Patterns of resource use by livestock during and after drought in a communal rangeland in Namaqualand

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In loving memory of my mother

Janap Samuels

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Keywords

- Namaqualand
- Paulshoek
- Drought
- Livestock farming
- Grazing distribution
- Livestock activity patterns
- Herding strategies
- Communal rangeland
- Spatial perceptions
- Local ecological knowledge

Abstract

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Pastoralists in Africa have developed complex mechanisms by which they can alleviate the threat of drought. They practice mobility as one of the strategies to avoid the worst effects of natural stress and disperse grazing pressure. In the past in South Africa, the indigenous Nama people occupied large areas of land and moved around extensively to exploit seasonal differences in the availability of forage and water. With the settlement of the Europeans in the Cape the indigenous people lost most of their land to the colonists. The Nama people were, therefore, restricted to smaller rangelands and their patterns of rangeland use had to adapt to the spatial constraints. Descendents now herd livestock from semi-permanent stockposts that are scattered throughout the commons. Herders use a range of practices to manage their livestock.

The aims of this study are to:

- Assess the agro-ecological knowledge of livestock keepers
- Assess the condition of the rangeland during drought
- Determine the herding strategies of herders during drought

- Determine the spatial foraging patterns of herds in the Paulshoek communal area during and after a drought and correlate these patterns with biotic and/or abiotic features along their grazing routes.

Field interviews were conducted with livestock keepers to collect information on local agro-ecological knowledge. Herders' perceptions of rangeland condition during drought were gathered through cognitive maps generated by herders. Herd management strategies of herders were observed during the grazing period. Herds were followed for a single day during and after the drought and the position of the herd in the rangeland was recorded with a GPS at regular intervals to determine daily grazing movements of individual herds.

Livestock keepers regard rain as the main determinant of rangeland condition. However, they still consider that livestock can impact negatively on the rangeland and try to prevent trampling by alternating their daily grazing routes. Herders regard mountains as the key resource areas for their livestock during a drought. Areas with high toxic plant abundance are regarded as forbidden for livestock.

Different herding strategies are used to manage the herds. A herd is either herded or allowed to graze freely. During drought some herders changed their herding strategy because they did not know which herding strategy would work best.

Water points were the foci of almost all grazing routes even after the drought, and the areas away from the water points were less heavily utilized. Grazing intensity was higher in the elevated areas of the rangeland than on the surrounding low lying areas during and after drought. Drought had no impact on the spatial patterns of resource use by livestock on the commons. The lengths of the daily grazing routes were similar for the drought and post-drought periods. The size of home ranges of the herds did not change during the two monitoring periods because herders try to avoid each other.

Herds grazed 11 % of the total grazing area of the Paulshoek Commons every day during the drought. This means that on average they graze the same area every ten days during the drought assuming the rangeland is used evenly. However, since some areas are more preferred than other areas the grazing intensity is even higher in selected areas. This indicates that the commons is continuously grazed. However, continuous grazing should not be viewed as a result of bad farming practices, but because there was no forage available on the lowlands. Herders are spatially constrained which do not allow them sufficient options to adapt to drought, hence many animals died.

Declaration

I declare that “Patterns of resource use by livestock during and after drought in a communal rangeland in Namaqualand” 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 references.

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Table of Contents

Page

Lists of Figures and Tables

Chapter Five

Chapter Six

List of Appendices

Chapter One

Introduction

1.1 Introduction

Pastoralism has been practiced for millennia in Africa. Pastoralists occupied extensive rangelands but due to assumed drier climates during the second millennium, forage became scarce and pastoralists were forced to move between grazing areas (Lane 1998). They practiced nomadism and transhumance between grazing areas so that their animals could have sufficient good quality food to eat. Their well-organized livestock management systems and opportunistic movement between grazing areas made them very successful in sustaining livestock in drier pastoral areas (Lane 1998).

About 27 % of the land in Namaqualand, a semi-arid area along the west coast of South Africa, is under communal land tenure and 53 % is commercial farmland (Rohde *et al*. 2001). Communal rangelands are utilized for fuelwood, construction materials, medicinal plants, crop farming and livestock farming. Livestock farming on the communal rangelands reflects a traditional way of life. Owning livestock ensures cultural identity, status and self-respect for communal farmers (Debeaudoin 2001). Livestock on communal farms is also seen as an investment that can generate cash during financial crisis (Debeaudoin 2001; Rohde *et al*. 2001; Ainslie 2002) rather than earning a daily income.

The Leliefontein Communal Rangeland in Namaqualand is stocked on average at twice the recommended stocking rate determined by the Department of

Agriculture for adjacent commercial farms (Todd & Hoffman 1999). Continuous grazing[1] due to the overcrowding in the communal areas has resulted in significant changes in the vegetation (Todd & Hoffman 1999). In some areas like the flat areas (Todd & Hoffman 1998; 1999), areas in close proximity to stockposts (Riginos & Hoffman 2003) and water points (P Anderson unpublished data), perennial palatable shrubs are being replaced by *Galenia africana* L., an unpalatable shrub. Annuals and geophytes have also increased due to continuous grazing (Todd & Hoffman 1999).

It has been hypothesized that climate change will cause variations in rainfall and temperatures over the globe (Hudson 1997), which will then cause significant shifts in climate zones (Rowlands 1996). It is also hypothesized that the Succulent Karoo will become so arid that only the hardiest plants will survive (Midgley *et al*. 2002). Floods and droughts are predicted to continue, and these will have negative impacts on people's livelihoods in the communal areas of South Africa (Rowlands 1996).

Most of the changes pastoralists in Africa will experience as a consequence of climate change will be through changes in natural resource availability (Thornton *et al*. 2003). The combination of drought and human activities such as overgrazing may lead to desertification of vulnerable areas; causing biological resources to become degraded (Kundzewics *et al*. 2002). The consequences of climate change for the biota have been hypothesized to be most severe in areas of high biotic

[1] The term grazing is used in this thesis to include both grazing and browsing.

diversity like the Succulent Karoo as a result of temperature changes outside the tolerance limits of most plants in the Succulent Karoo (Rutherford *et al*. 1999). Midgley *et al*. (2002) recommend the development of rangeland management tools that are appropriate in hotter and drier climates to mitigate the effect of climate change. One option is to have a spatial grazing management plan that allows for minimal impact to the rangeland. However, it is important to first understand the spatial patterns of livestock grazing and the factors affecting their spatial distributions, before any grazing management plan can be developed (Turner & Hiernaux 2002). Studying the patterns of resource use by livestock during drought might also provide the opportunity to assess the ability of communal livestock management practices to adapt to a drier climate.

The prevalence of income earning as the only justification for livestock faming and the 'tragedy of the commons' belief are the major reasons why commercial farming practices are promoted. There is also little empirical data on livestock activity patterns on communal rangelands in South Africa. Consequently, most decisions made by the Department of Agriculture for communal rangeland management are based on commercial farming practices. The management plans which the Department of Agriculture proposes for communal farms are based on technical knowledge that is scale dependent and not adapted to local conditions. As a result the agro-ecological knowledge of local communal farmers is not considered (Allsopp *et al*. 2003).

This study assesses whether livestock keepers in Paulshoek have the knowledge of ecosystem processes that occur during a drought period. This study will also determine the key resource areas for livestock during a drought period from a herder's perspective. I will assess how livestock is herded to the key resource areas. This study will then examine the spatial and temporal patterns of resource use by livestock during and after a drought period in Paulshoek.

In order to understand livestock activities, it is important to know why farmers use different strategies to manage livestock. This chapter will present the debate on what factors drive vegetation dynamics in rangeland systems. The way farmers manage their rangeland is determined by those factors they regard as the most important drivers of vegetation change. I will present the two main livestock management systems in South Africa. In this chapter, I will also discuss the distribution patterns of animals across rangelands and the strategies used by herders to manage their livestock.

1.2 Do Equilibrium or non-equilibrium factors drive rangeland systems?

The equilibrium model for vegetation dynamics is based on the traditional linear Clementsian successional model. The model predicts that vegetation will move from a pioneer state after a disturbance in the absence or reduction of grazing pressure along various seral stages towards a climax community (Wilson & Macleoid 1991). When grazing is introduced, the vegetation will move in the opposite direction. The degree and direction of movement is proportionate to the grazing pressure.

In contrast to the equilibrium model are the cyclic and stochastic non-equilibrium models. The cyclical model argues that vegetation state is not simply the result of the balance between herbivory and plant succession in a system (Illius & O'Connor 1999). This is because plant populations are governed by different abiotic processes (Ellis & Swift 1988, Vetter 2004; Teague *et al*. 2004). Plant and animal dynamics are regarded as largely independent of one another. Livestock under highly variable climates are hypothesized not to have long-term negative impacts on forage production. This is because sporadic die-offs during droughts regulate animal densities below equilibrium (Shackleton 1993; Illius & O'Connor 1999; Ward 2004).

The stochastic model, including the state and transition model first proposed by Westoby *et al*. (1989) suggests that vegetation shifts into alternative states and transitions between states. States are characterized by the physiognomy of the dominant vegetation (Milton & Hoffman 1994). Transitions often occur only in one direction. For example, fire may cause a transition of vegetation into another state but the absence of fire may not reverse the transition. Human related agents such as livestock grazing, fire, and woody plant control are the most important causes of vegetation change (Rodriguez Iglesias & Kothman 1997). However, climatic factors like rainfall (Llorens 1995) and large migrations of wild animals that maintain grazing lawns (McNaughton 1984) and prevent tall vegetation from developing (McNaughton 1976) also influence vegetation state.

The state and transition model differs from the equilibrium model because it rejects the complete reversibility of secondary succession (Walker 1993). The state and transition model is also more flexible than the successional model because it includes cyclic, successional and stochastic responses of vegetation to abiotic and/or biotic factors (Milton & Hoffman 1994).

Arid and semi-arid systems display more non-equilibrium characteristics (Simons & Allsopp 2003), whereas in humid systems, equilibrium dynamics predominate (Everson & Hatch 1999). Some researchers argue that equilibrium and non-equilibrium systems are extremes along a continuum where a range of conditions exist between the extremes (Vetter 2004). It has also been shown (Richardson *et al.* 2005) that semi-arid ecosystems are complex systems that cannot be described by concepts of linearity. A complex system has many interacting factors and at many different scales (Richardson *et al.* 2005).

The management of rangelands is influenced by the model which is used to explain vegetation dynamics. The use of conservative stocking rates is an important aspect of the management of equilibrium systems (Stoddard *et al*. 1975). Most of the grazing systems around the world are managed on the paradigm of Clementsian ecology (Sayre and Fernandez-Gimenez 2003).

Traditional grazing systems in Africa use opportunistic stocking rates and mobility to manage their livestock in variable environmental conditions (Sanford 1982). Allowing stocking densities to vary over time mean that pastoralists can make maximum use of the abundance of forage after good rains. Livestock keepers know that many of their animals will die off during drought even though they practice mobility to minimize the negative impacts of drought.

If livestock keepers on communal areas adopt the commercial model of range management, destocking and the establishment of fences will have to take place on the communal farms (Bayer & Walters-Bayer 2004). Destocking can have negative impacts on the livelihoods of the rural poor because livestock ensures cultural identity and status as well as food and savings (Debeaudoin 2001). Restocking after drought periods will also be too expensive for communal farmers who do not often have the capital to buy more animals. Fencing will disrupt their traditional system of livestock management since it will prevent them from spatially exploiting seasonal differences in forage abundance, and avoiding the threats of drought.

In addition to biotic and abiotic variables that drive vegetation dynamics, socio-economic factors like institutional control, levels of unemployment and local perceptions about rights and responsibilities are also important drivers of vegetation change in Africa (Twine 2003). Therefore, before any interventions can take place on communal areas, biotic, abiotic and socio-economic factors should be considered. This study will attempt to find out what factors livestock keepers in Paulshoek regard as the most important drivers of vegetation change in their grazing system and how these factors influence their livestock management strategies.

1.3 Grazing management systems in South African rangelands

In South Africa, two distinctive grazing management systems are employed to manage natural resources and sustain domestic animals. These are the commercial and communal farming systems.

Commercial farms in South Africa are privately owned by mostly ‘white’ farmers (Archer 2004) most of whom adopt a rotational farming approach whereby camps are grazed for different periods. The rotational farming system is seen by Department of Agriculture as the ‘ideal’ system to manage livestock, even though it is not been justified by empirical evidence (O’Reagain & Turner 1992).

Commercial farming is primarily aimed at sustained maximum production, especially of meat (Beaumont 1989). Goats are seldom produced on commercial farms and plants are seldom used for other purposes than animal forage (Bond 1999). Livestock graze in paddocks and are left unattended. This method of farming is perceived as beneficial for animal productivity and is aimed at ensuring uniform resource utilization. However, it has been shown (Baumont *et al*. 2000) that resources are selectively grazed or animals may restrict themselves to certain parts of the camp (Lange & Willcocks 1978). Animals in camps of similar vegetation in individual units also may not get a chance to diversify their diet.

Indigenous people of South Africa were restricted to diminishing areas of land during colonialism as colonists moved into the country. During the 20th century, land rights were delineated along racial lines through various land acts. This culminated in the apartheid policy which restricted black people's access to 13 % of the land surface (Thompson 1990). Land in this 13 % was usually communal with local chiefs or in the case of Namaqualand (including Leliefontein) "birthright", giving individuals rights to use the land. The history of Leliefontein will be discussed in the next chapter.

Communal farming is practiced by the indigenous 'black' people of South Africa. Communal framing practices contrast strongly with commercial farming. In Namaqualand, herds often have multiple owners. Herds are predominantly goats and sheep but can include cattle. People in communal areas engage in livestock farming for various reasons (Debeaudoin 2001; Ainslie 2002).

Traditional communal farming in African rural areas is generally considered by agricultural policy makers as unproductive and largely responsible for poverty, overgrazing and land degradation (Scoones 1992). According to the theory of the 'tragedy of the commons' (Hardin 1968), communal farms are regarded as completely uncontrolled, open to all and where farmers attempt to maximize immediate benefit at the expense of the resource and of other resource users. The ensuing environmental degradation from communal farming, the fact that communal farmers only want to increase their profit irrespective of impact on others, and livestock keepers act selfishly are the assumptions of the 'the tragedy of commons' (Hardin 1968).

Debeaudoin (2001) tested the relevance of the theory of the 'tragedy of the commons' in the Leliefontein Communal Area and found that the assumptions that the theory rests on are not relevant in this communal area. This is because access is not open to all, herders regulate their herd size and herders help one another. This paradigm has also been refuted in other areas such as the Otjimdingwe Communal Reserve, 200 km northwest of Windhoek (Ward *et al*. 1998) and in the Tauran Plain in Iran (Martin 1982). Ward (2004) argues that the 'tragedy of the commons' may not be the reason for environmental degradation on communal lands in Namibia. He hypothesizes that since commercial farms are placed on more fertile land, communal farmers are forced to make an existence off infertile lands where vegetation is limited.

It may not also be the traditional grazing management practices that caused this situation on communal rangelands, but rather the effect of too many people being concentrated on small pieces of land (Danckwerts & Palmer 1993). In the Leliefontein Communal Area about 9 000 people and 30 270 small stock units (SSU) are concentrated on 224 627 ha of land. There are 412 private farms in Namaqualand with an average size of 11 650 ha. The stocking rates on private farms in Namaqualand vary between 10 and 14 hectares per SSU (Rohde *et al*. 2001). Several of these commercial farmers may own more than one farm across agro-ecological zones. These commercial farmers practice transhumance between well defined seasonal grazing areas.

Livestock keepers on communal rangelands adopt an opportunistic strategy (Sanford 1982) by keeping high numbers of livestock (de Bruyn 1998) in a mixed herd. Having a large herd at the start of a drought will increase the chances that at least some individuals in the herd will survive (Kinlund 1996; Ward 2004). A diverse herd ensures that a range of habitats are exploited (Nolan *et al*. 2000; Galvin *et al*. 2001) and minimizes competition for resources (Niamir 1991). A multi-species herd is also a risk-mitigation strategy (Fernandez-Gimenez & Swift 2003) because different species have differing vulnerabilities to disease and environmental stresses. This study will establish what strategies livestock keepers in Paulshoek use to manage their livestock during a drought.

Commercial farmers concentrate on individual animal performance (Maasika *et al*. 1998) and adopt a conservative strategy where a constant population of grazing animals is kept through good and bad years alike (Sanford 1982). Due to the adoption of a conservative strategy, commercial farming is even argued to be more destructive to the natural environment than communal farming at certain times (Ward 2004). Maintenance of a stable livestock population sustains the impact on the environment during the critical recovery period after drought. In contrast, large livestock die offs on communal farms during drought allows forage plants to recover (Ward 2004). Overgrazing of commercial farms can also occur when wet periods coincide with low market prices, which encourage owners to retain animals until prices improve (Grainger 1990).

1.4 Spatial heterogeneity of resource use

Vegetation of grazing systems is spatially heterogeneous (Henkin *et al*. 2003). Spatial heterogeneity is caused by abiotic and biotic factors. Abiotic factors include rainfall (Sanford 1982), soil (Allsopp 1999), geology, geomorphology (Cingolani *et al*. 1998), topography (Pérez Corona *et al.* 1998), and seasonality (Scoones 1995; Pérez Corona *et al.* 1998). Biotic factors include plant–plant interactions (e.g. competition), disturbances by burrowing animals (Carlson & Crist 1999), selective grazing patterns (Cid & Brizuela 1998; Hirata 2000; 2002), and defaecation patterns of herbivores (Turner 1998).

The vegetation of Paulshoek is heterogeneous (Petersen 2004). The vegetation of the lower south-eastern part of the commons is classified as Namaqualand Blomveld and Namaqualand Klipkoppe Shrubland whereas the vegetation of the higher lying north-western part of Paulshoek is classified Namaqualand Granite Renosterveld that is dominated by *Dicerothamnus rhinocerotis* (L.f.) Less. (renosterbos) (Musina & Rutherford 2004). The disturbed (overgrazed and ploughed) areas are dominated by G. *africana*. During spring the flatlands, which occur between the numerous inselbergs in the commons are covered with ephemerals.

Due to the heterogeneity in resource availability, hence food quality, livestock grazing is spatially uneven across a grazing unit (Wiens *et al*. 2002; Henkin *et al.* 2003) in order to balance their intake of nutritional food (Wallis De Vries & Schippers 1994). The selection of habitats during grazing has also been related to factors like water availability, stocking rate (Hirata 2002), animal size and species (Henkin *et al*. 2003), distance to travel to food resources (Wallis De Vries & Schippers 1994), access and/or barriers (Turner & Hiernaux 2002), salt and mineral placement, seasonality, time of day, prevailing winds, and paddock size (Schacht *et al*. 1996). Due to the heterogeneity in vegetation, herders also herd more often to areas where there is abundant quality food available.

A study on feral horses in south central Wyoming shows that they prefer mountain sagebrush, stream sides and meadows habitats and avoid lowland sagebrush habitats (Crane *et al*.1997). On some private farms in Israel, cows avoid stony and steeper lands preferring flat and clear areas to graze (Henkin *et al*. 2003). Cattle avoid grazing near faeces, but later will prefer grazing near old and decomposed faeces due to higher biomass availability and more nutritious grass (Cid & Brizuela 1998).

In the Sahel, in West Africa, herders establish camps around pans because they have higher water retention capabilities and forage quality than the surrounding environment. Some pans act as major centres from where livestock radiate to graze during the early dry season (Turner 1998). In Paulshoek animals also forage outward from water points and animal encampments to where they often return to drink, rest, or ruminate (Debeaudoin 2001). The frequent return to water points creates a grazing pattern of decreasing intensity with distance from the water that is known as a piosphere (Lange 1969).

Studies in Namaqualand have recently documented herd mobility of communal livestock (Combrink 2004; Hendricks 2004). Hendricks (2004) assesses the seasonal movement patterns and daily grazing activities of livestock in the Richtersveld National Park between 1995 and 2001. Herds in the Richtersveld National Park practice transhumance between areas with seasonal abundance in forage.

Over three seasons (autumn, winter and spring) in Paulshoek, a herd grazed the sandy flatlands more than the mountainous areas (Combrink 2004). According to this study, the distance between the stockpost and the water point, the size of the grazing area and the length of the grazing period are the factors that describe the grazing regime of a herd in Paulshoek.

None of the studies on herd mobility in Namaqualand specifically looked at the distribution of livestock during a drought period. In dry seasons, livestock forage more intensely and their impact on vegetation around water points may be more severe than in wet years (Pickup & Bastin 1997). Therefore, assessing the grazing patterns of livestock during drought in Paulshoek will determine whether the impact of livestock on the rangeland is more severe than in wet years.

1.5 Herding strategies used to manage livestock

The uses of different herding strategies are opportunistic methods to make optimal use of limited resources (Fernandez-Gimenez & Swift 2003). There are various herding strategies to manage livestock and other rangeland resources due to spatial limitations. Baker and Hoffman (2006) examine the herding strategies in Paulshoek by looking at how often herders move their stockpost. They identify several mobility practices: sedentary herders who never moved during the six year study period; home range herders moved sometimes but not regularly; and mobile herders moved at least once a year (Baker and Hoffman 2006).

Turner and Hiernaux (2002) and Debeaudoin (2001) examine the herding strategies in terms of daily grazing management. They identify herders that herd the whole day and herders that only herd during the earlier part of the day and leave the herd in the rangeland to graze on their own until they are kraaled at night. Turner and Hiernaux (2002) also identify herders who leave their animals alone in the rangeland the whole day. Debeaudoin (2001) identify herders that only follow their animals the whole day, but never make any decisions about the direction the herd should take. This study will determine the herding strategies used in Paulshoek to management livestock during a drought period and whether different herding strategies manifest into different grazing patterns.

1.6 Aims of the research

The primary aim of this study is to determine the spatial foraging patterns of livestock in the Paulshoek communal area during and after a drought, and to establish whether these patterns are correlated with herding strategy, biotic and/or abiotic features along their grazing routes.

To achieve this, the objectives of the research will be:

- To document local agro-ecological knowledge
- To identify key resource areas for livestock during the drought period
- To identify the herding strategies employed by the herders
- To gain an understanding of the habitat utilization patterns of the livestock

The research problem can be formulated as follows: ***Are livestock keepers in and around the village of Paulshoek capable of managing their livestock effectively in adverse climatic conditions?***

<u>I will also try to answer the following questions:</u>

- Are there differences in livestock keepers' local agro-ecological knowledge?
- Are there differences in herders' spatial perceptions about their rangeland?
- What strategies do herders use to manage their livestock during drought?
- What factors do the herders take into account when choosing their daily routes?
- Are there recognizable patterns in their daily route?
- What differences in route patterns are found between different herds?
- Can the differences in route patterns be explained by abiotic features along their routes, or on the basis of animal behaviour, or herder choice?

1.7 Thesis structure

Chapter one contextualizes the study. The next chapter (Chapter Two) introduces Paulshoek, the study area, by describing its natural environment, the people, and their livelihoods. Chapter Three looks at the agro-ecological knowledge of livestock keepers and how they use their local agro-ecological knowledge to manage their livestock. Identification of key resource areas for livestock during a drought period from a herder's perspective are presented in Chapter Four. Chapter Five describes the diversity of herds and the different herders together with the herding strategies that they employ daily to manage their livestock within the commons. Chapter Six presents the results of how the commons are utilized by the different herds spatially. I show all the stockposts, water points, and various routes used by the herders in relation to abiotic factors along their grazing routes. This chapter compares the grazing patterns of livestock during and after the drought and compares grazing distribution between herded and free-ranging herds. The final chapter (Chapter Seven) draws conclusions about the whole study and gives some recommendations for future studies pertaining to grazing management in the Leliefontein Communal Rangeland.

Chapter Two

The physical and social environments of Paulshoek

2.1 Introduction

"*As jy nie die moed, wilskrag en kennis het om te boer nie, moet jy nie eens oorweeg om in Paulshoek te boer nie*."

- Herder 14

"If you do not have the courage, willpower and knowledge to farm, then you should not even attempt to farm in Paulshoek."

From the above statement it is clear that being a farmer in Paulshoek is not easy. This chapter will focus on the physical environment of Paulshoek to gain insight into what challenges livestock keepers have to endure in order to live. In the course of this chapter, it will become apparent that the natural environment of Paulshoek is harsh and variable, making it extremely difficult for people in Paulshoek to farm.

Knowledge of the local environment is a prerequisite for herders since they are constantly making decisions on choosing a grazing route (Chapter Five), or when to leave the stockpost in the mornings (Chapter Three). Making the wrong grazing decisions because of ignorance can be fatal as it may lead to herds being taken to the wrong grazing areas with high toxic plant abundance (Chapter Four) or little forage like old croplands. Environmental conditions sometimes determine the herding route used by the herder (Chapter Five) and the grazing intensity by livestock (Chapter Six).

This chapter will describe the physical environment of Paulshoek to show the environmental obstacles livestock keepers have to overcome in order to survive. A historical overview of the Namaqualand area and a description of the socio-economic environment of Paulshoek will also be given. This is to show why most people in Paulshoek are living below the poverty line and why inhabitants engage in livestock farming as a means of survival, even though farming is extremely tough and risky.

2.2 Geographical location

Paulshoek is situated in Namaqualand, which is approximately 4 810 000 ha in size, at the northwestern part of the Northern Cape Province. Agriculture is the primary land use in Namaqualand and is practiced on commercial farmlands and on communal areas. There are seven communal areas in Namaqualand that constitutes 27 % of the total area[2] (Rohde *et al*. 2001). One of these communal areas is the Leliefontein Communal Area, which is 224 627 ha in total area. This area comprises of 192 000 ha of the old commons that are cut longitudinally by the N7 national road, and five farms that were bought in the summer rainfall areas of Bushmanland between 1998 and 2000 that add a further 32 627 ha (Fig 2.1). The Leliefontein Communal Area is situated about 80 km south of Springbok, the administrative centre of Namaqualand. The Leliefontein Communal Area comprises of ten villages (Fig 2.2). One of these villages is Paulshoek. Paulshoek Village is situated at 30^0 20’ S and 18^0 15’ E, east of the town Garies, 56 km away by gravel road. The Paulshoek Commons is 20 000 ha in size.

[2] This area is currently increasing under land restitution and redistribution policies of South Africa.

