

**AN ASSESSMENT OF CARACAL POPULATION DENSITY AND HUMAN-PREDATOR
CONFLICT IN THE WINTERBERG, EASTERN CAPE, SOUTH AFRICA**

A thesis in fulfilment of the requirements for the degree of

MASTER OF SCIENCE
of
RHODES UNIVERSITY

By

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February 2012

“Sate sanguine divum, Tros Anchisiade, facilis descensus Averno: noctes atque dies patet atri ianua Ditis; sed revocare gradum superasque evadere ad auras, hoc opus, hic labour est.”

Virgil, Aeneid, VI, 126

ABSTRACT

Human-wildlife conflict frequently involves carnivores, mainly because of their large home ranges and dietary requirements. As such, carnivores tend to be the first animals to be lost in human-dominated ecosystems. This is significant because the removal of carnivores can alter the functionality of ecosystems. However, the conservation of carnivores depends as much on the socio-political and socio-economic landscapes as it does on the ecological one. The consolidation of vast, un-fragmented conservation areas in Africa and the world is unlikely. Thus, unravelling the factors (both biological and sociological) responsible for and influencing human-predator conflict is critical for carnivore conservation. The Winterberg district in the Eastern Cape, South Africa has been a sheep (*Ovis aries*) farming stronghold for nearly 200 years. Consequently, conflict between farmers and predators is commonplace and depredation of livestock by caracals (*Caracal caracal*) remains a perennial problem. However, the extent of this human-predator conflict (including a reliable assessment of caracal density) has not been quantified. This study used camera trapping to estimate the density of caracals (a non-individually recognisable species) in the Winterberg and a structured questionnaire to gauge the general attitudes of the farmers of the region.

Caracal density was estimated to be 0.20 caracals/km². This estimate equates to a population of approximately 54 caracals across the entire district. Therefore, caracals do not appear to occur at high densities in the Winterberg. However, the survey of the residents of the Winterberg Conservancy revealed that predators were rated as the greatest problem faced by farmers in the

area. Although not significant, it also showed that the size of a respondent's property and sheep mortality due to caracals had the greatest probability of affecting attitudes towards predators. The farmers lost less than 10% of their stock to caracal depredation on an annual basis. Therefore, the general perception that predators were the most important factor in stock loss in the area does not appear to be fully supported by my data. The Winterberg is a male-dominated, multigenerational society and it is likely this propagates certain perceptions towards predators which are a reflection of long-held family traditions and beliefs. Such situations can result in reactions which are disproportionate to the actual scale of the problem. However, my study was limited to a sub-set of the landowners in the Winterberg. Thus, more intensive assessments of caracal space use and community attitudes towards predators are recommended.

TABLE OF CONTENTS

ABSTRACT.....	I
TABLE OF CONTENTS.....	III
ACKNOWLEDGEMENTS.....	V
CHAPTER 1: GENERAL INTRODUCTION.....	1
1.1 General description	
1.2 Distribution	
1.3 Conservation status	
1.4 Human-predator conflict	
1.5 Motivation for study	
CHAPTER 2: DESCRIPTION OF THE STUDY SITE.....	11
2.1 General	
2.2 Historical background	
2.3 Climate	
2.4 Vegetation	
2.5 Geology and topography	
CHAPTER 3: CAMERA TRAPPING INVENTORY AND AN ESTIMATION OF THE CARACAL POPULATION IN THE WINTERBERG.....	23
3.1 Introduction	
3.2 Materials and Methods	
3.3 Results	
3.4 Discussion	

CHAPTER 4: DETERMINING BASELINE DEMOGRAPHIC DATA AND ATTITUDES OF FARMERS IN THE WINTERBERG, EASTERN CAPE, SOUTH AFRICA, TOWARDS CARACAL.....	61
4.1 Introduction	
4.2 Materials and Methods	
4.3 Results	
4.4 Discussion	
CHAPTER 5: SUMMARY AND CONCLUDING REMARKS.....	105
5.1 Estimation of caracal density and mammalian species inventory	
5.2 An assessment of the human-predator conflict through surveying the farmers in the Winterberg conservancy	
5.3 Management strategies for the Winterberg Conservancy	
5.4 Human-predator conflict: a South African perspective	
CHAPTER 6: REFERENCES.....	111
APPENDICES.....	133
Appendix A	
Appendix B	
Appendix C	
Appendix D	

ACKNOWLEDGEMENTS

I would like to gratefully acknowledge the following organisations and individuals for their contribution to this study:

- My supervisor, Dr Dan Parker thank you for all the time, effort and guidance you have put into this study.
- Rhodes University and National Wool Growers Association in particular Cape Wools for funding this research and logistical assistance.
- The Henderson Scholarship Prestigious Scholarship from Rhodes University and the National Research Foundation Prestigious and Equity Scholarship for personal funding over the last two years.
- The Winterberg Farmers' Association for all their support of this project and access to records.
- The Phillips' family: Malcolm, Cheryl and Rowan thank-you for all logistical assistance, accommodation, data and friendship. Thank-you for always being ready with a much needed braai and beer!
- Jane and Brian Nel thank-you for the accommodation and the support.
- Mark King, Larry King and Andrew Pringle for the use of their farmland for this project and the advice and logistical support.
- To my intrepid field assistants, a large proportion of this work would not have been possible without your help: Armand Kok, Sean Linkermann, Jessica Watermeyer, Andrea Parker, Adriano Mendes, Drs. Louise Allan, Benjamin Price, Ryan Young, Charlene Bissett. Thank-you for always bringing a positive attitude, ludicrous amounts of physical

strength, great music or conversation when in 'Creamy' and I only had to bribe you with fishing and wine.

- Armand Kok, your GIS genius and saintly patience for that programme was completely vital not to mention admirable. I cannot thank you enough for all your help in map creation and for calming me down when I wanted to hurl my computer out of the nearest window.
- Tanith Grant, for all your camera trapping knowledge and for being there when a moan about broken collars was required, a great person to vent to. Sometimes we just need to swallow a spoon of concrete, and harden up!
- My beloved friend and traveller on this journey, Jessica Watermeyer. We've been office mates for three years and you were my partner in crime for this study. We've laughed together, raged together, carried millions of traps together, impersonated animals together and been completely exhausted together and we still like each other. Amazing. Real pain for my sham friends and champagne for my real friends! So let's (finally) raise a glass in celebration and here's too many more years.
- To my sister, thank you for all the love, support and long distance phone calls. You are so good and dissecting the crazy that pours out of my brain and making me laugh at myself not to mention motivating me with a opportunity for working for you (ha ha). Here's to 2012 with Mrs Liebermann.

- Finally, to my parents. Coleridge wrote an epitaph for John Donne that talks about his ability to ‘wreath iron pokers into true love knots’ if anyone turns cold iron into love into joy it is you. Without you I could never begin to understand the almost otherworldly interaction of truth and beauty and the intrinsic marriage between the two, which is the essence of existence. For this, I can never thank you it is a gift beyond words. But I will endeavour to embody everything you taught me and continue to teach me. For a lifetime of laughter, arguments, sharing passions, beauty and unfaltering love, I thank you.

CHAPTER 1: GENERAL INTRODUCTION

1.1 General Description

Caracals (*Caracal caracal*) were first described by Von Schreber in 1776 from a specimen from Table Mountain in the Western Cape, South Africa. Initially, due to morphological resemblances, caracals were taxonomically classified with the lynxes (*Lynx* spp.). However, Werdelin (1981) found no phylogenetic relationship between the two species and caracals were thus reclassified into the genus *Felis*. However, they have since been grouped in the monotypic genus, *Caracal* (Wozencraft 1993).

The caracal is a solitary cat of medium build with females, on average, weighing 12kg and males, 15kg (Bothma & Walker 1999; Skinner & Chimimba 2005). Their coat has no distinctive markings but differs in colouration in different habitats: pale-reddish for animals from semi-desert areas to sandy-brown to brick red for animals from areas of higher rainfall (Skinner & Chimimba 2005). All animals have darker guard hairs along the back and white hair around the eyes and chin. The name caracal is derived from the Turkish and Uzbek words *karakulak* meaning 'black ear' as it is the distinctive black, tufted ear tips that identify caracals (Bothma & Walker 1999). Other notable features are their large paws. Each paw has strong, heavily built claws that are fully retractable. Caracals also have short, strong tails, instrumental in balance and control when jumping to catch prey (Bothma & Walker 1999).

Caracals are extremely agile and quick predators and can make fast dashes towards prey and often leap to catch airborne prey (Skinner & Chimimba 2005). Caracals are hunter-killers and

tend to use speed and surprise to ambush prey (Bothma & Walker 1999). They are generally believed not to return to kills in farming areas where they are persecuted (Bothma & Walker 1999). However, they sometimes return to kills in protected areas (Stuart & Hickman 1991). Caracals rarely scavenge but in resource limited situations, scavenging can occur (Stuart & Hickman 1991; Avenant 1993; Bothma & Walker 1999).

Caracals have poorly developed lower incisors, with a large diastema between the canines and molars allowing for deep, penetrative bites (Skinner & Chimimba 2005). This dentition, coupled with a tall coronoid process and thick zygomatic arch, allows for an extremely powerful bite (Skinner & Chimimba 2005). Caracals tend to kill their prey with a bite on the nape of the neck or the blood-supply rich area of the hindquarters (Bothma & Walker 1999; Skinner & Chimimba 2005).

Table 1.1: A summary of four South African studies that analysed caracal diet. MZNP = Mountain Zebra National Park; KNP = Kruger National Park; Robertson, Western Cape; WCNP= West Coast National Park, Western Cape.

Study area	MZNP ¹	KNP ²	Robertson, Karoo ³	WCNP ⁴
Prey species				
Artiodactyls	23.6	22	10.9	2.3
Domestic stock	-	-	16.8	-
Hyrax	53.3	17	9	1.8
Rodents	5.3	30	50	71.7
Hares	10.6	15	5.2	1.7
Carnivores	0.9	2	2.9	1.9
Total (%)	93.7	86	94.8	79.4
<i>n</i>	200	100	248	391

1. Grobler (1981)
2. Palmer (1985)
3. Stuart & Hickman (1991)
4. Avenant & Nel (2002)

Caracals tend to have a diet dominated by natural prey when they inhabit protected areas (Table 1.1)(MZNP, KNP and WCNP). In these three protected areas, domestic stock did not feature in the diet of caracals (Table 1.1). In MZNP, the caracals' diet was dominated by hyraxes (53.3%) (*Procavia capensis*) and artiodactyls (23.6%) (Table 1.1). In the KNP, caracal diet was dominated by rodents (30%) and artiodactyls (22%). For the WCNP, caracal diet was overwhelmingly dominated by rodents (Table 1.1). The only study conducted on farmland (Robertson, Karoo) showed that rodents made up 50% of the diet and artiodactyls and domestic stock made up 10.9% and 16.8%, respectively (Table 1.1). The review of these dietary studies emphasizes the broad dietary spectrum and adaptive nature of the caracal (Skinner & Chimimba 2005).

1.2 Distribution

Caracals are the most widely distributed felids in Africa, distributed across the entire southern African region and the tropical forest areas in the Democratic Republic of Congo (Figure 1.1). Their distribution extends to the margins of the Sahara desert, Morocco, Egypt, Sudan, Ethiopia, Somalia, Mauritania and northern Niger (Stuart 1984, Skinner & Chimimba 2005). The distribution of caracal also extends to the Middle East and includes eastern Turkey, Israel, United Arab Emirates, Syria, Iraq, Iran, the deserts of Turkmenistan, the area surrounding the Sea of Aral, Afghanistan, northern Pakistan and northern and central India (Figure 1.1). Consequently, caracals have a wide habitat tolerance and in South Africa they occur in savannah woodland, coastal sandveld and the Karoo (Skinner & Chimimba 2005).

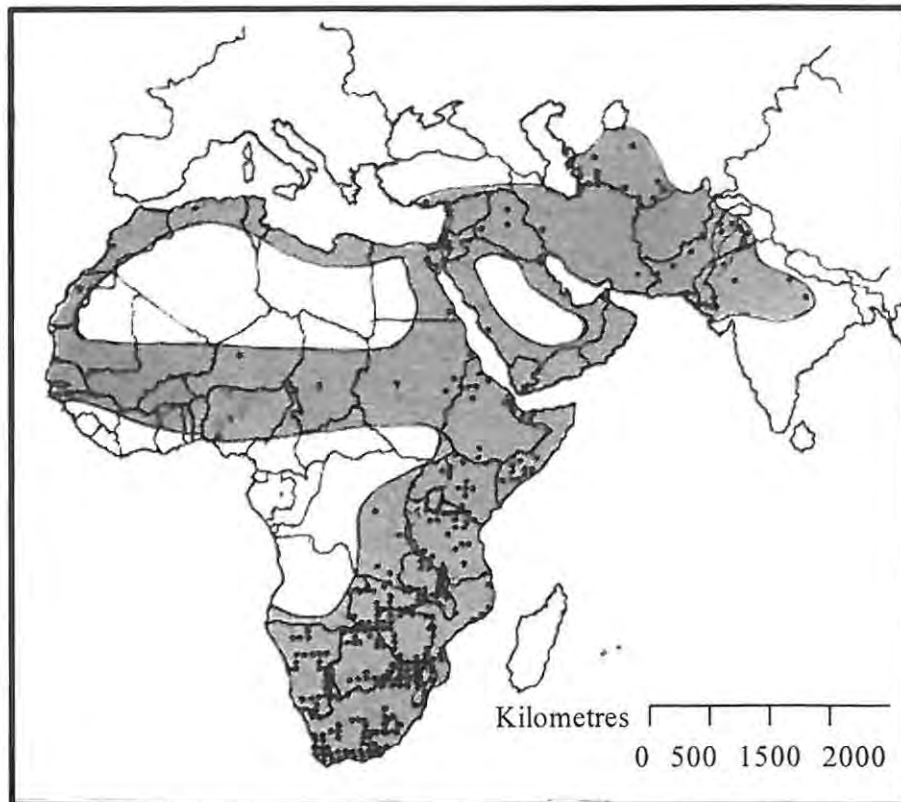


Figure 1.1: The distribution of caracals in Africa, the Middle East and Asia. The shaded region is the known range and the dots are indication of definite records of caracal in those areas (Stuart 1984).

1.3 Conservation status

The International Union for Conservation of Nature (IUCN) has categorised caracals as a species of least concern (IUCN Redlist 2008). Caracals are of least concern because they remain widespread and relatively common throughout southern and eastern African, with only minor range losses in northern Africa (IUCN Redlist 2008). Caracal populations that are

of conservation concern are those residing in Asia due to habitat destruction through agriculture and desertification (Ray *et al.* 2005).

Despite caracals being a species of least concern, there are two major threats to their populations: the systematic removal of animals in response to predation on livestock, and habitat loss (Stuart 1982; Norton & Lawson 1984; Avenant & Nel 1998; Avenant & Nel 2002; Ray *et al.* 2005). The threat of habitat destruction is significant where caracals are naturally sparsely distributed e.g. central, west, north and northeast Africa (Ray *et al.* 2005). However, it is the continued human-predator conflict between these animals and livestock farming communities that is currently of greatest concern for the southern African population (IUCN Redlist 2008).

1.4 Human- predator conflict

There is a worldwide trend of declining carnivore populations due to a number of direct and indirect interactions with humans (Patterson *et al.* 2004; Woodroffe & Frank 2005). Carnivores often have large home ranges, relatively low reproductive rates and high energy demands (Thirgood *et al.* 2005). These characteristics make carnivores extremely vulnerable to habitat fragmentation, which can occur through the conversion of natural landscapes to agricultural lands (Thirgood *et al.* 2005). This indirect effect of the growing human population and expansion is a serious threat to carnivores worldwide (Woodroffe & Ginsberg 1998; Patterson *et al.* 2004). Another threat to carnivores is the conflict that arises due to carnivore and human interaction (Treves & Karanth 2003). A survey of carnivore researchers revealed that livestock depredation by carnivores is the most frequently cited (40%) cause of

human-predator conflict (Sillero-Zubiri & Laurenson 2001). Carnivores have a protein-rich diet and large home ranges. These requirements bring them into competition with humans who are using the same resources (Woodroffe & Ginsberg 1998; Treves & Karanth 2003). Additionally, the expanding human populations and decreasing natural areas increase the encounter rate between humans and carnivores (Patterson *et al.* 2004). It is the killing of livestock and its economic consequences that yields the greatest conflict (Treves & Karanth 2003). The responses to these losses include eradication programmes, regulated harvests of predators for financial gain (this applies to trophy species such as lions (*Panthera leo*), tigers (*Panthera tigris*) and leopards (*Panthera pardus*) and preservation of enigmatic species such as tigers (Treves & Karanth 2003).

Society has a complex and often contentious relationship with charismatic felid species such as the caracal (Loveridge *et al.* 2010). On the one hand, cats are enigmatic, key ecosystem components and can become flagship species for conservation projects (Loveridge *et al.* 2010). On the other hand, habitat fragmentation, habitat loss, and the conversion of suitable habitats to livestock-based agriculture results in a negative interaction between people and felids (Loveridge *et al.* 2010). This negative interaction is the product of felids inhabiting areas where a large proportion of the ungulate biomass is made up of domestic stock (Loveridge *et al.* 2010). Therefore, predation occurs on livestock either through increased encounter rates or by domestic livestock providing a more rewarding source of food from an energetic perspective (Woodroffe *et al.* 2007). This is because livestock can be more regularly encountered than natural prey items, and the energy required to capture and handle livestock is less than for natural prey (*sensu* the optimal foraging theory) (Pyke 1984;

Loveridge *et al.* 2010). Generally, the smaller felid species such as the serval (*Leptailurus serval*) and the African wildcat (*Felis silvestris*) may occasionally prey on livestock but not to the extent where significant economic losses are incurred by the livestock owner (Loveridge *et al.* 2010). Loveridge *et al.* (2010) suggest that the felids which regularly prey on livestock range from the size of a caracal (~12kg) to that of a tiger. Smaller felids such as caracals tend to prey on smaller livestock such as sheep (*Ovis aries*) and goats (*Capra aegagrus hircus*) and rarely resort to mass killing (Avenant & Nel 2002; Loveridge *et al.* 2010).

The National Wool Growers Association of South Africa (NWGA) estimates that predation on sheep in South Africa costs the sheep farming community R1 billion per year (de Wet 2008). Caracals are one of the perpetrators of predation on livestock and this predation has led to extensive persecution of caracals by farmers throughout southern Africa, and to the classification of these animals as problem animals in both South Africa and Namibia (Marker & Dickman 2005). This perception and livestock depredation has caused the systematic removal of caracals in large numbers. For instance, between 1931 and 1952, over 2000 caracals were killed in the Karoo, South Africa (Marker & Dickman 2005). In the Eastern Cape, sheep farming is an integral part of the provincial economy and ultimately the South African economy (Roux & van der Vyver 1988). In the financial year 1980/1981, the sheep farming industry produced an income of R139 million, which contributed 79%, 56% and 8% of the mohair, wool and mutton industries respectively (Roux & van der Vyver 1988). It is clear that the sheep farming industry is of great economic importance in the Eastern Cape, and predation on sheep is putting considerable financial pressure on this industry.

1.5 Motivation for the study

The Winterberg region of the Eastern Cape, South Africa, is a sheep farming stronghold (Klug *et al.* 1999; The Wool Growers Association of South Africa 2011). All the farmers of the Winterberg are reliant on sheep farming as their primary source of income (M.King, Head of the Winterberg Farmer's Association 2010, pers. comm.) and any predation on sheep results in an economic loss for these farmers (de Wet 2008). Therefore, it is essential to independently assess the problem of human-predator conflict in this important sheep farming area.

There are several studies on caracals in South Africa (Pringle & Pringle 1978; Pringle 1981; Stuart 1982; Norton & Lawson 1984; Stuart & Hickman 1991; Stuart & Stuart 1992; Bothma & Le Riche 1994; Avenant & Nel 1998; Avenant & Nel 2002; Marker & Dickman 2005). However, most of these studies have been conducted in protected areas, including the Kalahari Gemsbok National Park (Bothma & Le Riche 1994), the West Coast National Park (Avenant & Nel 1998, Avenant & Nel 2002), Mountain Zebra National Park (Grobler 1981; Moolman 1984) and the Karoo National Park (Palmer 1985) with limited work on farmland area (Pringle & Pringle 1978; Stuart & Hickman 1991; Norton & Lawson 1985). Stuart & Hickman (1991) limited their study on farmland to an analysis of scats and stomach contents. Norton & Lawson (1984) collared two male caracals in the Stellenbosch mountains and estimated home range size. Pringle & Pringle (1978) conducted a broad study on the morphology and diet of caracals killed in an area which included the Winterberg. However, the data for the Winterberg were sparse (Pringle & Pringle 1978). Importantly, no study has been undertaken in the Winterberg region to investigate human-predator conflict on a fine

scale or to estimate the population size of caracals in the area. Furthermore, to date, the activity, density and role of caracals in human-predator conflict remains largely unstudied in South Africa. It is therefore, extremely difficult to assess the conflict situation that has arisen between livestock farmers and caracals. Moreover, worldwide data concerning the population dynamics and severity of human-predator conflict for small predators are generally lacking (Inskip & Zimmerman 2009).

Given the economic importance of livestock to the Winterberg (Pringle & Pringle 1978) and the limited data on the role of caracals in human-predator conflict, it is essential to gather baseline data for the Winterberg. This baseline data will contribute to the collection of research on caracals of which much of their biology, habits, role in human-predator conflict and population trends are poorly understood and studied, particularly for non-protected areas. The purpose of this study was to generate an estimate of the number of caracals in the Winterberg area using camera trap photographs and a model for the estimation of non-individually recognisable animals (Rowcliffe *et al.* 2008). The camera trap data will also be used for compiling an inventory of naturally occurring wildlife in the area. Furthermore, the study aimed to collar caracals in the area in order to determine their home range. However, this was hindered by only capturing one animal which was not relocated (Appendix A).

An assessment of the predation of caracals on sheep was also made by interviewing all the members of the Winterberg Farmer's Association. These surveys aimed to determine the general attitudes of the farmers in the area towards caracals, and hence produce an assessment of the caracal based human-predator conflict in the Winterberg area.

CHAPTER 2: DESCRIPTION OF THE STUDY SITE

2.1 General

This study was conducted in a farming district, the Winterberg Conservancy, which is in the Great Winterberg, Eastern Cape, South Africa. The Great Winterberg is an extensive east-west mountain range forming part of the Great Escarpment of South Africa. This district lies north of Adelaide (32°42'01.86" S; 26°17'59.80"E) and Bedford (32°40'59.91"S; 26°05'00.50"E) and east of the town Tarkastad (32°00'22.32"S; 26°15'39.17"E)(Figure 2.2).

