Anthropogenic threats to resident and dispersing African wild dogs west and south of the Kruger National Park, South Africa

A thesis submitted in fulfilment of the requirements for the degree of

MASTER OF SCIENCE

of

RHODES UNIVERSITY

By

JESSICA PATRICIA WATERMEYER

February 2012

This thesis is dedicated to my parents, Duncan and Lenore Watermeyer, for shaping me into the person I am today. Through your constant love, support and guidance you have raised four happy and devoted children. We owe all our achievements to you.

Abstract

African wild dog *Lycaon pictus* populations are declining and the species is listed as Endangered by the IUCN. The Kruger National Park (KNP) is home to the only viable population of wild dogs in South Africa, but census results reveal consistently low numbers since the late 1990s. Wild dogs display wide-ranging behaviour and it is possible that the species might frequently use unprotected lands adjacent to the KNP. However, very little is known about wild dog movements beyond the boundaries of the KNP, and whether or not adjacent land owners are tolerant of the species. Significantly, threats along the boundaries may have negative consequences for the KNP population. This research investigated the dispersal habits of wild dogs beyond the western and southern boundaries of the KNP, and gathered information on human tolerance, and anthropogenic threats in an area of mixed land use. The land west of the KNP presented the best prospect for wild dog range expansion. The wild dog packs operating outside the KNP had smaller home ranges and less home range overlap than the packs operating within the KNP. In addition, my data suggested that the development of conservancies and the formation of ecotourism-based land use practices would be beneficial for wild dog conservation. Failed wild dog dispersals due to snaring and human persecution could threaten the genetic stability and persistence of the KNP population. Therefore, raising awareness and an understanding of the plight of wild dogs is important for improving land owner perception and tolerance outside of protected areas. The rapidly increasing human population continues to infringe on protected lands and fragment landscapes, thus cooperation from individual land owners is vital for the conservation of free-ranging large carnivores.

Table of contents

Acknowledgements

The contributions of the following organisations and individuals to this study are gratefully acknowledged:

- I am greatly indebted to my supervisors, Dr Daniel Parker and Dr Harriet Davies-Mostert for guiding me through this research. Thank you for your patience, constructive criticism and advice. Dan in particular is thanked for his constant encouragement and personable nature, and for having a song for every moment.
- My colleagues at the Endangered Wildlife Trust, in particular Kelly Marnewick and Grant Beverley. Kelly for helping develop the initial project concept and for always being so calm in the face of many a 'logistical nightmare'. Grant your ability to sniff out a party in the most obscure of locations is truly remarkable. Field work would not have been the same without you.
- Everyone who opened their homes to us and made us feel so welcome, Michael Grover, Harry and Kitty van Tonder, Cornell ver Maak, Nick FitzGerald and Melanie Eva in particular.
- All the managers, rangers and private land owners who took the time to meet with us, fill in our survey and provide us with photographic data.
- Charlene Bissett and Kathleen Nowers for comments on previous drafts of this thesis.
- South African Weather Service for climatic data.
- The staff of the Zoology and Entomology department of Rhodes University.
- For financial support, Jaguar-Land Rover South Africa, Vaughn de la Harpe and his climb for Kruger Wild Dogs Expedition, Richard Bosman and GCCL^2 Management

Services and Rhodes University for the Henderson Prestigious Masters Postgraduate Scholarship.

- South African National Parks.
- My office mate and dear friend Emma Smith, it has been an absolute privilege. See you on the set of ‘Ab Fab’.
- Adriano Mendes for his unwavering love and commitment, you are my pillar of strength.
- Finally, to my friends and family for their constant support and belief in this project. In particular, Bronwyn Sheppard, Chloe Wilmot and Michelle Evans, I could not have done this without you.

CHAPTER 1: Introduction

1.1 Taxonomy

The African wild dog (wild dog) *Lycaon pictus* (Temmink, 1820) is a member of the family Canidae. As the only extant member of the genus *Lycaon*, wild dogs are phylogenetically unique, with a distant genetic affiliation to jackals *Canis* spp. (Girman *et al*. 1993). Southern and East African wild dogs were originally considered to be a distinct sub-species (Girman *et al*. 1993). However, despite morphological research indicating some regional differences, this is unlikely as genetic exchange appears to have occurred between these populations (Girman *et al*. 1997; Creel & Creel 2002). The species was originally described by C.J. Temmink in 1820 from a specimen from coastal Mozambique and was thought to be a type of hyaena (Skinner & Chimimba 2005; McNutt *et al*. 2008). The Latin name literally translates as 'painted wolf-like animal' (*Lycaon* meaning wolfish, from the Greek *lykaios*; *pictus* meaning ornate/painted, from the Latin *picta*) and consequently wild dogs have commonly been referred to as painted wolves and painted hunting dogs (Rasmussen 1999; Skinner & Chimimba 2005).

1.2 Physical characteristics

Wild dogs are medium-sized carnivores, averaging 61-78 cm in shoulder height and roughly 20-25 kg in weight (Creel & Creel 1995; Creel & Creel 2002; Skinner & Chimimba 2005). East African wild dogs are reportedly smaller than their central and southern counterparts (Estes & Goddard 1967; Girman *et al*. 1993), and male wild dogs tend to be three to seven percent heavier than females (Creel & Creel 2002; Skinner & Chimimba 2005). Wild dogs are unmistakable amongst Africa's carnivores (Figure 1.1). Characteristic features include their large rounded ears, bushy white-tipped tails and uniquely mottled coat patterns of brown, tan, black and white (Skinner & Chimimba 2005; Figure 1.1). Coat patterns are not bilaterally symmetrical (Creel & Creel 2002). It has been suggested that the unique coat pattern enables wild dogs to differentiate easily between conspecifics and prey during chaotic hunts, and could serve as a unifying camouflage for the pack (Estes & Goddard 1967). Likewise, the white tail portion is believed to assist with visual contact, especially when the pack moves through thick bush or tall grass (Estes & Goddard 1967). Wild dogs lack dew claws on the front limbs and have only four toes on each foot, compared with the usual five on the forefeet of all other canids (Creel & Creel 2002). Interestingly, female wild dogs have six to eight pairs of mammae, more than any other African predator (Creel & Creel 2002).

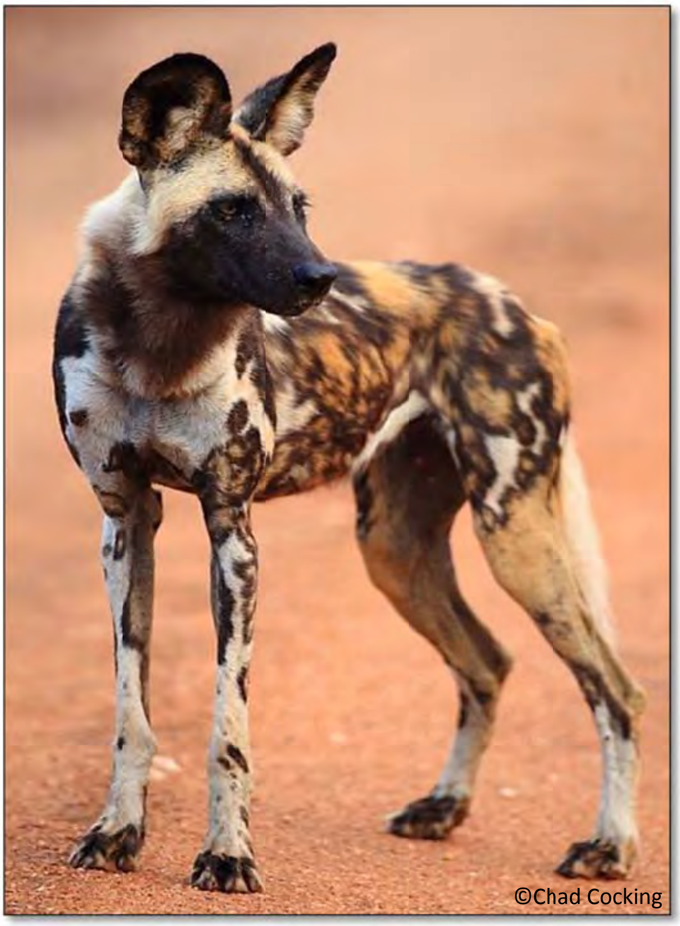

Figure 1.1. The African wild dog is easily identifiable from its large round years, uniquely mottled coat pattern and bushy, white-tipped tail.

1.3 Social behaviour

Reproduction

Wild dogs are highly social carnivores that live in cohesive packs and breed cooperatively (Malcolm & Marten 1982; Creel & Creel 2002). A typical pack includes a dominant breeding pair (an alpha male and female), the pairs' offspring from one or more litters, and additional subordinate adults (Girman *et al*. 1997). Wild dog packs can consist of two to 27 adults and yearlings (Creel & Creel 2002). Usually only the alpha female reproduces, but subordinates of both sexes sometimes produce offspring that are raised, particularly in larger packs (Malcolm & Marten 1982; Girman *et al*. 1997; Creel & Creel 2002). However, if a subordinate female breeds, she is generally socially excluded until such time as she cannot maintain her pups and they perish, or the alpha female may kill the pups (Girman *et al*. 1997). Wild dogs breed seasonally, occupying a den site between March and June after a 60-80 day gestation period (Creel & Creel 2002). Litter size ranges between eight and 12 pups (Creel & Creel 2002). Interestingly, the litter size of wild dogs is almost twice as large as that of related species and is disproportionally large for the breeding female (Creel & Creel 2002). This is possible only because of the cooperative nature of the pack, and the fact that all pack members help to nourish the alpha female during early lactation, and guard and feed the pups (Estes & Goddard 1967; Malcolm & Marten 1982; Courchamp & Macdonald 2001). Within four weeks of birth, the pups are provisioned with regurgitated meat by members of the pack (Courchamp & Macdonald 2001) and, after three months, the den is abandoned and the pups begin to move with the pack (Creel & Creel 2002). Wild dog packs rely heavily on each other to assist with vital aspects of their survival (McNutt 1996; Woodroffe & Ginsberg 1999b; Courchamp & Macdonald 2001; Creel *et al*. 2004; Graf *et al*. 2006). Consequently, it has been suggested that the pack, rather than the individual, should be considered the basic unit within the population (Mills *et al*. 1998; Woodroffe & Ginsberg 1999b).

Hunting

Wild dogs are cooperative and coursing hunters, relying on the stamina and power of the pack to bring down their prey (Creel & Creel 2002). They typically hunt at sunrise and sunset (i.e. they are crepuscular hunters), and rely on sight more than smell to locate prey (Estes & Goddard 1967; Hayward *et al*. 2006). Wild dogs tend to hunt medium-sized ungulates, with their preferred prey species varying according to the most abundant prey species in the area, and the size of the pack (Creel & Creel 1995; Hayward *et al*. 2006). Smaller packs tend to concentrate their hunting efforts on impala *Aepyceros melampus*, while larger packs prey on larger species, such as wildebeest *Connochaetes* spp. and zebra *Equus quagga* (Creel & Creel 2002; Hayward *et al*. 2006). The killing of prey is primarily through disembowelment (Hayward *et al*. 2006). Impala and Greater kudu *Tragelaphus strepsiceros* are the preferred prey species of wild dogs in the Kruger National Park (KNP), South Africa (Gertenbach 1983; Maddock & Mills 1994; Mills & Gorman 1997).

Dispersal

From about one year of age, same-sex groups of litter mates will disperse in search of breeding opportunities (Creel & Creel 2002). They will either join up with an unrelated sibling group or join an established pack (Girman *et al*. 1997; Graf *et al*. 2006). Contradictory information exists regarding the dispersal patterns of wild dogs (Frame & Frame 1976; Fuller *et al*. 1992; McNutt 1996), but females typically migrate into packs, whilst males tend to remain with their natal pack (Girman *et al*. 1997; Creel & Creel 2002). Dispersers introduce new genetic material into the larger population and are responsible for colonizing new or formerly occupied areas and provide an important link between populations (Woodroffe & Ginsberg 1999b). The rate and composition of dispersing groups is dependent on several factors, including the availability of food and the composition of the natal pack (Girman *et al*. 1997; Woodroffe & Ginsberg 1999b). Given the highly cooperative nature of the species, smaller wild dog packs (<5 individuals) rely on the recruitment of additional members to be successful (Graf *et al*. 2006). Dispersers can travel substantial distances (~250 km) before joining up with unrelated individuals and establishing a pack (Fuller *et al*. 1992).

1.4 Distribution

Wild dogs occupy only a fraction of their former range (southern edge of the Sahara to South Africa; Figure 1.2), and are largely confined to protected or remote areas (McNutt *et al*. 2008). The species has been removed from 25 of the 39 countries where they previously occurred, and has been virtually eradicated from West Africa (Fanshawe *et al*. 1997; McNutt *et al*. 2008; Figure 1.3). In comparison, southern and eastern Africa have several potentially viable populations (i.e. are genetically diverse enough to persist) with the largest occurring in northern Botswana, western Zimbabwe, eastern Namibia, north-eastern South Africa, northern Mozambique, southern Tanzania and central Kenya (Fanshawe *et al*. 1997; McNutt *et al*. 2008). The only viable population of wild dogs in South Africa occurs in the KNP (Fanshawe *et al*. 1997; Davies-Mostert *et al*. 2009). There are no other reserves of sufficient size that can sustain a second viable population (Lindsey *et al*. 2005a). Consequently, the remaining populations in South Africa occur in spatially isolated and fenced reserves (Davies-Mostert *et al*. 2009). These populations are collectively managed as a metapopulation where intermittent translocations between sites mimic natural dispersal and maintain gene flow (Mills *et al*. 1998; Davies-Mostert *et al*. 2009; Gusset *et al*. 2010).

Wild dogs occurring beyond the borders of protected areas in South Africa appear to be limited to the Limpopo and Mpumalanga provinces (Lindsey *et al*. 2004a).

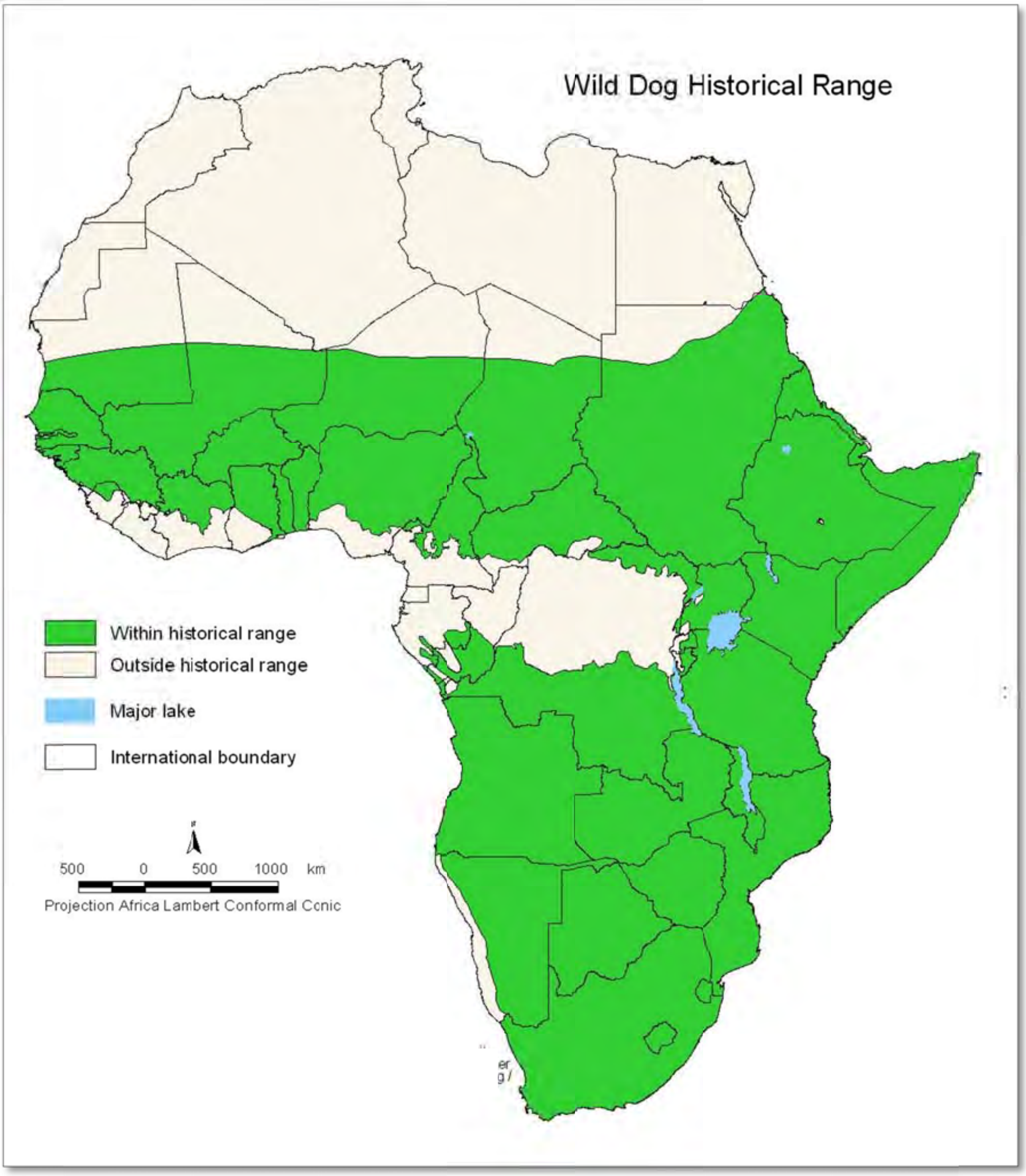

Figure 1.2. Wild dogs once occurred throughout sub-Saharan Africa, but have been virtually extirpated from West Africa (African Mammals databank 2010).

(African Mammals databank 2010).

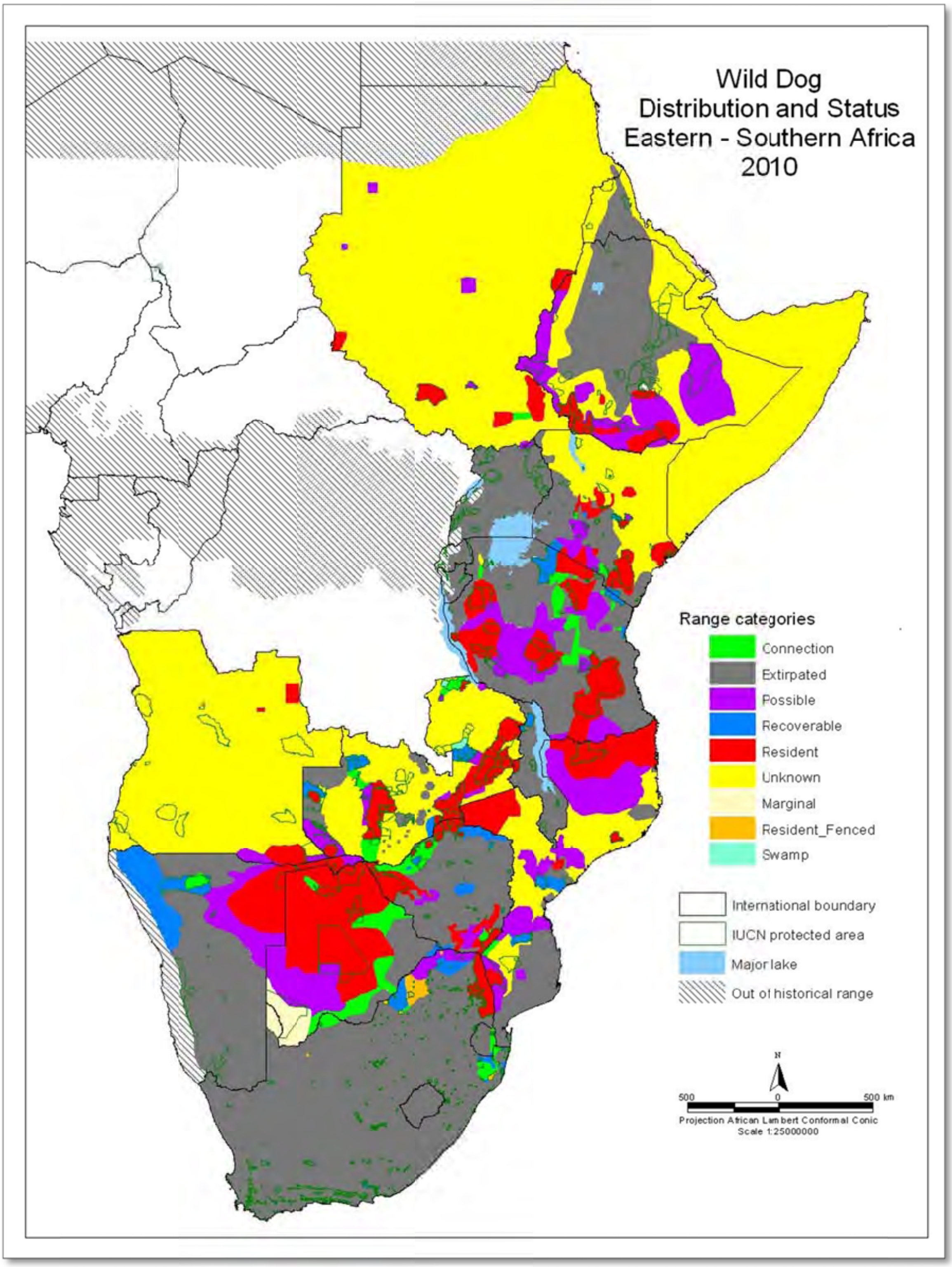

Figure 1.3. The distribution and status of wild dogs in southern and East Africa in 2010 (African Mammals databank 2010).

1.5 Conservation status

African wild dog populations are declining and the species is listed as endangered by the International Union for the Conservation of Nature (IUCN) (McNutt *et al*. 2008). There are an estimated 3 000–5 500 free-ranging wild dogs left on the continent, and approximately 369 in South Africa (McNutt *et al*. 2008; Lindsey & Davies-Mostert 2009). The management of wild dogs in South Africa is governed by the National Environmental Management Biodiversity Act, 10 of 2004 (NEMBA), and the Threatened and Protected Species (TOPS) regulations (Lindsey & Davies-Mostert 2009). Wild dogs are listed as endangered according to TOPS regulations which oversees any hunting or captive breeding of the species. Wild dogs are not listed on CITES because trade in products from wild dogs is not considered to be a conservation threat to the species (Lindsey & Davies-Mostert 2009). In the Mpumalanga Province, wild dogs are listed as Protected Game in terms of the Mpumalanga Nature Conservation Act, 10 of 1998 and, in the Limpopo Province they are a Specially Protected Wild Animal in terms of the Limpopo Environmental Management Act, 7 of 2003 (van der Linde & Feris 2006; Lindsey & Davies Mostert 2009). This legislation regulates nature conservation and provides for the management and protection of wild dogs (van der Linde & Feris 2006).

1.6 Conservation challenges

Research has revealed that increasing habitat fragmentation, human persecution (both within and outside of protected areas), and exposure to infectious pathogens are contributing to the overall decline of wild dog populations in Africa (Rasmussen 1999; Creel & Creel 2002; Davies & du Toit 2004; Hayward *et al*. 2006; McNutt *et al*. 2008). The species has been left with a much reduced geographical range (Courchamp & Macdonald 2001). Isolated populations are more susceptible to stochastic events (e.g. disease outbreaks) as their genetic stability and fitness is threatened (Fuller *et al*. 1992; McNutt *et al*. 2008; Davies-Mostert *et al*. 2009). Conservation initiatives are thwarted by the fact that wild dogs naturally occur at low densities, even when conditions are optimal, and frequently disperse beyond the borders of protected areas (Creel & Creel 1998; Woodroffe & Ginsberg 1999b; McNutt *et al*. 2008). Wild dogs are accidentally caught in snares and susceptible to road deaths (Woodroffe & Ginsberg 1999b; Creel & Creel 2002; Davies & du Toit 2004). In South Africa, the maintenance of large protected areas, and the mitigation of potentially fatal edge effects, represents the most beneficial strategies for wild dog conservation (Woodroffe & Ginsberg 1999b; Lindsey *et al*. 2005a; McNutt *et al*. 2008). However, with the expanding human population and increasing habitat fragmentation this is unlikely (Davies-Mostert *et al*. 2009). Consequently, a metapopulation approach to wild dog conservation was adopted (Mills *et al*. 1998).

1.7 Motivation for the study

For the last 20 years, the Endangered Wildlife Trust (EWT) has been monitoring the KNP wild dog population through the use of photographic censuses (Lindsey & Davies-Mostert 2009). The first wild dog census was completed in 1989 (Maddock & Mills 1994), thereafter one has been conducted every five years. The KNP population has fluctuated widely (Maddock & Mills 1994; Wilkinson 1995; Davies 2000; Kemp & Mills 2005). Importantly, there was a considerable decline in wild dog numbers from 434 individuals in 1995 (Wilkinson 1995) to 140 individuals in 2005 (Kemp & Mills 2005). Consequently, a decision was made to conduct the 2010 photographic census (2009 census) a year early. Preliminary results from the 2009 census suggest that there are only 161-191 wild dogs in the KNP (Davies-Mostert *et al*. unpublished data). Thus, research investigating the potential threats to the species and possible reasons for their perceived population decline is crucial.

Given the wide-ranging nature of wild dogs and that long-distance (250 km) north-south dispersals have been recorded within the KNP (Fuller *et al*. 1992), it is possible that the species might frequently use unprotected areas adjacent to the KNP. However, very little is known about wild dog movements beyond the boundaries of the KNP, and whether or not adjacent land owners are tolerant of the species. Anthropogenic threats along the boundaries may have negative consequences for the KNP population (Woodroffe & Ginsberg 1999b; Ogada *et al*. 2003; Woodroffe *et al*. 2007). Therefore, my research investigated the dispersal habits of wild dogs beyond the western and southern boundaries of the KNP, and gathered information on human tolerance and anthropogenic threats in an area of mixed land use. The data collected will enable a greater understanding of the factors driving wild dog dynamics in the KNP and surrounds.

CHAPTER 2: General description of study area

2.1 Location

The KNP stretches approximately 22 000 km², roughly 350 km from north to south with an average width of 60 km, and forms part of the north-eastern South African lowveld (Mabunda *et al.* 2003; Venter *et al*. 2003). The KNP is bordered by Mozambique in the east and Zimbabwe in the north, with two southern African provinces, Mpumalanga and Limpopo, neighbouring the KNP on the west (Ferreira & Funston 2010; Jori *et al.* 2011; Figure 2.1). The southern boundary of the KNP is bordered by the Mpumalanga Province and Swaziland extends into the southern reaches of the study area. The study area was naturally delineated by the Crocodile River in the south, the Limpopo River in the north and the Lebombo Mountains to the east (Ferreira & Funston 2010). The Olifants River runs through the centre of the KNP and defines the central and northern regions (Mabunda *et al*. 2003). The southern region of the KNP (south of the Sabie River) is 4 057 km² in size and the central region (between the Sabie and Olifants rivers) stretches for approximately 6 192 km² (Figure 2.1).

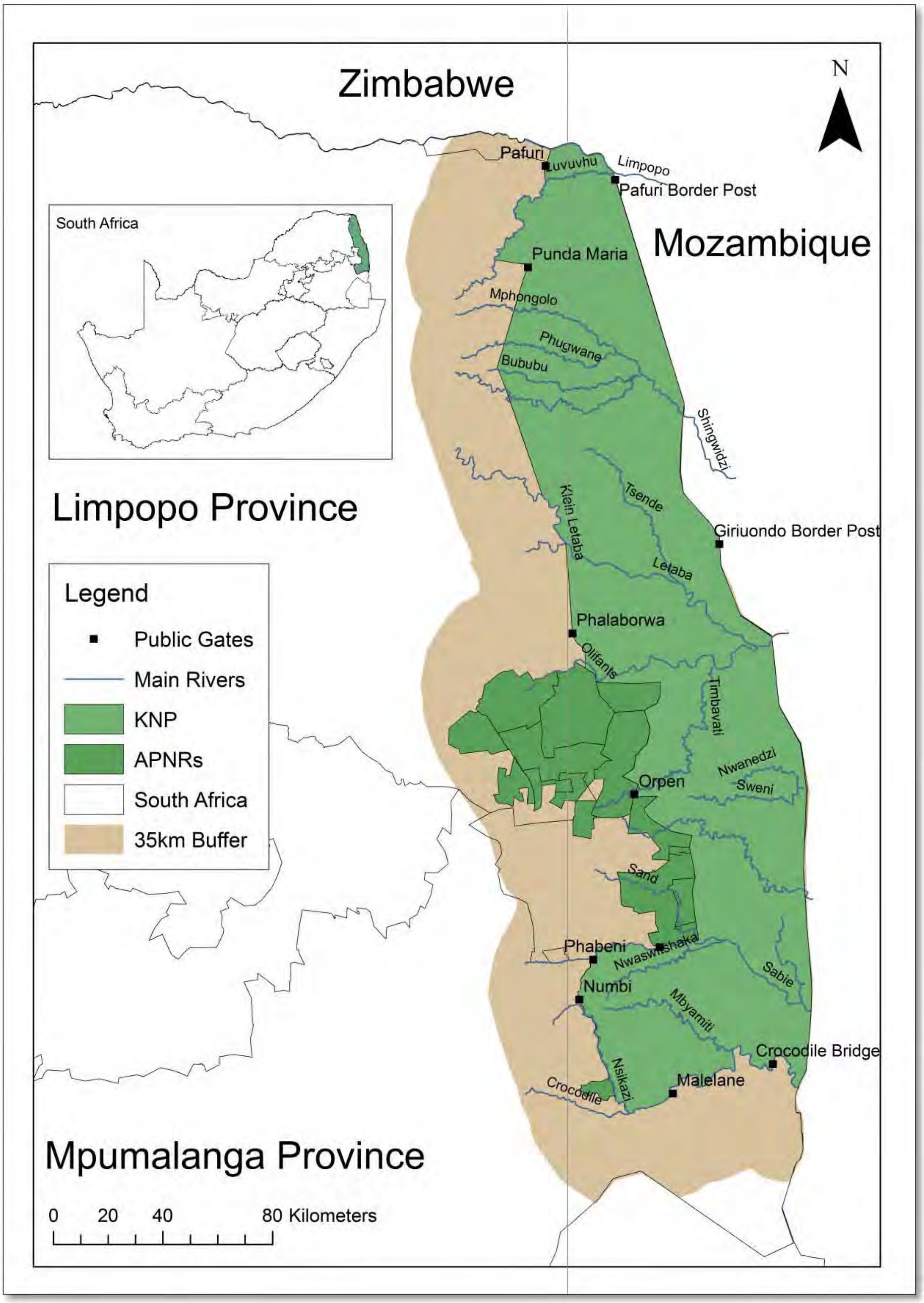

Figure 2.1. The location of the study area within South Africa. APNRs = adjoining private nature reserves (ArcGIS 9.3; projected: Transverse-Mercator, spheroid WGS84, central meridian 31; map units: meters).

2.2 Land use

The KNP boundaries are bordered by a matrix of land use types including private and communal lands, and human settlement (Pollard *et al.* 2003). The western and southern boundaries, in particular, span a total of 750 km from north to south and are largely (66.0%) borded by communal lands and private agricultural farms managed by the Department of Agriculture, Forestry and Fisheries (DAFF) of the South African Government (Jori *et al.* 2011). The land west of the central district of the KNP, between the Phalaborwa and Paul Kruger gates, is dominated by private nature reserves and wildlife ranching farms, estates and lodges which border 34.0% of the total fence and occupy the land further west (Pollard *et al.* 2003; Jori *et al.* 2011). The southern boundary fence stretches 122 km and is almost completely populated by commercial sugar cane *Saccharum* spp. and fruit (citrus *Citrus* spp. and bananas *Musa* spp.) farmers (Jori *et al.* 2011).

The land north of Phalaborwa and between the Paul Kruger Gate and Matsulu, at the south-western corner of the KNP, is bordered by communal, pastoral land and was excluded from the study (Pollard *et al.* 2003; Jori *et al.* 2011). There are ~120 different villages neighbouring the KNP boundaries and an estimated population size of 1.5 million people (Anthony 2007). Each community is varying distances from the boundary of the KNP and presents unique challenges with respect to economic conditions, local context and culture (Pollard *et al*. 2003; Anthony 2007). Further, given the variety of cultures and languages, it would have been necessary to have a translator to assist with all interviews and surveys, preferably a local member from each community (Anthony 2007). Consequently, great effort would have been required to ensure that the unique contexts, interests and perceptions of predators were accurately captured for private land owners and/or managers, and communities. This was not deemed feasible given the time frame of the research.

This assessment focussed on private lands south and west of the southern and central districts of the KNP (Maddock & Mills 1994; Ferreira & Funston 2010). This included neighbouring nature reserves, wildlife ranching farms, wildlife estates and lodges and agricultural lands. The study area was limited to private properties within a 35 km buffer zone along the south and south-western boundaries of the KNP, reaching as far north as Phalaborwa and covered an area of approximately 6 132 km² (excluding the KNP; Figure 2.1). A buffer of 35 km was chosen to encompass the most recent, maximum home range size for a wild dog pack in the KNP system (930 km², Mills & Gorman 1997). Although, the shape of home ranges may vary according to a number of environmental, ecological and social factors (Pole 1999; Vangen *et al*. 2001; Creel & Creel 2002), a standard circular home range was used to determine the extent of the study area beyond the western and southern boundaries of the KNP (Lindsey *et al.* 2004a). Accordingly, only private properties within 35 km (34.7 km is the diameter of 930 km²) west and south of the KNP boundaries were surveyed.

2.3 General climate

The study area is situated between two transitional climatic zones; the tropical and subtropical north and the more temperate south (Mabunda *et al.* 2003), and experiences a climate of hot, wet summers and mild, dry winters (Gertenbach 1980). The months of December, January and February are typically the wettest, and July and August the driest (Gertenbach 1980; Rutherford *et al.* 2006; Figure 2.2). There is a general decrease in precipitation from the south to the north within the KNP and surrounds (Gertenbach 1980;

Venter *et al.* 2003; Figure 2.3). Annual rainfall ranges between 450 mm in the north and 700 mm in the south west, except for a localized area in the north west of the KNP which is situated at a higher altitude and receives up to 800 mm of rain per annum (Gertenbach 1980). Gertenbach (1980) recorded a decrease in rainfall from the west to east and attributed this to a decrease in altitude (Venter *et al.* 2003). There is a slight spatial trend in temperature from cooler in the south to hotter in the north (Venter *et al.* 2003). Summer temperatures regularly exceed 35˚C and winter temperatures are moderate (9.1˚C minimum and 25.8˚C maximum). True frosts and freezing temperatures are rare (Venter *et al.* 2003; Rutherford *et al.* 2006).

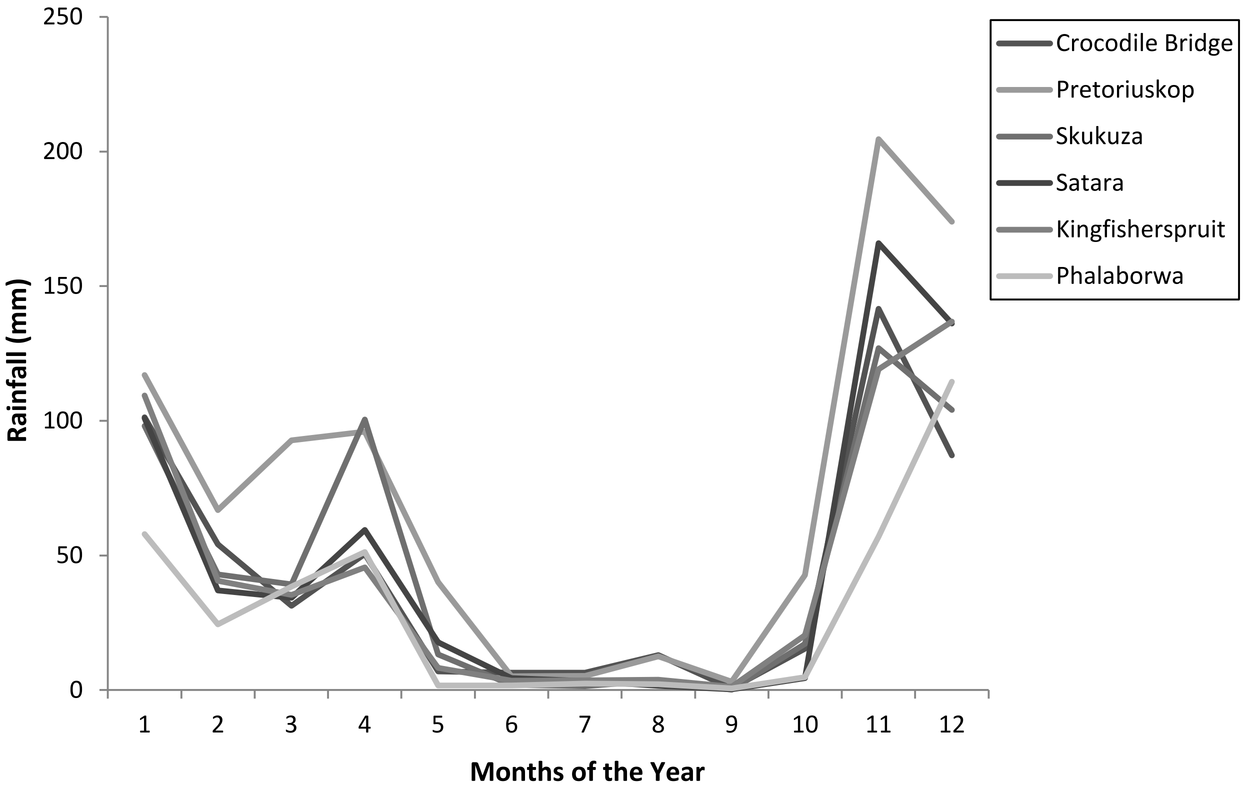

Figure 2.2. Average monthly rainfall from 2008-2011 for the main camps within the study area showing the wettest and driest months of the year. Averages were taken from all 12 months for the years 2008, 2009 and 2010 and from January-March of 2011 (South African National Parks 2011).