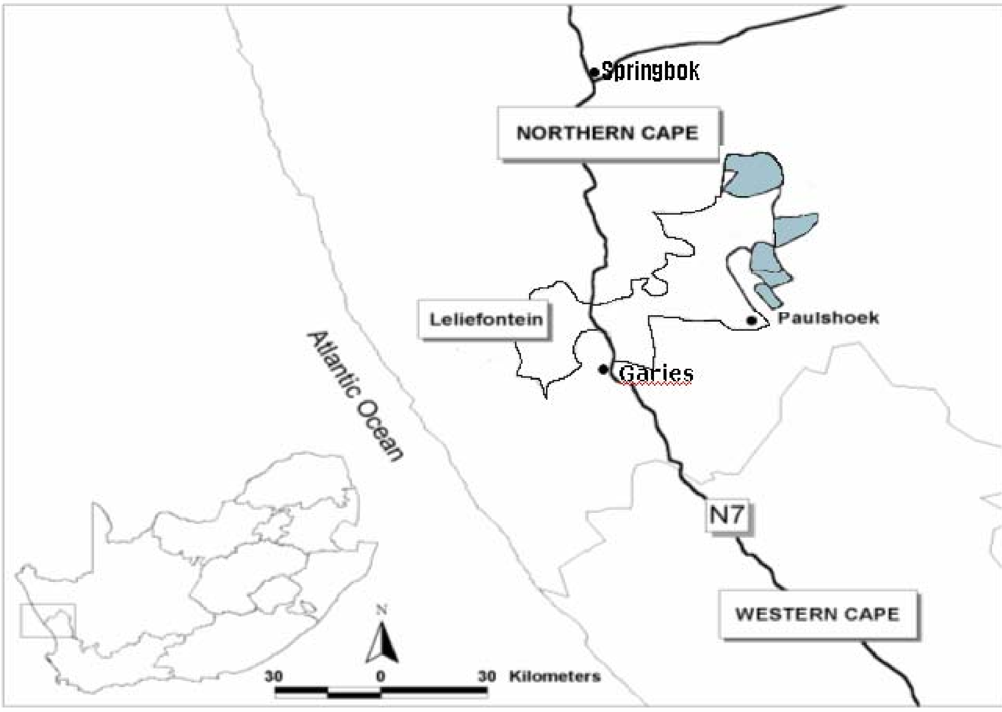


Figure 2.1: The location of the Leliefontein Communal Area in Namaqualand (modified from Rohde *et al*. 2003). The shaded areas indicate the location of the new farms.

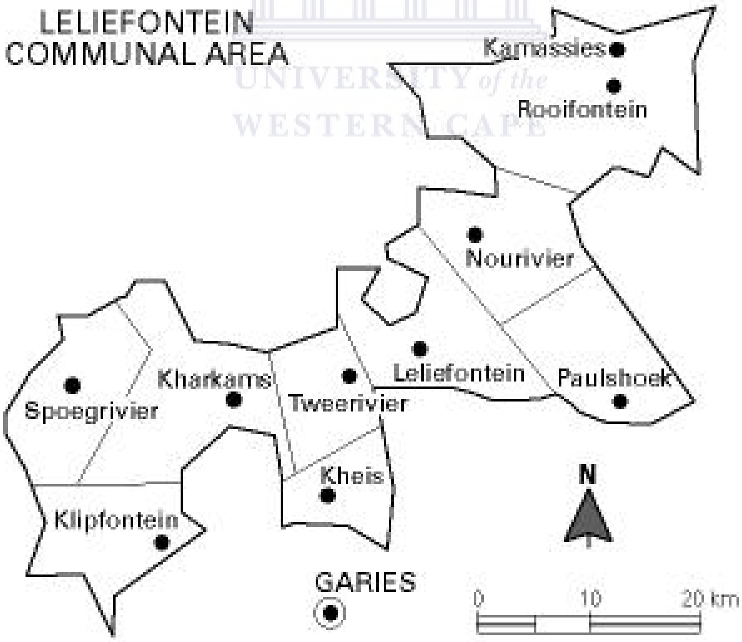


Figure 2.2: The location of Paulshoek Village in relation to the other nine villages within the Leliefontein Communal Area (from Rohde *et a*l. 2003).

2.3 Landscape

2.3.1 Topography

The Paulshoek Commons is situated on the eastern foothills of the Kamiesberg Mountain. The topography of Paulshoek is variable and plays an important role in the decision-making of daily grazing routes (Chapter Six). In the northwestern part of the commons the landscape is characterized by big mountains, high and steep inselbergs, and deep valleys. In the south and east of the commons are the flatter lowlands. These areas are characterized by numerous steep inselbergs and flatlands between the inselbergs.

The Paulshoek Commons can be classified into three elevation classes. The low elevation class (900 to 1 120 m.a.s.l.) covers 38.5 % of the total area. The medium elevation class (1 120 to 1 200 m.a.s.l.) covers 39 % and the high elevation class (1 200 to 1 400 m.a.s.l.) covers 22.5 % of the commons (Petersen 2004).

2.3.2 Geology

Rock-types in the Paulshoek area consist entirely of metamorphic basement gneisses of the mid-Proterozoic Namaqualand Metamorphic Complex (Joubert 1971 Cited in Petersen 2004). Augen gneisses occupy the cores of the dome-like structures in the northern half and southeastern corner of the commons whereas granite gneisses outcrop in the southwestern corner. Pink gneisses represent the commonest rock-type in the Paulshoek Commons.

Rock cover classes (20-50 cm, >50 cm and bedrock) are the most significant variables in determining plant community composition in Paulshoek. This may be because nutrient recycling status and infiltration rates are significantly higher on the rocky habitats. The rocky areas act as buffers in capturing moisture and nutrients (Petersen 2004).

2.4 Climate

2.4.1 Temperature

Moderate summers and cold to very cold winters characterize the Paulshoek Commons. The mean annual temperature for Paulshoek is 16.3 ^{0}C (Hoffman *et al*. 2000), while the mean maximum temperature for January, the hottest summer month, is 30 ^{0}C, and the mean minimum temperature for July, the coldest winter month, is 3 ^{0}C. During winter minimum temperature frequently reaches below freezing point, whereas maximum temperatures rarely surpass 37 ^{0}C in summer (Hoffman *et al*. 2000).

2.4.2 Rainfall

The seasonality of the rainfall is the most important factor contributing to the seasonally abundant ephemeral diversity of the Paulshoek grazing system (Todd and Hoffman 2000). Paulshoek has an annual rainfall that varies between 70 mm to 250 mm, which falls predominantly during the winter months of May to September (Hoffman *et al*. 2000). Since 1997, the annual rainfall (mean of 15 rain gauges) in Paulshoek has not exceeded 250 mm (Fig 2.3). Generally, there is also spatial variability in rainfall between the western higher lying areas and the eastern lower lying areas. Recurring droughts in this region are common (Cowling *et al*. 1999) but prolonged drought are rare (Desmet and Cowling 1999). This study was conducted during the drought period between September 2002 and August 2003. The post-drought period was from September 2003 to October 2003. The rainfall recorded for the drought period was 111.8 mm with 78.5 mm recorded in August 2003 (MT Hoffman unpublished data). Thus only 33.3 mm was recorded for eleven months during September 2002 and July 2003.

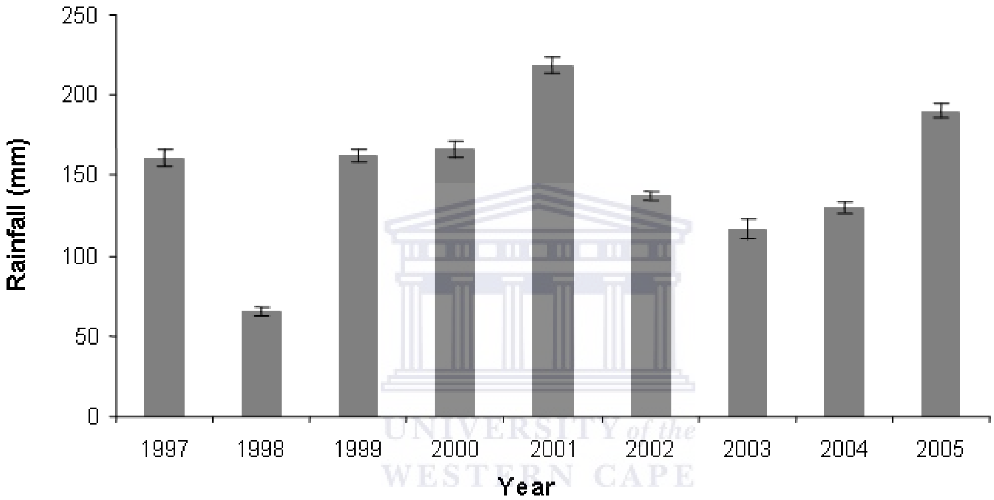


Figure 2.3: Annual rainfall from 1997 to 2005 from 15 rain gauges scattered in and around Paulshoek village (MT Hoffman unpublished data). Standard error bars are indicated.

2.5 Biodiversity

2.5.1 Soils

The soils in Paulshoek are very shallow, about 50-400 mm deep (du Plessis 1987). The sandy nature of the yellow and red soils combined with low soil organic matter content around 1.5% (Allsopp 1999) results in generally infertile soils. Cultivation results in the loss of soil nutrients but the subsequent colonization of old croplands by G. *africana* enrich the cultivated soil (Allsopp 1999). Soil texture and soil chemical properties (Ca, Na, N and Mg) also determine plant community distribution (Petersen 2004). Soil erosion is not extensive in Paulshoek.

2.5.2 Flora

Southern Africa has the highest plant species density in the world with 23 420 plant species, of which 80 % are endemic to Southern Africa (Cowling & Hilton-Taylor 1994). These plant species are not distributed evenly across Southern Africa. Most of the plant species are concentrated in 'hot-spots'. There are only twenty-five global hot-spots. One of the hot-spots in Southern Africa, namely the Cape Floristic Region, is the richest Mediterranean-climate region in the world. The Cape Floristic Region is 90 000 km^2 in size and boasts 8 600 plant species and a 68 % level of endemism. The Succulent Karoo, another hot-spot in Southern Africa, supports the richest succulent flora in the world. The Succulent Karoo is 116 000 km^2 in size and contains 4 750 species of which 35 % are endemic (Cowling & Hilton-Taylor 1994).

Namaqualand, one of four distinct regions in the Succulent Karoo biome, is the richest region in terms of plant diversity containing more than 75 % of the biome's plant species (Cowling and Pierce 1999). The BIOTA[3] research project provisionally listed 621 plant species that occur in the 20 000 ha of the Paulshoek Commons and Rooiwal, a 5 000 ha private farm adjacent to the commons

[3] BIOTA is an interdisciplinary and applied research project that studies the change of biodiversity caused by different land use systems and intensities in Namibia and the western parts of South Africa.

(BIOTA unpublished data). Peterson (2004) recorded 256 species and identified four plant communities (Table 2.1) in the Paulshoek Commons. Three species are endemic to the Kamiesberg bio-region, 50 species (19.5 %) are endemic to Namaqualand, while 122 (47.6 %) are endemic to South Africa. About 35 % are non-succulent shrubs, 20 % leaf succulents, 15 % herbs, 13 % annuals, 11 % geophytes, 4 % stem succulents, and 2 % grasses. The flora is dominated by the families Asteraceae, Mesembryanthemaceae, Crassulaceae, and Aizoaceae (Petersen 2004).

2.5.3 Fauna

The diversity of invertebrate groups like Colembolla, Arachnida, Thysanoptera, Diptera, Heminoptera, Hemiptera and Coleoptera are greater on the Paulshoek Commons than on an adjacent private farm (Seymour and Dean 1999). In contrast, the population density of small mammals like *Aethys namaquensis, Macroscelides proboscidens, Gerbillurus paeba* and *Rhabdomys pumilio* are higher on the private than on the communal side (Joubert and Ryan 1999). Larger mammal species seen frequently include *Procavia capensis* (Cape hyrax) and *Lepus capensis* (Cape hare). Klipspringer (*Oreotragus oreotragus*) and steenbok (*Raphicerus campestris*) were occasionally sighted in the rangeland during this study.

Table 2.1: The four different plant communities identified in Paulshoek (Petersen 2004).

Plant community	Location	% of total area covered	Topography	Vegetation characteristics	% Plant cover
1	Found south-east and north-east of village	16	Found mainly on low lying flats and foot slopes between 980 and 1 120 m.a.s.l.	Vegetation is dominated by low evergreen shrubs <50 cm high. Shrubs like *Galenia africana, Hypertelis salsoloides* (Burch.) Adamson, *Hermannia cuneifolia* I. Verd. and *Drosanthemum floribundum* (Haw.) Schwantes dominate.	12.8
2	Found east of village	51	Found on foot and mid-slopes of mountains between 1 054 and 1 210 m.a.s.l.	Vegetation is dominated by dwarf leaf succulents <50 cm high. Species like *Ruschia robusta* L. Bolus, *Hallianthus planus* (L. Bolus) H.E.K. Hartmann and *Crassula subaphylla* (Eckl. & Zeyh.) Harv. dominate.	22.1
3	Occur mainly west and northwest of village	29	Found on mid-slopes between 1 059 and 1 263 m.a.s.l.	Low evergreen shrubs such as *Pteronia laterifolius* L., *Eriocephalus microphyllus* DC., *Pelargonium karooicum* Compton & P.E. Barnes and *Asparagus capensis* (L.) Oberm. dominate.	29 .9
4	Occur northwest of village	4	Found on upper slopes and crests of mountains between 1 072 and 1 252 m.a.s.l.	Species with Mountain Fynbos affinities like *Diospyros austro-africana* De Winter, *Lebeckia multiflorum* E. May and *Dicerothamnus rhinocerotis* dominate.	23.8

2.5.4 Is the Paulshoek grazing system degraded?

Several studies (e.g. Todd & Hoffman 1998; 1999) suggest that high grazing pressure has altered the biophysical environment of the Paulshoek grazing system. Continuous grazing and ploughing of the lowlands has resulted in the decrease in important forage leaf succulent and large woody shrub species (Todd & Hoffman 2000) while annuals, geophytes and G. *africana* have increased (Todd & Hoffman 1998; 1999). Heavy grazing has also increased the seed bank of G. *africana* in the soil, reduced the seed bank of palatable perennials (Carrick 2001) and decreased vegetation cover (Simons & Allsopp 2003).

Dryland cropping has resulted in a loss of soil nitrogen and organic matter. However, G. *africana*, that invade old croplands, enriches the soil in nutrients (Allsopp 1999). There is no difference in moisture or organic matter, total nitrogen, total and available phosphorus or pH levels in soils from open patches from heavily and lightly grazed areas. Soils under shrubs from heavy and light grazing areas are also similarly enriched. This is regardless of the difference in the dominant shrub species. However, bare ground cover is more in heavily grazed areas than in lightly grazed areas, therefore has lower nutrient soils. This means that more soil is exposed to erosion and nutrient loss (Allsopp 1999).

Some people view these changes in the biophysical environment of the Paulshoek grazing system as degradation[4]. However, degradation can only be confirmed depending on which perspective is considered or which biota is measured. From

[4] Irreversible changes in the biophysical environment in human time frames.

an ecological perspective, I would argue that the Paulshoek grazing system is not degraded. Hoffman & Todd (2000) outline two main indicators of land degradation. These are soil and vegetation degradation. Soil erosion in Paulshoek is not extensive and there is no evidence of massive irreversible losses in topsoil. Despite an alteration in plant community structure, there has not been a significant reduction in species richness (Petersen 2004), despite stocking rates on average being twice the recommended rates for the last 30 years (Rohde *et al*. 2001).

Simons & Allsopp (2003) view these changes in vegetation cover as a change in vegetation state. The withdrawal of grazing results in little vegetation recovery which suggests that the Paulshoek grazing system non-equilibrium control (Simons & Allsopp 2003). Even though the recruitment of perennial shrubs in the absence of grazing is slow, grazing may still be regarded as a key factor that affects vegetation composition (Abrahams *et al*. 2003). The persistence of G. *africana* after grazing exclusion may indicate that the vegetation has undergone an irreversible transition to another state because of the dominance of G. *africana* (Simons & Allsopp 2003). Since herders are spatially confined (Chapter Six), they have to manage their livestock in this new state.

There is also no evidence that grazing or cultivation in the Leliefontein Communal Area has resulted in the extinction of any plant or animal species. Harvesting of medicinal plants has not negatively impacted on the natural populations of the 18 medicinal plant species most commonly used by the people in Paulshoek (Goldberg 1998). Harvesting of *Rhus undulata* Jacq. for fuelwood has not resulted in a decline in the natural populations in 50 years (Solomon 2000). Even though, about 200 *Polymita albiflora* (L. Bol.) L. Bol. individuals are used to construct a single cooking shelter; the use of this plant species is sustainable. This is partly because livestock keepers mostly use dead plants for construction (Evans 2001).

There is no significant difference in plant species diversity between communally and privately owned farms (Petersen 2004). The uplands vegetation of the Paulshoek Commons has similar plant species to the uplands of an adjacent private farm. There is no difference in the number of palatable and unpalatable plant species between private and communal farms.

Apart from biophysical factors, socio-economic factors also play a role in land degradation (Hoffman 2003). Rohde *et al*. (2001) do not regard overgrazing as the root cause of the observed fence-line contrast (Todd & Hoffman 1999) in Paulshoek. The difference in vegetation must be attributed to the political oppression of the Nama people through having a shortage of land for grazing (Rohde *et al*. 2001). From an economic perspective the Paulshoek grazing systems can also not be regarded as degraded. This is because income in terms of secondary production per hectare in Paulshoek is higher than an adjacent private area (Rohde *et al*. 2001).

2.6 History of Namaqualand

2.6.1 Pre-colonial Era

The first agricultural people, the Khoikhoi, arrived in southern Africa approximately 2000 years ago, bringing with them domestic animals (Smith 1999). The Khoikhoi were nomadic and moved extensively to exploit seasonal differences in the availability of good forage and water resources (Boonzaier *et al*. 1996). The Khoikhoi also brought about the concept of ownership in the form of herds and the control of land for grazing (Smith 1999). Both the San and Khoikhoi people inhabited the rangelands of Namaqualand for several centuries before the arrival the European settlers in the 17th century.

2.6.2 The Colonial Era

Europeans passing the Cape initially only stopped to trade with the indigenous Khoikhoi. The Dutch East Indian Company was the first European group to settle in the Cape in 1652 where they established a permanent colony (Boonzaier *et al*. 1996). In 1659 settlers started to farm. This reduced their dependence on the indigenous Khoikhoi people for agricultural products especially meat for their long sea journeys to the East (Redlinghuis 1981). These settlers, called ‘free-burgers’, rapidly expanded their farms, and the indigenous people lost more and more of their land to the colonist farmers (Elphick & Giliomee 1979). Their traditional patterns of utilization got disrupted and many became dependent on the colony for their livelihoods, and some were forced to settle at mission stations as a form of security to ensure that they retained access to some land (Kotze *et al*. 1987).

During the 1700s, the mission stations managed to secure land for occupation by indigenous Nama-speaking people at the time when the colonial government was granting title deeds to land to settlers to establish private farms (Boonzaier *et al*. 1996). Small villages developed around mission stations (Boonzaier *et al*. 1996). The missionaries introduced the communal land tenure system, which allows for some degree of movement, but on a much smaller scale compared to traditional systems (Boonzaier *et al*. 1996).

In 1816 the Leliefontein Reserve was founded which guaranteed Khoisan people access to some land (Kotze *et al*. 1987). This land was declared the common right of the community of the Klein Namaqualand, and the inhabitants of the reserve did not have to pay taxes to the colonial government (Kotze *et al*. 1987). However, the state refused to recognize the inhabitants' claims of ownership; awarding them occupational status instead.

In 1909 the Cape government passed the Communal Reserves and Mission Stations Act. This Act ended the secular authority of the missionaries and the sovereignty of the reserves (de Swart 1993). The control of mission lands was passed to the state (Rohde *et al*. 1999). In 1913 South Africa was divided into 'white' and 'non-white' areas through the Natives Land Act. This Act also prohibited people that were not regarded as of 100 % European descent from buying or hiring land from white farmers outside the reserves (Thompson 1990). The Natives Trust and Land Act of 1936, restricted 'non-whites' to 13 % of agricultural land. Insufficient grazing lands forced many people to seek employment outside the reserves. Consequently, people staying in the reserves became dependent on remittances sent by those relatives working outside the reserves (Thompson 1990).

2.6.3 The Apartheid Era

In 1948, the policy of separate development (apartheid) was officially adopted. In 1962 the Republic of South Africa was founded and government policies promoted 'white agriculture', and opportunities for development of 'non-white agriculture' were restricted. A plan to privatize the communal areas in Namaqualand was designed in 1978 (Rohde *et al.* 1999) and its implementation in Leliefontein began during 1984 (Krohne & Steyn 1991). This was an attempt to privatize 'coloured lands' based on the perception that this would increase production. The Leliefontein Reserve was divided into 47 farming units or 'economic units' that ranged from 1 500 to 6 175 ha, depending on local ecological conditions (Archer *et al*. 1989). Only 17 units were for communal use, with the rest being rented to individuals who had assets to the value of at least R3 000 or 200 head of livestock (Archer *et al*. 1989). The Paulshoek Commons was divided into five economic units and stock fences were erected, effectively closing the commons. Previously thirty or more communal farmers had grazed their stock across this landscape. Poorer farmers could not apply for farming units and they had to make the most of the small communal units. This scheme of economic units was not accepted by the majority of the Leliefontein community.

The matter was contested in court and on 21 April 1988 the court reinstated the "Communal Land Tenure System" that prevailed prior to 1984 (De Swart 1993).

2.6.4 The Post-Apartheid Era

When the first democratic elected government came into power in 1994, the Rural Areas Act was abolished and a plan of redistribution, restitution and reform of land was put into effect. The Transformation of Certain Rural Areas Act, Act 94 of 1998 (TRANCRAA) was the first comprehensive legislation to reform communal land tenure in South Africa (Wisborg & Rohde 2003). TRANCRAA aims to transfer land ownership of 23 'coloured rural areas', or so-called Act 9 areas, that are used in common by the community. The transitional phase of TRANCRAA was implemented in six rural areas of Namaqualand from January 2001 to January 2003. In November 2002 to January 2003, referenda over land ownership were held and people voted on three ownership alternatives:

1) Becoming Common Property Associations (CPA) in terms of the CPA Act, Act 28 of 1996
2) Forming part of newly enlarged municipalities (In the case of Leliefontein Communal Area, it is the Kamiesberg Municipality)
3) Option on choice that may include trust ownership and individual title

However, the Minister of Agriculture and Land Affairs must make the final decision on the transfer of land (Wisborg & Rohde 2003). This decision has yet to be made. Currently the Leliefontein Communal Area is managed by the Kamiesberg Municipality as chosen by the majority of people who participated in the poll.

2.7 The Social environment

The Paulshoek community consists of 492 inhabitants within 135 households where 60 % of the household heads are male. Half the residents of Paulshoek are females and about 40 % of the population is under the age of 18. High levels of poverty, illiteracy, unemployment and a general lack of resources typify this community. Only 10 % of the resident population is employed (South African Census 2001).

The average per household income per month is below R250, which makes these people among the poorest communities in South Africa (Hoffman *et al*. 2000). Fifty-one percent of the income in households is derived from remittance from migrants who are employed outside the reserve in mining, commercial farming or major towns like Springbok, Vredendal or Cape Town (Hoffman *et al*. 2000). These migrant workers were not included in the Paulshoek census in 2001. The rest of their income (29 %) is derived from state support grants, casual and permanent local wage employment 12 %, self-employment 4 %, and farming 4 % (Hoffman *et al*. 2000).

2.7.1 Crop farming

In Paulshoek, dryland cropping is practiced on the flatter, deeper soils of the valley systems that run southeast to northwest. The most important crops grown are oats, wheat, barley and rye, which are sown during the winter. The most common crop is oats and the grain and straw are used as fodder for livestock, particularly during drought when the rangeland is in poor condition. Wheat is a source of food and income, but is only cultivated on a small scale (N Allsopp, MT Hoffman & EM Young unpublished data).

The low and unpredictable rainfall is the main environmental constraint to crop farming and farmers will usually only sow and plough if there are good soaking rains before mid August. Ploughing may take place any time from May to August depending on rainfall. Traditionally donkeys are used for ploughing, but in the last eight years about half the farmers used tractors. Harvesting by hand using sickles takes place towards the end of November or early December. Threshing is done by donkeys on a dung-lined threshing floor.

Croplands in Paulshoek are located in 19 different areas consisting of 33 rented units that vary is size. Croplands can be leased on application from the Kamiesberg Municipality to people already paying for a residential plot in Paulshoek. Croplands are regarded as open grazing lands after the crops are harvested.

2.7.2 Livestock farming

More than 50 % of the households own at least one animal, which are kept at stockposts (Hoffman *et al*. 2000). There are about 30 semi-permanent stockposts scattered around the 20 000 ha of commons around the village. Some of the herders relocate their stockpost at least twice a year whereas others have used the same stockpost for the last six years (Baker & Hoffman 2006).

In the communal areas of Namaqualand, a stockpost is the nucleus around which all grazing activities occur (Hendricks 2004). Stockposts are located on the eastern side of a mountain so that the herd can capture the morning sun. A stockpost usually consists of three main constructions (Fig 2.4):

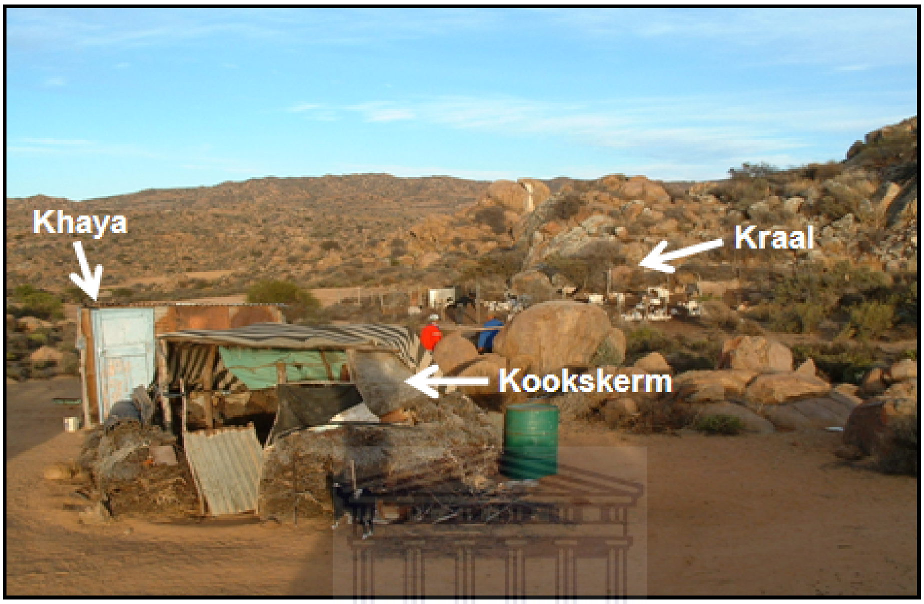


Figure 2.4: A characteristic stockpost in Paulshoek illustrating its three basic components.