The Winterberg Conservancy was established by the farmers of the area in 2000 and encompasses an area of 713.41km² (Figure 2.2). The aim of the Conservancy is to sustain and preserve the naturally occurring wildlife in the area and control the hunting of wildlife (C.Phillips, pers. comm.). The farms that comprise the Winterberg Conservancy are used for grazing livestock: sheep (*Ovis aries*) and cattle (*Bos domesticus*).

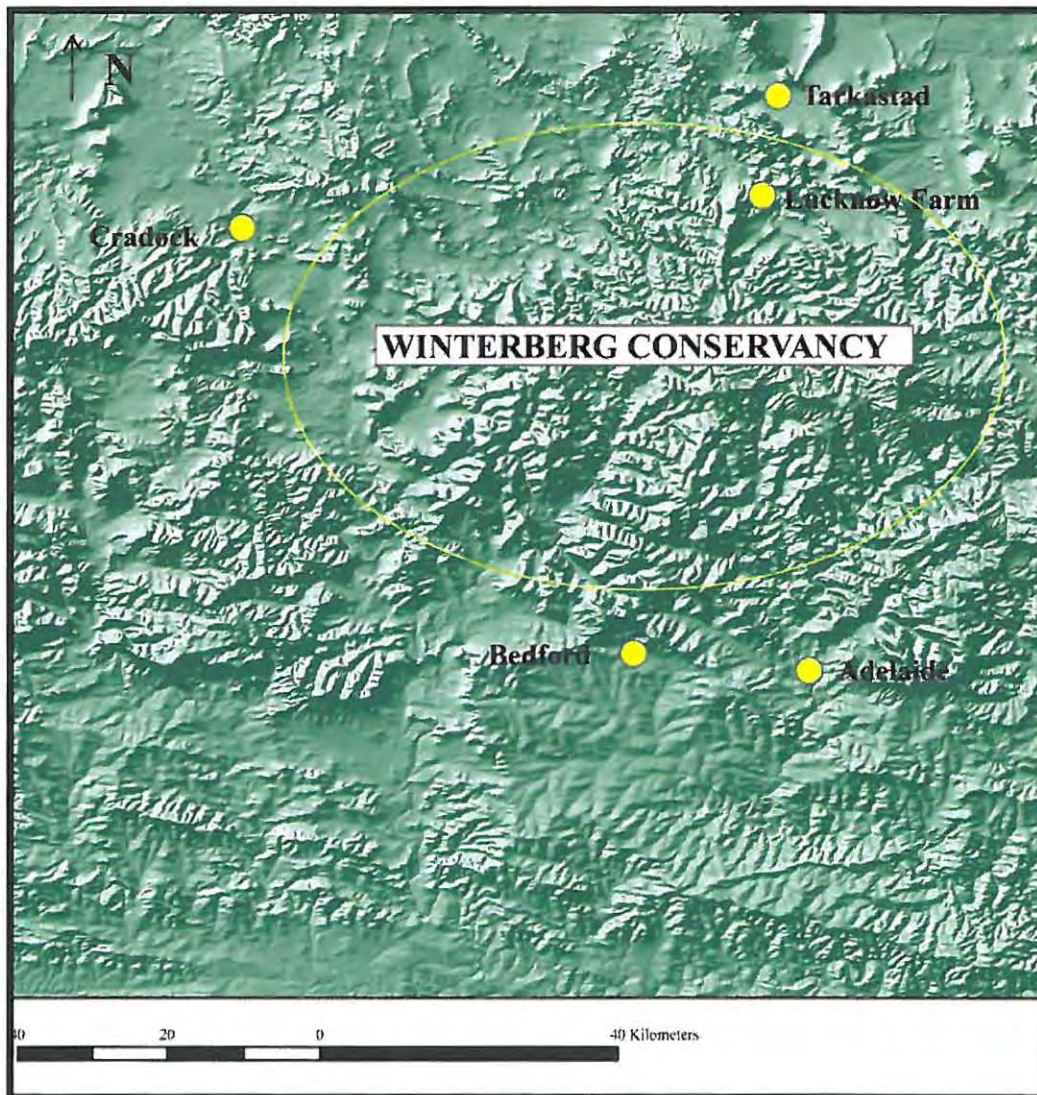


Figure 2.1: A three-dimensional topographic map of the Winterberg area. The Winterberg Conservancy is marked along with the site for camera trapping (see Chapter 3), Lucknow Farm. The nearest towns to the Winterberg area in the Eastern Cape are marked: Tarkastad, Cradock, Bedford and Adelaide.

2.2 Historical background

As the European travellers penetrated the Eastern Cape in the late 17th century, they encountered a number of indigenous pastoralists and agro-pastoralists in the Winterberg area (Hall 1986). Rock paintings in the area depict a geographic progression of pastoralists through the area long before the arrival of the European travellers (Hall 1986). It appears that sheep were the first domesticated livestock in the area as they not only occur alone in the rock paintings but when cattle were painted, they often appeared together with horses (Hall 1986). The presence of horses and Nguni cattle are associated with the expansion of isiXhosa people into area in the early 17th century (these early groups of isiXhosa were not known to possess sheep) (Hall 1986). Hence the Winterberg has long supported livestock. By the 1820s, Europeans had settled in the area and began farming domestic stock (predominately sheep), a situation which remains today (Pringle & Pringle 1978). Caracals were first recorded in the area in 1835, along with several other carnivores: lions (*Panthera leo*), leopards, servals (*Felis serval*), brown hyenas (*Parahyaena brunnea*), spotted hyenas (*Crocuta crocuta*) and wild dogs (*Lycaon pictus*).

2.3 Climate

The Winterberg Conservancy falls within the summer rainfall zone, with rainfall peaks in November-December (Mucina *et al.* 2006). It has a mean annual rainfall of 411.36mm (Figure 2.2). Temperatures in summer range from 20°C to 38°C (Mucina *et al.* 2006; personal observations). The rainfall increases from east to west across the area and increase with a rise in elevation. The Winterberg experiences an extreme climate (Pringle & Pringle 1978). The winters are extremely cold, temperature ranges from (-10°C to 15°C) with nightly frosts (between 20 and 100 days of the year) (Mucina *et al.* 2006) and snowfalls are frequent on the higher peaks

(Pringle & Pringle 1978). The winters are very dry, with mean annual precipitation increasing with elevation (Mucina *et al.* 2006). Periodic droughts are a normal feature of the Winterberg and generally occur in 10 year cycles (Figure 2.1) (Pringle & Pringle 1978).

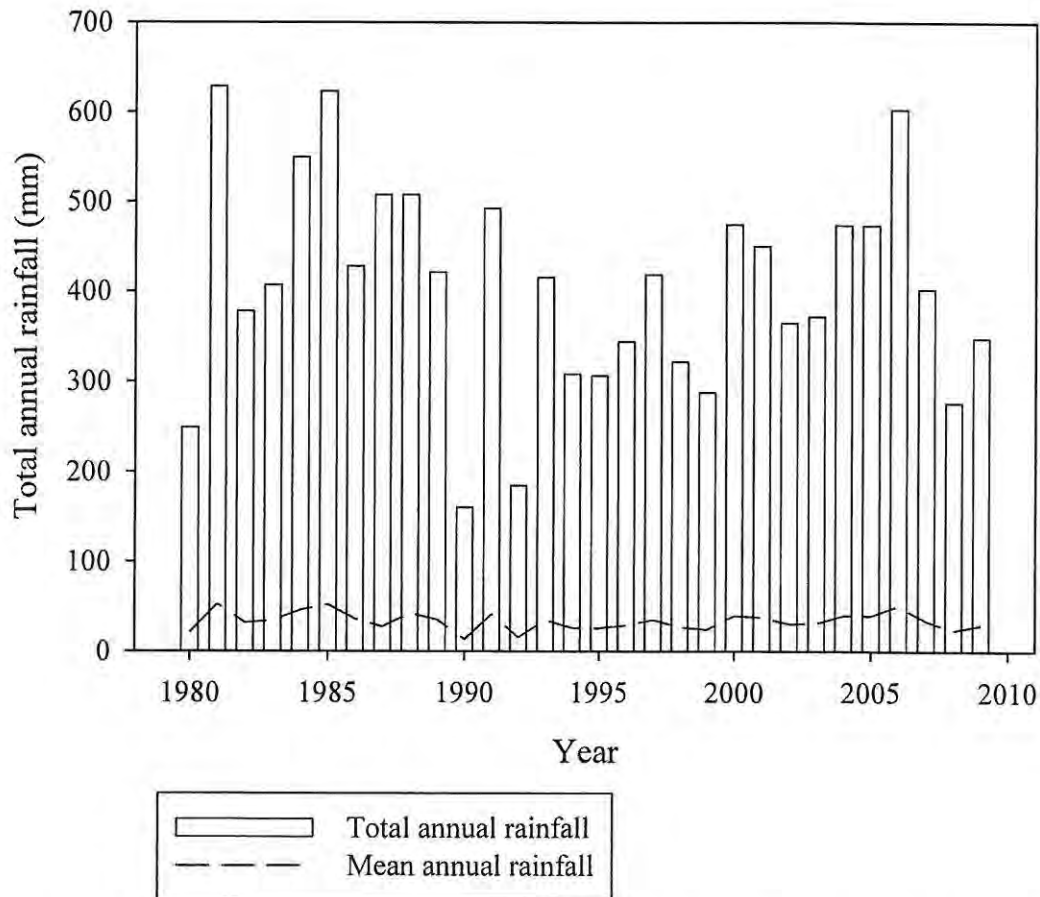


Figure 2.2: The total annual rainfall (mm) on Oxford Farm, Winterberg, Eastern Cape from 1980-2009 and the mean annual rainfall (data supplied by M. Phillips).

Figure 2.2 shows the total annual and average annual rainfall fluctuations from 1980-2009. Years exhibiting particularly high levels of annual rainfall were 1981 (622.8mm), 1985 (628.85mm) and 2006 (602.99mm) and 1990 had the lowest total annual rainfall between 1980-2009 with

160.27mm demonstrating the 10 year drought cycle that the area experiences (Figure 2.2) (Pringle & Pringle 1978).

2.4 Vegetation

The vegetation of the Winterberg area is a mosaic habitat consisting of three major vegetation types across the Nama-Karoo and Grassland biomes. The major vegetation types are the Karoo Escarpment Grassland, Eastern Upper Karoo Grassland and Tarkastad Montane Shrubland (Figure 2.3). There are small patches of Amatole Montane Grassland and Amatole Mistbelt Grassland on the south easterly periphery of the study area (Figure 2.3). Similarly, along the south-west periphery of the study area there is a small patch of Great Fish Thicket (Mucina *et al.* 2006) (Figure 2.3).

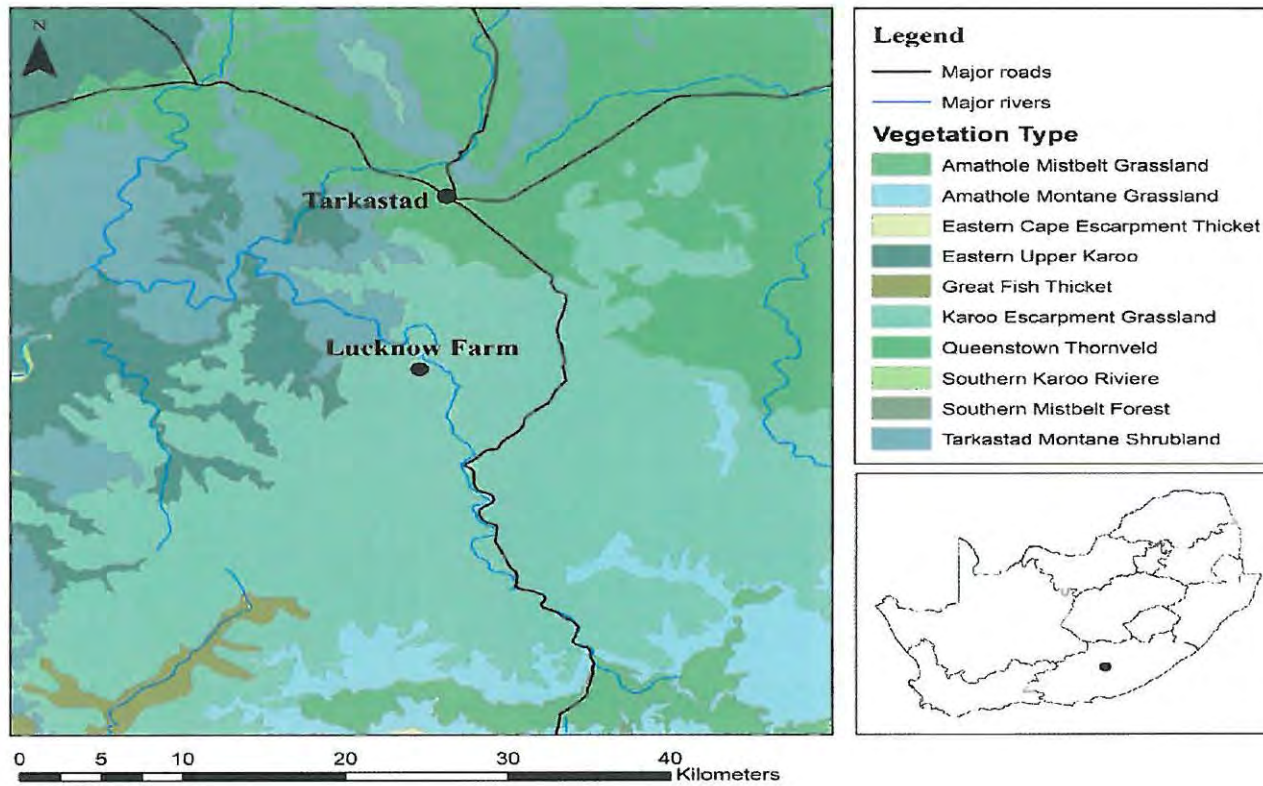


Figure 2.3: The vegetation of the Winterberg including the reference points of Lucknow Farm and Tarkastad (the nearest town to the Winterberg area) (ESRI ArcGis™ 9.3, decimal degrees, Mucina *et al.* 2006). The location of the Winterberg is also shown in reference to the geography of South Africa.

2.4.1 Karoo Escarpment Grassland

Karoo Escarpment Grassland covers the majority (75%) of the study area (Figure 2.4). This vegetation type is part of the Grassland Biome (Mucina *et al.* 2006). It is found predominately on the north facing slopes of the Winterberg Mountain Range (Mucina *et al.* 2006). The dominant grass is *Merxmuellera disticha* (Mountain wire grass). Other common grasses are of the genera *Eragrostis*, *Tetrachne*, *Karoochloa*, *Helictotrichon*, *Melica*, *Tragus*, *Elionurus* and *Aristida* (Mucina *et al.* 2006). Due to the grazing pressure of livestock in this farming area, large areas are dominated by pioneer colonising species such as *Eragrostis curvula* (Tainton 1999; M.Phillips, pers. comm.).



Figure 2.4: The major vegetation type, Karoo Escarpment Grassland of the Winterberg, Eastern Cape, South Africa. The image is courtesy of Mucina *et al.* (2006).

2.4.2 Eastern Upper Karoo Grassland

In the north-western areas of the study site there are small patches of Eastern upper Karoo Grassland (Figure 2.5). This vegetation type consists of small shrubs such as *Chrysocoma ciliate* and *Erocephalus ericoides* and tufts of ‘white’ grasses from the *Eragrostis* and *Aristida* genera (Mucina *et al.* 2006)



Figure 2.5: Another significant vegetation type, Eastern Upper Karoo Grassland, in the Winterberg, Eastern Cape, South Africa. The image is courtesy of Mucina *et al.* (2006).

2.4.3 Tarkastad Montane Shrubland

In the western region of the study site, and north of Tarkastad itself, there are patches of Tarkastad Montane Shrubland (Figure 2.6). This vegetation type consists of semi-open mixed shrub- grassland. The shrubs represented include *Diospyros austro-africana*, *Euryops annae* and *Lycium schizocalyx*. Grass species include those of the *Eragrostis* and *Aristida* genera (Mucina *et al.* 2006).



Figure 2.6: The third significant vegetation type, Tarkastad Montane Shrubland, of the Winterberg, Eastern Cape South Africa. The image is courtesy of Mucina *et al.* (2006).

2.5 Geology and Topography

The geology of the Winterberg consists mainly of the Tarkastad Subgroup, which is a subgroup of the Karoo Supergroup (Johnson *et al.* 2006). This subgroup consists of abundant sandstone and red mudstone layers and the maximum thickness of the subgroup is 2000m (Johnson *et al.* 2006). Within the Tarkastad Subgroup is the Burgersdorp Formation which is mudstone-rich, the Katberg Formation which is sandstone-rich, the Verkykerskop Formation consisting of fine to course-grained sandstone and the Driekoppen Formation which consists almost entirely of mudstone (Dewey 1988; Johnson *et al.* 2006). These sedimentary rocks lead to shallow soils which predominate in the Karoo Escarpment Grassland vegetation type and duplex soils in the Eastern Upper Karoo vegetation type (Dewey 1988; Johnson *et al.* 2006).

The Winterberg is a mountainous area consisting of deep rugged valleys and peaks (Pringle & Pringle 1978). The lowest valleys are 337m above sea level and the highest peaks are 2191m above sea level (Pringle & Pringle 1978). Some of the valleys have seasonal streams and the major perennial river is the Tarka River which flows through the Winterberg Conservancy for 58.18km, terminating in the Kommandodrif Dam (Pringle & Pringle 1978) (Maps of the Surveyor General of South Africa 1998).

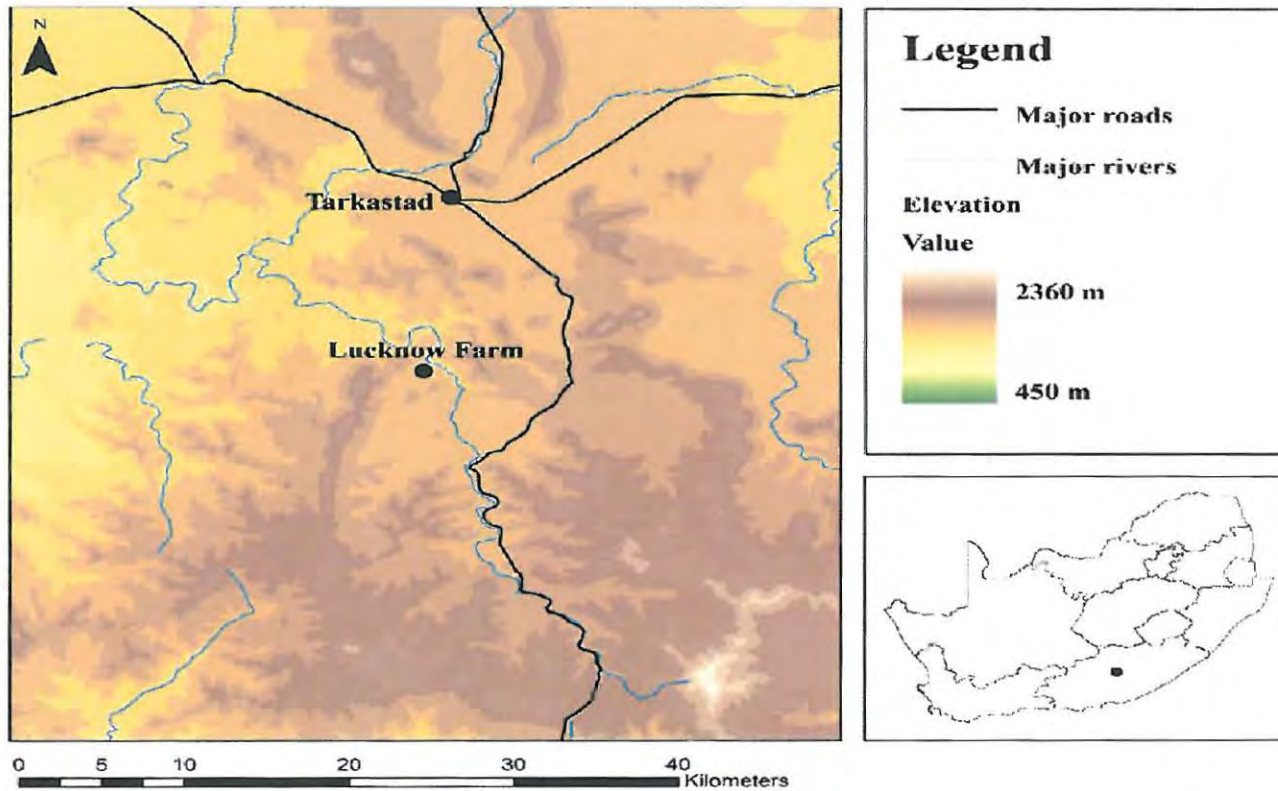


Figure 2.7: The general topography showing the range of 450m to 2360m for the area surrounding the camera trapping study site Lucknow Farm in the Winterberg, Eastern Cape, South Africa including the reference points of Lucknow Farm where the camera trapping took place (Chapter 3), and Tarkastad (the nearest town to the Winterberg area) (ESRI ArcGis™ 9.3, decimal degrees)

CHAPTER 3: CAMERA TRAPPING INVENTORY AND AN ESTIMATION OF THE CARACAL POPULATION IN THE WINTERBERG

3.1 INTRODUCTION

In 1877 the first animal-triggered photograph of a galloping horse was taken as it activated a series of cameras attached to trip wires (Guggisberg 1977). By the early 1900s a number of wildlife photographers had captured nesting birds, white-tailed deer (*Odocoileus virginianus*) and some African carnivores using a series of electric treadles and trip wires (Guggisberg 1977). Royama (1970) produced some of the first research using mechanically triggered cameras. He attempted to identify prey items brought to nestling great tits (*Parus major*) (Royama 1970; Guggisberg 1977). During the 1970s, the use of triggered cameras became more widespread across several fields and researchers began using it to study animal behaviour and generate indices of abundance (Cutler & Swann 1999). Camera trapping can therefore be defined as a non-invasive tool whereby cameras are remotely triggered by an animal (Gerber *et al.* 2009). Importantly, infrared-triggered cameras are weather resistant, able to capture animals at night, have become readily available and are continuously becoming more affordable (Cutler & Swann, 1999; Rowcliffe & Carbone, 2008).

The widespread use of infrared-trigger cameras was reflected in the literature towards the end of the 1990s. Cutler & Swann (1999) reviewed 107 papers in the camera trapping field. From these studies, the major research themes were: nest predation (21%), feeding ecology (18%), nesting behaviour (18%), descriptions or evaluations of camera equipment (18%), activity patterns

(12%), population parameters (7%) and detection of species (6%). Of these topics, 62% of the studies were of birds, 29% of mammals, 7% included multiple taxa and 2% were of herpetofauna (Cutler & Swann 1999). Rowcliffe & Carbone (2008) conducted a similar review and found that, since the early 1990s, there has been a 50% growth in publications that either assess camera trapping methodology or use camera trapping in their research (Figure 3.1, Rowcliffe & Carbone 2008). The authors attribute this increase to the affordability of remotely-triggered cameras and refinements to the methodology (Rowcliffe & Carbone 2008).