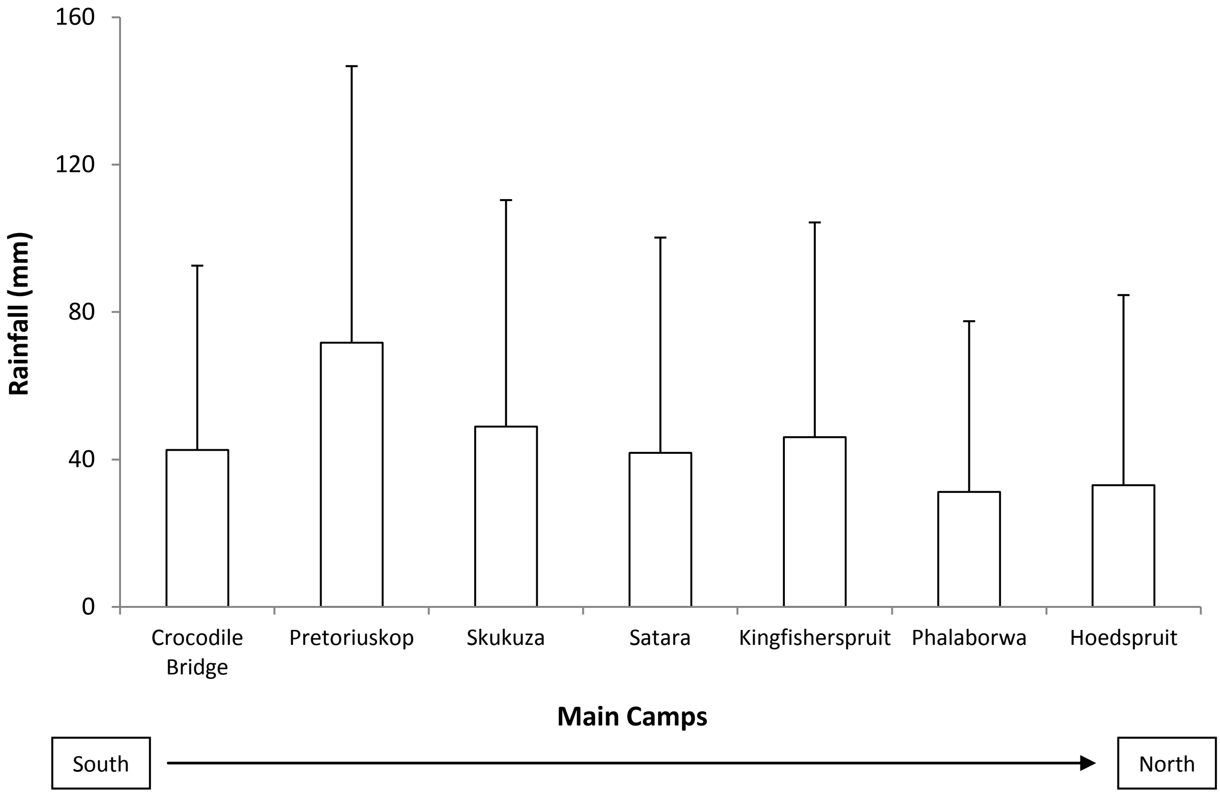

Figure 2.3. Average monthly rainfall for Hoedspruit and the main camps within the KNP showing the general decrease in average rainfall from the south of the study area to the north. Averages were taken from all 12 months for the years 2008, 2009 and 2010 and from January-March of 2011. Data are means + 1 SD. (South African National Parks 2011; South African Weather Services 2011).

2.4 Topography and geology

The study area is positioned at the base of the Drakensberg Great Escarpment to the west, the Malelane and Barberton mountains to the south and the Lebombo mountain range of the Mozambique coastal plain to the east (Venter *et al.* 2003). The Malelane and Barberton mountains form part of the Drakensberg foothills, as the Great Escarpment stretches southwards into the Mpumalanga Province, creating a natural southern border for the KNP. The Drakensberg Great Escarpment, Barberton and Malelane mountains range from 350 m to 600 m above sea level, with the Malelane mountain range representing the most mountainous part of the KNP with altitudes reaching as high as 800 m above sea level (Gertenbach 1983). The Lebombo Mountains average 300-400 m above sea level and serve as the international boundary between South Africa and Mozambique. In contrast, the lowveld lies approximately 300 m above sea level (Venter *et al.* 2003). The topography of the study area is a result of a combination of uplifts and deformations of the earth's crust, and oscillations at sea level, leaving behind an undulating landscape that was gradually flattened (Venter *et al.* 2003). Upon the dismantling of Gondwana, the Great Escarpment pulled west and the Lebombo Mountains retreated east exposing the underlying rock formations of the present day lowveld (Watkeys 2006). Subsequent erosion and weathering of the exposed rock led to the present topography of the lowveld and the KNP (Venter *et al.* 2003).

The geology of the study area is dominated by an ancient block of continental crust called the Kaapvaal Craton (Brandl *et al.* 2006; Rutherford *et al.* 2006), and is characterised by granite gneisses with infolded greenstone belts or greenstone belt remnants (Brandl *et al.* 2006). Today, the Barberton Mountains are evidence of some of the oldest formations of the Kaapvaal Craton (Brandl *et al.* 2006; Rutherford *et al.* 2006). The lowveld is characterised by six major types of rock and landform; granite, gabbro, Ecca Shales, basalt, rhyolite and sandstone (Venter *et al.* 2003). The southern and central districts of the KNP are characterised by basaltic and granitic basement rocks with granitic soils dominating the western part of the KNP and neighbouring lands (Venter *et al*. 2003). Basaltic rocks underlie the majority of the KNP in the east and a north-south strip of sedimentary rock separates the basaltic and granitic rock formations (Venter *et al.* 2003).

2.5 Vegetation units

Two of South Africa's eight biomes are represented within the study area. The KNP is situated within the Savanna Biome, with the Grassland Biome present in the south-western reaches of the study area (Rutherford *et al.* 2006). Within the Savanna Biome the vegetation composition varies from grassy plains and open savanna in the southern section of the KNP, to mopane woodlands from the Orpen area northwards (Rutherford *et al.* 2006). Specific vegetation units within the southern and central reaches of the study area include; Granite Lowveld, Tshokwane-Hlane Basalt Lowveld, Gabbro Grassy Bushveld, Pretoriuskop Sour Bushveld and Malelane Mountain Bushveld (Mills & Gorman 1997; Rutherford *et al.* 2006; Figure 2.4; Figure 2.5).

In the southern reaches of the study area, Pretoriuskop Sour Bushveld and Malelane Mountain Bushveld prevail (Mills & Gorman 1997; Rutherford *et al.* 2006). Pretoriuskop Sour Bushveld describes an open savanna with a tall layer of sour grasses (e.g. *Hyperthelia dissoluta*, *Elionurus muticus*). Typical tree species include *Terminalia sericea* and *Sclerocarya birrea* (Gertenbach 1983; Rutherford *et al.* 2006; Figure 2.5). In the most mountainous section of the KNP open savanna-type habitat occurs on the slopes of the Malelane Mountains (Gertenbach 1983; Mills & Gorman 1997) and typical species include *Vichellia caffra*, *Combretum molle* and *Euphorbia cooperi* (Rutherford *et al.* 2006). Towards the south-western extent of the study area, Barberton Serpentine Sourveld (grasslands and woody vegetation) and Montane Grassland (a mixture of short grasses and rocky shrubland) support the farms north and east of Nelspruit (Mucina *et al.* 2006; Rutherford *et al.* 2006).

Moderately open shrubland with few trees characterise the vegetation around Skukuza and Tshokwane in the KNP (Granite Lowveld and Tshokwane-Hlane Basalt Lowveld respectively), and the land west of the KNP (Figure 2.4; Figure 2.5). Typically dominant species include *Combretum apiculatum*, *S. birrea* and *Vichellia nigrescens* spread over fairly flat plains (Rutherford *et al.* 2006; Ferreira & Funston 2010). Gabbro Grassy Bushveld describes the open, low-lying savanna and dense grassland that dominates the land just north of Orpen in the KNP and the lands further west. *Themedra triandra* is the dominate grass and *V. nigrescens* is one of a few tree species present (Rutherford *et al.* 2006).

Specific vegetation units north of Orpen and in the northern reaches of the study area include; Tsende Mopaneveld, Lowveld Rugged Mopaneveld, Phalaborwa-Timbavati Mopaneveld and Mopane Gabbro Shrubland (Rutherford *et al.* 2006). The vegetation is described as medium-high shrubby savanna and the landscape is denser than the southern district of the study area (Gertenbach 1983). Similar tree species dominate (*C. apiculatum*, *S. birrea* and *V. nigrescens*) and common shrubs include *Commiphora africana*, *Melhania forbesii* and *Colophospermum mopane* (Gertenbach 1983; Rutherford *et al.* 2006; Figure 2.5).

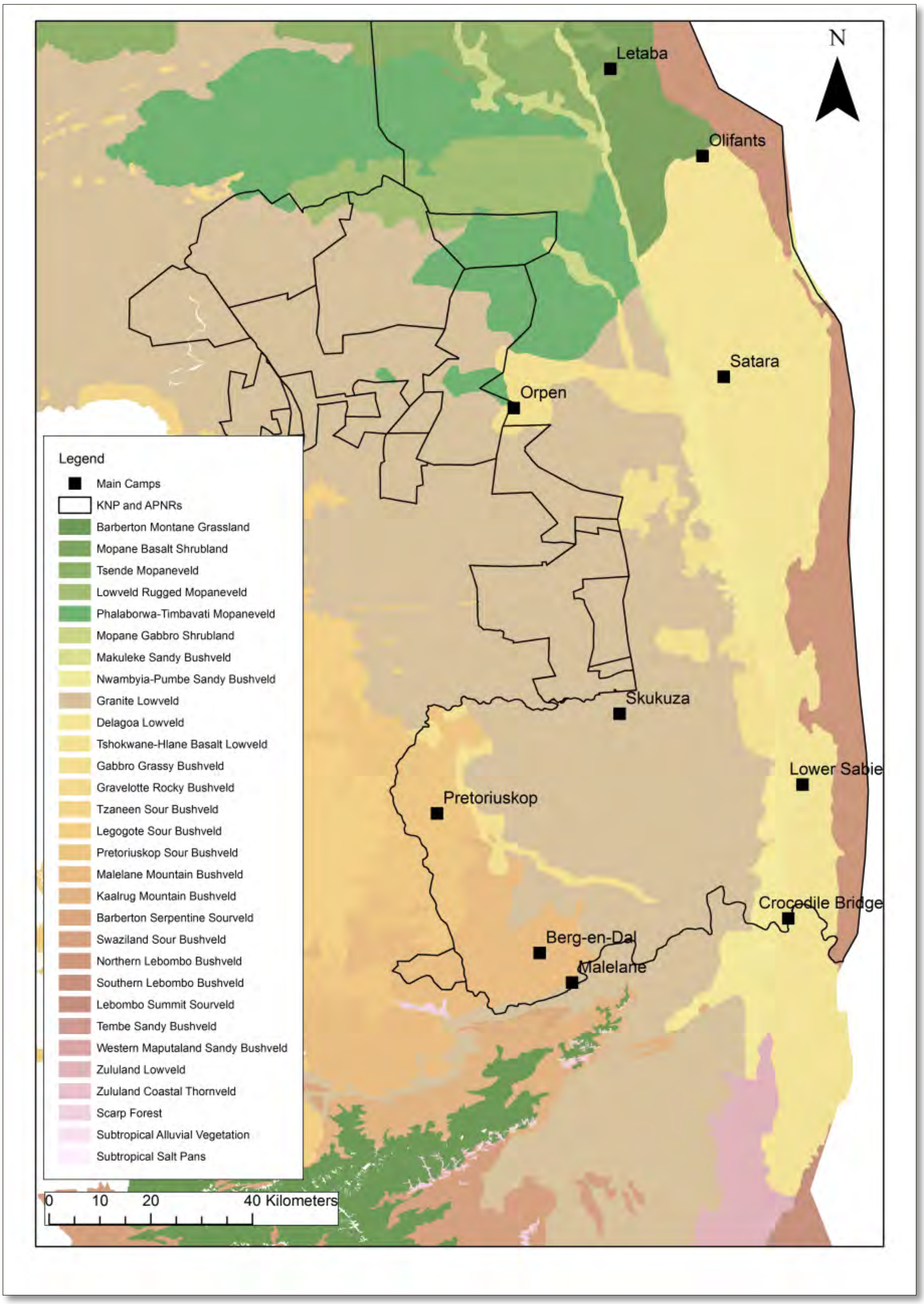

Figure 2.4. Specific vegetation units for the KNP and surrounds (ArcGIS 9.3; not projected; map units: decimal degrees; Mucina & Rutherford 2006).

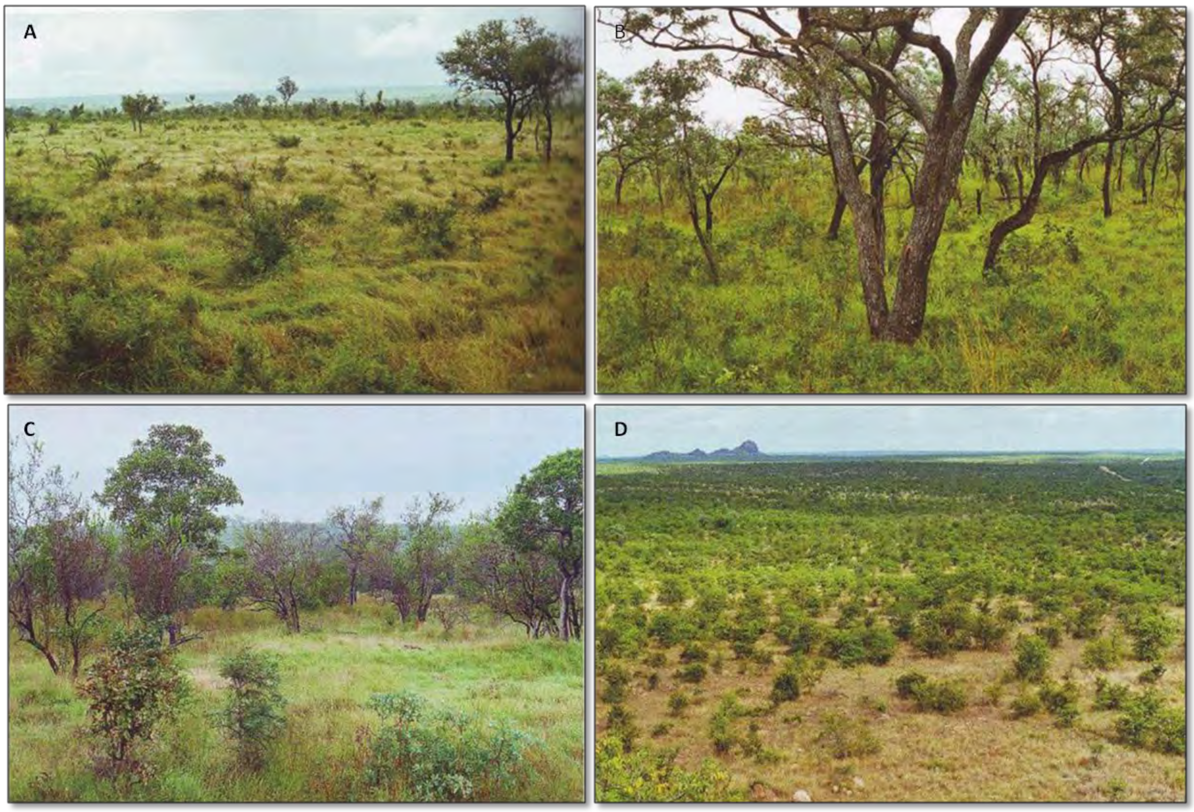

Figure 2.5. The study area is largely dominated by Granite Lowveld (C), with Gabbro Grassy Bushveld (A) and Pretoriuskop Sour Bushveld (B) present in the southern section of the KNP. Phalaborwa-Timbavati Mopaneveld (D), along with Granite Lowveld (C), are the most common vegetation types in the central section of the KNP (Mucina & Rutherford 2006).

2.6 Predator and prey populations

The KNP supports a rich diversity of mammals, including, five extant large (>20 kg) carnivores and one locally extinct species *Parahyaena brunnea* (Mills & Funston 2003). Spotted hyaenas *Crocuta crocuta*, lions *Panthera leo*, leopards *Panthera pardus*, cheetahs *Acinonyx jubatus* and wild dogs constitute the large carnivore guild of the KNP (Mills & Funston 2003). Wild dogs and cheetahs tend to occur at lower densities than lions and spotted hyaenas (Mills & Gorman 1997; Palomares & Caro 1999). Currently, there are an estimated 166-191 wild dogs and 369-545 cheetahs in the KNP (Davies-Mostert *et al*.

unpublished data), and ~1 684 lions (Ferreira & Funston 2010) and between 3 348 and 3 667 spotted hyaenas (Funston & Ferreira, unpublished data). Ungulates form the basis of each species diet (Mills & Funston 2003). There are some 30 species of large (>5 kg) herbivores within the KNP drawn from three orders (Artiodactyla, Perissodactyla, Proboscidea) and seven families, including Bovidae, Equidae and Elephantidae, amongst others (du Toit 2003). Herbivores are found in greater densities in the wetter south and show preference for the fertile basalts of the east (Gertenbach 1983; Venter *et al.* 2003 Ferreira & Funston 2010). Impala and Greater kudu, the preferred prey species of wild dogs in the study area, are more common in the Malelane, Sabie River and Crocodile River areas (Gertenbach 1983; Maddock & Mills 1994; Mills & Gorman 1997). Coincidently, wild dogs are thought to be amongst the most abundant predators in the aforementioned areas (Gertenbach 1983; Mills & Gorman 1997).

2.7 Site description and history

Humankind has always played an integral part in the landscape and environment of the KNP (Freitag-Ronaldson & Foxcroft 2003; Mabunda *et al.* 2003). History reveals the physical presence of humans ever since the early Stone Age (2.5 million years ago) and Iron Age (2 000 years ago), through to the colonial period (1836-1902) and the KNPs inception in the late 1800s (Mabunda *et al.* 2003). The colonial period, including the Anglo-Boer War, saw the decimation of game populations in the lowveld due to uncontrolled hunting for meat, skins and ivory (Carruthers 1994; Mabunda *et al.* 2003). In a response to conservation campaigns, and in an attempt to thwart unsustainable hunting practices, the Sabi Game Reserve was established with the appointment of James Stevenson-Hamilton as warden (Freitag-Ronaldson & Foxcroft 2003; Mabunda *et al.* 2003). The formation of the Sabi Game

Reserve in 1898 saw the first exclusion of the human component from the KNP landscape as native villages were cleared from the area and resettled west of the boundary (Carruthers 1994; Freitag-Ronaldson & Foxcroft 2003; Mabunda *et al.* 2003). In 1926 (following the passing of the National Parks Act, 1926) James Stevenson-Hamilton felt that the Sabi Game Reserve alone was not enough to protect the game of the lowveld and announced the expansion of protected areas to form the KNP (Carruthers 1994; Mabunda *et al.* 2003). The KNP soon developed a reputation as a conservation pioneer and was acknowledged for its wildlife research and management programs, many of which supported the exclusion of humans in order to maintain the biotic and abiotic components of the landscape (Freitag-Ronaldson & Foxcroft 2003, Anthony 2007). Ironically, it soon became apparent that for the KNP to function as a conservation initiative, the public needed to be exposed to the KNP (Carruthers 1994; Freitag-Ronaldson & Foxcroft 2003; Mabunda *et al.* 2003). This saw the formation of tourism facilities and infrastructure, and in 1927 the first three tourist cars entered the KNP (Freitag-Ronaldson & Foxcroft 2003; Mabunda *et al.* 2003).

By 1976, the entire KNP was fenced, defined by political and managerial incentives rather than ecological boundaries (Freitag-Ronaldson & Foxcroft 2003). The eastern and northern boundaries were defined by Mozambique in the west and Zimbabwe in the north, and the western boundary through negotiations with land owners (Freitag-Ronaldson & Foxcroft 2003; Mabunda *et al.* 2003). The southern boundary fence was established in accordance with veterinary control requirements (Freitag-Ronaldson & Foxcroft 2003). Since James Stevenson-Hamilton, the KNP had a suite of wardens and managerial bodies, and both the KNP and surrounding lands have changed substantially (Mabunda *et al.* 2003). Perhaps the most significant landmark of all was the acknowledgement of past injustices in 1994 and a promise to build relationships with the local neighbouring communities, previously displaced from the KNP (Mabunda *et al.* 2003; Pollard *et al.* 2003; Anthony 2007). Major cultural groups in the lowveld include the Vhavhenda, Tsonga, Pedi and Swazi and human population densities have been known to exceed 300 people/km^2 in many community-owned areas (Pollard *et al.* 2003).

Historically, the biotic and abiotic components of the KNP have been threatened by the circumstances beyond its boundary (Pollard *et al.* 2003). However, in the mid 1990s western fence segments from the central section of the KNP were removed as neighbouring land owners, sharing conservation goals, entered into agreements with the KNP (Freitag-Ronaldson & Foxcroft 2003). And, in the past 20 years farms and conservation areas west of the KNP have worked together and dropped fences to form an additional ~3 000 km^2 of protected land. Further, the recent formation of the Greater Limpopo Transfrontier Park represents an extra 36 000 km^2 of conservation land joining the north-eastern corner of the KNP with protected land in Mozambique and Zimbabwe (Mabunda *et al.* 2003; Pollard *et al.* 2003). Today, the KNP is seen as the benchmark of conservation in South Africa (Carruthers 1994; Freitag-Ronaldson & Foxcroft 2003; Mabunda *et al.* 2003; Anthony 2007). Indeed, the greater KNP currently represents a stronghold for the wild dog (Mills *et al*. 1998; Fanshawe *et al*. 1997). However, protected areas, the KNP included, do not operate in a vacuum. Consequently, building relationships with land owners beyond the boundaries could potentially benefit the conservation goals of the KNP, and ensure the persistence of the wild dog (Pollard *et al*. 2003; Lindsey *et al.* 2004a; Lindsey *et al.* 2005c).

CHAPTER 3: Factors influencing the spatial ecology of wild dogs within and beyond the boundaries of the Kruger National Park and potential population consequences

3.1 Introduction

The structuring influence of predators on ecosystem functioning has been demonstrated in many terrestrial and marine systems (Miller *et al*. 2001; Glen *et al*. 2007; Licht *et al.* 2010). In the absence of large predators, subordinate predators may invade areas where they have formerly been absent, and previously targeted prey populations may explode unchecked (Glen *et al*. 2007; Licht *et al.* 2010). The latter can have a profound effect on species richness and abundance at lower trophic levels (Crooks & Soule 1999; Miller *et al*. 2001; Hawkins & Racey 2005; Licht *et al.* 2010). For example, the absence of top-order predators has resulted in overabundant ungulate populations, negative effects on plant communities, and a loss of biodiversity and ecosystem processes in many natural landscapes in North America (Licht *et al.* 2010). The decline of coyotes *Canis latrans* in southern California resulted in an ecological release of smaller predators, and an increase in mortality rates of scrub-breeding birds (Crooks & Soule 1999). An absence of apex predators can influence the behaviour (e.g. hunting and feeding habits) and distribution of subordinate predators and prey, both temporally and spatially (Creel 2001; Glen *et al*. 2007; Licht *et al.* 2010). It is for these reasons that the maintenance of species interactions and the restoration of historic carnivore distributions are priorities for global conservation biology (Glen *et al*. 2007; Hayward *et al*. 2007).

Global species extinction has reportedly increased ~1 000 times more rapidly over the last century than previously predicted, with habitat loss and fragmentation identified as the greatest drivers (Miller *et al.* 2001; Hawkins & Racey 2005; Hayward *et al*. 2007; Rabinowitz & Zeller 2010). Urbanization and the ever-growing human population continue to dissect the natural habitats required for large carnivores to survive, bringing them more frequently into contact with humans and inhospitable habitat (Tigas *et al*. 2002; Dickson & Beier 2002; Thompson & Jenks 2005; Jackson *et al*. 2012). Habitat fragmentation and human persecution are responsible for a considerable reduction in the historic range of the jaguar *Panthera onca* (Rabinowitz & Zeller 2010) and cougar *Puma concolor* (Dickson & Beier 2002), and in Sweden, hunting of adult wolverines *Gulo gulo* has decreased the population significantly (Vangen *et al*. 2001). Importantly, wide-ranging carnivores face greater threats and more persistent declines than most other mammal species (Woodroffe & Ginsberg 1998; Lindsey *et al*. 2005b; Rabinowitz & Zeller 2010).

Wild dogs are highly active (Woodroffe & Ginsberg 1999b; Creel & Creel 2002), free-ranging carnivores (Lindsey *et al*. 2004b; Woodroffe 2010; Jackson *et al*. 2012) and rarely spend consecutive nights in the same place, except when denning. Wild dogs are highly susceptible to edge effects as they frequently roam beyond the borders of protected areas (Woodroffe & Ginsberg 1998; Woodroffe 2010; Jackson *et al*. 2012). Whilst traversing unprotected lands wide-ranging carnivores are often victims of human persecution (Woodroffe & Ginsberg 1998; Courchamp & Macdonald 2001; Rabinowitz & Zeller 2010; Jackson *et al*. 2012) and road/railway deaths (Woodroffe & Ginsberg 1999b; Dickson & Beier 2002; Thompson & Jenks 2005; Woodroffe *et al*. 2007). In addition, wild dogs are susceptible to diseases (mostly from domestic dogs *Canis familiaris*) and are frequently the victims of snares (Woodroffe & Ginsberg 1999b; Butler *et al*. 2004; Hayward *et al*. 2007; Gusset *et al*. 2008b; Woodroffe & Donnelly 2011). Wild dog conservation efforts are further thwarted as the species naturally occurs at low densities, even under optimal conditions (Creel & Creel 1998; Woodroffe & Ginsberg 1999b; Lindsey *et al*. 2005c; Jackson *et al*. 2012). Wide-ranging species that naturally occur at low densities and have sparsely distributed populations are the most sensitive to habitat loss and fragmentation (Tigas *et al*. 2002; Hawkins & Racey 2005). Wild dogs were once distributed throughout most of sub-Saharan Africa, but today occupy only a fraction of their former home range and are largely confined to protected or remote areas (McNutt *et al*. 2008; Licht *et al.* 2010). Consequently, the species has been left with a much reduced geographical distribution and far larger areas of fragmented habitat to traverse than before (Courchamp & Macdonald 2001).

In a response to the rapid reduction of favourable landscape, researchers and conservation managers promote the development of corridors (Tigas *et al*. 2002; Hawkins & Racey 2005; Rabinowitz & Zeller 2010), and the facilitation of translocations (e.g. Swift foxes *Vulpes velox* in North America; Moehrenschlager & Macdonald 2003) and reintroductions to augment wild populations and secure the future of wide-ranging carnivores (Moehrenschlager & Macdonald 2003; Hayward *et al*. 2007 Gusset *et al*. 2008b). In South Africa, recent wild dog conservation efforts have focused on establishing a metapopulation by reintroducing wild dogs into suitable conservation areas linked by management (Mills *et al*. 1998; Graf *et al*. 2006; Davies-Mostert *et al*. 2009; Gusset *et al*. 2010). Intermittent translocations between sites mimic natural dispersal and maintain gene flow (Gusset *et al*. 2010). The formation of conservancies has been highlighted as a priority for carnivore conservation (Lindsey *et al*. 2005c; Hayward *et al*. 2007; Lindsey *et al*. 2009), especially since charismatic predators have the potential to generate income through ecotourism (Lindsey *et al*. 2005b; Hayward *et al*. 2007; Licht *et al.* 2010). For example, wolf *Canis lupus* populations in America are estimated to be worth millions of dollars (Licht *et al.* 2010). However, each of these conservation efforts has logistical, legal and ecological challenges (Moehrenschlager & Macdonald 2003; Lindsey *et al*. 2005b; Davies-Mostert *et al*. 2009; Gusset *et al*. 2010; Rabinowitz & Zeller 2010).

The use of fences to contain predators has been suggested as the most effective method where protected areas are juxtaposed with developed/populated land (Hayward *et al*. 2007; Gusset *et al*. 2008b; Gusset *et al*. 2010; Licht *et al.* 2010). However, conventional fences are rarely one hundred percent predator-proof, especially in the case of wild dogs (Lindsey *et al*. 2005c; Jackson *et al*. 2012). In South Africa, wild dogs escaped from 78.0% of nine fully-fenced metapopulation reserves after translocation (Davies-Mostert *et al*. 2009). Interestingly, researchers have recently begun to experiment with the use of translocated scent marks to control the ranging behaviour of wild dogs (Jackson *et al*. 2012). Wild dog scent marks are deposited at the edge of an undesirable area thereby mimicking a neighbouring pack, and deterring territorial wild dogs from dispersing (Licht *et al.* 2010; Jackson *et al*. 2012). However, this method may have higher success amongst carnivores reliant on olfactory cues for communication (Licht *et al.* 2010). Enhancing public perception of wide-ranging predators may be the best way to reduce mortality beyond protected areas (Woodroffe & Ginsberg 1998; Lindsey *et al*. 2005c; Gusset *et al*. 2008b; Licht *et al.* 2010).

Dispersal has been defined as the movement of an individual from their natal area or birth place upon reaching sexual maturity to the first site of reproduction (Vangen *et al*. 2001; Thompson & Jenks 2005; Samelius *et al*. 2011). Dispersal patterns vary greatly amongst species (McNutt 1996; Vangen *et al*. 2001; Creel & Creel 2002) and can be influenced by a number of ecological, environmental and social factors (McNutt 1996; Vangen *et al*. 2001;

Thompson & Jenks 2005; Graf *et al*. 2006). Individuals may disperse to reduce competition for mates and resources or to pursue breeding opportunities (McNutt 1996; Vangen *et al*. 2001; Creel & Creel 2002; Thompson & Jenks 2005; Samelius *et al*. 2011). Contradictory information exists regarding the dispersal patterns of wild dogs (Frame & Frame 1976; Fuller *et al*. 1992; McNutt 1996; Creel & Creel 2002), and as yet no simple, unanimous definition of dispersal exists for the species (McNutt 1996; Creel & Creel 2002). A typical wild dog pack includes a dominant breeding pair (an alpha male and female), the pairs' offspring from one or more litters and additional subordinate adults (Woodroffe & Ginsberg 1999b). Occasionally, packs may contain beta litters (Girman *et al*. 1997; Creel & Creel 2002). Wild dog packs are formed when same-sex groups (usually siblings) leave their natal groups and join up with unrelated sibling groups of the opposite sex (Fuller *et al*. 1992; Woodroffe & Ginsberg 1999b; Graf *et al*. 2006). Thus, in newly formed packs all the females are related to each other and all the males are related to each other, but the males and females are unrelated (Woodroffe & Ginsberg 1999b). Occasionally individual dispersers will be accepted by an already established pack (McNutt 1995; Graf *et al*. 2006).

Dispersing groups or individuals are responsible for colonizing new or formerly occupied areas and provide an important link between populations (Woodroffe & Ginsberg 1999b; Samelius *et al*. 2011). Dispersals introduce new genetic material into populations and are important for their persistence and demographic compositions (Fuller *et al*. 1992; Vangen *et al*. 2001; Samelius *et al*. 2011). Dispersers are particularly important for species with a small population size (e.g. wild dogs; McNutt 1996). Consequently, where individual wild dogs fail to successfully disperse or subgroups are persecuted outside of protected areas, the genetic stability and fitness of the population is threatened. When packs fall below a critical threshold size (≤5) group members rely on the recruitment of additional members (McNutt 1995; Graf *et al*. 2006). Members of wild dog packs rely heavily on each other to assist with vital aspects of their survival (e.g. breeding, hunting, guarding pups and defending territories), and a positive effect of pack size on individual fitness (Graf *et al*. 2006), pup survival as well as pack and population persistence has been established (McNutt 1996; Woodroffe & Ginsberg 1999b; Courchamp & Macdonald 2001; Creel *et al*. 2004; Buettner *et al*. 2006; Graf *et al*. 2006). Dispersing groups or individuals can cover hundreds of kilometres before finding appropriate mates and establishing a new pack (Fuller *et al*. 1992; McNutt 1996).

Wild dog packs, on average, use an area of about 650 km^2 (Fuller & Kat 1990; Woodroffe & Ginsberg 1999b), but have been recorded to range over 400-1 100 km^2 (Reich 1981; Fuller *et al*. 1992; Mills & Gorman 1997). It has been suggested that a protected area as large as 10 000 km^2 is required to maintain a wild dog population (Woodroffe & Ginsberg 1999a; Hayward *et al*. 2007). However, wild dogs have been introduced into various smaller reserves within South Africa including, Hluhluwe-iMfolozi Park (960 km^2) and Marakele National Park (900 km^2), amongst others (Lindsey *et al.* 2004b; Davies-Mostert *et al*. 2009). Wild dogs have also been reintroduced to a number of reserves that are considerably smaller than the 1 000 km^2 deemed inadequate to sustain viable populations. For example, Venetia Limpopo Nature Reserve (316 km^2) (Lindsey *et al.* 2004b; Davies-Mostert *et al*. 2009). However, whether reintroductions in areas smaller than naturally occurring home ranges will be successful or not is debatable (Lindsey *et al.* 2004b; Hayward *et al*. 2007). It has been suggested that wild dogs would range beyond the borders of areas smaller than 1 000 km^2 and suffer persecution (Woodroffe & Ginsberg 1999a; Hayward *et al*. 2007).

The home range size of animals can be influenced by a number of factors (Lindsey *et al.* 2004b; Vangen *et al*. 2001). Wild dog packs may alter their home ranges in pursuit of favourable habitat or to avoid intra- and interspecific competition (Pole 1999; Vangen *et al*. 2001). For example, in the presence of high lion and spotted hyaena numbers, wild dog habitat utilization is reduced, requiring them to range further (Woodroffe & Ginsberg 1999b; Creel 2001; Lindsey *et al*. 2004b). Lions and spotted hyaenas are substantially larger than wild dogs and reduce wild dog densities, especially in smaller reserves and protected areas, both directly, through mortality (especially pups) and kleptoparisitism, and indirectly, by reducing the species' access to optimal habitats (e.g. areas of high prey density) (Creel 2001; Lindsey *et al*. 2004b; Woodroffe *et al*. 2007). Likewise, in North America, coyotes appear to avoid areas frequented by wolves *C. lupus* (Glen *et al*. 2007; Licht *et al.* 2010). Wild dogs have always had to cope with local competitors, but in the past local declines were more easily corrected naturally as neighbouring populations were less fragmented (Creel 2001). Consequently, interspecific competition compounded by habitat fragmentation and increasing exposure to humans could account for the overall decline of wild dog populations in Africa (Woodroffe & Ginsberg 1999b; Creel 2001; McNutt *et al*. 2008).