- Kraal – This is an enclosure where the livestock are kept at night to protect them against nocturnal predators.
- Kookskerm (cooking shelter) – This is a cooking shelter constructed mainly from perennial shrubs like *Polymita albiflora*, *Euphorbia mauritanica* L. and G. *africana*. This may be uncovered, or partially covered to protect against the weather.
- Khaya - This is a herder's sleeping shelter, which is typically constructed from corrugated iron. However, matjieshuise (reed mat houses), caravans and stone houses are also sometimes used.

Dogs are kept at stockposts to protect the herd against predators and to hunt rock hyrax and hares. Cats are used to keep rodents and snakes away, while chickens are kept for their eggs and meat.

2.7.3 Objectives of livestock farming in the Leliefontein Communal Rangeland

Owning livestock in the Leliefontein Communal Area ensures cultural identity, status and self-respect. Multiple benefits are derived from livestock in communal rangelands. Livestock products such as meat and milk are shared amongst the community; given as a contribution to a funeral or church auction; or as a wedding gift (Debeaudoin 2001). Livestock is seen as an investment that can generate cash in times of economic hardship (Debeaudoin 2001).

Livestock may be sold to the local inhabitants, visiting speculators or at the nearest auction, usually in Garies. Income generated from livestock sales may fluctuate annually in accordance with environmental conditions and disease. Livestock owning households on average receive a 34 % higher income than non-livestock owning households (Rohde *et al*. 2001). A higher income can be attributed to the sales of livestock and because livestock owning households have higher incomes from permanent jobs, self-employment and remittances than households without livestock (Rohde *et al*. 2001).

2.7.4 Infrastructure

Paulshoek has a community hall, primary school, a crèche and three guest houses. Inhabitants no longer use traditional matjieshuise as a form of shelter but live in brick or corrugated iron houses. There are no tar roads in and around the village.

Almost all of the homes have outside taps. Water for domestic use is supplied by a borehole located near the village. Due to the absence of ablution facilities, inhabitants have long-drop toilets. Electricity has been supplied to the village since June 2003. Some people have home telephones and there are also public phones located in the village. There is no reception for cell phones in Paulshoek. Refuse is removed weekly by the Kamiesberg Municipality.

There is no medical facility in Paulshoek but a mobile clinic run by two nurses visit the village every two weeks. A doctor comes on request for serious ailments or for emergencies; people go to the nearest doctor in Garies. Specialist care is provided by the Northern Cape Province in Springbok and in Kimberley, which is about 1 000 km from Paulshoek by road. People may also travel privately to public hospitals in the Western Cape. Some people still make use of medicinal plants or visit one of the three traditional herbalists in the village.

The only form of public transport in Paulshoek is a taxi service. A taxi can be hired to Garies or Cape Town directly from Paulshoek. People can also hire a private vehicle from one of the villagers to Garies.

2.8 Conclusion

The physical environment of Paulshoek is heterogeneous due to the high degree of spatial variability of climate, geology, soils, flora and disturbances. In order to survive, herders have to structure their lives in accordance with the temporal and spatial changes in their environment. The community of Paulshoek can be categorized as very poor, relying on remittances and pensions in order to live. Livestock farming is the main land use in Paulshoek. Livestock serves as a savings mechanism because of tradition and absence of other investments opportunities. Owning livestock also ensures status and cultural identity.

Many changes in the biophysical environment can be associated with different land use in the Paulshoek Commons. High grazing pressure has altered the biophysical environment of the Paulshoek grazing system by decreasing vegetation cover. Continuous grazing and ploughing of the lowlands has also resulted in a change in plant community composition from a perennial dominated plant community to a community dominated by annuals. These changes in the biophysical environment of the Paulshoek grazing system cannot be viewed as degradation either from an ecological or economic perspective. The problem that exists for livestock keepers in Paulshoek is not degraded land but a shortage of land.

Chapter Three

Local knowledge about arid ecosystem dynamics and livestock management during drought in a communal rangeland in Namaqualand

3.1 Introduction

The commercial model of rangeland management that was developed in the US during the early 1900's (Sayre & Fernandez-Gimenez 2003) drives most of the current agricultural policies in many parts of the world. This model is based on the equilibrium theory of vegetation change and assumes that the Clementsian successional concept can be applied across large and diverse pastoral systems (Sayre & Fernandez-Gimenez 2003). Only commercial farming practices are regarded as productive and communal farming practices are regarded as unproductive and often leading to land degradation (Hardin 1968). This is assumed to be because communal farmers lack the necessary knowledge and skills to manage their land sustainably. Interventions like fencing, destocking, and market orientated production have been implemented in communal areas because these interventions are regarded by policy makers as ways to restore plant diversity on the communal rangelands (Sayre & Fernandez-Gimenez 2003).

The commercial model of rangeland management has been widely challenged. Recently, studies have shown that climatic (e.g. Simons & Allsopp 2003) as well as social factors play an important role in vegetation dynamics in communal rangelands (Twine 2003). No study has clearly shown that land degradation has occurred in the Leliefontein Communal Area (Chapter Two). The 'tragedy of the commons' (Hardin 1968) has also been refuted in the Leliefontein Communal Area (Debeaudoin 2001). The Leliefontein Communal Area can be regarded as productive because livestock keepers meet their objectives, although these are not profit maximization (Debeaudoin 2001).

Interventions proposed on communal areas have also been disputed. In the Leliefontein Communal Area, the system of economic units failed to be implemented and formented social conflicts because it constrained the utilization of the rangeland by the poorest members of the community (Archer *et al*. 1989; Allsopp *et al*. 2003). Destocking would increase poverty on the rural areas because livestock keepers on communal areas regard livestock as their wealth. Further, destocking will erode the cultural identity and status of the community. Following a drought, restocking is not usually possible since the stock owners are unlikely to have money for their purchase.

It is now viewed that western paradigms of range management and livestock rearing cannot be applied to communal rangelands in Africa (Walters-Bayer *et al.* 2003). As a consequence of the failure to apply commercial models of range management to communal farms, scientists started to recognize the knowledge and creativity of communal livestock keepers which enabled them to manage their rangelands sustainably (Walters-Bayer *et al*. 2003). Scientists realized that technical knowledge is focused more on production outputs whereas local knowledge is aimed at several outputs. Many studies (Thapa *et al*. 1995; Sinclair *et al*. 2000; Sinclair & Joshi 2000; Waliszewski 2002) show that local agro-ecological knowledge can complement existing scientific knowledge and fill the gap in scientific understanding of agricultural practices (Davies 1999; Oba & Kotile 2001; Zurayk 2001). Ecological knowledge held by local farmers can be of high value as it represents centuries of farming experiences on how to manage limited resources under unfavourable environmental conditions (Bellon 1995).

Little information gained from land-based livelihood activities in communal rangelands has disseminated through to government policy and decision makers, planners and extension officers. Instead the information remains within the domain of scholars and NGO practitioners (Shackleton *et al*. 2000). As a consequence, rural development, land reform and agricultural policies and practices continually stay focused only on market orientated practices (Shackleton *et al*. 2000).

Ecological knowledge held by herders is a core factor in the implementation of their resource management strategies in the Leliefontein Communal Area (Debeaudoin 2001). The aim of this study is to determine local farmers' level of understanding of ecological processes in semi-arid ecosystems and to understand their livestock management decisions during drought conditions. This is to establish whether herders have the required agro-ecological knowledge to sustain their livestock during drought conditions. This study will try to answer the following questions:

- Are livestock keepers aware that changes occur in their natural environment? What causes these changes? Do they see change as a continuum or do they differentiate specific stages?
- Do livestock keepers know whether the numbers and distribution of a plant species are changing? What are the causes for such changes?
- What measures do livestock keepers take to conserve the environment when herding?

3.2 Materials and methods

Qualitative[5] local agro-ecological knowledge about arid ecosystem dynamics and livestock rearing was acquired by means of semi-structured interviews with 20 livestock keepers that were actively involved in livestock management. All the livestock keepers that were interviewed were males but of different ages. Livestock keepers were stratified into four strata consisting of five individuals each. Strata were based on ownership and their experiences in livestock management and not on age. The four strata used were lifelong herders, less-experienced herders, returning herders and livestock owners.

A lifelong herder is a full-time herder who has at least 35 years experience in livestock herding and has been involved in livestock rearing the whole of his adult life. Less-experienced herders are full-time herders younger than 40 years old with less than 5 years experience in livestock herding. A returning herder is a full-time herder who returned to herding after 1998 with an absence of at least 15

[5] Qualitative information include observational information and explanatory knowledge

years. During these years, the herder was employed in other industries excluding livestock farming outside the commons. However, prior to working outside the Leliefontein Communal Area these herders herded actively in the commons. A livestock owner helps in decision-making concerning herd management. He may also sometimes act as a stand-in herder for a day or two per week.

A checklist of questions (Appendix One) was designed and used to stimulate conversation during the comprehensive 30 – 45 minute sit-down interviews. The checklist contains questions that cover the knowledge of rainfall patterns, seasonality, droughts, climate change, plant-animal interactions, carrying capacity, overgrazing, land degradation and land rehabilitation. Interviews were allowed to deviate from the checklist in response to stakeholder interests with the aim of obtaining as much knowledge as possible. Certain informants were re-interviewed in order to clarify or resolve contradictory information. Interviews were conducted from June 2003 to October 2003. All interviews were conducted in the field or in the village in Afrikaans but notes were taken in English.

With the knowledge acquired, a knowledge database was created using the Agroecological Knowledge Toolkit (AKT5) software (Walker *et al.* 1994). The knowledge database contains only unambiguous unitary statements that are attached to their source or multiple sources, which permits for systematic analyses and easy interpretation of knowledge. The relationships between objects can be identified to create object hierarchies. Object hierarchies ensure a consistent use of terminology throughout the knowledge database. The AKT diagramming tool allows the user to view linkages between statements and provides a flexible means of synthesizing and representing complex information. The methodology involving the use of AKT5 in knowledge database construction is described in Sinclair & Walker (1998) and Walker & Sinclair (1998). The term local knowledge is used in preference to indigenous knowledge. Local knowledge is regarded as knowledge held by people in a specific locality (Sinclair & Joshi 2000) such as Paulshoek whereas indigenous knowledge is knowledge that is held by a specific culture (Sillitoe 1998) (e.g. the Nama) and therefore cannot be applied in this study.

3.3 Results

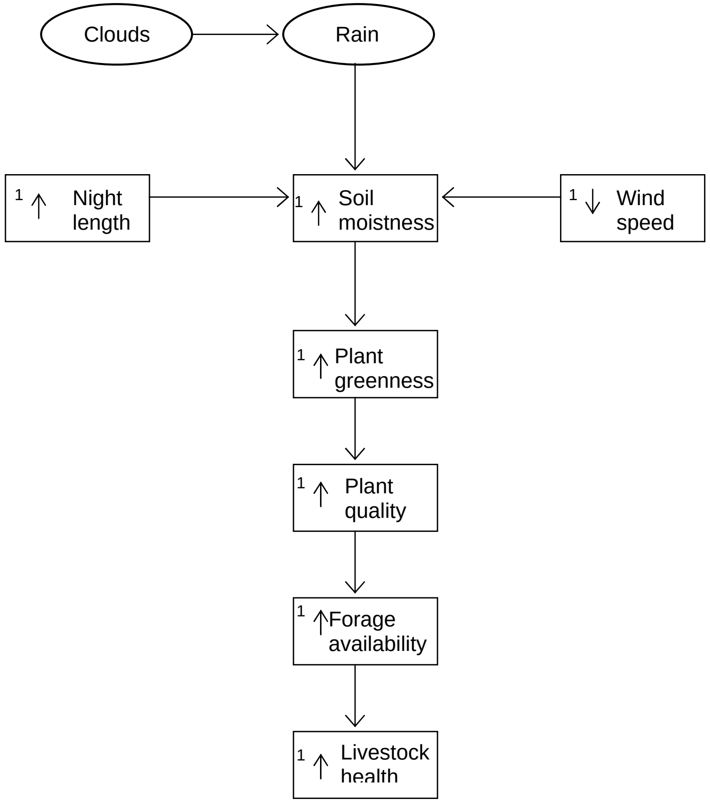
3.3.1 Perceptions on weather patterns

All respondents reported that the area receives both summer and winter rain. Winter rain is more frequent than summer rain. Whereas summer rain usually lasts a day, winter rain will last up to eight days. The old and more experienced herders say they have become aware of a definite shift in seasonality over the last 40 years. They mentioned that the rainy season use to run from June to August but now the rainy season sometimes only starts in August through to October. This might be the reason why all the respondents could not put a definite timeframe to a specific season. Some of the informants mentioned that winter starts in June, others said in July and August, while other respondents mentioned that seasonality in Paulshoek does not exists anymore. They mentioned that it can rain anytime of the year in Paulshoek. Therefore, no single time period could be given to when the flowering season is in Paulshoek. All livestock owners, experienced herders and returning herders say that they have observed a decrease in rainfall since the 1970's but no one could provide reasons for this decrease.

The possibility of rain is often associated with wind direction. However, herders do not have the same opinion on a specific wind direction that brings a specific type of rain. Some respondents associated the northerly wind with heavy rains whereas other informants mentioned that the southerly wind is associated with heavy rains. Rainfall distribution in Paulshoek is regarded by livestock keepers to be heterogeneous. Herders perceive that the higher lying northwestern area receives more rain than the rest of the rangeland. Hail and snow are said to occur during winter but are rare.

All the respondents interviewed have the opinion that rainfall is the most important factor that determines the condition of the rangeland. Rainwater infiltrates the soil and keeps the soil moist. Plants can take up water in the soil through their roots and grow. Greener plants are regarded as having high forage quality because they contain more plant sap in their leaves than dry plants (Fig 3.1).

Drought is regarded as unpredictable by respondents. It is seen as a large reduction or complete absence of winter rain for one or more years. The lack of forage during drought (Fig 3.2) makes animals more susceptible to diseases and pests (Waliszewski *et al*. submitted).



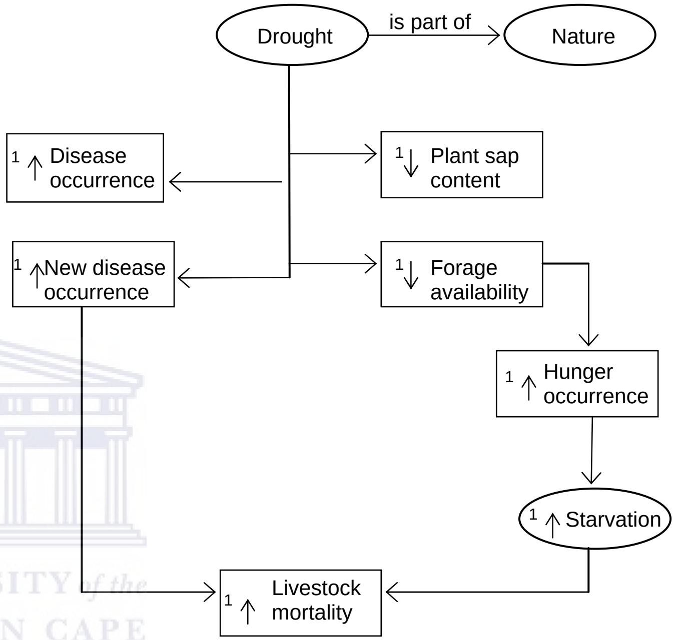


Figure 3.1: Causal diagram showing the effects of climatic conditions vegetation condition as described by livestock keepers in Paulshoek.

Figure 3.2: Causal diagram showing the effects of climatic on conditions on animal health as described by livestock keepers in Paulshoek.

Legend: Rounded boxes represent object nodes whereas attribute nodes are represented by square boxes. Nodes are linked together by arrows where the direction of the arrow indicates the direction of the causal influence. Small, upward (↑) or downward (↓) facing arrows on the links indicate an increase or decrease in the causal or effect nodes. Whether the causal effect is one-way (1) or two-way (2) is indicated by the number next to which the arrows lie (Waliszewski 2002).

Frost is said to appear only in winter at irregular intervals. Two types of frost were recognized by all namely: black frost that is invisible because it occurs beneath the soil surface, and white frost, which forms ice crystals on the soil surface. Black frost is perceived by herders to cause livestock hooves to split. When any frost conditions prevail, herders also claim animals cannot smell palatable plants and the animals will eat any green plant even if it is toxic. Therefore, when frost occurs, herders will only let their animals out of the kraal after the frost has melted.

3.3.2 Perceptions on soil processes

Three soils types namely: sandy, clayey and mountain soils were recognized by all the groups. Less-experienced herders could not give characteristics of the different soil types. The other three groups were able to describe soils types based on soil texture, hardness, water retention capabilities and fertility. Mountain soil is regarded as hard soil and the surface soils of mountains are shallower than sandy soil. Mountain soils are regarded as less fertile than sandy soils. This may be because of greater runoff on hard soils. Clayey soils have slower infiltration rates than sandy soils.

The processes of wind and water erosion were also identified by all groups except the less-experienced herders. Respondents regarded erosion as a process that can be caused by livestock trampling as well as a natural process. Herders say that trampling by livestock loosens the soil which is then washed away when it rains or is blown away by the wind. When the soil is blown away from an area it is redeposited in another area, which may be in areas adjacent to the Paulshoek Commons. When the soil is washed away by water, the soil is forever lost by the rangeland because it is transported by the rivers and redeposited into the ocean.

Some informants mentioned that the loose soil gets blown away by the wind and does not wash away by the rain. This may be because it seldom rains in Paulshoek. All the respondents that knew about erosion mentioned that erosion cannot occur in Paulshoek if the area has not been trampled by livestock. This may be because the soil is covered by vegetation. Herders alternate their daily grazing routes to avoid trampling (Chapter Five). Herders mentioned that they cannot prevent trampling around water points because the animals have to drink water.

As a result of erosion, herders say that the ground becomes hard. Eroded soils absorb less water and therefore hold less water than soils that have not been eroded. Seedling establishment is not possible on eroded soils. According to the lifelong herders and owners, it will take more than 100 years for the topsoil to come back if livestock are removed from the rangeland. Returning and less-experienced herders mentioned that it is impossible for the topsoil to come back because the soils have been lost forever. Respondents could not quantify how much soil in Paulshoek has been eroded away, but regard the amount of eroded soil as insignificant. Three lifelong herders practice soil conservation while the other groups do not (text box 3.1).

Text box 3.1

"Wanneer ek sien die grond is besig om weg the spoel, dan plaas ek sommer takke in die gleufies wat die vee maak as hulle so op dieselfde spoor loop. Dit is sodat die grond nie kan weg spoel nie en dan kan die saadjies wat tussen die sand voorkom ook vir hulle bevestig and ontkiem. Op hierdie manier help ek die veld om the herstel."

- Lifelong herder

"When I see the soil is washing away, I put branches in the paths made by the livestock. This is to stop the soil eroding away. The seeds in the soil establish themselves and germinate. In this way, I help the rangeland to recover."

3.3.3 Vegetation

Plant species in the rangeland are identified by all respondents through leaf morphology, leaf colour, flower morphology, flower colour, growth form, scent, and palatability. For example, *Salvia dentata* Ait. (bergsalie) was identified by some herders through its leaf morphology and scent of leaves whereas *Lebeckia multiflora* (fluitjiebos) was identified through its leaf colour, flower colour and growth form. Plant species are known by all livestock keepers to have different growth rates, life cycles and nutrient quality. Respondents regarded G. *africana* as having the fastest growth rate of all the plants in Paulshoek and its nutrient quality is very low especially during drought whereas the nutrient quality of *Viscum capense* L.f. (voëlentbos) is regarded as very high. They also understand that different plant species can be used for different medical and food purposes for humans. Some herders boil the leaves of *Salvia dentata* and *Rhus undulata* (taaibos) and drink the liquid to treat influenza and colds. Herders eat the fruits of *Carpobrotus edulis* (L.) L. Bolus (vygie) and some women in Paulshoek village make jam from these fruits.

Respondents know where specific plant species are most abundant. The spatiotemporal distribution of these plants is attributed by the experienced herders and livestock owners to micro-climatic variability, soil type, seed dispersal and grazing intensity. G. *africana* is recognized by all to replace other perennial shrubs when an area becomes overgrazed. Even though perennial species have declined in overgrazed areas, there was no confirmation about any plant species extinction. Some herders use their knowledge on the spatiotemporal distribution of plants to decide on a grazing route. For example, when a herder is ill, he may herd in the direction to where he has to pick medicinal plants for himself in the field.

Two major vegetation types namely sweetveld and sourveld were recognized by all respondents. Livestock keepers regard the vegetation of the higher slopes of the Kamiesberg Mountain as sourveld, which is dominated by *Dicerothamnus rhinocerotis* (renosterbos). Sourveld has taller shrubs than sweetveld. The leaves of bushes in sweetveld are regarded as containing more salt and have more succulent representatives. When livestock graze sourveld, herders say that they should be given a supplementary salt lick or molasses. The vegetation of Paulshoek is regarded as sweetveld and can survive with little annual rain.

However, no one could provide a minimum annual rainfall requirement for sweetveld to survive.

Only the experienced herders said that seeds from annuals that appear during spring need a specific soil temperature, air temperature, day length or rainfall to germinate. The experienced herders also mentioned that winter appearing seedlings need cold temperatures or certain amount of moisture to germinate. Other herders and owners could not say why annuals appear only in spring. Annuals and grasses are said by the experienced herders and owners to occur only in sandy soils. Ephemeral abundance is regarded by all as greater on the flats than the mountains especially after a long winter rainfall event. Old and fallow croplands that occur on the flats are perceived by herders as not having sufficient forage during drought and the dry summer period and herders will avoid these areas during the daily grazing period.

Mountains are regarded as containing greater plant diversity during drought than the flatlands. Respondents consider that livestock will be healthier if they eat a diversity of plants, since different plants will provide different nutrients. Therefore, all the herders take their herds to the higher lying areas during drought to ensure that the animals have good quality food to eat.

The two most common shrubs recognized by respondents in Paulshoek (text box 3.2) were:

Text box 3.2

Ruschia robusta L.Bol. (t'nouroebos)

The palatability of R. *robusta* is regarded as high and when available, livestock will prefer to eat this plant especially after a rainy period because the leaves will be more succulent. It has a brackish taste and is regarded as being more abundant than kraalbos about 20 years ago.

Galenia africana L. (kraalbos)

G. *africana* is regarded as the most abundant shrub at present. It is yellow in colour in summer and green in winter. The palatability is low, and causes dropsy in livestock if eaten to excess when yellow. Kraalbos has a high probability of invading an area if the area is overgrazed. G. *africana* is believed to be introduced by livestock through faeces from other areas when a farmer buys new livestock. Livestock keepers regard kraalbos as a reseeder that has a fast growth rate, greater than most of the plants in the rangeland. Respondents regard a rangeland as being good if the plant diversity is high and kraalbos is an insignificant element.

3.3.4 Perceptions on plant-animal interactions

Even though rainfall is regarded as the main determinant of rangeland condition, livestock grazing can determine rangeland condition. The browsing of the shoots of plants ensures that plants do not get overgrown. Informants regarded the condition of the rangeland as good when plants are not overgrown. When a plant is not overgrown, it will grow faster.

Livestock are regarded by livestock keepers as important seed dispersal agents. Seeds are dispersed when they stick to animals or when animals eat the fruit and pass the seed through their faeces. Herders say that seed dispersal is uneven and this causes vegetation heterogeneity. Livestock also bury seeds through trampling. Livestock keepers are also aware that seeds can be dispersed by wind.

The reason why livestock do not eat toxic plants is because livestock keepers believe that livestock first smell the plants before they eat them, except during frost. The experienced herders and owners say that each plant has got its own unique scent and livestock will smell if it is palatable. Livestock will eat more toxic plants during drought because many toxic plants like *Tylecodon wallichii* (Harv.) and *Castalis tragus* (Ait.) Norl. are evergreen or they eat these in plant litter.

Donkeys are considered by all herders to be destructive because they often uproot plants when they graze. They also damage plants with their hooves or through rolling. Donkeys graze night and day. One less experienced herder draws on donkeys to indicate the presence of good quality veld (text box 3.3).

Text box 3.3

Waar daar donkies is, is daar altyd groen veld. Ek vat altyd my trop na daardie area toe die volgende dag as die donkies weg is. Ek sal hulle nie daarna toe vat terwyl die donkies daar is nie want die donkies sal die vee aanval en hulle dood maak. - Less experienced herder

"Where donkeys are there is always green veld. I always take my herd to that area the following day when the donkeys are gone. I will not take them there while the donkeys are there because they can attack and kill the livestock"

3.3.5 Perceptions on herd management

A good herder is said by all respondents to have sound agro-ecological knowledge of his rangeland and apply his knowledge to manage livestock appropriately. The main priority of a good herder is always to ensure the well being of all the livestock (text box 3.4). This is achieved when the herder guarantee the safety, comfort and good health of animals (Fig 3.3).

In order to guarantee the safety of livestock, a good herder needs to know the behaviour of predators and know which plants are toxic to livestock. September is regarded as the breeding seasons of jackals. When jackals are still in the process of feeding their young, it is anticipated that there would be an increase in livestock predation. A jackal will kill more than one animal. Herders are able to track the spoor of jackals and use their dogs to hunt them down.

Text box 3.4

"Vandag vat ek die trop na die oop vlaktes toe want sommige ooie is swanger en met die tekort aan minerale in die plante, het hulle nie genoeg energie om te klim nie. Ek kan nie swak and swanger diere agter los nie want die jakkalse sal hulle vang. 'n Goeie veewagter kyk na al sy diere."

- Lifelong herder

"I am taking the herd to the open flats today because, some ewes are pregnant and with the lack of minerals in the plants, they don't have enough energy to climb. I cannot leave the weak and pregnant animals behind because the jackals will catch them. A good herder looks after all his animals."

It is believed that the comfort of livestock is achieved when a herder does not chase the livestock during the grazing period. Ewes should also be assisted during birth. Due to poor nutrition during drought, animals are too weak to be chased. Herders should keep the animals in the shade and feed them. I observed that herders feed livestock *Viscum capense* in the rangeland or supplementary feed at the stockpost. Herders must ensure that pregnant goats and sheep are as comfortable as possible when their birth date approaches.

