low	3.8	6.3	8.7	0.3
Aristida diffusa	Low	6.7	24.6	10.7	5.3
Aristida junciformis	Low	2.1	0.6	0.3	0.3
Brachiaria serrata	Moderate	1.6	0.7	1.3	1.3
Cymbopogon excavates(Mqungu)	Low	0.2	0.6	1.1	0.02
Cymbopogon plurinodis(Isiqungu)	Low	1.8	1.3	0.9	0.9
Cynodon dactylon(Uqaqaqa)	High	2	0.9	0.5	6.1
Digitaria eriantha (Isandla)	High	0.02	0.2	0.3	0.02
Eleusine corocana	Low	0.3	0.9	0.02	1.9
Elionurus muticus(Isilevu)	Low	13.9	13.9	17.6	7.7
Eragrostis capensis	Moderate	0.9	1.9	0.3	0.7
Eragrostis chloromelas	Moderate	11.2	1.3	4.8	15.5
Eragrostis plana (Msuba)	Low	12.6	3.9	2.4	2.9
Eragrostis superba	Moderate	1.2	2.4	2.2	0.3
Harpochloa falx	Low	0.02	0.02	0.02	0.7
Heteropogon	Moderate	3.9	8.1	10.6	2.7

contortus(Umkhonto)					
Hyparrhenia hirta(Igcelwana)	Moderate	1.5	0.02	1.7	0.1
Karroochloa curva	Low	0.02	0.7	0.02	0.4
Paspalum dilatatum	High	0.1	0.3	0.02	0.3
Pentachistis natalensis	Low	0.6	0.02	0.02	0.02
Sporobolus africanus(Injinca)	Low	9.1	6.1	5.3	8.4
Sporobolus centrifuges	Moderate	2.5	1.5	2.2	1.8
Themeda triandra (Iqunde)	High	10.4	16.8	20.9	27.2
Tristachya leucothrix	Moderate	1.9	0.8	1.3	1.2
Forb		7.3	3.1	2.4	7.3

- In brackets some grass species were given vernacular names (Xhosa)

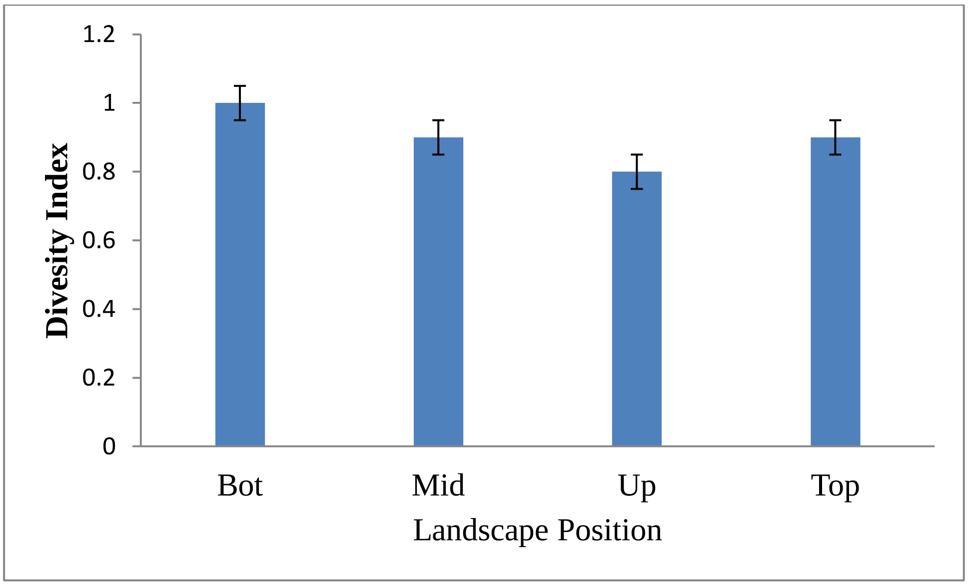

Figure.4.1. Species diversity along landscape gradient (Bot-Bottomland, Mid-middle slope, Up-Upper slope, Top-topland)

4.3.4. Herbaceous dry matter and ground cover

Grass dry matter yield was higher (P<0.05) at the bottomlands and sloppy gradients than the toplands. Forbs had generally greater biomass (P<0.05) at the flat terrains (bottom and toplands) than the sloppy sites. Except the toplands, which had the lowest herbaceous cover, all the remaining gradients had similar cover (Table 4.5).

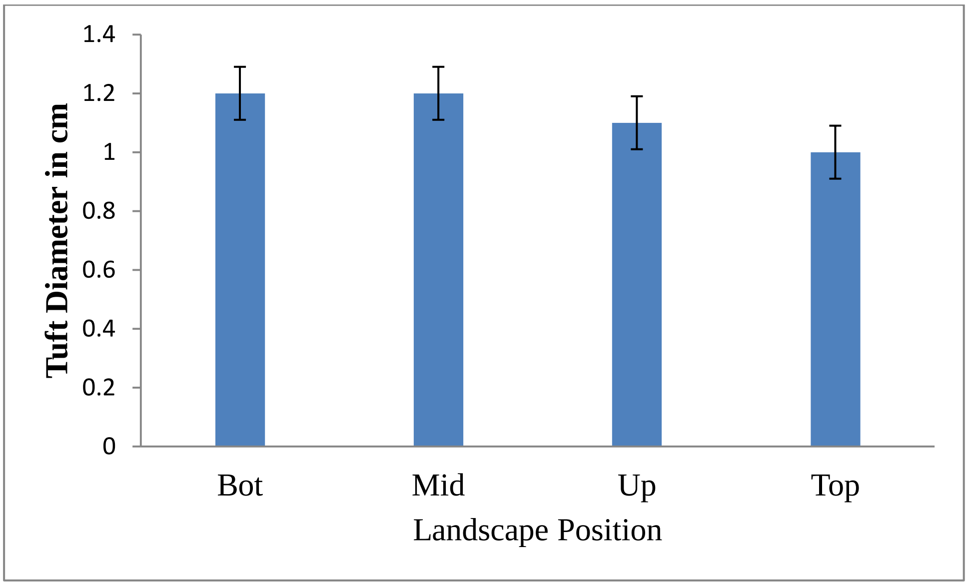

Figure 4.2. Tuft diameter along landscape gradients (Bot-Bottomland, Mid-middle slope, Up-Upper slope, Top-topland)

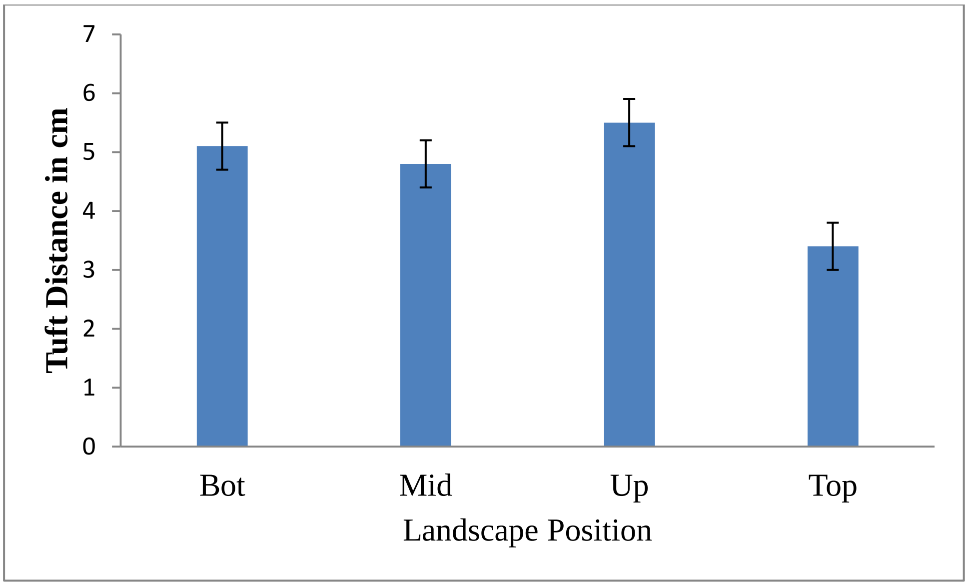

Figure 4.3. Tuft distance along landscape gradients (Bot-Bottomland, Mid-middle slope, Up-Upper slope, Top-topland)

Table 4.5 Herbaceous dry matter yield (Kg ha^{-1}) and cover (%) along landscape gradient

Landscape Position	**Grass**	**Forb**
Bottomlands	202.4^{a}	16.3^{a}
Middle slope	234.9^{a}	7.3^{b}
Upper slope	196.2^{a}	4.9^{b}
Topland	166.4^{b}	13.2^{a}
SE	25.4	2.13

*Means with different superscript letters vary significantly (P <0.05)

*SE: Standard Error

4.3.5. Effects of landscape gradient on soil chemical properties

Table 4.6 presents soil chemical properties along the landscape positions. Soil organic carbon (OC) was significantly higher (P<0.05) in the flat (bottom and toplands) than the sloppy terrains. Soils from higher elevations (toplands and upper slope) had significantly higher N than the lower elevations (bottomlands and middle slope). Middle slope sites had significantly higher (P <0.05) Ca content than other landscape positions. Soils from upper slope had significantly higher available P and resistance than other landscape positions. There was no significant difference (P ≥0.05) in soil pH, soil resistance, Ca and N contents between soil samples collected from 5 cm and 20 cm depths. However, soil OC and available P decreased greatly with increased soil depth (Table 4.6).