In South Africa, the KNP represents a stronghold for wild dogs (Mills *et al*. 1998; Lindsey *et al.* 2005b; Gusset *et al*. 2010). However, given the wide-ranging behaviour of wild dogs, it is possible that the species might frequently use unprotected areas adjacent to the KNP. Importantly, very little is known about wild dog movements beyond the boundaries of the KNP, or what consequences cross-boundary dispersals could have for the KNP population. Therefore, this study investigated the differences in spatial ecology and population demography among packs which operated solely within the borders of the KNP, and packs which frequently left the KNP boundaries. The aims of the chapter were to:

- Consider how differences in land use type affected the habitat use and ranging behaviour of wild dog packs inside and outside the KNP boundaries. Spatial analyses included an assessment of home range sizes and overlap, and vegetation preference.
- Investigate what environmental and anthropogenic factors may have influenced pack movements.
- Consider demographic differences and the potential consequences for population persistence. The differences in pack sizes among the wild dog packs inside and outside the KNP boundaries were evaluated.

3.2 Methods

Data collection

Wild dogs have individually distinct coat patterns of white, black, tan and brown which allows for individual recognition (Maddock & Mills 1994). The use of sightings data and photographic records to assess wild dog movements is well supported (Malcolm & Marten 1982; Maddock & Mills 1994; Fanshawe *et al.* 1997; Lindsey *et al.* 2004a), and represents an inexpensive and effective way to assess the status of large, wide-ranging carnivores over large areas (Gros *et al.* 1996). Photographic data were collected from managers, head rangers and rangers from all adjoining private nature reserves (APNRs) and as many conservancies, wildlife estates and private lodges as possible along KNP western and southern boundaries. Appeals were made to private land owners of game and crop farms surveyed for any sightings or photographic data. In addition, a pamphlet detailing the purpose of the research and the data required were distributed throughout the study area, and local anti-poaching/security companies were approached for any information. The research was publicised in English and Afrikaans media sources with appearances in one local environmental/wildlife magazine (Environment: People and Conservation in Africa, spring 2010/Issue 4) and two local newspapers (Kruger2Canyon, August 2010 and Die Lowvelder, March 2011). In every publication a picture of a wild dog was included to ensure proper identification of the species. Finally, appeals for photographs of sightings were made at the Wild Dog Advisory Group meetings (attended at the EWTs head office in Johannesburg) and conferences and symposia during the period of data collection (March 2010-April 2011).

Data analyses

Photographic data were sorted into relevant sightings and given a unique sighting identification. Thereafter, each sighting was entered into a comprehensive spreadsheet along with the following; the date and time of the sighting, the GPS location of the sighting, the submitter's contact details (name, cellular telephone number and email address), and any additional information (e.g. number of individuals seen, whether any pups were present, whether any of the wild dogs were injured and whether the wild dogs were on a kill etc.). Photographic data were analysed so as to be comparable with the data collected in the EWTs 2009 census. Accordingly, individual wild dogs from all photographs were cropped into a table with photographs of the same individual, and/or the matched right-hand side (RHS) shot of the individual, and compared against individual and pack profiles identified from the 2009 census. Once all the photographs from the sighting had been analysed, every identifiable wild dog was added to the data spreadsheet. If a new dog was identified (i.e. had not been previously recorded in the 2009 census), both the left-hand side (LHS) shot and the RHS (where possible) were recorded, and the dog was given a unique identification code. This applied to all previously unidentified wild dogs, regardless of age, provided their coat patterns were distinct. Wild dogs can be individually identified as large pups and, in some cases, even from birth (Creel *et al.* 2004). Where photographs were of extremely poor quality, or wild dog coat patterns were obscured as a result of tall grass or mud etc., sightings were marked as unidentifiable (3.1% of all 799 sightings).

Wild dog packs are cohesive social units (Creel & Creel 2002). It was evident certain individuals were consistently seen together within a well-defined area, and that successive sightings of a group contained the same, or a similar number of individuals (Maddock & Mills 1994). Mating incidences and denning periods were carefully recorded and used to identify alpha pairs (Maddock & Mills 1994). Given that alphas rarely disperse (Creel *et al*. 2004), if the breeding pair remained constant, and there was no evidence of new individuals vying for alpha-ship/displacing previous breeding males/females of the group, the pack was considered to be a consistent unit. The latter, together with the packs that were established by the 2009 census, allowed for the identification of 12 consistent groups of individuals separated into six 'Edge' and six 'KNP' packs. The Edge packs were defined as those packs that operated beyond KNPs boundaries, and the KNP packs were those packs that were always sighted within the southern and south-western boundaries of the KNP. To ensure that all sightings were representative of pack movements and individual dispersal events were excluded, all wild dogs that were consistently sighted alone and/or without members from the natal pack were excluded from the analyses. Ideally only sightings where either the alpha male or female where present should have been included in the analyses, but this would have resulted in a large amount of data being discarded. Unfortunately, due to the nature of the data collection methods, every individual from a pack was not observed in all records. Consequently, where the alpha male or female was not present, if the individual(s) had been seen with either of the alpha pair three months (90 days) before or after the sighting in question, they were still considered to be part of the pack. This did not apply for any new wild dogs or pups that had not previously been recorded. Although wild dogs are highly social and it is unusual to see an individual away from their pack for an extended period of time (Pole 1999; Woodroffe & Ginsberg 1999b), unsuccessful dispersers have been known to be absent from the natal pack for up to five months (Creel & Creel 2002). It was also noted that dispersing groups tended to exist in groups of ≤5 individuals (McNutt 1996; Creel & Creel 2002; Lindsey *et al.* 2004b).

Reported sightings were rarely accompanied by accurate GPS locations. Consequently, for sightings within the KNP, the closest camp or entrance gate relative to the wild dogs' location was used and, for sightings beyond the KNP boundaries, either the landing strip or main lodge was selected. If neither the landing strip nor the main camp was centrally located then a central location of the property on which the wild dogs were seen was recorded. However, wherever accurate GPS coordinates had been reported these were retained. Further, to reduce potential temporal and/or spatial autocorrelation which can result from a higher frequency of sightings within a particular area, or on a particular day, due to observer bias, location points were limited to one fix per day (Dray *et al.* 2010). Consequently, where wild dogs were sighted more than once on the same day, the earliest sighting of the day was used. GPS data points and location information for all 12 study packs were imported into ArcView GIS 3.2 (ESRI, California, USA) and ArcGIS 9.3 (ESRI, California, USA) for spatial analyses, and projected in Transverse Mercator, spheroid WGS84, central meridian 31.

Two measures of distribution were calculated for each of the 12 study packs, the extent of occurrence and area of occupancy (Lindsey *et al*. 2004a). The extent of occurrence for each pack was calculated by generating Minimum Convex Polygons (MCP 100%). MCPs 100% are created by joining the outermost points of a group of points (Pole 1999), and have been used before in wild dog home range studies (Fuller & Kat 1990; Mills & Gorman 1997; Pole 1999). In order to understand pack movements on a finer scale, the area of occupancy was calculated for each pack. The area of occupancy was the area within the extent of occurrence actually occupied (Lindsey *et al*. 2004a). To determine the area of occupancy for each pack, a grid of equally-sized, hexagon-shaped polygons was overlaid onto the study area and the frequency of sightings within each polygon determined (Figure 3.1). Hexagon size was determined based on the median daily distance (3.7 km) travelled by wild dogs in a straight line operating in an unfenced system (Jackson *et al.* 2012). This distance is comparable with previous studies where a mean daily distance of 3.5±0.4 km (Pole 1999) and a median daily distance of 2.3 km (van Dyk & Slotow 2003) have been recorded. Consequently, a grid of 35.4 km² cells (calculated using 3.7 km as the diameter of the hexagon) was overlaid onto the study area using the Generate Pattern of Repeating Shapes extension to ArcGIS 9.3 (Figure 3.1; Jenness 2011). This ensured a cell size which could be realistically covered by a pack in a day, but reduced the likelihood that a pack could occur in more than one cell simultaneously (Powell 2000; Balme *et al.* 2007; Hoffman & O'Riain 2011). Thereafter, the GPS data for each pack was spatially joined to the grid, and the grid for each pack was clipped to the boundary of its MCP 100% (Figure 3.1). Finally, the grid was graded according to the frequency of sightings within each cell (Figure 3.1), and the total area of the cells in which the pack was sighted recalculated. This enabled a comparison of the maximum (extent of occurrence) and minimum (area of occupancy) areas utilised between the Edge and the KNP packs.

The degree of overlap was determined by consecutively clipping the MCP 100% of each pack to the remaining relevant packs, and calculating the area shared (Figure 3.2). Overlap was calculated for the Edge packs and the KNP packs independently, as at no point did any of the Edge packs overlap spatially with any of the KNP packs. Data for all 12 packs overlapped temporally (Table 3.1). Further, whether wild dogs were sighted more frequently in a specific vegetation type over another was explored. The GPS coordinates for all sightings were spatially joined to a vegetation layer (Mucina & Rutherford 2006) which had been clipped to the study area. Consequently, a vegetation type was assigned to each GPS coordinate which enabled frequency data to be extracted for each vegetation type for the total sightings, and the sightings for both the Edge and the KNP packs. Finally, the mean pack size for each of the 12 study packs was determined by calculating the average number of individuals identified per sighting for each of the Edge and KNP packs.

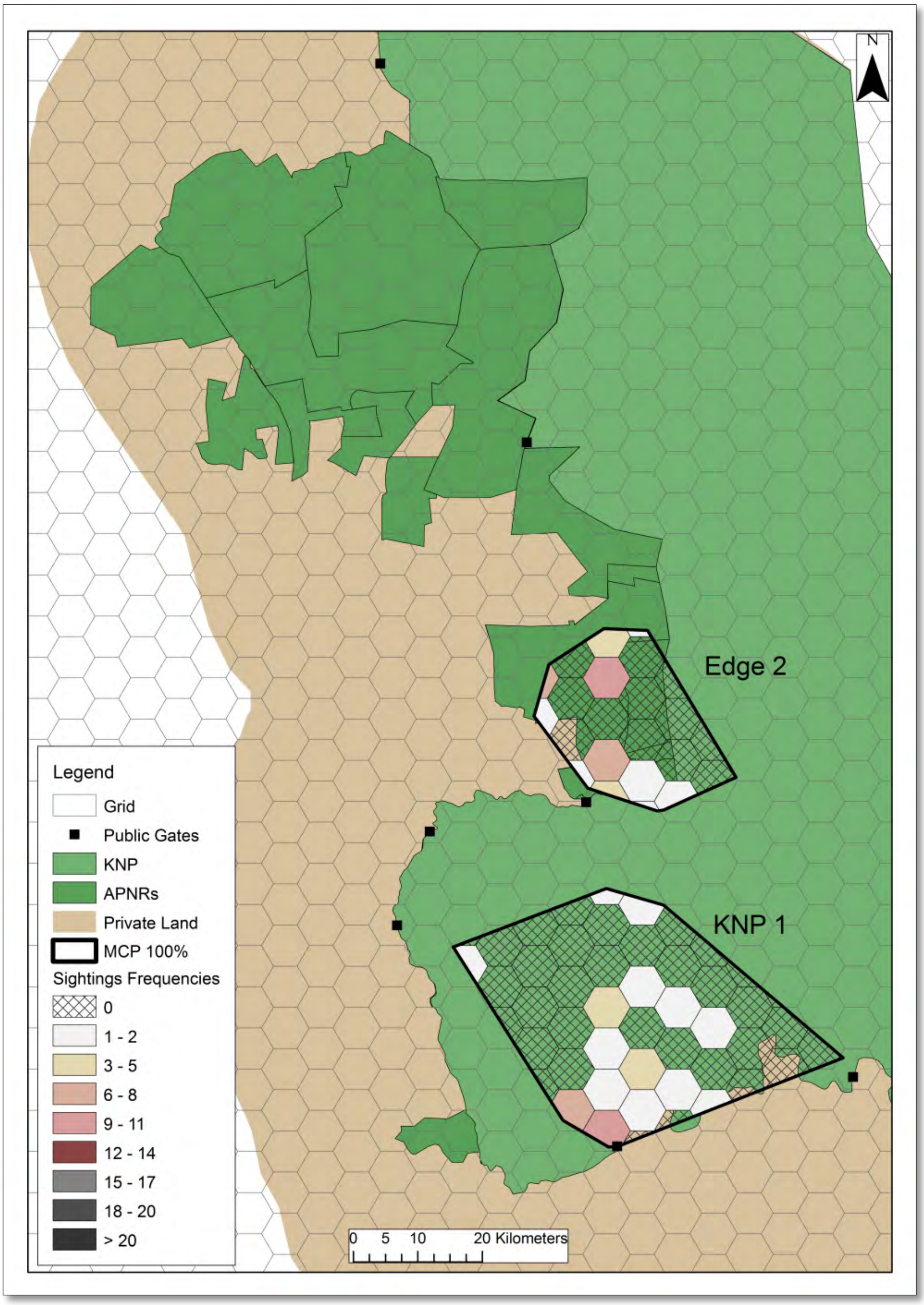

Figure 3.1. A grid of 35.4 km² cells overlaid onto the study area, and the frequency of sightings for Edge Pack 2 and KNP Pack 1 clipped to their MCP 100% (ArcGIS 9.3; projected: Transverse-Mercator, spheroid WGS84, central meridian 31; map units: meters). This was repeated for all 12 packs and the area of the cells in which they were seen totalled to determine the area of occupancy utilised by each of the packs relative to their extent of occurrence (MCP 100%).

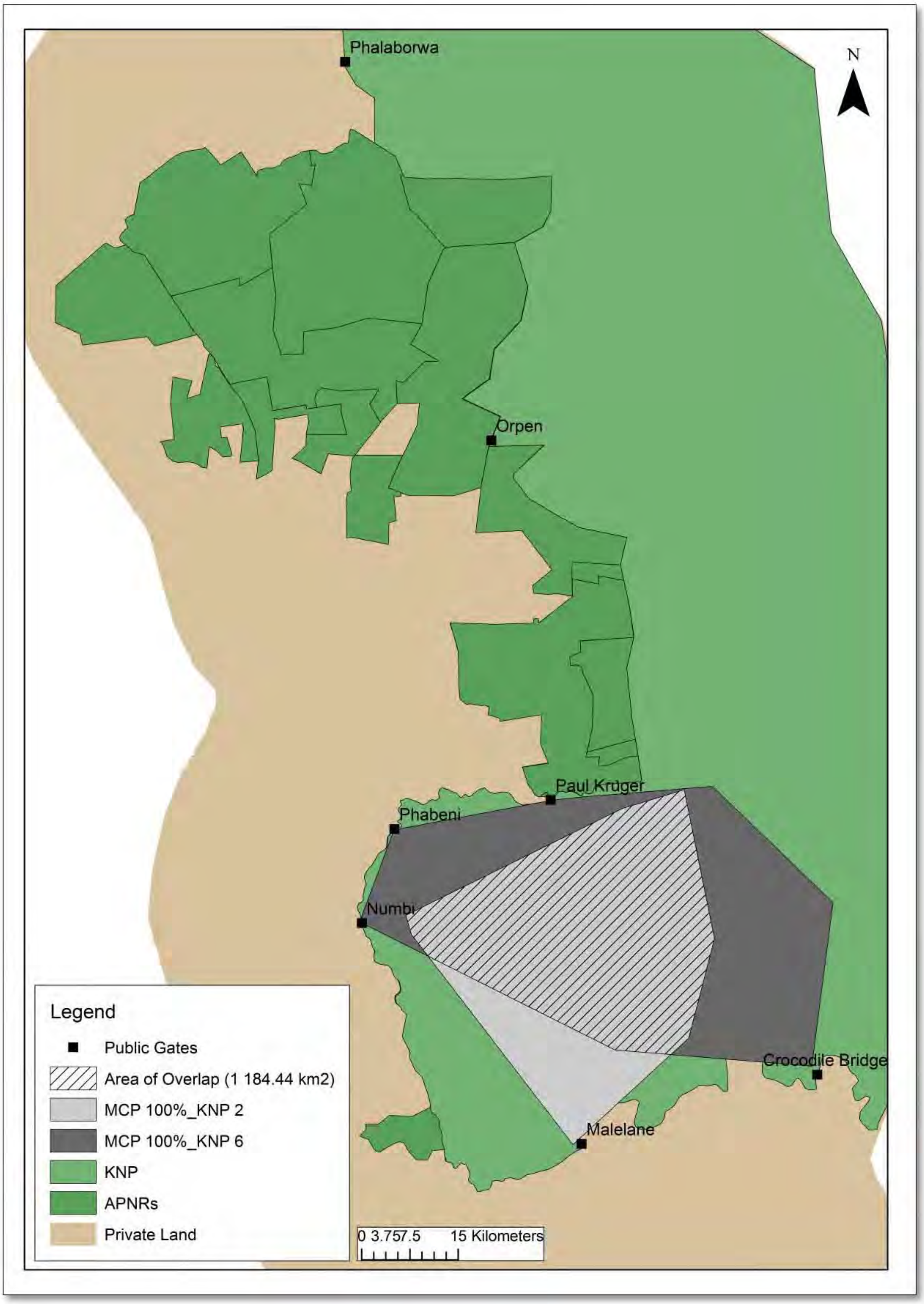

Figure 3.2. Overlap for two of the KNP packs (ArcGIS 9.3; projected: Transverse-Mercator, spheroid WGS84, central meridian 31; map units: meters).

Table 3.1. Periods of data collection for each of the 12 study packs and the temporal overlap among the packs. The degree of temporal overlap among all the packs was greatest between July 2008 and June 2009. In August 2009 four males usurped the males of Edge Pack 5 and joined the remaining females forming a new pack (Edge Pack 6).

Pack	Jan.-June '08	July-Dec. '08	Jan.-June '09	July-Dec. '09	Jan.-June '10	July-Dec. '10	Jan.-June '11
Edge 1		■	■	■	■	■	
Edge 2			■	■	■		
Edge 3		■	■	■	■	■	■
Edge 4		■	■	■	■	■	■
Edge 5	■	■	■	■			
Edge 6				■	■	■	■
KNP 1		■	■				
KNP 2		■	■	■	■		
KNP 3	■	■	■				
KNP 4	■	■	■				
KNP 5		■	■				
KNP 6		■	■	■	■	■	■

Finally, data from sections one (property characteristics) and two (sightings and frequency data on local predators) of the questionnaire surveys (see Chapter 4) were also included in this chapter to provide a more comprehensive analysis of the potential factors influencing the packs movements. For a detailed description of how these data were prepared for analysis, see Chapter 4.

Statistical analyses

All statistical analyses were completed using Statistica 10 (StatSoft, Inc. 2011). Two-sample independent t-tests were used to analyse differences between the extent of occurrence (MCP 100%) and area of occupancy between the Edge and the KNP packs, and to analyse the degree of overlap (MCP 100%) within the KNP and the Edge packs. Prior to analyses data were checked for normality and heteroscedasticity. A Chi-Square goodness-of-fit test was used to examine whether wild dogs were sighted more frequently in a specific vegetation type. Because a specific vegetation type was assigned to each GPS coordinate, it enabled frequency data to be extracted for each vegetation type for the total number of sightings, and the sightings for both the Edge and the KNP packs. These data served as the observed values. To obtain expected values, random GPS points were generated within the study area for all sightings (n=468), the KNP packs (n=206) and the Edge packs (n=262) and spatially joined to the vegetation layer (Mucina & Rutherford 2006). This was done using the Generate Random Points tool of ArcGIS 9.3. A two-sample independent t-test was also used to test whether there was a difference in the average pack size of the Edge and KNP packs. Prior to analyses data were checked for normality and heteroscedasticity. To investigate any effects of sampling bias, Pearson product-moment correlation coefficients (data did not satisfy the assumption of normality) were run to assess any relationship between the average number of individuals identified and the number of photographs processed per pack, and the average size of the packs and the total area that they used (MCP 100%). The same test was run to assess any relationship between the extent of occurrence and the number of GPS fixes used per pack.

Non-parametric Kruskal-Wallis tests were used to analyse whether wild dogs were sighted more frequently on one land use type over another, and to determine any differences in the recorded frequencies of wild dog sightings on properties in comparison to other predators. Student Newman-Keuls post-hoc tests were run to identify the sources of any significant variance. A Mann-Whitney U-test was run to identify any effect of predator-proof fencing on the movements of wild dogs. Finally, a General Linear Model (GLM) was used to determine any effects of, or interactions among, a number of independent continuous (i.e.

stock and game numbers and property size) and categorical (i.e. the degree of fencing and whether properties were part of conservancies or not) predictors on how frequently wild dogs were recorded on properties (dependent factor). Prior to analyses, residuals (predictors vs. residuals) were checked for constant variance (Sokal & Rohlf 1995), thereafter, Tukey HSD post-hoc tests were run to identify the sources of any significant variance. In subsequent graphs, where the frequency of wild dog occurrence is reported, sightings were recorded as more than once/month (5), once/month (4), every few months (3), less than once/year (2) and never (1).

3.3 Results

A total of 799 sightings was reported, amounting to 13 906 photographs from within the KNP (52.1% of sightings), the APNRs along the KNPs western boundary (35.4%), and additional private reserves and lodges (11.3%) and private farms (0.3%) along the KNPs southern and western boundaries (Figure 3.3). Eight of the 799 sightings had no associated location data. Sightings information and photographic data collected between March 2010-April 2011 dated from 9 January 2003 to 30 May 2011 and amounted to 441 sightings and 8 458 photographs. Thereafter, my data were supplemented with sightings and photographic data from the 2009 census that fell within the study area. Almost all sightings were reported on ecotourism (i.e. wildlife estates, private reserves and lodges and the KNP) properties (98.9%). Wild dogs were only encountered once not on an ecotourism property on the Schoemanskloof pass near Nelspruit, Mpumalanga (35.5 km in a straight line from KNP south-western boundary). Analyses only included photographs from 2008-2011 as data from 2003-2007 were sparse. Seventy-six percent of the sightings, and 80.0% of the photographs were included in the final analyses, with 6 646 and 4 489 photographs examined to assemble data on the Edge packs and the KNP packs, respectively.

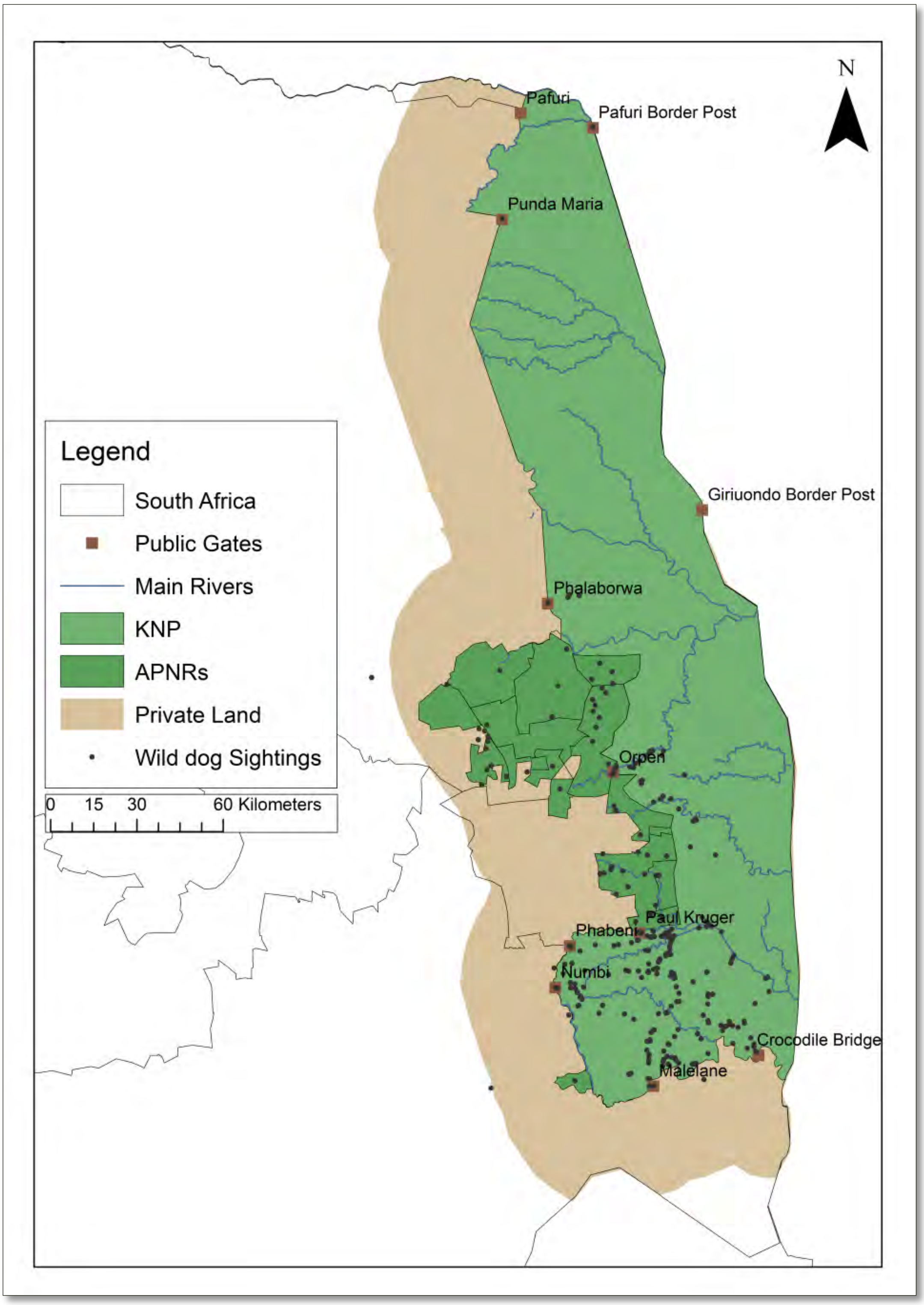

Figure 3.3. The majority of the 799 sightings (January 2003-May 2011) came from within the KNP (52.1%) and the western boundary of the KNP (45.3%), with considerably fewer sightings being reported from the KNP southern boundary (1.6%). Spatial and temporal autocorrelation was not accounted for in this figure (ArcGIS 9.3; projected: Transverse-Mercator, spheroid WGS84, central meridian 31; map units: meters).

Land use selection and spatial analyses

All of the 535 sightings (76.0% of 799) analysed to gather information on the 12 study packs, were recorded on ecotourism properties one hundred percent of the time (Table 3.2; Figure 3.4; Figure 3.5). Most of these sightings were captured within the Sabi Sand Wildtuin and the KNP, with the Blue Canyon Conservancy and Umbabat Private Nature Reserve also proving to be popular locations for wild dog viewing (Table 3.2). Edge Pack 5 and Edge Pack 6 were sighted consistently within the Sabi Sand Wildtuin (Figure 3.4) and the KNP packs were never sighted beyond the boundaries of the KNP (Figure 3.5). Along with the Blue Canyon Conservancy, Raptors View and Zandspruit Wildlife Estates in Hoedspruit were popular locations for sightings of Edge Pack 1, and Edge Pack 4 was most frequently sighted within the KNP as well as within Ngala Main and Tented Camps, Manyeleti Private Nature Reserve and Sandringham Private Nature Reserve (Table 3.2; Figure 3.4). No photographs were submitted from wildlife ranchers (i.e. breeding, live game sales and biltong and/or trophy hunting) or crop farmers. However, just because no photographs were captured does not mean that wild dogs did not occur on these properties (Lindsey *et al*. 2004b).

Table 3.2. Proportion of sightings recorded from within the KNP and the adjoining private nature reserves (APNRs) for all 12 study packs. PNR = Private Nature Reserve, BCC = Blue Canyon Conservancy, KNP = Kruger National Park. Values are percentages.

	Edge						**KNP**					
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
Sabi Sand Wildtuin		85.0		6.5	100.0	100.0						
Mala Mala PNR		2.5										
Manyeleti PNR				13.0								
Timbavati PNR			14.6									
Kapama PNR			2.1									
Thornybush PNR												
Umbabat PNR			66.7									
Klaserie PNR												
Balule PNR			10.4									
BCC	52.9											
KNP		12.5	6.3	50.0			100.0	100.0	100.0	100.0	100.0	100.0
Other	47.1			30.4								

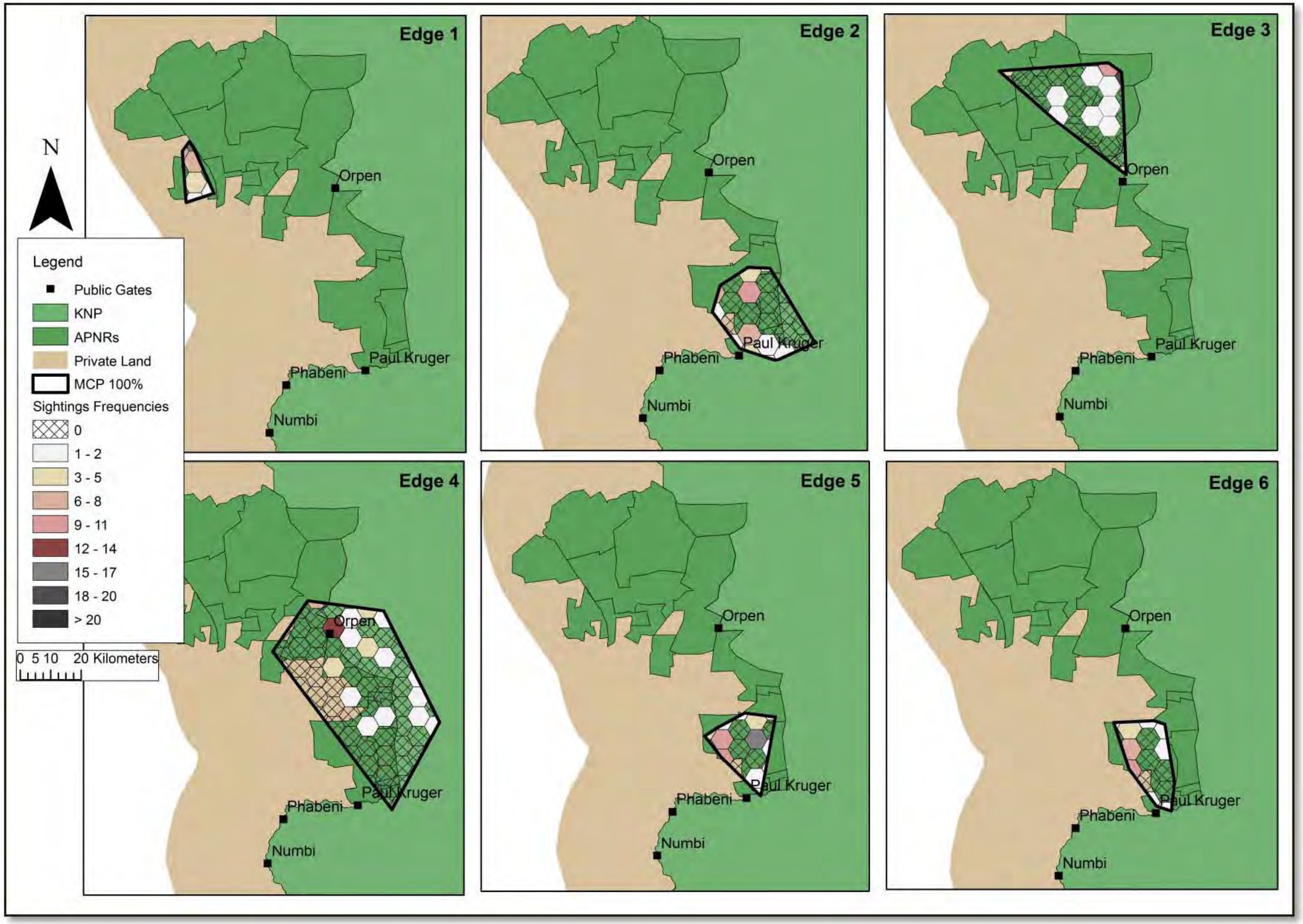

Figure 3.4. Area of occupancy for the Edge packs displayed within their extent of occurrence (MCP 100%) (ArcGIS 9.3; projected: Transverse-Mercator, spheroid WGS84, central meridian 31; map units: meters).

Figure 3.5. Area of occupancy for the KNP packs displayed within their extent of occurrence (MCP 100%) (ArcGIS 9.3; projected: Transverse-Mercator, spheroid WGS84, central meridian 31; map units: meters).

Questionnaire data revealed that while wild dogs were reported more frequently on ecotourism properties, their movements were not confined to this land use type. Wild dogs were recorded significantly more often on ecotourism (n=79) and wildlife ranching (i.e. breeders, production for live game sales and hunting operations; n=35) properties than on crop farms (n=72) ($H_{(2,\ 186)} = 31.1$; $p < 0.0001$; Figure 3.6), and occurred at similar frequencies on ecotourism and wildlife ranching properties (Figure 3.6). Notably, 94.4% of crop farmers, 48.6% of wildlife ranchers and just over half of ecotourism properties (54.4%) reported to have never seen wild dogs on their properties. The KNP and APNRs promote photo-tourism and have a more developed infrastructure and higher human presence than the other land use types surveyed (Maddock & Mills 1994; Creel *et al.* 2004). Thus, one can assume an equal distribution of photographers and adequate camera equipment, and a higher submission of photographs in the KNP and APNRs compared to wildlife ranches and crop farms (Maddock & Mills 1994). In addition, the 2009 census incentivised the submission of photographs taken of wild dogs within the KNP between July 2008 and April 2009.

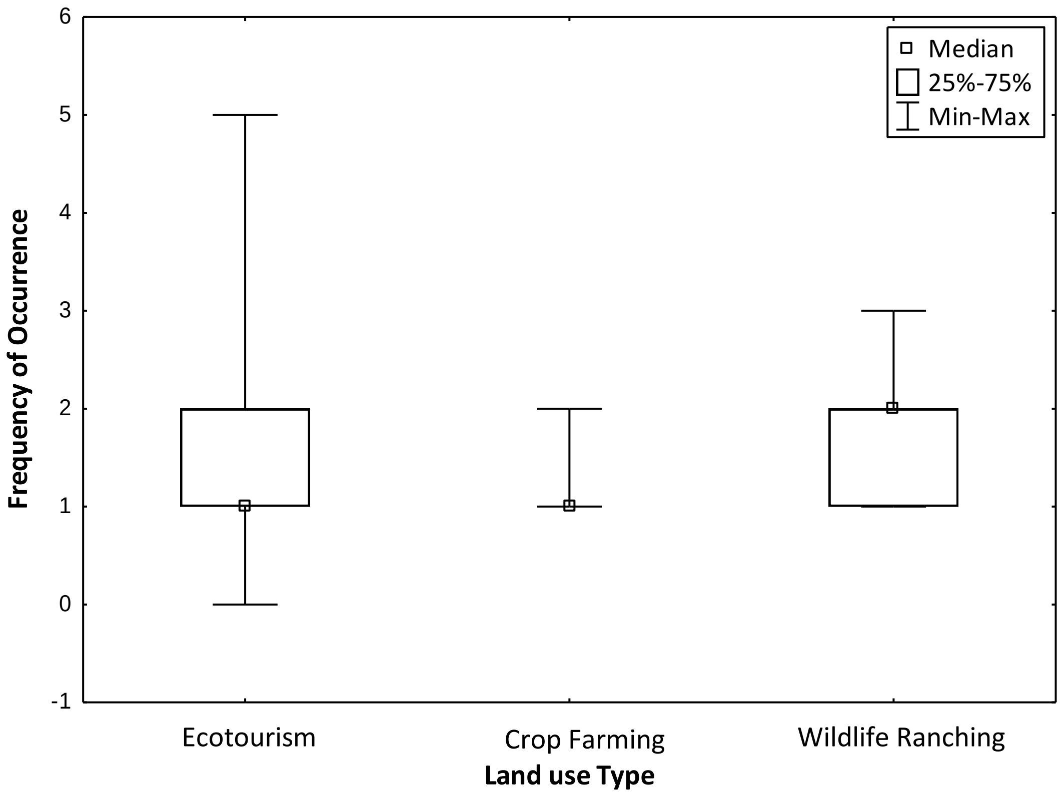

Figure 3.6. Reported frequencies of wild dogs for the three land use types surveyed. Significant ($H_{(2, 186)} = 31.1$; $p < 0.0001$) effects are described in the text.