Newborn goat kids are carried to the stockpost by a herder, as they are too weak to walk. Kids go with their mothers in the rangeland one or two days after birth to ensure that they bond with their mothers. After the two days the kids are kept at the kraal and are fed daily for about six months. Sheep lambs can graze with the herd straightaway after birth.

To ensure good health of livestock, herders treat their weak animals if possible with their own unique remedies (Waliszewski *et al*. submitted).

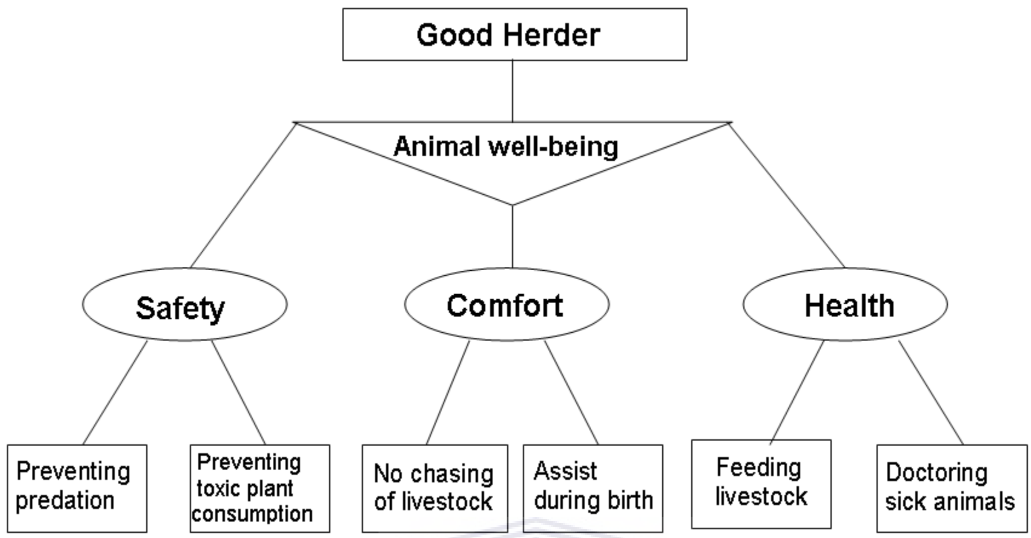


Figure 3.3: Duties performed by a herder who is perceived as good by other livestock keepers.

3.4 Discussion

Livestock keepers are aware of changes that occur within their environment. They perceive that change in rainfall patterns has occurred over their herding years. Livestock owners mentioned that rainfall has decreased since 1970. However, Hahn *et al*. (2005) show that there is no significant downward trend in rainfall patterns since 1970. Rainfall patterns are irregular with periods of high rainfall and low rainfall periods. I would deduce that the reason the experienced herders mentioned that rainfall has decreased since 1970 is because they experienced two droughts in the last six years.

Livestock keepers also perceived changes to have occurred in the vegetation composition of the rangeland. Although aerial photos suggest that land has not changed much since the 1960's (Hoffman et al. 2000), several studies have reported changes in vegetation due to continuous grazing but no time period could be given when these changes occurred. Todd & Hoffman (1998; 1999) show a decrease in perennial shrubs and an increase in annuals, geophytes and G. *africana* in the flatlands. Riginos & Hoffman (2003) observed the same changes in vegetation composition but around the stockposts in the rangeland. Maasai pastoralists in Tanzania also recognize changes in vegetation composition of their rangeland and similarly to the livestock keepers in Paulshoek, they could not confirm any plant species extinctions over their herding years (Mapinduzi *et al*. 2003).

The view that the Paulshoek rangeland is driven by rainfall is in accord with the findings of other studies (e.g. Fernandez-Gimenez 2000; Debeaudoin 2001) where the herders mentioned that their rangeland is driven by rainfall. This view is also in agreement with the non-equilibrium model of grazing systems (Ellis & Swift 1988). Livestock keepers mentioned that rainfall in Paulshoek is spatially and temporary uneven. The higher lying northwestern area receives more rain than the rest of the commons. This statement is confirmed by rainfall data (MT Hoffman unpublished data).

No respondents perceived change in the faunal diversity and composition of Paulshoek due to livestock farming. Changes in faunal diversity and composition have been documented in Joubert & Ryan (1999); Seymour & Dean (1999) and Hoffman *et al.* (2003). The reason why livestock keepers did not mention a change in animal diversity and composition may be because they regard other animals apart from livestock as unimportant to ecosystem processes.

The nature of agro-ecological knowledge amongst the four groups does not differ. It is rather the depth of knowledge that differs across the various groups. Lifelong herders have more in-depth knowledge of ecosystem processes which they acquired through herding experience. The younger, less–experienced herders have the least knowledge of rangeland dynamics but they are still learning through herding and through guidance from the experienced herders. Age has been correlated with the degree of knowledge of livestock keepers in other parts of Namaqualand (Hendricks 2004).

Communal farmers in Mongolia have been shown to have developed a system to manage their livestock in variable environments (Fernandez-Gimenez 2000). In the Leliefontein Communal Area, herders use their knowledge to assist livestock in finding the best pasture areas (Debeaudoin 2001). Livestock keepers do not regard the rangeland as overstocked. The inadequate amount of water points in the northern parts of the Paulshoek Commons (Chapter Six) and lack of transport to the new farms (Chapter Five) during drought constrain the use of their agro-ecological knowledge in managing their livestock and rangeland effectively. Herders were restricted and could not use more grazing routes to avoid veld trampling. Herders perceive that veld trampling could be avoided if you alternate your grazing routes regularly. Socioeconomic conditions such as the lack of transportation also constrain Mongolian pastoralists to use their ecological knowledge effectively in managing the rangeland (Fernandez-Giminez 2000). Failure to effectively apply ecological knowledge in rangeland management has been shown to cause overgrazing (Niamir-Fuller 1998) but in Paulshoek it is the lack of grazing land and broken water points rather than ignorance to apply local knowledge that causes overgrazing in certain parts of the rangeland.

This study shows that livestock keepers have developed in-depth knowledge of the dynamics of the Paulshoek system. They use their knowledge when they decide on a daily grazing route for the herd. Their knowledge may not necessarily be accurate but it is how they perceive things to be because of their experiences. Socioeconomic factors constrain the use of agro-ecological knowledge by livestock keepers and force them to graze the same pastures continuously and other areas very rarely.

Chapter Four

Assessing perceptions of the conditions of the communal rangelands in Namaqualand during a drought using cognitive maps prepared by herders

4.1 Introduction

In the communal areas of Namaqualand livestock rearing is the most common land use (Rohde *et al*. 2001). Due to the spatial and temporal variability of vegetation in arid environments, rangelands are selectively used by livestock. The choice of which areas to use is influenced by the herder and how he manages his herd. This requires herders to have developed an understanding of spatial phenomena so as to ensure the wellbeing of their stock. By investigating this spatial knowledge that herders have, we can identify key resource areas.

Perceptions of natural resources are usually investigated by qualitative and quantitative methods. Qualitative methods include open ended interviews (Sinclair *et al*. 2000; Zurayk *et al*. 2001; Tsegaye *et al*. 2003); participant observation (Fernandez-Gimenez 2000), and focus groups (Rowntree *et al*. 2001) in which individuals and small selected groups provide researchers with detailed accounts of their specific interests and perceptions. Rowntree *et al*. (2001) used this method to create awareness of landscape processes that cause land degradation, and to locate and map areas of environmental concern for the better management of the Kat River Valley Catchment in the Eastern Cape Province.

Other research on local community preferences within the landscape for resource management use quantitative methods that include ranking of photographs of landscapes (Ambrose-Oji *et al*. 2002) or structured questionnaires (Bandeira *et al*. 2003). Limitations in these methods exist, with questionnaires being easily applied but the descriptions of the landscape are imprecise since the same word can have different meanings to different people. Use of photographs to assess landscape features can incur bias since a degree of orientation by the researcher usually occurs and images are rarely completely up to date.

In order to understand the spatial patterns of when, how, and why people use their rangeland in a specific spatial manner, cognitive maps were used (Gärling et *al*. 1984). Spatial behaviour of people is based on perceptions on how they interpret their local environment, whether this is accurate or biased. In constructing spatial information people generate cognitive maps. Cognitive mapping essentially collects, stores, and interprets information on the everyday spatial environment (Downs & Stea 1973). By relating cognitive maps to measured reality, biases can be interpreted. Spatial objects that have larger representation or are shown closer than they occur in reality have cognitively been identified of especially importance. Similarly, objects that are shown as smaller as or further away than in reality hold less importance.

It is important to understand the herder's perception of the rangeland because it may provide us with information on why they only use certain parts of the rangeland. Cognitive maps were used to identify key resources by the herders in the Paulshoek communal rangelands. In undertaking spatial mapping I hoped to also identify whether there were critical spatial phenomena that both enhanced or depreciated the value of particular areas. Cognitive maps are also useful in assessing whether conflicts exist and the possible degrees of cooperation that may exist between the herders. In understanding how herders perceived their environment under adverse climatic conditions such as the drought period when this study was undertaken, we can assess which habitats are under greatest stress from livestock grazing. In getting herders to express themselves in cognitive maps it is also possible that further information may become available that was not necessarily conveyed in semi-structured interviews.

Cognitive maps have been used to determine how people in urban areas navigate in their surroundings (Gärling *et al*. 1984; Appleyard 1970). In rural areas, cognitive maps have been used in the management of natural resources and for conservation planning (Lucas 1965) but they have not been used as widely as they could.

Through cognitive mapping with herders in Paulshoek, this study will try to answer the following questions:

- What criteria do herders use when assessing the condition of the rangeland?
- Do herders identify similar landscape features that are of value and are hazardous?
- By integrating cognitive maps, can key resource areas be identified?
- Through cognitive maps, can disputed grazing areas be identified?

4.2 Materials and methods

Cognitive maps were prepared on A1 (813 x 584 mm) white sheets with felt tipped pens by the herder, or dictated by the herder and drawn by myself since some herders did not feel confident about drawing with pens. Different colours and labels were used to identify features. Herders were asked to provide estimates of distances so as to calibrate these maps.

Of the 24 herders that I studied at Paulshoek, 12 were interviewed for this exercise. Those excluded from interviews were (a) unavailable (n=2); (b) intimidated by the process (n=5); or (c) felt it was unnecessary (n=5) because the condition of the entire Paulshoek Commons was perceived be them as poor.

The cognitive maps were digitized using an electronic white board and Mimio™ Digital Meeting Assistant software and saved in JPEG format. Cognitive maps were then imported into the MapInfo Professional™ GIS software. These maps were registered as non-earth projections and were not georeferenced since proportional distances and spatial corrections were required rather than absolute georeferencing. Each map feature was re-digitized from the image into spatial objects that could be compared relatively. All areas covered by a feature on each map were calculated with the MapInfo area measurement and converted to percentage area coverage.

A matrix (Appendix Three) was constructed using the various features represented on the cognitive maps. The relative representations of features identified by each herder were analyzed using a cluster program, Plymouth Routines in Multivariate Ecological Research (PRIMER) Version 5.0 (Clarke & Warwick 2001). A cluster analysis represented by a dendrogram using a Bray-Curtis measurement of similarity was used to identify if there were relationships between herding experience and perceived rangeland conditions.

The cognitive map (Fig 4.1b) was selected for further analysis because this map shows how the herder perceives his grazing areas in relation to his fenced and unfenced boundaries. Cognitive maps 4.2b & c were selected for further analysis because these two maps represent the same grazing area but drawn by two herders of different levels of herding experience. Comparisons could therefore be made to illustrate the differences in landscape perception amongst herders of different levels of herding experience.

4.3 Results

Grazing areas are distinguished from one another in terms of forage quality, which herders describe as the amount of palatable plant species available in an area. The forage quality of an area is rated as good, average or poor. A grazing area can have high number of palatable plants but can still be regarded as poor for livestock to graze due to the high number of toxic plants.

Herders identified mountains, croplands between the mountains, flatlands, areas with high toxic plant abundance, stockposts and water points on their cognitive maps. Herders identified two types of mountains in the Paulshoek Commons, the

Kamiesberg Mountain and other mountainous areas (Table 4.1). The vegetation of the Kamiesberg Mountain was classified by the herders as sourveld and the vegetation of the other mountainous areas was classified as sweetveld. The vegetation of the Kamiesberg Mountain is identified as Namaqualand Granite Renosterveld and the vegetation of the other mountainous areas in Paulshoek is identified as Namaqualand Klipkoppe Shrubland and Namaqualand Blomveld (Musina & Rutherford 2004).

Sourveld on the Kamiesberg Mountain has been identified by the herders as unpalatable for livestock all year around whereas sweetveld is regarded as palatable for livestock. The key forage plants identified by the herders for livestock during the drought are listed in Appendix Two.

Croplands are regarded by herders as having poor forage quality during drought because of the dominance of unpalatable G. *africana*. The forage quality on the flatter areas of the commons is regarded as of average value. This is because G. *africana* is found in conjunction with other palatable shrubs like *Rhus undulata* that often contain the mistletoe, *Viscum capense*. Mistletoe is regarded by the herders as the most preferred plant by goats. Other palatable shrubs identified by the herders on the flats are *Lycium ferocissimum* Miers (kirriedoring), *Didelta spinosa* (L.f.) Aiton (perdebos) and *Ruschia robusta* (t'nouroebos), and a suite of species all commonly known as xhibbiebos, which include *Eriocephalus ericoides* (L.f.) Druce , *Hirpicium alienatum* (Thunb.) Druce and *Selago* sp. L. *Galenia* *africana* is not regarded as toxic if it is ingested with plants of higher forage quality.

Herders classified areas as toxic if there is an abundance of *Tylecodon wallichii* (krimpsiektebos), *Castalis tragus* (jakkalbos), *Moraea* sp. (tulp), *Euphorbia mauritanica* (gifmelkbos) and G. *africana* (kraalbos). These plants cause a variety of illnesses in livestock.

Areas with good forage quality can be regarded as most important to herders. This is because good forage quality areas represent most of the grazing areas represented on the cognitive maps (Table 4.1) and were more accurately described (Appendix Three) when the features on the cognitive maps were compared to the same features on the topographical maps. Mountains, inselbergs and the other areas with good forage quality comprised 47 % of the total grazing areas on the cognitive maps. Water points and stockposts were also prominently represented on the cognitive maps. Areas of less importance to herders include the fallow croplands that represent 25 % of the total grazing areas, the flats represent 13 % and areas with high toxic plant abundance represent only 4 % of the total grazing areas (Table 4.1).

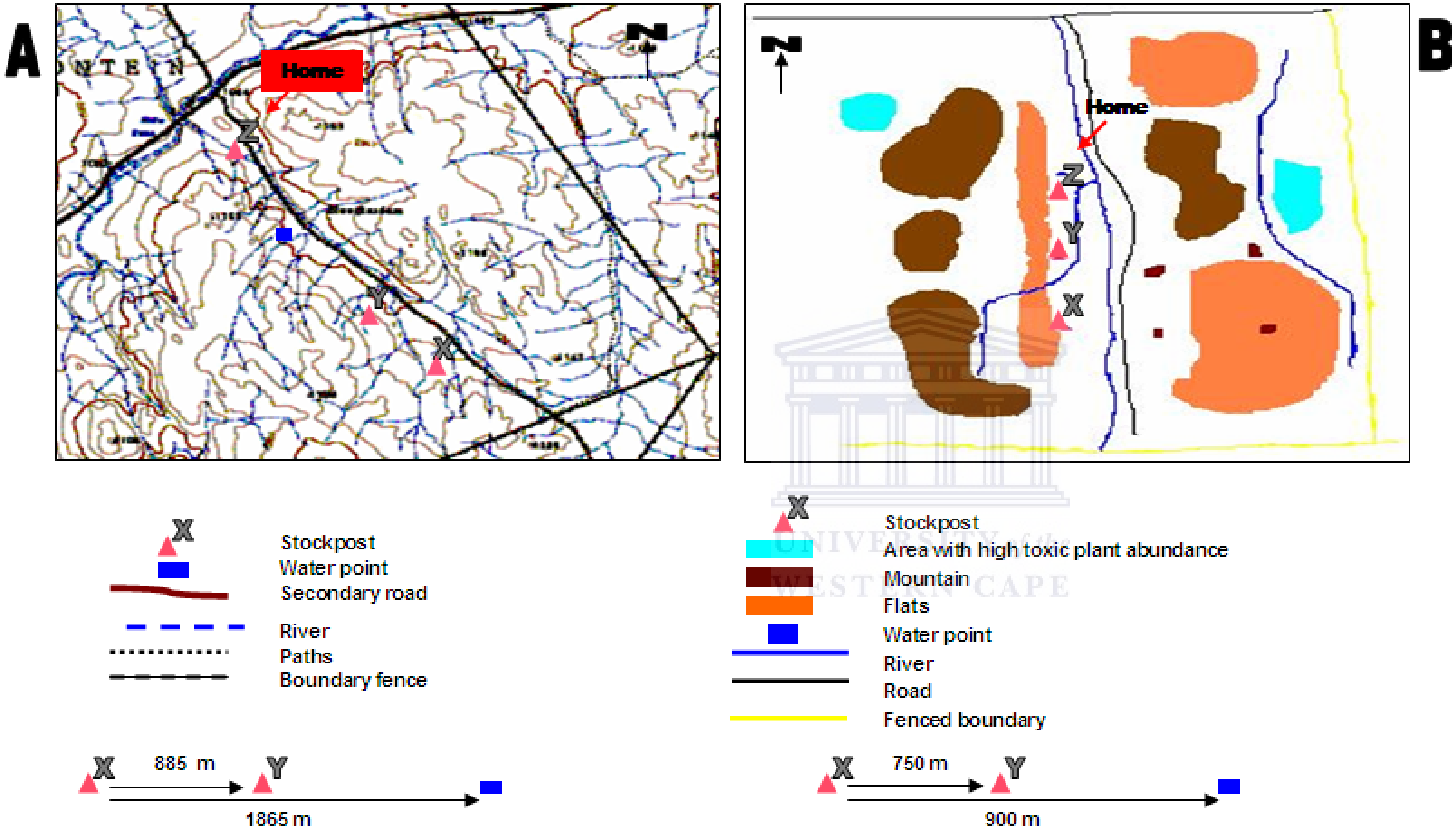


Figure 4.1: Topographical map of Slooitjiesdam (A) with a cognitive representation of Slooitjiesdam (B) which was generated by a lifelong herder. The cognitive map has been scaled to fit the topographical map.

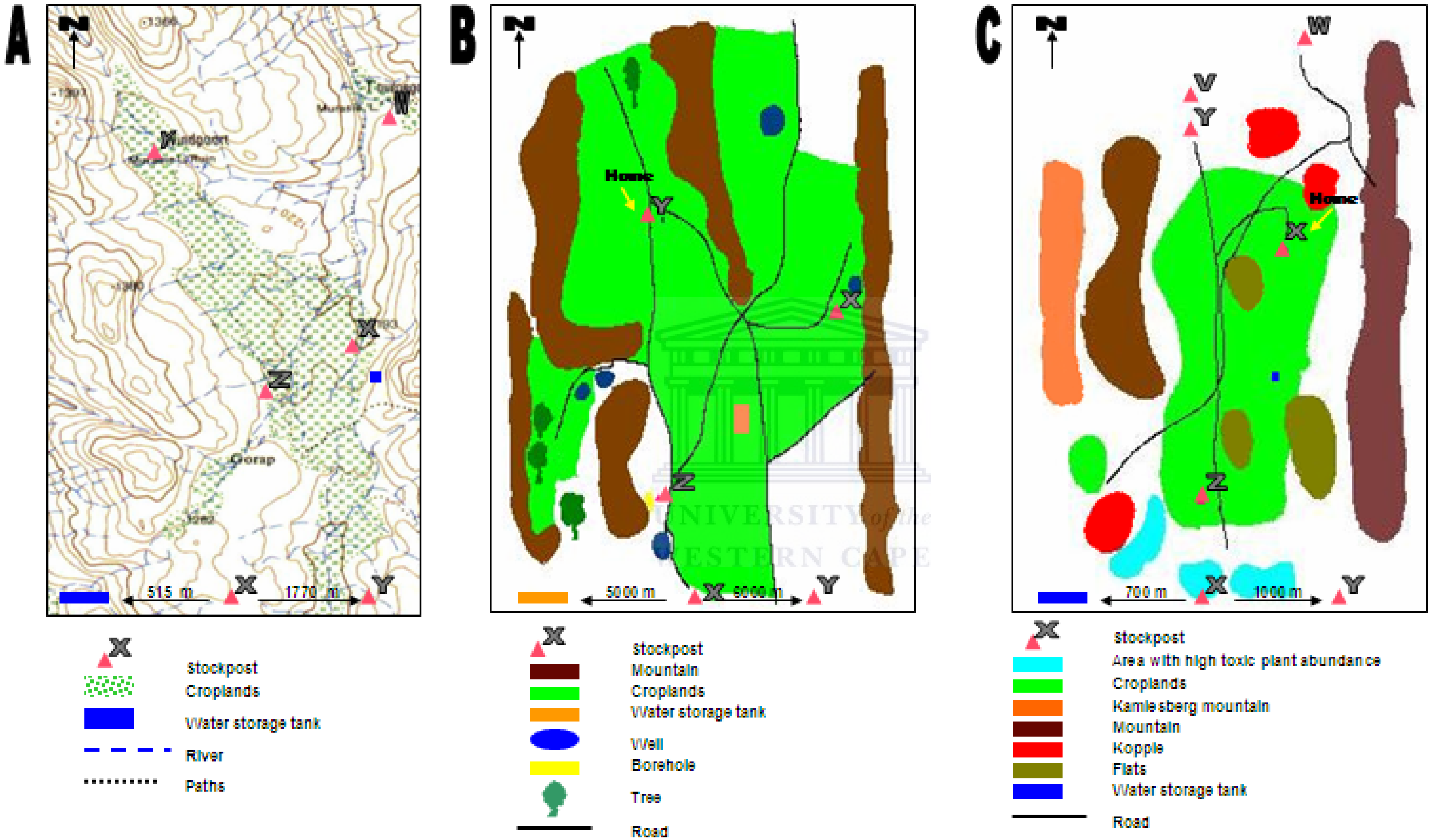


Figure 4.2: Topographical map of Gorap (A) with cognitive representations of Gorap generated by a less-experienced herder (B) and a lifelong herder (C). The cognitive maps have been scaled to fit the topographical map.

Table 4.1: Percentage cover of various features illustrated on the cognitive maps that were drawn by the 12 herders. A "/" indicates that the feature is not represented on the map. The water points indicated by the herders do not include the piospheres. Herding experience was assessed on the same criteria as described in Chapter Three. Herder 11 drew two cognitive maps of the two different grazing areas he used during the drought period.

Herd number	**1**	**22**	**10**	**20**	**11a**	**11b**	**23**	**12**	**16**	**14**	**17**	**5**	**3**
Herding experience	Inexperienced	Experienced	Inexperienced	Returning	Returning	Returning	Returning	Inexperienced	Experienced	Experienced	Experienced	Returning	Experienced
Area	Windpoort	Gorap	Aandblom	Klein-fontein	Boggel D	Klein Paulshoek	Kuile	Boggel	Gooikloof	T'roegworas	Mak se klip	Slooitjies-dam	Slooitjies-dam
Stockposts	< 1	< 1	/	< 1	< 1	< 1	< 1	< 1	/	< 1	2	< 1	< 1
Water points	2	< 1	< 1	< 1	1	< 1	< 1	< 1	/	< 1	< 1	< 1	< 1
Mountains	52	32	17	56	71	17	11	37	53	49	22	39	43
Koppies	/	5	/	2	4	/	/	5	< 1	/	/	/	< 1
Kamiesberg	/	8	/	/	/	/	/	/	/	/	/	/	/
Rocky ledges	/	/	/	4	/	/	/	/	/	/	/	/	/
Good forage quality areas	/	/	55	/	/	/	/	/	9	/	43	/	/
Flats	/	6	/	20	/	31	/	24	/	/	/	43	49
Croplands	46	43	19	9	19	/	55	26	29	50	29	/	/
Toxic areas	/	5	2	4	/	4	/	/	9	/	3	17	7
Trees	< 1	/	/	/	/	/	/	/	/	/	/	/	/
Village	/	/	/	6	/	44	/	8	/	/	/	/	/
Reservoir	/	/	/	/	/	4	< 1	/	/	/	/	/	/
Ram camp	/	/	/	/	/	/	17	/	/	/	/	/	/
Dirk's camp	/	/	/	/	/	/	16	/	/	/	/	/	/
Animal exclosure	/	/	7	/	/	/	/	/	/	/	/	/	/
Houses	/	/	< 1	/	< 1	/	/	/	/	/	/	/	/
Threshing floor	/	/	/	/	4	/	/	/	/	/	/	/	/

Forage quality under drought conditions				
Good	Average	Poor	Toxic	No forage available

Herders are well aware of the location of all the stockposts, water points, roads and rivers in their grazing area (Figs 4.1 & 4.2). They can easily distinguish between forage types which they may indicate as discrete (Figs 4.1b & 4.2c) or continuous (Fig 4.2b) features. Herders are also aware of informal grazing "boundaries". Herders set themselves informal boundaries so that they can allow other herds to have sufficient space to graze. Herders could not provide accurate distance estimates between features in their environment. The lifelong delegatory leader (Fig 4.1) underestimated the distance between water points and stockposts in his grazing area whereas the less-experienced delegatory leader (Fig 4.2b) overestimated the distances. The lifelong delegatory leader in Fig (4.2c) over- and underestimated the spatial distances between the features in his environment.

There is 60-80 % similarity between the spatial depictions of the Paulshoek rangeland by herders (Fig 4.3). These similarities in perceptions of grazing areas during the drought are not attributed to herding experience since perceptions differ amongst herders with the same herding experience. The similarities in perceptions also cannot be ascribed to the age of herders, herd size; herding strategy (Fig 5.2) or whether herders occupied the same grazing area. For example, it was expected that the perceptions of herders 1, 14 and 23 be the closest related because they occupied grazing areas adjacent to each other but only the perceptions of rangeland condition of herders 1 and 23 are closely related (Fig 4.3). The perceptions of herders 14 are more closely related to herder 12 who occupied a different grazing area.