4.3.6. Relationship between variables

Thirteen environmental variables were related to the species data. Four environmental variables, viz. soil Ca5, Ca20, P5, P20 and resistance 5 were omitted straight by automatic forward selection, because these variables had insignificant effect on the species variance.

Table 4.6 Soil chemical properties along landscape gradient

Landscape Position	Soil C	Calcium	Available P	Resistance	pH	Total N
Bottom	2.9a	5.8b	7.6a	781.3a	5.3	0.1c
Middle	2.2b	16.1a	6.9a	615.0a	5.7	0.1c
Upper	2.5b	6.5b	9.4a	823.8a	5.2	0.1ab
Top	3.3a	7.6b	7.2a	725.0a	5.2	0.2a
SE	0.29	3.6	1.7	103.8	0.2	0.03
Depth (cm)	**C**	**Ca**	**P**	**Res**	**pH**	**N**
5	3.1	8.2	8.8	773.1	5.4	0.2
20	2.3	9.8	6.7	699.4	5.3	0.2
SE	0.2	2.6	1.1	43.07	0.11	0.02

*Means with different superscript letters vary significantly ($P < 0.05$)
*SE: Standard Error

The eigenvalues of axis 1 and axis 2 were 0.59 and 0.01, respectively. The sum of the canonical eigenvalues was 1, species-environment correlation to axis 1 and axis 1 were 0.78 and 0.42, respectively. Based on the ordination diagram presented in Figure 4.4, dry matter, canopy of *E.floribundus* and young shrubs were positively associated with soil pH, whereas tuft diameter, canopy cover and basal cover were correlated negatively with soil pH. Tuft diameter, mature shrubs and canopy cover were positively correlated with altitude, and total density of *E. floribundus* was negatively correlated.

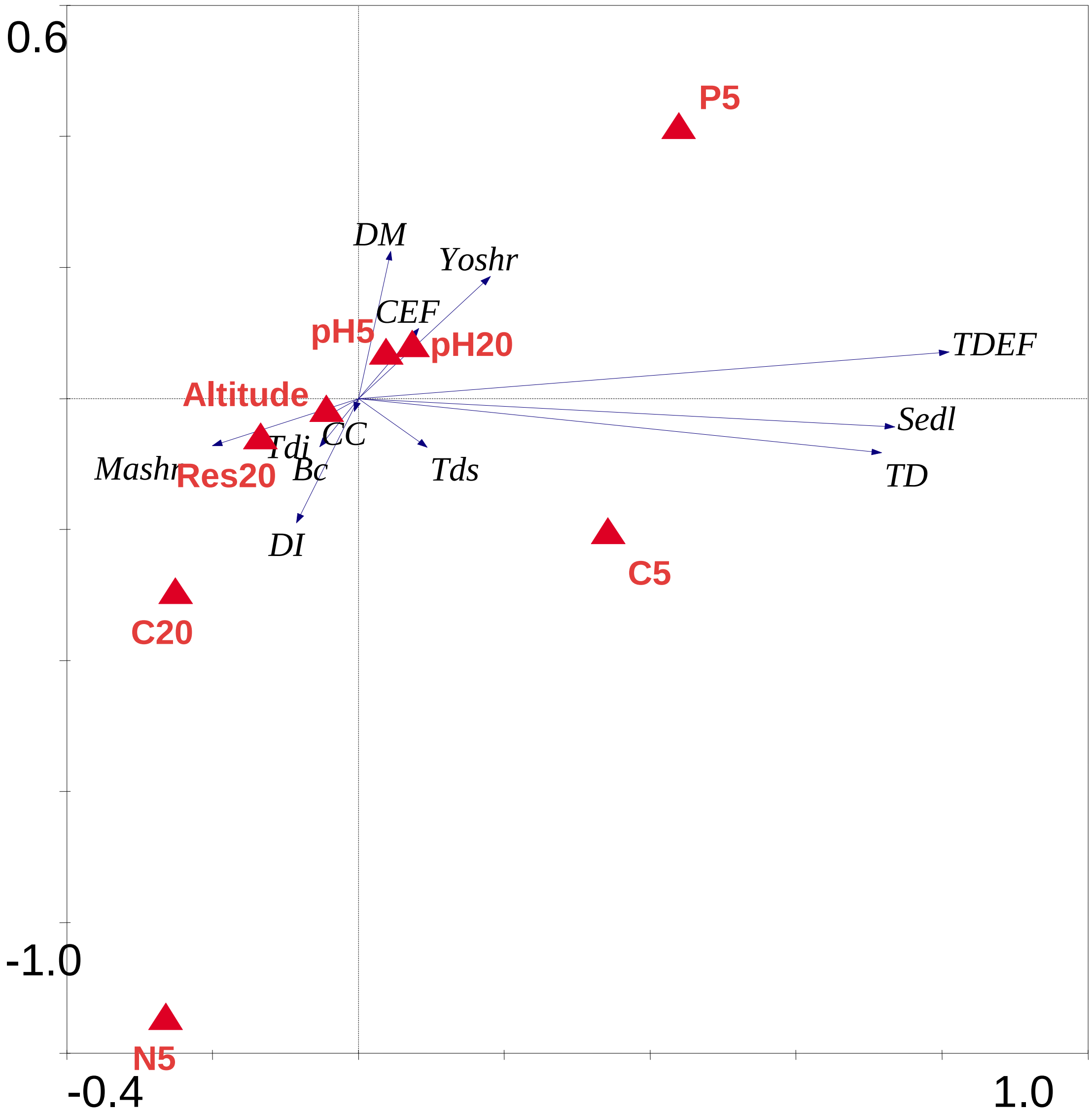

Figure 4.4. The analysis ordination diagram of the relationship between environmental and species variables along landscape gradient. Abbreviations: DM, Dry matter; CEF, Canopy of *E.floribundus* ;Yoshr, Young shrubs; P5, Phosphorus; pH20, pH at 20 cm depth; TDEF, Total density of *E.floribundus* ;TD, Total density; Sedi, seedling ; Tds, tuft distance; C5, Carbon at 5 cm depth; DI, Diversity index; Tdi, tuft diameter; Bc, Basal cover; CC, canopy cover; Mashr, Mature shrubs ; C20, Carbon at 20 cm depth; N5, Nitrogen at 5 cm depth.

4.4. Discussion

4.4.1. Density and size distribution of *E. floribundus*

All landscapes were invaded by *E. floribundus* but total shrub population and relative occurrence of age or size groups varied across the landscape positions. The total density of *E. floribundus* was high at the bottomlands and low at the toplands, where saplings were relatively more abundant than the other age or size groups. While the total population of *E. floribundus* may be strongly influenced by elevation, the relative occurrence of age or size groups within a population are more related to sloppiness. The combination of heavy grazing and a highly variable climate has contributed to extensive environmental problems throughout southern Africa (Darkoh, 2009). The variation in shrub population along the landscape gradients may be related to grazing pressure.

Bottomlands are closer to the communal homesteads and are more frequently and heavily grazed by animals than the other landscape positions. High levels of long term herbivory will reduce both aboveground and belowground grass biomass, reducing the grass's ability to re-grow, to replace itself and to compete. When this occurs, the woody plants are favored over the grasses and their establishment and growth is promoted (Van Auken, 2009) because more nutrients and moisture becomes available to the shrubs, allowing them to recruit en masse (Gil-Romera *et al*., 2010). Bottomlands experience higher soil moisture availability due to less chances of runoffs (Nicolau *et al*., 1996). The soil structure in the bottomlands may also allow shrubs to have developed root systems efficient to utilize the soil moisture (Wilcox *et al.,* 2004). In addition, movement of shrub seeds from topland and the middle slopes into the bottomland (Argaw*et al*., 1999) may increase the recruiting seed population and hence the abundance of *E. floribundus*. Rezaei *et al*. (2005) observed that overgrazing is common at bottomlands due to other factors including the presence of animal watering points (rivers).

In addition, findings of this study concur with Shackleton (2000), that woody plants were more abundant at the bottomlands than the topland and also with findings of O'Connor and Crow (1999) which stated that valleys were consistently two to three times more encroached than slopes in the same province. Variation of canopy cover along landscape gradient could be attributed to variation in the height class proportion. In fact, percentage of canopy cover of *E. floribundus* on certain landscape gradients is mainly determined by density of total plants and the density of mature plants. Saplings and young shrubs distributions differed markedly between the landscape gradients and are mainly related to slopiness.