MCP 100% analyses revealed that the KNP packs tended to have a larger extent of occurrence ($t_{(10)} = -1.6$, $p > 0.05$) than the Edge packs (Figure 3.7). Likewise, when the area of occupancy for each pack was recalculated, the KNP packs tended to occupy larger areas than the Edge packs ($t_{(10)} = -1.5$, $p > 0.05$; Figure 3.8). Therefore, the Edge packs tended to utilise smaller areas than the KNP packs when both the maximum (extent of occurrence) and minimum (area of occupancy) extent of the packs' ranges were considered (Table 3.3). Notably, there was no significant relationship between the maximum (MCP 100%) ($r = 0.0$, $n = 12$, $p > 0.05$) and minimum ($r = -0.0$, $n = 12$, $p > 0.05$) areas calculated and the number of GPS fixes used per pack. An average of 43.7±8.9 and 34.3±6.6 GPS fixes were analysed for the Edge and KNP packs, respectively. This would suggest that the variation between the areas used by the Edge and KNP packs were not significantly driven by the variation in the number of fixes used. Finally, the degree of overlap (MCP 100%) was significantly larger among the KNP packs than among the Edge packs ($t_{(18)} = -2.9$, $p < 0.05$; Figure 3.9).

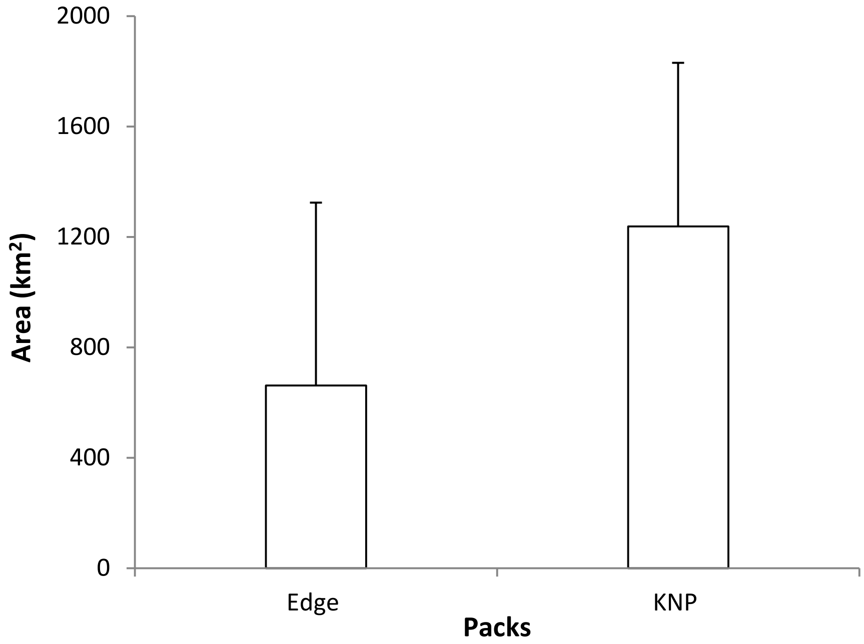

Figure 3.7. The maximum (MCP 100%) area occupied by the Edge (n=6) and the KNP (n=6) packs ($t_{(10)} = -1.6$, $p > 0.05$). Data are means + 1 SD.

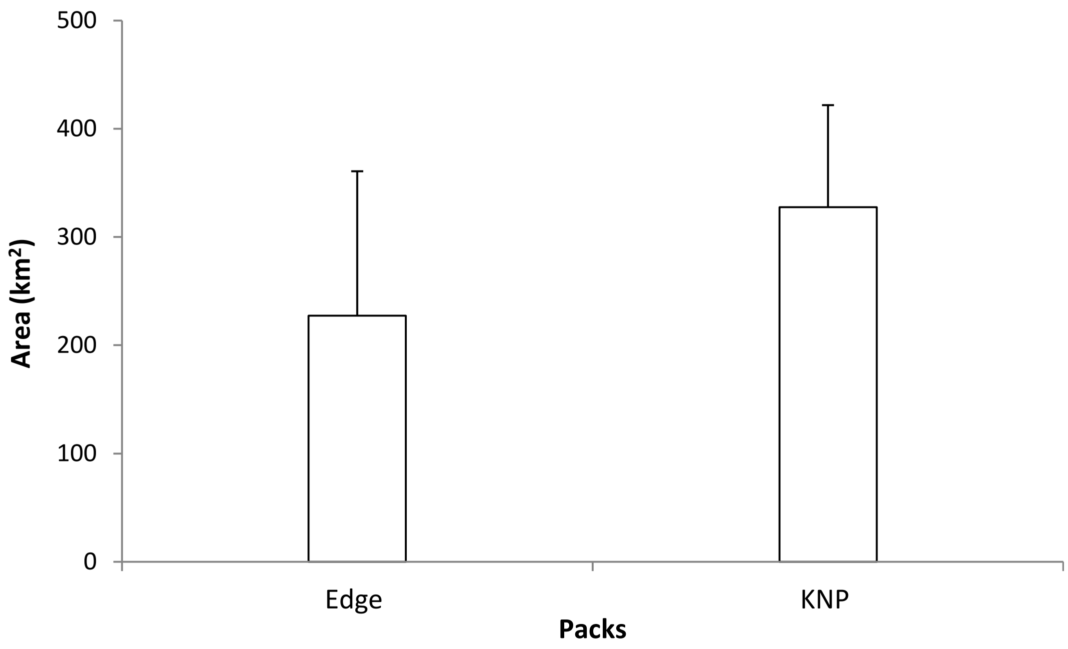

Figure 3.8. Area of occupancy for the Edge (n=6) and KNP (n=6) packs ($t_{(10)} = -1.5$, $p > 0.05$). Data are means + 1 SD.

Table 3.3. The extent of occurrence (MCP 100%) and area of occupancy for the Edge and the KNP packs.

Pack	MCP 100% (km²)	Area of Occupancy (km²)
Edge 1	100.4	90.6
Edge 2	554.6	196.1
Edge 3	721.2	275.6
Edge 4	1940.8	468.9
Edge 5	345.0	190.4
Edge 6	310.7	142.7
Mean±SD.	662.1±661.8	227.4±133.4
KNP 1	1347.2	441.1
KNP 2	1511.2	403.3
KNP 3	739.8	298.4
KNP 4	694.6	370.3
KNP 5	898.7	262.5
KNP 6	2240.7	190.5
Mean±SD.	1 238.7±591.7	327.7±94.1

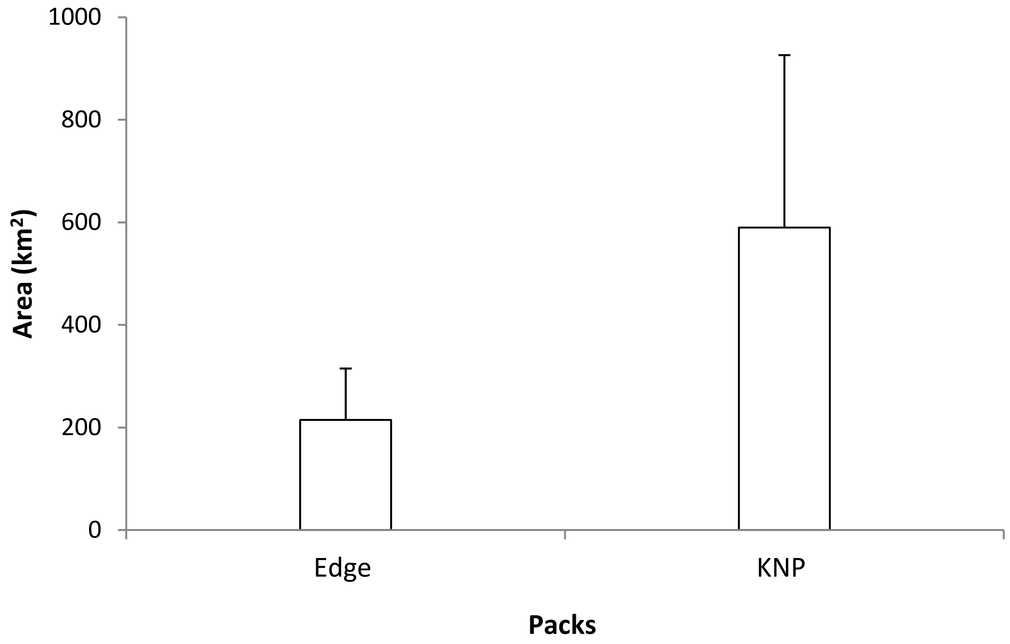

Figure 3.9. Overlap for the Edge (n=6) and the KNP (n=6) packs ($t_{(18)} = -2.9$, $p < 0.05$). Data are means + 1 SD.

The KNP packs tended to consist of fewer individuals, on average, than the Edge packs ($t_{(10)} = 2.1$, $p > 0.05$; Figure 3.10; Table 3.4). However, there was a strong, positive correlation between the number of photographs processed, and the average number of individuals identified per pack ($r = 0.8$, $n = 12$, $p < 0.01$; Figure 3.11). Six-thousand, six-hundred and forty-six photographs were examined to assemble data on the Edge packs, whilst 4 489 photographs provided data for the KNP packs. Notably, there was no significant relationship between the average size of the packs and the extent of occurrence (MCP 100%) that they used ($r = 0.0$, $n = 12$, $p > 0.05$). This would suggest that the variation between the areas used by the Edge and KNP packs were not significantly driven by the variation in the number of photos processed.

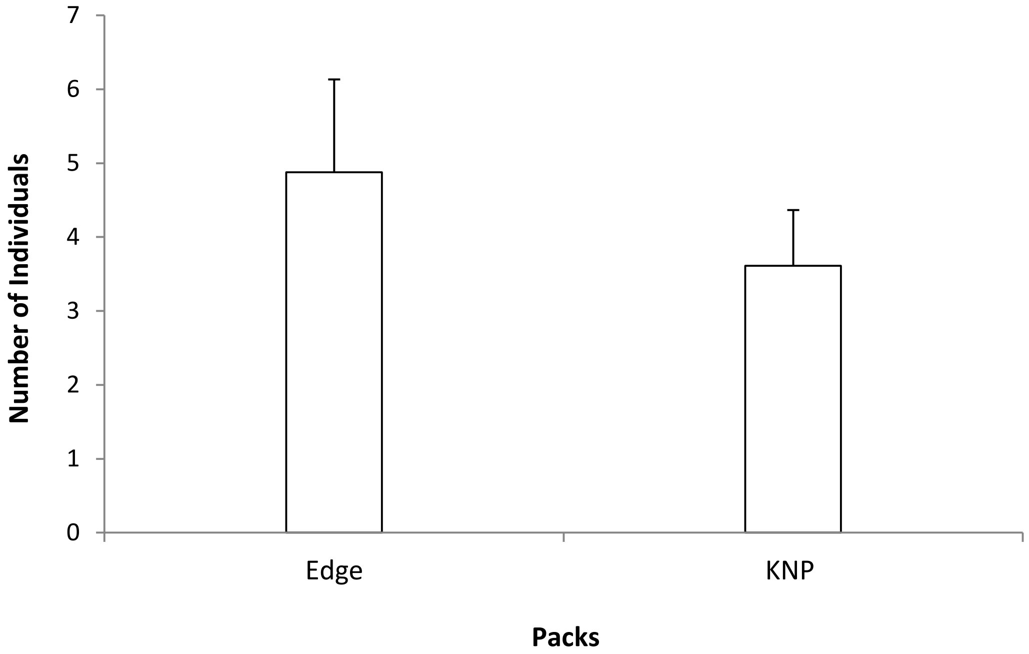

Figure 3.10. The number of individual wild dogs in both the Edge (n=6) and the KNP (n=6) packs ($t_{(10)} = 2.1$, $p > 0.05$). Data are means + 1 SD.

Table 3.4. Average number of individuals per sighting for each of the Edge and KNP packs. Data are means ± 1 SD.

Pack	Average Number of Individuals	Pack	Average Number of Individuals
Edge 1	5.8±3.9	KNP 1	4.4±1.8
Edge 2	4.4±2.9	KNP 2	4.2±1.7
Edge 3	5.9±4.0	KNP 3	2.6±1.2
Edge 4	6.1±3.9	KNP 4	4.2±2.8
Edge 5	2.9±1.8	KNP 5	3.1±1.3
Edge 6	4.1±2.6	KNP 6	3.2±1.8
Mean±SD.	4.9±1.3	**Mean±SD.**	3.6±0.8

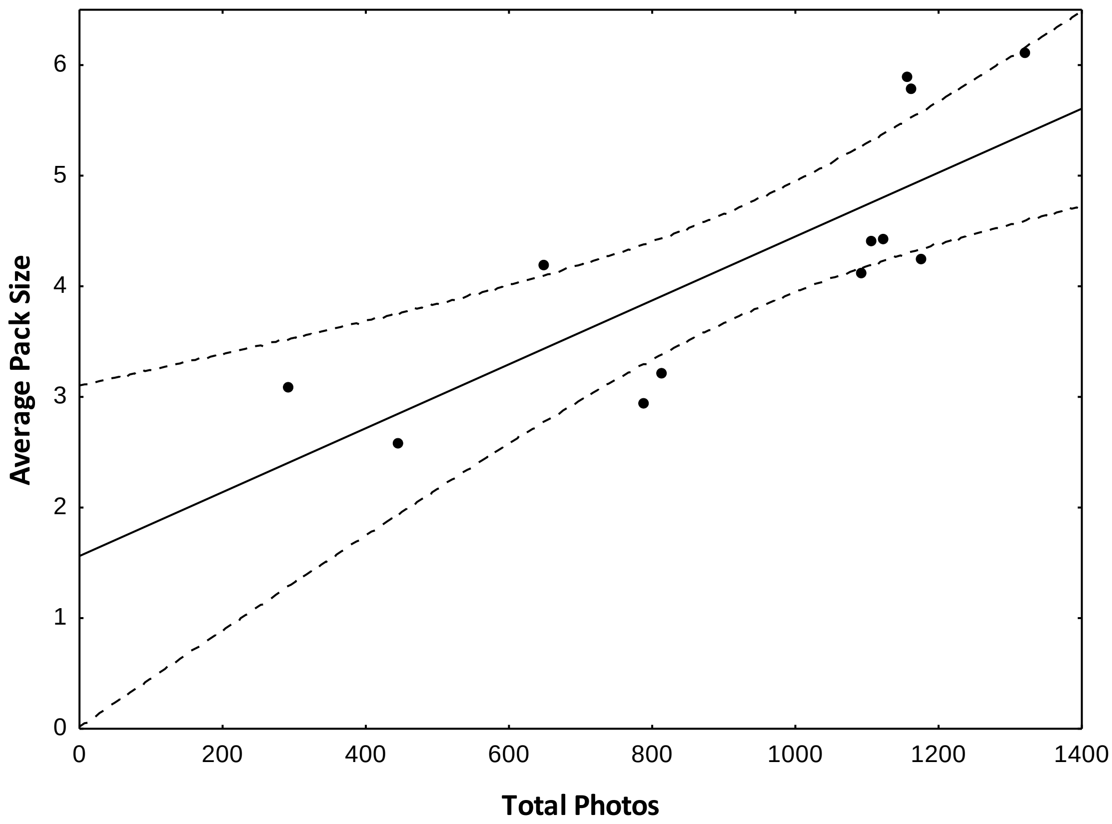

Figure 3.11. The relationship between the number of photographs processed, and the average number of individuals identified per sighting ($r = 0.8$, $n = 12$, $p < 0.01$). Dotted lines denote 95% confidence intervals.

Overall, the 12 study packs were sighted significantly more often in Granite Lowveld vegetation compared to any other vegetation type, and significantly more often than would be expected by chance ($\chi^2_{(1)} = 180.6$, $p < 0.0001$). For 73.9% of submitted sightings, wild dogs were recorded in Granite Lowveld, followed by Phalaborwa-Timbavati Mopaneveld (7.3%), Gabbro Grassy Bushveld (6.4%) and Pretoriuskop Sour Bushveld (5.8%), with just under 7.0% of the sightings occurring in Legogote Sour Bushveld, Malelane Mountain Bushveld, Tshokwane-Hlane Basalt Lowveld and Delagoa Lowveld. Likewise, both the Edge packs ($\chi^2_{(1)} = 228.6$, $p < 0.0001$) and the KNP packs ($\chi^2_{(1)} = 22.5$, $p < 0.0001$) were sighted significantly more often in Granite Lowveld vegetation compared to any other vegetation type, and more so than would be expected by chance (Figure 3.12).

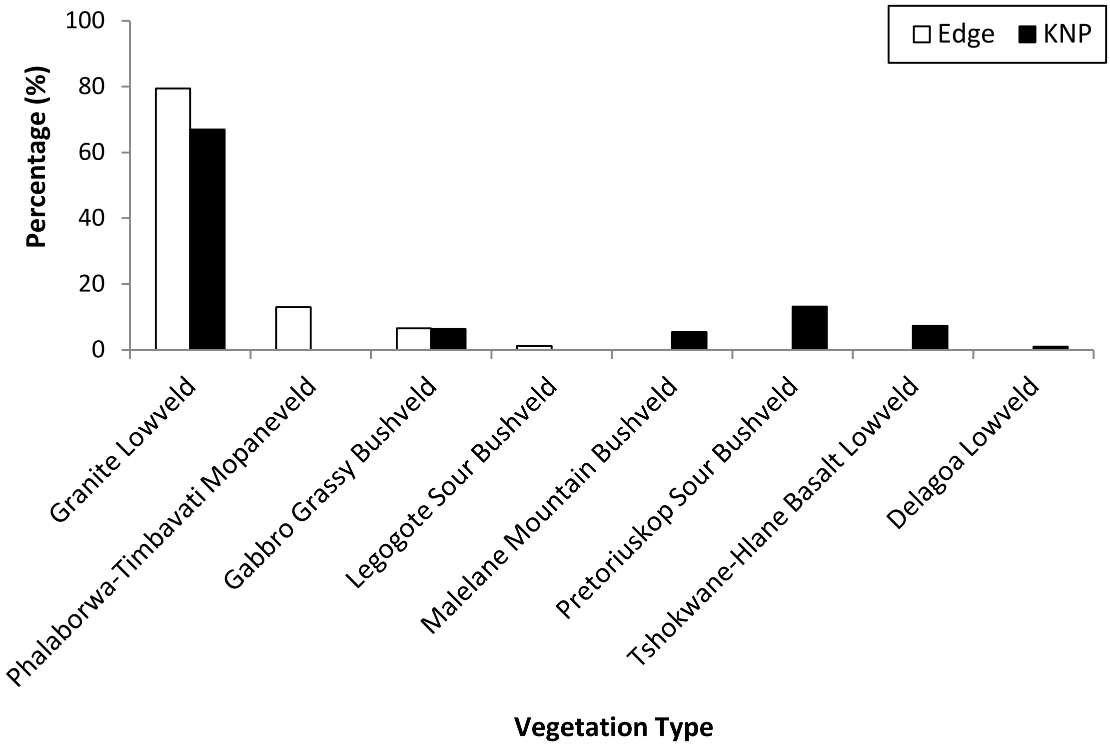

Figure 3.12. Vegetation types in which the Edge (n=6) and the KNP (n=6) packs were most frequently sighted. Significant effects are described in the text.

Questionnaire data

Wild dog packs operating beyond the KNP boundaries were recorded significantly more often on properties that were part of conservancies than properties that were not part of conservancies ($F_{(1,175)} = 4.5$; $p < 0.05$; Figure 3.13). Wild dog frequency of occurrence was positively correlated with an increase in property size ($F_{(1,175)} = 14.4$; $p < 0.001$; Figure 3.14). Stock ($F_{(1,175)} = 0.1$; $p > 0.05$) and game ($F_{(1,175)} = 0.0$; $p > 0.05$) numbers did not significantly affect the frequency with which wild dogs were sighted. However, wild dogs tended to be recorded more on properties with higher game numbers (Spearman $R = 0.5$, $n = 186$, $p < 0.0001$; Figure 3.15), and fewer stock (Spearman $R = -0.1$, $n = 186$, $p > 0.05$). Interestingly, wild dogs and cheetahs were recorded significantly less frequently on properties where lions, leopards, spotted hyaenas, caracals *Caracal caracal* and jackals *Canis* spp. were more prevalent ($H_{(6, 1302)} = 164.6$; $p < 0.0001$; Figure 3.16).

The degree of perimeter fencing significantly affected the frequency of wild dog sightings ($F_{(2,175)} = 3.3$; $p < 0.05$; Figure 3.17), but no pairs were significant. Wild dogs tended to be sighted more often on properties with no perimeter fencing than on properties that were either totally or partially fenced (Figure 3.17). Further, properties that were part of conservancies with either no perimeter fencing, or their perimeters totally fenced, recorded wild dogs significantly more often than properties that were not part of conservancies, regardless of fencing ($F_{(2,175)} = 4.3$; $p < 0.05$; Figure 3.18). However, on properties that were fenced, wild dogs were recorded significantly more frequently on properties with predator-proof fencing ($U_{(184)} = 2893.0$; $Z = 2.58$; $p < 0.01$; Figure 3.19).

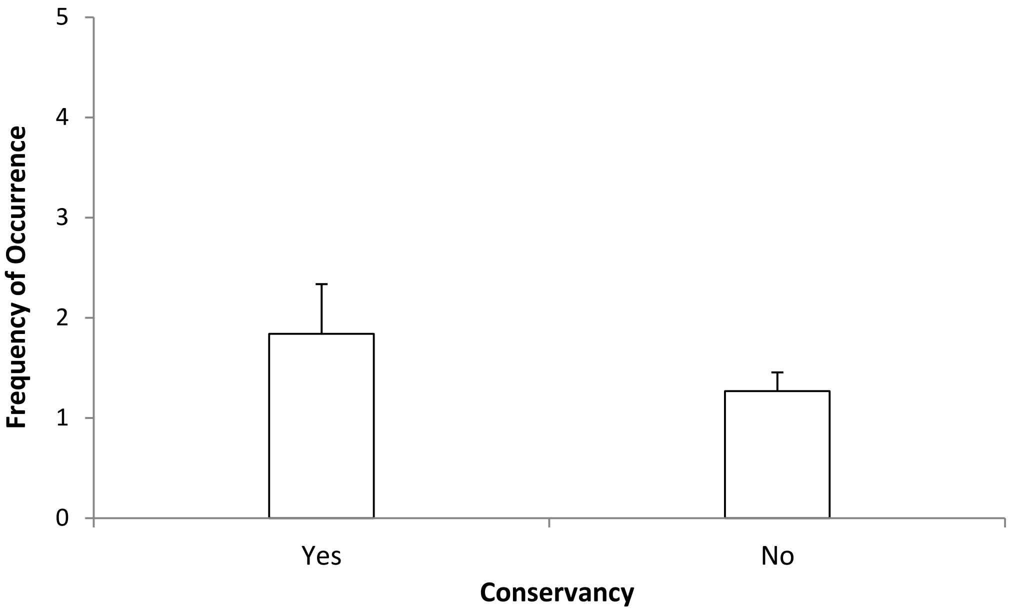

Figure 3.13. Frequency of wild dog occurrence on properties part of conservancies and properties not part of conservancies ($F_{(1,175)} = 4.5$; $p < 0.05$). Data are means + 95% confidence intervals.

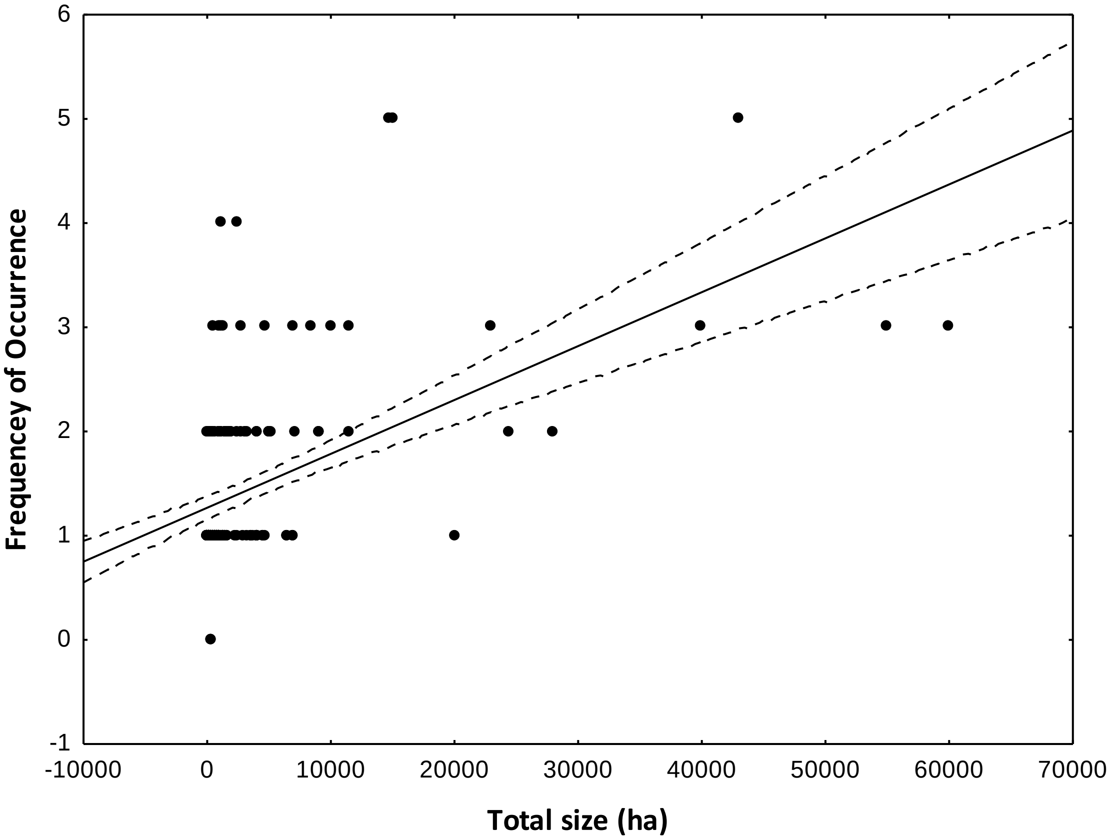

Figure 3.14. The significant relationship between the frequency of wild dog occurrence and property size ($F_{(1,175)} = 14.4$; $p < 0.001$). Dotted lines denote 95% confidence intervals.

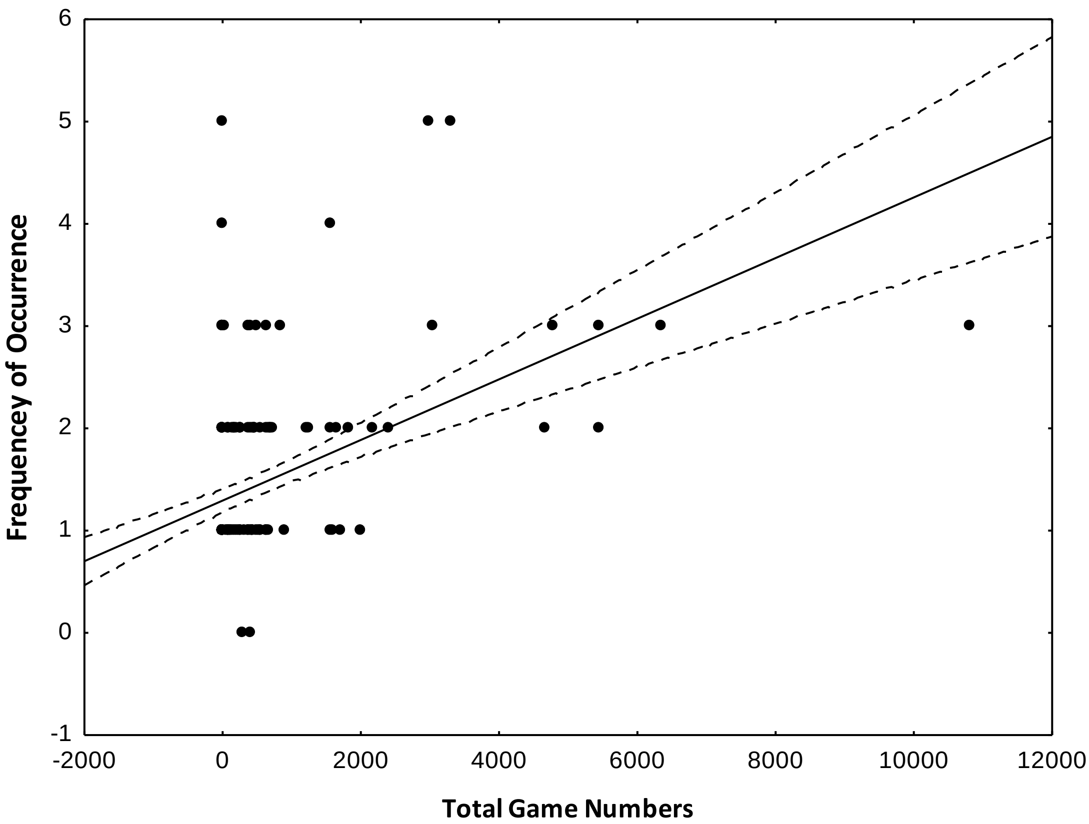

Figure 3.15. The significant relationship between the frequency of wild dog occurrence and total game numbers (Spearman R = 0.5, n = 186, p < 0.0001). Dotted lines denote 95% confidence intervals.

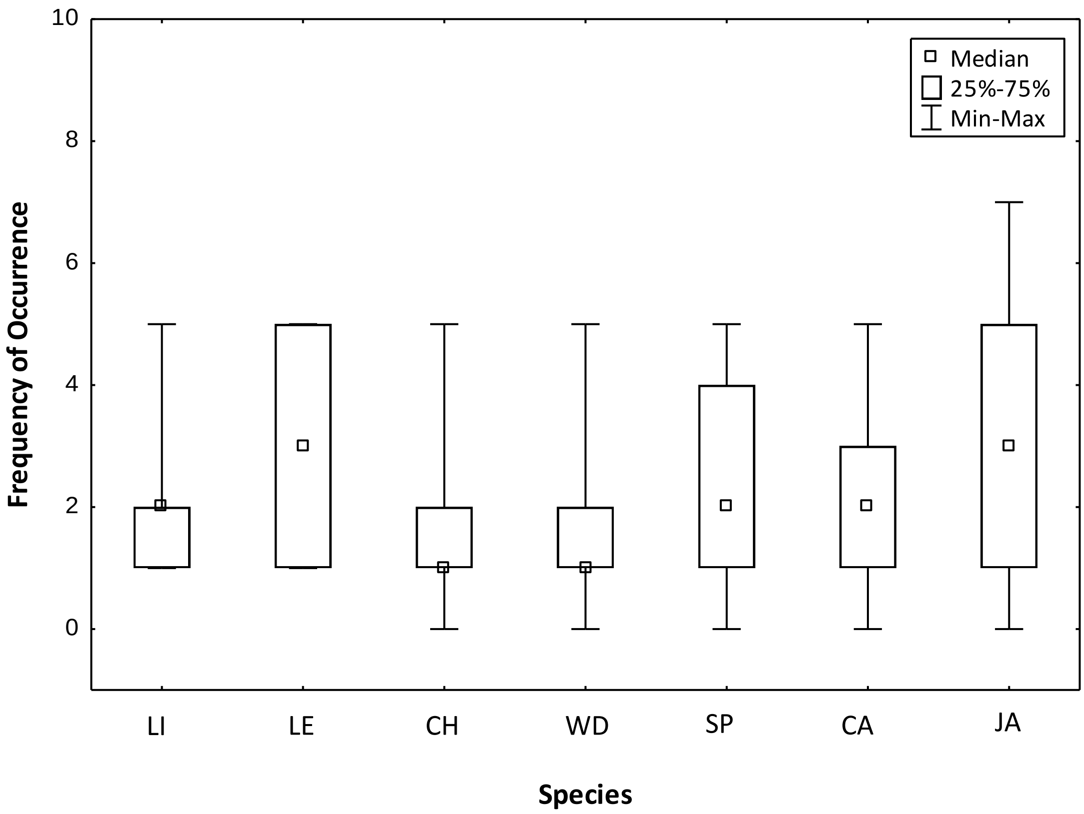

Figure 3.16. Frequency of occurrence for all predators. LI=lions, LE=leopards, CH=cheetahs, WD=wild dogs, SP=spotted hyaenas, CA=caracals and JA=jackals. Significant ($H_{(6, 1302)}$ = 164.6; $p < 0.0001$) effects are described in the text.

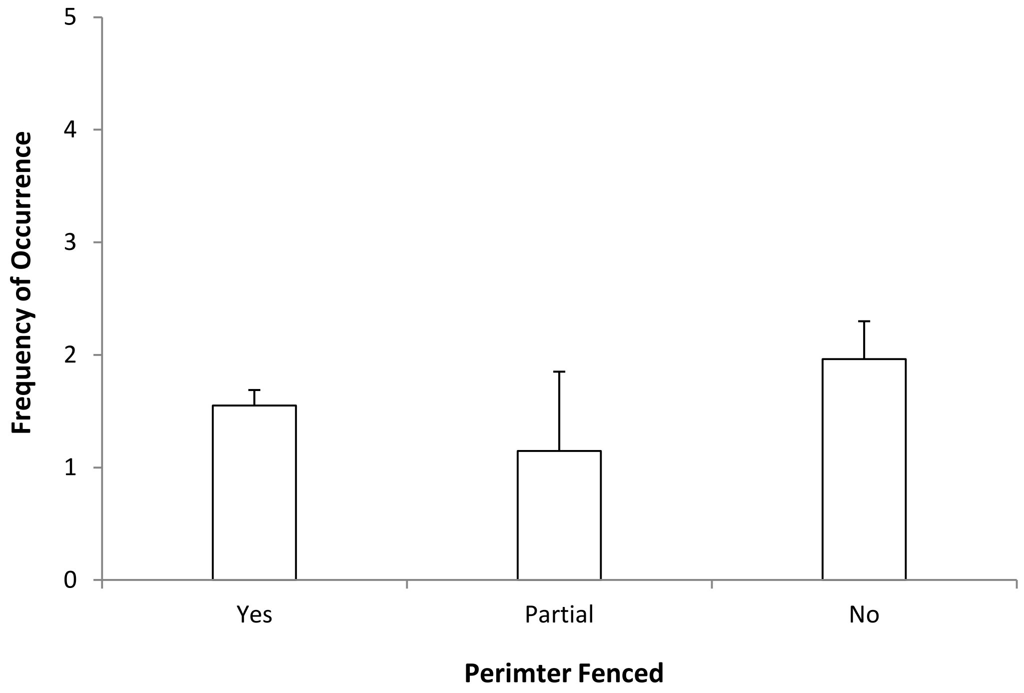

Figure 3.17. Frequency of wild dog occurrence for three degrees of perimeter fencing. Data are means + 95% confidence intervals. Significant ($F_{(2,175)} = 3.3$; $p < 0.05$) effects are described in the text.

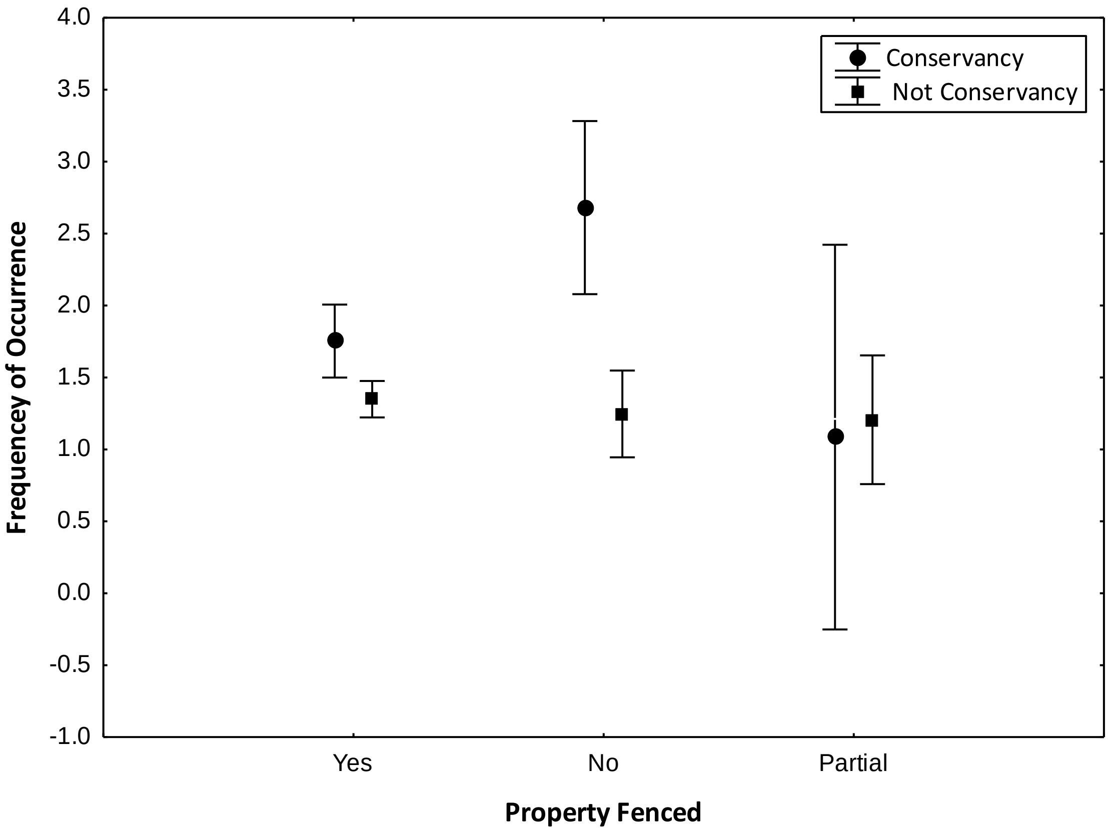

Figure 3.18. The effect of the degree of fencing and conservancies on the frequency of sightings of wild dogs. Data are means + 95% confidence intervals. Significant ($F_{(2,175)} = 4.3$; $p < 0.05$) effects are described in the text.