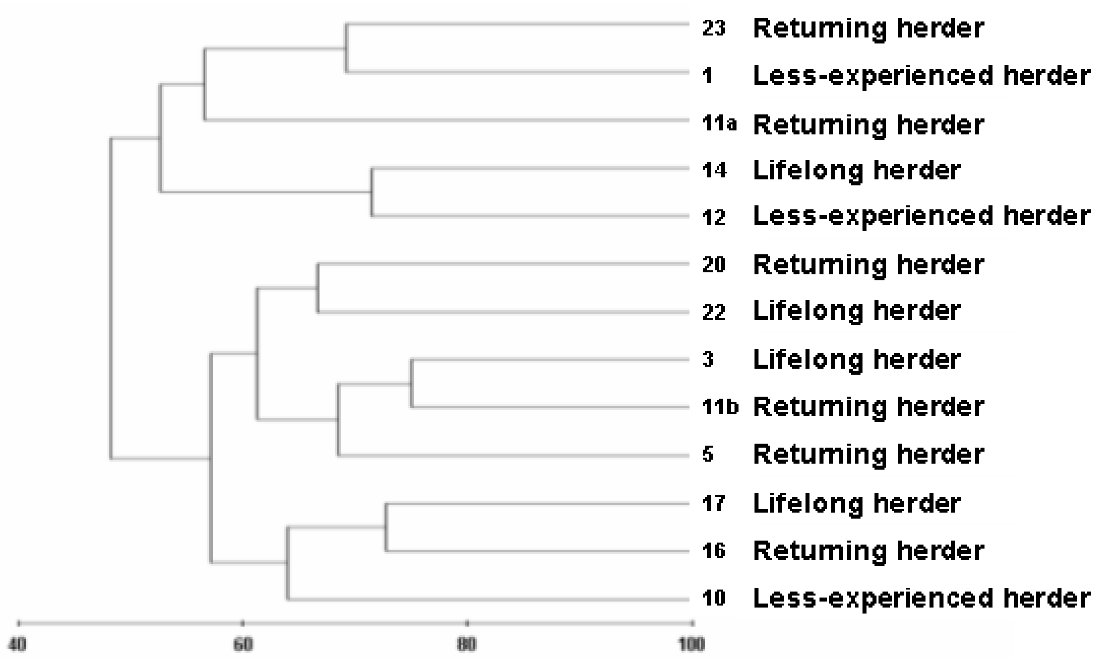


Figure 4.3: Similarities in the perceptions of herders on landscape features during a drought period in Paulshoek.

4.4 Discussion

The cognitive maps reveal that herders in Paulshoek recognized different types of forage. Other communal farmers in the Leliefontein Communal Area (Debeaudoin 2001) and Southern Ethiopia (Oba & Kotile 2001) also recognize different forage types in their rangeland but at different spatial scales. On a landscape scale the location of seasonal forage determines the direction of transhumance (Oba & Kotile 2001). On a patch scale the location of good quality forage areas such as the croplands after a good rainfall event, may determine the direction of the daily grazing route (Debeaudoin 2001). In Paulshoek, the location of perceived good quality forage areas such as the mountains during drought conditions often determines the direction of the daily grazing route.

Herders perceive the mountains and water points as key resource areas for herds during the drought. These key resource areas were well represented on the cognitive maps. Herders valued these key resource areas more than the surrounding lowlands. This is because herders perceived the mountains to contain the highest plant diversity during the drought and G. *africana* is virtually absent from these areas. The perceptions of the herders correlate with other observations made by Cowling *et al*. (1999) and Hendricks (2004) that mountainous areas in the Succulent Karoo biome contain high plant species diversity. Murray (1986) also found that farmers perceive land as more attractive if the quality of the farming land is good.

Areas underestimated on the cognitive maps of the herders such as areas with an abundance of high toxic plants are avoided by herders since livestock will attempt to eat any green plant during drought periods (Chapter Three). Most of the plants which remain green during drought periods are toxic plants (Piet Cloete pers. comm. 2003). Herders observed that toxic plant material can also be ingested by animals in plant litter. Croplands are also not regarded as important grazing areas for livestock during drought periods because these areas are dominated by G. *africana*. However, after a rainfall event croplands are considered by herders to be a key resource area for livestock since they will contain a great diversity of ephemerals.

Herders are spatially aware of all the features in their grazing area that are valuable to them as livestock keepers because they have shown them on the cognitive maps. However, most of the herders do not have the precision to perfectly distinguish between features (e.g. croplands from flatlands) in their local environments. Herders also cannot provide accurate distance estimates between features in their grazing area. I observed that herders use ordinal rather than metric spatial relations between features when herding their animals. They rank (in order of distance) spatial features from one another. Due to the fact that herders use ordinal spatial relations between features should not allow us to underestimate their spatial orientation and coordination. They know where they are in relation to other stockposts, they know their grazing "boundaries", and they know where to go to get good forage. Since they know their grazing area, they can base their decisions on grazing routes upon three considerations: (1) the forage quality of a particular grazing area; (2) the costs (time and energy) of movement to a specific grazing area and (3) the presence of other herds.

Herders are aware of the presence of other herds in their grazing area since they have shown on their cognitive maps all the stockposts in their grazing area that were used during the drought period. Being aware of the presence of other herds may prevent conflict amongst herders since they will allow other herds enough space to graze. The occurrence of informal boundaries on the cognitive maps concur with other findings (Debeaudoin 2001) that herders in the Leliefontein Communal Area respect each other's rights to use the natural resources and therefore allow each other enough space to graze.

Herders have between 60 – 80 % of spatial knowledge of the Paulshoek rangeland in common. These similarities in spatial knowledge may be attributed similar personalities. Personality as a factor in landscape perception has been recognized by Sonnefeld (1972) who investigated landscape preferences between the Alaskan and Delaware rural populations.

Herders use forage equality as the criterion to assess rangeland condition. They rate the forage quality of a grazing area as good, average or poor. They view similar features in their landscape as valuable or hazardous. Landscape features such as mountains and water points are regarded as valuable during drought whereas areas with high abundance of toxic plants are regarded as forbidden areas. Key resource areas such as the mountains and water points are regarded by herders as more important because mountains have the forage resources to carry livestock through during drought conditions (Chapter Three). No disputed grazing areas were identified because herders know their grazing boundaries. Herders respect each others rights to use the rangeland and therefore allowing each other enough space to graze. If there is not enough space some herders will move their stockpost where there are less or no herds. All herders know their grazing area very well; they always know where they are going; and they know the easiest way to get to any grazing destination.

The method of cognitive mapping allowed herders to construct a profile of their grazing area without any predetermined feature in their grazing areas as would be the case of ranking landscape photographs. Working with herders individually also allowed us to assess many views of a single issue (e.g. perceptions of forage quality on the mountains during drought). This method of assessing rangeland condition can be extended to include views and perceptions of the local communities at a time of more favourable environmental conditions. This is because attitude, moods, and other internal conditions can affect perception (Leibowitz 1965) as it did during the drought when some herders regarded the forage quality of the entire rangeland as poor.

Chapter Five

Herding strategies during drought in a communal rangeland in Namaqualand

5.1 Introduction

Before the arrival of Europeans in South Africa, the indigenous Nama people occupied large areas of land and moved around extensively to exploit seasonal differences in the availability of forage and water (Boonzaier *et al.* 1996). With the arrival and the settlement of the Europeans in the Cape in 1652, indigenous people lost most of their land to the colonist farmers (Elphick & Giliomee 1979). The Nama people were restricted to smaller rangelands and their traditional patterns of rangeland use were disrupted (Kotze *et al.* 1987). The sedetarization of the Nama, and other pastoralists in Africa (Niamir 1991), meant that they had to continuously graze the same pasture.

In South Africa, two farming systems are used to manage natural resources and livestock. There is the farming system that is mostly used by 'white' farmers based on sustained maximum production where a constant population of livestock is kept irrespective of climatic conditions. This farming system is based on privately owned farms. A few commercial farmers in Namaqualand also have farms in Bushmanland, a summer rainfall region, hence, another agro-ecological zone. These framers move seasonally between their farms tracking forage availability. This farming strategy is similar to the transhumant patterns of herding used by the early Khoikhoi pastoralists before they were dispossessed of their land (Rohde *et al*. 2001). Each farm has several fenced camps in which livestock graze freely for a certain period of time.

Until 1994, the only lands available to black people for farming were the overcrowded communal farms. Livestock on communal land in Namaqualand are kept at stockposts that are scattered around the rangeland. In the Leliefontein Communal Area, livestock are attended to by a herder every morning and evening (Debeaudoin 2001). This is particularly due to the fact that livestock can get lost easily as sheep usually do not return to the kraal at night if left alone (Koos van Wyk pers, comm. 2003). Livestock can also be preyed upon by predators such as jackals. The objectives of communal farming are not sustained maximum production. Under these circumstances livestock are traditionally seen as an investment and signs personal wealth and elevated status in the community (Debeaudoin 2001).

In Mongolia (Fernandez-Gimenez & Swift 2003) and East Africa (Niamir 1991), herders employ various herding strategies to manage livestock. In Paulshoek herders who never moved their stockposts over a six year period were identified as sedentary herders; home range herders who moved their stockpost at irregular times; and mobile herders who moved their stockpost at least once a year (Baker and Hoffman 2006).

Debeaudoin (2001) examined the herding strategies in the Leliefontein Communal Area on a finer scale than (Baker and Hoffman 2006) during a higher rainfall period (when the annual rainfall was above 150 mm). She grouped herders according to the livestock management practices they have in common and identified four types of herders. A herder that is a leader chooses the grazing route in the mornings and actively herds the herd the whole day. Delegatory leaders are herders who only herd up to the water point. 'Managers if necessary' are herders who let the animals decide on a grazing route in the mornings and only walked with the herd to look out for predators. They only intervene when animals graze too close to a patch of toxic plants. The fourth herder group was called followers who only give general directions in the mornings and follow the herd the whole day to look out for predators. They also direct the animal back to the kraal in the afternoon.

This study will find try to answer the following questions:

- What herding strategies do herders in Paulshoek use during drought conditions?
- Why do they use a particular herding strategy during drought?
- Do herders change their herding strategies during drought conditions?
- Do the herders is Paulshoek use the same herding strategies during drought conditions as the herders used during a higher rainfall year in the Leliefontein Communal Area?

5.2 Description of the herds in Paulshoek

5.2.1 Herd ownership

A single herd can be owned by one individual or have multiple owners of up to 11 individuals (MT Hoffman unpublished data) who are usually related or very good friends. Not all shareholders may reside in Paulshoek permanently but maintain frequent communication with other shareholders. A shareholder can pull his animals out of a herd at any time. In most cases an employed herder also owns a few animals in the herd he is herding.

5.2.2 Herd number

The number of herds in Paulshoek depends on factors such as climatic conditions and shareholder relationships. During the 2002-2003 drought, three herds occupied camps on commercial farms and the number of herds decreased from 25 to 21. Disagreement amongst stakeholders in various herds caused some herds to split and exist separately or some owners merged with existing herds. Some herders also attempted to move to the new farms but had to turn back because the animals were too weak to walk to these areas.

5.2.3 Herd composition

Herds are either composed of a mixture of sheep and goats, or sometimes only goats or only sheep. The ratio of goats to sheep is approximately 2:1. Mostly boer goats are farmed as they are regarded as very resilient to drought (Chapter Three). During the drought period, three herds had two milk goats each. These goats did not graze with the rest of the herd since they are not well suited to the harsh local environment (Jan ‘Waters’ Cloete pers. comm. 2003). Sheep are mostly hybrids of karakul, dorper, persian, or indigenous afrikaner sheep in which one or other genotype is expressed more strongly. Pure-bred individuals are very rare. Hybrids are kept for their robustness and ability to survive dry periods. At the start of the drought, six herds were composed only of goats, but at the end of the drought, only three herds composed only of goats. One herd was made up entirely of different breeds of sheep during and after the drought period (MT Hoffman unpublished data).

5.2.4 Herd size

The total number of livestock in Paulshoek at the start of the drought was 2 936 SSU and at the end of the drought period the livestock population decreased to 1 113 SSU (Fig 5.1). During December 2002 and January 2003 there was an increase in livestock numbers due to the lambing season but from February 2003 livestock mortality increased. Livestock mortality reached its peak during August 2003 due to the cold conditions that prevailed during this month. The stocking rate recommended by the Department of Agriculture for the 20 000 ha Paulshoek Commons is 12 ha/SSU, which means that the Paulshoek rangeland can theoretically only support 1 667 SSU. At the start of the drought the mean herd size was 126.6±91.9 (standard deviation) (n = 25) but at the end of the drought, the mean herd size was 52±43.7 (n = 21) (MT Hoffman unpublished data).

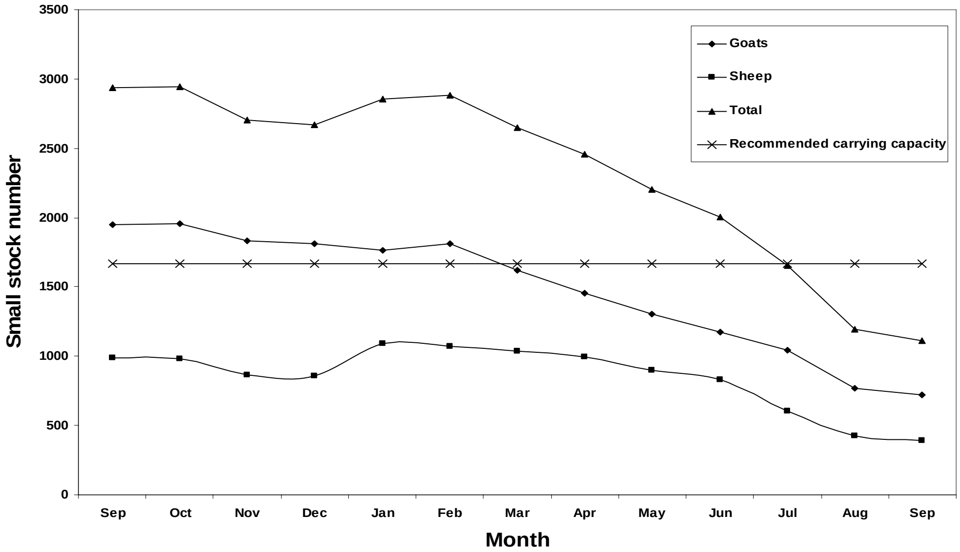


Figure 5.1: The number of livestock recorded in Paulshoek during September 2002 and September 2003 (MT Hoffman unpublished data).

5.3 The herders of Paulshoek

All the herders[6] that were involved in livestock management during the drought period were males and their ages varied between 17 and 71 years of age. The mean age of the herders was 50 years old and the median age was 55 years old (n = 27). Herders have different herding experience (see Chapter Three).

In Paulshoek, only one herder is used per herd per day. However, different herders may be used to herd. If the herd is herded by two or more herders, they rotate herding amongst themselves and do not herd at the same time. In many instances, a stand-in herder is also used. This happens when the full-time herder has to take time off to attend the clinic, church, when he has to collect his pension money. The stand-in herder is often an owner, relative of an owner or the herder, or a close friend. Sometimes stand-in herders may also be the owner's wife or a female owner. During the duration of the fieldwork, six female herders herded five herds.

[6] A herder is classified as full-time if he herds on a permanent basis the whole week irrespective of whether he gets paid or not.

Only one herder's family stayed with him permanently at the stockpost. His wife and daughter acted as stand-in herders and were part of the six female stand-in herders.

5.4 Materials and methods

Livestock management practices of the herds in Paulshoek were assessed through direct observation of daily herd management during the grazing period and before the herds were released to graze in the rangeland in the mornings. One day was spent with each of 24 herds in Paulshoek in the rangeland and the herder's management practices were observed. During my observations, I noted the factors that determined the direction of their daily grazing routes and the factors that affect the length of the daily grazing routes. Semi-structured interviews were conducted with the herders in the rangeland while they were herding. This was to establish why they adopt a specific management strategy, the reason for the composition of their herd, and to know more about the herders' herding experience. In the rangeland, all the herders were also shown aerial photographs of their grazing areas so that they could indicate all the daily grazing routes that they used during the drought period. I did not experience any difficulties with the herders' understanding of the aerial photographs. The aerial photographs were obtained from the Director General, Surveys and Mapping in Mowbray and the photographs were scaled at around 1:7000.

A matrix (Appendix Four) was constructed to determine the differences and similarities between the livestock management practices of the various herders.

This information was imported into the PRIMER 5.0 software (Clarke & Warwick 2001). A cluster analysis was performed on the different management practices in order to construct a Bray-Curtis similarity dendrogram of the livestock management practices of only 23 herds in Paulshoek. The herd management practices of herd 15 were not used because the herd grazed inside an enclosure permanently during the drought.

Herding strategies were identified based on (1) whether the livestock is herded; (2) who selects the grazing routes, animals or the herder; (3) time spent with herd by herder; and (4) means of homecoming of herd to the kraal at night. These practices were used as the criteria because they have spatial implications. Herding strategies were not assessed after the drought period because all the herds could not be visited.

Where there was congruency between the management practices that the herders in Debeaudoin (2001) use and the herders in study, the same terminology was used as in Debeaudoin (2001) to classify the herders.

5.5 Results

The Bray-Curtis similarity matrix (Fig 5.2) distinguishes between two main groups of herders during the drought. A herd was either herded or the herd was free-ranging (Fig 5.2). Eighteen out of the 23 herds were herded while five herds were free-ranging. Free-ranging herds compose only of goats and were mostly managed by collectors. Herded herds were managed by leaders, delegatory leaders, 'managers if necessary', selective herders and nomadic herders. Free-ranging herds were managed by collectors and collectors. A part-time herder only herded his herd on certain days.

A herder who chooses the grazing route in the mornings, actively herds the herd the whole day and kraal all his animals at nights is labeled as a *leader*[7]. Herders who only herd up to the water point were classified as *delegatory leaders*. Delegatory leaders only direct the herd back within a 1.5 km radius of stockpost after reaching the water point (if the water point is further than 1.5 km from stockpost) and don not walk with them the whole distance. A delegatory leader makes sure all sheep and preferably the goats too are back in the kraal at night. A delegatory leader, like all other herders who herd their animals daily may have up to five different grazing routes.

Herders who let the animals decide on a grazing route in the mornings and only walked with the herd to look out for predators or only intervene when animals graze too close to a patch of toxic plants, and kraal their all animals at night are labeled as '*managers if necessary*'.

A *selective herder* separated the herd into goats and sheep. He only herds the sheep because sheep do not always return to the kraal at night if they are left alone to graze.

[7] Debeaudoin (2001) also identified leaders, delegatory leaders, 'managers if necessary and collectors.

Selective herder

"*Die bokke is beter op hulle eie omdat hulle kan berge klim, Dit is net die skape wat opgepas moet word want hulle kom sommer saans nie terug nie.*"

- Herder 17

"The goats are better off on their own because they can climb the mountains. It is only the sheep that must be herded because they sometimes don't come back at night."

When other herders perceived that the health conditions of their animals are deteriorating, they changed their herding strategy and became selective herders to allow animals to graze more suitable areas. They separated the weak individuals from the strong ones. They only herd the weak animals because the strong animals have the energy to climb mountains and can graze on their own. Selective herders always kraal their sheep and sometimes do not kraal their goats.

A *part-time herder* only herded on days when ewes will give birth and adopted a delegatory leader strategy when he was herding. He kraals all his animals at night.

Part-time herder

"*Die vee is beter af op hulle eie, dit maak nie saak of ek hulle in die rigting of daai rigting stoot nie, die veld is swak orals*"

- Herder 20

"The animals are better off on their own, it is no use pushing them in this direction or that direction, the rangeland is poor everywhere."

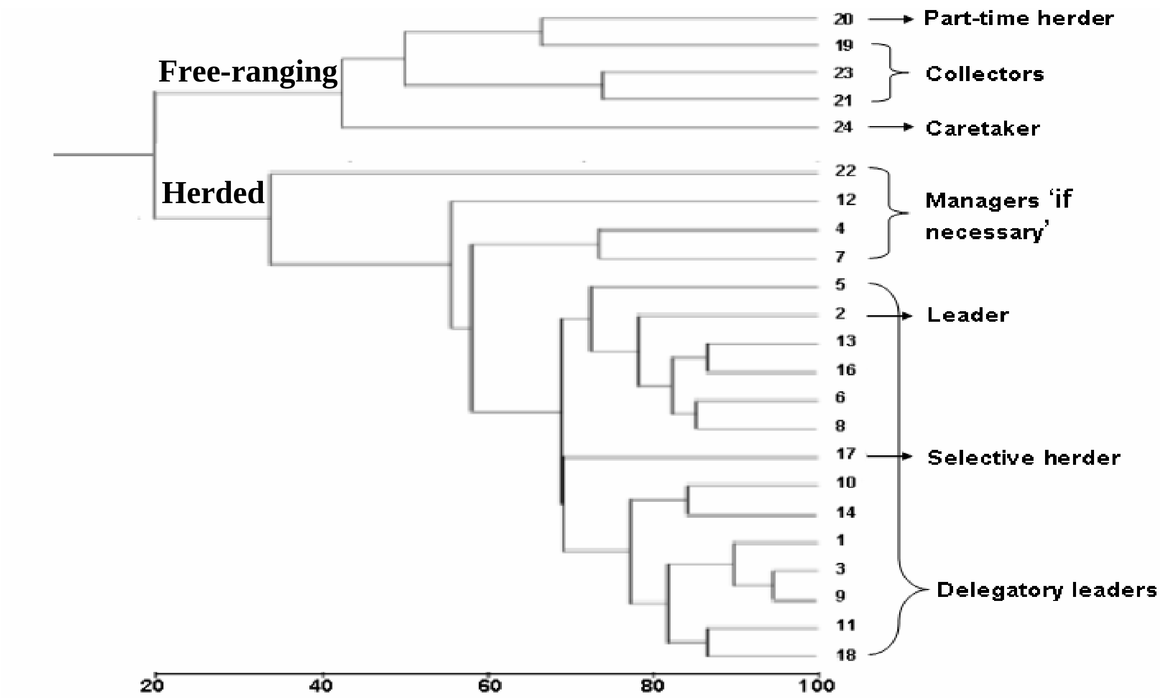


Figure 5.2: Bray-Curtis similarity dendrogram of the different types of herding strategies identified during the drought in Paulshoek.

Herders who did not walk with their herd but collects them in the evenings to kraal them are *collectors*. A *caretaker* is the only herder that did not kraal his animals. He only checks up on the herd two to three times a week, to feed them fodder and treat the sick animals. He is also the owner of the herd. All other herders also inspect and treat sick animals if possible.

In addition to the above herding strategies, another type of herd management was identified, i.e. nomadic herding. *Nomadic herders* will go to places that are not easily accessible with the hope of being rewarded with greener pastures. Water may not be available close by, so they transport water with a vehicle or a donkey-cart. Nomadic herders only stay at a location for a few days, then move to another site or they return to their stockpost. Herder one was a nomadic herder but the dendrogram does not show this because herder one adopted a delegatory leader strategy. Any herder who manages a herded herd can adopt this nomadic strategy if he is willing to do it.

Each type of herder has his reasons why he adopts a particular herding strategy to manage his livestock. Animals are mostly herded to ensure the safety of the animals by preventing predation or preventing animals from eating toxic plants (Table 5.1). The herding strategy adopted by a herder also depends on his other priorities or his own health. Some herders do not herd their animals because they regard animals as being better off on their own and the animals can make the best decisions for themselves (Table 5.1).

Table 5.1: Types of herding strategies identified in Paulshoek during the drought, the number of herders using the herding strategy and the reasons why the herder adopts a particular herding strategy.

Type of herder	Herders using the strategy	Reasons for using the herding strategy
Leader	1	- The herder perceives that he rather than the animals know which to graze and therefore make all the decisions for the herd. - Herder is aware that livestock can be stolen or predated at any time.
Delegatory leader	12	- Livestock will eat anything in the morning because they are hungry and excited. Thus they only need herding until they are full and more relaxed. - Herder has other duties to perform at the stockpost in the afternoon.
Managers if necessary	4	- Livestock can smell where the food is. Herder only looks out for predators. - Herder's father used to herd this way.
Collector	3	- Livestock can smell where the food is. They only need to be kraaled at night and treated in the morning.
Caretaker	1	- Herder's health or other commitments does not allow him to be at the stockpost daily.
Selective herder	1	- Goats can graze on their own because they will return at night. Sheep will usually not return to the kraal at night on their own.

		- Weak animals will prevent the stronger ones from grazing sufficiently.
Part-time herder	1	- Herder is too busy to herd everyday. He only herds on the days when the goats will give birth. Newborn kids need to be carried to the kraal after birth. Sheep lambs do not have to be carried since they are strong enough to graze with the herd immediately after birth.

5.6 Discussion

The number of herds in Paulshoek does not stay constant. During the drought three herders attempted to relocate to the newly bought farms but had to turn back because the animals were too weak to walk to these areas. Walking was their only option as there was a general lack of transportation to take the animals to these farms. Certain herders also took their herds to adjacent rangelands in the Leliefontein Communal Area but returned because of the distance from their family, and the animals are not use to sourveld[8] in the higher altitude areas in the northwestern part of the Paulshoek Commons i.e. Namaqualand Granite Renosterveld Vegetation (Musina & Rutherford 2004). Emigration from the rangeland during unfavourable climatic conditions and returning when environmental conditions are more benign is also reported in Galvin *et al*. (2001); Fernandez-Gimenez & Swift (2003); Galvin *et al*. (2003) and Hendricks (2004).

Approximately 75 % of the herds in Paulshoek were mixed. There are several advantages of keeping a diverse herd. Since different livestock types have different forage and habitat preferences, a diverse herd ensures that a range of habitats are exploited (Nolan *et al.* 2000; Galvin *et al.* 2001; Little *et al.* 2001;

[8] Vegetation type that is characterized by herders as comprising predominantly of tall shrubs with low nutritional value.

Galvin *et al*. 2003; Hendricks 2004). A diverse herd also minimizes competition for the already scares resources (Niamir 1991; Fernandez-Gimenez & Swift 2003) since goats prefer more perennial species than ephemerals (Hendricks *et al*. 2002) whereas sheep prefer the ephemerals and grasses (Grainger 1990; Kumar *et al*. 1999). When there are no ephemerals or grasses the sheep in Paulshoek eat shrubs, which conflicts with the general view that sheep do not browse.