Similar findings were also reported by Rubino *et al*. (2003) who noted that saplings had different distribution along landscape gradient. Bottomlands and toplands were dominated by woody seedlings implying that succession is at early stage of development (Senbeta and Teketay, 2001) and/or the growth of seedlings establishment were active after deaths of mature shrubs. This incidence of dying of mature shrubs was observed at the topland during the study. The reason for this phenomenon requires further research. In sum, the causes of shrub encroachments in grasslands have been debated for several decades, but generally suggestions spin around anthropogenic activities such as human induced livestock pressure, seed dispersal (Araujo *et al.,* 2008; Paudel and Andersen, 2010), changes in fire regime and climatic factors such as rainfall variability and elevated atmospheric Co_2 (Polley *et al*., 2002; Pausas, 2004; Angassa, 2005; Ward, 2005; Angassa and Oba, 2010).

Many researchers have undermined the landscape factors such as slopes and elevations, and their interaction with abiotic and biotic processes as determinant to shrub invasion or encroachment.

4.4.2. Herbaceous layer composition and diversity

All the landscape positions shared in common a large number of herbaceous species. As expected, however, species composition of the predominant herbaceous layer varied significantly across landscapes. The abundance of *T. triandra* increased with increasing elevations from the bottomlands to the uplands, but this effect was against previous studies of (Cole *et al*., 2005) who reported the absence of any strong influence of landscape position. It is quite likely that *T. triandra* would have been more abundant in the lower landscape position where there is more soil moisture and nutrient deposition to support its fast growth and establishment.

This was not so because bottomlands have often more livestock concentration and therefore, the influence of grazing disturbance is stronger than landscape factor. The dominance in the abundance of *A. diffusa* in the sloppy terrain compared to the flat terrain is expected because this species grows mostly in slopes, gravel and shallow soils (Van Oudtshoorn, 2012). The dominance of *E. chloromelas* in the sloppy sites is against the report of Van Oudtshoorn (2012) who considered that this species more abundant in the open grassland than bushveld regions. The higher disturbance of communal lands was reflected in the structural attributes of the herbaceous layer composition. It is clear from the results that *E. plana* dominated the bottomlands; the occurrence of this species is an indicator of degraded rangeland due to overgrazing (Van der Westhuizen *et al*., 2005). The abundance of *H. contortus* in the sloppy terrain is poorly understood but Orr *et al*. (2004) reported that *H. contortus* was influenced by landscape position.

Herbaceous plant diversity varied across the landscape gradients with bottomlands supporting the highest diversity despite the highest shrub invasion, and the upper slope having the least diversity. Wang *et al*. (2002) presented curvilinear relationship between species diversity and elevation gradient in China. It is difficult to understand the relative contribution of landscape factors to vegetation diversity, but overall governing factors should have a strong influence on resource availability and mobility to support a mix of species. There has been much debate as to the effects of livestock grazing on diversity. Some researchers suggest negative impacts, in particular in response to heavy grazing (Olsvig-Whittaker *et al.,* 1993; Fleischner, 1994; Shaltout *et al*., 1996). It is well documented that species diversity of natural communities is significantly related to productivity (Palmer 1992; Abrams 1995; Weiher 1999; Braakhekke and Hooftman 1999; Kassen *et al.*, 2000; Brown 2001).

4.4.3. Tuft diameter, tuft distance, herbage cover and yield

The results of this study showed significant difference in the plant functional characteristics with the lowest values recorded on the topland sites. Beckerling *et al*. (1995) suggest that an average tuft distance below 3 cm indicates high basal cover, while a distance between 3 and 6 cm, and above indicates moderate to low basal cover, and low or very low basal cover, respectively. Based on these values, the basal cover in this study falls between moderate to low, with moderate cover being in the bottomlands, middle slope and upper slope, and low cover in the toplands. Nevertheless it is not advised to rely on tuft distance alone for basal cover estimation. The main reason for a significantly low grass production in the topland compared to the bottomland and sloppy sites is the smaller tuft diameter of grasses.

4.4.4. Soil chemical properties

Results on soil chemical properties are varied. Flat terrains at both low and high elevations had similar but greater OC concentrations than areas characterised by gentle or steep slopes with higher or lower elevations. This suggests that at small land scale level, slope characteristics of a landscape are more important to influence the OC than elevation because greater leaching of litter may occur in sloppy areas. The studies of Zhang *et al*. (2011) in China reported increased OC with increasing altitude and attributed this to changes in soil temperature and moisture. The effect of landscape positions was further explained by Hattar *et al.* (2010) that bottomland believed to be the main beneficiary of the addition of soil organic matter from plant residue and litter which are leached from the higher landscape positions.

Results on N level show that both slopiness and elevation combined seem to affect the soil N contents. The lower N content was observed at bottomland than the topland within the same flat terrain and higher in the steeper slope (upper slope) than gentle slope (middle). This could be attributed to potential of topland to retain added soil organic matter from plant residue and litter because bottomland might have some sloppiness. Moreover, toplands have less erosion and slower oxidation of the new organic material (Mandal *et al.*, 2010). Many studies utterly disagree with the present findings indicating that soil N decrease with the increase in elevation (Tateno and Takeda, 2003; Bai *et al*., 2009). The study of Smith *et al.* (2002) in Arid USA concluded that soil pH decreased with increased elevation, but this relationship was absent in the current study probably because the leaching of basic cations in the sloppy areas was not great enough to cause significant changes in soil pH. Lesoli (2008) also did not find any significant different on soil pH along landscape gradient in the same province.

Several factors including erosion, geological substrate and altitude may influence the nature of the soil in the landscape gradient (Mandal *et al.*, 2010). Soil differences along landscape gradient may influence soil chemical properties. Xue *et al*. (2013) pointed out that landscape position associated with erosion result in a high variation among nitrogen concentrations. Soil P and soil resistance did not show marked difference along landscape gradient. In contrast, Burke *et al*. (1995) reported significant variation of soil nutrients including available P along landscape gradient. In this study, soil C and available P showed variation between soil depths (i.e 5 cm and 20 cm). Similar findings were also reported by Kalbitz (2001) that soil carbon and available P were decreasing with increase in soil depth. This could be attributed to lower organic matter and high fraction of recalcitrant at the sub surface soil than the top soil (Gaudinski *et al*., 2000). Moreover, findings of this study support the prediction of Jobbagy *et* *al*. (2001) that nutrients required in large amounts in relation to soil supply have the shallowest distributions.

4.5. Conclusions

In conclusion, this study indicates that landscape gradient plays a major role in the abundance of *E. floribundus*, herbaceous vegetation and soil nutrients. The study presents the existence of some relationship between elevation gradients and mature shrubs of *E. floribundus.* Findings of this study showed that landscape gradient influence the distribution of *E. floribundus* in terms of density and height distribution. Herbaceous composition and diversity varied between landscape gradient. Additional studies are needed to investigate how landscape position influences the distribution of *E. floribundus*. Findings of this study clearly depict the effect of landscape position and abundance of *E. floribundus* on herbaceous dry matter yield, since high dry matter yield was in the high on bottomland and middle slope than upper slope and topland. The variation of tuft diameter was associated with variation between landscape positions with effect of different shrub density. Therefore, increase in tuft diameter at bottomland and middle slope point out that tuft diameter was mainly determined by landscape position and shrub density.

Understanding the impacts of *E. floribundus* abundance and landscape position on the performance of grasses is important in the management of *E. floribundus*. Therefore, this study motivate for other researchers to critically consider topographic position during control of this species.

CHAPTER 5. EFFECT OF *EURYOPS FLORIBUNDUS* INVASION ON FORAGE YIELD, SPECIES COMPOSITION, DIVERSITY AND SOIL PROPERTIES

Abstract

The objectives of this study were to determine the effect of *Euryops floribundus* on forage productivity and soil chemical properties. The study was conducted in plain landscape site. Initially, four areas with different invasion levels of *Euryops floribundus* were identified. These are heavy invaded sites, moderately and lightly invaded as well as areas without invasion (control). Three plots (replicates) of 50 m x 50 m were marked in each area at different sites, giving a total of 12 plots. Within each plot woody and herbaceous vegetation was collected. Soil samples were collected from each plot for chemical analysis. All data were analysed using a General Linear Model (GLM) of SAS (2001). The canopy cover of *E. floribundus* in the heavily invaded sites ranged from 39 to 66%, respectively, and under the moderate and light invasion, the canopy cover ranged from 3 to 38 %, respectively. A total of 17 grass species were identified in all the study sites. Of these, three species are highly palatable, poorly palatable of the identified species were strongly perennials, weak perennials and the remaining are annuals. The lowest ($P < 0.05$) dry matter was observed at low density invasion site compared to the other sites. Soil organic carbon and available P in the moderate invasion level was higher as compared to other sites. *E. floribundus* has highest proportion of saplings (>0-1) across all encroaching levels. The higher pH level at high density could be associated to the released allelochemicals from *E. floribundus.* Further research is essential to understanding this phenomenon. Moreover, further research is needed to understand the influence of *E.floribundus* on grass species composition