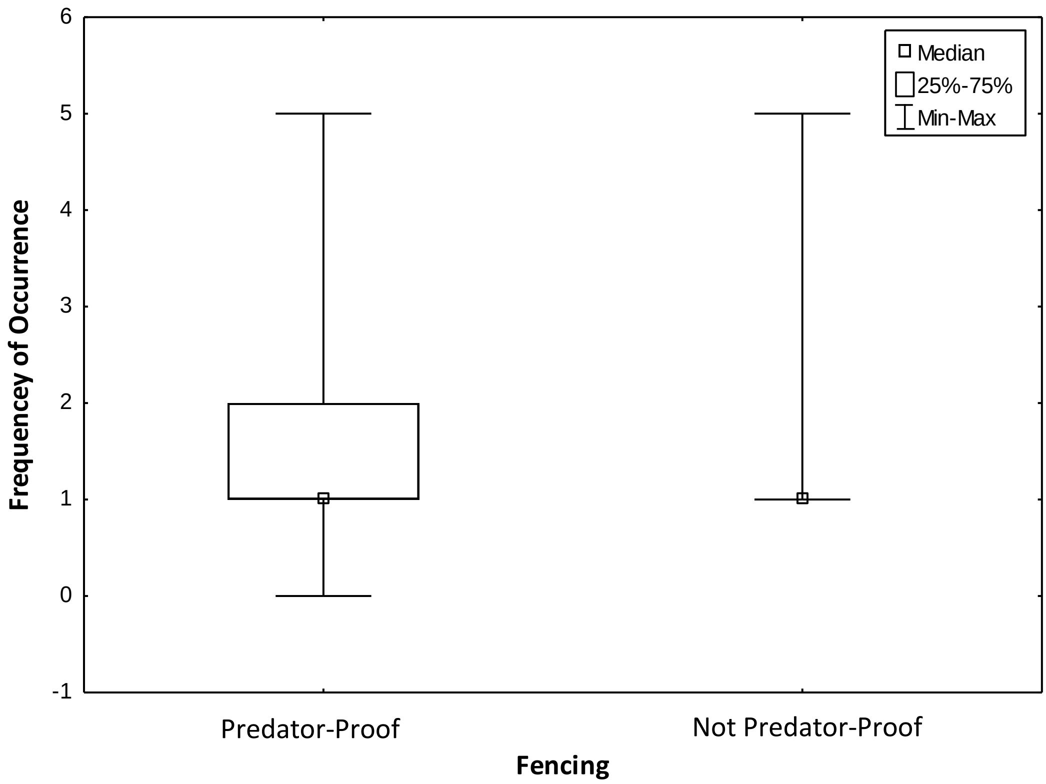

Figure 3.19. Frequency of wild dog occurrence for areas with predator-proof and not predator-proof fencing ($U_{(184)} = 2893.0$; $Z = 2.58$; $p < 0.01$).

3.4 Discussion

Drivers of land use selection

Wild dogs were frequently sighted within the southern and central districts of the KNP (~52% of all sightings). However, wild dogs occurring beyond the KNP borders were more often sighted to the west of the KNP (~45% of all sightings) than to the south (~2% of all sightings). The Edge packs were only ever recorded west of the KNP boundaries and never beyond the KNP southern fence. And, of the 11 reports of wild dog den sites between 2008 and 2011, all occurred along the western boundary of the KNP and ~91% were located on ecotourism properties. Considering that 60.0% of land owners on the west managed and/or owned ecotourism properties this is unsurprising. Almost every reported sighting (98.9%), and all sightings used in the analyses, occurred on properties where ecotourism was the primary economic incentive. However, this could be an effect of sampling bias as more ecotourism properties were surveyed than crop farms or wildlife ranches. Importantly, questionnaire data revealed no difference in the frequency with which wild dogs occurred on ecotourism and wildlife ranching properties. Twenty-seven percent of land owners on the west managed and/or owned wildlife ranches. By contrast, the majority (94.4%) of crop farmers reported having never seen wild dogs on their properties, and of the four that had seen wild dogs, three farmed west of the KNP.

Ecotourism properties and wildlife estates naturally dominate larger stretches of land and have a higher abundance of game with natural vegetation typically intact (Lindsey *et al*. 2004a; Lindsey *et al*. 2005c). Adequate space and prey are factors known to be major drivers of habitat selection in highly active and free-ranging carnivores such as wild dogs (Lindsey *et al*. 2004a; Lindsey *et al*. 2005c). Wild dogs are recognised as amongst the most efficient hunters in Africa, and with extremely high energetic requirements, the amount of prey required to sustain a pack can become substantial (Fuller & Kat 1993; Creel & Creel 1998; Lindsey *et al*. 2004b). This is so, particularly for larger packs (≥10 adults), which have been shown to kill more members of a herd and take larger prey (Fuller & Kat 1993; Creel & Creel 2002). This is consistent with my results, where the frequency with which wild dogs were recorded on properties beyond the KNP borders was positively correlated with property size, and tended to increase with an increase in game numbers and less stock. Contrary to common perception, wild dogs rarely actively hunt livestock and are only likely to kill livestock in areas where natural prey densities are low (Rasmussen 1999; Woodroffe *et al*. 2005).

Wild dogs were significantly more frequent on properties that were part of conservancies. The formation of conservancies and/or the collaboration of neighbouring farms consolidates fragmented land and provides more space and prey availability for wide-ranging carnivores (Lindsey *et al*. 2005c; Lindsey *et al*. 2009). Ranchers in northern South Africa are increasingly forming conservancies, which is potentially beneficial for wild dog conservation (Lindsey *et al*. 2004a). Almost 30.0% of properties surveyed along the west of the KNP formed part of conservancies, compared to the ~15% of properties along the south. And, eight of the 11 properties on which den sites were reported between 2008 and 2011 were located within a conservancy. The development of conservancies creates areas with fewer fences and accommodates the spatial needs of wild dogs (Lindsey *et al*. 2004a; Hayward *et al*. 2007; Licht *et al*. 2010). Fences serve as an obstacle to dispersing wild dogs and can stifle their movements (Lindsey et al. 2004a). Indeed, wild dogs were recorded significantly more often on properties with no perimeter fencing than on properties that were either partially or totally fenced. Where properties were totally fenced, wild dogs were recorded significantly more often on properties with predator-proof fencing. Private reserves or conservancies, where wild dogs were most likely resident, were more often than not equipped with predator-proof fencing reducing the chances of the species 'breaking out' and subsequently increasing the frequency of sightings. Wild dogs will readily move through poorly fenced areas, but game fencing upgraded to the specifications of wild dogs may serve as an effective barrier to dispersal (Lindsey *et al*. 2005c; Jackson *et al*. 2012).

Wild dogs and cheetahs were sighted significantly less frequently on properties where lions, spotted hyaenas, caracals and jackals were more frequent. In the Selous Game Reserve, Tanzania, the high density of wild dogs was attributed to weak competition from lions and spotted hyaenas (Creel & Creel 1998). Cheetahs face similar conservation challenges to wild dogs in that they are wide-ranging, and are vulnerable to edge effects and interspecific competition (Creel & Creel 1998; Lindsey *et al*. 2004a; Hayward *et al*. 2007). Wild dogs and cheetahs occur at lower densities than other predators in the study area. In 1997, Mills and Gorman (1997), reported densities of 16.7 wild dogs/1 000 km² compared to lions and hyaenas at 100/1 000 km² each. Currently, there are only an estimated 166-191 wild dogs and 369-545 cheetahs in the KNP (Davies-Mostert *et al*. unpublished data) compared to the ~1 684 lions (Ferreira & Funston 2010) and 3 348-3 667 spotted hyaenas (Funston & Ferreira, unpublished data). Alternatively, wild dogs and cheetahs may simply have a lower detectability in the study area.

The 12 study packs were never sighted beyond the KNP southern boundary fence. Since the expansion of farms and conservation areas west of the KNP, the KNP wildlife can move freely between similar land use types. In contrast, the south-western border of the KNP is bounded entirely by communal, pastoral land where human densities reach up to 300 people/km² (Pollard *et al.* 2003), and the southern boundary is dominated by agricultural lands (Jori *et al*. 2011). Areas of intensive human activity can present an immediate barrier to dispersal for wild dogs (Lindsey *et al*. 2004a; Woodroffe 2010) and other large carnivores. In southern California, cougars consistently avoided developed, disturbed and agricultural vegetation types (Dickson & Beier 2002). When carnivores disperse through areas of high human density the risk of potentially fatal situations (e.g. persecution, road deaths, snares etc.) increases (Tigas *et al*. 2002; Jackson *et al*. 2012; Woodroffe & Donnelly 2011). Moreover, the Crocodile River serves as a natural barrier along the southern edge of the KNP. Following the reconstruction of the southern boundary fence after the 2000 floods, land owners south of the KNP reported a considerable decrease in the movement of most animals through their properties. Importantly, the movement of packs/individuals east of the KNP into Mozambique and Zimbabwe is unknown. The KNP packs were never sighted in the central section of the KNP and appear to operate in a smaller area of land compared to the Edge packs.

Wild dogs are territorial and pack confrontations can be fatal (Creel & Creel 1998; Creel & Creel 2002; Woodroffe 2010; Jackson *et al*. 2012) but, with adequate scent marking and well-defined territories, packs rarely meet and conflict situations are reduced (Mills & Gorman 1997; Woodroffe 2010; Woodroffe & Donnelly 2011). In fact, wild dog packs have been shown to move as though actively avoiding each other (Mills & Gorman 1997; Pole 1999). When packs make direct contact, larger packs invariably attack and drive off smaller packs (Creel & Creel 2002; Creel *et al*. 2004). The Edge packs tended to consist of more individuals, on average, than the KNP packs thus intraspecific competition may have precluded the KNP packs from utilizing the central district of the KNP. However, inter- rather than intraspecific competition could be the main driver of habitat selection for the packs. There are ~632 lions in the central district of the KNP compared to ~48 in the south (Ferreira & Funston 2010). Therefore, with higher lion, and possibly spotted hyaena, numbers in the centre of the KNP, the KNP packs utilize the southern district while the Edge packs disperse beyond the western border. Indeed, Lindsey *et al*. (2004a) attributed wild dogs being sighted more frequently on game ranches to lions being scarce.

Drivers of differences in spatial ecology

The KNP packs tended to have larger extents of occurrence and areas of occupancy compared to the Edge packs, and a significantly larger degree of overlap. While the average extent of occurrence of the Edge packs (662.1±661.8 km²) appears comparable with the average area reportedly used by wild dogs (650 km², Fuller & Kat 1990; Woodroffe & Ginsberg 1999), and the average home range recorded for wild dogs in the KNP (537 km², Mills & Gorman 1997), the average extent of occurrence of the KNP packs was more than double that (1 238.7±591.7 km²). However, home range sizes ~1 000 km² have been recorded previously in the KNP (Reich 1981, Mills & Gorman 1997). Importantly, the variation in extents of occurrence among the Edge and KNP packs were not significantly influenced by sampling bias. No significant relationship was found between the average size of a pack and its extent of occurrence, and the differences in the home range areas calculated were not significantly driven by the variation in the number of fixes used per pack.

The differences between the ranging behaviour of the Edge and KNP packs appears to be influenced by differences in inter- and intraspecific competition. Wild dog densities are higher in the south of the KNP (Creel *et al*. 2004). Therefore, the KNP packs could range further to avoid confrontation with intraguild competitors and to locate prey in sub-optimal habitats (Pole 1999; Lindsey *et al*. 2004a). Intraspecific competition could also account for the significantly higher degree of overlap between the KNP packs. Home range overlap has been shown to increase with an increase in wild dog densities (Pole 1999; Creel & Creel 2002; Woodroffe 2010). Interspecific competition can cause wild dogs to range further and, unlike the Edge packs, the KNP packs operated solely within the borders of the KNP where lion and hyaena densities are undoubtedly higher (Woodroffe & Ginsberg 1999b; Creel 2001; van Dyk & Slotow 2003; Lindsey *et al*. 2004b). The effects of competition are compounded in areas of reduced habitat (Creel 2001; Creel *et al*. 2004). Further, interspecific competition in the south could be exacerbated by the open savanna habitat as the increased visibility makes it easier for lions and hyaenas to follow and locate wild dog kills (Creel 2001; Woodroffe 2010). Consequently, home ranges may be smaller where inter- and intraspecific competition is reduced/absent (Pole 1999; Woodroffe 2010). This seems a likely explanation for the smaller extents of occurrence and reduced overlap of the Edge packs, which appear to operate over a larger stretch of land. The Edge packs frequently move beyond the borders of the KNP where lion, and spotted hyaena, densities are likely to be reduced (Lindsey *et al*. 2004a). Overlap is reported to be lower between packs operating in a 'discontinued habitat' (Lindsey *et al*. 2004a), such as the land west of the KNP, compared to within the boundaries.

MCPs are the oldest and most commonly used method of estimating home range sizes (Mohr 1947; Hayne 1949; Worton 1987; Powell 2000). MCPs are created by joining the outermost points of a group of points (Hayne 1949), and have been used before in wild dog home range studies (Reich 1981; Fuller & Kat 1990; Mills & Gorman 1997; Pole 1999). However, MCPs are crude estimates of home range size, are sensitive to extreme data points and fail to consider space use within the home range perimeter (Worton 1987; Powell 2000). MCP home range estimates are also affected by the number of fixes used (Worton 1987). In this study the activity within the MCPs was considered and any effect of the number of fixes per pack on their home range size evaluated. Importantly, the majority of GPS fixes used were not accurate and my findings should be interpreted with some caution. However, even crude estimates of home range can provide insights into animal behaviour, and the MCP method of analysis is strictly comparable across studies (Powell 2000). Finally, quantitative longitudinal data on prey biomass and lion and hyaena densities for the entire study area, would have allowed for a more comprehensive analysis of the possible drivers of home range differences between the Edge and the KNP packs (Mills & Gorman 1997; Creel & Creel 2002; Dickson & Beier 2002; Lindsey *et al*. 2004a).

Vegetation preference

My results revealed that wild dogs were sighted more often in Granite Lowveld vegetation than in any other vegetation type and this was true for packs within and outside the KNP. However, this could be more a consequence of sampling bias than an actual preference. Granite Lowveld vegetation dominates the south and central stretches of the KNP, and almost entirely covers the land occupied by the APNRs. The APNRs were 'hotspots' for sightings and the south of the KNP, especially the Skukuza Camp, is the most popular destination for tourists (Maddock & Mills 1994). Considering that the prey species of the KNP have been shown to prefer the fertile basalts of the east than granite based vegetation, this result is surprising. Further, the preferred prey species of wild dogs are more common in the savanna-type vegetation characteristic of the Malelane, Sabie River and Crocodile River areas (Gertenbach 1983; Mills & Gorman 1997; Ferreira & Funston 2010), but the 12 study packs were rarely sighted in these regions. Open savanna vegetation appears more suited to the hunting style of wild dogs which are coursing and highly visual predators (Pole 1999; Lindsey *et al*. 2004b). However, Granite Lowveld has been described as moderately open shrubland with few trees, and wild dogs are known to prefer thicker vegetation over grasslands (Fuller & Kat 1993; Creel & Creel 2002; Woodroffe 2010).

Demographic differences

The KNP packs tended to have smaller pack sizes than the Edge packs. These differences, however, appear to have been driven by sampling bias. More photos were processed for the

Edge packs than the KNP packs, and a positive relationship was found between the number of photographs processed and the average number of individuals identified per pack. While photographic records are an effective method for evaluating predator demographics (Maddock & Mills 1994; Gros *et al*. 1996; Fanshawe *et al.* 1997; Lindsey *et al.* 2004a), there are a number of factors which could influence the quality of the data collected. For example, poor quality photos and observer fatigue can negatively affect the accuracy with which individuals are identified. More people are likely to take photos of larger packs, and where sightings occur in 'popular locations', different groups of people are likely to capture photographs of the same pack from different angles. This increases the probability of detecting individuals and matching the left and right hand sides of wild dogs. The Edge packs were frequently sighted within the APNRs where a substantial number of photographs were collected (45.3%). Nevertheless, both the Edge and the KNP packs consisted of less than five individuals on average, with only three of the 12 packs above the critical threshold size (≤5) (McNutt 1995; Graf *et al*. 2006). A pack size of five is the threshold below which reproductive failure is likely (Creel *et al*. 2004; Lindsey *et al*. 2004b). Further, the average pack sizes are lower than those previously recorded within the KNP; 13.7±7.1 (Maddock & Mills 1994), 8.8±0.6 (Mills & Gorman 1997) and 10.4 individuals (Creel *et al*. 2004).

Inter- and/or intraspecific competition, could explain the smaller pack sizes of the KNP and Edge packs (Pole 1999; Lindsey *et al*. 2004a; Ferreira & Funston 2010). Lions and spotted hyaenas can threaten the fitness of a pack by reducing the species' access to optimal habitats and appropriating wild dog kills, and reduce wild dog numbers through direct predation (Creel 2001; Creel & Creel 2002; Lindsey *et al*. 2004b). In the KNP, lions were responsible for 39.0% of wild dog pup deaths and 43.0% of adult deaths in 1997 (Mills &

Gorman 1997). Wild dog densities are higher in the south of the KNP (Creel *et al*. 2004), and a negative relationship has been reported between species survival and density for lions in the KNP (Ferreira & Funston 2010). In addition, anthropogenic threats beyond the KNP boundaries could negatively impact wild dog numbers (Woodroffe *et al*. 1999b; Woodroffe *et al*. 2007). Given the positive relationship between pack size and individual fitness, and pack size and pup survival as well as pack and population persistence (McNutt 1996; Woodroffe & Ginsberg 1999b; Courchamp & Macdonald 2001; Buettner *et al*. 2006; Graf *et al*. 2006), this is a cause for concern. However, an average pack size of ≤5 adults and yearlings did not affect pack reproductive success in the KNP (Buettner *et al*. 2006).

Summary

- The APNRs and properties west of the KNP presented the best prospects for range expansion for wild dogs and could be beneficial for the KNP wild dog population.
    - Wildlife ranching farms and ecotourism properties were more abundant.
    - More properties formed part of conservancies, and fewer fences play to the spatial needs of wild dogs.
    - Adequate space, high natural prey biomass and natural vegetation provided suitable habitat for the species. And, lion and hyaena densities were probably lower than within the KNP.
    - The smaller extents of occurrence and reduced overlap of the Edge packs was indicative of reduced inter- and intraspecific competition.
- Wild dogs were sighted more frequently within Granite Lowveld vegetation.
- The average pack size of both the Edge and the KNP packs was below the critical threshold indicating cause for concern.

CHAPTER 4: Potential anthropogenic threats to wild dogs dispersing beyond the boundaries of the Kruger National Park

4.1 Introduction

In most areas where wildlife and humans coexist, conflict situations arise, generally with costs both to people and wild animals (Vangen *et al*. 2001; Gillingham & Lee 2003; Kaczensky *et al*. 2004; Zimmerman *et al*. 2005). Every continent and almost all countries, whether developed or not, are affected by human-wildlife conflict (Woodroffe *et al*. 2005). It is an issue of global concern and is threatening the survival of many species, and posing significant challenges for conservation authorities (Mladenoff *et al*. 1999; Zimmerman *et al*. 2005; Holmern *et al*. 2007; Stein *et al*. 2010). Human-wildlife conflict occurs in a variety of situations and impacts a diverse range of species, from grain-eating rodents to crop-raiding elephants *Loxodonta africana* (Gillingham & Lee 2003; Dickman 2010). Indeed, human persecution is responsible for a considerable reduction in the historic range of the jaguar *P. onca* (Zimmerman *et al*. 2005) and, in Sweden, hunting of adult wolverines *G. gulo* has decreased the population significantly (Vangen *et al*. 2001). Further, bears *Ursus arctos* are persecuted for sheep predation in Slovenia (Kaczensky *et al*. 2004), and conflict between baboons *Papio hamadryas* and humans in the Cape Peninsula, South Africa, has resulted in high levels of human-induced injury and baboon mortality (Hoffman & O'Riain 2011).

Human persecution, either direct or indirect, is one of the greatest causes of species loss worldwide (Ogada *et al*. 2003). Direct persecution is primarily based on perceptions that animals threaten humans and/or economic resources such as livestock, game (e.g. predation and/or disease transmission) and crops (decimation and/or raiding) (Kaczensky *et al*. 2004; Lagendijk & Gusset 2008; Dickman 2010). Livelihoods can be severely affected by such loss, and the response to these costs/threats is often lethal control and a negative perception of the perceived culprit (Davies & du Toit 2004; Zimmerman *et al*. 2005; Holmern *et al*. 2007; Dickman 2010). Habitat loss and fragmentation are considered to be the most influential, indirect drivers of global species decline (Kaczensky *et al*. 2004; Hayward *et al*. 2007; Rabinowitz & Zeller 2010). Urbanization and the ever-growing human population continue to dissect the natural habitats required for wildlife to survive, bringing them more frequently into contact with humans and inhospitable habitat (Tigas *et al*. 2002; Dickson & Beier 2002; Thompson & Jenks 2005). While animals may have an ability to adapt to anthropogenic landscapes (e.g. change activity patterns and space use), their survival ultimately relies on their acceptability to humans and level of conflict with human interests, particularly outside protected areas (Dickson & Beier 2002; Tigas *et al*. 2002; Thompson & Jenks 2005; Holmern *et al*. 2007).

In Africa, wild dogs, like many other predators, are a species of contention, especially for land owners bordering protected areas (Gillingham & Lee 2003; Holmern *et al*. 2007; Lagendijk & Gusset 2008). Previously, wild dogs were considered vermin and managers of reserves and national parks ordered their extermination as recently as the 1970s (Creel & Creel 1998; Rasmussen 1999; Woodroffe & Ginsberg 1999b). In Zimbabwe, more than 3 400 animals were killed between 1916 and 1975 (Childes 1988). Wild dogs earned part of their negative perception as a result of their hunting practices (Fanshawe *et al*. 1991; Creel & Creel 2002). Wild dogs kill their prey by disembowelment it or tearing it to pieces and have consequently been perceived as destructive, cruel and high-impact predators that kill more than necessary (Woodroffe & Ginsberg 1999b). Wild dogs have extremely high energetic requirements and the amount of prey required to sustain a pack can be substantial (Lindsey *et al*. 2004b). Further, wild dogs have shown the ability to adapt and utilize surrounding fence lines, or the contours created by fences, to trap and capture larger prey (van Dyk & Slotow 2003; Lindsey *et al*. 2004b). Thus, wild dogs can have negative effects on prey numbers and target non-typical prey species and this can be problematic for smaller properties (Lindsey *et al.* 2004b). Consequently, many ranchers and land owners still have negative perceptions of wild dogs and a low tolerance for the species on their properties (Davies & du Toit 2004; Lindsey *et al*. 2005a).

It has been suggested that wild dogs are unjustifiably, and irrationally, persecuted for livestock and/or game losses (Rasmussen 1999; Woodroffe *et al*. 2005). Wild dogs have been persecuted for livestock depredation in Zimbabwe (Rasmussen 1999), Kenya (Woodroffe *et al*. 2005) and Botswana (Gusset *et al*. 2009). However, they rarely actively hunt livestock and are more likely to kill livestock in areas where natural prey densities are low (Rasmussen 1999; Woodroffe *et al*. 2005; Gusset *et al*. 2009; Whittington-Jones 2011). Indeed, in Zimbabwe, wild dogs were found responsible for <10% of cattle losses (Rasmussen 1999). Importantly, wild dogs are crepuscular and highly active and this makes them a 'visible' species compared with other, more cryptic predators (Fuller & Kat 1993; Creel & Creel 1998). Consequently, wild dogs are often unduly persecuted for game predation and/or livestock losses (Rasmussen 1999). Culpability is often attributed more to the visibility of a carnivore than actual evidence (Rasmussen 1999). For example, farmers in Namibia believed black-backed jackals *C. mesomelas* to be the most common predator on their farms, and the most responsible for livestock losses (Stein *et al*. 2010). Culpability was not assessed in this study.

Wide-ranging carnivores, like wild dogs, are more likely to leave the boundaries of protected areas and come into conflict with humans, consequently facing greater threats and more persistent declines than most other mammal species (Woodroffe & Ginsberg 1998; Lindsey *et al*. 2005a; Rabinowitz & Zeller 2010). Wild dogs existing primarily outside protected areas tend to experience higher mortality than those occurring mainly inside, with human-induced mortality being the most important contributor (Woodroffe *et al*. 2007). Wild dogs are frequently the victims of snares and road collisions (Woodroffe & Ginsberg 1999b; Woodroffe & Donnelly 2011). In addition, wild dogs are prone to rabies, anthrax and canine distemper, and there are cases where entire packs have been extirpated by these diseases (Creel & Creel 2002; Woodroffe & Ginsberg 1999b; Woodroffe & Donnelly 2011). Canine distemper is transmitted mostly by inhalation and rabies through the saliva, while anthrax is contracted by consuming infected prey (Creel & Creel 2002). Given the highly social nature of wild dogs (e.g. regurgitating food and social rallies before hunts) one infected individual could be fatal for a pack (Creel & Creel 2002). Pups, in particular, are vulnerable to canine parvovirus which is shed in the faeces (Creel & Creel 2002). Domestic dogs are carriers of rabies, canine distemper and parvovirus, and are used widely as hunting dogs and associated with human settlements, providing additional threats to dispersing wild dogs (Woodroffe & Ginsberg 1999b; Ogada *et al*. 2003; Butler *et al*. 2004; Davies & du Toit 2004; Woodroffe & Donnelly 2011).

Wild dogs are accidentally caught in snares that are set on the edges of protected areas and along fences to capture wild ungulates for personal consumption, or the bush-meat trade (Davies & du Toit 2004; Hayward *et al*. 2007; Gusset *et al*. 2008a). Wild dogs are vulnerable to road deaths, especially in areas of high human-densities where infrastructure supports tarred roads and/or highways with higher speed limits (Woodroffe & Ginsberg 1999b; Davies & du Toit 2004). However, threats to wild dogs may not only exist on the edges of reserves and national parks, but may also extend into protected areas. For example, domestic animals penetrating the boundaries of the KNP could expose wildlife to potentially fatal pathogens (Jori *et al*. 2011), and snaring has been found to contribute to adult wild dog mortality in Hwange National Park, Zimbabwe, and the KNP (Davies & du Toit 2004). This could have detrimental consequences, particularly for an endangered species like the wild dog (Jori *et al*. 2011; Woodroffe & Donnelly 2011).

As long as the rapidly growing human population continues to infringe on protected lands and fragment landscapes, private land owners and communities will play a substantial role in the conservation of wildlife (Kaczensky *et al*. 2004; Holmern *et al*. 2007; Stein *et al*. 2010). Without the support of neighbouring land owners and communities, efforts to conserve wildlife may fail (Lagendijk & Gusset 2008), and land owners cannot be expected to provide support if the costs outweigh the benefits (Gillingham & Lee 2003; Lindsey *et al*. 2005b; Holmern *et al*. 2007). Consequently, conservation authorities need to determine the most appropriate measures to offset the costs of human-wildlife conflict with the hope of increasing land owners' attitudes and tolerance (Gillingham & Lee 2003; Stein *et al*. 2010). The use of fences has been suggested as an effective measure to contain animals within protected areas (Hayward *et al*. 2007; Gusset *et al*. 2008a; Gusset *et al*. 2010). However, conventional fences are rarely one hundred percent predator-proof and protected areas, however large, often cannot contain 'damage-causing' animals within their boundaries (Mladenoff *et al*. 1999; Ogada *et al*. 2003; Lindsey *et al*. 2005c; Holmern *et al*. 2007; Lagendijk & Gusset 2008; Davies-Mostert *et al*. 2009; Jori *et al*. 2011). Upgrading property and/or game camp fencing to the specifications required for wild dogs is extremely costly (Lindsey *et al*. 2005a).

Compensation and/or incentive-based approaches can be problematic, especially where land owners misrepresent or exaggerate their losses (Holmern *et al*. 2007; Lagendijk & Gusset 2008; Gusset *et al*. 2009; Stein *et al*. 2010). This can be exacerbated where trained conservation officials fail to respond to, or verify incidents of conflict (Whittington-Jones 2011). However, the implementation of incentive-based schemes provided encouraging results for the conservation of the snow leopard *Uncia uncia*, supporting a link between benefits and conservation-friendly behaviour to reduce human-wildlife conflict (Mishra *et al*. 2003). Changes to husbandry practices and enhancing public perception of wide-ranging predators may be the best way to reduce mortality beyond protected areas (Woodroffe & Ginsberg 1998; Ogada *et al*. 2003; Kaczensky *et al*. 2004; Lindsey *et al*. 2005c; Zimmerman *et al*. 2005; Holmern *et al*. 2007; Gusset *et al*. 2008a). Simple changes in husbandry practices reduced cattle depredation by jaguar *P. onca* in Venezuela (Zimmerman *et al*. 2005), and livestock farmers in Namibia that had employed at least one husbandry technique (e.g. kraaling livestock within 30 m from the house) experienced ~85% less stock losses compared to farmers using no formal livestock husbandry (Stein *et al*. 2010). Moreover, the use of education and raising awareness has been successful in increasing the attitudes' of land owners and their tolerance of 'problem animals' (Lindsey *et al*. 2005c; Woodroffe *et al*. 2005; Zimmerman *et al*. 2005; Whittington-Jones 2011).

In South Africa, the maintenance of large protected areas represents the most beneficial strategy for wild dog conservation (Woodroffe & Ginsberg 1999b; Lindsey *et al*. 2005a; Woodroffe *et al*. 2007). Unfortunately, apart from the KNP, no other suitable reserves of sufficient size exist that will hold a second viable population of wild dogs (Mills *et al*. 1998). Nevertheless, the increasing prevalence of game ranching in South Africa, and the development of the APNRs west of the KNP has created additional areas of potentially suitable habitat, and increased the potential for conserving wild dogs on private land (van Dyk & Slotow 2003; Lindsey *et al*. 2004a; Lindsey *et al*. 2005a). However, potential edge effects which could cause decline or hinder recovery need to be considered (Woodroffe & Ginsberg 1999b; Ogada *et al*. 2003; Woodroffe *et al*. 2007). For example, the attitudes of land owners bordering the KNP towards wild dogs need to be explored before their potential contribution to wild dog conservation in South Africa can be determined (Woodroffe & Ginsberg 1999b; Lindsey *et al*. 2005b).

The extent to which people tolerate 'damage-causing' animals is site-specific and dependent on a number of factors (e.g. relative wealth, education and personal values and regard for conservation) (Zimmerman *et al*. 2005; Lagendijk & Gusset 2008; Gusset *et al*. 2008a). It is therefore necessary to have an understanding of the most influential factors driving the attitudes of land owners in order to target the most appropriate mitigation measures (Zimmerman *et al*. 2005; Lagendijk & Gusset 2008). This can best be explored by establishing relationships among land owners and wildlife management authorities (Gillingham & Lee 2003; Gusset *et al*. 2008a). To date, research has focused on the context of local communities (Pollard *et al*. 2003; Jori *et al*. 2011) and wildlife ranchers (Lindsey *et al*. 2005c) bordering the KNP, and assessed their attitudes towards, and tolerance of, 'problem animals' (Anthony 2007; Lagendijk & Gusset 2008). However, no research has collectively considered the matrix of land use types bordering the KNP (Jori *et al*. 2011), or evaluated the unique economic activities and contexts which could influence land owners and/or managers tolerance of wild dogs. Consequently, this study addressed wildlife ranchers and crop farmers, and the managers and/or owners of private reserves, lodges and wildlife estates with the hope of gaining a greater understanding of the factors driving wild dog dynamics in the study area. The aims of the chapter were to:

- Assess land owner perceptions of predators across a matrix of land use types.
- Examine the influence of human demographic variables and property characteristics on land owner attitudes towards, and knowledge of, wild dogs across a matrix of land use types.
- Evaluate the potential for private land owners to contribute to wild dog conservation in the greater KNP.
- Determine the prevalence of human-induced mortalities for wild dogs dispersing beyond the borders of the KNP.

4.2 Methods

Data collection

Questionnaire surveys have become a popular method for obtaining information from a specific human target population (White *et al.* 2005). In ecological studies, questionnaires have proven particularly useful for assessing human impacts on wild species, fuelling environmental policies and shaping strategies to reduce human-wildlife conflict (Lindsey *et al.* 2005c; Zimmerman *et al*. 2005; White *et al.* 2005; Lagendijk & Gusset 2008; Gusset *et al.* 2009). They are also often the best means of obtaining quantitative data from a large number of sites, or an extensive study area (White *et al.* 2005). Information on the land use practices and perceptions of land owners along the western and southern boundaries of the KNP was collected by means of a questionnaire survey. Every effort was made to complete the questionnaires via face-to-face interviews to ensure maximum completion and understanding of questions. The questionnaire consisted of four pages and was designed to take an average of 10-15 minutes to complete (Appendix A). No pilot study was conducted, but the questionnaire was constructed with reference to relevant literature (Davies & du Toit 2004; Lindsey *et al.* 2004a; Lindsey *et al.* 2005c; White *et al.* 2005; Lagendijk & Gusset 2008; Gusset *et al.* 2008a; Gusset *et al.* 2009), and was reviewed by experts in the field from Rhodes University and the EWT.

The questionnaire consisted of four sections (Appendix A). In the first section, respondents were asked to comment on the structural elements of their land/property characteristics (e.g. land use, type of fencing, size of the property), livestock and/or game information and whether the property was part of a conservancy or not. The second section, accompanied by a sighting sheet at the end of the document, collected sightings and frequency data on wild dogs and other predators. The third section was designed to gather data on respondents' knowledge of, and attitudes towards, predators. Finally, respondents' personal information was recorded (e.g. age, gender, highest level of education), and information on the threat of snares (number of snares cleared/month) collected.

Data were collected between March 2010 and April 2011. All APNRs were visited and thereafter properties along KNP western and southern boundaries were surveyed opportunistically. The date, time and location of the interview and the property/farm name/number and location was recorded for each questionnaire, and each questionnaire was given a unique number. Not all respondents were interviewed on their properties/farms. In fact, 9.7% of respondents were interviewed at the closest town/restaurant or at their place of business. By interviewing respondents away from their farms/properties bias towards 'easily accessible'/closest properties was reduced and respondents were more widely distributed throughout the study area (Zimmermann *et al.*

2005). Before administering the questionnaire, the structure of the document and the motivation for the research was explained (Anthony 2007). Further, a key card of the indigenous large predators was presented at all face-to-face interviews, and questionnaires completed via email, to ensure species were correctly identified, and information on potential 'problem animals' or conflict situations accurately recorded (Holmern *et al*. 2007; Lagendijk & Gusset 2008).

Data analyses

In section one, respondents were asked to stipulate their land use type (e.g. stock or crop farming, wildlife ranching or ecotourism). In situations where more than one land use type was applicable, the respondent's most important economic activity defined the land use type. Game and stock numbers were totalled separately for each property, and fencing was defined as predator-proof (e.g. standard electric game fence with either a trip wire/bonnox/buried mesh) or not (e.g. cattle fencing/security fencing/barbed fencing). In section two, the frequency of local predators was defined as more than once/month (5), once/month (4), every few months (3), less than once/year (2) and never (1). Thereafter, respondents' attitudes towards, and knowledge of, wild dogs were explored using a series of suggested statements about wild dogs and other predators, and conservation in general. Responses were limited to three categories (i.e. yes, no, don't know), and open-ended questions allowed respondents to expand on their responses (Anthony 2007). A three-point rating scale, as opposed to a five-point Likert scale, was used to simplify the questionnaire and reduce miscommunication (Anthony 2007; Lagendijk & Gusset 2008). The knowledge statements were addressed at the end of the questionnaire once a relationship had been established with the respondent (Appendix A).

