THE DISPERSAL OF AFRICAN WILD DOGS (*LYCAON PICTUS*) FROM PROTECTED AREAS IN THE NORTHERN KWAZULU-NATAL PROVINCE, SOUTH AFRICA

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By

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ABSTRACT

The number of African wild dogs *Lycaon pictus* in Northern KwaZulu-Natal, South Africa has increased substantially over the last six years. This is largely due to a managed metapopulation approach of introductions onto protected areas and private game reserves since 1998. Because of the increasing wild dog population, the likelihood of rural communities surrounding protected areas encountering dispersing wild dogs in northern KwaZulu-Natal has also increased. Resident wild dog populations currently occur in Hluhluwe-iMfolozi Park (HiP), Mkhuze Game Reserve (MGR) of Isimangaliso Wetland Park and Thanda Private Game Reserve (TPGR) all of which are bordered by a matrix of natural habitats and human settlements. Thus, land outside these protected areas could be utilized to expand wild dog distribution and provide connectivity between existing resident populations of wild dogs within KwaZulu-Natal.

To investigate the viability of such an approach, Maximum Entropy Modelling (Maxent) was used to characterize habitat niche selection of dispersing wild dogs, and to identify potential dispersal linkages between current wild dog metapopulation reserves. The model was calibrated using 132 location points collected from 2006 until 2009. From 2008 to 2009 I also conducted a survey of 247 community members in tribal authorities bordering HiP and MGR, to understand factors influencing attitudes towards wild dogs.

A habitat suitability model with seven predictor variables had an AUC of 0.96 (SD = 0.02) and indicated four variables which best predicted probability of presence for dispersing wild dogs: elevation, road density, land cover and human density. The results suggest that elevation and land cover may be of greater influence for dispersing wild dogs than human density or activity. Elevation was the single most effective variable indicating a higher probability of presence for dispersing wild dogs in lower lying locations; peaking at approximately 200 – 300m a.s.l. Wild dogs also showed a preference for Woodland and Bushland habitats which in KwaZulu-Natal tend to be found on lower lying topography. A preference for areas of lower human density and a highest probability of presence at road densities of approximately 0.7km/km^2 or less would suggest that while wild dogs may show a tendency to avoid areas of high human activity, they can coexist in close proximity to humans.

Respondent's attitudes, knowledge of wild dogs and livestock husbandry were interpreted by the development of a set of indices. Attitudes were positively related to formal education levels and wild dog-specific education, but were not influenced by demographic factors such as gender, age and employment status. Eighty three percent of respondents believed efforts to protect wild dogs should continue. Respondents with higher numbers of livestock tended to have more positive attitudes towards wild dogs despite generally incurring higher losses to carnivore depredation than those with less livestock. This appears to be because the financial burden of livestock losses to those with fewer livestock is perceived to be a loss of a greater proportion of total financial wealth. The study highlighted the substantial scope for improvement in livestock management. Theft (34%), drought (30%) and disease (14%) were ranked as the greatest problems facing livestock owners while predators were ranked as the greatest problem by only 4% of respondents.

My findings suggest that wild dogs are generally viewed positively or with ambivalence. Concerns over the potentially increasing threat to livestock, as natural prey numbers outside protected areas decline and wild dogs disperse from natal packs, are likely to be manageable. However, wild dog population expansion within KwaZulu-Natal will continue to rely on managed core populations on perimeter-fenced metapopulation reserves with tolerant communities and landowners contributing to the connectivity of isolated reserves. Generation of tolerance can be instilled through continued advocacy and education, supported by conflict mitigation initiatives and rapid response to conflict reports. The implementation of incentive schemes for adjoining private landowners to co-manage wild dog populations will need to be addressed in conjunction with managed metapopulation practices and law enforcement, to promote range expansion, and reduce potentially lethal edge effects and wild dog-human conflict.

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CHAPTER 1. Introduction

1.1 Description

The African wild dog (wild dog) *Lycaon pictus* is a 20-25 kg, slightly built, highly social carnivore (Creel & Creel 1995; Woodroffe *et al.* 2004). Males tend to be three to seven percent heavier than females (Creel & Creel 2002). Wild dog coat patterns are individually unique and highly variable combining black, white and varying shades of brown (Woodroffe *et al.* 2004). The ears are large and black, a black line runs along the saggital crest and the tails are usually predominantly white. The white tail portion is believed to assist with maintaining visual contact among the pack when moving through thick bush, tall grass or during crepuscular activities (Estes & Goddard 1967). Wild dogs lack dew claws on the front limbs and the pads on the second and third toes are usually partially fused (Creel & Creel 2002; Martinez-Navarro & Rook 2003; Woodroffe *et al.* 2004). Wild dogs can reach running speeds while hunting of over 60 km/hr (Creel & Creel 1995; pers. Obs.). Packs average 13 adults and the trend is towards a male bias in sex ratio (Fuller *et al.* 1992a; Maddock & Mills 1994). This may relate to the increased survival rate of males compared with females (Creel & Creel 2002). A pack usually comprises a dominant breeding pair, subordinate non-breeding adults and subordinate offspring of the alpha pair (Girman *et al.* 1997). However, recent research indicates that shared breeding with subordinates within a pack appears to be more common among wild dogs than was previously thought (Spiering *et al.* 2010).

1.2 Taxonomy

Wild dogs are classified in the family *Canidae.* As the only remaining representatives in the genus *Lycaon* they are phylogenetically unique (Woodroffe *et al*. 1997; Martinez-Navarro & Rook 2003). Wild dogs from East and southern Africa were previously considered to be a distinct sub-species. However, despite genetic and morphological research indicating some regional differences among populations, the features are not sufficiently distinct to merit sub-species classification (Girman *et al*. 1997; Woodroffe *et al.* 1997).