Keywords: Shrub-grass competition, woody-plant invasion, herbaceous composition

5.1. Introduction

Spatial and temporal vegetation assessment indicate that woody plant encroachment or invasion has been widespread on many semi-arid grasslands and savannas of Africa resulting in a decline of rangeland productivity and ecosystem services (O'Connor and Crow 1999; Hudak and Wessman, 2001; Moleele *et al.,* 2002; Tefera *et al.,*2008; Wigley *et al.,* 2009). Encroaching woody species may be trees or shrubs, and often they are collectively referred to as bushes in the South African literature (Hudak and Wessman, 2001). Bush encroachment or invasion can be defined as the increase in density, cover and biomass of indigenous woody or shrubby plants (Van Auken, 2009). The causes of such invasion have been debated for the past many years, and are still a subject of controversies. Some argued that bush encroachment is natural phenomenon prompted via irregular exceptional events, such as periods of high rainfall which leads to high shrub density (Belay and Moe, 2012). Anthropogenic activities including exceptionally high cattle densities are also associated with bush encroachment (Moleele *et al.,* 2002). There is no universal knowledge that links woody plant encroachment to the state of health of ecosystems. Many researchers and ecologists viewed that woody plant invasion is an indication of range degradation, loss of land productivity, economic returns and livelihoods, while others still maintain the view that there are some ecological advantages associated to it. The former (e.g. Scholes and Archer, 1997; Moleele, 2002; Van Auken, 2009; Belay and Moe, 2012) argued that woody plant proliferation may reduce grass growth, cover and production. Invasion also reduces plant and animal's diversity to the risk of extinction (Gaertner *et al.,* 2009), alters ecosystems functions and services (Krug *et al.,* 2010). The magnitude of these effects depend on the type and number of the encroaching species and their density because woody species vary on several traits such canopy cover, photosynthetic pathway, life cycles (Scholes and Archer, 1997), root morphology and distribution. On the other hand, the latter (e.g. Moleele, 1998) insisted that this is not always the case because woody plants may enrich soil fertility (Eldridge *et al.*, 2011), favour the production of some desirable grasses such as *Panicum maximum* and offer better habitats for diverse mammals and birds species. Moreover, improvement of physical characteristics (Cao *et al.*, 2004) may also add advantage due to the accumulation of litter and the trapping of wind-blown organic material under the shrub canopies.

Euryops floribundus, a multi-stemmed indigenous shrub, has been observed to widely spread in parts of the Eastern Cape province of South Africa. About 90-97% of *E. floribundus* is usually less than 2 m tall (Gxasheka *et al.*, unpublished). In recent years, this species has been regarded as an invasive shrub in grazing lands subjected to heavy grazing pressures and causing further deterioration (Shackleton and Gambiza, 2008). Local communal elders and livestock owners agreed that *E. floribundus* invasion has generally impacted their livelihoods (Gxasheka et al., unpublished). The local residents also indicated that *E. floribundus* has been used as medicinal plants and source of fire woods, but as the second choice or as an alternative source. Specially, its use as source of fire wood is limited because it produces heavy smoke that has chocking effect and terrible headache.

The majority of the communal people in the Eastern Cape rely on livestock and rangeland resources for their livelihood. Livestock depend on rangelands for their feed, water and mobility. Also, people use the range resources including the land for rituals and cultural ceremonies. Therefore, the integrity and stability of the rangeland ecosystems to provide goods and services for sustaining the socio-economic activities are of a vital concern. It was for this main reason that a communal-based rangeland restoration program was initiated in the study areas in 2005 to clear grazing lands invaded by *E. floribundus* and open up for grasses to recover. This was largely based on the motivation of the local communal people. However, this initiation was not supported by adequate studies that assessed the impact of the invasion on herbaceous and soil productivity. This study would therefore help give better understanding that will support to make wise decision in the current or future restoration and management of rangelands. Indeed, an integrated knowledge constituting a thorough ecological assessment are necessary to develop a sustainable and cheaper rehabilitation programmes. Farmers from encroached areas by *E. floribundus* expressed their view that *E. floribundus* caused low forage yield which became a constraint to livestock production. The objectives of this study were therefore to determine the effect of *Euryops floribundus* 1) on forage biomass and productivity, species composition, and diversity, and 2) on soil chemical properties.

5.2. Materials and methods

5.2.1. Description of the study area

The study was conducted in Cala communal areas at Upper Mnxe located at coordinates of and 31º33´S, 27º36´E. The altitude ranges from1294 to 1441m a.s.l. The vegetation type of the study area is Tsomo grassland (Mucina and Rutherford, 2006). The average summer (November to April) and winter (May to October) rainfall are 600 mm and 200 mm, respectively. The mean temperature in January and July is 22ºC and 12ºC, respectively (Lesoli, 2008). Upper Mnxe is generally flat with some hills, gentle to steep slopes (12%) and wide valleys. The main agricultural activity is communal livestock farming with cattle, sheep, and goat species. The animals are not kraaled except during animal inspection and supplementary feeding (Lesoli *et al*., 2010).

5.2.2. Site selection and experimental layout

A total of about 4 ha communal land was selected in an accessible area that had largely a flat terrain. The area was selected to have adjacent sites with no *E. floribundus* invasion (<5% cover), and with light (5-15%), moderate (>15-35%) and heavy invasions (>35%) cover. Three plots (replicates) of 50 m x 50 m were randomly marked at each invasion level. The average distance between the plots was 10 m. Within each plot, three belt transect of 50 m x 2 m were marked to record vegetation and soil data. The short side of the belt transects was laid horizontally, while the long site was vertical.

5.2.3. Data collection

In each belt transect, individual woody plants were counted, their height, and canopy diameter (long and short canopy diameters) measured. Plants were grouped into the following height groups: >0-1m (Saplings), >1-2 m (young shrubs) and >2 m (mature shrubs). Five 0.5 m x 0.5 m ($0.25m^2$) quadrants were also laid randomly within each belt transect. All herbaceous species within each quadrant were recorded; their tuft diameter and distance between any two tufts were measured. Each species was then cut separately and placed in paper bags. Collected samples of herbaceous vegetation were taken to the laboratory and oven dried at 60°c for 48 hours to determine the dry matter biomass. Basal cover was estimated from average tuft diameter using the following: $\pi\ (d/2)^2$ where d is sum of the average diameter. Species diversity was estimated using Shannon-Wiener index (H) using the formula: $H' = -\sum [(n_i/N) \times \ln (n_i/N)]$

n_i= amount of biomass

N= Total amount of biomass

Ln= the natural log of biomass

5.2.4. Soil sampling and analysis

A total of 10 soil samples were collected randomly from each corner and centre of the plots. All soil samples from each plot were composite (mixed) based on depths (5cm and 20 cm) then total of two samples were taken each plot.

5.2.5. Statistical analysis

Woody vegetation and herbaceous data were analysed using a General Linear Model (GLM) of SAS (2001). For data that do not require analysis, simple descriptive statistics was employed where appropriate.

5.3. Results

5.3.1. Total density and canopy cover

Table 5.1 presents the total density and canopy cover of *E. floribundus,* while Table 5.2 shows the proportion of the size range. The density and canopy cover of *E. floribundus* in the heavily encroached sites ranged from 6867-9433 plants ha^{-1} and 39-66% canopy cover, respectively. Moderately invaded areas have 3168-6000 plants ha^{-1} and canopy cover of 16% -38%. Lightly encroached sites have 568-3000 plants ha^{-1} and cover >3-15%, respectively. Non-encroached sites are characterised by a rare occurrence of *E. floribundus* usually with a bush cover of < 3%. The presence of other woody species in this study was negligible.

Table 5.1. Total density (no ha^{-1}) and canopy cover (%) of *E . floribuduns* at the four levels of invasion

Density Level	Total density	Range	Canopy cover	Range
High	8167	6867-9433	55.03	38.55-66
Moderate	4579	3168-6000	17.81	15.8-38
Low	879	568-3000	5.31	3.3-14
No density	<500			<3

With regard to height class distribution, seedlings (>0-1m) were more abundant in the moderate encroached and ranged from 69.1-79.1%. Sapling (>1-2 m) were more abundant in the heavy encroached sites and ranged from 28.5-92.2%. Shrubs (>2 m) had the lowest proportion of all sizes and were denser in the heavy encroached sites (Table 5.2).

Table 5. 2. Height class distribution (%) of *E. floribuduns* at the four levels of invasion

Density level	>0-1m	Range	>1-2m	Range	>2m	Range
High density	26.9	5.6-68.7	69.4	28.5-92.2	3.7	2.1-6.8
Moderate density	75.2	69.1-79.1	24.3	19.4-29.1	0.5	0.02-0.6
Low density	54.4	48.4-70.4	45.5	29.3-51.5	0.1	0.09-0.2
No density	<10		<7		<0.1	

5.3.2. Species composition of grasses, tuft distance and tuft diameter

A total of 17 grass species were identified in all the study sites. Of these, three species were highly palatable, six were moderately palatable and the remaining were poorly (low) palatable. Of the total grass species, fourteen were strongly perennials, one is weak perennial and the remaining are annuals. *Themeda triandra, Eragrostis plana, E. chloromelas, Heteropogon contortus* and *Sporobolus africanus* were recorded abundantly throughout the study sites. Results on tuft distance and diameter are presented in Figure 5.1 and 5.2. Tuft distance was significantly (P <0.05) highest at heavily invaded site, but tuft diameter was not significantly affected by invasion level.

5.3.3. Plant density, herbaceous dry matter yield and plant diversity

Table 5.4 shows the herbaceous yield of grass in relation to the level of *E. floribundus* invasion. The lowest dry matter yield of grass was observed at low *E. floribundus* density and in sites with no encroachment. Forbs were significantly (P<0.05) higher at non encroached site and lowest at low density. Basal cover was not statistically different between invasion levels.