A multi-species herd is also a risk-mitigation strategy (Fernandez-Gimenez & Swift 2003). This is because different species have differing vulnerabilities to diseases and environmental stresses and thus a multi-species herd increases the probability that some part of the herd may survive a drought. In Paulshoek, the ratio of goats to sheep frequently changes due to environmental conditions (MT Hoffman unpublished data) and livestock keepers' preferences. Herders say that a mixed herd ensures a wider variety of livestock products: milk from goats and wool from sheep that they care share amongst the community.

More herding strategies were used during the drought period than in a normal rainfall period. During drought conditions there are more constraints that are placed on herders. Drought-related constraints include the weak conditions of the animals, increase in diseases and pests, drying up of ephemeral water sources, lack of good quality forage and a perceived increase in toxic plant consumption. Herders respond differently to these constraints by using different herding strategies.

Seventeen herders used herding strategies that they were more familiar with and also identified by Debeaudoin (2001). They probably used herding strategies that they were more familiar with because they did not know how to deal with their constraints. Herders might have also perceived that animals will die if they change to a herding strategy that the animals are not familiar with.

Two herders responded to the drought-related constraints by using innovative herding strategies, which include selective and nomadic herding. Selective herding by splitting herds into different species is resource partitioning strategy that ensures better access to suitable resources for particular species (Fernandez-Gimenez & Swift 2003). Goats are better climbers than sheep and can therefore graze the steeper slopes whereas the sheep can graze the flatter slopes. Nomadic herding is also regarded by the herders in Paulshoek as a flexible and opportunistic way of obtaining good quality forage during the drought.

Four herders (three collectors and one part-time herder) did not know how to deal with drought constraints and adopted a hands-off approach by allowing their herds to graze freely. Collectors perceived the condition of the veld was poor everywhere and actively herding the animals will not improve their condition.

Herders keep large and mixed herds and carry out more herding strategies to exploit a variety of habitats during drought. Mixed grazing has biological, economic, environmental and management advantages over monospecific grazing (Nolan *et al*. 2000). The type of herding strategy used affects grazing distribution.

A greater variety of herding strategies during drought occurred because some herders may have not been sure which herding strategy will work best for them and therefore used innovative herding approaches. Selective herding and nomadic herding can be regarded as drought-related strategies. Selective herding that ensures animals are herded to areas desirable for a specific animal species. Nomadic herding ensures that animals use the underutilized areas of the commons. Part-time herders and collectors adopt their specific herding strategy as an act of despair because of the poor condition of the rangeland during drought.

One perspective would be to reduce the number of livestock on the commons during drought. However, herders have other objectives. Herders keep more animals because they regard livestock rather than the land and its vegetation as their resource base. Herders know that many animals will die during a drought, and the number of animals will decrease. Therefore, herders keep large herds to ensure that there is a greater chance that more animals would survive calamities like drought and epidemics. Also, the herd owner cannot sell animals in poor condition. It is more economically viable for livestock owners to try and get as many animals through the drought.

Chapter Six

Patterns of resource use by livestock during and after drought on the commons of Namaqualand

6.1 Introduction

Two-thirds of Africa is considered desert or drylands (UNCCD 2006). Within Africa's arid areas, droughts are recurrent and animals occupying these environments have to adapt to variable climatic conditions (Oba & Lusigi 1987). Wildlife move seasonally to track resource availability (Leuthold & Sale 1973; McNaughton 1985; Milton *et al*., 1994), expand their home range (Odendaal & Bigalke 1979) or change their diet (Knight 1991; Nagy & Knight 1994) during the dry periods in order to survive.

Pastoralists in Africa have developed complex mechanisms by which they can alleviate the threat of drought. They also practice mobility as one of the strategies to avoid adverse environmental conditions (Bovin 1990; Al-Eisa 1991; Adriansen & Nielsen 2002). These pastoralists practice either transhumance between well-defined seasonal grazing areas, or more opportunistic movements to best available forage resources (Coughenour 1991; Sieff 1997). However, with increased human population associated with higher levels of cultivation and increased livestock numbers on communal rangelands, as well as policies to restrict movement of pastoralists and aridification of the environment, these mechanisms have become increasingly ineffective because of limited grazing areas.

In the past, the Khoekhoen of Namaqualand, South Africa, were nomadic but these strategies for coping with environmental variability became constrained and seasonal livestock movements were restricted within the smaller commons associated with each village (Baker & Hoffman 2006; Debeaudoin 2001). Herders in Namaqualand now select daily grazing routes from semi-permanent stockposts to satisfy the nutritional needs of their animals.

Studies in Namaqualand have recently documented herd mobility of communal livestock (Baker & Hoffman 2006; Combrink 2004; Hendricks et al. 2005), but none have specifically looked at herding patterns during drought periods. During dry periods, studies have shown that herds may move long distances to greener pastures (Sieff 1997), expand their home range (Bassett 1986), concentrate in key resource areas within their home range (Coughenour 1991), rotate between camps (Goldstein et al. 1990) and forage more intensely around water points (Pickup & Bastin 1997). The impact of livestock on rangeland resources during drought may differ to that of higher rainfall years.

The primary aim of this study was to determine the effect of drought on grazing patterns of livestock in a communal rangeland in Namaqualand. We will try to answer the following questions:

- What biophysical and social factors explain the distribution patterns of the daily grazing routes of the herds during and after drought periods in Paulshoek?

- Are some parts more grazed than other parts of the rangeland?
- Are there differences in the home ranges of herds during drought and non-drought periods?

6.2 Materials and methods

6.2.1. Data collection

The spatial patterns of resource use by livestock were determined by recording the position of a herd every 15 minutes for the duration of a day using a Garmin eTrex Summit hand held Global Positioning System (GPS). One female goat was selected for recording the herd's location since goats formed the majority of the herds and a female was selected because rams move around the herd more. Each herd was followed on foot from the time they left the stockpost in the morning until they returned to the stockpost in the late afternoon. The position of all water points used by the herds during the grazing period was determined. During the drought period, there were 24 herds in Paulshoek. Herd 15 grazed inside an enclosure permanently during the drought and therefore this herd's grazing measurements was not used in the analysis of grazing routes.

To compare grazing patterns during drought and after drought, 12 of the herds followed during the drought between April - June 2003 were compared to ten herds in existence after the drought. The animals in the ten herds after the drought were distributed in 12 herds during the drought. Of these herds two were not herded during the drought and two were not herded after the drought broke. It was impossible to compare exactly the same herds during and after the drought since there were three splits and four mergers of herds during this period.

Herders were interviewed informally whilst following their herds to determine their rationale for decision-making enroute.

6.2.2 Data analysis

MapInfo Professional Version 7.0 (MapInfo Corporation 1992-2002) was used to produce maps of the grazing routes of the herds and determine length of routes based on the collected waypoint data. To determine the area that a herd grazed, a grazing utilization zone was put around the line of the grazing route. A 100 m grazing utilization zone was put on either side of the daily grazing route of the herd if the size of the herd was greater than 100 individuals, a 75 m grazing utilization zone was used for herds of between 50 and 100 individuals and a 50 m grazing utilization zone was used if the herd size was less than 50 animals. Different size grazing utilization zones were placed around herds because smaller herds did not graze as far apart as the larger herds. A grazing width of about 200 m is the maximum width of straying that one herder allows (pers. obs.).

A natural neighbour Voronoi polygon (Hayen & Quine 2002) was constructed from the point data for each herd using Vertical Mapper Version 2.5 (Northwood Geoscience 1999). This generates a territory where the smaller the area of the polygon the greater the intensity of grazing. The polygons were overlaid onto a Digital Elevation Model (DEM) of 20 m resolution to assess the role of relief in influencing grazing intensity. The DEM was supplied by ComputaMaps CC. The grazing density was calculated by dividing the size of each Voronoi polygon by the number of animals present in each polygon.

Statistical tests were performed on the grazing parameters of the herds using Jandel SigmaStat Version 2.0. A normality test was first performed and when normality was established a t-test was used to test for significance differences between distance measurements. When normality was not established, the data were log transformed for normality to be established.

6.3 Results

6.3.1 Grazing patterns of livestock during a drought period

The stockposts used by the herds during the drought were scattered throughout the 20 000 ha of rangeland commons (Fig 6.1). The stockposts were located near tracks suitable for motorized vehicles or donkey carts and hence concentrated on the more accessible lowland areas.

Water points consisted of wells, boreholes (powered by wind or solar energy), piped water and springs. There are no permanent rivers and the ephemeral streams were dry throughout the drought. Twenty out of all the 23 herds visited a water point during their monitored daily grazing route during the drought. Those that did not visit a water point on the monitored route said that they had watered their animals the night before or because the stockpost and water point were located at the same place and had no need to herd to a water point.

Animals were not allowed to graze in the village (100.2 ha), Kliphoek camping site (9 ha), Moedverloor animal exclosure (251.1 ha) and the ram camp (255 ha). Due to the scarcity of forage during the drought, some herders allowed their animals to graze in the ram camp throughout the drought period even though it was not allowed by the Paulshoek Development Forum. The animals entered the ram camp through an opening in the fence. Dirk's camp (38.72 ha) was an animal enclosure where herd 15 (13 animals) grazed during the drought. After the drought, Dirk's camp was dismantled because Dirk Joseph, the livestock owner erected the enclosure without the consent of the municipality. The other livestock keepers were also unhappy because the enclosure prevented other herds from grazing there.

The stockpost is the nucleus from where all grazing activities radiate. Herds were usually released from the stockpost before 08h30 except following frost when they would leave later in the morning. The herd would return to the stockpost by 16h00. Figure 6.2 only shows one route per herd, but herders have from 2-5 daily grazing routes. Grazing pressure is unevenly distributed across the Paulshoek Commons. Greater grazing intensity is concentrated on the higher elevated areas of the rangeland (Fig 6.3) and around water points (Fig 6.4). On average it takes three hours for a herd to reach the highest point on their grazing route (Table 6.1).

During the drought, the herds grazed 19.3 % faster in the mornings than in the afternoons ($t=3.721$; $df=22$; $p<0.005$) (Table 6.1). Larger herds had significantly longer grazing routes than smaller herds in all directions ($r^2=0.191$; $p<0.05$) during the drought period in Paulshoek. Larger herds grazed significant faster in any direction than smaller herds in the mornings ($r^2=0.253$; $p<0.05$) but the herds grazed at similar speeds in the afternoon ($r^2=0.025$; $p>0.05$) irrespective of herd size.

6.4.2 Comparison of grazing routes during and after a drought period

Nine of the 12 herds visited a water point along their daily grazing route during the drought (Fig 6.5a), and six herds of 10 visited a water point following the drought (Fig 6.5b). Following the drought they visited water points less frequently because they felt that water was available from natural wells or pools in the rangeland or from the now turgid vegetation. Water points varied between 165 and 3700 m from a stockpost. The mean distance to water was not significantly different ($t=0.446$; $df=20$; $p>0.05$) during and after the drought.

Greater grazing intensity is concentrated around higher elevated areas of the rangeland (Fig 6.6a) during the drought period. The croplands between the village and the animal exclosure were not used by the herds during and after the drought due to the abundance of G. *africana* and the lack of water points. This pattern persisted after the drought broke (Fig 6.6b) despite only five of the 12 stockposts occupied during the drought being used after the drought (Fig 6.5b). Seven stockposts used during the drought monitoring period were unoccupied five months later and five alternative stockposts were occupied in the post-drought period. Animal density is highest around water points (Figs 6.7a & b) especially during the drought. Animal density after the drought was highest southeast of the village. More herders moved to southeast of the village after the drought since some livestock keepers ploughed their croplands in the northwest after the heavy rains in August 2003.

The mean total lengths of grazing routes were similar (t=0.686; df=20; p>0.05) during and after the drought (Tables 6.2 & 6.3). There was considerable difference in the length of grazing routes of individual herds ranging from less than 3 km to more than 10 km. The maximum distance a herd moved away from a stockpost (grazing orbit) ranged between 0.7 and 4.3 km but this did not vary significantly between the two monitoring periods (t=-0.308; df=20; p>0.05). No significant relationship existed between herd size and the total length of the daily grazing routes of the herds in Paulshoek during ($r^2 = 0.36$; $p > 0.05$) and after ($r^2 = 0.13$; $p > 0.05$) the drought.

In the mornings the herders usually chose a route that took the livestock to higher elevations. Herders said that they perceived vegetation quantity and quality to be better in the mountains and that this would satiate the hunger of their animals and calm excited animals. The time taken to reach this highest point (t=-0.2; df=20; p>0.05) and the vertical distance climbed both in terms of net (t=-0.637; df=20; p>0.05) and cumulative (t=-0.426; df=20; p>0.05) elevation gains did not change between the two monitoring periods (Tables 6.2 & 6.3).

Herds walked at similar speeds in the earlier part of the day and later in the day during and after the drought (f=0.299; df=1,43; p>0.05). This translated into the same size area covered by each herding route in the earlier part of the day and the afternoon period during and after the drought (f=0.219; df=1,43; p>0.05). Each individual herd did not cover a significantly different area during and after the drought. Therefore, sizes of the areas grazed by herds during and after the drought are not significantly different. The total area covered by the herds in one day during the drought was 1024.4 ha but that grazed by the remaining animals was 752.4 ha after the drought.

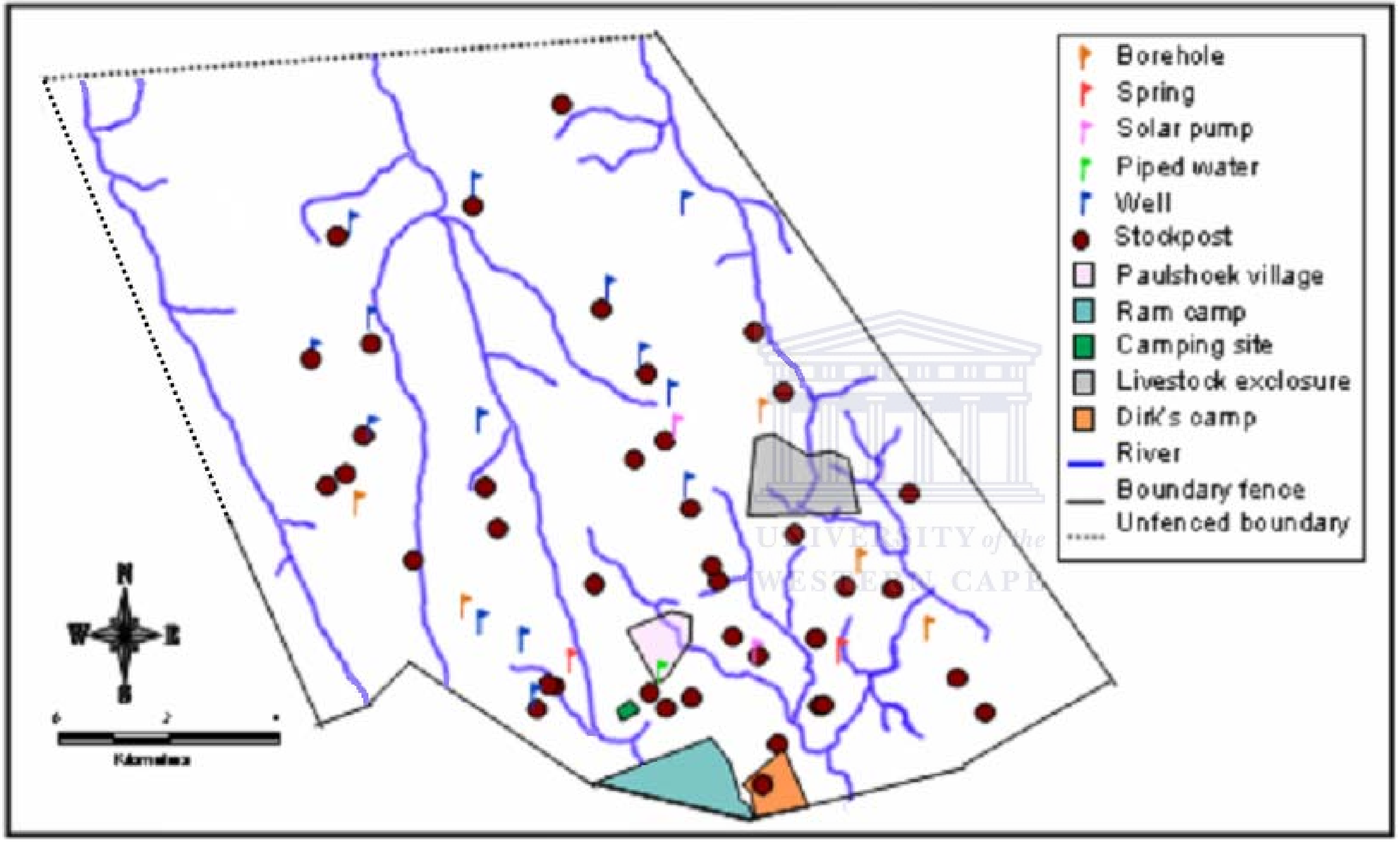


Figure 6.1: Location of all stockposts and water points that were used by herds during a drought period in Paulshoek. Forbidden areas for livestock to graze are indicated by the coloured polygons (Paulshoek village, ram camp, camping site, livestock exclosure). Dirk's camp was grazed by herd 15.

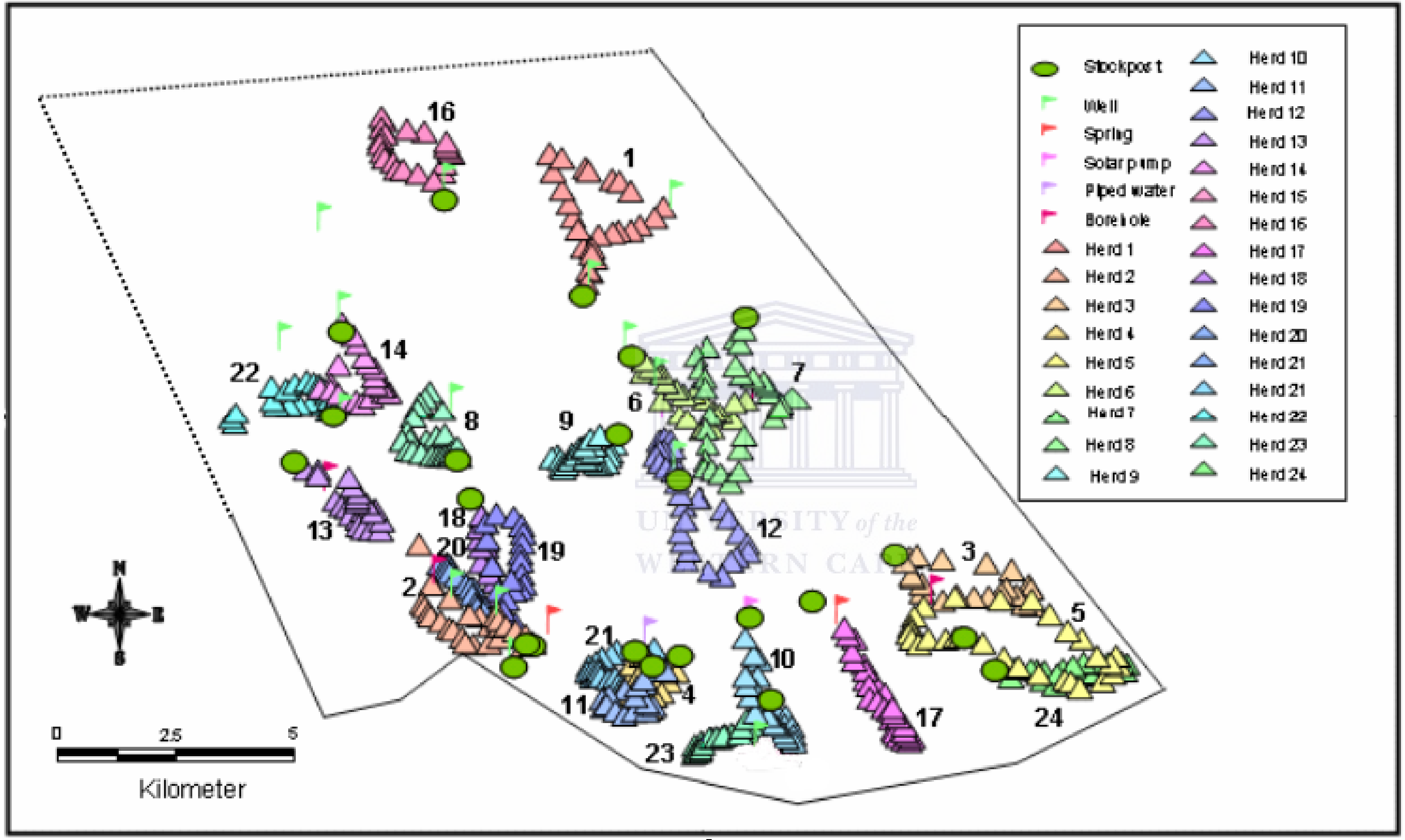


Figure 6.2: Grazing routes of the herds (n=23) during a drought period in Paulshoek. Only one grazing route of a herd is shown but a single herd may have up to five grazing routes originating from one stockpost. The grazing distribution of herd 15 is not shown.

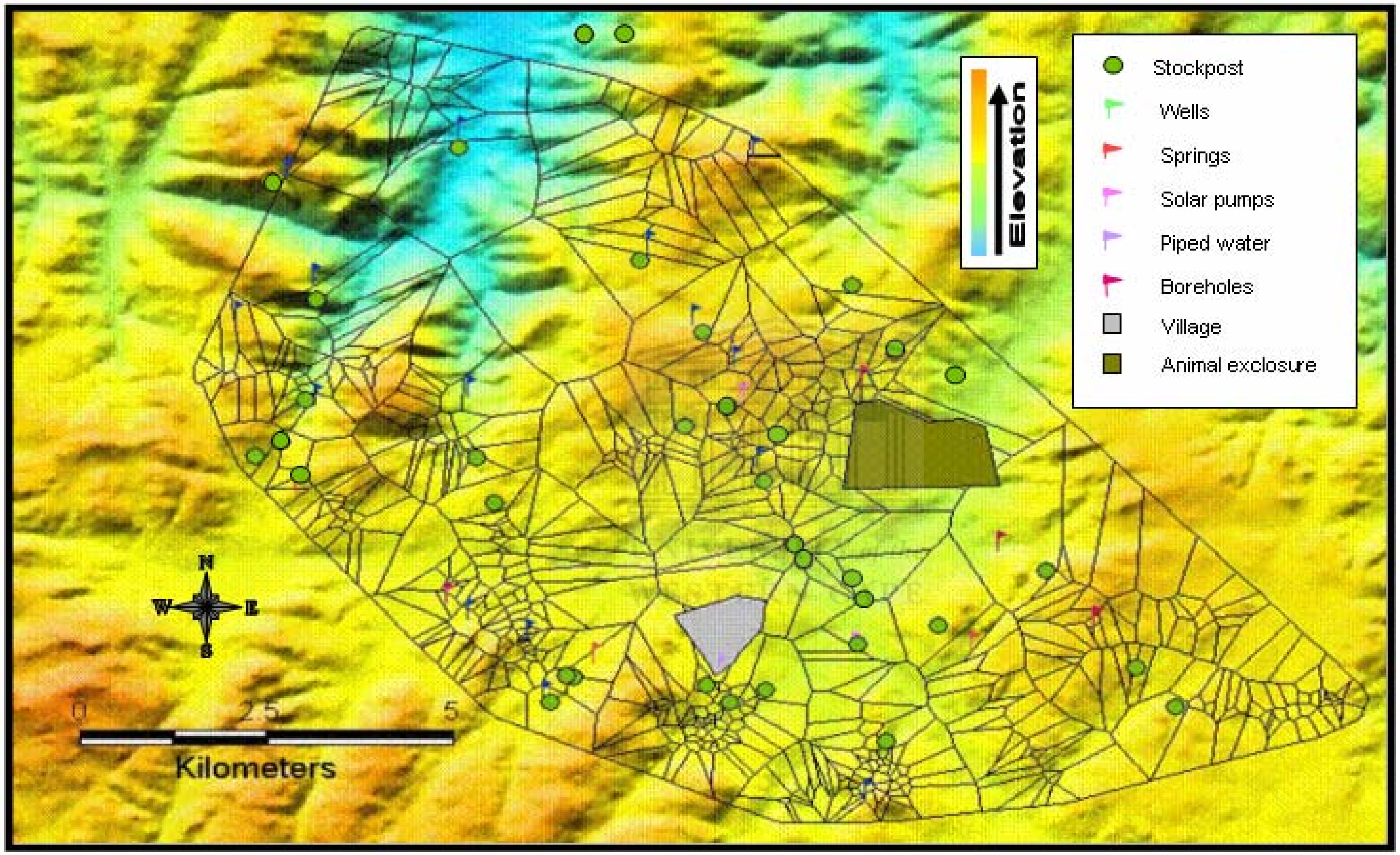


Figure 6.3: Grazing intensity map of the herds (n=23) during the drought superimposed over a 20 m digital elevation model of the Paulshoek Commons. Each polygon represents territory generated from 15 minute interval GPS readings. The smaller the polygon, the more time was spent by a herd in an area and these are smallest in association with more elevated land.