1.3 Distribution

Wild dogs were once distributed throughout much of sub-Saharan Africa (Figure 1.1). However, a distribution status review in 1997 suggests they have been extirpated from 25 of their former 39 range states (Figure 1.2; Woodroffe *et al.* 1997). Viable populations, those which are genetically diverse enough for a population to persist, remain in several countries in southern and eastern Africa, with the largest occurring in northern Botswana, western Zimbabwe, eastern Namibia, north-eastern South Africa, northern Mozambique, southern Tanzania and central Kenya (Woodroffe *et al.* 1997; Woodroffe *et al.* 2004). In South Africa, the wild dog population in the Kruger National Park is currently considered to be the only viable population. The remaining populations in South Africa, which occur within fenced reserves, are spatially isolated from each other as a result of land use changes and the consequent habitat fragmentation in their former range. These populations are collectively managed as a metapopulation within which intermittent emigration or immigration is simulated through actively translocating individuals, single-sex groups or packs, to conserve genetic diversity (Lindsey & Mills 2004). Current reserves in the metapopulation network are Madikwe and Pilanesberg in the North West province, Tswalu in the Northern Cape province, and Hluhluwe-iMfolozi (HiP), Mkhuze (MGR) and Thanda (TPGR) in KwaZulu-Natal province. Populations of wild dogs do also occur outside of formally protected areas in South Africa although these appear to be limited to the Limpopo and Mpumalanga provinces.

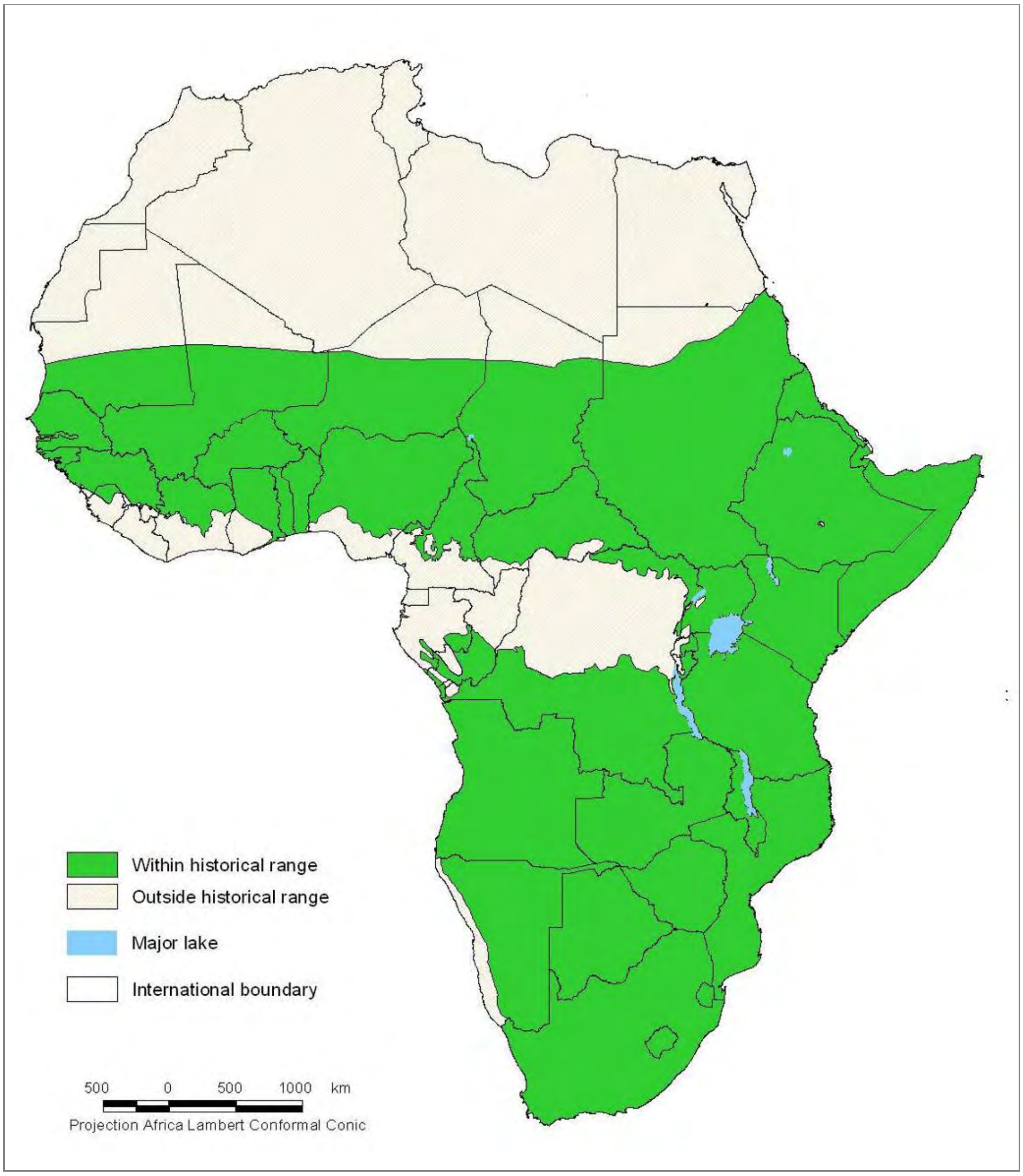

Figure 1.1: The historical range of wild dogs (AMD 2010).