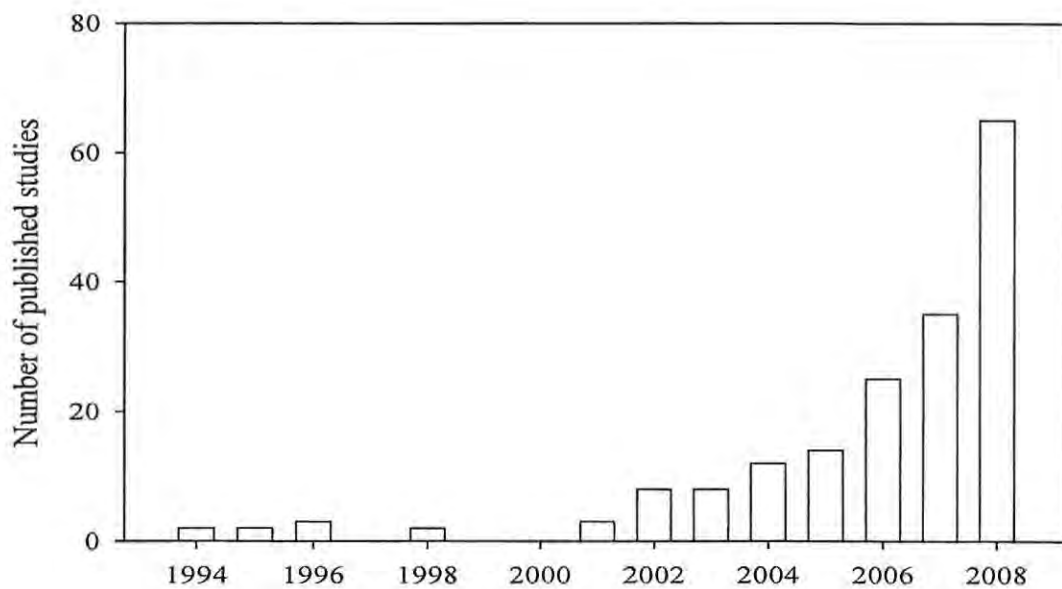


Figure 3.1: The number of peer-reviewed publications that either used or analysed camera trapping as a methodology from 1994 to 2008. These data were derived from a Web of Science search for ‘camera trapping’ and the figure was edited from data presented in Rowcliffe & Carbone (2008).

It is clear that the use of infrared-triggered cameras and camera-traps, in general, has become an integral part of vertebrate ecology (Swann *et al.* 2004). This remote monitoring system has several major uses in vertebrate ecology. Firstly, for monitoring and detecting elusive species such as tigers (*Panthera tigris*), elephant-shrews (*Rhynchocyon* spp.) and jaguars (*Panthera onca*) (Karanth and Nichols 1998, Carbone *et al.* 2001, Weckel *et al.* 2006; Rovero *et al.* 2008). Secondly, for abundance and diversity estimates across various habitats. The method is particularly effective in habitats with poor visibility or those that are logistically challenging to work in e.g. forests (Beck & Terbough 2002, Weckel *et al.* 2006, Tobler *et al.* 2008). Finally, camera trapping has also proved to be an effective tool for generating vertebrate species inventories (Silveira *et al.* 2003, Ginman *et al.* 2007).

Species inventories generated by camera trapping can be viewed as a form of biological monitoring (Yoccoz *et al.* 2001). Yoccoz *et al.* (2001) defined the monitoring of biological diversity as the gathering of information pertaining to system state variables (i.e. species richness, species diversity biomass and population size) on either an ecosystem or component scale (i.e. communities or populations). The species inventory data supplied by camera trapping is therefore a tool for ecosystem monitoring. This species inventory data can be used as indicators of diversity which, in turn, provides the fundamental knowledge required for making informed management decisions (Yoccoz *et al.* 2001). These management decisions can involve the sustainable conservation of endangered species, the co-existence of people and wildlife and in some cases, the necessary data to attract funding for further research (Yoccoz *et al.* 2001). For researchers, these kinds of inventories allow for comparisons between sites, the evaluation of

human impact on communities and the refinement of distribution maps which is critical for all species, particularly endangered species (Yoccoz *et al.* 2001).

Inventories can be extremely difficult to perform in habitats with poor visibility or accessibility such as dense rainforest vegetation (Tobler *et al.* 2008). Species inventories in places like the Amazon have tended to be done using line transects, direct observations, track and faeces identification and interviews with local people (Haugaasen & Peres 2005; Tobler *et al.* 2008). However, Tobler *et al.* (2008) used camera trapping as a vehicle for generating a species inventory in the lowland Amazonian forest of Peru. Camera trap surveys using 24 cameras were carried out over two trapping sessions of 60 days, each incorporating the dry and the rainy seasons (Tobler *et al.* 2008). When surveying these kinds of areas using traditional methods, elusive species were often missed or estimates were based on erratic and sometimes unreliable local sources (Tobler *et al.* 2008). Therefore, Tobler *et al.* (2008) designed their camera trap survey around the requirements for estimating jaguar density. During their study, 86% of the mammalian species known to occur in the area were caught on the cameras, including the rare bush dog (*Speothus venaticus*) and the southern naked-tailed armadillo (*Cabassous unicinctus*). Prior to the camera trapping survey, there was little local knowledge of these species and only one study had reported their presence using historical records (Vos & Emmons 1996). Moreover, the camera trapping survey recorded 28 mammalian species over 120 days, which was much shorter than the time required for the more traditional methods (e.g. line transects) to record a similar numbers of species in this habitat type (Tobler *et al.* 2008). Therefore, camera trapping is extremely efficient for rapid surveys.

Clearly, species inventories conducted using camera trapping techniques are extremely effective in habitat that is poorly explored or has poor visibility. Moreover, these kinds of inventories can provide important baseline data for areas of critical biodiversity concern, such as the Amazon rainforest (Gerber *et al.* 2009)

Camera traps can also provide the same baseline data for less challenging environments. Stein *et al.* (2008) set-up a series of camera traps within the Waterberg Plateau Park and the surrounding farmlands, Namibia to assess leopard (*Pathera pardus*) density. They found that camera trapping allowed them to accrue a large body of information on vertebrate diversity across the two habitats. Given this information, Stein *et al.* (2008) suggested further methods for improving the ability of camera traps as a monitoring tool. They suggested using only one trap per camera trap station in order to minimise the occurrence of double photographs and maximise the potential for photographic opportunities, more trapping nights at multiple independent locations to increase the capacity to detect differences in relative abundance of species, and finally, the placement of cameras along animal paths to increase the likelihood of capturing, on camera, a larger proportion of the species present in the area (Stein *et al.* 2008). Marnewick *et al.* (2008) used a camera trapping survey to estimate the abundance of cheetahs (*Acinonyx jubatus*) on ranching areas in the Thabazimbi district, Limpopo Province, South Africa. Not only were cheetahs captured on camera and identified, but Marnewick *et al.* (2008) presented a convincing case for the use of camera traps in an area where human-predator conflict is high. The cheetahs in this study threatened livestock and there was therefore a negative attitude from local residents (particularly farmers) towards collaring these predators for monitoring purposes (Marnewick *et*

al. 2008). Camera trapping provided a less contentious monitoring procedure that was also effective for population estimations (Marnewick *et al.* 2008).

Thus, camera trapping may allow for the detection and estimation of abundance of animals at the source of human-predator conflict (Marnewick *et al.* 2008; Wang & Macdonald 2009). Caracals are considered vermin by the livestock farmers of the Winterberg, which makes justifying the release of collared animals onto their land extremely difficult. On the other hand, camera-traps are non-invasive, they provide wildlife data about the area and allow for the researcher to maintain a working relationship with the community.

Wildlife and livestock co-exist in the Winterberg Conservancy. However, no formal data have been collected on the mammalian species diversity. In addition, the top predators of the area, black-backed jackals (*Canis mesomelas*) and caracals continue to be hunted due to their depredation on livestock. The hunting pressure on these apex predators could be causing a trophic cascade, whereby connectivity between the species is disrupted, resulting in perturbations throughout the wildlife community which could be reflected in changes in species diversity (Elmhagen & Rushton, 2007; Estes *et al.* 2011). These trophic cascades can have severe landscape-level effects. For example, in the Venezuelan forests on the islands of Lago Guri, the absence of jaguars, cougars (*Puma concolor*) and harpy eagles (*Harpia harpyja*) resulted in an eruption of herbivores which dramatically reduced plant recruitment and survival (Terbough *et al.* 2001). For livestock farming communities, the quality of the available grazing is of critical importance. Therefore, it is essential to estimate the abundance the of apex predators and determine a species inventory of the area.

3.1.1 Density estimation

One of the seminal works on density estimation is by Karanth & Nicols (1998), who estimated tiger density in the National Parks of Pench, Kanha, Kaziranga and Nagarahole, India. Tigers are individually recognisable due to their striped coat patterns (Loveridge *et al.* 2010). Consequently, each tiger photograph could be treated as a 'capture' within the context of a theoretical 'capture-recapture' model (Karanth & Nicols 1998). The 'capture-recapture' model can be broadly defined as a series of models for closed and open populations (Karanth & Nicols 1998). Pollock *et al.* (1990) defined open populations as populations where there are additions (births and/or immigrations) and deletions (deaths and/or emigrations). In closed populations, neither additions nor deletions occur and the population has a constant size throughout the study (Pollock *et al.* 1990). Therefore, within these defined parameters, the 'capture-recapture' theory is where a population is studied k times (k is usually > 2), unmarked animals are caught and uniquely marked (in the case of tigers the stripe patterns provides the marking) and previously caught animals have their captures recorded and released back into the population (Pollock *et al.* 1990). Within 'capture-recapture' theory, there are two main statistical models used to generate population estimates. The Lincoln-Peterson method is used to determine the population size of closed populations (Pollock *et al.* 2002). This method assumes that every animal has equal catchability, is in a closed population and has no mark loss during the study (Pollock *et al.* 1990). By capturing and recapturing marked individuals (recaptured animals are uniquely marked to avoid pseudo-replication) population size and density can be calculated using the probability of detection at various times (i.e. each recapture) (Pollock *et al.* 1990). By contrast, the Jolly-Seber model generates population estimates for open populations under the assumptions that every animal has an equal probability of capture, the same probability of survival between captures, no

marks are lost during sampling and that animals are released immediately after capture (Cormack 1964; Burnham *et al.* 1987; Pollock *et al.* 1990; Nichols, 1992; Royle *et al.* 2009). Camera traps provide the ideal, non-invasive methodology for monitoring ‘marked’ and ‘unmarked’ animals for use in the ‘capture-recapture’ theory.

The use of camera trapping to effectively estimate population sizes with ‘capture-recapture’ theory has been predominately restricted to distinctly marked felids such as tigers (*Panthera tigris*), jaguars (*Panthers onca*), snow leopards (*Oncia oncia*), wildcat (*Felis silvestris*) (Karanth & Nicols 1998; Maffei *et al.* 2004; Jackson *et al.* 2006; Weckel *et al.* 2006; Can *et al.* 2011). However, work using camera traps to estimate the abundance of animals without individual markings has been less prolific because of analytical limitations (Karanth *et al.* 2010). For non-individually recognisable animals, research has focused on using some other kind of distinguishing feature. Density estimations using minor markings have been done for maned wolves (*Chrysocyon brachyurus*) (Trolle *et al.* 2007) and bobcats (*Lynx rufus*) (Heilbrun *et al.* 2003). Furthermore, research has been undertaken for a series of Neotropical mammals in Belize using a combination of photographs and track data (Harsem *et al.* 2010). However, these studies have been criticised as they do not account for potential observer misidentification of markings (Oliveira-Santos *et al.* 2010).

Other abundance or density estimation studies involving non-individually recognisable animals have tended to focus on the generation of a relative index of abundance (O’Brien *et al.* 2003; Srbek-Araujo & Garcia 2005). This approach has also been criticised for failing to consider the effects of the probability of detection and the influence of different rates of movement on

trapping rate (Jennelle *et al.* 2002). These authors further suggested that unless an animal can be individually recognised and the ‘capture-recapture’ analyses applied, camera trapping for non-individually recognisable animals should be done only to establish absence or presence. This caveat, in itself, is fraught with problems due to the capture time required to detect rare or elusive species (Jennelle *et al.* 2002). Given these shortcomings, Rowcliffe *et al.* (2008) proposed a model for density estimation without the need for individual recognition based on the encounter theories exhibited in the ideal gas model.

Physics has provided multiple templates for the basis of ecological modelling (Hutchinson & Waser 2007; Rowcliffe *et al.* 2008), and the ideal gas model is one such template. This model has been reframed to estimate animal interactions, encounter rates and density, amongst other variables (Hutchinson & Waser 2007). The original ideal gas model was the work of the physicist James Clerk Maxwell in 1860, whereby Maxwell stated that the movements of molecules are independent, equally likely to occur in all directions with speeds based on normally distributed velocities (Maxwell-Boltzmann distribution) (Maxwell 1860; Hutchinson & Waser 2007). The nature of this model lends itself to a reinterpretation for encounter rates between animals. Other than for camera trapping, this reinterpretation has been used for a broad spectrum of studies on ‘encounter rates’. These include modelling the effect of human hunting on mammalian density, assuming that the rates at which a mammal encounters a snare can be predicted (Rowcliffe *et al.* 2008), mate finding (Mosiman 1958) and comparing the mating success of primates (Van Schaik & Dunbar 1990).

Rowcliffe *et al.* (2008) define their model through an equation incorporating a factor that linearly scales trapping rate with density, depending on average animal group size and day range, and the underlying observation process (i.e. the detection range and angle of the camera). Camera traps have a segment-shaped detection zone with a radius r and angle of detection θ (Rowcliffe *et al.* 2008). Therefore, the detection zone is dependent on the angle of approach and this incorporates the probability of detection within the range of the camera (Rowcliffe *et al.* 2008).

This chapter had two major objectives. Firstly, to generate a species inventory for the medium-large vertebrates of Lucknow Farm in the Winterberg, Eastern Cape. Secondly, to estimate the density of caracals in the area using the density model proposed by Rowcliffe *et al.* (2008).

3.2 MATERIALS AND METHODS

3.2.1 Study site

The camera trapping survey was conducted on Lucknow Farm (4500Ha) (32°13519'S; 26°26045'E) in the Winterberg, Eastern Cape, South Africa (see Chapter 2; Figure 2.1). Lucknow Farm experiences a similar climate to the overall Winterberg Conservancy, with extreme temperature ranges in winter (-10°C to 15°C) and summer (20°C to 38°C) (see Chapter 2). The vegetation on the farm falls within the Karoo Escarpment Grassland vegetation type (Figure 3.1, Chapter 2, Figure 2.4). Lucknow Farm has a mountainous topography, and comprises of two major valleys surrounded by mountains. The highest peaks range between 1564m and 1596m (Figure 3.1, Chapter 2, Figure 2.7).

Lucknow Farm was used for the camera trapping site because during the cage trapping process the only animal caught and collared was captured on this farm (Appendix A). One of the aims of the camera trapping survey was to photographically capture caracals in order to estimate their density in the Winterberg Conservancy. It, therefore, seemed logical to set up the camera trapping survey on the farm where caracals were present.



Figure 3.1 Lucknow Farm, Winterberg, Eastern Cape, South Africa, where the camera trapping took place. The Karoo Escarpment Grassland vegetation type is visible in this photograph, as are the valleys surrounded by high mountains. Photograph courtesy of Larry King.

3.2.2 General

The camera trapping survey was conducted between 1 June and 2 August 2011 (i.e. 63 days). For the survey, 20 ‘Wildview Xtreme 5’(Wildview, Grand Prairie, Texas) cameras were used on a three burst mode, 24 hours a day. Therefore, when the infrared beam detected movement, a series of three photographs was taken (Karanth *et al.* 2010). The delay between these three second bursts was set at five minutes (Rowcliffe *et al.* 2008). These digital cameras also had a strobe flash for low level light and night photographs.

3.2.3 Camera placement and experimental procedure

For adequate coverage of the entire farm, a grid of equal area squares was created in ArcView 9.0 (ESRI, California, USA) (Figure 3.2). This grid was constructed to cover the area in a systematic fashion and produce three trapping areas for camera placement. The size of the grid cells (20.7Ha) was determined by dividing one of the three sections by 20 (the number of available cameras). These grid squares were then sub-divided into four blocks A-D (Figure 3.2). These blocks were randomised (using the random generator in Microsoft Excel 2007) and a random block was allocated for camera placement in each major grid square.

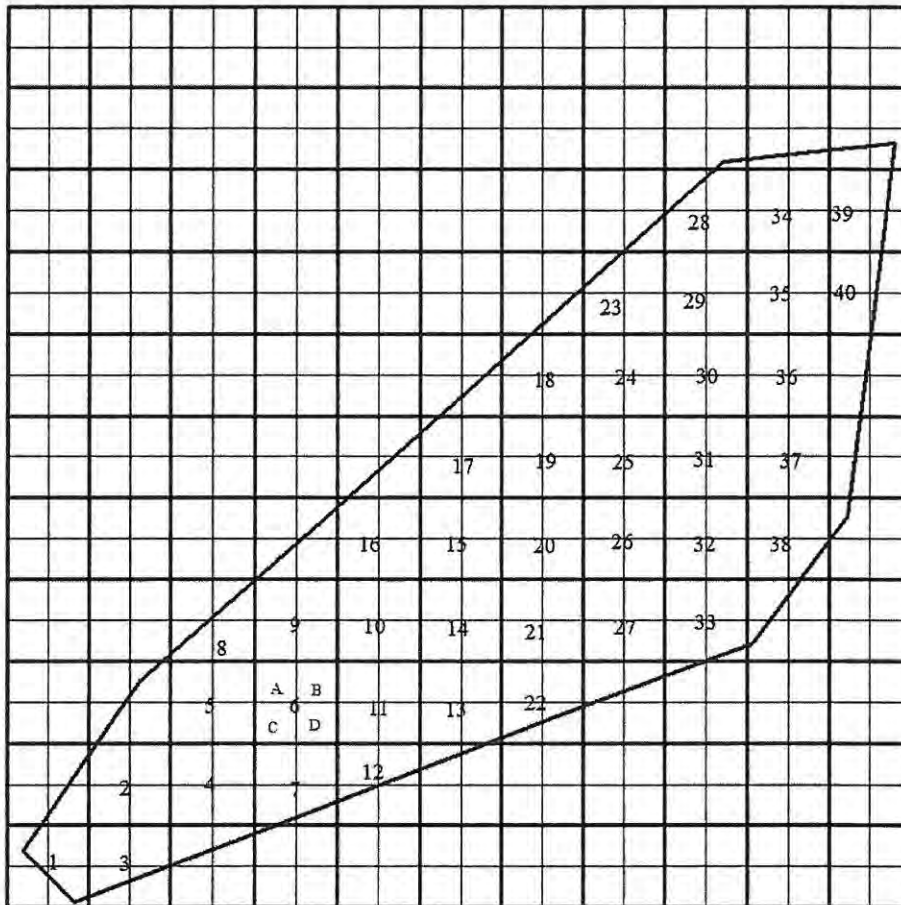


Figure 3.2: A schematic representation of the camera placement on Lucknow Farm, Winterberg. Major grid number six shows how the blocks were allocated a letter reference. (Note: that the quarter grid next to grid five was land no longer owned by the land owner, a change that is not reflected in the official farm boundaries of the property from maps of the Surveyor General of South Africa 1998).

A single camera was placed in the most appropriate position (usually along an animal path) within each predetermined block. The cameras were placed approximately 0.5m off the ground to increase the likelihood of capturing the target species (caracals) and other smaller vertebrates

(Rowcliffe *et al.* 2008). Due to the limited number of cameras (20) and the size of the property (4500Ha), the farm was first divided into two equal sections. Each section was sampled sequentially with 20 cameras (camera placements 1-40 in Figure 3.2). After these first two trapping sessions, the central portion of the farm (camera placements 6, 9 and 12-27 in Figure 3.2) was sampled. All 20 cameras were set up in each section for sampling periods of 21 days each (Rowcliffe *et al.* 2008). The cameras were checked every second day to download photographs and batteries were replaced every five days.

All photographs were manually sorted, and repeat images of the same species at the same camera trap sites were separated by half-hour periods to generate statistically independent captures (O'Brien *et al.* 2003). The pictures taken over the three second bursts were treated as one capture (O'Brien *et al.* 2003)

3.2.3 Density modelling parameters

To estimate the density of caracals in the Winterberg, the published model of Rowcliffe *et al.* (2008) was used. The model is based on the ideal gas model, whereby the contacts between gas molecules can be equated to the 'contact' between cameras and target species (photographs) (Rowcliffe *et al.* 2008). To effectively use this model, the parameters of the cameras needed to be defined and calculated.

For camera trapping, the area of movement is wedge-shaped (this is the detection area of the lens) (Figure 3.3). The width of the animal's path is therefore, a function of the angle of approach (θ) (Figure 3.3). To calculate θ , a series ($n = 10$) of field tests, using three different

cameras, was conducted to measure the detection range of the cameras (i.e. the straight line distance) and the point at which the cameras first registered movement (i.e. the baseline of the isosceles triangle) (Figure 3.3). These field tests were done at night to calculate the minimum values for the required parameters because detection was restricted by the flash.

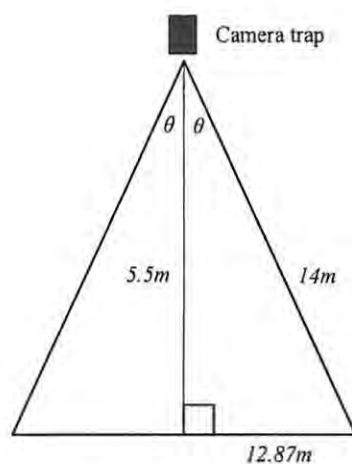


Figure 3.3: A schematic representation of the field testing of three Wildview Xtreme 5 camera traps used in this study to determine the angle of approach (θ) of an animal and the detection distance (m) of the cameras. The sides of the triangle are mean distances of each field trial ($n = 10$).

Using the distances from Figure 3.3 and the law of cosines, the value of θ was solved ($\theta = 132.72^\circ$). This parameter was then substituted into the following equation to estimate animal density (Rowcliffe *et al.* 2008):

$$D = \frac{y}{t} \frac{2 + \theta}{vr(2 + \pi)}$$

Where D = density; y/t is the number of photographs per unit time (days), v = animal speed of movement (km.day^{-1}), r = radius of the detection zone of the camera (m) and θ = angle of detection of the camera. To investigate variance in the model, Rowcliffe *et al.* (2008) used a series of game counts across their study area. In my study, the potential variance in the caracal density estimated from the model was tested on data for sheep and cattle, for which the population numbers were known. Sheep and cattle occur naturally in cohesive groups. Therefore D was multiplied by the mean number of animals found in each group (g); caracals are considered solitary, so this variable was not included in the equation to calculate their density (Rowcliffe *et al.* 2008). In order to estimate densities of sheep, cattle and caracals using the model three additional variables were required: average day range, average group size (for cattle and sheep) and the number of photographs taken of each species over the camera trapping period (Table 3.1)

Table 3.1: The summary of the variables substituted into the model equation generated by Rowcliffe *et al.* (2008) for sheep, cattle and caracals after 63 days of camera trapping.