Two broad indices were generated (attitude and knowledge) to determine respondents' attitudes towards wild dogs, and knowledge of wild dog behaviour, biology and conservation in general. The knowledge indices were established from five statements (Appendix B), while the attitude indices were established from 13 statements (Appendix C). Index scores were calculated by allocating values of between -1 and 1 to a series of suggested statements depending on the positive (1), don't know/neutral (0) or negative responses (-1) of respondents. Thereafter, an attitude (n=186) and knowledge (n=186) index value was determined for each respondent as the sum of the scores of the relevant questions (Zimmermann *et al*. 2005; Anthony 2007). Higher scores indicated a more positive overall attitude towards wild dogs and a greater knowledge of wild dog behaviour, biology and conservation in general (Zimmermann *et al*. 2005). The 10 attitude statements in section three were supplemented with the respondents' perceptions of wild dogs on their properties, and the properties of their immediate neighbours. Finally, in section four, socio-demographic and economic questions were used to determine the age, gender, education level and first language of respondents. Information on the threat of snares (number of snares cleared/month) was collected. The level of snaring per month was categorized accordingly; less than 20 (1), 21-40 (2), 41-60 (3) and more than 60 (4).

This chapter focuses on the data collected in the first (property characteristics), third (knowledge of, and attitudes towards, wild dogs) and final (demographic variables) sections of the questionnaire (Appendix A). Any effects of the demographic variables or property characteristics on the attitude and knowledge indices of respondents were explored. In Chapter 3, any effects of the property characteristics on the frequency data of predators (section two) were explored (see Chapter 3). This enabled a more comprehensive analysis of the potential factors influencing wild dog movements.

Assessing the relative importance of variables

The use of models is increasing in areas of applied ecology and offers an effective way to analyse outcomes in light of a number of potentially influential variables (White *et al*. 2005; Murray & Conner 2009). Questionnaires, in particular, can yield large amounts of information and modelling can improve the efficiency with which researchers statistically analyse their data (White *et al*. 2005). Consequently, Akaike Information Criterion (AIC) best subsets models were used to identify the most influential predictors and guide the analyses. The potential influence of selected demographic and property characteristics on the knowledge and attitude indices were explored (Table 4.1). The AIC has been suggested as a useful technique for assessing the relative importance of variables (Burnham & Anderson 2002; Murray & Conner 2009). Since AIC scores are not comparable in their raw form, Delta AIC (ΔAIC) values and Akaike weights (W_i) needed to be calculated to facilitate interpretation (Burnham & Anderson 2002; Murray & Conner 2009; Table 4.1). Thereafter, the relative importance of a variable was estimated by summing the Akaike weights (W_i) for all models in which the variable appeared (Burnham & Anderson 2002; Murray & Conner 2009; Rowe 2009). Once the Akaike weights (W_i) for all variables had been calculated, relative importance was assessed (Table 4.1). Akaike weights (W_i) normalize to one, and larger sums indicate a variable that is relatively more important than other variables, and more likely to explain most of the variability in the data (Murray & Conner 2009; Rowe 2009). Variables were recognised as being influential if they had an Akaike weight (W_i) of ≥

0.8 (Rowe 2009). All analyses and model building were carried out in Statistica 10 (StatSoft, Inc. 2011).

Table 4.1. The Akaike weights (W_i) and potential influence of the demographic and property characteristic predictors on the attitude and knowledge indices. Demographic variables are highlighted in grey and Akaike weights (W_i) ≥0.8 are highlighted in bold.

Index	Predictors	Wt
Attitude Index	First language	0.6
	Age	0.2
	Education level	0.6
	Knowledge index	**0.9**
Attitude Index	Size of property	0.7
	Total game numbers	0.4
	Property fenced	0.3
	West or south of the KNP	**0.9**
	Land use	**0.9**
	Conservancy	**0.9**
Knowledge Index	First language	**0.9**
	Age	**0.8**
	Education level	0.7
Knowledge Index	West or south of the KNP	**0.9**
	Land use	0.6
	Conservancy	**0.9**

Statistical analyses

All statistical analyses were completed using Statistica 10 (StatSoft, Inc. 2011). General Linear Models (GLM) were used to determine any effects of, or interactions among, a number of independent demographic and property characteristic predictors on the attitude and knowledge indices of respondents (dependent factors). Demographic variables included the age, education level and first language of respondents, and the property characteristics referred to the land use type (wildlife ranching, crop farming or ecotourism), the location (west or south of the KNP), the size of the property and whether the property was part of a conservancy or not. Prior to analyses residuals (predictors vs. residuals) were checked for constant variance (Sokal & Rohlf 1995), thereafter, Tukey HSD post-hoc tests were run to identify the sources of any significant variance. A linear regression was conducted to understand the relationship between the attitude and knowledge indices of respondents. The sample size for analyses exploring the effects of the demographic variables was n=180. This sub-sampling ensured equal representation of all samples as only the demographic variables of English and Afrikaans first language respondents were analysed.

Non-parametric Kruskal-Wallis tests were run to assess any differences in the responses of respondents towards each of the indigenous large predators in the area, to determine any effect of land use type on the response of land owners towards the predators, and to determine any effects of land use type on the number of snares cleared per month. Student Newman-Keuls post-hoc tests were run to identify sources of significant variance. Further, Mann-Whitney U-tests were run to identify whether the number of snares cleared per month were affected by the location of the properties (west or south of the KNP), and whether the properties formed part of conservancies or not. Finally, descriptive statistics were used to explore a variety of answers for questions and/or statements where statistical testing was not appropriate.

4.3 Results

Two hundred surveys were completed between March 2010 and April 2011. However, surveys collected from stock farmers (n=5) and properties classified as 'other' (n=9) were excluded as sample sizes were inadequate for a valid comparison of land use type. The remaining 186 surveys consisted of 72 crop farmers, 35 wildlife ranchers and 79 respondents involved in ecotourism ventures. Ninety-seven percent of the surveys were completed by face-to-face interviews, with the remainder being completed via email (n=5) and over the phone (n=1). Ecotourism ventures constituted the largest proportion (65.5%) of the total area surveyed (6 132 km^2), and substantially less land was occupied by wildlife ranchers (24.7%) and crop farmers (9.9%). Almost 60.0% and 26.8% of respondents surveyed along the western boundary of KNP were involved in ecotourism and wildlife ranching incentives, respectively. By contrast, more than half (58.7%) of the surveys along the southern boundary were completed by crop farmers (Figure 4.1).

The majority of respondents surveyed were male (93.6%). A large proportion of respondents (61.3%) had tertiary education, and 79.6% were between the ages of 31-50 years (Table 4.2). Just over half of the respondents interviewed were Afrikaans (51.1%). The remainder of the respondents were English (45.2%) or communicated in another language (e.g. German, Portuguese, Shangaan, Vhavhenda and Tsonga) (Table 4.2).

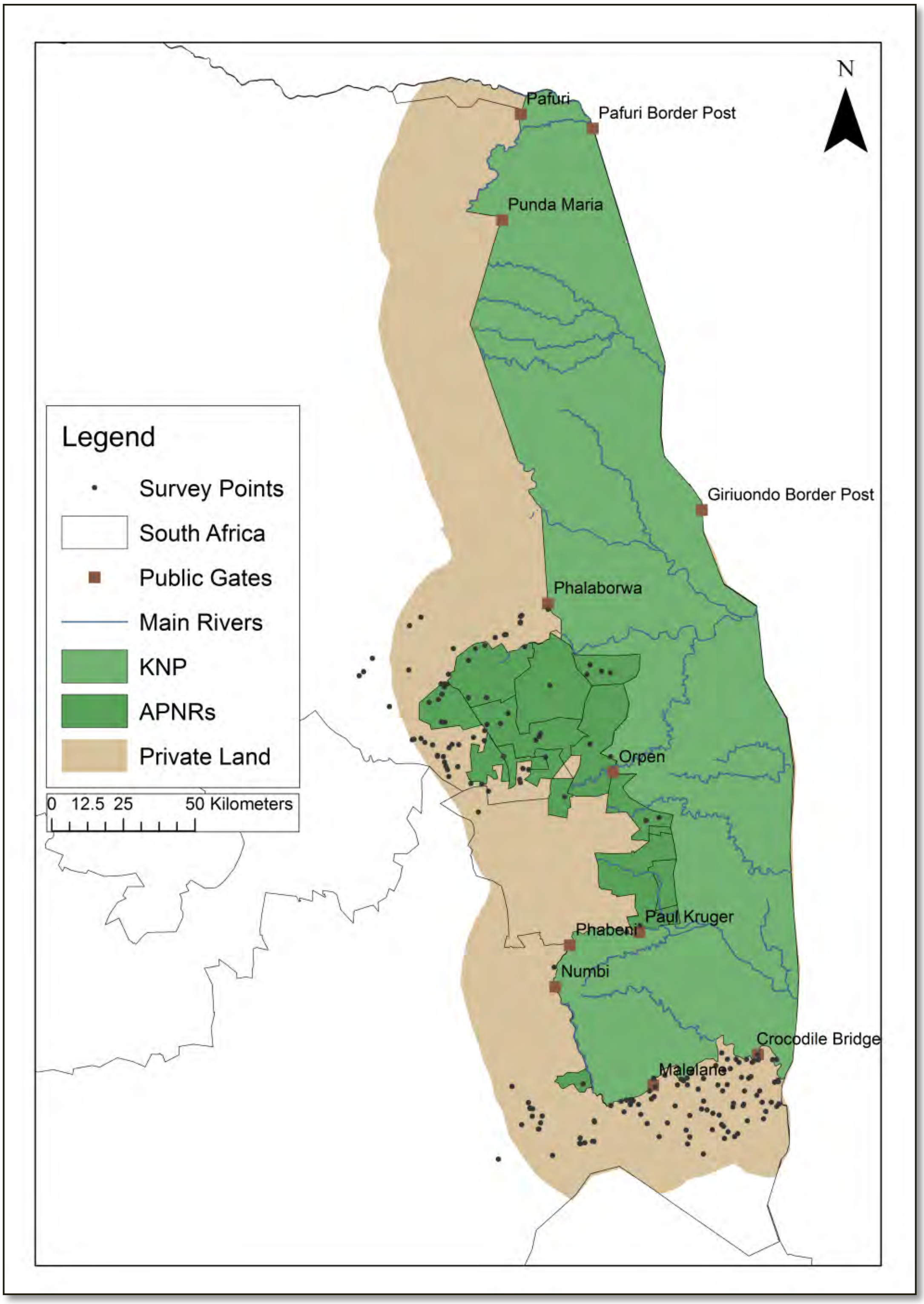

Figure 4.1. Locations of land owners' surveys (n=186) along the western and southern boundary of the KNP (ArcGIS 9.3; projected: Transverse-Mercator, spheroid WGS84, central meridian 31; map units: meters).

Table 4.2. Demographic characteristics of survey respondents.

Gender	**Male**	**Female**				
	93.6%	6.5%				
Education Level	**Matric**	**Tertiary Education**	**No Response**			
	15.6%	61.3%	23.1%			
Age	**<21**	**21-30**	**31-40**	**41-50**	**>50**	**No Response**
	0.0%	8.1%	39.3%	40.3%	10.8%	1.6%
Language	**English**	**Afrikaans**	**Other**	**No Response**		
	45.2%	51.1%	3.2%	0.5%		

Attitude indices

All of the respondents stated that they enjoyed seeing wild dogs in the bush (Table 4.3). Almost all respondents wanted to learn more about wild dogs (99.0%), and believed that wild dogs held cultural value for them (93.0%). Moreover, 99.0% of the respondents believed the species formed an important part of the natural environment and should be protected (99.0%). There was a substantial decrease in the percentage of positive responses when respondents were asked to comment on statements pertaining to wild dogs on their properties. Just under half of the respondents believed that they were more tolerant of wild dogs than their neighbours (48.0%) or stated that they would tolerate wild dogs denning on their properties (47.0%) (Table 4.3). However, more than half of the respondents were happy to have wild dogs on their properties (63.0%). Ten percent believed wild dogs negatively impacted their business, and 6.0% of respondents reported knowledge of their neighbours successfully removing wild dogs from their properties. Twelve percent of respondents stated that they would be happy if wild dogs were completely absent from their properties (Table 4.3), and negative comments were mostly associated with fear of livestock and/or game losses (5.3%) and human safety (4.8%) (Table 4.4). Just over a quarter of respondents disagreed with the statement and believed that the presence of wild dogs could generate benefits for them (25.8%) (Table 4.4). Forty-seven percent of the respondents believed the species could generate tourism income (Table 4.3).

The attitude index had a potential maximum of 13 points and a minimum of -13 points. The mean (±SD) score for all respondents was 8.0±3.0, while the maximum achieved was 13 and the minimum 0 (Appendix C).

Table 4.3. Statements illustrating the attitudes of respondents towards wild dogs. Values are percentages of 186 respondents. WD = wild dogs.

Attitude Statements	Yes	No	Unsure
You are more tolerant of WD than your neighbours.	48.0	6.0	45.0
WD negatively impact your business.	10.0	84.0	6.0
WD form an important part of the environment.	99.0	1.0	0.0
You would be happier if WD were completely absent from your property.	12.0	71.0	17.0
WD should be protected.	99.0	0.0	1.0
You would tolerate a pack of WD denning on your property.	47.0	33.0	20.0
WD could produce tourism benefits for your business.	47.0	44.0	9.0
You enjoy seeing WD in the bush.	100.0	0.0	0.0
WD are culturally important to you.	93.0	3.0	4.0
You would like to learn more about WD.	99.0	0.0	1.0
You are happy to have WD on your property.	63.0	7.0	30.0
Surrounding land owners are tolerant of WD.	55.0	11.0	33.0
Your neighbours have successfully removed WD.	6.0	77.0	17.0

Table 4.4. Comments given by respondents for agreeing with or rejecting the statement "You would be happier if wild dogs were completely absent from your property." Values are percentages of 186 respondents. WD = wild dogs.

Responses	Proportion of Respondents
Fear of loss of livestock and/or game.	5.3
Concern over own safety and/or the safety of employees.	4.8
WD belong in protected areas.	2.7
WD would be tolerated temporarily.	2.2
Land owner draws benefits (aesthetic and/or tourism).	25.8
No comment.	59.1

Knowledge indices

Almost all respondents correctly identified a wild dog from the key card (99.0%) and generally showed a sound understanding of wild dog behaviour, biology and conservation in general (Table 4.5). Ninety-six percent of respondents knew that wild dogs were social carnivores that existed in packs, and 85.0% agreed that fewer wild dogs occurred in the area compared to lions. Twenty-one percent believed that wild dogs were dangerous to humans, and 10.0% believed that cheetahs kill more than necessary (Table 4.5).

The knowledge index had a potential maximum of 5 points and a minimum of -5 points. The mean (±SD) score for all respondents was 4.0±1.6, while the maximum achieved was 5 and the minimum -4.

Table 4.5. Statements illustrating the knowledge of respondents of wild dog behaviour, biology and conservation status. Values are percentages of 186 respondents. WD = wild dogs.

Knowledge Statements	Yes	No	Unsure
Respondent could identify a WD.	99.0	1.0	0.0
WD are dangerous to humans.	21.0	76.0	3.0
WD are more common than lions in the Lowveld.	11.0	85.0	4.0
Cheetahs kill more than they require.	10.0	81.0	9.0
WD are pack animals.	96.0	2.0	2.0

Demographic variables

The attitudes of respondents' were not influenced by age ($F_{(3,118)} = 2.0$; $p > 0.05$), education level ($F_{(1,118)} = 0.0$; $p > 0.05$) or language ($F_{(1,118)} = 0.2$; $p > 0.05$), nor were there any significant interactions ($p > 0.05$ in all cases), although, there was a non-significant tendency for younger, more highly educated, English-speaking respondents to have more positive attitudes towards wild dogs. Importantly, respondents with a higher knowledge index had a significantly higher attitude index and were more positive towards wild dogs ($F_{(1,178)} = 30.0$; $p < 0.0001$; $r^2 = 0.1$; Figure 4.2). First language English speakers were significantly more knowledgeable about wild dog behaviour, biology and conservation in general than first language Afrikaans speakers ($F_{(1,119)} = 5.7$; $p < 0.05$; Figure 4.3). Finally, there were no significant effects of age ($F_{(3,119)} = 0.9$; $p > 0.05$) or education ($F_{(1,119)} = 0.8$; $p > 0.05$) on the knowledge indices of respondents, nor were there any significant interactions ($p > 0.05$ in all cases). However, respondents between the ages of 41-50 tended to have higher knowledge indices than respondents aged 21-40 years and older than 50 years. And, knowledge indices tended to be higher amongst respondents with tertiary education.

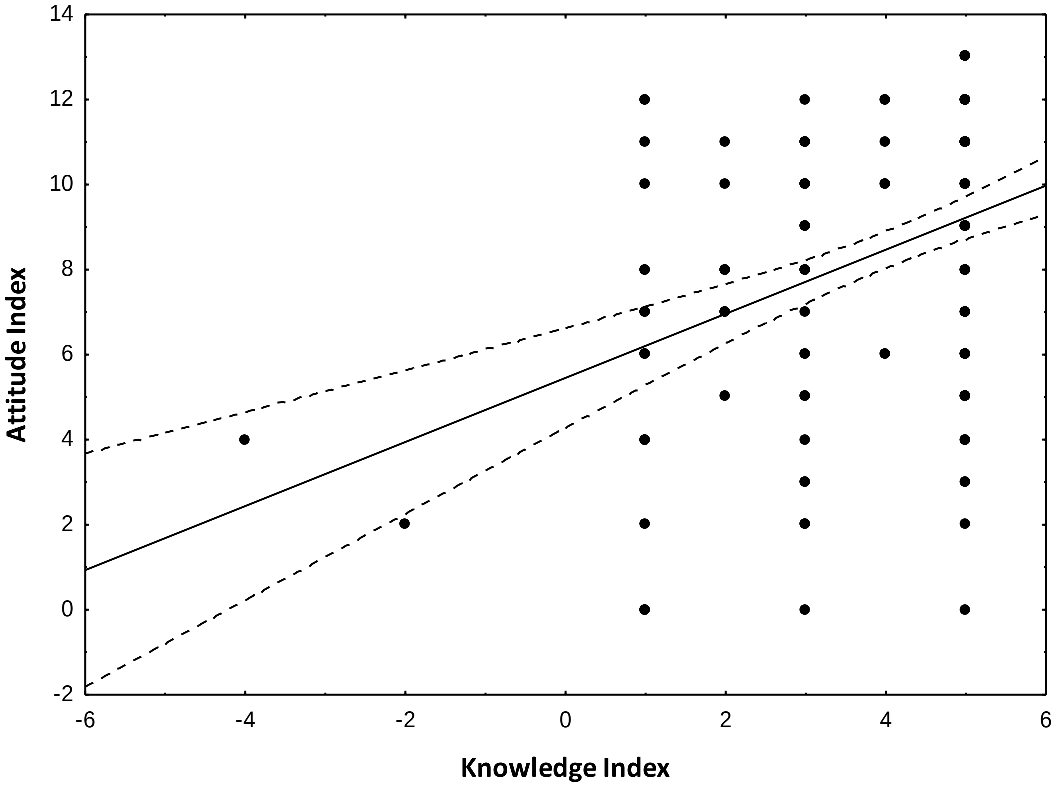

Figure 4.2. There was a positive relationship between the knowledge index of a respondent and his/her attitude index ($F_{(1,178)} = 30.0$; $p < 0.0001$; $r^2 = 0.1$). Dotted lines denote 95% confidence intervals.

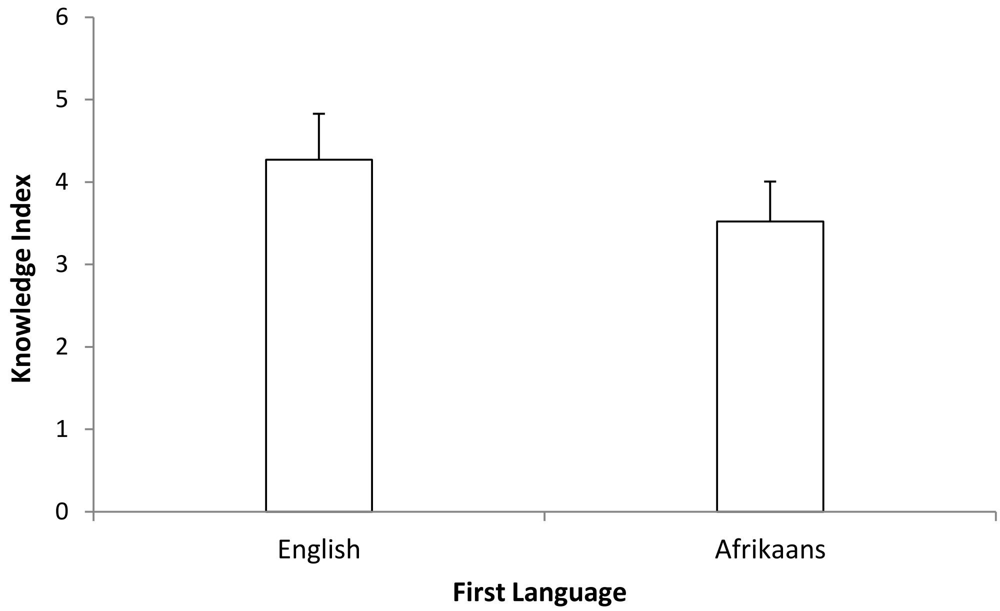

Figure 4.3. The knowledge indices for first language English and Afrikaans speakers ($F_{(1,119)} = 5.7$; $p < 0.05$). Data are means + 95% confidence intervals.

Property characteristics

Across all land use types, wild dogs were recorded as the second least preferred predator after lions, but this result was not significant ($H_{(6, 1302)} = 11.9$; $p > 0.05$; Figure 4.4). There was a significant effect of land use type on the perceptions of respondents towards wild dogs ($H_{(2, 186)} = 6.55$; $p < 0.05$) and lions ($H_{(2, 186)} = 6.07$; $p < 0.05$), but no pairs were significant. Ecotourism ventures tended to be more positive towards lions and wild dogs than the other two land use types (Figure 4.5). Crop farmers were significantly less positive towards leopards ($H_{(2, 186)} = 19.9$; $p < 0.0001$), cheetahs ($H_{(2, 186)} = 13.8$; $p < 0.01$), spotted hyaenas ($H_{(2, 186)} = 17.3$; $p < 0.001$) and jackals *Canis* spp. ($H_{(2, 186)} = 18.8$; $p < 0.001$) than respondents involved in ecotourism ventures, and there was no significant difference between the perceptions of wildlife ranchers and the other two land use types (Figure 4.5). Crop farmers were significantly less positive towards caracals than respondents involved in wildlife ranching or ecotourism ($H_{(2, 186)} = 21.6$; $p < 0.0001$; Figure 4.5), and there was no significant difference between the perceptions of ecotourism ventures and wildlife ranchers.

Respondents involved in ecotourism ventures had significantly higher attitude indices than respondents involved in wildlife ranching or crop farming ($F_{(2,174)} = 3.8$; $p < 0.05$; Figure 4.6), and there was no significant difference between the attitudes of wildlife ranchers and crop farmers. Respondents that were part of conservancies were significantly more positive towards wild dogs than respondents not part of conservancies ($F_{(1,174)} = 4.1$; $p < 0.05$; Figure 4.7). There was no significant effect of property size on the attitude indices of respondents ($F_{(1,179)} = 1.9$; $p > 0.05$). Respondents along the KNP southern boundary had significantly higher attitude indices than respondents located west of the KNP ($F_{(1,174)} = 8.5$; $p < 0.01$; Figure 4.8). While there were no significant interactions of land use type ($p > 0.05$ in all cases), respondents part of conservancies in the south had significantly higher attitude indices than respondents part of conservancies in the west, and respondents not part of conservancies regardless of location ($F_{(1,174)} = 8.8$; $p < 0.01$; Figure 4.9).

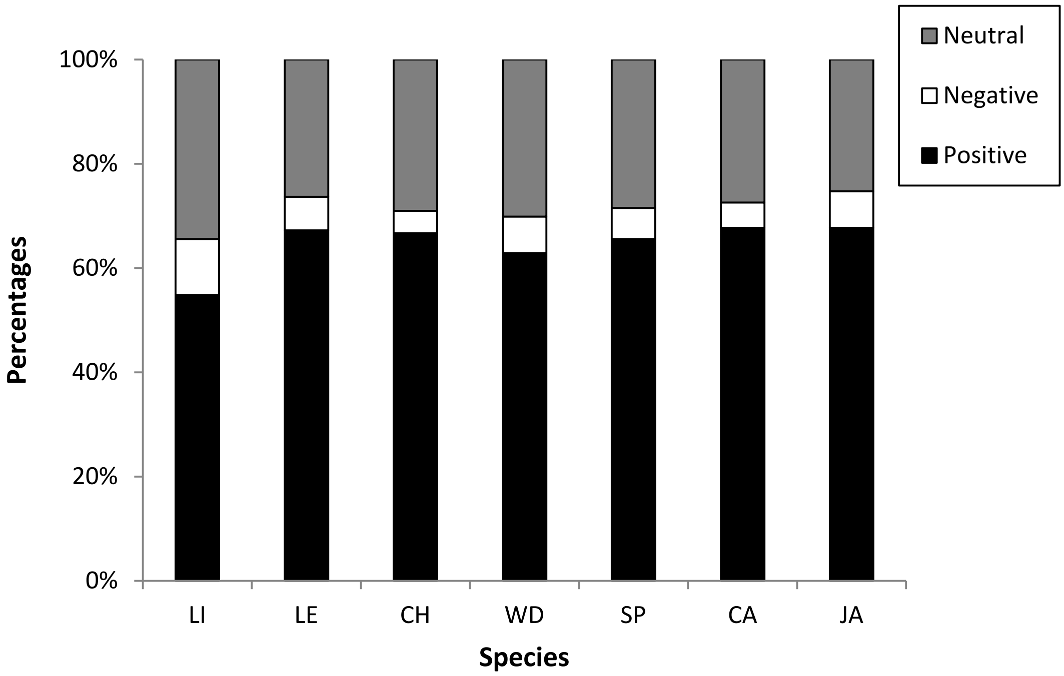

Figure 4.4. Overall positive, negative and neutral responses of land owners/managers towards predators. LI=lions, LE=leopards, CH=cheetahs, WD=wild dogs, SP=spotted hyaenas, CA=caracals and JA=jackals. Values are percentages of all 186 respondents. Significant ($H_{(6, 1302)} = 11.9$; $p > 0.05$) effects are described in the text.

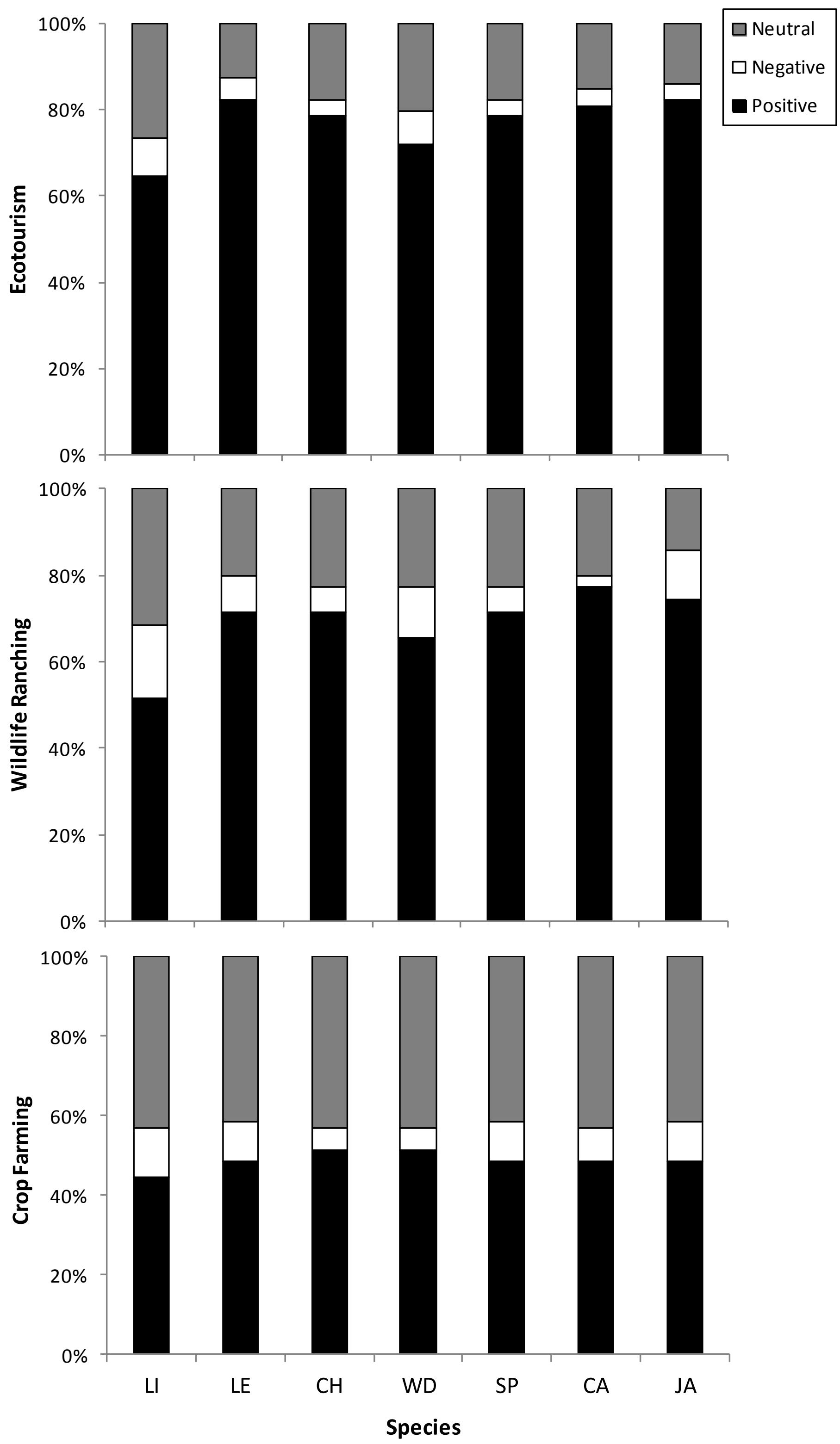

Figure 4.5. Positive, negative and neutral responses of land owners/managers towards local predators for each land use type. LI=lions, LE=leopards, CH=cheetahs, WD=wild dogs, SP=spotted hyaenas, CA=caracals and JA=jackals. Values are percentages of all 186 respondents. Significant effects are described in the text.

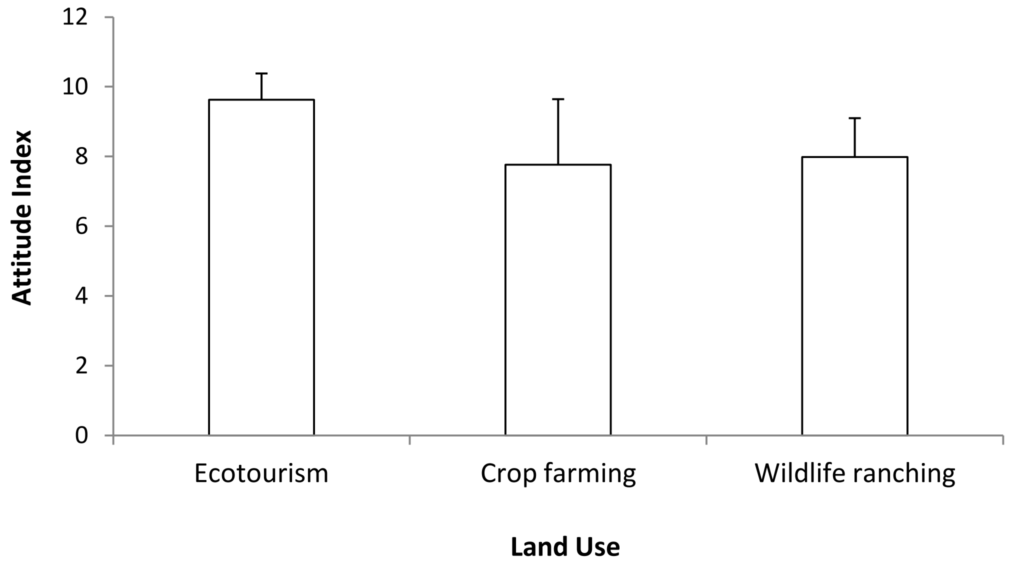

Figure 4.6. Attitude indices for the three land use types surveyed. Data are means + 95% confidence intervals. Significant ($F_{(2,174)} = 3.8$; $p < 0.05$) effects are described in the text.

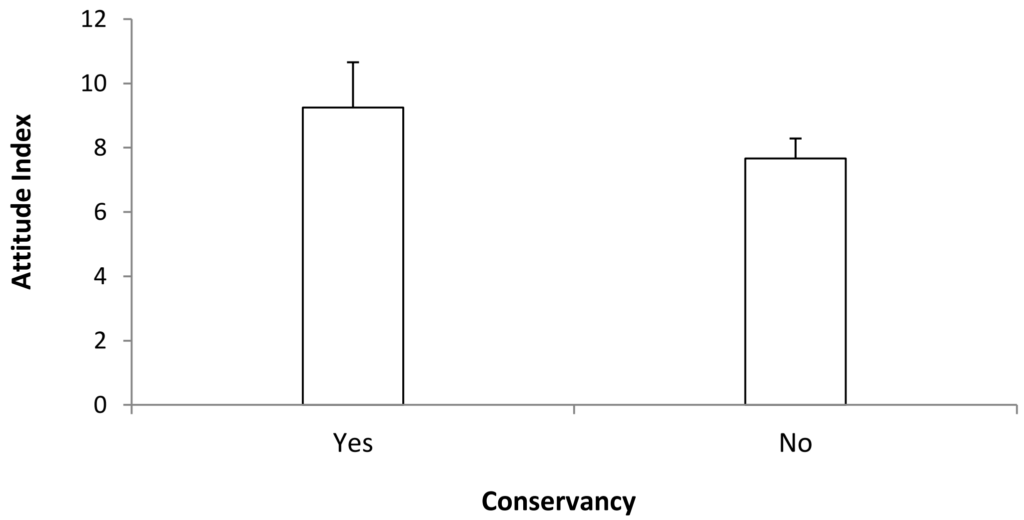

Figure 4.7. Attitude indices of respondents belonging to conservancies and those not belonging to conservancies ($F_{(1,174)} = 4.1$; $p < 0.05$). Data are means + 95% confidence intervals.

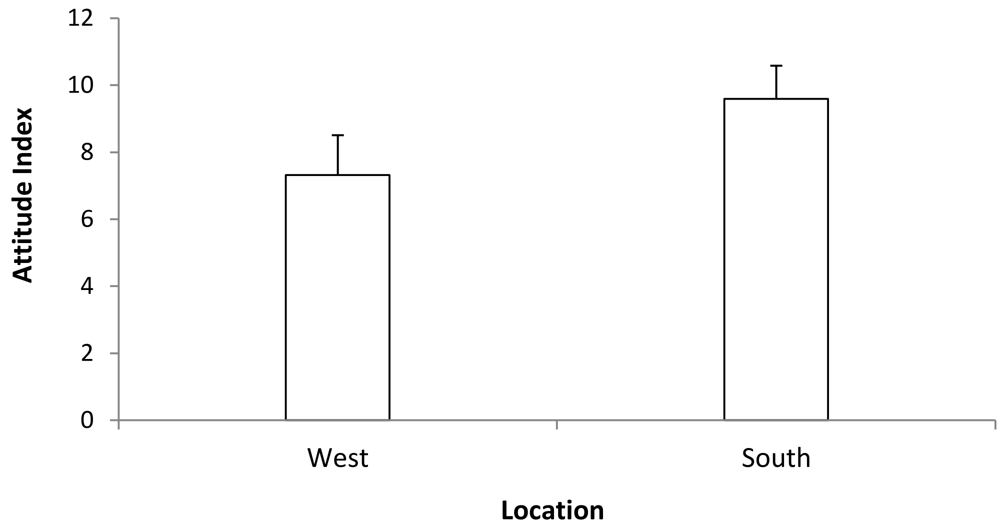

Figure 4.8. Attitude indices of respondents located along the KNP western and southern boundaries ($F_{(1,174)} = 8.5$; $p < 0.01$). Data are means + 95% confidence intervals.