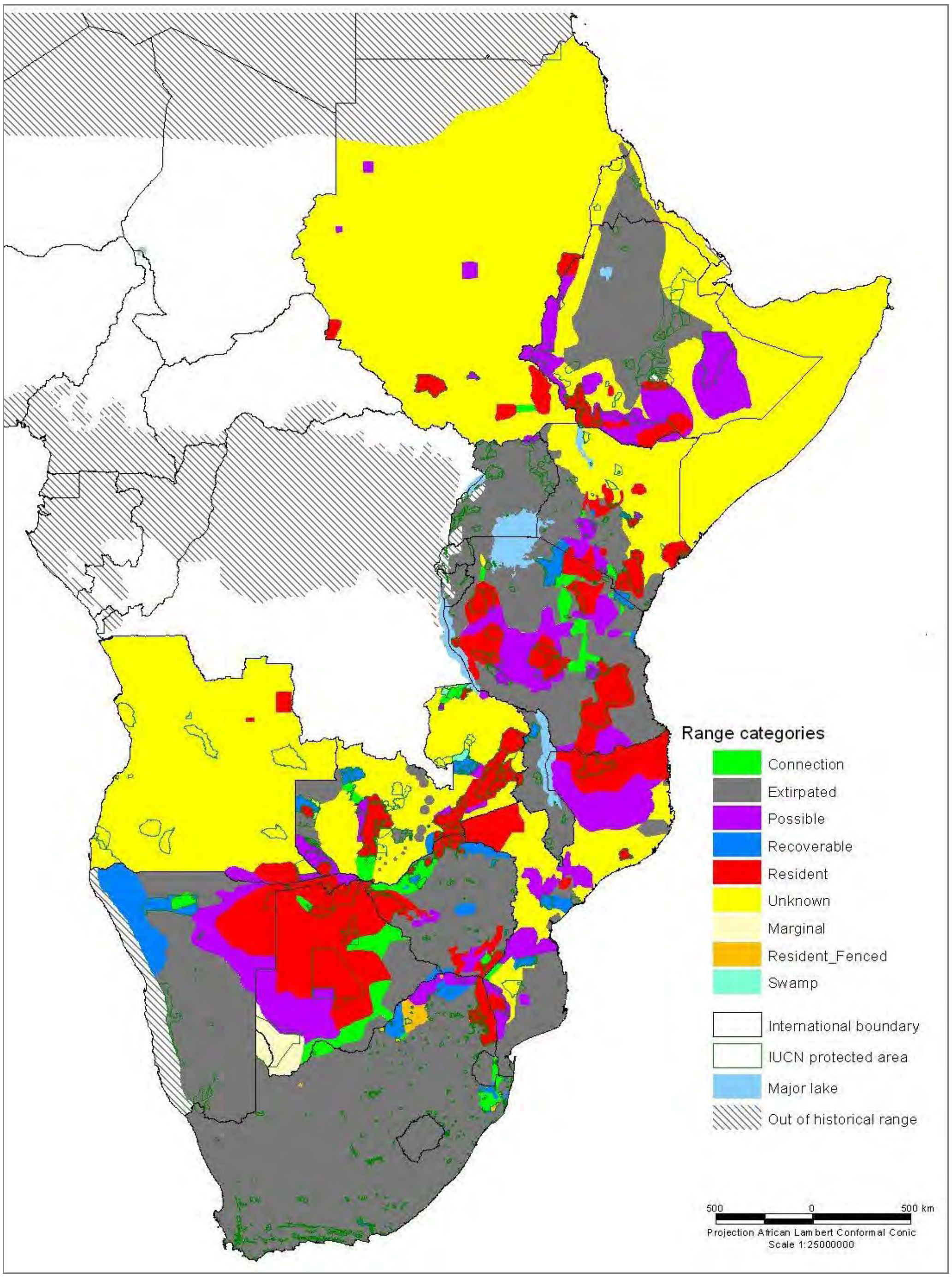

Figure 1.2: The distribution and status of wild dogs in southern and East Africa in 2009 (AMD 2010).

1.4 Conservation Status

There are an estimated 3 000 – 6 000 free-ranging wild dogs left in Africa (Woodroffe *et al.* 1997; Woodroffe *et al.* 2004). Wild dogs are the rarest carnivore in South Africa with an estimated population of less than 400 individuals in 2009 (Lindsey & Davies-Mostert 2009). The KwaZulu-Natal provincial population has increased from 80 individuals in 2006 to approximately 120 in 2010. Despite being legally protected in many of their current range states the remnant populations continue to face widespread persecution (Woodroffe *et al.* 2004). Wild dogs are listed as endangered by the IUCN but are not listed on CITES (Lindsey & Davies-Mostert 2009). In 2009 wild dogs were included on the list of the United Nations Environment Program's Convention on the Conservation of Migratory Species of Wild Animals which serves to facilitate intergovernmental conservation of species across international borders (Lindsey & Davies-Mostert 2009). However, although South Africa is a signatory to this treaty, none of its six neighbours are. In South Africa, management of wild dogs is governed by the National Environmental Management Biodiversity Act (Act No. 10 of 2004) (NEMBA) and by the Threatened or Protected Species (TOPS) regulations (Van der Linde 2006). TOPS regulations classify wild dogs as endangered. In KwaZulu-Natal wild dogs are listed as Specially Protected Game in terms of the Nature Conservation Ordinance, 15 of 1974 and this provides legal protection against killing or capture and defines permit requirements for import and export from the province (Van der Linde 2006).

1.5 Reproduction

Wild dogs are cooperative breeders in which socially subordinate adults assist with rearing of the offspring (Creel *et al.* 1998; Spiering *et al.* 2010). It has generally been considered that wild dogs are monogamous and breeding is restricted to a dominant pair (McNutt 1996a; Girman *et al.* 1997). However, subordinate females do sometimes breed successfully (Moueix 2006; Spiering *et al.* 2010). Recent genetic studies have indicated the existence of multiple sires among pups in a single pack (Burrows 1995; Girman *et al.* 1997; Courchamp & MacDonald 2001; Woodroffe *et al.* 2004; Moueix 2006; Spiering *et al.* 2010).

Wild dogs breed seasonally, usually settling at a den site in May-June towards the end of a gestation which is approximately 70 days (Woodroffe *et al.* 2004). Litter sizes average 8-12pups but can be as many as 21 (Fuller *et al.* 1992a). If a subordinate female gives birth, these pups are either combined in a communal den where suckling is shared amongst the females (Fuller *et al.* 1992a; Courchamp & MacDonald 2001) or she is socially excluded until such point as she cannot maintain her pups and they perish (C. Kelly, pers. comm.).