Table 5.3. Life forms and abundance (%) of grass species across invasion levels

Species	Grazing Value	Life forms	High density	Moderate density	Low density	No density
Themeda triandra (Iqunde)	High	P	18.52	15.67	32.07	52.40
Eragrostis plana(Msuba)	Moderate	P	7.68	34.51	6.85	3.93
Eragrostis chloromelas	Low	P	18.52	21.72	10.59	11.43
Aristida diffusa	Low	P	6.75	0.90	-	-
Heteropogon contortus (Umkhonto)	Moderate	P	11.95	5.79	27.90	9.03
Sporobolus africanus	Low	P	14.94	12.88	2.64	1.58
Microchloa caffra	Low	P	0.63	-	3.09	6.53
Eragrostis capensis	Moderate	P	0.63	-	1.41	1.08
Hyparrhenia hirta (Ingcelwana)	Moderate	P	-	0.88	1.45	-
Cynodon dactylon (Uqaqaqa)	High	WP	0.63	0.7	-	-
Elionurus muticus (Isilevu)	Low	P	0.63	-	7.13	6.36
Brachiaria serrata	Moderate	P	-	-	0.52	-

Aristida congesta	Low	A	3.35	6.751	0.99	-
Eragrostis superb	Moderate	P	3.29	-	3.47	1.10
Cymbopogon plurinodis (Isiqungu)	Low	P	-	2.50	0.50	-
Digitaria eriantha (Isandla)	High	P	-	0.95	-	-
Karroochloa curva	Low	A	2.93	-	-	-

- In brackets some grass species were given vernacular names (Xhosa)
- P (perennials) and A (annuals)

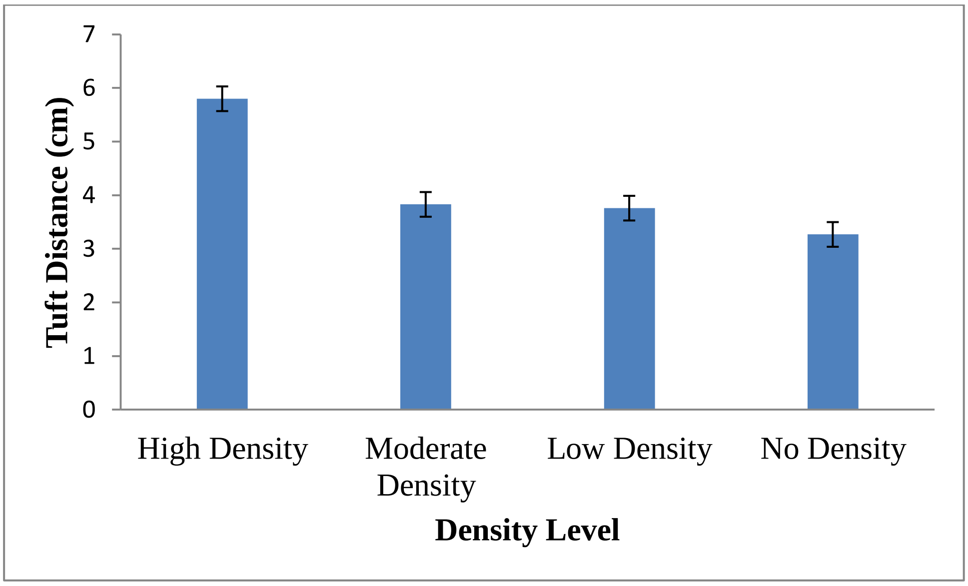

Figure 5.1. Average tuft distance of grass species at the four level of invasion

5.3.4. Effects of shrub density on soil

Soil pH and soil resistance were significantly (P < 0.05) highest at high *E. floribundus* invaded site (Table5.5). Soil OC and N were highest at the moderately encroached area and lowest at the lightly encroached site.

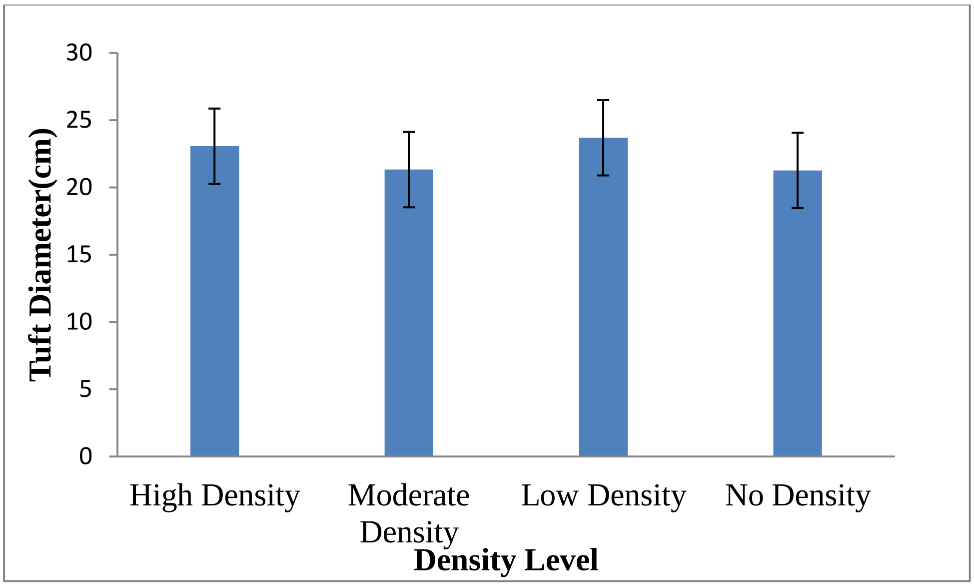

Figure5.2. Tuft diameter of the grass species at different invasion levels

Moderately invaded area had significantly ($P<0.05$) the highest level of P. Ca content was not significantly affected by bush density level. Soil OC, Ca content, available P and soil resistance decreased with soil depth (20 cm).

Table 5.4. Herbaceous dry matter yield on different density level of *E. floribundus*

Density Level	Grass density	Forb density	Ground Cover
High	1999.44^{a}	61.49^{b}	17.83^{a}
Moderate	2104.62^{a}	56.57^{b}	15.28^{a}
Low	1619.27^{b}	16.68^{c}	20.46^{a}
No Density	1635.91^{b}	135.39^{a}	15.99^{a}
SE	134.20	16.0	4.44

*Means with different superscript letters vary significantly ($P <0.05$)

*SE: Standard Error

Results on species diversity are presented in Figure 5.3. *Euryops floribundus* invasion did not have significant effect on diversity index and generally ranged from 0.68 to 0.77.

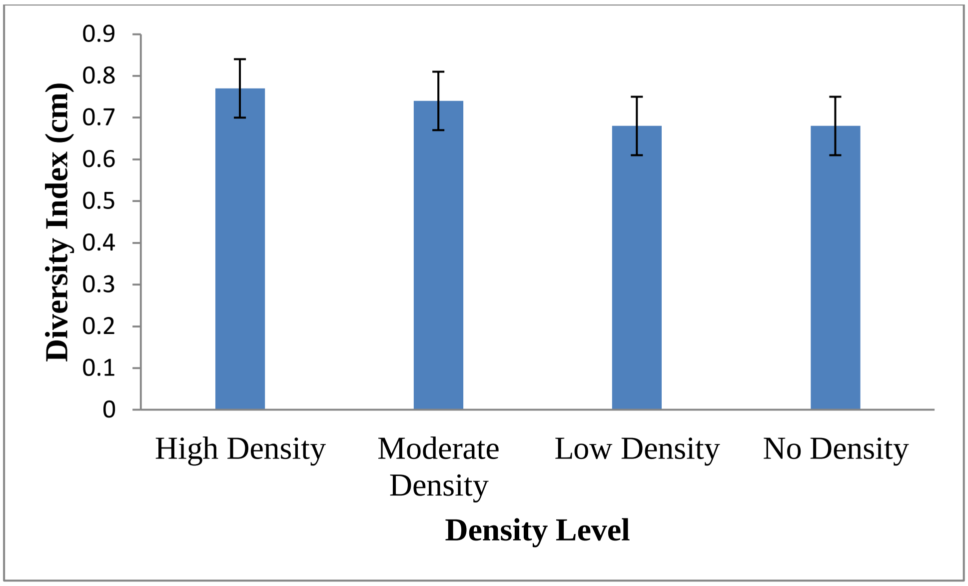

Figure 5.3. Diversity Index at four level of invasion

5.4. Discussion

5.4.1. Density, cover and size distribution of *E. floribundus*

Different from this study, Shackleton and Gambiza (2008) described invaded sites to have meant canopy cover of *E. floribundus* in the range of 17.8-22.6% and a density of approximately 27 000 plants ha^{-1}. However, similar to this study, the authors described non-invaded sites as having no large stems, but a few small stems or seedlings ranging from 200-300 plants ha^{-1}. Occurrence of age or size groups varies across the density levels. The relative proportion of size groups may indicate the developmental phases of the invasion. The dominance of seedlings may suggest a transition of grasslands to heavy invasion state, while the dominance of saplings may be a typical characteristic of heavily invaded sites. This is against the view of Joubert *et al.* (2008) who stated that dominance of saplings characterizes the transition state, while mature plants characterize heavy encroached state. Shackleton and Gambiza (2008) indicated that *E. floribundus* plants can be killed by fire, and seedlings, saplings and mature shrubs are within the reach of a fire length for effective killings. Therefore, control of this shrub could be effective because the fuel load recorded in both moderate and heavily invaded sites were equivalent to the recommendation made by Trollope (1984) to apply fire to control mature *Acacia karroo* trees in southern Africa, and well above the recommendation of Joubert et *al.* (2008) to control seedlings and saplings of *A. mellifera* in the highlands of Namibia.