	Sheep*	Cattle**	Caracal***
Average day range (v , km day ⁻¹)	9.116 ± 3.04	5.913 ± 2.45	5.904 ± 8.14
Average group size	5.073 ± 4.58	1.555 ± 0.92	-
Detection arc (θ , radians)	2.33	2.33	2.33
Number of photographs	450	55	5

* Squires & Wilson, 1971; Squires, 1976; Thomas *et al.*, 2008.

** Herbel & Nelson, 1966; Anderson & Koffman 1977; Gannskop, 2001.

*** Q Martins, Unpublished data, 2011.

To estimate the number of caracals in the Winterberg Conservancy area, the mean home ranges for females and males were used. Females have an average home range of ~15 km² (Stuart 1982; Norton & Lawson 1984; Moolman 1984; Avenant & Nel 1998). Males have an average home range of approximately 112 km² (Stuart 1982; Norton & Lawson 1984; Bothma & Le Riche 1994; Avenant & Nel 1998). By using the known area of the Winterberg Conservancy (713.41km²) and the home ranges of the males and females, the total area of the Winterberg was divided by the home ranges to calculate how many animals may be present in the conservancy. It was assumed that males and females had overlapping home ranges (Skinner & Chimimba 2005).

3.2.4 Statistical analyses

To conduct a comprehensive inventory, there needs to be an evaluation of the completeness of the estimate (Longino *et al.* 2002; Tobler *et al.* 2008) (i.e. Have all the species known to be present been sampled? How much more sampling effort is required to detect any species that have not been sampled?).

To address these issues, species estimators were used to estimate the species richness of the study area (Tobler *et al.* 2008). The estimators used were the observed species estimator (Sobs), incidence-based coverage estimator (ICE) and the abundance-based coverage estimator (ACE) (Tobler *et al.* 2008). These estimators were used as camera trapping is not like the traditional method of counting species directly, some species may not be captured during the camera trapping period (Colwell & Coddington 1994). Therefore, the observed species estimator (Sobs) was calculated to compare the trapping efficiency of recording species in the area in comparison to the known number of species in the area. This was done by using the number of species photographically captured as a function of the effort (camera trapping days), assuming that the habitat was homogenous (Colwell & Coddington 1994). The order in which the species are added to the total number of species affects the shape of the curve (Colwell & Coddington 1994). Variation in the curve arises from sampling error or real heterogeneity among the units sampled (in this case the photographs of the different species) (Colwell & Coddington 1994). The Sobs curve was generated using EstimateS V 7.5.2TM (Colwell *et al.* 2004). Since camera trapping is not a direct count, rare or less abundant species may not be recorded. Therefore, ICE and ACE estimators were also calculated. The ICE and the ACE are geared towards detecting the least abundant species in a community. They are therefore estimates of the overall species richness in

an area (Chazdon *et al.* 1998; Tobler *et al.* 2008). The ICE estimation is based on species found in less than 10 sampling units (in this case photographs) and the ACE is based on species with less than 10 individuals found per sample unit (the trap day) (Chazdon *et al.* 1998). Both the ICE and the ACE were calculated using EstimateS V 7.5.2TM. These estimators allow for the completeness of the inventory to be assessed based on the estimation of species richness. However, it is important to note that these non-parametric estimators (Sobs, ICE and ACE) are a relation of the closed population, capture-recapture models. Consequently, they are underpinned by the assumption that the community composition does not change over time (Tobler *et al.* 2008).

To assess the effectiveness of the trapping effort, a cumulative species curve for the number of species detected during the camera trapping period was plotted against time along with the estimated number of species (i.e. Sobs, ICE and ACE) in the area (Tobler *et al.* 2008). As the curves reach an asymptote it is possible to infer completeness of sampling (Tobler *et al.* 2008). This is particularly important for overcoming sampling limitations such as detecting elusive species or the impracticality of sampling all habitats (Longino *et al.* 2002).

3.3 RESULTS

3.3.1 Species inventory using camera trapping

Over a trapping period of 63 days (1512 hours, 30 240 camera trapping hours), 1237 photographs (excluding misfires) were taken, including the study species (caracals) (Appendix B). Excluding photographs of anthropogenic content (i.e. domestic dogs (*Canis familiaris*), humans (*Homo sapiens*) and vehicles), 22 mammal and five bird species were recorded (Table 3.2). Of the mammal species photographed, members of the Bovidae family were the most commonly captured animals (342 photographs) and the group with the greatest species richness (Table 3.2). Within the bovids, *Tragelaphus strepsiceros* (Greater kudu) were photographed most frequently (15 photographs per 100 days) and were also the most commonly photographed animal overall (Table 3.2). Common duikers (*Sylvicapra grimmia*) were the second most commonly photographed bovid (Table 3.2). There were 65 and 58 photographs of vervet monkeys (*Cercopithecus pygerythrus*) and baboons (*Papio hamadryas*), respectively. The least commonly photographed mammals were *Felis lybica* (African wildcat) and *Aonyx capensis* (the Cape clawless otter) (Table 3.2). The least photographed birds were *Corvus corvus* (the Pied Crow) and *Cossypha caffra* (the Cape Robin-chat) (Table 3.2). However, birds were not photographed regularly during the survey (Table 3.2). Common species to the area that were not photographed were *Raphicerus campestris* (steenbok), *Antidorcus marsupialis* (springbok), *Pedetes capensis* (springhare), and *Suricata suricatta* (meerkat) (M. Phillips pers. comm.). The less common mammals that were not photographed, but do occur in the area (M. Phillips, pers. comm.), were *Tragelaphus scriptus* (bushbuck), *Felis nigripes* (black-footed cat), *Mellivora*

capensis (honey badger) and *Ictonyx striatus* (striped polecat). The anthropogenic pictures consisted of the domestic dogs that belonged to the farm owner, the farmer and farm workers and farm vehicles.

Excluding photographs with anthropogenic content, kudu required the least trapping effort to get a photograph (Table 3.2). By contrast, the trapping effort required to obtain one photograph of a caracal was thirty-five times greater (647 days/photograph; Table 3.2). African wild-cat, Cape clawless otter, Pied Crow and the Cape Robin-chat were the species that required the greatest trapping effort (> 3800 days/photograph; Table 3.2). Species such as porcupine (*Hystrix africae australis*), scrub hare (*Lepus saxatilis*), warthog (*Phacochoerus africanus*) and aardwolf (*Proteles cristatus*) required approximately the same amount of trapping effort (Table 3.2).

Table 3.2: A species inventory of the vertebrate diversity of Lucknow Farm, Winterberg, Eastern Cape, South Africa. The total number of photographs taken for each species (n), the percentage contribution of each species to the total number of photographs taken (% contribution), each species' capture frequency (CF = the number of photographs per 100 camera trapping days) and the trapping effort (in camera trapping days) required to register at least one photograph of the species, in days (E).

Family	Species	Common name	n	% Contribution	CF	E
Anthropogenic	<i>Bos domesticus</i>	Cattle	55	4	4.2	N/A
	<i>Ovis aries</i>	Sheep	450	36	34.6	N/A
	<i>Capra aegagrus hircus</i>	Goats	100	8	7.7	N/A
	<i>Homo sapiens sapiens</i>	Humans	9	0.7	0.7	N/A
	<i>Canis familiaris</i>	Domestic dogs	2	0.2	0.2	N/A
	<i>Equus ferus</i>	Horse	3	0.2	0.2	N/A
Bovidae	<i>Damaliscus dorcas phillipsi</i>	Blesbok	5	0.4	0.4	777.39
	<i>Sylvicapra grimmia</i>	Common duiker	119	9.6	9.2	31.2
	<i>Aepyceros melampus</i>	Impala	16	1.3	1.2	241.9
	<i>Pelea capreolus</i>	Grey rhebok	2	0.2	0.2	1945.73
	<i>Tragelaphus strepsiceros</i>	Kudu	195	16	15	18.43
	<i>Redunca fulvorufula</i>	Mountain reedbuck	5	0.4	0.4	777.39
Protelidae	<i>Proteles cristatus</i>	Aardwolf	7	0.6	0.5	554.85
Felidae	<i>Caracal caracal</i>	Caracal	6	0.5	0.5	647.58
	<i>Felis lybica</i>	Africa wild cat	1	0.08	0.07	3892.95
Canidae	<i>Otocyon megalotis</i>	Bat-eared fox	34	3	2.6	113.04
	<i>Canis mesomelas</i>	Black-backed jackal	6	0.5	0.5	647.58
Mustelidae	<i>Aonyx capensis</i>	Cape clawless otter	1	0.08	0.07	3892.95
Viverridae	<i>Genetta genetta</i>	Small-spotted genet	3	0.2	0.2	1296.65
	<i>Galerella pulverulenta</i>	Small grey mongoose	2	0.2	0.2	1945.73
Cercopithecidae	<i>Papio hamadryas</i>	Chacma baboon	58	5	4.5	65.64
	<i>Cercopithecus pygerythrus</i>	Vervet monkey	65	5	5	58.4
Orycteropodidae	<i>Orycteropus afer</i>	Aardvark	2	0.2	0.2	1945.73
Hystriacididae	<i>Hystrix africae australis</i>	Porcupine	9	0.7	0.7	431.23
Leporidae	<i>Lepus saxatilis</i>	Scrub hare	9	0.7	0.7	431.23
Procaviidae	<i>Procavia capensis</i>	Rock hyrax	2	0.2	0.2	1945.73
Suidae	<i>Potamochoerus porcus</i>	Bushpig	6	0.5	0.5	647.58
	<i>Phacochoerus africanus</i>	Warthog	7	0.6	0.5	554.85
Corvidae	<i>Corvus capensis</i>	Pied Crow	1	0.08	0.08	3892.95
Numididae	<i>Numida meleagris</i>	Helmeted Guineafowl	44	4	3.4	87
Threskiornithidae	<i>Bostrychia hagedash</i>	Hadedda Ibis	3	0.2	0.2	1296.65
Anatidae	<i>Alopochen aegyptiaca</i>	Egyptian Goose	9	0.7	0.7	431.22
Muscicapidae	<i>Cossypha caffra</i>	Cape Robin-Chat	1	0.08	0.07	3892.95

n = 1237

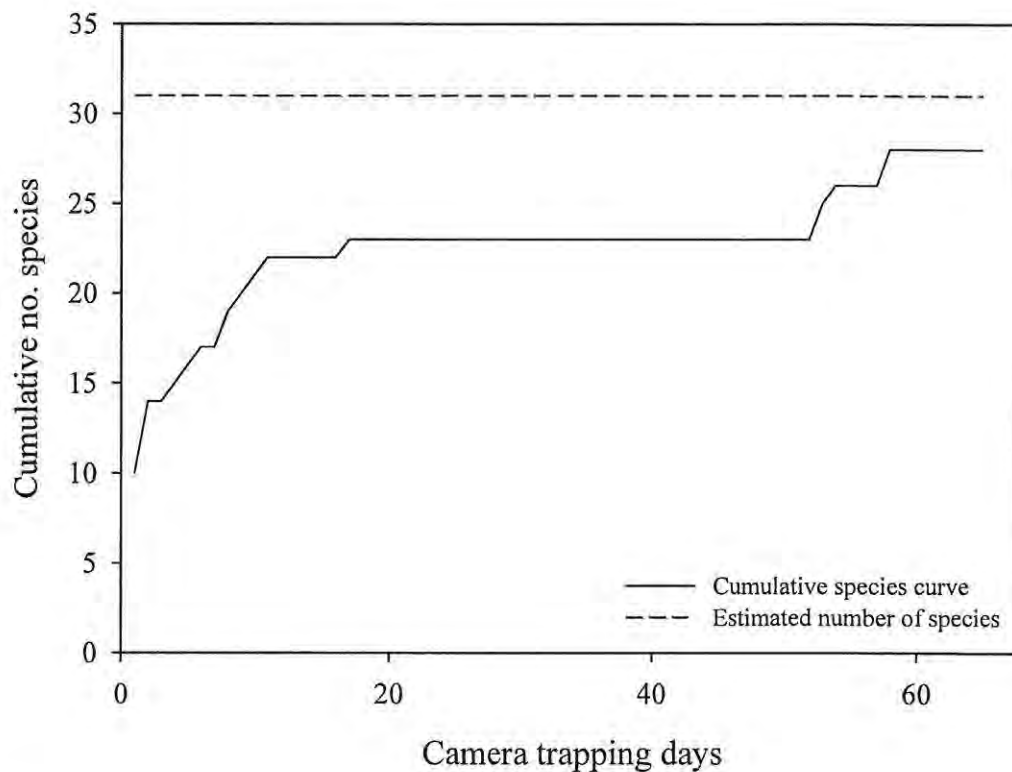


Figure 3.4: The cumulative species richness of the mammalian species after 63 days of camera trapping on Lucknow Farm in the Winterberg Conservancy, Eastern Cape, South Africa. The estimated number of species (Skinner & Chimimba 2005; M. Phillips pers. comm) is plotted as a dashed-line for the period.

The cumulative mammalian species richness reached an initial asymptote between days 20 and 56 (Figure 3.4). After day 56, the cumulative number of species increased to a second asymptote of 27 species (Figure 3.4). The estimated number of mammalian species for the area is 31 (M. Phillips pers. comm.). A longer sampling time would therefore be required to photograph all the mammalian species present. The same result could be achieved by increasing the number of cameras or both the number of cameras and the length of trapping time or by baiting the camera

trap stations (Long *et al.* 2003; Srbek-Araujo & Garcia 2005). Baiting the traps would however, violate the assumptions of the estimation model (Long *et al.* 2003; Srbek-Araujo & Garcia 2005; Rowcliffe *et al.* 2008).

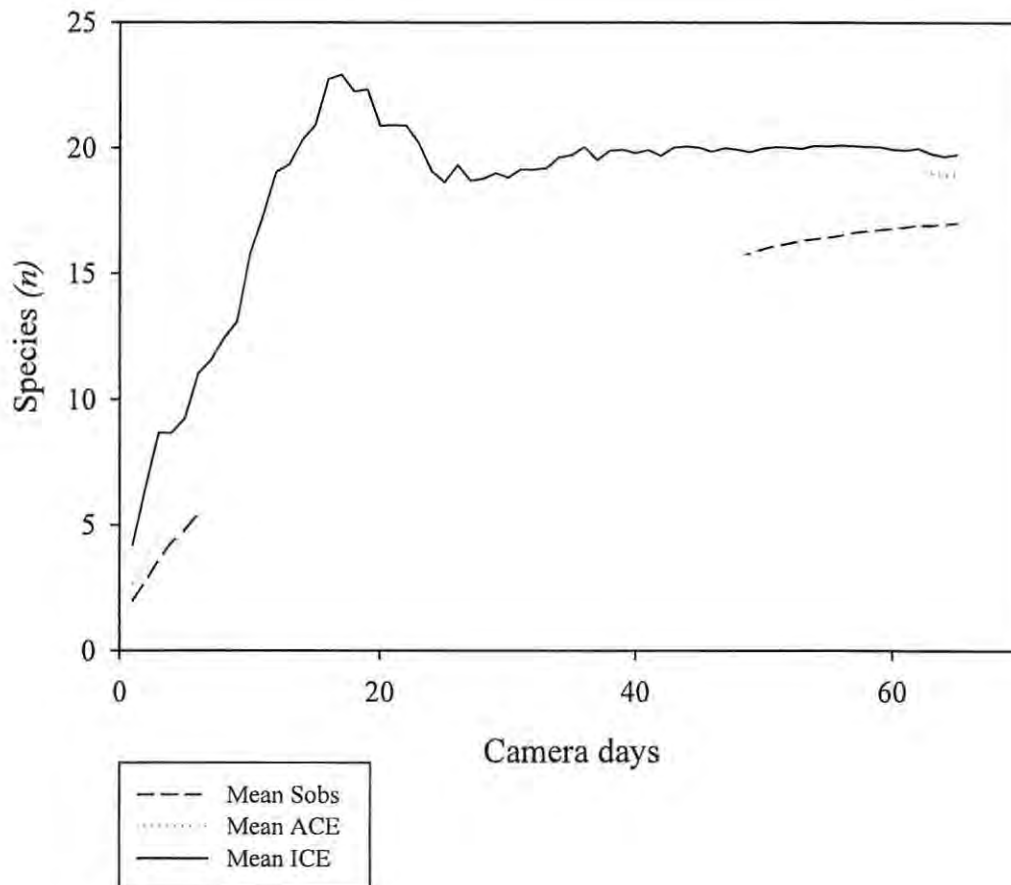


Figure 3.5: The mean species observed estimator (Sobs), abundance coverage estimator (ACE) and incidence coverage estimator (ICE) over the 63 camera trapping days on Lucknow Farm in the Winterberg Conservancy, Eastern Cape, South Africa.

In contrast to the cumulative species richness (27), the Sobs estimator estimated a mean of 17 mammal species, the ACE a mean of 19 species and the ICE a mean of 20 species over 63 days of camera trapping (Figure 3.5). It thus appears that the three estimators (Sobs, ACE and ICE) slightly underestimated the number of potential species that could be captured on camera.

However, this does suggest a reasonable sampling effort for Lucknow Farm, in that almost all of the potential mammalian species (as determined by the estimators) were sampled by the camera traps (Figure 3.5).

Table 3.3: The estimated densities (animals/km²) of sheep, cattle and caracal on Lucknow Farm, compared with the known numbers of sheep and cattle in the Winterberg, Eastern Cape, South Africa.

	Estimated	Known	Percentage difference (%)
Sheep	507.75	555.55	9.41
Cattle	29.31	55.55	89.53
Caracal	0.20	-	-

The density of sheep was calculated as ~508 animals/km² and the known density was 556 animals/km² (Table 3.3). The percentage difference between the estimated number of animals and the known number of animals was 9.41%. This indicates that there is very little difference between the two calculated densities from the model and the known densities of sheep and cattle (Table 3.3).

The estimated density for cattle was ~29 animals/km² in comparison to the known number (56 animals/km²). There was a percentage difference of 89.5% between the two densities (Table 3.3).

The density of caracals on the property was calculated to be 0.20 animals/km² (Table 3.3). Given that the Winterberg Conservancy is 713.41km², therefore approximately 143 caracals could be present. Based on caracal home ranges and assuming no same sex overlap, it is possible that the Winterberg could contain 48 adult females and six adult males (Moolman 1984, Bothma & Le Riche 1994). It is difficult to calculate how many sub-adults are in the area without knowing home ranges for these animals and whether there are vacant territories.

3.4 DISCUSSION

Over the camera trapping sessions, 22 mammalian and five bird species were recorded. The estimated number of mammalian species indicates that the maximum number of mammalian species that could be caught by the camera traps was 31 (Skinner & Chimimba 2005; M. Phillips pers. comm.). These estimates were determined through distribution maps and personal experience and may not be accurate. However, given the poorly studied nature of the area it was the only available data. Based on this information, the camera trapping sampling had a 71% success rate at capturing species in the area. Tobler *et al.* (2008) had 24 camera stations running for two 60 day sessions, allowing the authors were able to record 75-86% of medium sized mammalian species known in the area. Therefore in comparison to this study, my species sampling appeared to be adequate.

However, the camera trapping captured more species than what was estimated by the Sobs, ACE and ICE estimators. This may be because the estimated number of species for the area was based on personal communication and the broad distributions of mammals in South Africa (Skinner & Chimimba 2005; M. Phillips pers. comm.). Nevertheless, these estimators do not account for heterogeneity in capture probability as a factor of spatial distribution and movement of animals (Brose *et al.* 2003; Brose & Martinez 2004). Therefore, the way animals moved through the area and their spatial distributions through territories or geographic boundaries such as mountains may have affected the likelihood that they were caught on camera. This means there may be animals that were not photographically captured, so this may have affected the accuracy of the

estimators and partially explain the underestimations for species diversity (Brose *et al.* 2003; Tobler *et al.* 2003).

The cumulative species richness curve showed that although the majority of the mammalian species had been captured on camera during the trapping period, more sampling would be needed to capture all the species. However, species capture is limited by a number of confounding factors such as body size, habitat usage in relation to camera placement, camera performance and trap shyness (Tobler *et al.* 2008; Royle *et al.* 2009). Sequin *et al.* (2003) demonstrated wariness of alpha male coyotes (*Canis latrans*) to camera traps within their territories. Alpha male coyotes are extremely territorial and are the main defenders of their territories. They become extremely familiar with these areas and suspicious of changes within those territories (Sequin *et al.* 2003). Therefore, it is likely that alpha coyotes noticed the new objects in their territories (cameras) and actively avoided them (Sequin *et al.* 2003). Additionally, alpha males develop cognitive maps which may allow them to effectively avoid camera traps, even at night (Sequin *et al.* 2003). This may explain the capture rate of caracals (and other cryptic species in the area) as territorial males may have been avoiding camera trap placements in their territories. Without home range data and individual recognition it is impossible to confirm this. On the other hand, caracals may occur at relatively low densities in the area and therefore, have not been frequently photographed (Tobler *et al.* 2008).

Unsurprisingly for a study conducted on farmland, sheep contributed the highest number of photographs to the overall total. The second most frequently photographed species was kudu (*Tragelaphus strepsiceros*) with baboons (*Papio hamadryas*) and vervet monkeys (*Ceropithecus*

pygerythrus) being the third and fourth most frequency captured animals. All these wild mammals exhibit a gregarious social structure (Skinner & Chimimba 2005). Treves (2000) observed that gregarious foraging behaviour in primates can increase the number of photographic captures of individuals from the same group. This behaviour can increase the probability of capturing gregarious primates, a trend that was observed in this study. In addition, Treves *et al.* (2010) intimated that gregarious animals which forage on small arthropods or fruits and vegetation show meandering behaviour and often return to the same area. These behavioural traits could explain the frequency of captures for kudu (Treves *et al.* 2010). Further, the concept of site fidelity, territoriality and central place foraging would also increase the probability of capturing large to medium sized ungulates and primates (Larrucea *et al.* 2007; Treves *et al.* 2010). Tobler *et al.* (2008) and O'Brien *et al.* (2003) found that species which were habitat generalists, terrestrial and large bodied had a higher probability of detection. Kudu, baboons and vervet monkeys fulfil all these criteria and this could further explain their frequent detection. Related to this concept, Treves *et al.* (2010) found that the carnivores they captured on camera were generally captured alone, at low densities and far less frequently than the gregarious mammals. A similar trend was observed in this study. Nearly all the carnivores were captured alone and far less frequently than the gregarious birds and mammals. Mammals captured in groups were the gregarious species such as kudu or animals that live in pairs such as bat-eared foxes (*Otocyon megalotis*) (Skinner & Chimimba 2005). In addition, domestic stock (sheep and cattle) were almost always captured in their herds.