During early lactation the mother is generally confined to the den and is provisioned with regurgitated meat by members of the pack (Malcom & Marten 1982; Fuller *et al.* 1992a; Courchamp & MacDonald 2001; Woodroffe *et al.* 2004). Pups will begin to consume meat within four weeks of birth (Woodroffe *et al.* 2004). Pups can continue to be fed with regurgitated meat, or with pieces of a carcass brought to the pups for two to three months (Malcom & Marten 1982; Woodroffe *et al.* 2004). Such cooperative behaviour plays a significant role in increasing pup survival and may facilitate the large litter sizes (Malcom & Marten 1982; Burrows 1995; Courchamp & MacDonald 2001). Nevertheless, pup mortalities average 50% in most populations (Woodroffe *et al.* 2004).

1.6 Dispersal Behaviour

Packs are normally formed when same-sex dispersing groups (usually siblings) leave their natal pack and join with dispersing, unrelated, groups of the opposite sex (Malcom & Marten 1982; Fuller *et al.* 1992a; Maddock & Mills 1994; Courchamp & MacDonald 2001; McCreery & Robbins 2001; Woodroffe *et al.* 2004). This occurs when animals are approximately one and a half to two years of age (Fuller *et al.* 1992a; Fuller *et al.* 1992b). Factors such as food availability and natal pack composition likely influence the rate and composition of dispersal groups (Fuller *et al.* 1992a). Dispersing groups have been recorded travelling up to 250km before finding appropriate mates and forming a new pack with which to establish a home range territory (Fuller *et al.* 1992b).

1.7 Diet

Wild dogs are opportunistic carnivores using a cursorial, cooperative hunting strategy to chase down prey (Fanshawe & Fitzgibbon 1993; Mills & Gorman 1997; Krüger *et al.* 1999; Lindsey *et al.* 2004a; Hayward *et al.* 2006). Such a pack hunting strategy can enable metabolic requirements to be met by hunting larger prey than could be caught by an individual dog (Fanshawe & Fitzgibbon 1993; Hayward *et al.* 2006). Killing of prey is primarily through disembowelment (Hayward *et al.* 2006). Wild dogs feed predominantly upon the most abundant medium sized (16-32 kg) or large (120-140 kg) antelope available, although they are able to subsist off smaller prey such as dik-dik *Madoqua kirkii* and hares (Mills & Gorman 1997; Krüger *et al.* 1999; Lindsey *et al.* 2004a; Hayward *et al.* 2006; Woodroffe *et al.* 2007). The bimodal classification of preferred prey weights reflects the foraging success, and energetic cost-benefit dynamics of wild dog packs in relation to varying pack sizes (Hayward *et al.* 2006). A pack size of 12-14 adults maximizes the daily kilograms killed per dog per kilometre chased (Creel 1997a). Geographic variations in prey preference have been associated with regional prey abundance (Ginsberg & Macdonald 1990). In KwaZulu-Natal nyala *Tragelaphus angasii* and impala *Aepyceros melampus* are the prey species favoured by wild dogs (Krüger *et al.* 1999; Lindsey *et al.* 2004a; Hayward *et al.* 2006).

1.8 Conservation challenges

Wild dog populations have declined across the continent as a result of increasingly fragmented habitat, an expanding human population and through direct persecution both within and outside of protected areas (Fuller *et al.* 1992b; Woodroffe *et al.* 1997; Andreka *et al.* 1999; Maddock 1999; Rasmussen 1999; Creel & Creel 2002; Davies & Du Toit 2004; Lindsey *et al.* 2004a; Lindsey *et al.* 2004b). Increased habitat fragmentation can increase a population's susceptibility to stochastic, catastrophic events and can lead to an increasing number of encounters with domestic dogs infected with diseases such as rabies, or may result in a reduction of genetic diversity through inbreeding (Fuller *et al.* 1992b; Kat *et al.* 1995; Woodroffe *et al.* 1997). Wild dogs occur at lower densities than competing carnivores such as lions *Panthera leo* and spotted hyaenas *Crocuta crocuta*, and are susceptible to edge effects such as vehicle collisions, snaring and diseases because of their wide ranging behaviour (Lindsey *et al.* 2004b; Woodroffe & Ginsberg 1999a). The highest priority for wild dog conservation is thus considered to be the maintenance of contiguous, suitable landscapes and the mitigation of lethal edge effects (Fuller *et al.* 1992b; Kat *et al.* 1995; Woodroffe *et al.* 1997; Mills *et al.* 1998; Woodroffe & Ginsberg 1999a; Rasmussen 1999; Creel & Creel 2002; Davies & Du Toit 2004; Woodroffe *et al.* 2004).

A considerable proportion of land in Northern KwaZulu-Natal is under some form of conservation management (private, government and/or conservancy); particularly in the east of the region (Maddock & Benn 2000). The region has been classified within the Maputaland-Pondoland-Albany Hotspot, and maintains globally significant levels of biodiversity and endemism (CEPF 2010). Of concern for biodiversity conservation, and the conservation of wide ranging terrestrial carnivores in particular, is the fragmented configuration of much of this landscape as a result of the diversity of land use, political pressure to develop infrastructure, commercial agriculture requirements and the complexity of opinions among landowners. The initiation of the Zululand Wild Dog Management Forum (renamed the KwaZulu-Natal Wild Dog Management Group (KZNWDMG)) in 2004; acted as a catalyst for the promotion of cooperative wild dog management among a diversity of stakeholders. Few reserves in northern KwaZulu-Natal are capable of sustaining resident wild dog packs due to prey and spatial requirements, financial constraints of reserve and wild dog management, and operating financial models. Perceptions that wild dogs may inflict severe livestock losses, or deplete regionally high-value game species (such as nyala) on neighbouring properties has also increased the reluctance of potential reintroduction reserves to accept resident packs. The convergence of wild dog range expansion objectives, the pack sizes and densities currently in existence in resident reserves, dispersals from resident reserves, and perceptions of regional tolerance towards wild dogs has thus provided an opportunity to investigate the viability of developing safe-passage routes linking KwaZulu-Natal metapopulation reserves.