5.4.2. Herbaceous layer composition

Though not statistically compared, grass species that seem to correspond with the density levels of *E. floribundus* include *T. triandra, E. plana, E. chloromelas and S. africanus*. *T. triandra* was the most abundant species in all density levels, but exceptional higher occurrence was found in non-invaded areas followed by lightly invaded sites. Finding of this study does not concur with Kinyamario *et al*. (1995) who reported that *T. triandra* does not grow abundantly in the sub-canopy habitats or under shrub or tree canopies. The occurrence of significant amount of *T. triandra* in rangelands indicate fair to good range condition despite the abundance of *E. floribundus* (Forbes and Trollope, 1991). *Themeda triandra* is a perennial climax grass that grows in a wide range of climate and soil. This species is highly palatable (Snyman *et al*., 2013) and support wildlife and livestock production in many semi-arid grasslands and savannas. A decline in the abundance of this species may be caused by the invasion of grasslands by *E. floribundus* invasion, and this may result in a decline in the ecosystem functions and services and may threaten the rural livelihoods. In addition, there was also a greater occurrence of certain less palatable species such as *E. plana*, *E. chloromelas* and *S. africanus* at moderately to heavily invaded areas. These grass species occur on disturbed soils, although they are more commonly found in the open grassland (Van Oudtshoorn, 2012). Danckwerts *et al*. (1983) reported that *E. chloromelas* species was least preferred but avoided during winter particularly when leaves are dry and tough. During autumn, Stoltsz and Danckwerts (1990) reported that *Sporobulus africanus* was the second preferred species at high altitude grasslands.

Table 5.5. Soil chemical properties on the different density and soil depth

Density	**C**	**Ca**	**P**	**pH**	**Res**	**N**
High Density	1.82^{ab}	5.43^{a}	4.50^{b}	5.32^{a}	1136.67^{a}	0.12^{ab}
Moderate Density	2.11^{a}	4.50^{a}	6.17^{a}	5.07^{b}	1435.00^{b}	0.14^{a}
Low Density	1.56^{b}	3.31^{a}	2.67^{c}	5.00^{b}	1738.33^{c}	0.07^{b}
No Density	1.99^{a}	66.46^{a}	4.17^{b}	5.07^{b}	2008.33^{d}	0.11^{ab}
SE	0.14	31.32	0.85	0.05	101.12	0.02
Depth	**C**	**Ca**	**P**	**Res**	**pH**	**N**
5	1.94^{a}	35.79^{a}	4.92^{a}	1600^{a}	5.17^{a}	0.12^{a}
20	1.80^{a}	4.06^{b}	3.83^{b}	1559.17^{b}	5.06^{b}	0.11^{a}
SE	0.10	22.15	0.60	71.50	0.03	0.01

*Means with different superscript letters vary significantly ($P < 0.05$)

*SE: Standard Error

S. africanus was also reported by du Toit and Aucamp (1985) as species that increases in abundance as the rangeland is overgrazed. Indeed, further research is needed to understand the influence of *E. floribundus* on grass species composition.

5.4.3. Herbaceous diversity, yield and cover

Both grass cover and average grass tuft diameter were statistically similar under all invasion levels. Despite this similarity and higher average distance between grass tufts in the heavily invaded areas, the grass yield was significantly higher in the heavily and moderately invaded sites than the light and non-invaded sites. This was not expected though given the scenario of cover, tuft diameter and distance tuft. The higher biomass yield in the heavily and moderately invaded sites may result from higher plant height associated to the lower current grazing pressure in the invaded areas compared to the light or non-invaded areas. Invasion of bushes may prevent movement of animals and accessibility of grazing. Higher yield may also be related to higher soil fertility and better micro-environments under and sub-canopy zones that favour grass production by exploiting necessary nutrients, although shading or allelopathy effects may be present in the heavy invaded sites.

Similarly, Stuart-Hill *et al.* (1987) demonstrated a consistent pattern of grass production around isolated *Acacia karroo* trees in the false thornveld of the Eastern Cape, South Africa. Several researchers worldwide also reported high grass dry matter yield under woody plants canopy (Belsky *et al*., 1993; Abule *et al*., 2005; Abdallah *et al*., 2008). Moreover, a high number of plant individuals support fixing of soil particles, which has a positive effect on fertility and water balance of soil (reduction of evapotranspitation) and allows the creation of a microclimate which favors the establishment of palatable perennial species with high water-use efficiency (Amundson *et al.*, 1995). In contrast, Tefera *et al.* (2008) reported low grass dry matter yield within encroached areas by *Chromolaena odorata* in the lowveld regions of Swaziland. In Ethiopia, Angassa (2005) also reported low grass dry matter yield within encroached areas in the rangeland of Borana. The absence of significant difference in grass cover reported in this study does not concur with Vetter *et al*. (2006); Shackleton and Gambiza (2008) and Wigley *et al*. (2009) who reported lower grass cover in the invaded sites than the non-invaded ones. This study did not provide evidence of change in herbaceous diversity with the increased levels of the woody plant density. Many studies (Lett and Knapp, 2005; Ratajczak *et al*. 2012) considered that woody plant invasion as a major threat to grass diversity because of replacement of grass species by the woody seedlings and saplings. Others reported that woody invasion increases species diversity by providing more space for various species (Eldridge *et al*., 2011); by increasing in available niches and environmental resources (Cramer and Willig, 2005; Belay *et al*., 2013); and by improving harsh environmental conditions (such as heat stress), by altering substrate characteristics or by increasing resource availability (Gomez-Aparicio *et al*., 2005; Maestre *et al*., 2009).

5.4.4. Shrub density on soil chemical properties

Shrub invasion seems to improve availability of soil nutrient due to high number of soil OC, N and P levels in the encroached sites. Biggs *et al.* (2002) also reported similar findings that encroached sites by *Prosopis* plants produced substantial changes in soil nutrient concentrations in the southeastern Arizona. In this study, soil OC, N and P levels were considerably high at encroached sites, and exceptionally high at the moderate density. This can be attributed to enough soil enrichment under shrub canopy (Smit, 2004). It has been reported that soils under tree canopies are more fertile than soils from the surrounding grassland (Belsky *et al*., 1989; Callaway *et al.,* 1991; David *et al*., 2005). Moreover, accumulations of soil C and N in the encroached sites are certainly a consequence of greater rates of primary production that has increased inputs through surface litter and roots in the wooded areas (Hibbard *et al*., 2001). Lesoli (2008) reported lower soil OC and P level compared to the findings of this study. The higher pH level at high density could be associated to the released allelochemicals from *E. floribundus.* Further research is essential to understanding this phenomenon. Lesoli (2008) reported low soil pH (5.3) level compared to the findings of this study in the same area. In addition, findings of this study on soil pH were against with findings of Yang *et al*. (2011) who reported that soil pH was low under shrub canopy. All the soil properties decreased with the increase in the depth level. Similar findings were also reported by Liao *et al.* (2006) where soil pH and carbon were high in the upper layer of the soil.

5.5. Conclusion

Occurrence of age or size groups varies across the density levels but highest proportion of saplings (>0-1) was observed at moderate density. Soil properties were varied based on the density level; although, soil C was high at moderate density and pH in the high density. The biomass recorded in this study is adequate as fuel load to support hot in order to control the invasion. Also, the plants are predominantly short in size which allows fire to get easily from the bottom to the top to kill them. Furthermore, strategic research to understand height distribution of *E.floribundus* will be essential for easy management of the invasive species.

An ecological change in the species composition of the herbaceous layer due to heavy encroachment also requires special considerations via research.

CHAPTER 6. SUMMARY

6.1. General

This study has three main sub-studies. The first sub-study investigated the local people's knowledge and perceptions of livestock husbandry in three communal areas, 2) their perceptions of rangeland condition and invasion by *Euryops floribundus.* The second sub-study investigated the landscape distribution of *E. floribundus* and their relationship. In the third sub-studies attempted to investigate the effect of *E. floribundus* on forage biomass and productivity, species composition, diversity, and soil chemical properties.