The most frequently captured carnivores were the bat-eared fox, aardwolf (*Proteles cristatus*) and caracals (*Caracal caracal*). Of these, the bat-eared fox and aardwolf can be classified as

obligate termitivores (Skinner & Chimimba 2005). Aardwolves have a diet dominated by various termite species and tend to be more active during the summer months when termites are in higher abundance (Skinner & Chimimba 2005). In winter, aardwolves spend 84% of the day in their dens to lower their metabolic rate and conserve energy (Anderson 1994; Skinner & Chimimba 2005). Given that the camera trapping period was in winter, it was surprising that aardwolves were photographed so frequently. This may mean that aardwolves are extremely abundant in the area or that the cameras were placed in areas that maximised the likelihood of capturing them (i.e. they were placed within discrete aardwolf territories). However, camera placement was achieved using a random approach, and thus it is likely that aardwolves were in high abundance. The other frequently photographed termitivore was the bat-eared fox. These animals shift their activity patterns to the diurnal period during the winter months to conserve energy (Skinner & Chimimba 2005), as was demonstrated in the majority of the photographs, which were taken in the late afternoon. The abundance of these two termitivores may be an indication of ecosystem functioning in the Winterberg. The presence of grazing sheep lowers the grass height, making it more accessible to the isopteran which dominate the diet of these mammals, thereby allowing their numbers to increase (Kreuss & Tschantke 2002). This is an example of how the grazing of livestock can alter the community structure of farm land, allowing unthreatened representatives of particular trophic levels to increase in abundance (Dennis *et al.* 1998; Kreuss & Tschantke 2002; Pöyry *et al.* 2006). As noted earlier, increase in populations at any trophic level can have a cascade affect (Elmhagen *et al.* 2010). In this case, an increase in isopteran as a food resource can result in smaller carnivores such as aardwolves and bat-eared foxes increasing in number, which may subsequently exclude other animals for which termites are a dietary component through resource competition (Ritchie & Johnson 2009).

Removing caracals from the ecosystem entirely could have a detrimental effect on grazing quality through trophic cascade effects (Elmhagen *et al.* 2010). The 'exploitation ecosystem hypothesis' argues that in areas of unproductive biomass, herbivore populations are low and thus unable to support predators (Oksanen & Oksanen 2000). When predators are not controlled, herbivores maintain a low plant biomass which stimulates plant productivity. The herbivore population then reaches levels that can support a predator population (Oksanen & Oksanen 2000). Therefore, the increase in plant productivity increases predator populations whilst herbivore populations are controlled (Oksanen & Oksanen 2000). This could have a particular impact for an area like the Winterberg, where livestock graze in natural pastures. By not removing predators the plant productivity and ultimate grazing quality could improve, bringing long-term economic benefits to the farmers as natural pastures become more sustainable in the long-term (Tainton 1999; Oksanen & Oksanen 2000).

Caracals were the most frequency photographed 'true' carnivore. All the photographs were taken during the day, (Appendix B) which is somewhat conflicting to their reported nocturnal activity patterns (Skinner & Chimimba 2005). This trend may be a function of trap shyness. Wegge *et al.* (2004) found that tigers showed a significant decrease in trapping rate after individual tigers had been captured on camera at night, probably because of the camera flash. The tigers seemed to actively avoid crossing the camera trap station and encountering the photo flash (Wegge *et al.* 2004). There were no pictures of caracals at night in this study. Therefore, it is unlikely that they were actively avoiding the flash. However, on the property where the camera trapping took place, the landowner often hunted at night. Therefore, caracals may have been avoiding

excessive movement at night to avoid persecution by the farmer. To substantiate this hypothesis, camera trapping sessions would need to occur on farms where hunting did not occur.

The model proposed by Rowcliffe *et al.* (2008) estimates the density of non-individually recognisable animals, from which abundance can be calculated. My study used this model because it addresses one of the fundamental issues surrounding use of trapping rates as an index of abundance for non-individually recognisable animals. Pollock *et al.* (2002) stated that the nature of abundance estimates is that they are intrinsically related to the assumption that the probability of detection is constant both spatially and temporally. Clearly, when using camera traps, this assumption becomes inappropriate as the height of the trap, its location and the camera properties (such as capturing fast movements and nocturnal species) all influence the probability of photographing a species. Mackenzie *et al.* (2002) maintain that the lack of detection of a species at a site does not imply that it is absent and that the length of the experimental period can have a significant influence on detection probabilities. Rowcliffe *et al.* (2008) addressed these concerns by deriving a model that uses the underlying properties of the detection process, including the properties of the camera.

In this study, the livestock were used as the closed population comparison to investigate the variability in the predictions of the model (Rowcliffe *et al.* 2008). The model provided an estimate of the sheep population only 9% less than the actual number. However, the estimate for the cattle on the farm did not agree with the known density (a difference of ~90%). This indicates that as the population number decreases, the percentage difference between the model estimate and the actual number increases (Rowcliffe *et al.* 2008). The fewer photographs there

are of a particular species, the more potential there is for variation in the model's predicted estimate (Rowcliffe *et al.* 2008). With this in mind, the estimated number of caracal for the area (0.20 animals per km²) should be seen as a minimum estimate rather than a definitive abundance.

Rowcliffe *et al.* (2008) base their model on three major assumptions. Firstly, that the animals conform to the detection process. Secondly, that the photographs are independent contacts between the animal and the camera and thirdly, that the population is closed (Rowcliffe *et al.* 2008). This study fulfils the first two assumptions in that caracals are not individually recognisable and that the cameras were not baited and were randomly positioned to allow independent interactions between the animals and the cameras. However, the assumption of a closed population was probably violated. The populations of sheep and cattle were definitely closed as no births or deaths occurred in the study period and the animals were confined to the study area by fences. Caracal births generally peak between October and February (Skinner & Chimimba 2005). However, births have been recorded in all months of the year (Skinner & Chimimba 2005). Therefore, although it is unlikely that there would have been any caracal births during the trapping period (July-August), there was no way to confirm that the population did not increase during this time. Equally, caracals are not restricted by farm boundaries (Bothma & Walker 1999; Marker & Dickman 2005). Thus, although the study farm did not hunt caracals over the period of camera trapping, animals moving out of the study farm may have been removed from the population either by anthropogenic means (hunting) or natural causes.

However, the violation of this underlying assumption may be less problematic if the study area were considered as part of a contiguous patch (Rosenzweig 2003). Rosenzweig (2003) defines

contiguous patches as areas that experience high levels of immigration as a function of their being well connected to similar patches. Therefore, when species on one patch decline, more species move into that patch from a neighbouring patch (Rosenzweig 2003). Consequently, if caracals caught on camera were killed on another farm or 'patch', more animals may have moved into the now vacant 'patch', limiting the variability in the population (Rosenzweig 2003). This theory of contiguous patches can be applied successfully to this study site as there is very little variation in the vegetation or abiotic factors across the Winterberg (Chapter 2). Statistically, it is important to operate within closed systems for calculating variables such as diversity and abundance (Rosenzweig 2003). However, an open system can still provide ecologically relevant data (Mikkelsen 2007). Mikkelsen (2007) argues that working on understanding the mechanistic principals underlying changes in a population or ecosystem, and using a closed system to elucidate the mechanisms, is fundamentally reductionist and disregards the potential interactions of macro-effects such as trophic level interactions. In my study, the abundance of caracals was influenced by the macro-effect of hunting. Therefore, from an ecological perspective, it is illogical to assume or desire that the population is closed. Kilpatrick & Ives (2003) proposed treating populations as open systems within ecological communities and that these open populations experience 'diffuse interactions' with the other species in their community. Applied to this study, it would appear that not only will prey availability be influencing the abundance of caracals but that the caracal population will also be affected by fluctuations in the densities of competitors (e.g. black-backed jackals) (Bothma & Walker 1999). Bothma & Walker (1999) found that many farmers in South Africa observed that when black-backed jackals are abundant, caracals tend to occur in lower numbers and *vice versa*. A dietary study of dingoes (*Canis lupus dingo*) and red fox (*Vulpes vulpes*) in the Greater Blue Mountain region of New South Wales,

Australia revealed that these animals may experience resource competition on a fine geographic scale but that there was no evidence to support resource competition on the landscape-scale (Mitchell & Banks 2005). Mitchell & Banks (2005) propose that it is the different hunting mechanisms of the two species that allow for sympatric existence. Similarly, caracals are stalking to rapid ambush predators, whereas jackals are searching predators which often hunt in packs or pairs (Bothma & Walker 1999; Skinner & Chimimba 2005). Such contrasting hunting strategies may allow the two species to co-exist in the Winterberg.

The interaction between caracals and jackals could be seen as a community level interaction and may explain a population-level relationship (Taylor's Law) (Kilpatrick & Ives 2003). In other words, not all mechanistic explanations entail a reductionism or are a product of a closed system (Kilpatrick & Ives 2003). Mechanistic explanations can also be applied to open systems (Kilpatrick & Ives 2003). Therefore, the data obtained from this population may or may not be statistically 'closed' but from an ecological perspective if it is an open population the estimate of caracal density is still relevant.

With Rowcliffe *et al.*'s (2008) model it was possible to estimate the abundance of non-individually recognisable caracals in the Winterberg. These data were then extrapolated to the whole Winterberg area, based on the assumption that there was no same sex overlap and indicated that there could be six males and 48 females in the area (based on their average home range from the literature) (Stuart 1982; Norton & Lawson 1984; Moolman 1984; Bothma & Le Riche 1994; Avenant & Nel 1998). Clearly this kind of extrapolation should ideally be done using home range data from animals in the area and multiple camera trapping surveys. However,

this was beyond the scope of the research. Nevertheless, this study does initiate the possibility of using camera trapping as a tool for estimating the abundance of elusive, non-recognisable animals and provides essential information on these predators for an area which is characterised by intense human-predator conflict. I was also able to produce the baseline data for a mammalian species inventory for an area where the current species inventory is based on local sightings and knowledge which can be spurious or misleading. Critically, this study provides an independent estimation of the abundance of caracals which, in conjunction with longer term monitoring, could allow for the implementation of more sustainable management strategies for dealing with the human-predator conflict in the area.

CHAPTER 4: DETERMINING BASELINE DEMOGRAPHIC DATA AND THE ATTITUDES OF FARMERS IN THE WINTERBERG, EASTERN CAPE, SOUTH AFRICA TOWARDS CARACALS

4.1 INTRODUCTION

Human populations and wildlife interact in numerous ways and environments. Humans have used wild animals for food and fur for millennia and modified environments with expanding human populations and the growth and development of civilisations. One of the major consequences of these developments has been the establishment of agriculture in the habitats of free-ranging animals, creating conflict, as wildlife prey on livestock and damage crops (Thirgood *et al.* 2005).

Depredation of livestock is very often the result of interactions between livestock and free-ranging carnivores (Marker & Dickman 2004; Romañach *et al.* 2007; Gussett *et al.* 2009). The control response for these carnivores has tended to be dominated by lethal measures, and since carnivores often occur at low densities, these lethal control measures have resulted in the removal of carnivores from ecosystems (Wielgus & Bunnell 1994; Powell *et al.* 1996; Quigley & Herrero 2005). Lethal control measures have been favoured because of the belief that carnivore predation has enormous socio-economic effects, loss of livelihood through the loss of livestock (particularly for rural, agricultural-based economies) and fear-based attitudes towards carnivores (Breitenmoser 1998; Woodroffe & Ginsberg 1998; Inskip & Zimmerman 2009). Despite the use of lethal control on carnivores, habitat destruction and fragmentation are also significant factors threatening carnivore populations worldwide (Woodroffe & Ginsberg 1998; Sunquist & Sunquist

2001; Karanth & Chellum 2009). The indirect effects of habitat fragmentation are a direct consequence of the most productive lands being cultivated first: floodplains, savannahs and riverine forest. These habitats are not only productive for agriculture but also for carnivore species (Sunquist & Sunquist 2001). Carnivores are particularly vulnerable to these habitat changes as they generally occur at low densities, have large home ranges, low reproductive output and are territorial, leading to sub-adults dispersing over large distances (Sunquist & Sunquist 2001; Linnell *et al.* 2001). Large, wide-dispersing carnivores may adapt to fragmented landscapes as multiple fragmented patches of habitats may appear as one connected landscape unit. However, this potential for adaptation does not apply for smaller species, such as caracals. To these smaller carnivores, openings between patches can become obstacles (Sunquist & Sunquist 2001). Consequently, resource availability becomes confined within much smaller areas. Should these areas be agricultural lands, livestock become a food resource for predators, creating a conflict between the livestock farmers and predators (Sunquist & Sunquist 2001). This conflict affects the attitudes of the farmers, and negative attitudes towards predators severely affect the implementation of sustainable management programmes aiming to conserve carnivores in areas of conflict (Bjerke & Kaltenborn 1999; Romañach *et al.* 2007).

Kellert (1985) surveyed a broad spectrum of people across Alaska, USA, on their attitudes towards wolves (*Canis lupis*) and coyotes (*Canis latrans*). People with general affection for animals and who understood and supported conservation tended to have positive attitudes towards wolves and coyotes (Kellert 1985). In addition, these were also generally respondents with a higher socio-economic status and were non-livestock producers (Kellert 1985). However, those respondents who more generally encountered these animals and were economically

affected by their presence, such as livestock farmers, had a negative attitude towards predators in general and favoured lethal control measures (Kellert 1985). However, this clear-cut division of attitude is not always the case. A survey conducted amongst cattle ranchers in the Pantanal, Brazil, regarding their attitudes towards jaguars (*Panthera onca*) showed that although they appreciated the intrinsic value of the Pantanal region and thought that jaguars deserve protection, they would not conserve them on their own ranches (Zimmerman *et al.* 2005). These conflicting attitudes have been observed in a number of studies where tolerance towards wildlife decreases as economic losses increase (Newmark *et al.* 1993; de Boer & Baquete 1998; Lindsey *et al.* 2005). Many socio-economic factors influence the attitudes of people directly affected by predators (Conforti & de Azevedo 2003; Dar *et al.* 2009; Inskip & Zimmerman 2009).

Education level, the value of cattle and the belief system of a community, livestock husbandry practices and the availability of natural prey are all factors known to influence attitudes towards predators (Inskip & Zimmerman 2009). Education is a vital part of encouraging community involvement, which is necessary for the implementation of any successful predator management strategy (Woodroffe *et al.* 2007). In a survey of inhabitants surrounding Manyeleti Game Reserve, South Africa it was found that respondents had more favourable attitudes towards predators if they possessed a higher education level (Legendijk & Gusset 2008). Similarly, Rodriguez *et al.* (2003) surveyed a number of Mexicans across several socio-economic spheres on the re-establishment of the Mexican gray wolf (*Canis lupus baileyi*). They found that the most educated group (academics) had the most positive response towards the re-introduction of wolves (Rodriguez *et al.* 2003). Several studies have also linked the demographic relationship between education levels and household affluence (i.e. the potential to provide education)

(Infield 1988; Bruskotter *et al.* 2007; Dar *et al.* 2009). Moreover, the level of education is also a product of the underlying belief systems and values of a community (Shivik *et al.* 2003). Traditional beliefs which can cause negative attitudes towards predators continue through the generations failing new education input (Shivik *et al.* 2003).

Communities regularly experiencing small-scale conflicts with predators have, over time, developed strategies for coping with these conflicts (Treves & Karanth 2003). Many of these strategies involve lethal control measures which removes the problem in the short term. These control measures continue through multi-generational farming communities, often regardless of their long-term effectiveness (Shivik *et al.* 2003; Treves & Karanth 2003). Primm & Clark (1996) stress the need to consider these ingrained beliefs and the vital role they play in constructing community attitudes towards predators. These ingrained attitudes could be seen as a by-product of education and the basic understanding and appreciation of conservation (Primm & Clark 1996). The economic value of livestock is also an important contributing factor influencing attitudes towards predators. The attitudes of two communities of different agricultural structure towards snow leopards (*Uncia uncia*) were surveyed in the Spiti region, Indian Trans-Himalaya (Bagchi & Mishra 2006). Whilst both communities experienced heavy livestock losses, one community was more economically reliant on cash crops whilst the other community was more economically reliant on livestock (Bagchi & Mishra 2006). They found that the community inhabiting the areas around the Kibber Wildlife Sanctuary (KWS), which had traditionally bred horses and had moved to the more profitable cash crops, had a more positive attitude towards snow leopards (Bagchi & Mishra 2006). However, the communities surrounding the Pin Valley National Park (PVNP), which were still reliant on horses as a major source of income, had

negative attitudes towards snow leopards and their conservation (Bagchi & Mishra 2006). Given the attitudes of the people in these two regions, it appears that communities often perceive conflict in terms of the greater economic loss.

Various strategies, such as altering livestock husbandry practices, have been employed to reduce depredation by predators and create a more positive attitude towards predators in livestock economy based communities (Breitenmoser *et al.* 2005). Woodroffe *et al.* (2007) undertook a case-control study of various livestock husbandry techniques in northern Kenya, attempting to reduced predation on livestock by African wild dogs (*Lycaon pictus*), cheetahs (*Acinonyx jubatus*), lions (*Panthera leo*), leopards (*Panthera pardus*) and spotted hyenas (*Crocuta crocuta*). They found that overall risk of attack was lower during the day when small herds were accompanied by herding dogs and human herders (Woodroffe *et al.* 2007). At night, predation risk was lowest for herds held in bomas (Woodroffe *et al.* 2007). These preventative measures improved losses and increased positive opinion towards the predators (Woodroffe *et al.* 2007). However, when losses do not decrease, even when employing different livestock husbandry techniques, this can have a detrimental effect on the attitudes of the community as previously held ingrained beliefs become justified by the lack of results, and communities return to previous control measures. For example, Kolowski & Holecamp (2006) found that improved fencing, more watch dogs and higher levels of human activity did not reduce livestock losses due to spotted hyenas, lions and leopards in the villages adjacent to the Maasai Mara National Reserve, Kenya. Consequently, negative attitudes towards predators persisted in the area (Kolowski & Holecamp 2006).

4.1.1 *The human-predator conflict in the Winterberg*

The Winterberg area consists predominately of sheep farms which have long had livestock-predator conflict (Pringle & Pringle 1979). The Winterberg was declared a conservancy in 2000 by the Winterberg Farmers' Association. The conservancy aimed to reconstruct intact wildlife communities and have controlled hunting on these populations. However, no clear guidelines were drafted with respect to the control of predators in the area. Thus, the sheep inhabit, and move freely through a habitat shared with the general wildlife population and predators (C. Phillips pers. comm.). In 1835 there are records of lions, leopards, servals (*Felis seval*), brown (*Parahyaena brunnea*) and spotted hyena (*Crocuta crocuta*) and wild dogs (*Lycaon pictus*) in the Winterberg area (Pringle & Pringle 1978; Skead 2007). However, by the early 1900s, these predators had disappeared from the Winterberg (Skead 2007) and caracals and black-backed jackals became the apex predators (Pringle & Pringle 1978). Nevertheless, from 1920, caracals and jackals have been systematically hunted due to livestock losses (Pringle & Pringle 1978). Despite the continual hunting of these predators, they persist in the Winterberg and are at the centre of the human-predator conflict in the area (Pringle & Pringle 1978, A. Pringle pers. comm). However, there have not been any detailed assessments of the problem, nor of the baseline demographic data or attitudes of the people affected by the conflict.

Effective conservation management strategies hinge on a broad knowledge and understanding of an area and the attitudes of the people inhabiting this area (Gros *et al.* 1996). Surveys are particularly useful when information is required from a target population. The use of surveys recognises and accounts for the human dimension, an integral part of understanding and ultimately managing human-wildlife conflict (Redpath *et al.* 2004). Surveys are inexpensive and,

if the questions are structured correctly, can be extremely valuable tools for collecting baseline data (Gros *et al.* 1996). However, Gros *et al.* (1996) found that interviews were not only the most accurate indirect method of data collection but that the most accurate data from interviews was the product of interviewing small areas thoroughly. Thus, the Winterberg is an ideal area for collecting baseline ecological and attitude data through interviews as it is small enough for all the major land owners in the area to be surveyed.

The aims of these surveys were divided into two broad categories, baseline data and attitude data:

- The questions contributing to the accumulation of baseline data aimed to:
 - 1) Accumulate basic demographic data relating to age, education, property size, and numbers of livestock.
 - 2) Generate an inventory of the various livestock husbandry practices employed.
 - 3) Determine the general population trends for wildlife in the area.
 - 4) Assess the predator control measures and the proportions of respondents using non-lethal, lethal and no control methods.
 - 5) Determine the scale of the livestock-predator conflict.

- The attitude data used a series of questions to determine the attitudes of the respondents to:
 - 1) Conservation in general and predators specifically.
 - 2) Predator-related livestock losses.
 - 3) The use and effectiveness of non-lethal and lethal control measures.
 - 4) Compensation due to stock losses.

4.2 MATERIALS AND METHODS

4.2.1 Data collection

A structured questionnaire (Appendix C) for determining baseline demographic data and the attitudes of the farming community towards caracals was conducted for all the members of the Winterberg Farmers' Association ($n = 21$) in the Winterberg, Eastern Cape. Interviews were conducted in the home language, which in all cases was English. For the interviews, the interviewer maintained an unbiased, open persona to encourage honesty. Respondents have a tendency to withhold their honest opinion if they feel that the interviewer has preconceptions towards them (McColl *et al.* 2001). Therefore, no intimation for the 'ideal' answer was given by the interviewer (McColl *et al.* 2001). Similarly, McColl *et al.* (2001) showed that when the respondent is interviewed by someone with more education than them they tend to withhold information and become more guarded. Therefore, in order to retain a more open, non-judgemental atmosphere, questions on education levels were withheld until the end of questionnaire when the respondent was more relaxed and comfortable with the interviewer.

The data on the number of caracals and jackals killed by farmers from 2002 to May 2011 were not taken from the interviews. These data were obtained from the Winterberg Farmers' Association records, where members submit data on the number of caracals and jackals they have killed on their farm, either through hunting with a dog pack or trapping the animals and then shooting them (M. King pers. comm.). Therefore, these data probably represent an under-estimation of how many animals were killed over that period.

4.2.2. Questionnaire structure

The survey was structured so that general questions were asked first, followed by those assessing attitudes and opinions. Basic property characteristics, visual sightings and predation-related livestock losses formed the initial set of questions (Appendix D). The predation-related livestock losses was put in the initial section to make the respondent feel more empowered and so that the survey had the interests of the farmers at the forefront of its aims. With the feeling of empowerment, it aimed to elicit a more honest response to questions surrounding the potential conservation status of caracals (McColl *et al.* 2001).