1.9 Motivation

A Population and Habitat Viability Assessment (PHVA) 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, and re-establishing extirpated populations into protected areas (Mills *et al.* 1998). HiP and MGR are high-priority areas suitable for wild dog packs due to their adequate prey populations, sufficient reserve size and stable conservation status. After several successful reintroductions, resulting in an increasing number of individuals and packs, natural dispersal events have begun to take place. The result is that wild dogs are moving outside of formally protected areas. Inaccurate assumptions of the threat posed by wild dogs rather than direct, experienced conflict generate a significant risk to wild dog persistence. Creating fact-based tolerance towards the species is vital in improving cooperative management among the diversity of stakeholders. Therefore, my research aims to inform cost-effective management decisions and focus community cooperation to secure dispersal routes favoured by wild dogs; particularly when transient on properties which are incapable of, or unwilling to sustain resident packs.

CHAPTER 2. General Description of the Study Sites

2.1 Location

The study was conducted in the northern KwaZulu-Natal province of South Africa (Figure 2.1). Two Ezemvelo KZN Wildlife (EKZNW) reserves, HiP and the MGR section of the isiMangaliso Wetland Park, were selected for community surveys on the basis that they had resident populations of wild dogs. The Endangered Wildlife Trust had also conducted wild dog-specific education initiatives within the communities bordering these two reserves. The study of the variables influencing wild dog dispersal routes outside of protected areas was conducted throughout the northern region of the province to cover all possible dispersal events from the resident populations between 2006 and 2009. At the time of the study three reserves within KwaZulu-Natal held resident populations of wild dogs; HiP, MGR and TPGR (Figure 2.1).

HiP (-*28.217* S *31.742* E) lies approximately 60km north-west of Richards Bay and MGR (-*27.645*˚ S *32.150* ˚E) 140km north of Richards Bay (Figure 2.1). TPGR (-*27.836*˚ S *32.065*˚ E) is located between these two reserves, approximately 20km north of HiP and 20km south-west of MGR (Figure 2.1).

2.2 Regional climate

The humid, sub-tropical climate (Köppen–Geiger Classification System) of northern KwaZulu-Natal is based on seasonal peaks in rainfall and temperature during the summer months of December to March (Jury 1997; Kotek *et al*. 2006). Onshore flows contribute significantly to convective rainfall, high soil temperatures and thus dense vegetation (Jury 1997). Lowest temperatures occur in the winter months of June and July (Richards Bay June mean = Min 12°C – Max 23°C) and coincide with the lowest period of annual rainfall (Richards Bay June mean = 57mm; WeatherSA.co.za). Mean annual rainfall for KwaZulu-Natal is in excess of 800mm (Jury 1997).

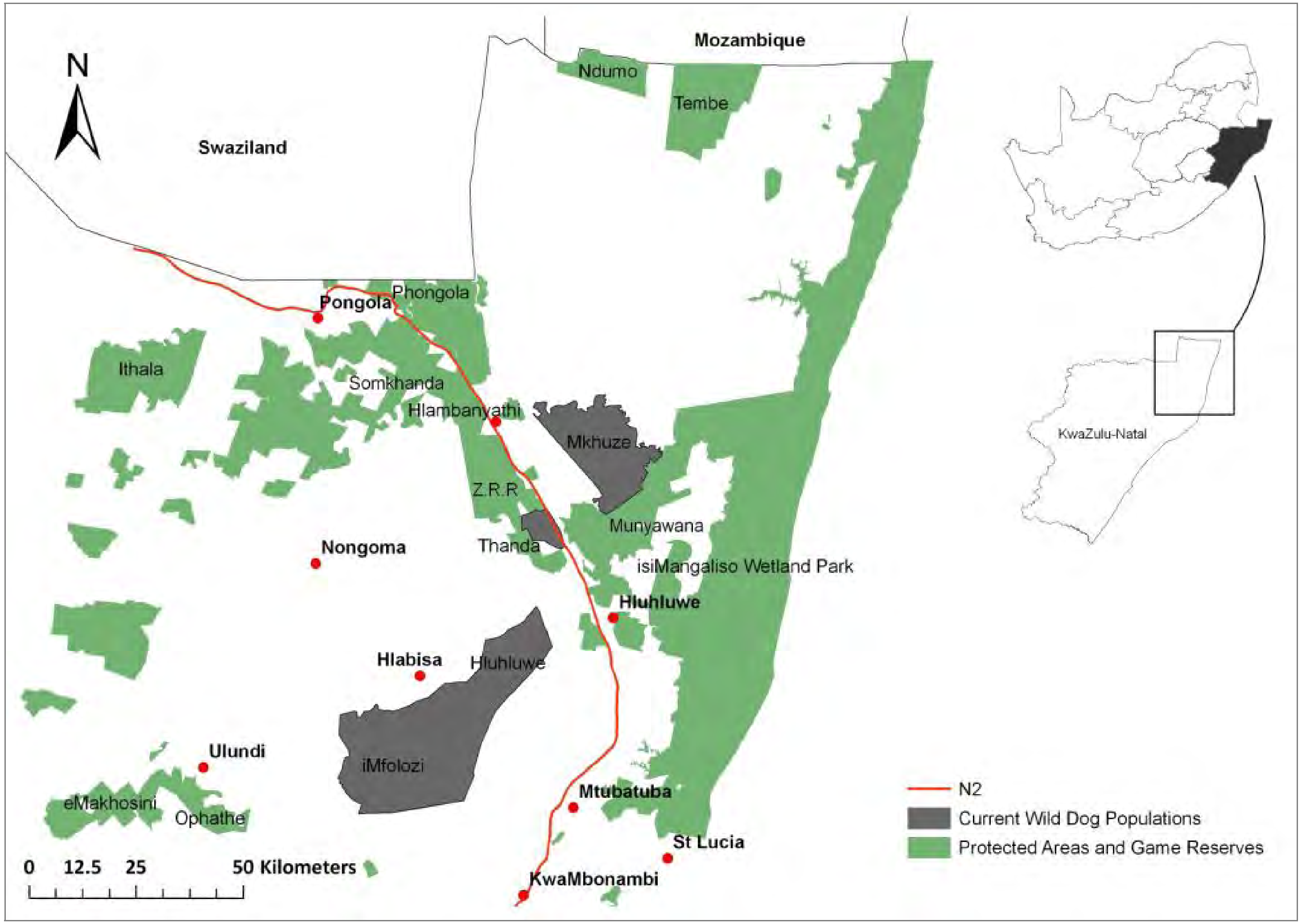

Figure 2.1: Map illustrating the study area within northern KwaZulu-Natal province of South Africa. Game reserves with current wild dog populations, indicated in dark grey, are Hluhluwe-iMfolozi Park, Thanda Private Game Reserve and Mkhuze Game Reserve. The N2 highway runs in a NW – SE direction between Thanda and Mkhuze game reserves.