Study on the perception of local people revealed that that sheep population was higher than the other livestock populations could be attributed to farmers' preference of raising small stock and to the high rainfall (sourveld) characteristics of the study areas which favours the dominance of low growing grasses that are preferred by sheep for grazing. In the second sub-study, it was found that all landscapes were invaded by *E. floribundus* but total shrub population and relative occurrence of age or size groups varies across the landscape positions. The total density of *E. floribundus* was high at the bottomlands and low at the toplands, where saplings were relatively more abundant than the other age or size groups. All the landscape position shared in common large number of herbaceous species. In the third study, canopy cover of *Euryops floribundus* in the heavily invaded sites ranged from 39 to 66%, respectively. Under the moderate and light invasion, the canopy cover ranged from 3 to 38%, respectively. The grass yield was significantly higher in heavily and moderately invaded sites than the light and non-invaded sites. This study did not provide evidence of change in herbaceous diversity with the increased levels of the woody plant density. In this study, invaded sites had higher soil C, N and P levels.

6.2. Conclusion

It was concluded that rangeland deterioration is more pronounced in the recent years. Encroachment of *Euryops floribundus* as perceived by local people was low during their teenage stage but became heavy since recently. Findings of this study showed that landscape gradient influence the distribution of *Euryops floribundus* across all flat terrain and sloppiness in terms of density and height distribution. Herbaceous composition and diversity varied between landscape gradient. *Euryops floribundus* have highest proportion of saplings (>0-1) across all encroached sites. This trend of height class distribution indicates the potential of high encroachment of *Euryops floribundus* in few years to come and this increase the potential of detrimental effect to livestock production in those communities. This study depicted higher biomass yield in the heavily and moderately invaded sites may result from higher plant height associated to the lower current grazing pressure in the invaded areas compared to the light or non-invaded areas. The invasion of *Euryops floribundus* give the impression that it improve availability of soil nutrient due to high number of soil C, N and P level in the encroached sites.

6.3. Recommendations

This study motivates understanding of the impacts of *E. floribundus* abundance and landscape position on the performance of grasses and it is important factor in the management of *E. floribundus*. Therefore, development of specific management plan by researchers with government is required in order to remove *Euryops floribundus* with support and participation of local communities.

- ✓ Further research is required to focus on ways of improving supplementary feed during time of feed scarcity.
- ✓ This study motivate for other researchers to critical consider topographic position during control of this species.

- ✓ Strategic research to understand height distribution of *Euryops floribundus* is imperative.

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APPENDICES

Appendix 1 Questionnaire

EURYOPS FLORIBUNUDS ENCROACHMENT IN EASTERN CAPE COMMUNAL RANGELANDS: INDIGENOUS AND SCIENTIFIC UNDERSTANDINGS OF EFFECTS ON RANGE ECOLOGY, FOOD SECURITY AND CLIMATE

University of Fort Hare
Together in Excellence

The objective of the survey is to investigate indigenous knowledge and perceptions of the communal people on *E. floribundus* encroachment and its relationship with food security and climate change.

Enumerator's name…………………………Date…………………………Village…………..

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

A.HOUSEHOLD DEMOGRAPHY

	Relation to head	Age	Gender	Marital status	Education	Occupation
A1.1						
A1.2						
A1.3						
A1.4						
A1.5						
A1.6						
A1.7						
A1.8						
A1.9						

Codes:

Relation to head: **1** Head, **2** Spouse /husband, **3** Child, 4 Grandchild, **5** Father or mother, **6** other

Marital status**:** (**S**) single (**M**) married (**D**) divorced or separate **(W) w**idow

Education: **1** Preschool **2** Up to std 5, **3** Std 6-9 **4** Std 10 **5** Tertiary

6 None

Status: (**F**) farming (**H**) household wife, **(E**) employee (**P**) pensioner (**B**) business
(**N**) No occupation (**S**) student

A.2. Household size…………… Adults …………… Children (less than 13 years)……..
A.3.1. Do you belong to any farmers' organisation? Yes or no

A.3.2.If yes, which one..

A.3.3. If no, what are your reasons..

B. Livestock population

Livestock type	Livestock population Age group			
Cattle	3yrs <	3yrs	3yrs >	Total
Male				
Female				
Age group				
Sheep	2yrs <	2 yrs	2 yrs>	Total
Male				
Female				
	Age			
Goats	2 yrs <	2 yrs	2 yrs>	Total

B.1. Importance of livestock species (ranking in order of importance 1-most important, 3-least important)

Class	Cattle	Sheep	Goat
Rank			

B.2.Purpose of rearing cattle (ranking in order of importance 1-most important, 5-least important)

Purposes	Sale	Lobola	Wealth status	Food	Gift to friend or relative	Other (specify)
Rank						

B.3.Crop farming

B.3.1. what do you farm (from most important to least important?)

Crop type	Area

1)	
2)	
3)	
4)	

B.3.2. Choose (A-C), size of crop area (A-decreased, B-increased, C-not changed) after

1) 25 years ago

2)15 years ago

3) 5 years ago

B.3.3.If there is change in size, what are the reasons (in order of importance)

Reasons
1)
2)
3)

B.4.Do you feed crop residues to livestock?

Crop	Livestock(cattle=1,goat=2,sheep=3)	When (months)
1)		
2)		
3)		
4)		

B.5.1Do you have cultivate pasture?

B.5.2.If yes, name the species………………………………………………………………...

B.6.1.Do you have protected natural grazing land? Yes or no

B.6.2. what is the size of the area

B.6.3. is it for common to the villagers? Or private?

B.6.4.The protected area is used all over the year or when there is drought or in winter, spring, summer, autumn and for grazing

……………………………………………………………………………………………………

C. Rangelands / Grazing

C.1. Do you have access to rangeland? Yes ☐

No ☐

C.2. how did you obtain access?

By virtue of being resident in this community	
Through an application to the Tribal Authority	
Through an application to the village committee	
Local Authority	

Other (specify)	

C.3.At what time of the year would you experience a shortage in grazing? (Winter, summer, autumn, spring)-specify the month

…………………………………………………………………………………………………..

C.4.What could be the cause of such a shortage?

1)

2)

3)

C.5. Who monitors that users of the grazing land adhere to rules and regulations?

....

C.6. Rangeland is access for? (In order of importance: 1-most important 5-least important)

Uses	Rank	Season of access(summer, winter, year round)
Grazing/browsing of animals		
Collecting fire wood		
Collecting wood and grass for building and Fencing		
Collecting plants for medicinal purposes		
Collecting dry dung for cooking		
Other (specify) ………………………………………………		

C.7.1. Are there times of restricted access to rangelands? Yes ☐

No ☐

C.7.2.If Yes, Which month/s……………………………………......................................

C.8.1. Does your community have grazing camps? Yes ☐

No ☐

C.8.2. If yes, what is the purpose of camps? (Give answer in order of importance)

………………………………………………………………………………………

C.9. Do you manage livestock movement during grazing?

a) Permanently (daily) YES / NO if yes, who?..

b) Monthly YES / NO if yes, who?.......................................

c) In Summer YES / NO if yes, who?.......................................

d) In Winter YES / NO if yes, who?..

e) When rain comes? YES / NO if yes, who?......................................

f) Free ranging? YES / NO if yes, who?......................................

EURYOPS FLORIBUNDUS ENCROACHMENT IN EASTERN CAPE COMMUNAL RANGELANDS: INDIGENOUS AND SCIENTIFIC UNDERSTANDINGS OF EFFECTS ON RANGE ECOLOGY, FOOD SECURITY AND CLIMATE

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The objective of the survey is to investigate indigenous knowledge and perceptions of the communal people on *E. floribundus* encroachment and its relationship with food security and climate change.

Enumerator's name…………………………Date…………………………Village…………..

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

A. Key informants

A.1. Do you classify land scape for grazing/browsing (yes or no)?

A.2.1. How many landscape do you have in your village rangelands

A.2.2. what are the criteria for classification? (Soil, topography, etc)

A.3. Do you assess the range condition?

A.4. what criteria do you take into account (in order of importance)

Criteria
Grass (what aspect of grass-yield, quality? Etc) a) b) c)
Soil (erosion, Compaction, colour, texture etc) a) b) c)
Bush (density, cover, species distribution etc) a) b)

c)

A.2. how would you describe the condition of your rangeland?

	Description
Deteriorating- Very Poor	
Deteriorating -Poor Condition,	
Fair	
Good	
Very Good	
I don't know	

A.6.1. what has led to the current state of rangelands? (in order of importance)

	Rank
Grazing(overgrazing or under-grazing or optimum grazing)	
Burning (presence or absence)	
Soil Depth	
Rainfall (constant, variable or recurrent drought)	
Woody plants (bush encroachment)	
Human population (increase, decrease or unchanged)	
Topography (slopy, plain or mountainous)	
Development of water points, kraals/dip-tanks	
Other(specify)	

A.6.2. what are the reasons for your answer above?

....

A.6.1.Doyou considers your soil? ☐ Good

Fair ☐

Poor ☐

Very poor ☐

A.6.2. What is the reason for your answer above?..

A.7.List control measures (in order of importance) need to be put in place to ensure a sustainable utilization of grazing resources?

....

A.8. what problems or constraints do you face in management of grazing areas?

…………………………………………………………………………………………

………………………………………………………………………………………….

A.9.1.Do you use arable land for grazing purpose? Yes or No

A.9.2. If yes, when and why?

when……………………………..why…………………………………………………………....
....

B. *E. floribundus* on land degradation

B.1. what are the condition / level of *E. floribundus* in your grazing lands?