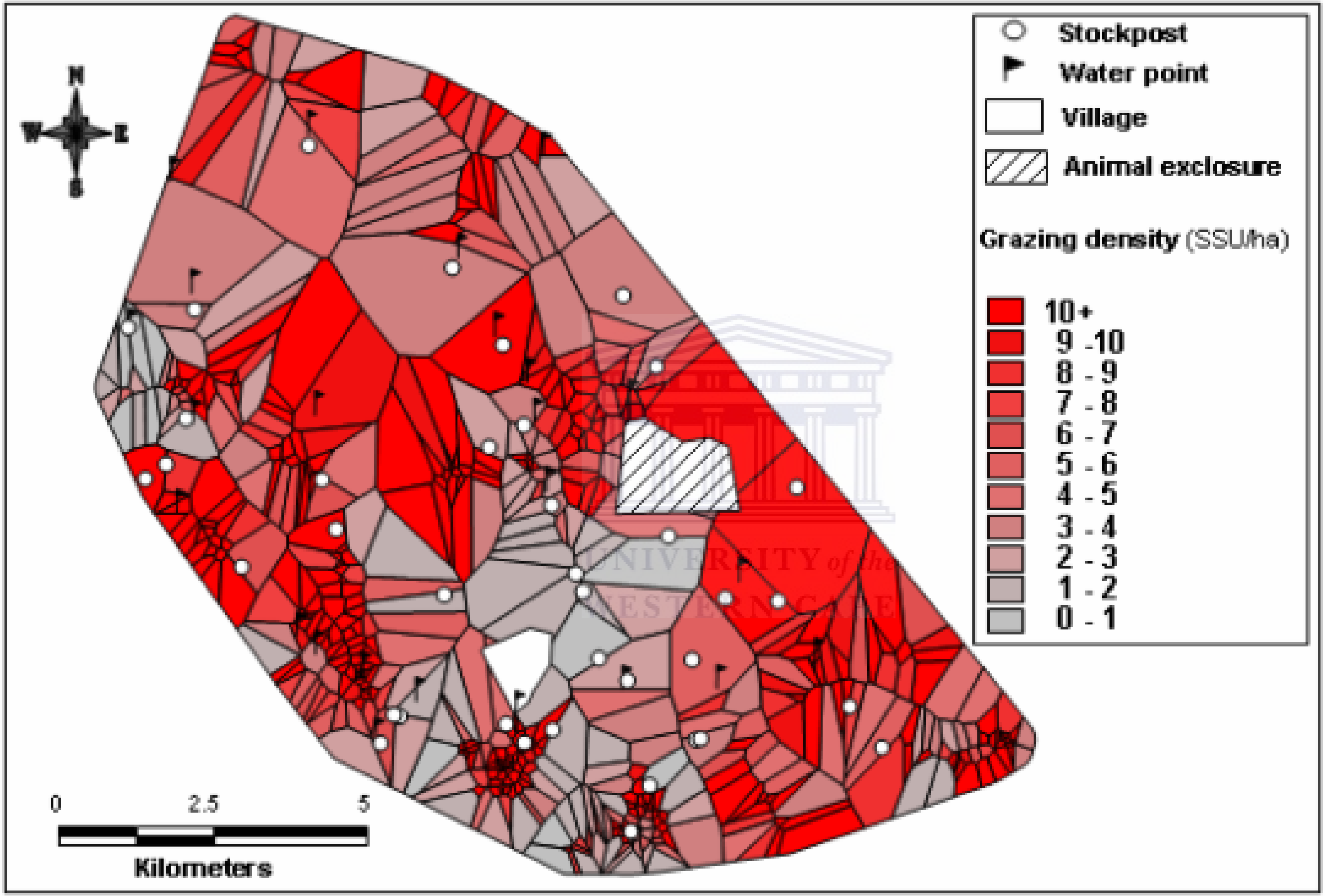


Figure 6.4: Grazing density of 23 herds during the drought in Paulshoek. Each grazing density unit (polygon) represents territory generated from 15 minute interval GPS readings. The redder the colour of the polygon, the higher the grazing density and these are highest around water points.

Table 6.1: Spatial parameters associated with grazing routes of the herds (n=23) during the drought period in Paulshoek. The table is ordered according to herd size. Averages for 23 herds and standard deviations are given in last column.

Herd ID	**4**	**12**	**20**	**21**	**22**	**23**	**24**	**2**	**10**	**11**	**14**	**18**
Herd size	<50	<50	<50	<50	<50	<50	<50	50-100	50-100	50-100	50-100	50-100
Elevation of stockpost (m.a.s.l.)	1078	1085	1082	1102	1219	1043	1129	1098	1052	1044	1143	1196
Distance of water point from stockpost (m)	540	277	1158	223	147	1070	1311	1013	165	1388	284	2436
Distance walked before reaching water point (m)	3224	5138	1169	281	147	*	*	1282	6039	*	4951	2826
Net vertical distance climbed (m)	40	67	147	73	43	49	22	110	29	67	133	43
Cumulative vertical distance climbed (m)	112	153	155	130	79	95	64	142	178	96	174	173
Time taken to reach highest point (min)	105	465	120	60	105	0	180	180	360	60	210	315
Furthest point reached from stockpost (m)	919	2089	2672	933	1344	1787	2311	2266	2760	1729	1560	2559
Total length of grazing route (m)	4053	7840	5872	4586	3867	4341	5349	7140	6252	4736	5327	5912
Total area grazed (ha)	46.6	73.8	53.3	37.8	37.0	34.8	50.1	96.9	86.8	77.5	72.2	74.6
Area grazed in the morning (ha)	20.3	43.9	30.5	21.0	16.7	21.5	32.0	73.4	54.1	42.5	49.2	39.8
Area grazed in the afternoon (ha)	30.8	32.0	29.7	17.4	21.2	20.1	23.5	48.8	40.9	44.6	28.0	45.1
Speed walked in the morning (km/hr)	0.66	1.08	0.76	0.53	0.67	0.56	0.83	1.27	0.95	0.63	0.88	0.68
Speed walked in the afternoon (km/hr)	0.88	0.74	0.65	0.42	0.59	0.49	0.54	1.02	1.05	0.69	0.51	0.67

The table is continued over leaf.

Herd ID	**1**	**3**	**5**	**6**	**7**	**8**	**9**	**13**	**16**	**17**	**19**	**All**
Herd size	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	**Average**
Elevation of stockpost (m.a.s.l.)	1164	1075	1102	1123	1145	1176	1150	1243	1087	1048	1110	1117±56
Distance of water point from stockpost (m)	2419	1117	1068	2334	1793	1085	872	791	193	635	841	1007±705
Distance walked before reaching water point (m)	5825	5097	7340	3006	6227	1778	0	925	5259	693	987	3273±2481
Net vertical distance climbed (m)	18	90	64	24	28	114	94	41	84	131	197	74±47
Cumulative vertical distance climbed (m)	142	112	170	71	144	191	165	185	150	186	199	142±40
Time taken to reach highest point (min)	30	180	345	270	45	195	240	195	60	255	150	179±118
Furthest point reached from stockpost (m)	3071	2668	2786	2334	3553	1562	1277	2083	2191	3309	2943	2205±729
Total length of grazing route (m)	8553	6359	9321	6193	9558	5055	3944	5453	5442	6944	7523	6070±1645
Total area grazed (ha)	150.0	121.5	182.5	117.7	181.8	90.9	64.9	91.0	99.3	114.3	132.7	90.8±42.6
Area grazed in the morning (ha)	114.6	86.7	93.6	81.0	110.7	74.9	44.5	54.2	60.9	66.4	89.2	57.4±29.0
Area grazed in the afternoon (ha)	58.7	46.8	95.2	45.1	84.1	27.3	37.1	51.8	48.7	80.3	67.9	44.6±21.1
Speed walked in the morning (km/hr)	1.40	1.21	1.32	1.13	1.28	1.00	0.59	0.70	0.79	0.92	1.16	0.91±0.27
Speed walked in the afternoon (km/hr)	0.95	0.58	1.32	0.71	1.04	0.41	0.59	0.73	0.58	0.99	0.85	0.74±0.24

- 0 minutes was recorded for herd 23 to reach the highest point in the grazing route because the stockpost was the highest point along the grazing route
- ***** indicate that the water point frequently used by the herds was not visited the day I accompanied the herd
- Herd 15 was not used in analyses because the herd was grazing inside an enclosure (Dirk's camp)
- The grazing routes of the herds during the drought were monitored from 13 April to 29 May 2003.

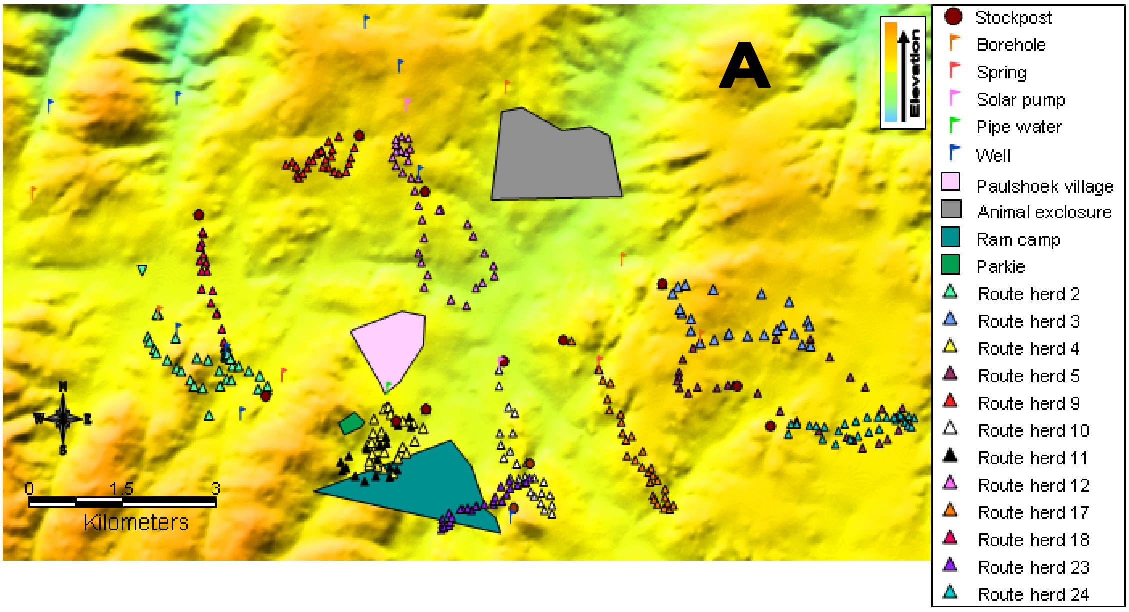


Figure 6.5a: Grazing routes of 12 herds during a drought period superimposed over a 20 m digital elevation model of the Paulshoek Commons.

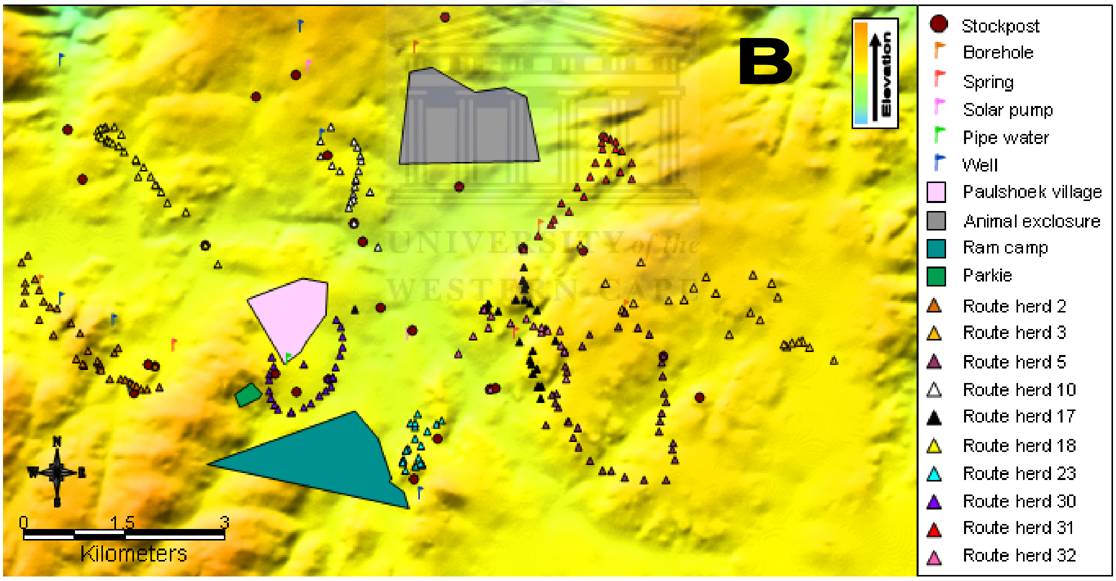


Figure 6.5b: Grazing routes of ten herds after a drought period superimposed over a 20 m digital elevation model of the Paulshoek Commons.

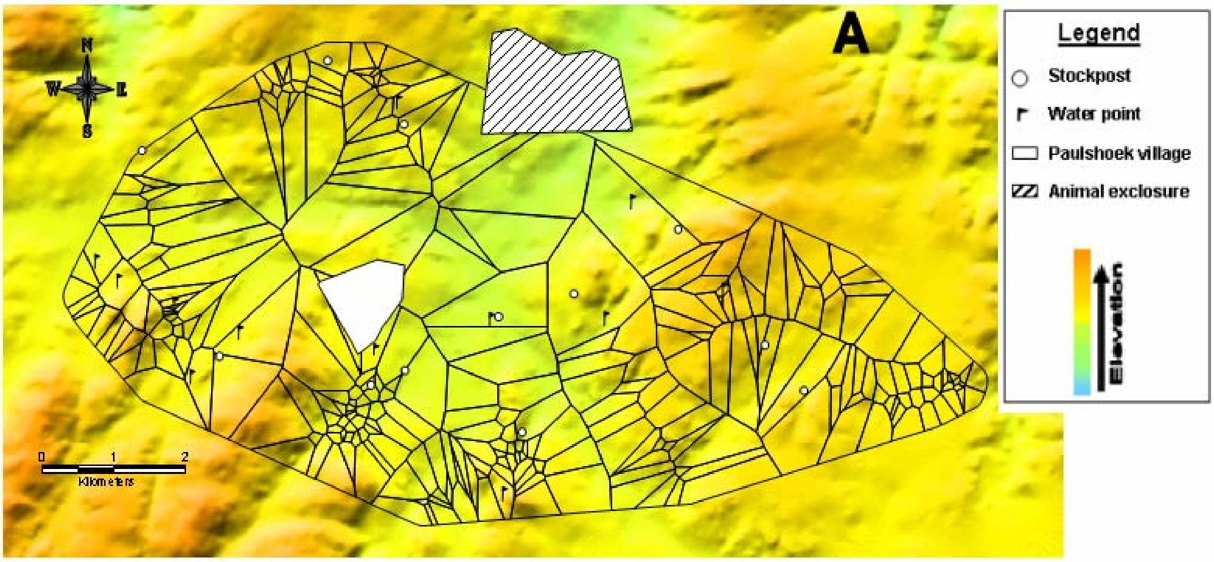


Figure 6.6a: Grazing intensity of 12 herds during a drought period superimposed over a 20 m digital elevation model of the Paulshoek Commons. The smaller the polygon, the more time was spent by a herd in an area and these are smallest in association with more elevated land.

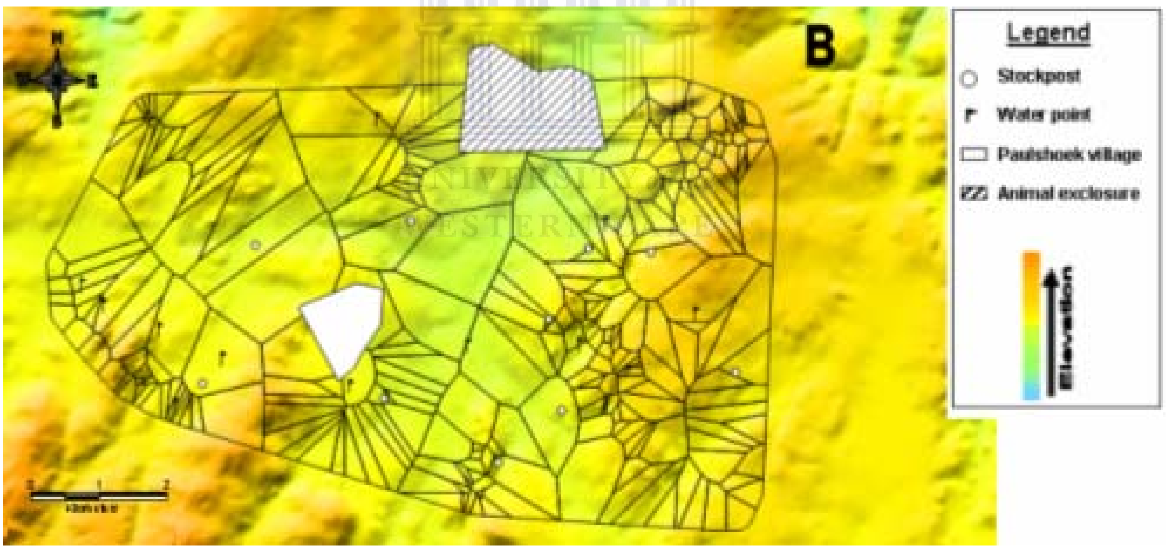


Figure 6.6b: Grazing intensity of ten herds after a drought period superimposed over a 20 m digital elevation model of the Paulshoek Commons. The smaller the polygon, the more time was spent by a herd in an area and these are smallest in association with more elevated land.

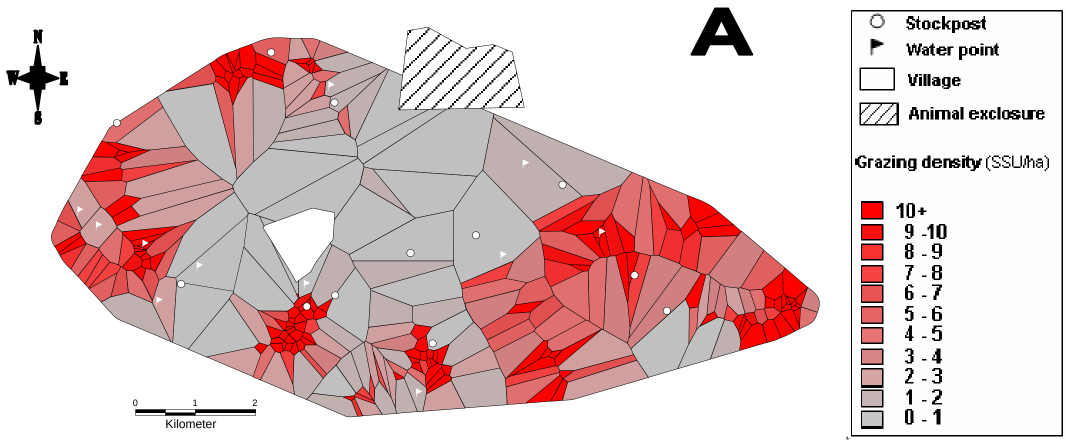


Figure 6.7a: Grazing density of 12 herds during a drought period in Paulshoek. Each grazing density unit (polygon) represents territory generated from 15 minute interval GPS readings. The redder the colour of the polygon, the higher the grazing density and these are higher close to water points.

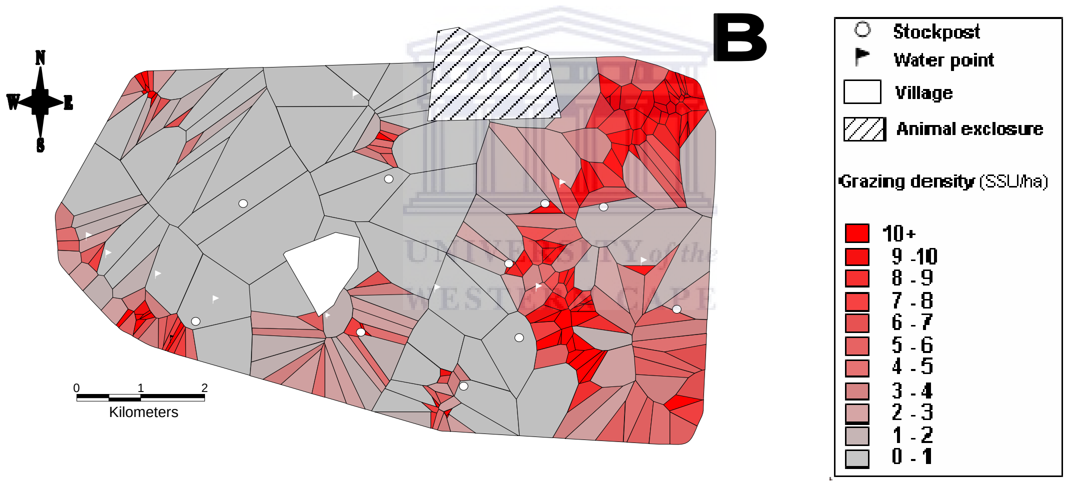


Figure 6.7b: Grazing density of ten herds after a drought period in Paulshoek. Each grazing density unit (polygon) represents territory generated from 15 minute interval GPS readings. The redder the colour of the polygon, the higher the grazing density and these are higher close to water points southeast of the village.

Table 6.2: Spatial parameters associated with grazing routes of 12 herds during the drought period in Paulshoek. The table is ordered according to herd size. Averages and standard deviations are indicated in the last column.

Herd ID	**4**	**12**	**23**	**24**	**2**	**10**	**11**	**18**	**3**	**5**	**9**	**17**	**Average**
Herd size	<50	<50	<50	<50	50-100	50-100	50-100	50-100	>100	>100	>100	>100	
Elevation of stockpost (m.a.s.l.)	1078	1085	1043	1129	1098	1052	1044	1196	1075	1102	1150	1048	1092±47
Distance of water point from stockpost (m)	540	277	1070	1311	1013	165	1388	2436	1117	1068	872	635	991±596
Net vertical distance climbed (m)	40	67	49	22	110	29	67	43	90	64	94	131	67± 34
Cumulative vertical distance climbed (m)	112	153	95	64	142	178	96	173	112	170	165	186	137± 40
Time taken to reach highest point (min)	105	465	0	180	180	360	60	315	180	345	240	255	224±134
Furthest point reached from stockpost (m)	919	2089	1787	2311	2266	2760	1729	2559	2668	2786	1277	3309	2205±684
Total length of grazing route (m)	4053	7840	4341	5349	7140	6252	4736	5912	6359	9321	3944	6944	6016±1640
Total area grazed (ha)	46.57	73.8	34.8	50.1	96.9	86.8	77.5	74.6	121.5	182.5	64.9	114.3	85.4±40.2
Area grazed in the morning (ha)	20.3	43.9	21.5	32.0	73.4	54.1	42.5	39.8	86.7	93.6	44.5	66.4	51.6±23.9
Area grazed in the afternoon (ha)	30.8	32.0	20.1	23.5	48.8	40.9	44.6	45.1	46.8	95.2	37.1	80.3	45.4±22.0
Speed walked in the morning (km/hr)	0.66	1.08	0.56	0.86	1.26	0.95	0.63	0.68	1.21	1.32	0.59	0.92	0.89±0.28
Speed walked in the afternoon (km/hr)	0.88	0.74	0.48	0.54	1.02	1.05	0.68	0.67	0.58	1.32	0.59	0.99	0.80±0.26

- 0 minutes was recorded for herd 23 to reach the highest point in the grazing route because the stockpost was the highest point in the grazing route

Table 6.3: Spatial parameters associated with grazing routes of 10 herds after the drought period in Paulshoek. The table is ordered according to herd size. Averages and standard deviations are indicated in the last column.

Herd ID	**2**	**10**	**18**	**23**	**31**	**32**	**5**	**17**	**30**	**33**	**Average**
Herd size	<50	<50	<50	<50	<50	<50	50-100	50-100	>100	>100	
Elevation of stockpost (m.a.s.l.)	1098	1080	1091	1043	1078	1062	1102	1048	1044	1075	1072±22
Distance of water point from stockpost (m)	605	1453	3693	1070	374	1009	1068	635	1352	1117	1238±926
Net vertical distance climbed (m)	97	51	110	63	40	74	122	121	39	46	76±34
Cumulative vertical distance climbed (m)	127	105	122	63	113	198	237	153	282	74	147±71
Time taken to reach highest point (min)	150	270	285	0	210	165	345	315	210	240	219±99
Furthest point reached from stockpost (m)	2651	1663	2493	706	2244	1407	2157	2415	928	4265	2093±1014
Total length of grazing route (m)	7152	4993	5551	2921	6942	5643	10416	7351	4549	10660	6618±2458
Total area grazed (ha)	49.2	40.4	48.8	50.9	39.6	37.2	99.3	78.6	140.5	167.9	75.2±46.3
Area grazed in the morning (ha)	29.8	31.9	24.5	24.6	26.9	29.7	40.26	40.0	54.3	55.6	35.8±11.5
Area grazed in the afternoon (ha)	26.7	28.8	24.8	22.8	27.0	23.4	39.5	38.0	69.1	85.9	38.6±21.6
Speed walked in the morning (km/hr)	1.17	1.05	0.77	1.29	0.86	0.98	1.02	0.88	0.76	0.93	0.97±0.17
Speed walked in the afternoon (km/hr)	0.56	1.10	0.63	0.98	1.02	0.76	1.04	0.98	1.24	1.22	0.95±0.23

6.4 Discussion

6.4.1 Grazing patterns of all the herds in Paulshoek during a drought period

Herders move their stockpost for a variety of environmental and social reasons (Baker & Hoffman 2006). During 2003, 20 movements took place compared to 47 in 2001 (Baker & Hoffman 2006). More stockpost movements in 2001 can be attributed to the fact that good rains fell during the winter of 2001 and herders moved their stockpost so that croplands could be ploughed whilst no ploughing took place in 2002 and 2003. Drought itself did not motivate livestock keepers to move more often. This might be because most of the livestock keepers regarded the condition of the rangeland as poor everywhere.

Almost every part of the commons was used during the drought for grazing because the 40 stockposts that were used are scattered throughout the rangeland. Because of the shortage of forage during the drought herders had to move their herds around the rangeland in order to find enough forage for the animals to survive. Some herders even allowed their animals to graze in the ram camp.

Herds did not go to the water point directly after leaving the stockpost in the morning. This may allow herders to choose alternative routes to the watering point to ensure that their animals get good quality forage and to reduce their impact on the vegetation along the way. Despite this the area immediately around water points experiences the highest grazing pressure (see also Combrink 2004) exacerbated by the overlap of grazing routes at water points by different herds.

During the drought period the average grazing route was shorter than that of three seasons (autumn, winter and spring) in 2001 in Paulshoek (Combrink 2004). During hot conditions livestock in Paulshoek and other grazing systems (Lange 1969) have shorter daily routes because livestock are unable to conserve water efficiently and the animals can easily suffer from heat exhaustion. Wildlife (Ealey et al. 1967) and larger domestic stock (Dörges & Heucke 1996 cited in James et al. 1999) have lower water requirements than livestock and are able to stay away from water for days.

The average distance that the herds grazed from their stockpost (grazing orbit) during the drought period is not different to the grazing orbits in the Richtersveld (Hendricks 2004), or over three seasons in 2001 in Paulshoek (Combrink 2004). This means that 2 000-2 500 m might be the average distance that a herd moves away from a stockpost to find enough food irrespective of rainfall. Moreover, herders believed that they may not reach better food sources by grazing further from the stockpost because these are limited on the rangeland. The total length of the daily grazing routes of the herds in Paulshoek during the drought was correlated with herd size. It is possible that for larger herds greater competition amongst the individuals occurs and this requires the need to forage further.