2.3 Hluhluwe-iMfolozi Park

Site description and history

The Hluhluwe and Umfolozi game reserves were separately proclaimed in 1897. Connected through a corridor of state-owned land, the reserves were formally joined in 1989 to create the 960 km² Hluhluwe-Umfolozi Game Reserve. Completion of the integrated management plan and formal proclamation of the reserve as Hluhluwe-iMfolozi Park is still in process. The reserve is bisected by the tarred R618 district road which runs through the corridor and links the towns of Mtubatuba and Hlabisa (Figure 2.2).

The primary water sources in the reserve are the Black and White iMfolozi Rivers in the south and the Hluhluwe River in the north (Figure 2.2). Numerous pans retain water for varying periods during the dry season and springs tend to be perennial but sparsely located.

In 1932, a campaign to rid the Umfolozi Game Reserve of the trypanosomosis vector, tsetse fly *Glossina sp*., resulted in the mass culling of all ungulate species with the exception of black (*Diceros bicornis*) and white (*Ceratotherium simum*) rhinoceroses (Walker *et al.* 1987). Although this was considered partially successful, in 1931 the Harris Fly Trap was introduced into the reserve and resulted in substantial tsetse fly capture (Emslie 2005). Between 1942 and 1946 the most severe trypanosomosis outbreak experienced in Zululand killed more than 60 000 cattle (Emslie 2005). Mass extermination of wild ungulates was once again carried out and by 1952 blue wildebeest *Connochaetes taurinus* and Burchell's zebra *Equus quagga* had been extirpated from Umfolozi Game Reserve. From 1946 until 1952 extensive spraying of the insecticide DDT (dichlorodiphenyltrichloroethane) was also carried out in Zululand. By 1954 the tsetse fly *G. pallides* was considered to have been exterminated, *G. austeni* and *G. brevipalpis* were considered largely reduced, and the spread of livestock trypanosomosis appeared to be contained (Brown 2008). However, in 1990 serious trypanosomosis outbreaks were once again being reported in the region (Emslie 2005). From 1952 ungulate species recolonized Umfolozi Game Reserve from the Hluhluwe Game Reserve and by 1959 management of the reserve implemented new culling regimes to limit perceived grazing competition with white rhinoceros (Walker *et al.* 1987).

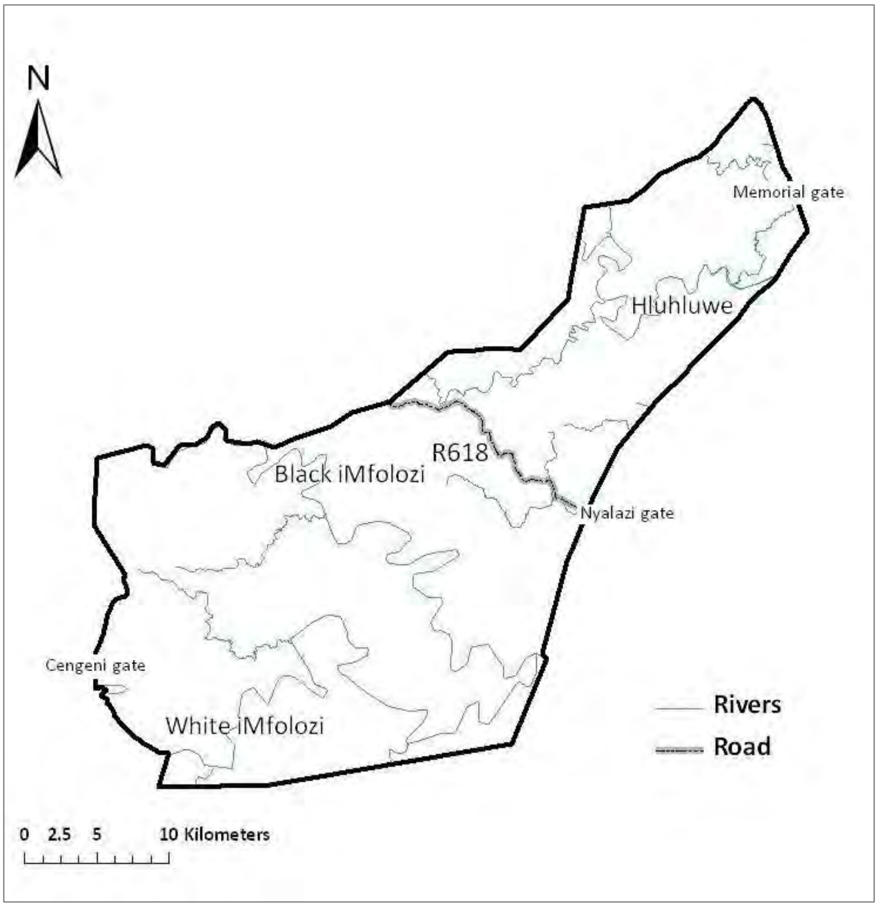

Figure 2.2: The primary river courses of Hluhluwe-iMfolozi Park.