High ☐

Average ☐

Low ☐

None ☐

B.1.1. If high, do you apply any bush encroachment measures on your grazing lands? Yes or No

B.1.2. If yes, what methods of bush encroachment control measures do you use (Describe)?

…………………………………………………………………………………………………

……………………………………………………………………………………………….....

B.1.3. is the control measure effective? Yes or No

B.1.4. Give reasons for your answer above?...

………………………………………………………………………………………………...

B.2. Are there any benefits you derive from the *E. floribundus* species? Yes or No

B.3. List the benefits in order of importance?........

C.Climate change of *E. floribundus* encroachment

C.1. Has the climate changed? Yes or no

C.1.2.if yes, is the rain higher, lower, no change than 25 years ago, 15 years ago, 5 years ago?...

C.1.3. if yes, is the temperature higher, lower, Unchanged than 25 years ago, 15 years ago, 5 years ago?

C.1.4. or how do you perceive climate change (ask the farmer to define climate change)..

C.2. Do you think *E. floribundus* encroachment is climate related? Yes or No

C.2.1.If yes, how..

C.3. Do you think *E. floribundus cause climate change?*

If yes, how*?*

C.4. what was condition of the *E. floribundus* when you were teenager, 20 years ago, 10 years ago, 5 years ago?? Tick on the table below.

Lower density	

No *E. floribundus*	
higher density	
Same as today	

C.4. *E. floribundus* is indigenous species? Yes or No

C.4.1.Give reasons for your answer above?

....

C.5.Does *floribundus* encroach fields or gardens? Yes or No

C.5.1. If yes, may be why?

....

C.6. Do animals browse *E. floribundus* species? Yes or No

C.6.1 Give reasons for your answer above?

....

C.7. How do you perceive its effects on grasses?

C.7.1.On forage production……………………………………………………………………..

C.7.2. On highly palatable grasses………………………………………………………...

C.7.2. On quality……………………………………………………………………………..

C.8.Which grass species is (are) affected most?

C.9.How do you perceive its effect on soil?

C.9.1. Becomes to have more bare…………………………………………………………...

C.9.2. High erosion.………………………………………………………………………....

C.9.3. Becomes compact……………………………………………………………………..

C.9.4. Loss of fertility……………………………………………………………………….

C.10.How do you perceive its effect on livestock production?

C.10.1. No effect……………………………………………………………………………..

C.10.2.Loss of body weight………………………………………………………………….

C.10.3.Decreased number……………………………………………………………………

C.10.4. Poisoning…………………………………………………………………………….

C.11. Do you perceive vegetation change in the grazing areas?

C.11.1.Compared to 25 years ago……………………………………………………………

C.11.2.Compared to 10 years ago……………………………………………………………

C.11.3.Compared to 5 years ago……………………………………………………………..

C.12.What are the factors that induce vegetation change? (Rank 1 as the most important cause of the change)

Factors	Rank
Grazing	
Human settlement	
Drought	
Bush encroachment (*E. floribundus*)	
Crop farming	
Land alienation	
Water, diptank, kraals development	
Other (specify)	

C.13. has the livestock population in the area

C.13.1.Declined, increased or not changed compared to 25 years ago…………………………

C.13.2. Declined, increased or unchanged compared to 15 years ago………………………….

C.13.3.Declined, increased or unchanged compared to 5 years ago……………………………

C.13.4.What is the reasons (rank 1 as most important reasons for declining)

Reasons	Rank
Low forage quality	
Low forage yield	
Recurrent drought	
High bushes	
Soil degradation	
Crop farming	

C.14.How does *E. floribundus* affect

C.14.1.Your livestock production…………………………………………………………...

C.14.2.Your crop production……………………………………………………………………

C.14.3.Your income……………………………………………………………………………….

C.14.4.Your total food production……………………………………………………………...

C.15.1.Do you link invasion of *E. floribundus* with climate change? Yes or no

C.15.2.If yes, how……………………………………………………………………………

C.16. Do you receive any advice from extension services? Describe the type of advice

…………………………………………………………………………………………………

…………………………………………………………………………………………………..

C.17. How has this advice impacted on *E. floribundus* species in the rangeland?

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C.18. How would gauge your knowledge on veld management?

…………………………………………………………………………………………….....

C.19. where did you gain this knowledge from?

……………………………………………………………………………………………………..

C.20.1. Have you or the community ever had any training on veld management? Yes or No

C.20.2. If yes, what kind of training did you receive?

....

C.20.3. If no, what kind of training would you or the community like to receive?

…………………………………………………………………………………………………

C.4. Give five suggestions which in your opinion can improve communal grazing areas, especially on *E. floribundus* encroachment?

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Any other comments

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Appendix 2 Consent Form

Ethics Research Confidentiality and Consent Form

Please note:

This form is to be completed by the researcher(s) as well as by the interviewee before the commencement of the research. Copies of the signed form must be filed and kept on record

(To be adapted for individual circumstances/needs)

Our University of Fort Hare / Department is asking people from your community / sample / group to answer some questions, which we hope will benefit your community and possibly other communities in the future.

The University of Fort Hare / Department/ organization is conducting research regarding: **Sustainability of the Tsengiwe village members' livelihoods.** We are interested in finding out more about **Methods, knowledge and technologies used by Traditional Health Practitioners at Tsengiwe to sustain Livelihoods of their community members** . We are carrying out this research **to capacitate all members of the village to improve strategies to sustain their livelihoods.**

Please understand that you are not being forced to take part in this study and the choice whether to participate or not is yours alone. However, we would really appreciate it if you do share your thoughts with us. If you choose not take part in answering these questions, you will not be affected in any way. If you agree to participate, you may stop me at any time and tell me that you don't want to go on with the interview. If you do this there will also be no penalties and you will NOT be prejudiced in ANY way. Confidentiality will be observed professionally.

I will not be recording your name anywhere on the questionnaire and no one will be able to link you to the answers you give. Only the researchers will have access to the unlinked information. The information will remain confidential and there will be no "come-backs" from the answers you give.

The interview will last around (30-45) minutes *(this is to be tested through a pilot).* I will be asking you a questions and ask that you are as open and honest as possible in answering these questions. Some questions may be of a personal and/or sensitive nature. I will be asking some questions that you may not have thought about before, and which also involve thinking about the past or the future. We know that you cannot be absolutely certain about the answers to these questions but we ask that you try to think about these questions. When it comes to answering questions there are no right and wrong answers. When we ask questions about the future we are not interested in what you think the best thing would be to do, but what you think would actually happen. (*adapt for individual circumstances*)

As we are in partnership with this village, our organisation would like to come back to this area once we have completed our study to inform you and your community of what the results are and discuss our findings and proposals around the research and what this means for people in this area.

CONSENT

I hereby agree to participate in research regarding …….. ***Euryops floribundus*** **Encroachment in Eastern Cape communal Rangelands: Indigenous and Scientific Understandings of Effects on Range Ecology, and Food Security and climate**

I understand that I am participating freely and without being forced in any way to do so. I also understand that I can stop this interview at any point should I not want to continue and that this decision will not in any way affect me negatively.

I understand that this is a research project whose purpose is not necessarily to benefit me personally.

I have received the telephone number of a person to contact should I need to speak about any issues which may arise in this interview.

I understand that this consent form will not be linked to the questionnaire, and that my answers will remain confidential.

I understand that if at all possible, feedback will be given to my community on the results of the completed research.

……………………………..

Signature of participant **Date**:…………………..

I hereby agree to the tape recording of my participation in the study

……………………………..

Signature of participant **Date**:…………………..

Appendix 3 Ethical clearance certificate

University of Fort Hare

Together in Excellence

ETHICAL CLEARANCE CERTIFICATE

Certificate Reference Number: BEY02 1SGXA01

Project title: ***Euryops floribundus* Encroachment in Eastern Cape communal Rangelands: Indigenous and Scientific Understanding of Effects on Range Ecology, and Food Security and Climate.**

Nature of Project: Masters

Principal Researcher: Masibonge Gxasheka

Supervisor: Dr ST Beyene

Co-supervisor:

On behalf of the University of Fort Hare's Research Ethics Committee (UREC) I hereby give ethical approval in respect of the undertakings contained in the above-mentioned project and research instrument(s). Should any other instruments be used, these require separate authorization. The Researcher may therefore commence with the research as from the date of this certificate, using the reference number indicated above.

Please note that the UREC must be informed immediately of

- Any material change in the conditions or undertakings mentioned in the document

- Any material breaches of ethical undertakings or events that impact upon the ethical conduct of the research

The Principal Researcher must report to the UREC in the prescribed format, where applicable, annually, and at the end of the project, in respect of ethical compliance.

The UREC retains the right to

- Withdraw or amend this Ethical Clearance Certificate if
    - ✓ Any unethical principal or practices are revealed or suspected
    - ✓ Relevant information has been withheld or misrepresented
    - ✓ Regulatory changes of whatsoever nature so require
    - ✓ The conditions contained in the Certificate have not been adhered to
- Request access to any information or data at any time during the course or after completion of the project.

The Ethics Committee wished you well in your research.

Yours sincerely

Professor Gideon de Wet

Dean of Research

03 September 2013