The section on livestock losses due to caracals was divided into two subsections in order to disclose as much detail as possible surrounding these events (Appendix C). Respondents were asked to clarify the number of livestock killed, how the predator responsible for the kill was identified (e.g. spoor, faeces, call or the carcass itself), at what time of day and where the incident took place, and whether kraaling took place. Kraaling was defined as grouping pregnant ewes and ewes with lambs together in a fenced area during this period of vulnerability (Ogada *et al.* 2003). To minimise exaggeration of losses, it was stressed that the information gleaned from this section was entirely anonymous and for research purposes only and therefore had no bearing on government policies regarding compensation for farmers who have suffered livestock losses (Romañach *et al.* 2007, Dar *et al.* 2009).

The second section of the survey addressed the observed population trends for potential prey items and other wildlife in the Winterberg. Before being asked the population trend questions, all respondents were shown a series of photographs of the animals in question and asked to identify

them (Appendix D). The animals were baboon (*Papio hamadryas*), bushbuck (*Tragelaphus scriptus*), mountain reedbuck (*Redunca fulvorufula*), common duiker (*Sylvicapra grimmia*), grey rhebok (*Pelea capreolus*), steenbok (*Raphicerus campestris*), springbok (*Antidorcus marsuipialus*), impala (*Aepyceros melampus*), rock hyrax (*Procavia capensis*) and Greater kudu (*Tragelaphus strepciceros*). All respondents identified the animals correctly.

All the opinion-based questions were all a series of open and closed-ended questions. For the closed-ended questions, the answers were scaled using a 5-point Likert scale (White *et al.* 2005). Trichotomous questions (forming the attitude index) were a series of statement-like questions to which the respondent could answer 'yes', 'no', 'maybe' or 'don't know' (White *et al.* 2005). These categories were then numerically ranked 1, -1 and 0 respectively (White *et al.* 2005). From these data, an attitude index was calculated for each respondent (Zimmerman *et al.* 2005). Attitude indices were calculated from a series of 11 questions which covered themes such as the role of caracals in the Winterberg ecosystem, the effectiveness of various control measures and impact of caracal predation on socio-economic factors. A strongly positive attitude scored 11 and a strongly negative attitude scored -11 (Appendix C).

4.2.3.1 Akaike Information Criteria for attitude indices

To analyse which variables were most likely to influence the attitudes of the respondents, an Akaike Information Criterion (AIC) model selection procedure was used (Burham & Anderson, 1998). There were two categorical variables: education level (secondary and tertiary) and control type (lethal, non-lethal, no control) and three continuous variables: age, number of livestock killed and the size of the property. From the AIC figures, the AIC weights were calculated and

values > 0.8 (accounting for over 80% of the AIC weights) were deemed the best model set (Burham & Anderson, 1998; Rowe, 2009; Fortúrbal, 2010). The AIC values and subsequent weighted variables were calculated using Microsoft Excel™ 2007.

4.2.3.3 Statistical analysis

A series of linear correlations and regressions was plotted to investigate the potential relationships between the size of properties, number of sheep lost, the distance of a caracal attack from a dwelling and the total number of sheep killed by caracals. Linear correlations were also used to determine whether the attitude index of the respondents was affected by the area of the property and the number of livestock killed by caracals. A Spearman's Rank Correlation was conducted to determine if there was a relationship between the number of caracals killed and lamb mortality due to caracal predation. All analyses were done using SigmaPlot™ V10.0, Systat Software Inc., Germany.

The major problems facing the farmers in the Winterberg were ranked in severity from 1 (not a problem) to 5 (a major problem). A non-parametric Kruskal-Wallis test was performed to determine if there was a significant difference among the problems facing the farmers. A Student Newman-Keuls post-hoc test was used to distinguish significant differences among the problems facing the respondents. The same statistical procedure was used to determine if there was a difference in the number of sheep lost to caracal predation and the type of control measure employed by the respondent. This was done using Statistica™ V9.0, Statsoft 2009, Tulsa, Oklahoma.

A Mann-Whitney U-test was used to determine if there was a significant difference between the number of sheep lost to caracals by the respondent and their livestock husbandry practices for pregnant and lambing ewes, and whether the level of education (secondary or tertiary) of the respondent affected their attitudes. All these analyses were done using Statistica™ V9.0, Statsoft 2009, Tulsa, Oklahoma.

4.3 RESULTS

4.3.1 Demographics

The average age of the respondents was 49, and 43% had been educated up until the end of secondary school. Whilst the remaining 57% of the respondents had undertaken some form of tertiary education (Table 4.1). The respondents were male, and their home language was English. The average size of the respondents' farms was 3397.19Ha \pm 2045 Ha, indicating a fairly sizeable range in property sizes.

Table 4.1: The basic demographics of the respondents ($n=21$) in the Winterberg Conservancy, Eastern Cape, South Africa. Age and area of farm are expressed as means \pm standard deviations.

<hr/>	
Education	
<i>Secondary (%)</i>	43
<i>Tertiary (%)</i>	57
<hr/>	
Age	49.05 \pm 11.23
Area of farm (Ha)	3397.19 \pm 2045.02
Home language	English
Sex	Male
<hr/>	

4.3.2 Livestock management and predation

Table 4.2: General farm information for farmers in the Winterberg Conservancy, Eastern Cape, South Africa, including the numbers of livestock and predation control measures employed by the respondents.

	Single stock	Mixed	
Farm type (%)	14	85	
Average number of stock (\pm SD)	211.67 \pm 132.88	<i>Cattle</i>	456 \pm 351.21
		<i>Sheep</i>	2091 \pm 1848.17
	Non-Lethal	Lethal	None
Predator control (%)	6	83	11
Average stock lost to caracal (%)	0	21.5	6.6

Of the 21 respondents, 14% were solely cattle farmers and the majority of the respondents (85%) were mixed stock farmers having both sheep and cattle (Table 4.2). On average, the single stock farmers had 211 cattle and the mixed stock farmers had 456 cattle and 2091 sheep.

Out of the respondents, 4.76 % (one farmer) employed non-lethal control methods, 71.4% lethal control methods, 23.8% employed no predator control (Table 4.2). The average number of sheep lost to caracals was estimated by the respondents over a period of two years. The respondent employing non-lethal control did not lose any sheep over the two years (Table 4.2). Those employing no form of control (five respondents) lost 6.6% of their stock over two years and those employing lethal control measures (15 respondents) lost 21.57% of their sheep over two years (Table 4.2). There was a significant difference between the number of sheep lost and the control measure employed ($p < 0.05$, $H_{2,21} = 10.87$). Significantly more sheep were lost by

respondents who employed lethal control than to those who did nothing to prevent stock losses from predators (Table 4.2).

Additionally, 67% of the respondents kraaled their sheep during the lambing period (i.e. the period of highest vulnerability). There was no significant difference ($P > 0.05$, $Z = 0.41$, $df = 20$) between the number of sheep lost by a respondent and whether or not their lambs were kraaled.

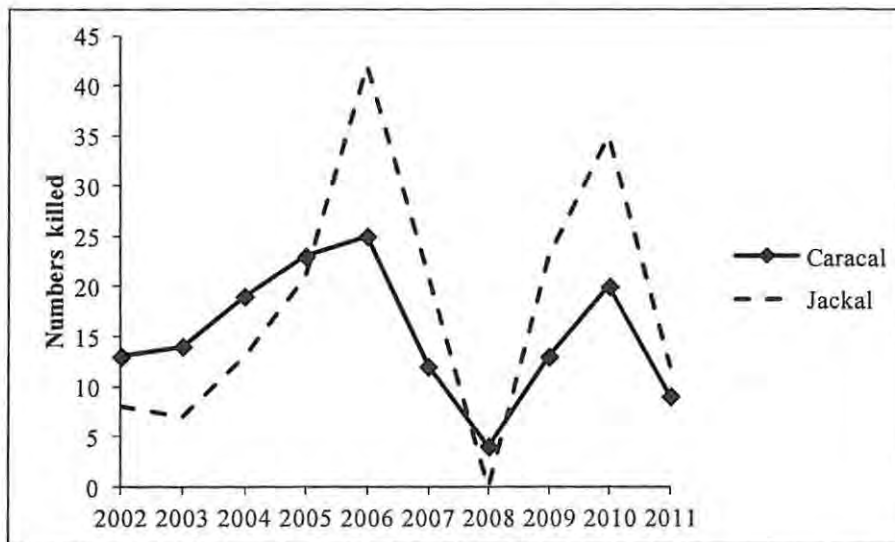


Figure 4.3: The number of caracals and jackals killed by farmers in the Winterberg, Eastern Cape, South Africa between 2002 and 2011.

The numbers of caracals and jackals killed between 2002 and 2011 show bimodal peaks, one in 2006 and one in 2010 (Figure 4.3). Twenty-five caracals were killed in 2006 and 20 in 2010 (Figure 4.3). Similarly, 40 jackals were killed in 2006 and 35 in 2010 (Figure 4.3). Both the predators show the same trend of a high number killed followed by a dramatic drop (Figure 4.3).

Despite reflecting a similar pattern, consistently more jackals than caracals appear to have been caught and killed over this ten-year period (Figure 4.3)

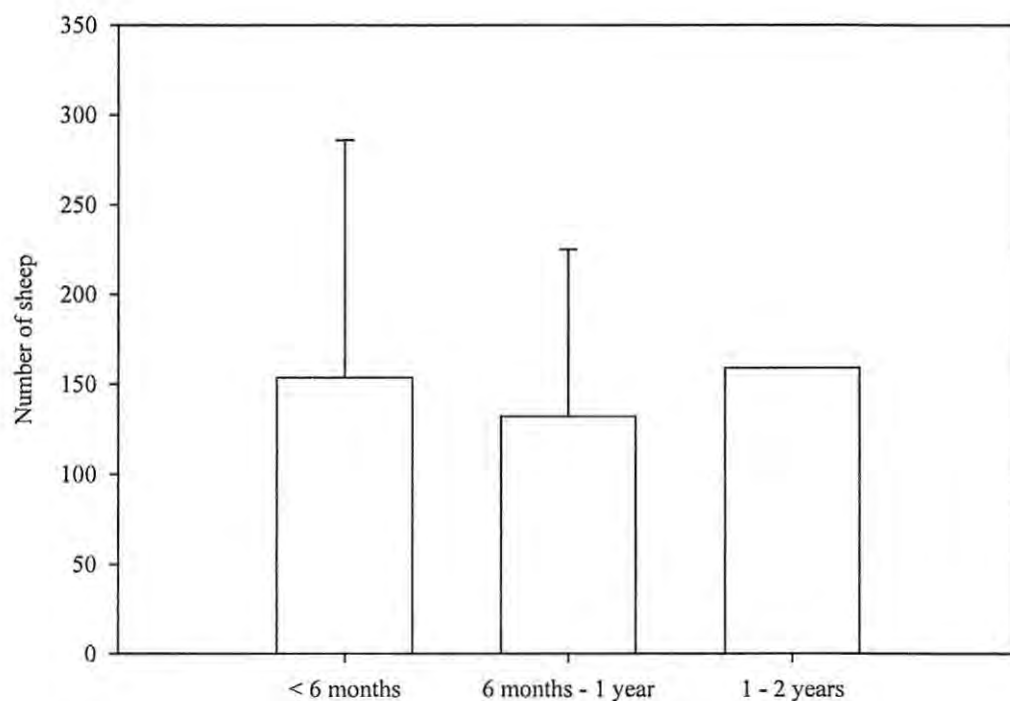


Figure 4.4: The mean (\pm SD) number of sheep that respondents lost to caracals between 2009 and the start of 2011 in the Winterberg Conservancy, Eastern Cape, South Africa.

In the first 6 months of 2011, the respondents reportedly lost, on average, 153 sheep, 7.3% of their stock (Figure 4.4). In 2010 (6 months to 1 year), the respondents lost an average of 139 sheep, 6.6% of their stock (Figure 4.4). Between 2009- 2010 (1-2 years ago), the respondents lost an average of 159 sheep, 7.6% of their stock. There was no significant difference ($p > 0.05$, $H_{2,63} = 0.82$) among the three time periods for the number of sheep lost (Figure 4.4).

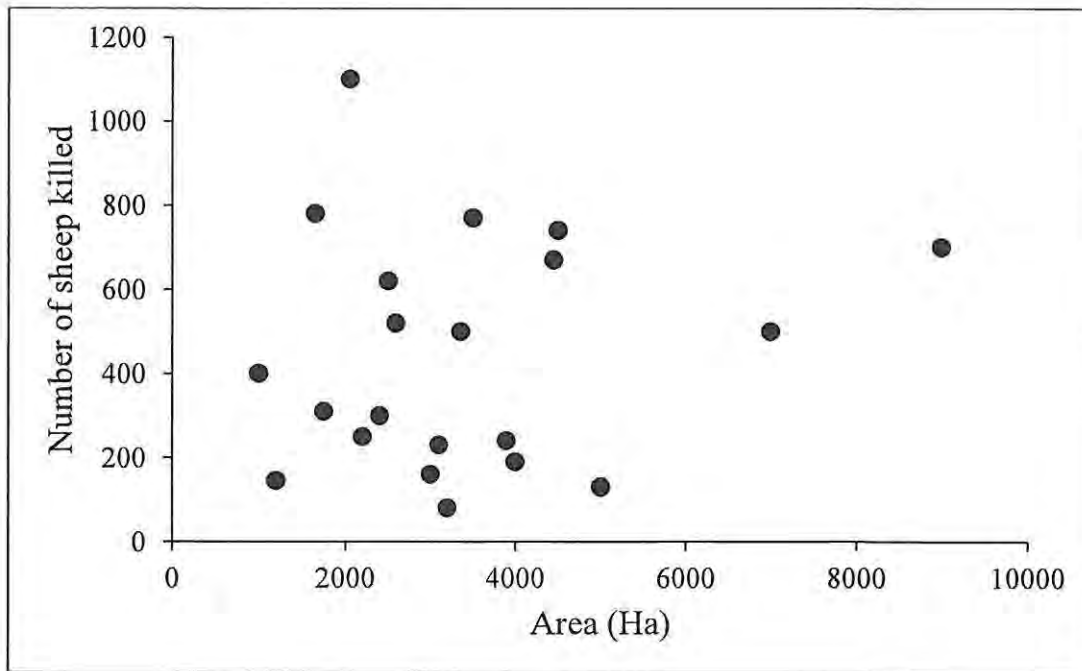


Figure 4.5: The relationship between area of a respondent's farm and numbers of sheep killed by caracals.

There was no relationship between the number of sheep killed by caracals and the size of the respondent's properties (Figure 4.5; $R = 0.03$, $df = 20$).

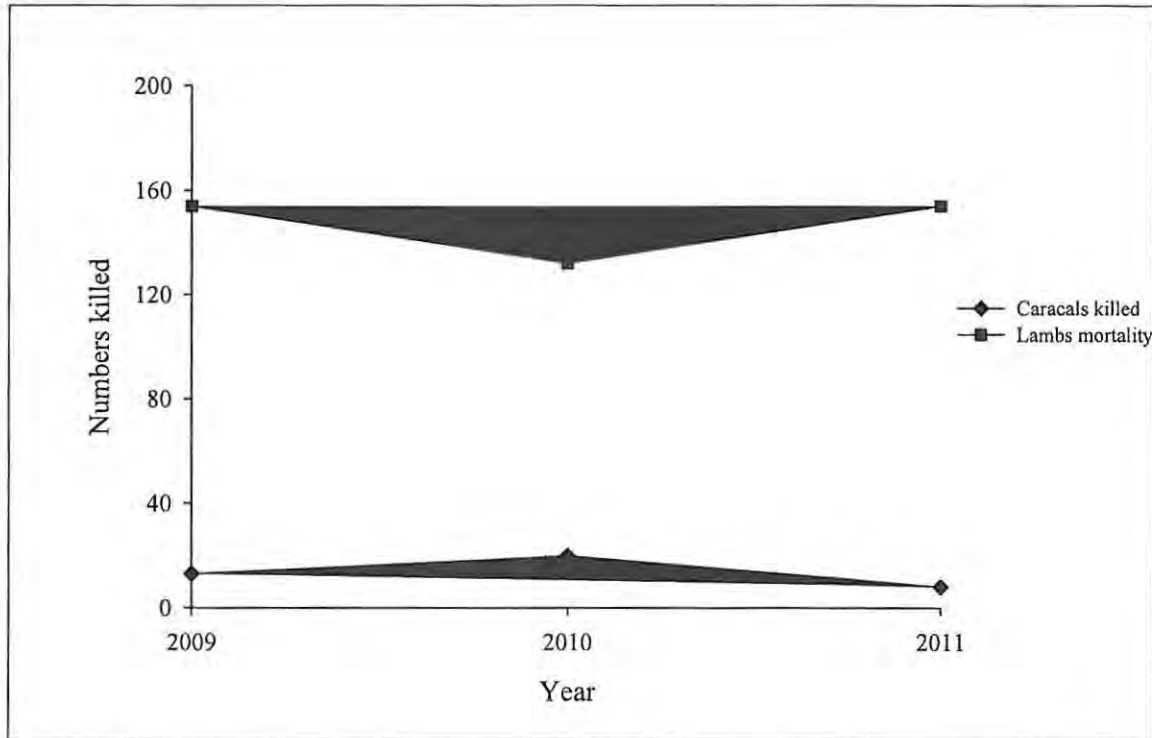


Figure 4.6: The annual fluctuations (2009-2011) in the number of caracals killed and the average lamb mortality due to caracal predation.

Kills of caracals reported to the Winterberg Farmers' Association were 13 in 2009, 20 in 2010 and eight in 2011 (Figure 4.6). Over the same period, the lamb mortality was 154 lambs due to predation by caracals in 2009, 132 in 2010 and 154 in 2011 (Figure 4.6). There was a slight decrease in lamb mortality in 2010, coinciding with an increase in the number of caracals killed by farmers (Figure 4.6). Nevertheless, there was no significant correlation between lamb mortality and the number of caracals killed by the farmers (Figure 4.6; $p > 0.05$; $R = -0.86$).

Table 4.3: The number of caracal sightings and the overall number of caracals killed between 2008 and 2010. Data for the number of caracals killed were supplied by the Winterberg Farmer's Association and the caracals sighted were as reported by the respondents.

	Sightings	Killed
2008	1 every 6 months	4
2009	1 every 6 months	13
2010	1 every 6 months	20

In the interviews, the respondents were asked how often they saw caracals. All of the respondents believed that they only saw 1 caracal every 6 months (Table 4.3). Because caracals are not individually recognisable, it was not possible to estimate a total for each year. However, these low sightings do not coincide with the high numbers of caracals killed in 2009 and 2010 (Table 4.3).

4.3.3 Potential prey population

Table 4.4: The observed population trends of the potential prey items of caracals in the Winterberg Conservancy as estimated by the respondents ($n=21$).

	Status	Sighted	Observed population trend
Baboon (<i>Papio hamadryas</i>)	Common	Weekly	Increasing
Bushbuck (<i>Tragelaphus scriptus</i>)	Absent	N/A	N/A
Mountain reedbuck (<i>Redunca fulvorufula</i>)	Common	Weekly	Stable
Common duiker (<i>Sylvicapra grimmia</i>)	Common	Weekly	Increasing
Grey rhebok (<i>Pelea capreolus</i>)	Common	Weekly	Stable
Steenbok (<i>Raphicerus campestris</i>)	Common	Weekly	Stable
Springbok (<i>Antidorcus marsupialis</i>)	Common	Weekly	Stable
Impala (<i>Aepyceros melampus</i>)	Absent	N/A	N/A
Rock hyrax (<i>Procavia capensis</i>)	Common	Weekly	Stable
Kudu (<i>Tragelaphus strepsiceros</i>)	Common	Weekly	Increasing

Of the 10 potential prey which could also act as indicator species for ecosystem health, 67% of the respondents thought that they were common and observed them weekly, except for bushbuck and impala, which 90% of the respondents thought were absent from the area (Table 4.4). In addition, 86% of the respondents thought that baboon, common duiker and kudu populations had increased whilst the remaining species' populations had remained stable (Table 4.4).

4.3.4 Livestock husbandry

Table 4.5: The respondents' opinions on the effectiveness of human guards and guard dogs for protecting sheep in the Winterberg Conservancy, Eastern Cape, South Africa.

Human guard	
Strongly disagree	23.80%
Disagree	28.50%
Neither agree or disagree	0%
Agree	19%
Strongly agree	28.50%
Guard dog	
Strongly disagree	5%
Disagree	38%
Neither agree or disagree	14.30%
Agree	19%
Strongly agree	23.80%

Overall, 23.80% of the respondents strongly disagreed that a human guard was effective at protecting sheep from attacks by caracals (Table 4.5). In addition, a further 28.50% disagreed that a human guard was effective (Table 4.5). Nineteen percent agreed that a human guard was effective and 28.50% strongly agreed that a human guard was effective at protecting sheep (Table 4.5). None of the respondents were ambivalent (Table 4.5). This equates to an approximately equal (~52% disagree versus ~48% agree) split between the respondents as far as their opinion on the effectiveness of herders was concerned (Table 4.5). By comparison, a slim majority of the respondents (~57%) either had no opinion or felt that guard dogs would be an effective, non-lethal way to protect sheep from caracal attack (Table 4.5).

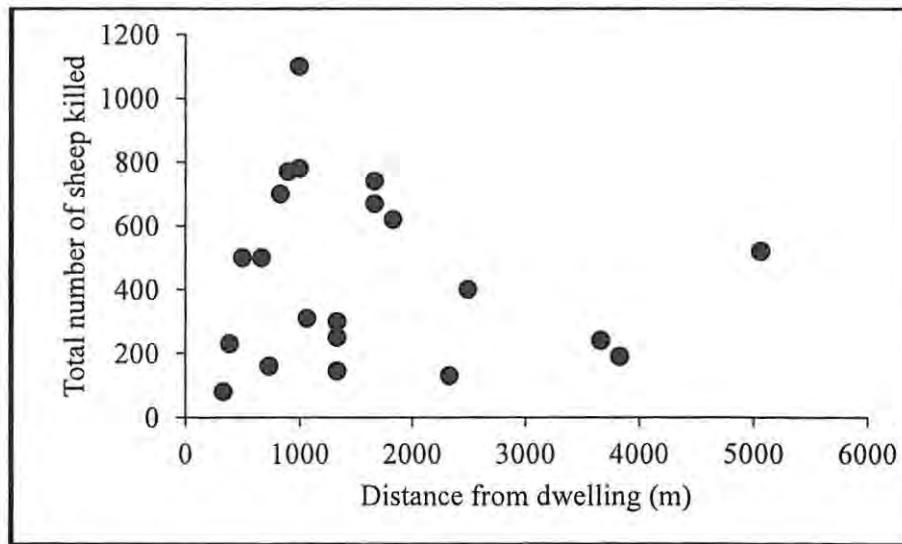


Figure 4.7: The relationship between the number of sheep killed and distance to the nearest dwelling between 2009 and 2010 in the Winterberg Conservancy, Eastern Cape, South Africa.