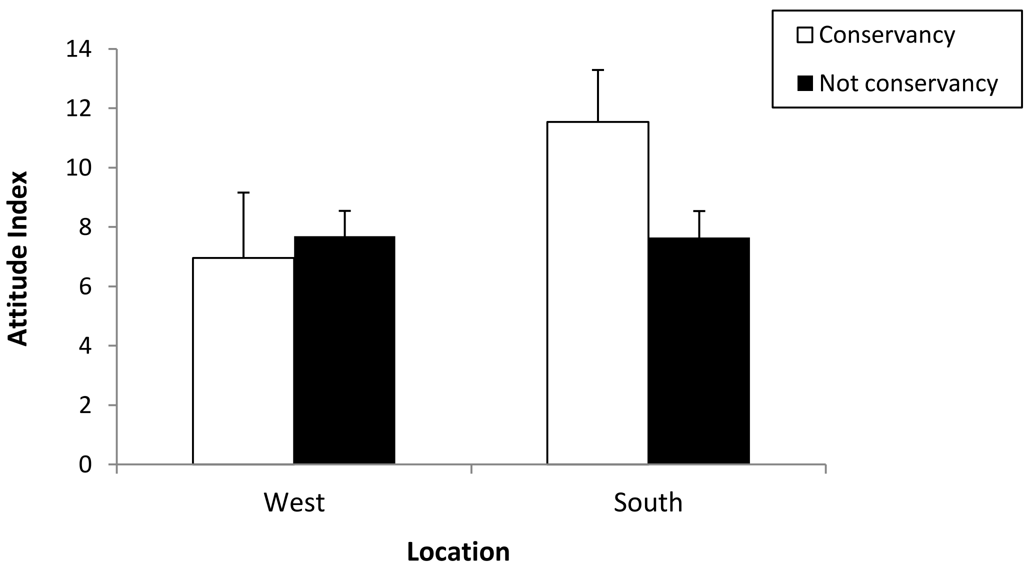

Figure 4.9. Attitude indices for respondents west and south of the KNP and part/not part of conservancies. Data are means + 95% confidence intervals. Significant ($F_{(1,174)} = 8.8$; $p < 0.01$) effects are described in the text.

There were no significant effects of land use type ($F_{(2,174)} = 0.6$; $p > 0.05$) or location (west or south of the KNP) ($F_{(1,174)} = 3.0$; $p > 0.05$) on the knowledge indices of respondents, nor were there any significant interactions ($p > 0.05$ in all cases). Wildlife ranchers and respondents involved in ecotourism ventures tended to have higher knowledge indices than crop farmers. Respondents located south of the KNP tended to have higher knowledge indices than respondents west of the KNP. Respondents belonging to conservancies had a significantly greater knowledge of wild dog behaviour, biology and conservation status than respondents not part of conservancies ($F_{(1,174)} = 4.6$; $p < 0.05$; Figure 4.10).

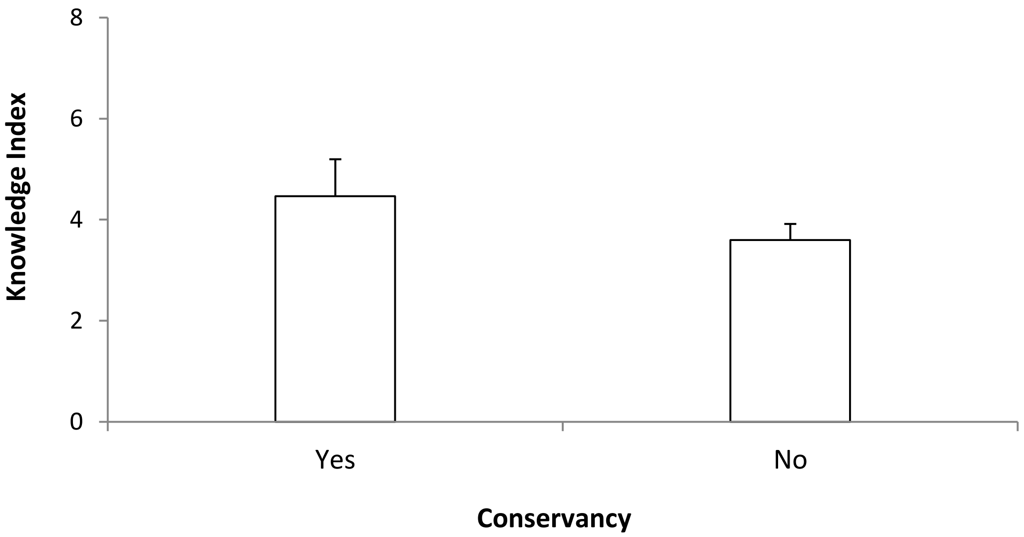

Figure 4.10. Knowledge indices of respondents belonging to conservancies and not belonging to conservancies ($F_{(1,174)} = 4.6$; $p < 0.05$). Data are means + 95% confidence intervals.

Additional threats

Most of the properties surveyed (75.0%) cleared less than 20 snares a month, while fewer cleared 41-60 snares per month (3.0%) or more than 60 snares per month (9.0%) (Figure

4.11). There was no significant effect of land use type on the number of snares cleared per month ($H_{(2,\ 180)} = 4.1$; $p > 0.05$). However, wildlife ranchers tended to clear more snares per month than crop farmers, and those involved in ecotourism ventures. Respondents belonging to conservancies tended to clear fewer snares per month than properties not part of conservancies ($U_{(178)} = 2573.5$; $Z = 0.3$; $p > 0.05$). Properties along the southern boundary of the KNP tended to clear more snares per month than properties along the west ($U_{(178)} = 3753.0$; $Z = -0.6$; $p > 0.05$).

Additional threats to wild dogs appear to be greater on the borders of the KNP and APNRs (Figure 4.12). For these data, respondents were asked to comment on any knowledge of wild dogs being removed or persecuted (i.e. shot, poisoned, trapped) within their immediate 'neighbourhood', and any incidences of wild dogs being caught in snares (section three of the questionnaire). Figure 4.12 may be slightly misleading as respondents reported incidences of wild dog persecution that occurred before this research (March 2010–April 2011), and this was not accounted for in the figure (Table 4.6). However, during this research (March 2010-April 2011), an adult wild dog was hit and killed on the R40 out of Hoedspruit (18 October 2010), and wild dogs with snares on were sighted at Orpen Gate (25 July 2010) of the KNP and moving through the Sabi Sand Wildtuin (04 March 2011) (Figure 4.13; Table 4.6). Further, a wild dog suspected of having rabies was shot on the Timbavati Private Nature Reserve in early 2010 (test results were negative), and a wild dog died on the Raptors View Wildlife Estate (10 September 2010) after sustaining serious injuries to her head and face, the cause of which was unknown (Figure 4.13; Table 4.6).

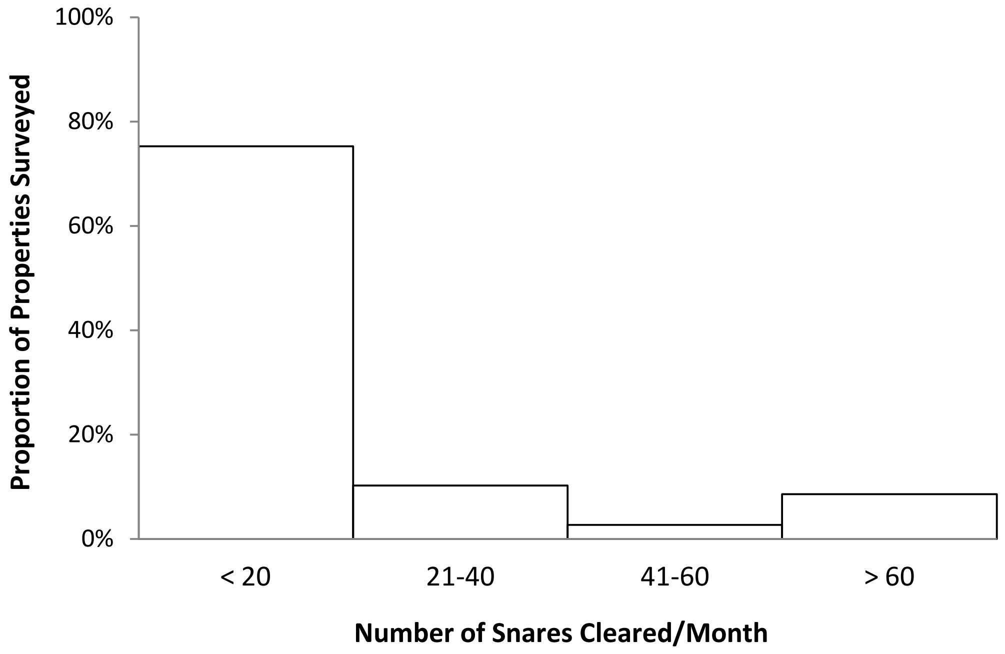

Figure 4.11. Proportion of properties surveyed and the number of snares cleared per month. Values are percentages of the 186 respondents.

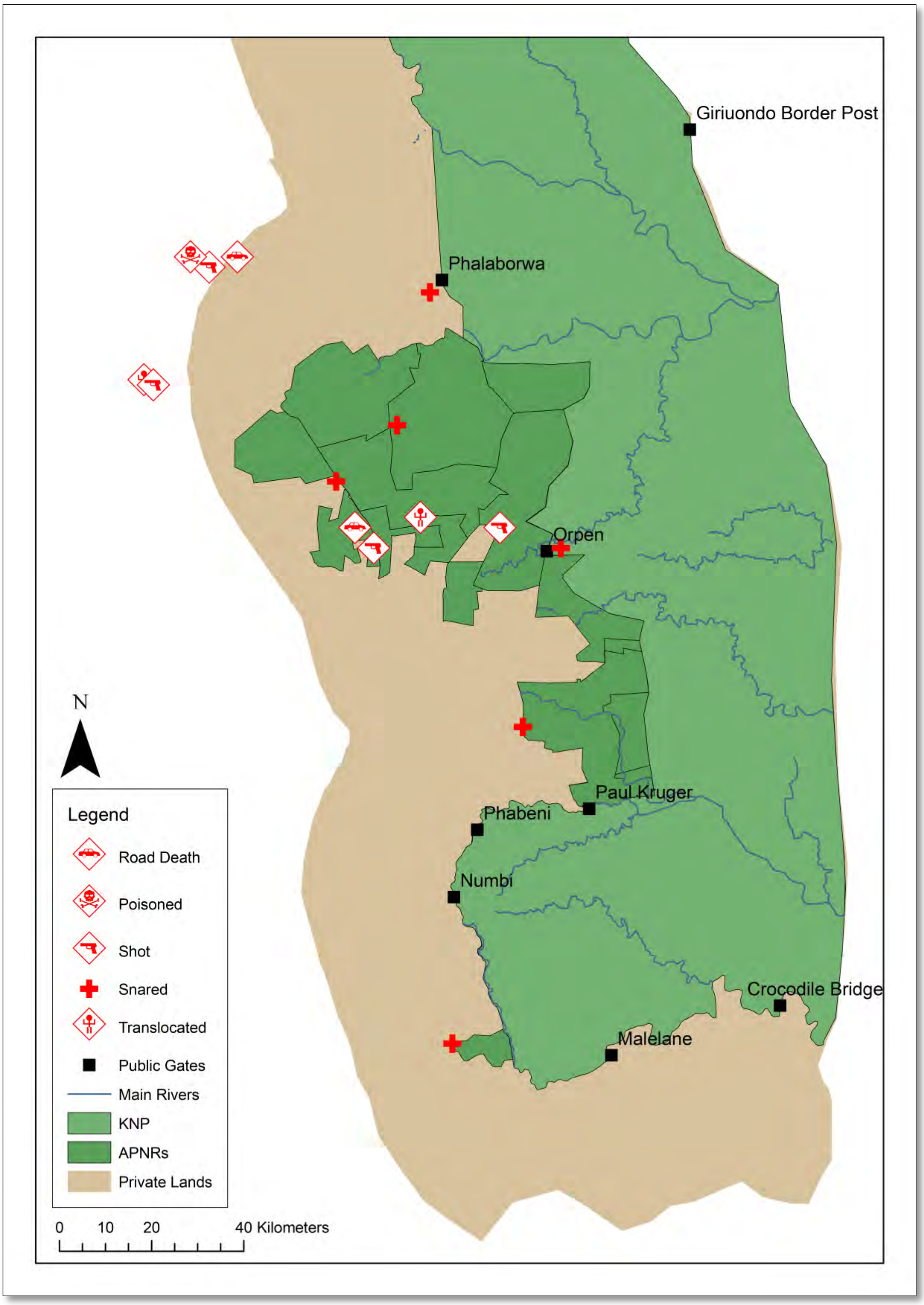

Figure 4.12. Threats to wild dogs in the study area (ArcGIS 9.3; projected: Transverse-Mercator, spheroid WGS84, central meridian 31; map units: meters).

Table 4.6. Threats to wild dogs in the study area. 'Previously' refers to incidences reported before this research, and 'recently' denotes incidences that occurred between March 2010 and April 2011.

Threats	**Previously**	**Recently**	**Total**
Snares	5	2	7
Road Deaths	1	1	2
Poisoned	1		1
Translocated	2		2
Shot	4	1	5

Figure 4.13. A=Adult wild dog killed on the R40 near Hoedspruit (Photograph courtesy of Protrack Anti-poaching, Hoedspruit). B=snared wild dog sighted on the Sabi Sand Wildtuin (Photo courtesy of Michael Grover). C=snared wild dog sighted at Orpen Gate of the KNP (Photograph courtesy Keith Miller). D=Female wild dog that died due to severe injuries to her head and face (Photograph courtesy of David Go-Lightly).

4.4 Discussion

Demographic variables

Generally, respondents were found to have positive attitudes towards wild dogs and a sound knowledge of the species, and their responses were independent of their age or education level (Gusset *et al*. 2008a). However, the tendency for respondents with tertiary education to have both a higher knowledge and attitude index, and for younger (21-30 years) respondents to be more positive towards wild dogs is promising (Kaczensky *et al*. 2004; Lindsey *et al*. 2005c; Zimmerman *et al*. 2005; Holmern *et al*. 2007; Lagendijk & Gusset 2008). There is an increasing awareness of the importance of conservation and the plight of our wildlife, and the fact that younger respondents appeared more accepting and aware, implies that tolerance will increase over time (van Dyk & Slotow 2003; Lindsey *et al*. 2005c; Hayward *et al*. 2007).

It has been suggested that more positive attitudes should be expected with a higher knowledge or awareness (Kaczensky *et al*. 2004). Indeed, a strong positive relationship was found between the attitude and knowledge of respondents. However, this may not always be the case, especially with a highly controversial predator (Davies & du Toit 2004; Kaczensky *et al*. 2004). Interestingly, Afrikaans first language respondents had a significantly lower knowledge of wild dog behaviour, biology and conservation status than English speaking land owners. However, there was no significant difference between the attitudes of English and Afrikaans first language speakers, and no significant effect of education. Administrators of the questionnaires were English speaking, thus difficulties in communication could have accounted for this result. It would have been interesting to consider gender differences (Kaczensky *et al*. 2004; Lagendijk & Gusset 2008), but the gender composition of the study population was skewed with males making up ~94% of the sample.

Property characteristics

It has been suggested that highly visible predators are more likely to be negatively perceived by land owners when 'problem animals' are considered (Rasmussen 1999; Lagendijk & Gusset 2008; Stein *et al*. 2010). However, after lions, respondents were the least positive towards wild dogs, even though wild dogs and cheetahs were recorded less frequently on properties than other predators (see Chapter 3). Negative perceptions of wild dogs were not consistent across the three land use types. Respondents managing and/or owning ecotourism ventures tended to have more positive perceptions of the species, and a significantly higher attitude index. This result is unsurprising considering that ecotourism properties promote photo-tourism and draw aesthetic and/or monetary benefits from having wild dogs on their properties. Wild dogs are charismatic and their conservation plight well publicised, factors that make the species both appealing to tourists and captivating to residents (Ogada *et al*. 2003; Lindsey *et al*. 2005b; Hayward *et al*. 2007; Licht *et al*. 2010). In fact, almost 75.0% of guests were willing to pay to see wild dogs in the KNP (Lindsey *et al*. 2005b). In comparison, wildlife ranchers and crop farmers had lower attitude indices than respondents involved in ecotourism ventures. Considering that wildlife ranchers and crop farmers generally receive no economic gain from having wild dogs on their properties, the costs of accommodating the species is likely to outweigh the benefits, especially for wildlife ranchers (Zimmerman *et al*. 2005). Wildlife ranchers typically breed rare game or facilitate trophy and/or biltong hunting. Consequently predators compete directly for the economic resource and any loss of game immediately translates into economic loss (Lindsey *et al*.

2005b; Lindsey *et al*. 2005c). This is likely to result in unhappy and intolerant land owners (Gillingham & Lee 2003; Holmern *et al*. 2007).

Almost all respondents had an appreciation for wild dogs and believed them to be a natural part of the environment. Ninety-nine percent believed that wild dogs should be protected and an overwhelmingly proportion stated that wild dogs held cultural importance for them. The respondents displayed an inherent appreciation for wild dogs which could be considered promising for their conservation (Davies & du Toit 2004; Lagendijk & Gusset 2008). However, considering the attitudes of the land owners, there is no guarantee that they will either tolerant and/or protect the species (Zimmerman *et al*. 2005; Lagendijk & Gusset 2008). Only 63.0% of respondents were happy to have wild dogs on their properties, and whilst some would tolerate the species temporarily, others believed that wild dogs had no place outside of protected areas (Zimmerman *et al*. 2005). Fear for human safety and livestock and/or game losses are the two key factors predicting the attitudes of land owners towards carnivores (Davies & du Toit 2004; Kaczensky *et al*. 2004; Holmern *et al*. 2007; Lagendijk & Gusset 2008; Gusset *et al*. 2008a; Licht *et al*. 2010). The two most influential reasons for respondents not wanting wild dogs on their properties was a concern over the economic implications of having the species move through their land, and a concern for their safety and the safety of their employees. In fact, 21.0% of respondents believed that wild dogs were dangerous to humans. Crop farmers and residents of wildlife estates expressed concern over human-safety, and crop farmers were the least positive towards predators. However, crop farmers rarely reported any encounters with, or sightings of, predators (see Chapter 3) and consequently had many neutral responses regarding their perceptions of predators. This could have accounted for the lower than average perceptions of crop farmers compared to wildlife ranchers and respondents involved in ecotourism ventures.

There was no significant difference between the frequencies of wild dog occurrence on wildlife ranching estates and ecotourism properties (see Chapter 3), but wildlife ranchers had significantly lower attitude indices than those involved in ecotourism ventures. Wild dogs are often accused of killing too often and eating more than they require, as well as disrupting/unsettling game and damaging fences (Rasmussen 1999; Woodroffe & Ginsberg 1999b; Lindsey *et al*. 2005c; Gusset *et al*. 2008a; Romanach & Lindsey 2008). However, the presence of denning wild dogs did not negatively disrupt game in a case study in Zimbabwe (Romanach & Lindsey 2008). Respondents used phrases such as 'destructive', 'wasteful' and 'cruel' to describe the presence of wild dogs on their properties. Particular concern was shared over the perceived impacts of wild dogs on prey numbers by those managing smaller reserves and farms. Wild dogs have shown the ability to utilize surrounding fence lines to trap and capture larger prey than usual (van Dyk & Slotow 2003; Lindsey *et al*. 2004b). For example, wild dogs in Pilanesberg National Park, South Africa, used the fences as a hunting aid and were able to capture larger prey (e.g. a female eland *Tragelaphus oryx*) while it was stunned and confused (van Dyk & Slotow 2003). Thus, wild dogs can have effects on prey numbers and target non-typical prey species which may be problematic for smaller reserves and wildlife ranches (Lindsey *et al.* 2004b). Wildlife ranches are typically smaller in size and are often stocked with prized game, compared to ecotourism reserves which tend to be larger and support low value impala and kudu which constitute wild dogs primary prey species across most of southern Africa (Maddock & Mills 1994; Mills & Gorman 1997; Rasmussen 1999; Lindsey *et al*. 2005b). Consequently, the impacts of wild dogs may be exacerbated on wildlife ranches (Lindsey *et al*. 2005b). Generally, land owners who experience the most 'damage' tend to have the most negative perception of predators and a lower tolerance (Kaczensky *et al*. 2004; Woodroffe *et al*. 2005; Zimmerman *et al*. 2005; Holmern *et al*. 2007; Stein *et al*. 2010).

Lindsey *et al*. (2005c) found the attitudes of ranchers to be more positive towards wild dogs where ecotourism-based land uses predominated. This suggests that negative attitudes and perceptions of land owners could be improved through the use of ecotourism-based benefits to offset the costs of having wild dogs on their properties (Lindsey *et al*. 2005c; Stein *et al*. 2010). In contrast, some case studies have suggested trophy hunting of predators as an option to reduce conflict (Zimmerman *et al*. 2005; Stein *et al*. 2010). This simultaneously removes the problem animal and provides an incentive for the land owner to tolerate the losses (Zimmerman *et al*. 2005; Stein *et al*. 2010). However, the endangered status of wild dogs and their formal legal protection would prohibit this form of incentive-based mitigation (Stein *et al*. 2010). Alternatively, land owners with valuable game are encouraged to erect predator-proof game breeding camps. In this study, respondents with securely constructed predator-proof camps rarely reported conflict with predators. However, upgrading property and/or game camp fencing to the specifications required for wild dogs is extremely costly (Lindsey *et al*. 2005a).

The promotion of ecotourism operations alongside wildlife ranching may be the best way to improve land owner attitudes and benefit conservation, not only for wild dogs, but also other predators (Lindsey *et al*. 2005b; Stein *et al*. 2005). There are a number of challenges and limitations in doing so (e.g. tourism is subject to political instability), and the potential for wild dogs to generate tourism revenues may be unreliable (Lindsey *et al*. 2005b). Wild dogs, alongside caracals, were ranked as the least preferred mammal by tourists in Namibia (Stein *et al*. 2010), while tourists visiting Hluhluwe-iMfolozi Park, South Africa, ranked wild dogs as the top preferred predator and the predator they were most willing to pay to see (Gusset *et al*. 2008a). Consequently, range expansion may need to be limited to ranches and smaller reserves that are willing to incur the potential economic costs associated with wild dogs without additional support from ecotourism-based revenues (Lindsey *et al*. 2005a). Forty-seven percent of respondents believed that wild dogs could generate tourism benefits for them, and ~26% of respondents rejected the suggestion that they would be happier if they never saw wild dogs on their properties based on the aesthetic, and potential monetary benefits, the species could generate. Importantly, wildlife ranchers and respondents involved in ecotourism ventures did not only have higher attitude indices, but were also more knowledgeable about wild dog behaviour, biology and conservation than crop farmers. Ecotourism-based ventures of sufficient size have been recognised as the most appropriate land use type for wild dog reintroductions and range expansion (Lindsey *et al*. 2005b).

The collaboration and/or expansion of farms to form conservancies have proven to be beneficial for the conservation of biodiversity (Marker *et al*. 2003; Lindsey *et al*. 2005c; Hayward *et al*. 2007; Lindsey *et al*. 2009). The formation of conservancies reduces the burden on individual land owners and creates conditions more conducive to predator conservation (e.g. more space and prey for wide-ranging carnivores such as wild dogs) (Lindsey *et al*. 2005b; Lindsey *et al*. 2009). This has the potential to dilute the impacts of large carnivores on individual properties and reduce conflict between land owner and predator (Kaczensky *et al*. 2004; Zimmerman *et al*. 2005; Holmern *et al*. 2007; Stein *et al*.

2010). With an increase in space land owners tend to introduce larger and more charismatic species and land use shifts to ecotourism (Lindsey *et al*. 2009). This has shown to have financial benefits for land owners (Lindsey *et al*. 2009). My research supports the development of conservancies as a tool to promote wild dog conservation. Respondents belonging to conservancies had a significantly higher knowledge and attitude index than respondents not part of conservancies. Interestingly, respondents south of the KNP had significantly higher attitude indices and tended to be more knowledgeable than respondents west of the KNP. The southern boundary of the KNP is dominated by agricultural lands (Jori *et al*. 2011), and the Crocodile River and the recently reconstructed southern boundary fence present immediate barriers to dispersing animals (Lindsey *et al*. 2004a; Woodroffe 2010). Consequently, a considerable decrease in the movement of animals through the south of the KNP has been reported (see Chapter 3). Wild dogs present very little economic threat to crop farmers and the species is rarely seen, two factors which could account for the more positive attitudes and higher level of tolerance of these land owners (Rasmussen 1999; Kaczensky *et al*. 2004; Zimmerman *et al*. 2005; Holmern *et al*. 2007; Lagendijk & Gusset 2008; Stein *et al*. 2010).

Respondents in the study area who maintained negative attitudes towards, and perceptions of, wild dogs could be detrimental for the KNP population. Given the low number of wild dogs in the greater KNP compared to other predators, and the importance of the KNP wild dog population, any individual lost is a cause for concern (Lindsey *et al*. 2005c; Ferreira & Funston 2010; Davies-Mostert *et al*. unpublished data; Funston & Ferreira, unpublished data). On properties where wild dogs are not welcome, they may continue to be persecuted despite their protected status (Creel & Creel 1998; Zimmerman *et al*. 2005; Holmern *et al*.

2007; Gusset *et al*. 2008a; Stein *et al*. 2010). The KNP wild dog population is of national conservation importance (Mills *et al*. 1998). Wild dogs dispersing beyond the KNP provide an important link between other populations (Woodroffe & Ginsberg 1999b). Failed dispersals, or the persecution of subgroups beyond the boundaries of the KNP, could threaten the genetic stability and persistence of the population (Fuller *et al*. 1992). Isolated populations are more vulnerable to environmental shocks (McNutt *et al*. 2008).

Enhancing public perception and knowledge of wide-ranging predators through the use of education and awareness programmes may be the best way to improve land owner attitudes and reduce mortality beyond protected areas (Woodroffe & Ginsberg 1998; Kaczensky *et al*. 2004; Gusset *et al*. 2008a; Licht *et al.* 2010; Whittington-Jones 2011). Education programmes helped reduce cheetah persecution by land owners in Namibia (Marker *et al*. 2003). Dispelling the myths of wild dogs being a threat to humans, and practical advice on how to deal with wild dog encounters, may help to increase the perceptions of residents outside the KNP (Kaczensky *et al*. 2004). It has been suggested that changing the species common name from 'wild dog' to 'painted hunting dog', or something more in line with the scientific name, may help to diffuse negative attitudes and prejudice towards the species (Rasmussen 1999). The potential exists for wild dogs to persist in human-dominated areas devoted to game and/or livestock practices (Lindsey *et al*. 2004a; Woodroffe *et al*. 2005; Woodroffe *et al*. 2007; Gusset *et al*. 2009; Woodroffe 2010). Consequently, the land owners bordering the KNP could be important facilitators in safe-guarding the KNP wild dog population.

Additional threats

Potentially significant threats exist for wild dogs on the borders of the KNP and the APNRs, including both accidental (e.g. snares and road deaths) and deliberate (e.g. persecution from land owners) anthropogenic impacts. Snares are traditionally laid for bush meat, but are indiscriminate (Davies & du Toit 2004; Gusset *et al*. 2008a). Indeed, the snaring of a spotted hyaena and a white rhino *Ceratotherium simum* were reported by respondents. The wide-ranging nature of wild dogs makes them easy targets for snares, especially on or outside the borders of protected areas (Woodroffe & Ginsberg 1999b; Hayward *et al*. 2007; Gusset *et al*. 2008a). The majority of respondents believed snaring to be of 'little consequence' on their properties. However, any single snare has the potential to have detrimental consequences for frequently dispersing animals, especially for endangered species (Woodroffe & Ginsberg 1999b). Snaring was the second greatest reported threat, after direct persecution (shooting), both previously and during this research.

Wildlife ranchers tended to clear more snares per month than the other two land use types, and properties along the south of the KNP tended to clear more snares per month than properties along the west. Considering that wildlife ranches are typically stocked with game and prey species, targets of poachers, this result is unsurprising (Lindsey *et al*. 2005b). However, perhaps when wildlife ranchers patrol for snares they search their lands more thoroughly than crop farmers or those involved in ecotourism ventures. The southern boundary of the KNP is dominated by agricultural lands (Jori *et al*. 2011), and crop farmers reported an abundance of relatively small ungulate and mammal species (e.g. common duiker *Sylvicapra grimmia*, bushpigs *Potamochoerus porcus* and warthogs *Phacochoerus africanus*) on their properties. The level of activity (e.g. fence patrols and vehicles traversing the property) on crop farms may be less than on the other two land use types which could account for the higher prevalence of snares south of the KNP (Davies & du Toit 2004). An increase in snaring has been correlated with a decrease in anti-snare patrols (Davies & du Toit 2004). Respondents situated within control areas and/or that had employed the services of an anti-poaching company reported a decrease in snaring and poaching incidences. In contrast, land owners and/or managers bordering communities generally believed snaring to be worse on their properties, and stated that residents from the local communities were invariably the culprits. Snaring reportedly escalates during specific times of the year, for example, when contractors or other external labour forces operated on properties. Importantly, respondents belonging to conservancies tended to clear fewer snares, highlighting the potential contribution of conservancies to wild dog conservation (Lindsey *et al*. 2005c; Hayward *et al*. 2007). However, the level of snaring may have been greater than perceived by respondents.

Areas of high road densities, especially in the vicinity of high human-densities where infrastructure supports tarred roads and/or highways with higher speed limits, may serve as population sinks for wide ranging carnivores (Creel & Creel 1998; Mladenoff *et al*. 1999; Woodroffe & Ginsberg 1999b; Tigas *et al*. 2002; Davies & du Toit 2004). For example, accidental or deliberate killing of wolves *C. lupus* on roads contributed to wolf mortality in America, and a negative relationship was found between wolf territories and road densities (Mladenoff *et al*. 1999). The national road (N4) along the south of the KNP and the matrix of regional tarred roads to the west of the KNP are additional threats to wild dogs dispersing beyond the borders of the KNP (Woodroffe & Ginsberg 1999b; Davies & du Toit 2004). In fact, one wild dog was hit and killed on the R40 near Hoedspruit during this research.

Carnivores may be attracted to roads as they offer easy routes for travel and hunting (Mladenoff *et al*. 1999; Woodroffe 2010). Road deaths have been recorded as the single most important cause of mortality for wild dogs in Hwange National Park, Zimbabwe (Woodroffe & Ginsberg 1999b).

Measures to reduce mortality outside the boundaries of the KNP include anti-snare collars, reflective collars and warning signs of wild dog crossing points (Woodroffe & Ginsberg 1999b; Ogada *et al*. 2003; Davies & du Toit 2004). However, most of these options are expensive and require intensive management (Woodroffe & Ginsberg 1999b). Consequently, reducing the anthropogenic threats to dispersing wild dogs ultimately depends on the land owners and residents bordering protected areas (Rasmussen 1999; Woodroffe *et al*. 2007; Gusset *et al*. 2009). Land owners should be encouraged to regularly conduct anti-snare patrols and to report incidences of persecution of local predators (Davies & du Toit 2004). There is an inherent bias in collecting mortality data for un-collared dogs (Woodroffe *et al*. 2007). Un-collared dogs that die of natural causes are less likely to be detected and reported, whereas wild dogs killed on roads, for example, are conspicuous. The level of human-induced mortality among radio-collared dogs has been found to be lower than that recorded for unmonitored individuals (Woodroffe e*t al*. 2007). A study of collared wild dogs operating within the greater KNP will enable potential anthropogenic threats to be better monitored.

Summary

- Respondents' attitude and knowledge indices were largely independent of their demographic variables. However, Afrikaans speaking respondents had a significantly lower knowledge index than English speaking respondents.

- A positive relationship was found between the knowledge index of a respondent and his/her attitude index.
- Respondents belonging to conservancies had significantly higher attitude and knowledge indices. Consequently, the formation of conservancies may positively benefit wild dog conservation in the greater KNP.
- Respondents involved in ecotourism-based land use types were the most positive towards wild dogs. Strategies that incentivise this form of land use may have positive benefits for wild dogs in the long term.
- Snaring and road deaths present potentially significant threats to wild dogs operating within the greater KNP. Failed dispersals, or the persecution of subgroups beyond the boundaries of the KNP, could threaten the genetic stability and persistence of the population.

CHAPTER 5: General discussion

5.1 Potential for wild dog range expansion in the greater KNP

In 1997, a Population and Habitat Viability Assessment resulted in a conservation action plan for wild dogs in southern Africa, part of which included protecting and enlarging existing wildlife areas that support wild dog populations (Mills *et al*. 1998; Davies-Mostert *et al*. 2009). Since the expansion of farms and conservation areas west of the KNP to form additional stretches of available habitat, the KNP wildlife can move freely between similar land use types. However, there is no guarantee that adjacent private land owners will either tolerate and/or protect species (Lagendijk & Gusset 2008). The KNP wild dog population is of national conservation importance, but the population appears to be declining (Fanshawe *et al*. 1997; Mills *et al*. 1998). The average pack size of both the Edge and the KNP packs was below the critical threshold (≤5). Anthropogenic threats along the KNP boundaries may have negative consequences for local wildlife, including wild dogs (Woodroffe *et al*. 2007). Wild dog packs living on the edge of the KNP provide an important link between other populations, and failed dispersals could have negative consequences for population persistence (Woodroffe & Ginsberg 1999b; McNutt *et al*. 2008).

The results of my study suggest that the APNRs and properties west of the KNP present the best prospects for range expansion and could benefit the KNP wild dog population. Wildlife ranching farms and ecotourism properties, land use types that have been recognised for their potential contribution to wild dog conservation, are abundant along the west of the KNP (Lindsey *et al*. 2005b). Ecotourism properties and wildlife ranches provide potentially suitable habitat for wild dog persistence. These land use types generally dominate larger stretches of land and have a higher abundance of game with natural vegetation typically intact (Lindsey *et al*. 2004a; Lindsey *et al*. 2005c). Ranches are normally free of other carnivores and/or support lower densities of lions and spotted hyaenas, conferring additional benefits to wild dogs (Lindsey *et al*. 2004a; Gusset *et al*. 2008b; Woodroffe 2010). The smaller home ranges, reduced overlap and larger pack sizes of the Edge packs were indicative of reduced inter- and intraspecific competition.

The management activities of the KNP and the adjacent private land owners will be important in securing the future viability of wild dogs in the region (Lindsey *et al*. 2005c). However, not all land owners are tolerant of the species, and wild dogs may continue to be persecuted on properties where they are not welcome, despite their protected status (Creel & Creel 1998; Gusset *et al*. 2008a; Stein *et al*. 2010). Conflict situations are likely to arise where land owners feel that their safety is threatened, or have concerns over the economic implications of having the species move through their land (Davies & du Toit 2004; Gusset *et al*. 2008a; Licht *et al*. 2010). Given the nature of the business, it is unsurprising that wildlife ranchers would be less positive towards wild dogs than land owners involved in ecotourism ventures that generally draw benefits from having charismatic predators on their properties (Ogada *et al*. 2003; Lindsey *et al*. 2005b). Consequently, despite the potentially suitable conditions for range expansion west of the KNP, dispersals across the matrix of land use types will most likely require management to mitigate conflict with unhappy and/or intolerant land owners, and reduce potential edge effects which could cause decline or hinder recovery (Lindsey *et al*. 2004a; Lindsey *et al*. 2005a; Woodroffe *et al*. 2007).

5.2 Future management considerations

Ecotourism-based land use types were shown to be the most positive towards wild dogs (Lindsey *et al*. 2005c; Stein *et al*. 2010). Strategies that promote ecotourism operations alongside wildlife ranching may have positive benefits for wild dogs dispersing beyond the boundaries of the KNP. Crop farmers reported very little conflict with the species, but the threats facing wild dogs dispersing through communal lands are uncertain. Every land owner, regardless of land use type, perceived and dealt with 'problem animals' in a different manner. Site-specific studies are required to help adjacent land owners identify the benefits of co-existing with large carnivores, and the best non-lethal mitigation measures given their socio-economic context (Winterbach *et al*. 2012). The use of education and awareness programmes in enhancing the public perception of wide-ranging species has proven beneficial on private (Marker *et al*. 2003; Gusset *et al*. 2008a) and communal lands (Whittington-Jones 2011). Future research should focus on understanding the tolerance of community members in greater KNP towards wild dogs and other predators and identifying potential conflict situations. Given the positive relationship between the knowledge index of a respondent and his/her attitude index, future conservation planning should aim to raise awareness of the plight of the wild dog and knowledge of the species amongst community members and private land owners adjacent to the KNP.