Fauna

Lions, wild dogs, brown hyaena *Parahyaena brunnea* and cheetah *Acinonyx jubatus* were extirpated from the reserves by 1920 through vermin control (Walker *et al.* 1987). Leopards *Panthera pardus* and spotted hyaenas are indigenous to the reserve and although hunted, they were never extirpated. Lions were reintroduced into the reserve in 1958, cheetahs in 1965 and wild dogs in 1980. The most favoured prey species for wild dogs in the reserve, impala and nyala, are also the most abundant antelope species (Table 2.1; Krüger *et al.* 1999).

Twenty two wild dogs, sixteen of which were captive reared, were reintroduced into HiP in four stages from 1980 until September 1981 and formed a single pack (Maddock 1999). Four additional wild dogs were introduced in 1986 but emigrated from the reserve shortly thereafter (Maddock 1999, Gusset *et al.* 2006).The maximum pack size fluctuated between 28 animals in 1986 and seven animals in 1995 (Maddock 1999). Additional introductions took place in 1997 (3 males + 1 female), 2001 (2 males + 2 females), 2003 (5 males + 3 females), 2006 (3 females), 2008 (1 male) and 2008 (3 females). The population currently comprises 81 adults and yearlings and 24 pups in nine packs. Although wild dogs were recorded to have left HiP sporadically since 1984, with the exception of *ad hoc* reports from members of the public or from private game reserves, the routes or fates of many of these dogs are unknown (Maddock 1999). However, the dispersal of two female wild dogs from HiP to TPGR in 2004 was the catalyst for a formal wild dog reintroduction into that reserve in 2005 (ZWDMF 2005).

Table 2.1: Predator and prey population numbers for Hluhluwe-iMfolozi Park determined through walked and aerial transects (2010). *Black and White rhinoceros numbers are excluded for security reasons (HiP Game Census 2010).

Species	Total
Black rhinoceros	*
Buffalo	4 789
Cheetah	40
Elephant	550
Giraffe	874
Hippopotamus	20
Impala	14 054
Kudu	717
Leopard	80
Lion	200
Nyala	4 082
Spotted hyaena	303
Warthog	1 531
Waterbuck	136
White rhinoceros	*
Wild dog	105
Wildebeest	3 002
Zebra	2 749

Topography and geology

The hilly terrain in the reserve ranges in elevation from 60 to 750m a.s.l. (Boundja & Midgley 2010). The larger rivers have alluvial floodplains while rocks and clays are generally found on slopes and hilltops (Boundja & Midgley 2010). Soils are derived from Ecca shales and sandstone of the Karoo system, as well as dolerite intrusions (Walker *et al*. 1987).

Rainfall

Climatic data were taken from published and unpublished reports generated by Hluhluwe Research Centre, HiP. Mean annual rainfall in the reserve ranges from 600 to 1 000mm; with a peak in the summer months of October to April (Boundja & Midgley 2010). Annual rainfall is affected by altitude within the reserve, resulting in the higher Hluhluwe reserve experiencing on average 22.7mm/month more rainfall than the lower lying iMfolozi reserve over the study period (Archibald *et al*. 2005). Both reserves are currently experiencing what is considered to be below average annual rainfall (Figure 2.3; Walker *et al*. 1987; Archibald *et al*. 2005; ZLTP unpublished).

Temperature

Daytime temperatures in HiP range from 13°C to 35°C (Greyling & Huntley 1984). Over the study period mean monthly temperature peaked from November to March (Figure 2.4). During the winter months, although evening temperatures dropped below 10°C, mean daytime temperatures rarely dropped below 16°C (ZLTP unpublished).

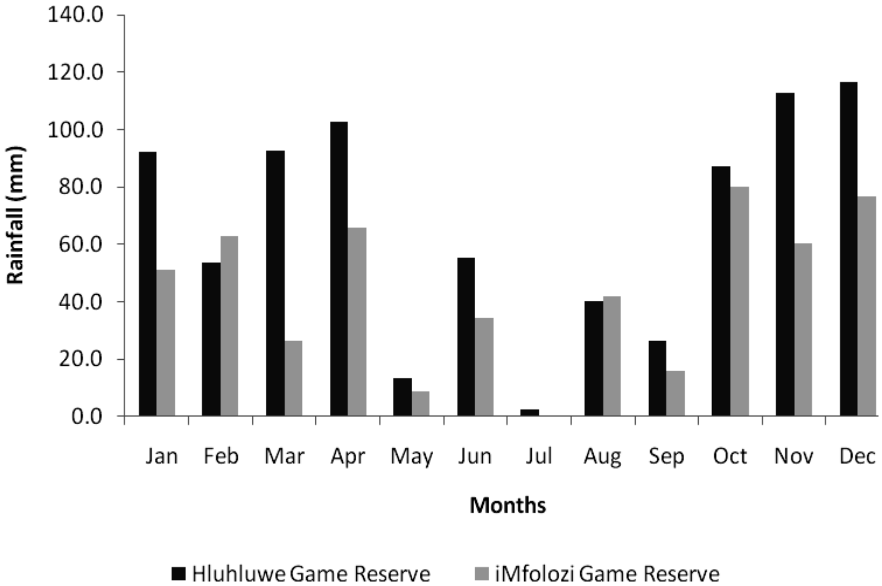

Figure 2.3: The mean monthly rainfall for Hluhluwe and iMfolozi game reserves over the study period of 2006 – 2009 (ZLTP unpublished).