There was no correlation between the number of sheep killed and distance to the nearest dwelling (Figure 4.7; $R = 0.02$, $df = 20$).

4.3.5 Attitude Index

Table 4.6: A summary of the responses to the attitude index survey ($n = 21$) by the farmers in the Winterberg Conservancy, Eastern Cape, South Africa.

	Yes	No	Maybe	Don't know
1. Caracal can pass through your land unseen/unnoticed?	19	2	0	0
2. Are caracal a natural part of the ecosystem in the Winterberg?	21	0	0	0
3. Caracal should be protected?	2	17	2	0
4. Would the Winterberg be a better place without caracal?	6	13	1	1
5. Do caracal play the biggest role in livestock losses in the Winterberg?	1	20	0	0
6. Can caracal pass through the Winterberg without killing livestock?	8	12	0	1
7. Are livestock losses due to caracal increasing?	4	15	1	1
8. Do caracal significantly negatively impact your profit from your livelihood?	12	9	0	0

9. If there was an effective non-lethal control for these animals would you use it?	19	2	0	0
10. Is lethal control the only control that works?	13	6	1	1
11. Are you concerned about the wildlife in the Winterberg?	19	2	0	0

In general, farmers had a positive attitude and understanding of the natural ecosystem in the Winterberg (Table 4.6). All the respondents believed that caracals are a natural part of the ecosystem and that the Winterberg would not be a better place without them (Table 4.6). Moreover, the majority of the respondents were concerned about wildlife in the Winterberg (Table 4.6). The understanding of the ecological balance of the Winterberg is expressed in the fact that 17 of the respondents believed that caracals should not be protected which would seem justified as caracals are not endangered (Table 4.6). The attitude towards and their effect on livestock predation was more mixed. Twenty of the respondents believed that caracals do not play the biggest role in the loss of livestock in the Winterberg, and 15 believed that livestock loss due to caracals was not increasing. Only eight of the respondents thought that caracals could pass through the area without killing livestock and that caracals significantly impacted on the profit from their livelihood (Table 4.6). On the more positive side, 19 of the respondents would use an effective non-lethal control if it were available (Table 4.6). However, only six of the respondents thought that lethal control was not the only effective control (Table 4.6).

4.3.6 Exploratory Data Analysis

Table 4.7: The categorical and continuous predictors used in the AIC model for determining which variables had the highest probability of influencing the attitudes of the respondents and their respective AIC weights derived from the AIC model.

Variable	AIC Weight
Size	0.96
No. Killed	0.95
Control type	0.66
Education	0.61
Age	0.31

The AIC model revealed that the size of the property and the number of livestock killed were the two variables most likely to affect a respondent's attitude (Table 4.7). The model suggested that control type, education and age were less likely to affect attitude (Table 4.7).

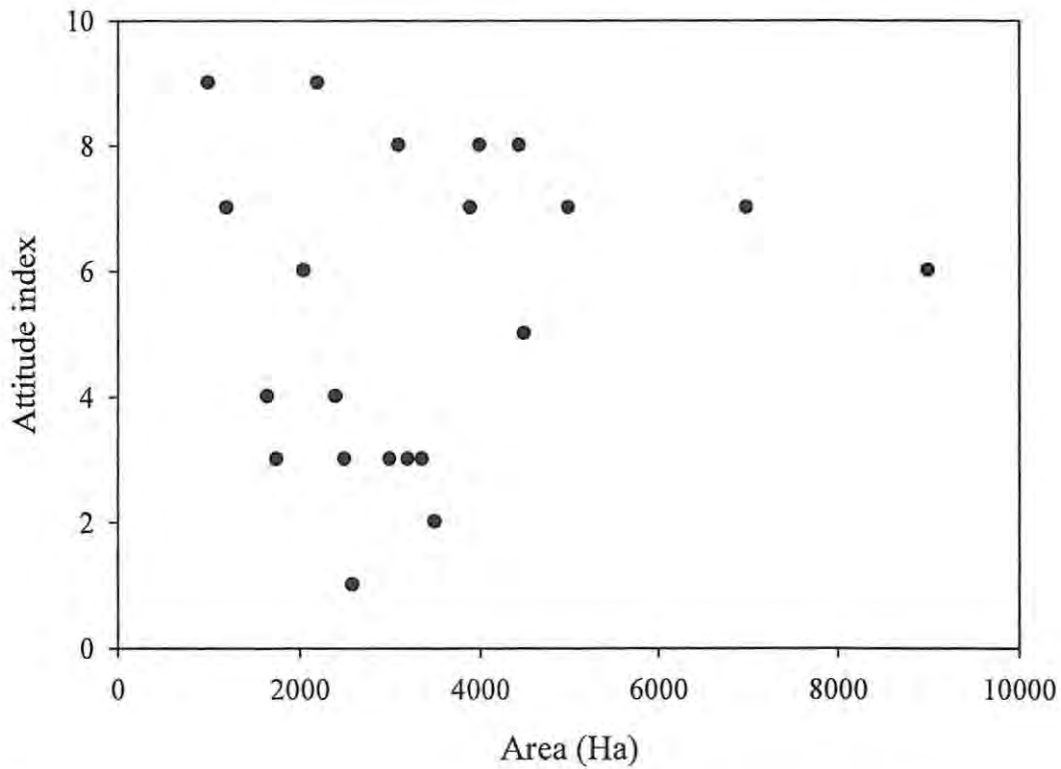


Figure 4.8: The relationship between the attitude index of the respondents and the farm area (Ha) in the Winterberg Conservancy, Eastern Cape, South Africa.

However, there was no relationship between attitude and the size of a respondent's farm (Figure 4.8; $R^2 = 0.01$, $F = 0.37$, $df = 20$). Therefore, the attitude index of the respondents was not influenced by the size of the property owned.

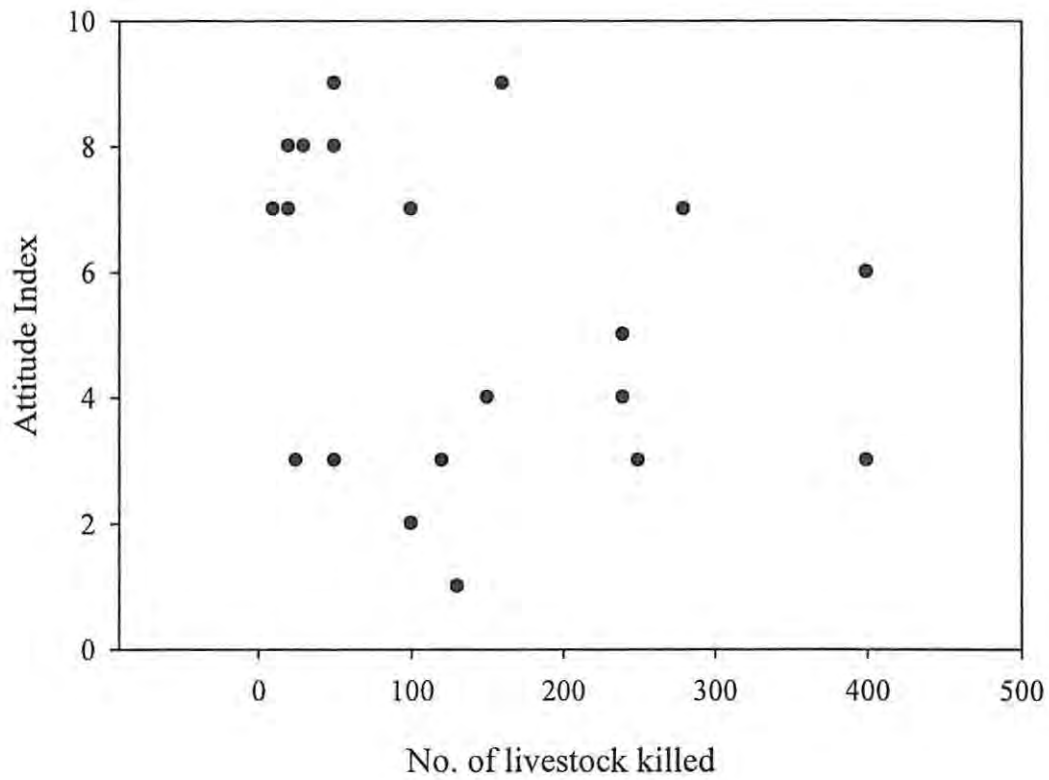


Figure 4.9: The relationship between the number of livestock killed by caracals and the attitude index of respondents in the Winterberg Conservancy, Eastern Cape, South Africa.

Similarly, there was no relationship between the number of livestock killed by caracals and the attitudes of respondents (Figure 4.9; $R^2 = 0.02$, $F = 0.87$, $df = 20$).

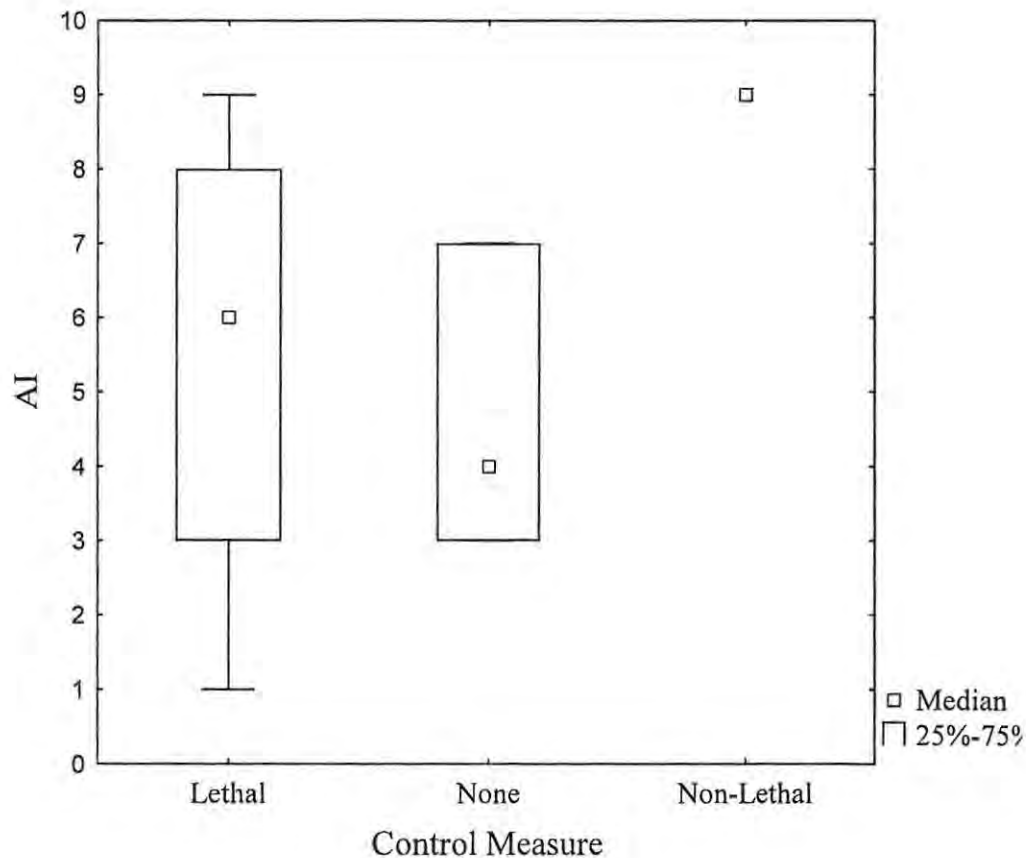


Figure 4.10: The median attitude indices of farmers in the Winterberg Conservancy, Eastern Cape, South Africa, who killed caracals on their farms (Lethal) to protect their stock, those who did not use any particular control method (None) and those who used an alternative method (Non-Lethal) for protecting their stock.

The attitudes of respondents were not significantly influenced by the type of control measure they employed to prevent stock loss (Figure 4.10; $p > 0.05$, $H_{2,21} = 2.71$). However, it does appear that the farmer who employed a non-lethal control approach e.g. alpacas (*Vicugna pacos*), had the highest attitude index score (Figure 4.10). By contrast, respondents who did not

use any particular measure ($n = 5$) had the lowest attitude index score, lower than those who used lethal control measures ($n = 15$) (Figure 4.10).

There was no significant difference between the level of education of the respondent (secondary or tertiary) and their attitude towards predators ($U_{21} = 35.00$; $Z = -1.32$; $p > 0.05$). Therefore, there were attitudes were similar regardless of education level.

4.4. DISCUSSION

The AIC analysis indicated that the attitudes of the respondents were most probably dependent on the number of sheep they lost to caracals and the size of their properties. Importantly, a correlation between the number of livestock killed by a predator and a negative attitude index has been reported previously in a number of studies (Kellert 1985; Reading & Kellert 1993; Ericsson & Herberlein 2003; Lindsey *et al.* 2005; Zimmerman *et al.* 2005; Karlsson & Sjöström 2007; Romañach *et al.* 2007). In this study, however, there was no relationship between the number of sheep killed by caracals and the attitude index of the respondents. This may be because 20 of the 21 respondents felt that caracals were not playing the greatest role in livestock losses in the Winterberg. All 20 respondents felt that jackals were more important in terms of livestock depredation in the Winterberg. The jackal population was not monitored in this study, but this overwhelming consensus of opinion may provide an explanation for the lack of a relationship between the attitudes of respondents and the number of sheep lost. However, it is far more likely that the low number of interviews ($n = 21$) conducted in this study prevented the detection of any significant trends.

4.4.1 Socio-economic factors

The basic demographic data from the surveys revealed that all respondents were male, English first language speakers, were an average age of 49 and educated to at least secondary level. Given this level of general education, it is not surprising that all the respondents believed that caracals are a natural part of the ecosystem in the Winterberg. Shivik *et al.* (2003) found that poor education can lead to misconceptions and general ignorance of ecological systems which

can in turn increase hunting pressure on carnivores. Another measure of ecological understanding of the respondents was the fact that 17 of the 21 respondents stated that caracals should not be protected given that caracals are listed as non-threatened (IUCN Redlist). This response suggests that the respondents were aware of the population status of caracals. These two responses appeared to indicate a more positive response to caracals in general. However, 13 of 21 respondents believed that the Winterberg would be a better place without caracals. It may be that the response that caracals should not be protected is a reflection that the respondents do not want caracals on their own property but elsewhere in the Winterberg Conservancy is acceptable. This response repudiates the positive responses to caracals forming a natural part of ecosystem functioning as removing them from the area could result in a trophic cascade effect (Elmhagen & Rushton 2007; Estes *et al.* 2011). Mesopredators are often generalist predators and in the absence of top-down control from top predators they can reach high population densities and place pressure on small prey species (Elmhagen *et al.* 2010). Top predators control mesopredators, and thus indirectly protect the biodiversity at lower trophic levels from the effects of over-predations (Elmhagen *et al.* 2010).

For all the respondents, livestock (14% cattle only, 85% cattle and sheep) was economically important and the sole source of income, and the livestock did not carry religious or cultural importance to the respondents (Ale *et al.* 2007; Inskip & Zimmerman 2009). Of the 21 respondents, 12 thought that caracals negatively impacted on their livelihoods and all of the respondents would accept compensation for livestock losses. The underlying basis behind compensation schemes is that compensating farmers for livestock losses will reduce hunting pressure on the predators (Bulte & Rondeau 2005; Schwerdtner & Gruber 2007). However,

compensation can lead to a decreased effort to conserve wildlife and an increase in cultivating land for crops and livestock which can dramatically affect the habitat suitability and availability for wildlife (Bulte & Rodeau 2005). This potential outcome from compensation schemes could have dire repercussions for the Winterberg area as it is a conservancy aimed at protecting populations of natural wildlife. Naughton-Treves *et al.* (2003) investigated tolerance towards recovering populations of wolves (*Canis lupus*) in Wisconsin, USA, and whether compensation increased tolerance towards wolves. They found that all the respondents approved of compensation but that livestock producers who had been compensated for their losses were not more tolerant of wolves (Naughton-Treves *et al.* 2003). It is possible that a similar situation could arise in the Winterberg if a compensation scheme is implemented. All the respondents approved of compensation, but it is unlikely to improve tolerance towards caracals as the lack of tolerance towards these animals is based on attitudes formed in early life (Naughton-Treves *et al.* 2003).

One of the fundamental problems linked to compensation is the accuracy of reported kills (Schwerdtner & Gruber 2007). The reported losses in a survey should be considered with some degree of scepticism because the majority of the respondents kept either none or only very vague records of losses. This seems to lend credence to the theory that ex-post compensation is ineffective due to unreliable records of livestock losses (Schwerdtner & Gruber 2007).

These poor records of losses can increase negative attitudes and distort the scale of the conflict, which can cause reactions disproportionate to the actual scale of the problem (Conforti & Azevedo 2003; Marker *et al.* 2003; Inskip & Zimmerman 2009). The majority of the respondents

to this survey indicated that they saw one caracal every six months between 2008 and 2010. However, it was not possible to determine whether the respondents were seeing the same animals or different ones due to lack of individually recognisable features on caracals. The submission of hunting records to the Winterberg Farmers' Association is entirely voluntary and therefore probably represents an underestimation of the number of caracals killed in the area. It does show a disproportionate reaction given the number of caracals seen in the area over that period. Between 2009 and 2010 33 caracals were killed and, on average, each farmer lost 159 sheep.

Other potentially influential socio-economic factors considered were age and the education level of the respondents. The average age of the respondents was 49, and all respondents had received at least secondary education. There was no relationship between the attitude index score and the age of the respondents. Similarly, there was no relationship between the education level of the respondents and the attitude index scores. Stronen *et al.* (2007) surveyed farmers in Manitoba, Canada to assess the attitude of farmers towards wolves (*Canis lupis*) on their farms. Similar to the results of this survey, Stronen *et al.* (2007) found that age and education did not influence attitudes of the farmers. This contradicts the results of a body of work suggesting that respondents with higher levels of education will have a more positive attitude towards predators (Infield 1988; Williams *et al.* 2002; Ericsson & Heberlein 2003). The age range of the farmers was between 32 and 63 years, indicating a multigenerational society. Stronen *et al.* (2007) consider this a form of social structure which propagates certain perceptions towards predators and the various control measures are a reflection of family traditions and beliefs. These traditions and beliefs are highly influential on attitudes towards predators (Kellert *et al.* 1996; Chavez *et al.* 2005; Stronen *et al.* 2007; Inskip & Zimmerman 2009).

4.4.2 Human behaviour and attitude

A key area where these family traditions and belief systems could be playing a significant role is in the type of control measure employed against predators. In the study area, only one of the respondents employed non-lethal control measures using alpacas. This respondent also lost 50% of his stock to caracals. However, this is most likely to be a product of his low stock numbers (250 animals) and that the greater proximity of his grazing pastures human habitation in comparison to other land owners. Therefore, the sheep were easily monitored by the respondent. To analyse the effectiveness of non-lethal controls, more respondents employing the technique would need to be surveyed. Additionally, 11% of the respondents (5) employed no control measures either because they were cattle farmers only or had limited livestock numbers. This is reflected in the fact that they lost, on average, only 6% of their livestock to predators. However, the majority (83%) of the respondents employed lethal control measures which ranged from cage traps to dog hunting packs. Of these respondents, no one used one method alone but rather a suite of different lethal methods. On average, these respondents lost 21.5% of their livestock to predators. This is probably a reflection of the larger sample set rather than a reflection of the effectiveness of lethal control measures. There was also a significant difference between the number of sheep lost and the control measure that was employed. Furthermore, there was a significant difference between the number of sheep lost and the use of no control measures or lethal control measures. This result is probably due to the fact that the respondents employing lethal control had far higher numbers of sheep than those that did not employ any form of control, hence a higher probability of losing more sheep.

Of the 21 respondents, 13 believed that lethal control was the only effective method. However, 19 of them would use a non-lethal method if it was effective. The 'loyalty' towards lethal control measures may be a function of tradition. Lethal control has historically been used in the region and enjoyed periods of success, hence the continued support for this approach despite the fact that the predation continues to be a problem in the Winterberg (Pringle & Pringle 1978). Likewise, in KwaZulu-Natal, South Africa, the majority of farmers surveyed used a variety of lethal control measures and 86% felt that lethal control measures were effective at controlling predators (Lawson 1989). The 14% of respondents who felt that these control measures were ineffective believed that this was due to the lack of time and expertise available (Lawson 1989). Therefore, like the respondents in this survey, Lawson (1989) concluded that lethal controls are still the most effective.

All the respondents' farms were within the Winterberg Conservancy. The conservancy aims to protect the wildlife in the Winterberg area and was initiated by the community. However, despite these ecological aims, the survey revealed that there was disagreement on which animals should be conserved. Although 13 of the 21 respondents thought that the Winterberg would not be a better place without caracals, six of 21 respondents thought that it would be a better place and 13 respondents believed that lethal control was the only effective method for controlling caracal numbers (i.e. permanently removing them from the ecosystem). These results appear to contradict the notion that the creation of conservancies can protect predators outside of conservation areas (Marker *et al.* 2003; Lindsey *et al.* 2005). Marker *et al.* (2003) analysed the attitudes of Namibian rangeland farmers towards cheetahs and suggested that the establishment of conservancies could alleviate the human-predator conflict occurring on private land. However,

in the Winterberg, the establishment of a conservancy does not appear to have had a beneficial effect on the predator populations which continue to be systematically removed from the ecosystem.

In this study, livestock husbandry practices such as the kraaling of ewes and lambs (the livestock most vulnerable to predation) had no significant effect on preventing livestock losses. This may be because the sheep were kraaled without livestock guarding dogs. Espuno *et al.* (2004) found that when sheep were confined at night, the presence of three or four dogs prevented 94% of attacks by predators. However, 38% of respondents in my study did not think that dogs were effective at guarding livestock and expressed doubt over the long-term effectiveness of kraaling. However, 23.80% of the respondents thought that a guard dog was an effective herd protector, indicating that there is some openness to using dogs as herd protectors. This is because excessive kraaling can cause overgrazing, erosion and land degradation (Pimental & Kounang 1998; Abril & Bucher 1999). Lambs and ewes were kraaled during the birth period. However, they were then moved to open pastures, approximately one month after birth (although still vulnerable to predation) (M. King pers. comm.). It appears that this strategy is employed to reduce the effects of over-grazing pressure and soil degradation when animals are kraaled in one area for a long period of time (Villamil *et al.* 2001). General comments revealed that the respondents felt that rotating kraal positions was too expensive, impractical and labour intensive. These results contradict a large body of research which supports changes in livestock husbandry such as kraaling as an effective predation preventative measure (O’Gara 1983; Landa *et al.* 1999; Breitenmoster *et al.* 2005; Woodroffe *et al.* 2007).