During the drought, the Paulshoek rangeland was grazed heterogeneously. The higher elevated areas of the rangeland were more utilized than the lower lying areas. The higher areas are regarded as having better grazing than lower lying areas by herders. Croplands are concentrated on the lower lying areas, and the associated ploughing as well as grazing pressure has left the lower lying areas dominated by the unpalatable and, at times, toxic G. *africana* whilst higher elevation areas tend to retain a more diverse vegetation (Cowling et al. 1999). Rates of nutrient cycling and infiltration and soil stability levels are better on high altitude vegetation communities than on lower vegetation communities in Paulshoek (Petersen *et al*. 2004). This may indicate that the mountains are the best place to graze during drought because the higher altitude plant communities are able to resist grazing impacts better and will recover from the impacts sooner than the lowlands communities (Petersen 2004).

Even though animals usually avoid steep slopes on their grazing routes (Ganskopp & Vavra 1987), herders in Paulshoek take their animals to the higher elevation areas of the rangeland during drought periods even when the animals are not in good shape. Herders see this trade-off as an opportunistic strategy to take advantage of better grazing (Bovin 1990). The survival of the herd as a whole was more important to the herder, and therefore accepted by the herders that some individuals had to suffer. The flats were more heavily grazed than the mountainous areas by a single herd over three seasons because the flatter areas were more easily accessible. The flats comprised about 59 % in grazing orbit of the herd (Combrink 2004). In contrast, communal cattle in Zimbabwe show high levels of feeding preference for small low lying ‘key resources’ areas during the dry season because of greater forage quality (Scoones 1995). Upland grazing areas are preferred during the cropping season.

During this drought period stockposts were 1007 m on average from a water point (range 147 m – 2419 m). The fact that the stockposts were close to an underground water source means that the location of their stockpost is strongly influenced by the drainage lines. During 1998 and 2001 in Paulshoek, stockpost were 868 m on average from a water source (Combrink 2004). Herds during drought spent slightly less than 25 minutes on average at the water point. At the water point the herders allow their animals unrestricted access to water and provided rest.

During the drought period, herds grazed significantly faster in the mornings than in the afternoons. A significant difference was also found in the speed herds grazed in the morning and afternoons in the Richtersveld National Park (Hendricks 2004). In the mornings, the herder wanted to reach a particular destination at a certain period of time, and therefore moved faster. After visiting a water point herds are more relaxed and graze at a slower pace. Herders know this behaviour in the animals and this might be the reason why most of the herders in Paulshoek adopt a delegatory leader strategy where they only herd up to the water point. Herders know that when the animals are excited in the mornings, the animals will eat toxic plants because they are hungry.

A herd grazes an area of 90.8 ha per day on average during the drought. Approximately 63 % of the area is grazed in the morning and 37 % of the area is grazed in the afternoon. The total area grazed by the 24 herds was 2 179.2 ha per day during the drought. This means that if the area was grazed evenly, about 11 %

of the 20 000 ha of the Paulshoek Commons was grazed every day. This in turn indicates that the same area was grazed at least every ten days during the drought assuming the rangeland is used evenly. However, some areas in the rangeland especially the mountains were more preferred than the surrounding lowlands (Fig 6.3). This means that the mountains were actually more heavily grazed than the lowland areas. However, continuous grazing of the mountains should not be viewed as a result of bad farming practices, but because there was no forage available on the lowlands.

6.5.2 Comparison of daily grazing routes of herds during and after the drought

The availability of water and forage are among the factors that guide livestock keepers in the location of stockposts in Namaqualand (Hendricks et al. 2005). During this study there was no significant difference between distance of the stockposts from the water point during or after the drought. It may be that the Paulshoek communal area has an overwhelming abundance of water points, since wherever the herders in Paulshoek establish their stockpost; they will still be less than three kilometers from a water point. Other pastoralists in Africa specifically move their herds closer to water sources during the dry season so that their animals could be watered regularly (Bassett 1986; Sieff 1997; Hendricks et al. 2005).

During the drought herders mentioned that the animals were too weak to walk far. This may also be the reason that there were no significant differences between distances covered during the drought, when forage resources were scarcer, and after the drought. Different grazing patterns were observed in other parts of Africa where cattle herds expand (Sieff 1997) or sometimes double (Bassett 1986) the length of their daily grazing routes when forage resources are scarce. Different traveling distances of livestock in Namaqualand during dry seasons were also attributed to differences in food availability and quality (Hendricks et al. 2005).

The grazing orbits of all the herds during and after the drought were not significantly different. Home ranges of kangaroos and ungulates similarly do not change when resources become scarce (Wickstrom et al. 1984; Viggers & Hearn 2005). These herbivores maximize their food intake by grazing at a slower pace rather than increasing their home range. Other biotic factors such as an increase in population density (Viggers & Hearn 2005) and a decrease in vegetation cover that causes greater visibility for predators (Tufto et al.1996) cause these animals to increase their home range. However, other studies have shown that domestic animals (Berman & Jarman 1967; Hodder & Low 1978; Lawrence et al. 1988) and wildlife (Hulbert et al. 1996; Tufto et al. 1996) increase their home range due to a decrease in food availability.

Social relationships between herders rather than resource availability better explain the distribution of the home ranges of the herds in Paulshoek. Herders did not want to expand their home range in an effort to avoid other herds. Avoiding other herds prevents animals from mixing, competing for the same resources and spreading diseases. Fulani herders in West Africa adopt the same management strategy by moving their herds to areas with lower livestock densities (Bassett, 1986). Resource partitioning is also displayed by free-ranging domestic stock when they graze different areas of the same pastures or graze the same areas but at different times (Bailey et al. 2004). However, herders in Paulshoek also believed that they may not reach better food sources by grazing further from the stockpost because these are limited on the rangeland.

Mountains were more used by the herds than the surrounding flatlands during the drought. This pattern persisted after the drought. This can be explained by the low levels of ephemeral plant growth, which makes up the dominant grazing resource on the lowlands, following the late winter rains. Ephemeral growth in Namaqualand is usually at its best if good rains fall in the autumn period (van Rooyen 2002).

A difference was found in the speed herds grazed in the morning and afternoons in the Richtersveld National Park (Hendricks et al. 2005). In our study herds did not graze significantly faster in the mornings than in the afternoons during and after the drought. This could be attributed to the fact that herds grazed the mountainous areas in the mornings during and post-drought, which made it difficult to graze at a fast speed since they are also moving vertically.

Water points are the foci of all grazing routes irrespective of season (Combrink 2004) or drought. During drought conditions the impact around water points could be considered greater since herds visited fixed more than after the drought period. Forage around the water points is therefore depleted, and these piospheres should be regarded as sacrifice zones. Other water points in the northern parts of the commons and the areas adjacent to it are inaccessible to some herders. This is due to a lack of roads and motorized transport to bring in the herder's supplies.

Herders used the mountainous areas of the commons more than the lower lying areas during and after the drought. The higher elevated areas were considered by the herders as having better forage quality. Croplands were avoided due to the abundance of G. *Africana*. Herders sometimes move their stockpost around in the rangeland and alternate their grazing routes to reduce the impact on vegetation and to ensure that their animals get good quality forage. However, herders are spatially constrained and do not have sufficient options to sustain their animals during drought. Hence, many animals died during the drought since herds have to graze the same pastures continuously. Only in some periods of the year, if sufficient rains have fallen, do herders allow their animals to graze the flats more often than the mountains. Also, when the croplands have been harvested herders allow their animals to graze crop residues. This study therefore presents an accurate description of grazing distribution at all times except after good (autumn) rains and ploughing.

Drought had no impact on the spatial patterns of resource use by livestock on the Paulshoek commons. The lengths of the daily grazing routes were similar between the two monitoring periods. When forage was scarce during the drought, animals were too weak to walk far. The size of home ranges of the herds did not change because herders try to avoid other herds spatially.

The management options proposed by government on communal rangelands are not based on the objectives of livestock keepers. Interventions like fencing and destocking are likely to constrain livestock keeper's responses to poor rainfall further as well as negatively impact on the poorer livestock keepers. It was found that animal die-offs during droughts in dry-season refuges were related to these key resources areas being fenced off (Campbell 1981). Fencing the commons will also deprive other members of the community from accessing resources like fire wood from their own land. Destocking is not an option for land management because herd size does not play a role in grazing distribution. The fact that herds were much smaller after the drought did not manifest into a significantly different area grazed by each herd although the total area grazed was smaller.

One option to manage the communal area in Namaqualand better is to increase communal grazing areas. The Kamiesberg Municipality has acquired additional land for communal farmers but the land is not accessible to all because of a lack of transportation. Therefore, only the richer farmers with their own transport benefits from the new land (Lebert in prep.). Increasing the land adjacent to the commons also mean that farmers may increase their herd's size, but droughts in turn may reduce herd sizes. Another management option is to disperse the grazing pressure more uniformly across the rangeland. This can be achieved by fixing the broken water points rather than establishing new water points as this will cause more piospheres (Lange 1969). However, these water points need to be maintained constantly.

Chapter Seven

Study Synthesis

7.1 Introduction

Management plans for communal rangelands in the semi-arid regions of South Africa (e.g. the division of the Leliefontein Reserve into 'economic units') have been proposed and implemented over the years (Archer *et al*. 1989). These plans have not usually resulted in positive changes in animal production, and are often rejected by the communities. The reasons for this failure are because the perceptions, knowledge and practices of local farmers are not taken into account when management plans are developed. Moreover, the livestock management systems on communal area are not properly understood and, therefore, communal rangelands are often perceived as overgrazed, degraded and unproductive (Scoones 1992).

The aims of this study were to:

1. Examine the agro-ecological knowledge and perceptions of the herders in Paulshoek during a drought period
2. Identify key resource areas for livestock during a drought period
3. Determine the herding strategies used by the herders to manage their livestock during a drought period
4. Determine the grazing patterns of livestock during and after the drought period.

I propose that through an understanding of the livestock keepers' objectives and practices, that more appropriate land use management plans for communal areas can be developed in conjunction with the land users.

During the study a database of local agro-ecological knowledge held by livestock keepers in Paulshoek was developed. This knowledge-database can act as a resource for the planning of future research on rangeland dynamics in the communal areas of South Africa. The knowledge-database covers the livestock keepers' knowledge of rainfall patterns, seasonality, droughts, climate change, plant-animal interactions, carrying-capacity and overgrazing.

This research demonstrated how herders conceptualize their landscape and how they understand the spatial features in their grazing areas. Debeaudoin (2001) identifies that herders employ various herding strategies during a normal rainfall season in the Leliefontein Communal Area. This study outlined the herding strategies herders employed during a drought period in the Paulshoek Commons, which form part of the Leliefontein Communal Area. Thus spatial foraging patterns of livestock in Paulshoek during and after a drought are described. This study correlated daily grazing patterns to abiotic features along their grazing routes; and associated these patterns with the herding strategy used by herders to manage livestock.

7.2 Differences in livestock management practices between drought and non-drought periods

Recurrent droughts are common in Namaqualand (Cowling *et al*. 1999). Since the nineteenth century droughts have occurred every three to six years (Kelso & Vogel 2005). Our research shows that livestock keepers have an understanding of ecosystem processes during drought conditions.

Livestock keepers regard rainfall as the main determinant of rangeland condition and this accords with similar studies (e.g. Fernandez-Gimenez 2001; Debeaudoin 2001) done elsewhere in the world. Even though herders have the opinion that the vegetation dynamics in the Paulshoek rangeland is driven by rainfall, they recognize that livestock can have negative impacts on the environment. Herders, therefore, alternate their grazing routes on a daily basis to minimize the negative impacts of livestock. Livestock keepers regard the alternation of grazing routes as a soil conservation strategy that will reduce wind and water erosion. In addition herders move their stockposts seasonally (Baker & Hoffman 2006). This movement is to allow some grazing areas to be rested; to allow croplands to be ploughed and sowed, and to make optimal use of seasonal forage resources especially on the flatlands after good rains.

Herders identified the water points and the quality (not quantity) of forage as most important to them during drought conditions. Herders view that animals may still die of starvation if they eat a large amount of less nutritious plants because the livestock will not get all the '*krag*' (energy) they need to live. Thus, during drought they guide their animals to areas such as the mountains where the plants are perceived to be greener and more nutritious. The lowlands are infested with G. *africana* and, therefore, not used by herders during drought periods. Herders are also aware of other areas with high abundance of toxic plants, and avoid these areas especially in drought since their animals are seen as more susceptible to eating toxic plants in when hungry. This is because animals are attracted to green plants and during drought conditions, many of the green plants are toxic. Animals may also ingest dry litter of toxic plants because they cannot see this as toxic. Most adult animals know to avoid toxic plants, but the ingestion of dry litter, which may contain toxic plants possibly indicate that the animals are desperate.

Herders vary widely in their representation of spatial features of their landscape. Some herders view the features represented on their cognitive maps as discrete objects, while others view features continuous with each other. Even so all herders possess spatial knowledge of a particular location that allows them to coordinate their activities spatially. They know where they are in relation to other herders, they know where to graze, and they know the least strenuous way to reach a targeted grazing area.

Returning herders, lifelong herders and livestock owners showed more knowledge of ecosystem processes than less experienced herders and, therefore, may have the ability to cope better with drought conditions. Returning herders, lifelong herders and livestock owners acquired their knowledge through their own herding experience, interactions with each other and exposure to other grazing systems on commercial farms, or other commonages. Therefore, their knowledge of managing livestock and treating sick animals is more detailed.

Two main livestock management practices were employed to manage herds during the drought. Herds were either herded by a herder (herded) or allowed to graze freely (free-ranging). Herded herds were managed by leaders, delegatory leaders, selective herders, 'managers if necessary', nomadic herders or part-time herders. Free-ranging herds were composed of goats only and were managed by collectors and caretakers. When goats are left unsupervised they will usually return to the kraal at night, but sheep do not return if they are left alone in the veld. A caretaker was the only type of herder that did not kraal his animals at night. When part-time herders are not herding, their herds also graze on their own.

Herders were innovative in their herd management strategies during the drought. They adopted drought related strategies such as selective and nomadic herding. Selective herding allows for resource partitioning between animal species and also between sick and healthier animals within the same herd. A selective herder would only herd the sheep and leave the goats to range freely. If a herd is split according to animal condition than only the weak animals will be herded. The weak animals prevent the healthier animals from accessing good quality forage on the high elevated areas of the commons.

As another drought strategy, nomadic herding ensures that animals use the underutilized areas of the commons. All the herders are aware of this strategy, but few are willing to move around more extensively. Some herders do not want to be far from their families in the village. Also, the herders that are away from the village have their home base at the stockpost. Therefore, if herders are nomadic then they need to move everything with them by having a mode of transport or they have to do without it.

During the drought, the mountains were used more than the flatlands. This is because the forage quality on the mountains was perceived by the herders as better than on the flatlands. The mountains acted as forage refuges during the drought and these areas are perceived by the herders as the 'capital' to push herds through a drought period. Water points were also more regularly visited by herds during the drought because the dry forage animals had to graze does not provide sufficient moisture in their diet. However, during the drought there was not an increase in resources used since herds did not graze significantly larger areas after the drought. This is because herders try to avoid each other to allow each other enough space to graze and to prevent animals from mixing. Animals were also too weak during the drought to walk far distances to optimize their forage intake.

7.3 Management implications of this study for livestock management on communal farms

7.3.1 Goats and Sheep

There is a diversity of practices that herders employ to manage their livestock during drought conditions. Some of these practices are used during non-drought years, but others can be regarded as adaptive management strategies. This suggests that livestock keepers think that there is not a single livestock management strategy that works best under drought conditions. Even though this study does not show the efficiency of each management practice in terms of animal productivity, I would argue that the practices of livestock keepers in general are not unproductive. This is because they meet their objectives of livestock farming, which are not profit maximization. Owning livestock in communal areas ensures cultural identity, self-respect and elevated status in the community (Debeaudoin 2001). Livestock also has a savings function where livestock can be sold in times of financial crises (Debeaudoin 2001; Ainslie 2002). However, livestock keepers do not meet the savings objective during drought since the animals die or the conditions of the animals are too poor to be sold. This is because of a lack of quality forage during drought conditions.

There is no evidence that the practices of livestock keepers in the Leliefontein Communal Area have led to an extinction of any plant species. By using the literature, I argue (Chapter Two) that their practices have not led to land degradation even though the Paulshoek Commons has been stocked on average at twice the recommended stocking rate for the last 30 years (Rohde *et al*. 2001).

In view of the fact that communal farming practices are perceived as unproductive and leading to desertification and loss of biodiversity, there has not been great support from government institutions to promote and sustain traditional livestock management practices (Allsopp *et al*. 2003). This is because agricultural services do not understand the objectives and practices of livestock keepers. In consequence of the ignorance on the part of support services, the impact of their farming methods are often confused with the impact of too many animals on the commons. There are too many communal farmers that have to make an existence from limited land and herders are spatially constrained. They do not have sufficient options to sustain their animals especially during drought. Therefore most animals died during the drought since herds have to graze the same pastures continuously. The fact that most animals died during the drought is in accord with the opinions of the livestock keepers that non-equilibrium factors drive the animal production system in Paulshoek.

In addition to the lack of support from government, the existence of communal framing practices globally are threatened by factors such as:

- Human population increase which forces more people to use commonages
- The privatization of communal land by a few elites
- The increased pressure to declare large rangelands as protected areas especially in Africa
- Climate change where some areas in Africa are hypothesized to become more arid

The future of traditional farming practices will depend on political decisions by governments in countries with extensive rangelands. In South Africa, various policies have recently been implemented to support agriculture in communal areas. These include the Land Redistribution for Agricultural Development Programme (LRAD) and AgriBEE. These policies aim to produce black commercial farmers and ensure that 30 % of agricultural land is owned by black

South Africans. Then again, South Africa government policies are sometimes conflicting because through the Communal Land Rights Act, Act 11of 2004, government wants equitability on communal lands but the system of gazing management proposed on the new farms in Leliefontein only benefit a few elites.

7.3.2 Donkeys

Donkeys are seen by livestock keepers in Paulshoek as a major problem (Chapter Three). During 2002, before the drought, about 183 donkeys were counted in the Paulshoek Commons (Johannes 'Vonkie' Claassen pers. comm. 2003) and during 2005 approximately 243 donkeys were counted in Paulshoek. Some people own donkeys that they use for pulling carts and ploughing. Livestock keepers have realized that wild donkeys threaten their existence because donkeys are destructive feeders (Chapters Three) and compete with livestock for good quality forage during drought (one donkey eats the equivalent of seven SSU (Vetter 1996). In my opinion donkeys are robbing the livestock keepers of the opportunity to keep more productive livestock during drought conditions.

A solution to alleviate the donkey problem in Paulshoek is to sell the feral donkeys. On a few occasions, the community sold feral donkeys but at a low price (about R80 to R100 whereas more than R500 can be obtained for one goat). However, due to the difficulty in catching a wild donkey, the low price that the donkeys are sold and the fact that people often claim ownership of donkeys after they have been caught make it difficult to sell donkeys frequently. Livestock keepers are also aware that if the donkey population is reduced in only one communal area such as Paulshoek, feral donkeys from other commonages such as Nourivier (Fig 2.2) will move to Paulshoek since the boundaries between the commonages are not fenced. Therefore, livestock keepers do not have the capacity to reduce the donkeys on their own. They need the help of researchers and agricultural extension services to facilitate this process.

7.4 Recommendations for future studies on livestock management on communal rangelands

Livestock farming is not the only land use in Paulshoek. In order to assess the impact of land use on the rangeland, the patterns of resource use by donkeys and other land uses like reed, fire wood, and medicinal plant collectors should also be mapped. This is to determine the relative impacts of each land use on the biophysical environment. The foraging patterns of donkeys should be studied to determine their impacts on the rangeland. This is to determine how many donkeys can be kept on communal areas without damaging the rangeland. Then, the donkey population should be managed in accordance with the livestock population and rainfall.

The uses of adaptive management strategies by livestock keepers during the drought (Chapter Five) show that they may be willing to test innovative ideas regarding natural resource management in communal areas. This may include the testing of alternative land use options or the implementation of an integrated land use management that has been comprehensively developed between the land users, municipality, scientific community and the Department of Agriculture. The main objective of this plan should not focus on attempting to change their land use practices but to promote management practices are suited for the different circumstances of the various land users.

According to government policy on land redistribution more land still has to be made available for communal use in the Northern Cape. This may lead to greater flexibility in existing farming systems where nomadic pastoralism can even be practiced. An ideal grazing system in the Leliefontein Communal Area would be to return to the seasonal migration of both livestock and wild animals. This can be achieved if more land is purchased in the summer rainfall areas in Bushmanland so that livestock keepers can practice transhumance between the seasonal grazing resources. This can only be achieved if livestock keepers are willing to move over greater distances and if they want to be away from their families for longer periods.

Therefore, research has to be conducted to determine whether livestock keepers are willing to move between seasonal grazing areas. If the livestock keepers want to move seasonally, what spatial patterns do they have to follow? Will there be enough forage and water for the animals? If alternative water sources should be needed, where along their migratory route should they be established? What are the costs and benefits of this transhumant pattern in terms of rural livelihoods and land use impacts? Local livestock keepers have the knowledge to monitor the condition their animals and their local environment therefore they should be the people developing the management plans. Researchers are only needed to facilitate the process maybe and to help provide solutions to their constraints.

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Appendix One: Checklist of questions used in field interviews to stimulate conversation with stakeholders.

Rainfall patterns

- How many seasons are there in Paulshoek? Name and describe them?
- Have the seasons shift over the time you have been herding? Why?
- When, why and how does drought occur?

Rangeland condition

- What determines rangeland condition? How?
- Are livestock, donkeys, wildlife and jackals important for the rangeland? Why or why not?
- How does the condition of the rangeland in terms of plant palatability, plant diversity and forage availability differ during drought from that of a normal rainfall year?
- What do you regard as the carrying capacity of Paulshoek rangeland for small stock?
- Can livestock cause overgrazing? If yes, How?

Livestock management

- Why do you have this herd composition?
- What criteria do you use when choosing your daily grazing routes?
- Why do you herd your animals?
- What is a good herder?
- How do differently do you manage your herd during drought conditions and good rainfall years?

Appendix Two: Key forage species consumed by livestock during the drought as identified by livestock keepers.

Key forage species during drought			
Common name	**Scientific name**	**Family**	**Growth form**
fluitjiebos	*Lebeckia multiflora* E. May	Fabaceae	Mid-high deciduous shrub
jeukbos	*Hermannia disermifolia* Jacq.	Sterculiaceae	Mid-high deciduous shrub
kirriedoring	*Lycium ferocissimum* Miers	Solanaceae	Low deciduous shrub
perdebos	*Didelta spinosa* (L.f.) Aiton	Asteraceae	Mid-high deciduous shrub
skaapbos	*Tripteris sinuata* D.C.	Asteraceae	Low deciduous shrub
taaibos	*Rhus undulata* Jacq.	Anacardiaceae	Mid-high evergreen shrub
xhibbiebos	*Selago* L. *Eriocephalus ericoides* (L.f.) Druce *Hirpicium alienatum* (Thunb.) Druce	Selaginaceae Asteraceae Asteraceae	Low evergreen shrub Dwarf evergreen shrub Low evergreen shrub
t'nouroebos	*Ruschia robusta* L. Bol. *Leipoldtia* L. Bolus	Mesembryanthemaceae Mesembryanthemaceae	Mid-high shrubs
t'noutsiama	*Cheiridopsis denticulata* (Haw.) N.E. Br.	Mesembryanthemaceae	Low perennial succulent
voëlentbos	*Viscum capense* L.f.	Viscaceae	Mistletoe
skilpadbos	*Zygophyllum meyeri* Sond.	Zygophyllaceae	Mid-high deciduous shrub

Appendix Three: Similarities between the perceptions of herders on different landscape features during a drought period in Paulshoek. (LEH – Less-experienced herder; LLH – Lifelong herder; RH – Returning herder)

Herding experience	LEH	RH	RH	LLH	RH	LLH	RH	LEH	LLH	RH	LEH	LLH	RH
Herd number	1	23	11a	22	20	17	16	10	3	11b	12	14	5
Stockposts													
Water points													
Roads													
Mountains													
Toxic areas													
Stockposts of other herders													
Croplands													
Koppies													
Rivers													
Rivers accurately described													
Roads accurately described													
Water storage facility													
Koppies accurately described													
Flatlands													
Paulshoek Village													
Mountains accurately described													
Croplands accurately described													
Boundary fences													
Good forage quality areas													
Flatlands accurately described													
Linkage between features													
Water points of other herders													
Kraal													
Village accurately described													
Rocky ledges													
Moedverloor animal exclosure													
Houses													
Threshing floor													
Ram camp													
Dirk's camp													
Trees													
Kamiesberg Mountain													

- A black block indicates that the feature was represented on the herder's cognitive map.
- A red block indicates that the feature was more or less accurately drawn on the cognitive map.

Appendix Four: Matrix of livestock management practices by herders during a drought in Paulshoek. A shaded block indicates that the herder uses the management strategy.

Herd number	**1**	**5**	**6**	**16**	**3**	**8**	**9**	**10**	**11**	**13**	**17**	**14**	**18**	**12**	**2**	**4**	**7**	**22**	**20**	**19**	**23**	**21**	**24**
Herder treats sick animals in the morning	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
Herder feeds animals in the morning	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
Dogs present in herd	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■				
Avoid toxic areas always during grazing period	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					
Dogs used for hunting	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		■				
Herd comprises of goats and sheep	■	■	■	■	■	■	■	■	■	■	■	■	■		■	■	■	■					
Herd always herded	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					
Herder collects herd afternoon	■	■	■	■	■	■	■	■	■	■	■	■	■	■					■	■	■	■	
Herder destroys toxic plants	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■						
Herder returns to kraal alone from water point	■	■	■	■	■	■	■	■	■	■	■	■	■	■		■			■				
Herder changes grazing route daily	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			■					
Herder chooses grazing route	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■								
Herd always graze the mountains in the morning			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■						

Used more than one stockpost during drought																							
Kraal sheep and goats together																							
Herd has three or more owners																							
Kids remain at the kraal during the day																							
Full-time herder has more than 20 years herding experience																							
Have more than three grazing routes																							
Full-time herder returned to herding after retirement/retrenchment																							
Animals rest after drinking water																							
Full-time herder has less than 10 years herding experience																							
Herder collects forage for kids at kraal																							
Co-herders used																							
Herd comprises of sheep																							
Dogs used in herd management																							
Kraal sheep only																							
Sheep and goats graze separately																							
Only sheep are herded																							

Herd comprises of goats only																		
Herder does not stay with the herd at all during grazing period																		
Herder only checks up on herd only 2-3 times a week																		