My study supports the development of conservancies as a tool to promote wild dog conservation. Conservancies have the potential to dilute the impacts of large carnivores on individual properties and reduce conflict between land owner and predator (Zimmerman *et al*. 2005; Holmern *et al*. 2007). Respondents belonging to conservancies had significantly higher attitude and knowledge indices, and tended to clear fewer snares per month.

This research revealed snaring and road deaths to be potentially significant threats to wild dogs operating within the greater KNP. Warning signs of wild dog crossing points could be erected on identified 'problem roads' (Davies & du Toit 2004). Land owners should be encouraged to regularly conduct anti-snare patrols or employ the services of anti-poaching companies. Importantly, the prevalence of pathogens (e.g. rabies) within the study area was not assessed and needs to be determined. A study of collared wild dogs operating within the greater KNP will not only enable anthropogenic threats to be better monitored, but will allow for a more comprehensive understanding of dispersal habitats (Woodroffe *et al*. 2007). The dispersal of wild dogs east into Zimbabwe and Mozambique and potential edge effects need to be analysed.

Land owners should report incidences of persecution of wild dogs and other predators (Ogada *et al*. 2003; Davies & du Toit 2004). National and provincial legislation has thus far failed to prevent the decline of the wild dog (Winterbach *et al*. 2012). Policies and legislation providing for the management and protection of wild dogs need to be established, and effectively executed in the greater KNP (van der Linde & Feris 2006). Where conservation authorities fail to mitigate conflict situations, the onus falls on land owners to protect their livelihoods, often with detrimental consequences for large carnivores (Winterbach *et al*. 2012).

5.3 Potential contribution of land owners in greater KNP to national wild dog conservation

The future conservation of wild dogs is focused on securing viable populations, that contribute to ecosystem integrity and which coexist with people (Lindsey & Davies-Mostert 2009). Further, to improve the status of wild dogs across a matrix of land use types of suitable habitat, within their historical range (Lindsey & Davies-Mostert 2009). My study suggests that suitable habitat for wild dog range expansion exists in the most important conservation area of South Africa. I have identified some of the environmental and anthropogenic factors which may influence pack movements across a heterogeneous landscape. In addition, the attitudes of private land owners potentially affected by dispersing wild dogs have been assessed, and future management considerations and mitigation options recommended. The potential exists for wild dogs to persist in human-dominated areas, and the land owners bordering the KNP should be viewed as important facilitators in safe-guarding the only viable population of wild dogs in South Africa (Woodroffe *et al*. 2007; Gusset *et al*. 2009; Woodroffe 2010). Ensuring the persistence of the KNP wild dog population is important for the national conservation of the species, and will undoubtedly benefit conservation endeavours elsewhere in the country (Mills *et al*. 1998; Lindsey *et al*. 2005b).

CHAPTER 6: References

African Mammals databank. (http://mercury.ornl.gov/metadata/nbii/html/ma/www.nbii.gov_metadata_mdata_Millenium_nbii_wdc_ma_d_africanmamldb.html). Digitised by Justina Ray and Luke Hunter (WCS) and modified by participants at the Eastern and Southern Wild Dog/Cheetah workshops, 2007.

Anthony, B. 2007. The dual nature of parks: attitudes of neighbouring communities towards Kruger National Park, South Africa. *Environmental Conservation*. 34: 236-245.

Balme, G. A., Hunter, L.T.B. & Slotow, R. 2007. Evaluating methods for counting cryptic carnivores. *The Journal of Wildlife Management*. 73: 433-441.

Brandl, G., Cloete, M. & Anhaeusser, C.R. 2006. Archaean Greenstone Belts. In: *The geology of South Africa*. (eds.) Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. Geological Society of South Africa, Johannesburg/Council for Geoscience, Pretoria. pp. 9-56.

Buettner, U.K., Davies-Mostert, H.T., du Toit, J.T. & Mills, M.G.L. 2006. Factors affecting juvenile survival in African wild dogs (*Lycaon pictus*) in Kruger National Park, South Africa. *Journal of Zoology*. 272: 10-19.

Burnham, K.P. & Anderson, D.R. 2002. *Model selection and multimodel inference: a practical information-theoretic approach*. Springer-Verlang, New York.

Butler, J., du Toit, J.T. & Bingham, J. 2004. Free-ranging domestic dogs (*Canis familiaris*) as predators and prey in rural Zimbabwe: threats of competition and disease to large wild carnivores. *Biological Conservation*. 115: 369-378.

Carruthers, J. 1994. Dissecting the Myth: Paul Kruger and the Kruger National Park. *Journal of Southern African Studies*. 20: 263-283.

Childes, S.L. 1988. The past history, present status and distribution of the hunting dog *Lycaon pictus* in Zimbabwe. *Biological Conservation*. 44: 301-316.

Courchamp, F. & Macdonald, D.W. 2001. Crucial importance of pack size in the African wild dog *Lycaon pictus*. *Animal Conservation*. 4: 169-174.

Creel, S. & Creel, N.M. 1995. Communal hunting and pack size in the African wild dogs, *Lycaon pictus*. *Animal Behaviour*. 50: 1325-1339.

Creel, S. & Creel, N.M. 1998. Six ecological factors that may limit African wild dogs, *Lycaon pictus*. *Animal Conservation*. 1: 1-9.

Creel, S. & Creel, N.M. 2002. *The African Wild Dog: Behaviour, Ecology and Conservation*. Princeton University Press, Princeton and Oxford.

Creel, S. 2001. Four factors modifying the effect of competition on carnivore population dynamics as illustrated by African wild dogs. *Conservation Biology*. 15: 271-274.

Creel, S., Mills, M.G.L. & McNutt, J.W. 2004. African Wild Dogs: demography and population dynamics of African wild dogs in three critical populations. In: *The Biology and Conservation of Wild Canids*. (eds.) Macdonald, D.W. & Sillero-Zubiri, C. Oxford University Press, Oxford. pp. 337-350.

Crooks, K.R. & Soule, M.E. 1999. Mesopredator release and avifaunal extinctions in a fragmented system. *Nature*. 400: 563-566.

Davies, H. 2000. The 1999/2000 Kruger National Park wild dog photographic survey. Unpublished South African National Parks Board Report. South Africa.

Davies, H.T. & du Toit, J. 2004. Anthropogenic factors affecting wild dog *Lycaon pictus* reintroductions: a case study in Zimbabwe. *Oryx*. 38: 32-39.

Davies-Mostert, H.T., Marnewick, K. & Ferreira, S.M. Endangered Wildlife Trust and South African National Parks. Unpublished data.

Davies-Mostert, H.T., Mills, M.G.L. & Macdonald, D.W. 2009. A critical assessment of South Africa's managed metapopulation recovery strategy for African wild dogs and its value as a template for large carnivore conservation elsewhere. In: *Reintroduction of* *top order predators*. (eds.) Hayward, M. & Somers, M. Blackwell Publishing. pp. 10-42.

Dickman, A.J. 2010. Complexities of conflict: the importance of considering social factors for effectively resolving human-wildlife conflict. *The Zoological Society of London*. doi. 10. 1111/j. 1469-1795.2010.00368.x.

Dickson, B.G. & Beier, P. 2002. Home-range and habitat selection by adult cougars in southern California. *Journal of Wildlife Management*. 66: 1235-1245.

Dray, S., Royer-Carenzi, M. & Calenge, C. 2010. The exploratory analysis of autocorrelation in animal-movement studies. *Ecological Research*. 25: 673-681.

du Toit, J.T. 2003. Large herbivores and savanna heterogeneity. In: *The Kruger Experience: ecology and management of savanna heterogeneity*. (eds.) du Toit, J.T., Rogers, K.H. & Biggs, H.C. Island press. pp. 292-309.

Estes, R.D. & Goddard, J. 1967. Prey selection and hunting behaviour of the African wild dog. *The Journal of Wildlife Management*. 31: 52-70.

Fanshawe, J.H., Frame, L.H. & Ginsberg, J.R. 1991. The wild dog - Africa's vanishing carnivore. *Oryx*. 25: 137-146.

Fanshawe, J.H., Ginsberg, J.H., Sillero-Zubiri, C. & Woodroffe, R. 1997. The status and distribution of remaining wild dog populations. In: *The African wild dog: status, survey and conservation action plan.* (eds.) Woodroffe, R., Ginsberg, J.H., Macdonald, D.W. & IUCN/SSC Canid Specialist Group. Gland, Switzerland. pp 11-57.

Ferreira, S.M. & Funston, P. J. 2010. Estimating lion population variables: prey and disease effects in Kruger National Park, South Africa. *Wildlife Research*. 37: 194-206.

Frame, G.W. & Frame, L.H. 1976. Female African wild dogs emigrate. *Nature*. 263: 227-229.

Freitag-Ronaldson, S & Foxcroft, L.C. 2003. Anthropogenic influences at the ecosystem level. In: *The Kruger Experience: ecology and management of savanna heterogeneity*. (eds.) du Toit, J.T., Rogers, K.H. & Biggs, H.C. Island press. pp. 391-421.

Fuller, T.K. & Kat, P.W. 1990. Movements, activities and prey relationships of African wild dogs (*Lycaon pictus*) near Aitong, southwestern Kenya. *African Journal of Ecology*. 28: 330-350.

Fuller, T.K. & Kat, P.W. 1993. Hunting success of African wild dogs in southwestern Kenya. *Journal of Mammalogy*. 74: 464-467.

Fuller, T.K., Mills, M.G.L., Borner, M., Laurenson, M.K. & Kat, P.W. 1992. Long distance dispersal by African wild dogs in East and South Africa. *Journal of African Zoology*. 106: 535-537.

Funston, P.J. & Ferreira, S.M. Tshwane University of Technology and South African National Parks. Unpublished data.

Gertenbach, W.P.D. 1980. Rainfall patterns in the Kruger National Park. *Koedoe*. 23: 35-43.

Gertenbach, W.P.D. 1983. Landscapes of the Kruger National Park. *Koedoe*. 26: 9-121.

Gillingham, S. & Lee, P.C. 2003. People and protected areas: a study of local perceptions of wildlife crop-damage conflict in an area bordering the Selous Game Reserve, Tanzania. *Oryx*. 37: 316-325.

Girman, D.J., Kat, P.W., Mills, M.G.L., Ginsberg, J.R., Borner, M., Wilson, V., Fanshawe, J.H., Fitzgibbon, C., Lau, L.M., & Wayne, R.K. 1993. Molecular genetic and morphological analyses of the African wild dog (*Lycaon pictus*). *The Journal of Heredity*. 84: 450-459.

Girman, D.J., Mills, M.G.L., Geffen, E. & Wayne, R.K. 1997. A molecular genetic analysis of social structure, dispersal, and interpack relationships of the African wild dog (*Lycaon pictus*). *Behavioural Ecology and Sociobiology*. 40: 187-198.

Glen, A.S., Dickman, C. R., Soule, M. E. & Mackey, B. G. 2007. Evaluating the role of the dingo as a trophic regulator in Australian ecosystems. *Austral Ecology*. 32: 492-501.

Graf, J.A., Gusset, M., Reid, C., van Rensburg, S.J., Slotow, R. & Somers, M.J. 2006. Evolutionary ecology meets wildlife management: artificial group augmentation in the re-introduction of endangered African wild dogs (*Lycaon pictus*). *Animal Conservation*. 9: 398-403.

Gros, P.M., Marcella, J.K. & Caro, T.M. 1996. Estimating carnivore densities for conservation purposes. *Oikos*. 77: 197-206.

Gusset, M., Maddock, A.H., Gunther, G.J., Szykman, M., Slotow, R., Walters, M. & Somers, M.J. 2008a. Conflicting human interests over the re-introduction of endangered wild dogs in South Africa. *Biodiversity Conservation*. 17: 83-101.

Gusset, M., Ryan, S.J., Hofmeyr, M., van Dyk, G., Davies-Mostert, H.T., Graf, J.A., Owen, C., Szykman, M., Macdonald, D.W., Monfort, S.L., Wildt, D.E., Maddock, A.H., Mills, M.G.L., Slotow, R. & Somers, M.J. 2008b. Efforts going to the dogs? Evaluating attempts to re-introduce endangered wild dogs in South Africa. *Journal of Applied Ecology*. 45: 100-108.

Gusset, M., Stewart, G.B., Bowler, D.E. & Pullin, A.S. 2010. Wild dog reintroductions in South Africa: a systematic review and cross-validation of an endangered species recovery programme. *Journal for Nature Conservation*. 18: 230-234.

Gusset, M., Swarner, M.J., Mponwane, L., Keletile, K. & McNutt, J.W. 2009. Human-wildlife conflict in northern Botswana: livestock predation by endangered African wild dog *Lycaon pictus* and other carnivores. *Oryx.* 43: 67-72.

Hawkins, C.E. & Racey, P.A. 2005. Low population density of a tropical forest carnivore, *Cryptoprocta ferox*: implications for protected area management. *Oryx*. 39: 35-43.

Hayne, D.W. 1949. Calculation of size of home range. *Journal of Mammology*. 30: 1-18.

Hayward, M.W., Adendorff, J, O'Brien, J., Sholto-Douglas, A., Bissett, C., Moolman, L.C., Bean, P., Fogarty, A., Howarth, D., Slater, R. & Kerley, G.I.H. 2007. The reintroduction of large carnivores to the Eastern Cape, South Africa: an assessment. *Oryx*. 41: 205-214.

Hayward, M.W., O'Brien, J., Hofmeyr, M. & Kerley, G.I.H. 2006. Prey preferences of the African wild dog *Lycaon pictus* (Canidae: Carnivora): ecological requirements for conservation. *Journal of Mammalogy*. 87: 1122-1131.

Hoffman, T.S. & O'Riain, M.J. 2011. The spatial ecology of Chacma Baboons (*Papio ursinus*) in a human-modified environment. *International Journal of Primatology*. 32: 308-328.

Holmern, T., Nyahongo, J. & Roskaft, E. 2007. Livestock loss caused by predators outside the Serengeti National Park, Tanzania. *Biological Conservation*. 135: 518-526.

Jackson, C.R., McNutt, J.W. & Apps, P.J. 2012. Managing the ranging behaviour of African wild dogs (*Lycaon pictus*) using translocated scent marks. *Wildlife Research*. http://dx.doi.org/10.1071/WR11070.

Jenness, J. 2011. Repeating Shapes extension for ArcGIS 9.x. v. 1.5.138. Jenness Enterprises http://www.jennessent.com/arcgis/repeat_shapes.htm. Accessed 18 November 2011.

Jori, F., Brahmbhatt, D., Fosgate, G.T., Thompson, P.N., Budke, C., Ward, M.P., Ferguson, K. & Gummow, B. 2011. A questionnaire-based evaluation of the veterinary cordon fence separating wildlife and livestock along the boundary of the Kruger National Park, South Africa. *Preventive Veterinary Medicine*. 100: 210-220.

Kaczensky, P., Blazic, M. & Gossow, H. 2004. Public attitudes towards brown bears (*Ursus arctos*) in Slovenia. *Biological Conservation*. 118: 661-674.

Kemp, L.V. & Mills, M.G.L. 2005. The 4th wild dog and 2nd cheetah photographic census in the greater Kruger region September 2004-April 2005. Unpublished report. Endangered Wildlife Trust, Johannesburg.

Lagendijk, D.D.G. & Gusset, M. 2008. Human-carnivore coexistence on communal land bordering the greater Kruger area, South Africa. *Environmental Management*. 42: 971-976.

Licht, D.S., Millspaugh, J.J., Kunkel, K.E., Kochanny, C.O. & Peterson, R. O. 2010. Using Small Populations of Wolves for Ecosystem Restoration and Stewardship. *BioScience*. 60: 147-153.

Lindsey, P. du Toit, J.T. & Mills, M.G.L. 2004a. The distribution and population status of African wild dogs (*Lycaon pictus*) outside protected areas in South Africa. *South African Journal of Wildlife Research*. 34: 143-151.

Lindsey, P.A. & Davies-Mostert, H. T. 2009. South African action plan for the conservation of cheetahs and African wild dogs. Report from a national conservation action planning workshop. Limpopo Province, South Africa. pp. 1-77.

Lindsey, P.A., Alexander, R., du Toit, J.T. & Mills, M.G.L. 2005a. The cost efficiency of wild dog conservation in South Africa. *Conservation Biology*. 19: 1205-1214.

Lindsey, P.A., Alexander, R.R., du Toit, J.T. & Mills, M.G.L. 2005b. The potential contribution of ecotourism to African wild dog *Lycaon pictus* conservation in South Africa. *Biological Conservation*. 123: 339-348.

Lindsey, P.A., du Toit, J.T. & Mills, M.G.L. 2004b. Area and prey requirements of African wild dogs under varying habitat conditions : implications for reintroductions. *South African Journal of Wildlife Research*. 34: 77-86.

Lindsey, P.A., du Toit, J.T. & Mills, M.G.L. 2005c. Attitudes of ranchers towards African wild dogs *Lycaon pictus*: conservation implications on private land. *Biological Conservation*. 125: 113-121.

Lindsey, P.A., Romanach, S.S. & Davies-Mostert, H.T. 2009. The importance of conservancies for enhancing the value of game ranch land for large mammal conservation in southern Africa. *Journal of Zoology*. 277:99-105.

Mabunda, D., Pienaar, D.J. & Verhoef, J. 2003. The Kruger National Park: a century of management and research. In: *The Kruger Experience: ecology and management of savanna heterogeneity*. (eds.) du Toit, J.T., Rogers, K.H. & Biggs, H.C. Island press. pp. 3-21.

Maddock, A.H. & Mills, M.G.L. 1994. Population characteristics of African wild dogs *Lycaon pictus* in the eastern Transvaal lowveld, South Africa, as revealed through photographic records. *Biological Conservation*. 67: 57-62.

Malcolm, J.R. & Marten, K. 1982. Natural selection and the communal rearing of pups in African wild dogs (*Lycaon pictus*). *Behavioural Ecology and Sociobiology*. 10: 1-13.

Marker, L.L., Mills, M.G.L. & Macdonald, D.W. 2003. Factors influencing perceptions of conflict and tolerance towards cheetahs on Namibian farmlands. *Conservation Biology*. 17: 1290-1298.

McNutt, J.W. 1995. Adoption in African wild dogs*, Lycaon pictus*. *Journal of Zoology*. 240: 163-173.

McNutt, J.W. 1996. Sex-biased dispersal in African wild dogs, *Lycaon pictus*. *Animal Behaviour*. 52: 1067-1077.

McNutt, J.W., Mills, M.G.L., McCreery, K., Rasmussen, G., Robbins, R. & Woodroffe, R. 2008. IUCN Red List of Threatened Species. Version 2011.2. www.iucnredlist.org. Accessed 31 January 2012.

Miller, B., Dugelby, B., Foreman, D., Martinez del Rio, C., Noss, R., Phillips, M., Reading, R., Soule, M.E., Terborgh, J. & Willcox, L. 2001. The importance of large carnivores to healthy ecosystems. *Endangered Species*. 18: 202-210.

Mills, M.G.L. & Funston, P.J. 2003. Large carnivores and savanna heterogeneity. In: *The Kruger Experience: ecology and management of savanna heterogeneity*. (eds.) du Toit, J.T., Rogers, K.H. & Biggs, H.C. Island press. pp. 370-388.

Mills, M.G.L. & Gorman, M.L. 1997. Factors affecting the density and distribution of wild dogs in the Kruger National Park. *Conservation Biology*. 11: 1397-1406.

Mills, M.G.L., Ellis, S., Woodroffe, R., Maddock, A., Stander, P., Pole, A., Rasmussen, G., Fletcher, P., Bruford, M., Wildt, D., Macdonald, D. & Seal, U. 1998. Population habitat and viability assessment for the African wild dog (*Lycaon pictus*) in southern Africa.

Unpublished IUCN/SSC Conservation Breeding Specialist Group workshop report. Pretoria. pp. 1-102.

Mishra, C., Allen, P., McCarthy, T., Madhusudan, M.D., Bayarjargal, A. & Prins, H.H.T. 2003. The role of incentive programs in conserving the snow leopard. *Conservation Biology*. 17: 1512-1520.

Mladenoff, D.J., Sickley, T.A. & Wydeven, A.P. 1999. Predicting Gray wolf landscape recolonization: logistic regression models vs. new field data. *Ecological Applications*. 9: 37-44.

Moehrenschlager, A., & Macdonald, D.W. 2003. Movement and survival parameters of translocated and resident swift foxes *Vulpes velox*. *Animal Conservation*. 6: 199-206.

Mohr, C.O. 1947. Table of equivalent populations of North American small mammals. *American Midland Naturalist*. 37: 223-249.

Mucina, L. & Rutherford, M.C. 2006. *The vegetation of South Africa, Lesotho and Swaziland*. Strelitzia. South African National Biodiversity Institute. Pretoria.

Mucina, L., Hoare, D.B., Lotter, M.C., du Preez, P.J., Rutherford, M.C., Scott-Shaw, C.R., Bredenkamp, G.J., Powrie, L.W., Scott, L., Camp, K.G.T., Cilliers, S.S., Bezuidenhout, H., Mostert, T.H., Siebert, S.J., Winter, P.J.D., Burrows, J.E., Dobson, L., Ward, R.A., Stalmans, M., Oliver, E.G.H., Siebert, F., Schmidt, E., Kobisi, K. & Kose, L. 2006. Grassland Biome. In: *The vegetation of South Africa, Lesotho and Swaziland*. (eds.) Mucina, L. & Rutherford, M.C. Strelitzia. South African National Biodiversity Institute. Pretoria. pp. 439-539.

Murray, K. & Conner, M.M. 2009. Methods to quantify variable importance: implications for the analysis of noisy ecological data. *Ecological Society of America*. 90: 348-355.

Ogada, M.O., Woodroffe, R., Oguge, N.O. & Frank, L.G. 2003. Limiting depredation by carnivores: the role of livestock husbandry. *Conservation Biology*. 17: 1521-1530.

Palomares, F. & Caro, T.M. 1999. Interspecific killing among mammalian carnivores. *The American Naturalist*. 153: 492-508.

Pole, A.J. 1999. The behaviour and ecology of African wild dogs, *Lycaon pictus*, in an environment with reduced competitor density. Ph.D. thesis. University of Aberdeen, Aberdeen.

Pollard, S., Shackleton, C. & Carruthers, J. 2003. Beyond the Fence: people and the lowveld landscape. In: *The Kruger Experience: ecology and management of savanna heterogeneity*. (eds.) du Toit, J.T., Rogers, K.H. & Biggs, H.C. Island press. pp. 422-446.

Powell, R.A. 2000. Animal home ranges and territories and home range estimates. In: *Research techniques in animal ecology*. (eds.) Boitani, L. & Fuller, T.K. Columbia University Press, New York. pp. 65-103.

Rabinowitz, A. & Zeller, K.A. 2010. A range-wide model of landscape connectivity and conservation for the jaguar, *Panthera onca*. *Biological Conservation*. 143: 939-945.

Rasmussen, G.S.A. 1999. Livestock predation by the painted hunting dog *Lycaon pictus* in a cattle ranching region of Zimbabwe: a case study. *Biological Conservation*. 88: 133-139.

Reich, A. 1981. The behaviour and ecology of the African wild dog (*Lycaon pictus*) in the Kruger National Park. Ph.D. thesis. Yale University, New Haven, Connecticut.

Romanach, S.S. & Lindsey, P.A. 2008. Conservation implications of prey responses to wild dogs *Lycaon pictus* during the denning season on wildlife ranches. *Animal Conservation*. 11: 111-117.

Rowe, J.R. 2009. Environmental and geometric drivers of small mammal diversity along elevational gradients in Utah. *Ecography.* 32: 411-422.

Rutherford, M.C., Mucina, L., Lotter, M.C., Bredenkamp, G.J., Smit, J.H.L., Scott-Shaw, C.R., Hoare, D.B., Goodman, P.S., Bezuidenhout, H., Scott, L., Ellis, F., Powrie, L.W., Siebert, F., Mostert, T.H., Henning, B.J., Venter, C.E., Camp, K.G.T., Siebert, S.J., Matthews, W.S., Burrows, J.E., Dobson, L., van Rooyen, N., Schmidt, E., Winter, P.J.D., du Preez, P.J., Ward, R.A., Williamson, S. & Hurter, P.J.H. 2006. Savanna Biome. In: *The vegetation of South Africa, Lesotho and Swaziland*. (eds.) Mucina, L. &

Rutherford, M.C. Strelitzia. South African National Biodiversity Institute. Pretoria. pp. 439-539.

Samelius, G., Andrén, H., Liberg, O., Linnell, J.D.C., Odden, J., Ahlqvist, P., Segerström, P. & Skold, K. 2011. Spatial and temporal variation in natal dispersal by Eurasian lynx in Scandinavia. *Journal of Zoology*. doi:10.1111/j.1469-7998.2011.00857.x

Skinner, J.D. & Chimimba, C.T. 2005. *The mammals of the southern African subregion*. Cambridge University Press, Cambridge. pp. 474-480.

Sokal, R.R. & Rohlf, F.J. 1995. Multiple and curvilinear regression. In: *Biometry the principles and practice of statistics in biological research*. (eds.) Sokal, R.R. & Rohlf, F.J. W.H. Freeman and Company. pp. 654-664.

South African National Parks: http://www.sanparks.org/parks/kruger/conservation/scientific/weather/. Accessed 09 November 2011.

South African Weather Services: http://www.weathersa.co.za/web/. Accessed 03 November 2011.

StatSoft, Inc. 2011. STATISTICA (data analysis software system). Version 10. www.statsoft.com.

Stein, A.B., Fuller, T.K., Damery, D.T., Sievert, L. & Marker, L.L. 2010. Farm management and economic analyses of leopard conservation in north-central Namibia. *Animal Conservation*. 13: 419-427.

Thompson, D.J. & Jenks, J.A. 2005. Long-distance dispersal by a subadult male cougar from the Black Hills, South Dakota. *Journal of Wildlife Management*. 69: 818-820.

Tigas, L.A., Van Vuren, D.H. & Sauvajot, R.M. 2002. Behavioral responses of bobcats and coyotes to habitat fragmentation and corridors in an urban environment. *Biological Conservation*. 108: 299-306.

van der Linde, M. & Feris, L. 2006. Compendium of South African environmental legislation (2nd edition). Pretoria University Law Press, Pretoria. pp. 1-696.

van Dyk, G. & Slotow, R. 2003. The effects of fences and lions on the ecology of African wild dogs reintroduced to Pilanesberg National Park, South Africa. *African Zoology*. 38: 79-94.

Vangen, K.M., Persson, J., Landa, A., Andersen, R. & Segerström, P. 2001. Characteristics of dispersal in wolverines. *Canadian Journal of Zoology*. 79:1641-1649.

Venter, F.J., Scholes, R.J. & Eckhardt, H.C. 2003. The abiotic template and its associated vegetation pattern. In: *The Kruger Experience: ecology and management of savanna heterogeneity*. (eds.) du Toit, J.T., Rogers, K.H. & Biggs, H.C. Island press. pp. 83-129.

Watkeys, M.K. 2006. Gondwana Break-up: a South African perspective. In: *The geology of South Africa*. (eds.) Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. Geological Society of South Africa, Johannesburg/Council for Geoscience, Pretoria. pp. 531-539.

White, P.C.L., Jennings, N.V., Renwick, A.R. & Barker, N.H.L. 2005. Questionnaires in ecology: a review of past use and recommendations for best practice. *Journal of Applied Ecology*. 42: 421-430.

Whittington-Jones, B.M. 2011. The dispersal of African wild dogs (*Lycaon pictus*) from protected areas in the Northern Kwazulu-Natal Province, South Africa. M.Sc. thesis. Rhodes University, South Africa.

Wilkinson, I. 1995. The 1994/1995 wild dog photographic survey. Unpublished South African National Parks Board report.

Winterbach, H.E.K., Winterbach, C.W., Somers, M.J. & Hayward, M.W. 2012. Key factors and related principles in the conservation of large African carnivores. *Mammal Review*. doi: 10.1111/j.1365-2907.2011.00209.x

Woodroffe, R. & Donnelly, C.A. 2011. Risk of contact between endangered African wild dogs *Lycaon pictus* and domestic dogs : opportunities for pathogen transmission. *Journal of Applied Ecology*. 48: 1345-1354.

Woodroffe, R. & Ginsberg, J.R. 1998. Edge effects and the extinction of populations inside protected areas. *Science*. 280: 2126-2128.

Woodroffe, R. & Ginsberg, J.R. 1999a. Conserving the African wild dog *Lycaon pictus*: is there a role for reintroduction? *Oryx*. 33: 143-151.

Woodroffe, R. & Ginsberg, J.R. 1999b. Conserving the African wild dog *Lycaon pictus*. Diagnosing and treating causes of decline. *Oryx*. 33: 132-142.

Woodroffe, R. 2010. Ranging behaviour of African wild dog packs in a human-dominated landscape. *Journal of Zoology*. 11: 1-10.

Woodroffe, R., Davies-Mostert, H., Ginsberg, J., Graf, J., Leigh, K., McCreery, K., Mills, G., Pole, A., Rasmussen, G., Robbins, R., Somers, M. & Szykman, M. 2007. Rates and causes of mortality in Endangered African wild dogs *Lycaon pictus*: lessons for management and monitoring. *Oryx*. 41: 215-223.

Woodroffe, R., Lindsey, P., Romanach, S., Stein, A. & ole Ranah, S.M.K. 2005. Livestock predation by endangered African wild dogs (*Lycaon pictus*) in northern Kenya. *Biological Conservation*. 124: 225- 234.

Worton, B.J. 1987. A review of models of home range for animal movement. *Ecological Modelling*. 38: 277-298.

Zimmerman, A., Walpole, M.J. & Leader-Williams, N. 2005. Cattle ranchers’ attitudes to conflicts with jaguar *Panthera onca* in the Pantanal of Brazil. *Oryx*. 39: 406-412.

Questionnaire #:

Appendices

Appendix A: Questionnaire survey

1) Date:	5) Property/farm name and #:
2) Time:	6) Position (land owner, manager etc.)
3) Location of interview:	7) Interviewer:
4) GPS coordinates of area/property:	

Property characteristics and livestock/game information

8) Land tenure (Please tick where applicable):

State protected area	Provincial area	Private area

9) Land use (Please tick applicable):

Stock ranching	**Crop farming**	**Wildlife ranching**	**Ecotourism**
Small stock		Live game sales	Wildlife estate
Large stock		Trophy hunting	Private lodge
		Biltong hunting	Private reserve
		Game breeding	

10) Please circle the activity most important to you.

11) Size of the property (hectares)? ________________________________

12) Does this property form part of a conservancy? Yes______ No______ Don't know______

13) Is this property perimeter fenced? Yes______ No______ Don't know______

14) If yes, please specify (Please tick applicable):

Cattle fencing	Game fencing (18-22 strand)	Electrified with trip wire inside / outside / both	Bonnox	Meshed with buried apron	Other

15) Have you had wild dogs moving in or out of your property?

	In	Out	Don't know
Wild dog			

16) Please specify what kinds of livestock and/or game are on this area and how many? If numbers are unknown than just tick.

Stock	Cattle	Sheep	Goats	Pigs	Poultry	Donkeys	Horses	Other	Don't know	None
Quantity										

Game	Impala	Kudu	Nyala	Bushbuck	Ostrich	Warthog	Wildebeest	Other	Don't know	None
Quantity										

17) Please indicate how frequently the following predators are seen on this property. Please tick where applicable.

	Never	< Once/year	Every few months	Once/month	> Once/month	Don't know
Lion						
Leopard						
Cheetah						
Wild dog						
Spotted hyaena						
Caracal						
Jackal						

18) Have you had wild dogs denning on your property? Yes_____ No_____ Don't know_____
If yes, when was the last year? ____
What did you do? ____

Wild dog distribution
19) If you have any GPS/photographic data and/or details of any sightings of wild dogs on this property please fill out the sightings record attached or, if possible, provide data and photographs on a CD or memory stick.

Attitudes towards wild dogs

20) How do you feel about the presence of the following predators on your property? Please tick where applicable.

	Positive	Neutral	Negative	Not applicable	
Lion					
Leopard					
Cheetah					
Wild dog					
Spotted hyaena					
Caracal					
Jackal					

21) What is the general feeling towards the following predators in the district? Please tick where applicable.

	Positive	Neutral	Negative	Not applicable	
Lion					
Leopard					
Cheetah					
Wild dog					
Spotted hyaena					
Caracal					
Jackal					

22) Do you know if any of your neighbours have ever successfully removed predators from their property? If yes, please specify the preferred method of removal (Please tick where applicable).

	Yes	No	Don't know	Method of removal (select from the list below; if other please specify)
Lion				
Leopard				
Cheetah				
Wild dog				
Spotted hyaena				
Caracal				
Jackal				

Firearm	Snare	Poison	Dogs	Gin traps	Cage traps	Other

23) Please indicate your disagreement/agreement with each of the following statements (Please tick where applicable).

24) You are more tolerant of wild dogs than your neighbours.	Yes	No	Don't know
25) Wild dogs negatively impact your business/livelihood/profit.	Yes	No	Don't know
26) Wild dogs form an important part of the environment.	Yes	No	Don't know
27) You would be happier if wild dogs were completely absent from your reserve/property.	Yes	No	Don't know
28) Please explain your responses to question 27 above:			
29) Wild dogs should be protected.	Yes	No	Don't know
30) You would tolerate a pack of wild dogs denning on your reserve/property.	Yes	No	Don't know
31) Wild dogs could produce tourism benefits for you/your business.	Yes	No	Don't know
32) You would like to see wild dogs in the bush.	Yes	No	Don't know
33) Wild dogs are culturally important to you.	Yes	No	Don't know
34) You would like to learn more about wild dogs.	Yes	No	Don't know

Questionnaire #:

Personal information about respondent

35) Name: ____

36) Age (Please tick where applicable)

< 21	21-30	31-40	41-50	> 50

37) Gender: ____

38) Contact number: ____

39) Level of education (Please tick where applicable)

None	Primary school level	Junior school level	School leavers certificate	Senior leavers certificate/Matric certificate	Tertiary education (Please specify)	Not applicable

40) First language: ____

Knowledge of the species and conservation in general

41) Respondent could correctly identify a wild dog. Yes_____ No_____ Don't know____

42) Wild dogs are dangerous to humans. Yes_____ No_____ Don't know____

43) Wild dogs more common than lions in the lowveld. Yes_____ No_____ Don't know____

44) Cheetahs kill more than they require. Yes_____ No_____ Don't know____

45) Wild dogs are social animals. Yes_____ No_____ Don't know____

Snaring on the property

46) Please state whether snaring is a problem on the property or not?

____

____

47) Please indicate the number of snares cleared monthly:

____

Sightings record

Species	Date*	General location	GPS coordinates	# seen	Pups present	Time of day seen	# of photos submitted	Additional Information
* Insert 1/2/3 etc. as coded below, but if specifics are known please state. **(1)** < 6 months ago; **(2)** 6 months - < 1 year; **(3)** 1 year - < 2 years; **(4)** 2 years- 5 years; **(5)** > 5 years								

Appendix B: The statements and scoring system used to determine the knowledge index.

WD = wild dogs.

Knowledge Statements	**Scores**		
	Yes	**No**	**Unsure**
Respondent could identify a WD.	1	-1	0
WD are dangerous to humans.	-1	1	0
WD are more common than lions in the lowveld.	-1	1	0
Cheetahs kill more than they require.	-1	1	0
WD are pack animals.	1	-1	0

Appendix C: The statements and scoring system used to determine the attitude index. WD = wild dogs.

Attitude Statements	**Scores**		
	Yes	**No**	**Unsure**
You are more tolerant of WD than your neighbours.	1	-1	0
WD negatively impact your business.	-1	1	0
WD form an important part of the environment.	1	-1	0
You would be happier if WD were completely absent from your property.	-1	1	0
WD should be protected.	1	-1	0
You would tolerate a pack of WD denning on your property.	1	-1	0
WD could produce tourism benefits for your business.	1	-1	0
You enjoy seeing WD in the bush.	1	-1	0
WD are culturally important to you.	1	-1	0
You would like to learn more about WD.	1	-1	0
You are happy to have WD on your property.	1	-1	0
Surrounding land owners are tolerant of WD.	1	-1	0
Your neighbours have successfully removed WD.	-1	1	0