Linnell *et al.* (1999) in describing the environments susceptible and experiencing livestock-predator conflict distinguished two major grazing systems. Firstly, a system where livestock are entirely free-ranging and unattended within a natural carnivore habitat, and secondly where animals are kept in open fields but herded and confined at night (Linnell *et al.* 1999). In the first system, the distribution of livestock is effectively random and most individual carnivores have equal opportunity to encounter and kill livestock (Linnell *et al.* 1999). Therefore, so-called 'problem individuals' are unlikely to occur. In the second system, when livestock are confined to a particular area, the predator is required to develop specialised behaviour to overcome this new obstacle. It is in this scenario that 'problem-individuals' occur, and removing the one individual could solve the immediate predation problem (Linnell *et al.* 1999). However, the continued use of this livestock husbandry practice could promote the 'problem-individual' syndrome, resulting in a constant cycle of removal of the predator and replacement with another (Linnell *et al.* 1999). The Winterberg area does not fall completely into either one of these categories.

The animals in the Winterberg are free-ranging within natural habitat for carnivores. However, pregnant ewes are kraaled at night during pregnancy and the first month after birth. Stahl *et al.* (2002) had a similar intermediate situation in Jura, France, when they radio-collared nine Eurasian lynx (*Lynx lynx*) between 1995 and 1999. Of these nine animals, only two became habitual livestock killers in this intermediate environment. The monitoring data revealed that the two animals repeatedly attacked neighbouring flocks, forming areas of clustered attacks (Stahl *et al.* 2002). When these clusters were protected by dogs, predation rates decreased but shifted to a nearby flock (Stahl *et al.* 2002). The risk of attack also appeared to be higher in areas that were closely connected to forests and provided adequate cover (Stahl *et al.* 2002). This high risk of

attack is probably a product of grazing livestock in natural areas which provide areas of bush and shrubs to act as cover, increasing the risk of predation. The vegetation of the Winterberg generally consists of long grass and bushes which provide ideal cover for ambushing prey. Grazing animals in these natural areas could be at a greater risk of attack by predators as opposed to those in open areas (Sunde *et al.* 1998; Mech *et al.* 2000). Stahl *et al.* (2002) found that in these intermediate areas there was a high variability of predation rates on livestock between individuals and variation in the explanations behind which individuals preyed on heavily on livestock. Therefore, they suggested that the removal of lynx at a population level through lethal methods would be ineffective in the long-term due to the high spatial heterogeneity of lynx predation, and the territoriality of these animals (Stahl *et al.* 2002). They proposed that habitat variation is the ultimate factor influencing whether an area will experience high levels of lynx predation, and therefore alternating sheparding techniques such as grazing sheep away from areas which provide cover would be an effective control measure (Stahl *et al.* 2001; Stahl *et al.* 2002). Given the intermediate nature of the agricultural environment in the Winterberg, a similar situation may be occurring. Kraaling may be an ineffective protection measure due to the position of the kraal, which may be providing cover for caracals. The cover itself is a function of the vegetation which the conservancy aims to sustain. Thus, it is possible that the formation of the conservancy comes with the caveat that it also provides a potentially higher risk environment for livestock.

4.4.4 Spatial factors

The natural vegetation structure of the Winterberg and the agricultural practices are all taking place within the natural habitat of caracals. Therefore, by excluding 'problem-individuals', it is possible that caracals may frequently encounter livestock as a function of the size of the property (smaller properties may have higher densities of livestock per Ha) in addition to the cover provided by the vegetation structure. In this study, there was no relationship between the attitude indices of the respondents and the area of the farm. Therefore, if caracals are more likely to encounter sheep on smaller properties it does not appear to be affecting the attitude of the farmers. Predators are more likely to encounter livestock in areas of high livestock densities than wild prey densities (Woodroffe *et al.* 2007; Romañach *et al.* 2007). Similarly, there was no relationship between the attitude index score and the number of sheep owned by the respondent. Thus, it does not appear that respondents with large numbers of sheep are being affected by caracal predation to such an extent that it is promoting a noticeable negative attitude.

There was no relationship between the total number of sheep lost to caracals over the past two years and the distance from where the sheep were killed to the nearest dwelling. Therefore, it appears that sheep close to human habitation are at a risk of predation equal to those that are far from human habitation. This contradicts Stahl *et al.* (2002), who found that distance from human habitation and abundance of wildlife influenced the risk of attacks. It may be that the establishment of the conservancy in the Winterberg area means that wildlife populations are evenly distributed, negating the need to travel to remote areas, or that the densities of livestock in the area make it unnecessary for caracals to move close to human habitation. However, the

limited number of respondents and hence the small sample size may preclude the detection of a significant trend.

Romañach *et al.* (2007) propose that reducing livestock densities could potentially reduce attacks by predators. Reducing livestock densities can potentially increase the sustainability of livestock production, improve the quality of the livestock and increase the carrying capacity of the habitat for wild prey (Romañach *et al.* 2007). The Winterberg is already a conservancy, so by improving the available habitat for wild species it could recuperate funds lost through reducing the stock rate by the increasing ecotourism and hunting opportunities provided by improving the naturally occurring wildlife (Lindsey *et al.* 2005).

4.4.5 Wildlife prey availability

The distribution and abundance of prey has an important influence on the spatial distribution of carnivores (Sunquist & Sunquist 1989; Bunnefeld *et al.* 2006). With this in mind, the respondents were asked to systematically assess the current population trends of potential prey items for caracals and the indicator species for sustainable ecosystem functioning in the Winterberg. The majority of respondents thought that baboons, mountain reedbuck, common duikers, grey rheboks, steenboks, springboks, rock hyraxes and Greater kudu were common and were observed on a weekly basis. These respondents also felt that the populations of baboons, duiker and kudu were increasing whilst the potential prey populations remained stable. These observed trends may indicate the ungulate populations are either stable or increasing but more detailed ecological monitoring, independent of the survey opinions, would be required to thoroughly understand the population trends of the ungulates.

It has been proposed that depredation rates on livestock tend to be higher where wild prey is less abundant (Pederson *et al.* 1999; Polisar *et al.* 2003; Bagchi & Mishra 2006; Melville & Bothma 2006). In essence, predation on domestic ungulates is higher when the availability of wild ungulates is low; predators will switch from domestic to wild ungulates depending on their availability (Meriggi & Lovari 1996; Meriggi *et al.* 1996). It would appear from the survey responses that the prey and larger ungulate populations are stable, healthy and sustainable yet predation on livestock is still occurring. However, depredation on domestic sheep has also been linked to high prey abundance (Stahl *et al.* 2002; Herfindal *et al.* 2005). Stahl *et al.* (2002) isolated 'hot-spots' where sheep were frequently attacked by lynx. These 'hot-spots' also contained a high density of roe deer (*Capreolus capreolus*) and areas rich in roe deer were used intensively by lynx, leading to higher encounter rates between lynx and sheep (Stahl *et al.* 2002). Similarly, Herfindal *et al.* (2005) found that populations of roe deer in the Norwegian counties of Hedmark, Telemark and Nord-Trøndelag were stable with small annual variations throughout the study period. They concluded that variations in losses of domestic sheep were unrelated to roe deer densities (Herfindal *et al.* 2005). It may be that in the Winterberg, predation of sheep is occurring at wildlife prey 'hot-spots', but that the wildlife prey population remains noticeably unaffected, or that sheep densities in the Winterberg may be increasing the encounter rate between caracals and domestic prey, causing the observed livestock losses. However, the predation on wild prey and caracal dietary composition was not monitored in this study. Therefore it was not possible to determine which prey species (domestic or wild) were contributing more to the diet of caracals or which species were under the greater predation pressure.

The survey was an effective mechanism for compiling much needed baseline demographic data for the Winterberg and its inhabitants. The respondents generally had a positive attitude towards predators. However, this attitude was not affected by the number of livestock killed by caracals, the type of control measure employed by the respondents, their education level or age. Furthermore, the farmers of the Winterberg wish to conserve wildlife, including predators, but still consider lethal-control measures to be the only effective way to protect their livestock from depredation. The conclusions drawn from these opinions would benefit from additional independent data on caracal home-range and habitat usage and diet.

CHAPTER 5: SUMMARY AND CONCLUDING REMARKS

5.1 Estimation of caracal density and mammalian species inventory

Using a model for estimating density of non-individually recognisable species (Rowcliffe *et al.* 2008), this study successfully estimated the number of caracals inhabiting the Winterberg Conservancy. By using animals for which the density was already known (cattle and sheep) this allowed for calculating the variability of the model (the accuracy of the estimation) as regards to the number of photographic captures. The greater the number of photographs the more accurate the population estimate. The camera trapping survey of Lucknow Farm also enabled an inventory of animals to be compiled which provides some baseline data as to the species diversity of the Winterberg. The camera trapping photographs, in fact, captured a greater number of species than estimated by the Sobs, ICE and ACE abundance estimators, indicating that camera trapping provided a thorough mechanism for creating an inventory of species diversity.

The use of camera trapping in a non-protected area proved to be an effective tool for estimating a non-individually recognisable predator and creating a species inventory. It was efficient, affordable and practical for the habitat of the Winterberg.

However, a potential area of concern was that when Rowcliffe *et al.* (2008) conducted the study using this model it was in a closed population (physically and reproductively), whereas my study was unable to confirm that caracals did not move out of the area or reproduce. However, if the study area is considered a similar habitat of contiguous patches between which caracals moved, it increases the probability that a large proportion of caracals in the area were captured on camera

(Rosenzweig 2003). This study showed that estimating the population of non-individually recognisable animals is possible and effective in open systems. This is an essential ecological tool if we are to monitor population trends and the impact of non-individually recognisable predators on human-predator conflict. The fact that it can produce pertinent estimations in an open system creates a multitude of potential research opportunities particularly for monitoring predators considered 'pests' on farmlands but for which very little research has been done on their actual role in human-predator conflict on farmland.

5.2 An assessment of the human-predator conflict through surveying the farmers in the Winterberg Conservancy.

Almost no baseline demographic or human-predator conflict data exist for the farming community of the Winterberg. By surveying the members of the Winterberg Farmers' Association, this study was able to determine baseline demographic data on education levels, property size, livestock husbandry, observed wildlife trends, predator control measures and the scale of the livestock-predator conflict. More specifically, an attitude index score was calculated for each respondent which allowed interpretation of the potential factors determining their attitudes towards conservation in area, predation related livestock losses, the effectiveness of control measures and compensation due to predation.

5.2.1 Baseline demographic data

These data revealed that all the landowners are male, on average 49 years old and educated to at least secondary level. For all respondents, livestock farming was their sole form of income and carried no cultural or religious significance. From a livestock husbandry perspective, the majority of respondents kraaled pregnant ewes and ewes that had just given birth. Additionally, almost all respondents employed lethal control measures against predators. Only one respondent employed non-lethal control measures in the form of herd protectors (alpacas). Significantly, predation of livestock was ranked as the most important problem facing all respondents when it came to stock loss.

Personal interviews using a series of survey questions was an ideal method for collecting this baseline data, although data on prey items would benefit from a long term independent monitoring study. The personal interview allowed for interaction with the community and provided an amicable interview atmosphere encouraging honest responses (McColl *et al.* 2001). It was a practicable method for this area, inexpensive and extremely effective.

5.2.2 Attitude indices

The attitude indices of the farmers were not influenced by the number of stock they lost to caracals, the area of their farm, which control measure they employed, age or education level. Numerous other studies have found that education level can have a positive effect on attitudes towards predators (Woodroffe *et al.* 2005; Lagendijk & Gusset 2008) but the generally high level of education does not appear to be affecting the attitudes of farmers in the Winterberg. This may be an indication that further education programmes about predators would not be an effective

mediating tool for managing human-predator conflict. However, the fact that none the above factors influenced the attitudes of the farmers in the Winterberg may be a product of the unavoidably small sample size. Notably, from a management perspective, the survey revealed that all respondents were in favour of compensation. Compensation can be effective where livestock predation is irregular and rare. However, problems arise with the accuracy of reported kills and records (Schwerdtner & Gruber 2007; Boitani *et al.* 2010). The geographical isolation of the Winterberg and the unlikelihood of governmental compensation given the economic priorities of South Africa mean that compensation is unlikely to be a practical, realistic or feasible management solution.

5.3 Management strategies for the Winterberg Conservancy

Famers in the Winterberg have been employing lethal control measures on caracals since 1968, yet these animals remain a problem in the area. Clearly, hunting caracals is not a sustainable or effective solution to the human-predator conflict in the Winterberg Conservancy. Complete eradication of caracals was not supported by the survey responses and would compromise the conservancy status of the area and ecosystem functionality. This study also indicated that the estimated caracal population is relatively healthy, however it was an estimation and would require further study to categorically confirm these population numbers. Given this estimated population size, the removal of only 'problem' individuals (animals that have been repeatedly observed killing sheep) may be an effective form of lethal control without having a severe impact on the overall population's sustainability. However, before this is implemented it would be essential to collar caracals in the area to assess their home range size and spatial ecology as

removing 'problem' individuals may provide opportunities for more animals to move into the area.

In general, the respondents had a positive response to the use of dogs as herd protectors. It may be that herd protectors could be effective on a small scale, for example focussing the use of herd protectors on kraaled animals only, rather than running herd protectors with free ranging stock. This control method would need to be tested on farms with large stock numbers.

The population estimation and the survey data indicated that the caracal population is a relatively healthy size and has suitable natural prey items. Additionally, farmers were losing less than 10% of their stock to caracal predation. Hence, there does not seem an enormous need to use intensive lethal control measures for these animals, particularly with regard to the fact that the area is attempting to create a sustainable conservancy. Furthermore, the surveys indicated that respondents saw jackals as the biggest threat to livestock in the area. Therefore, assessments of caracal and jackal diet and habitat use should be prioritised.

5.4 Human-predator conflict: a South African perspective

This project is one of only a handful of studies to have focussed on livestock and caracal interactions in a non-protected area. Through surveying landowners it became clear that local residents wish to keep predators in the area and maintain and sustain the established conservancy, despite livestock losses. Many of the farmlands in South Africa are not part of a conservancy therefore it seems necessary to assess the livestock-predation conflict for these areas. In order to quantify the predator problem in South Africa it is essential that similar

studies are undertaken across the livestock farming areas of South Africa. If accurate data can be accumulated on primary predator offenders, the effectiveness of control techniques and population estimations, major trends may be revealed which could lead to the establishment of more sustainable and effective management schemes and reduce the economic losses caused by predation on livestock.

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APPENDIX A: THE CAGE TRAPPING PROCEDURE AND PROTOCOL

In an attempt to empirically determine the home range and habitat usage of caracals in the Winterberg, cage trapping took place between July and December 2010 across four farms (Kelso (32°480833'S; 26°950833'E), Oxford (32°345833'S; 26°098611'E), Lucknow (32°13519'S; 26°26045'E) and Newstead (32°086389'S; 26°305833'E). Across these four farms, 39 single-door walk-in cage traps measuring 1.8 x 0.6 x 0.6m covered in cubic mesh were set. The cages were sunk into the ground and the base of the trap was covered in soil and leaves. The sides of the cage were camouflaged with branches until the cage was completely concealed. The cages were baited with caracal urine and feathers were used as a visual lure (Figure 1).

During this trapping period only one caracal was caught on Lucknow Farm. This animal was sedated using DAN-INJECT[®] (Aps, Denmark) CO₂ rifle with a 1.5ml dart containing 0.5ml/kg Xylazine and 10mg/kg Ketamine by a qualified veterinarian. The animal was a sub-adult male, weighing 8.5kg and was in good condition (Figure 2). It was fitted with a GPS/VHF collar (Africa Wildlife Tracking, Pretoria) with UHF download capabilities (Figure 3). Repeated attempts were made to track the animals using radio tracking. However, the collared animal was not re-located in the Winterberg area. All live-capture and handling procedures were conducted under the Rhodes University Ethical Standards Committee's ethical standards protocol, clearance number ZOOL-16-2010.



Figure 1: The cage traps were camouflaged using vegetation and baited using caracal urine and road kill (when available) to create scent lure. The traps were placed along well used animal paths.



Figure 2: The collared caracal exhibiting good overall body condition with the cage trap in the background.



Figure 3: The captured caracal fitted with the VHF/GPS collar.

APPENDIX B: THE SURVEY THAT WAS USED TO ACCUMULATE BASELINE DEMOGRAPHIC DATA AND ASSESS THE ATTITUDES OF THE RESPONDENTS TO HUMAN-PREDATOR CONFLICT IN THE WINTERBERG, EASTERN CAPE, SOUTH AFRICA.

CARACAL COMMUNITY SURVEY

1. FARM DETAILS

	Cattle	Sheep	Goats	Donkeys	Horses	Pigs	Poultry	Dogs	Other
Quantity									
Vaccinations									

	Lucerne	Oats	Other
Crops			
Area			

2. VISUAL SIGHTINGS

2.1 How many caracal did you see on your land?

	>1/month	1 every month	1 every 6 months	< 1 per year
2008				
2009				
2010				

2.2 Explain any predation related livestock loss over the past 2 years:

< 6 months ago 6 month – 1 year ago 1 year – 2 years ago	Type and number of livestock killed	Predator responsible	How predator identified (spoor, faeces, call, carcass)	Incident took place in daylight or dark	Distance to nearest dwelling of incident site

Comments:

	Status: Absent (A), Rare (R), Common (C), Unknown (U)	How often do you see this species? Weekly (W), Monthly (M), every six months (EM)	Trend over the last 5 years: Increase (I), Decrease (D), Stable (S)
Baboon			
Bush buck			
Mountain reedbuck			
Common duiker			
Grey rhebok			
Steenbok			
Springbok			
Impala			
Dassies			
Greater kudu			

3. ATTITUDE

3.1 What are the main problems facing you as a livestock owner?

Score Significance: 1 to 5 where 1 = no problem 3 = occasional problem 5 = major problem

Disease	Drought	Infertility	Poor Grazing	Unreliable Market	Predators	Theft	Hit by vehicle	No herder

3.1.1 If several are equally scored which one do you consider is the biggest problem?

3.2

	Yes	No	Maybe	Don't know
1. Caracal can pass through your land unseen/unnoticed?				
2. Caracal are a natural part of the ecosystem in the Winterberg?				
3. Caracal should be protected?				
4. Would the Winterberg be a better place without caracal?				
5. Do caracal play the biggest role in livestock losses in the Winterberg?				
6. Can caracal pass through the Winterberg without killing livestock?				
7. Are livestock losses due to caracal increasing?				
8. Do caracal negatively impact your profit from your livelihood?				
9. If there was an effective non-lethal control for these animals would you use it?				
10. Is lethal control the only control that works/				
11. Are you concerned about the wildlife in the Winterberg?				

4. OPINION SECTION

4.1 Why do you think caracals are considered a problem animals in the Winterberg?

4.2 There has been a lot of publicity surrounding non-lethal control measures many of which are being heralded as the most effective solution. What do you think about the viability of these methods? Would you use them?

4.3 What are the main problems facing you as a livestock owner?

Score Significance: 1 to 5 where 1 = no problem 3 = occasional problem 5 = Major problem

Disease	Drought	Infertility	Poor Grazing	Unreliable Market	Predators	Theft	Hit by vehicle	No herder

If several are equally scored, which is the biggest problem?

5. LIVESTOCK HUSBANDRY

5.1 Which of these livestock husbandry practices to you employ?

	Free roaming	Enclosure	Herder	Dogs	Other
Day					
Night					

5.2 In what season(s) are your livestock born?

Sheep	Cattle	Goats	Horses	Pigs	Poultry	Dogs

5.3 During birthing and weaning season to you employ specific livestock husbandry practices?

Yes	No
-----	----

5.4 If yes, what kind of measure do you employ?

5.5 Do you keep records of births/deaths?

Yes	No
-----	----

5.6 Explain you closure design.

Livestock	Shape	Height	Materials	Width	Numbers in enclosure

5.7 If a herder is used:

5.7.1 How many animals does a herder guard?

5.7.2 Is the herder: a paid worker, child, dog or other?

5.8 Please score the following questions on a scale of 1= strongly disagree, 2= disagree, 3= neither disagree or agree, 4= agree or 5= strongly agree.

5.8.1 A human herder is effective at guarding livestock.

5.8.2 A dog is effective at guarding livestock

5.8.3 Other methods are more effective for guarding livestock
If so, please specify?

5.8.4 How many animals does the dog/other herder guard?

5.8.5 Are animal husbandry methods changed after attacks? If so, how?

5.8.6 Are the changes successful?

Yes	No
-----	----

GENERAL INFORMATION

Date: _____ Location (GPS): _____
Name: _____ Phone number: _____
Age: _____ Sex: _____
Education level (highest achieved): _____
Occupation: _____
Whole area of farm: _____
Type of fencing, if different in different areas please specify _____

APPENDIX C: THE PHOTOGRAPHS OF CARACAL CAPTURED DURING THE CAMERA TRAPPING SESSION



Figure 1: Two caracals photographed at 08.59am on 10 June 2011 on Lucknow Farm, Winterberg, Eastern Cape, South Africa.



Figure 2: A caracal photographed at 14.17pm on 31 July 2011 on Lucknow Farm, Winterberg, Eastern Cape, South Africa.



Figure 3: A caracal photographed at 17.11pm on 21 July 2011 on Lucknow Farm, Winterberg, Eastern Cape, South Africa.



Figure 4: A caracal photographed at 16.03pm on 29 July 2011 on Lucknow Farm, Winterberg, Eastern Cape, South Africa.



Figure 5: A caracal, in the distance, photographed on 29 June 2011 at 11.18am on Lucknow Farm, Winterberg, Eastern Cape, South Africa.

APPENDIX D: SPECIES IDENTIFICATION

The following sheet was shown to the respondents to ensure they could identify the prey species that were referred to in the survey. All the photographs are courtesy of www.arkive.org with the exception of picture 5 which was courtesy of www.sanparks.org.za. The pictures 1-10 are: chacma baboon (*Papio hamadryas*), bushbuck (*Tragelaphus scriptus*), mountain reedbuck (*Redunca fulvorufula*), common duiker (*Sylvicapra grimmia*), grey rhebok (*Pelea capreolus*), steenbok (*Raphicerus campestris*), springbok (*Antidorcus marsupialis*), impala (*Aecyyceros melampus*), dassie (*Procavia capensis*) and Greater kudu (*Tragelaphus strepsiceros*).



1.



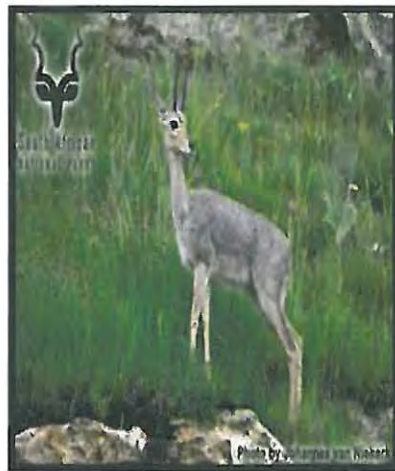
2.



3.



4.



5.

6.



7.



8.



9.



10.