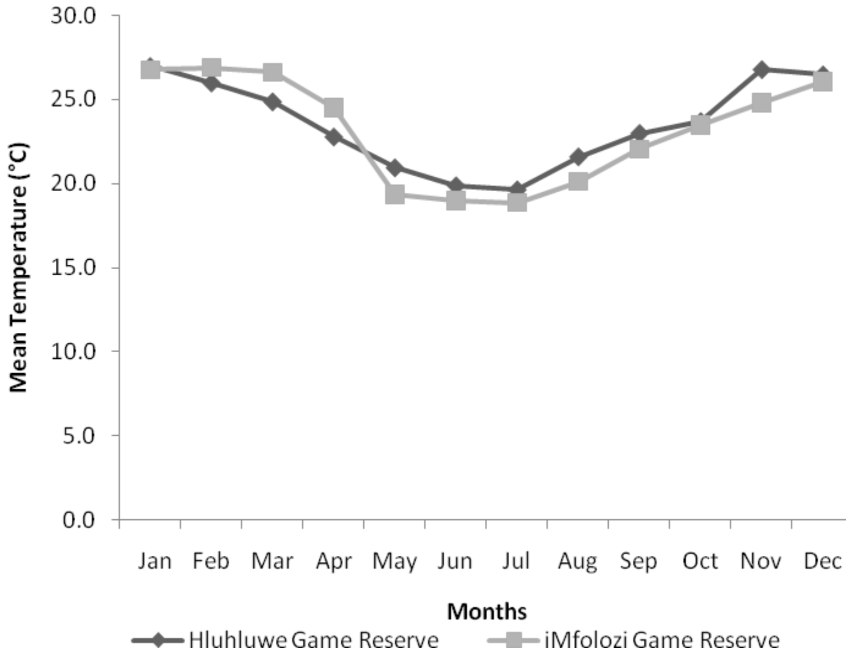

Figure 2.4: The mean monthly temperatures for Hluhluwe and iMfolozi game reserves over the study period of 2006 – 2009 (ZLTP unpublished).

Vegetation

The reserve is situated in the southern African savannah biome and characterized by high habitat heterogeneity (Cromsigt *et al.* 2009). Habitats range from open grasslands to closed *Acacia* and broad-leaved woodlands (Whateley & Porter 1983). Northern Zululand Sourveld represents about 30% of the reserve's vegetation; Zululand Lowveld represents about 60% and Scarp Forest less than 10% (Figure 2.5; Mucina & Rutherford 2006). The dominant tree species include *Acacia karroo, A. nilotica, A. nigrescens, A. tortillis, Spirostachys africana* and *Sclerocarya birrea* (Boundja & Midgley 2010). Grasses in the bunch-grass communities are dominated by *Themeda triandra, Sporobolus pyramidalis and Eragrostis* curvula, and on the grazing lawns by palatable grasses such as *Urochloa mosambicensis*, *Digitaria longifolia* and *Panicum coloratum* (Archibald *et al.* 2005).

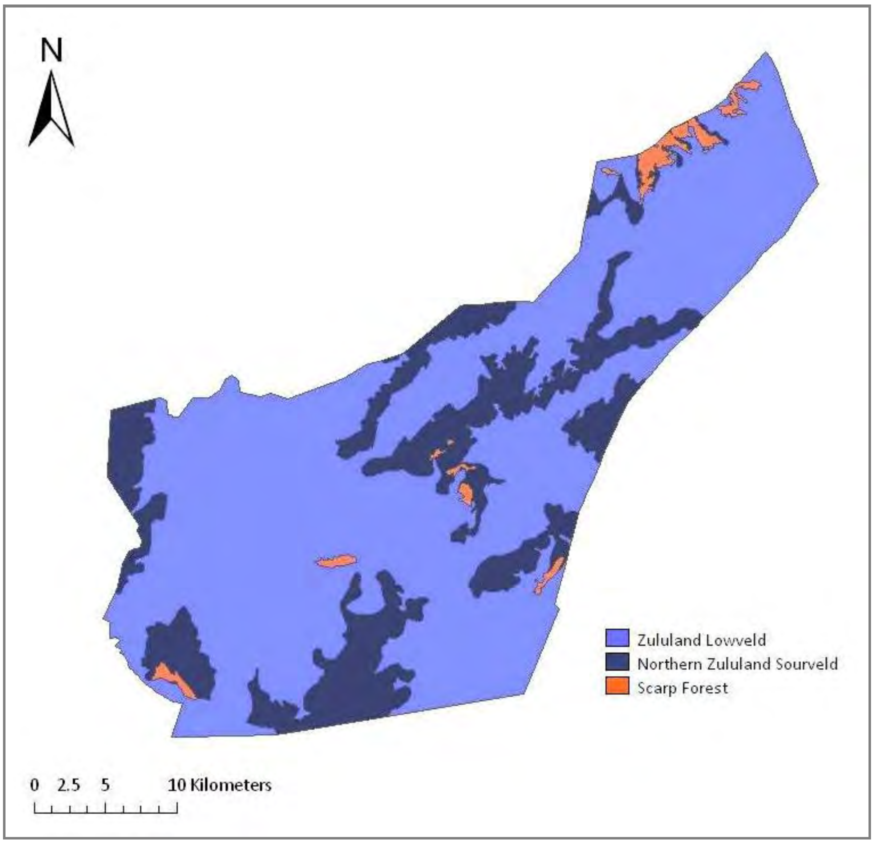

Figure 2.5: Vegetation map of Hluhluwe-iMfolozi Park (Mucina & Rutherford 2006).

2.4 Mkhuze Game Reserve – isiMangaliso Wetland Park

Site description and history

Mkhuze Game Reserve (MGR), located on the coastal plain east of the Lebombo Mountains, was proclaimed in 1912. Initially a 250km^2 reserve, it was expanded in 1984 by the inclusion of the 55km^2 Nxwala Estate. Subsequent acquisitions of several smaller properties between 1990 and 1992 expanded the reserve to its current size of approximately 370km^2 (Greyling & Huntley 1984; Mulqueeny 2005; White & Goodman 2009). In 1999 the Greater St Lucia Wetland Park (renamed isiMangaliso Wetland Park in 2007) was proclaimed a World Heritage Site. In 2000 the World Heritage Site status was extended to include MGR.

In 1917, 25 000 wildebeest were shot in an attempt to eradicate tsetse fly from MGR. Similar attempts between 1942 and 1950 resulted in the culling of 38 500 game animals (Mulqueeny 2005). Subsequent DDT spraying and trapping finally resulted in the eradication of the fly over much of its initial range (Mulqueeny 2005).

Two major rivers flow through the reserve, the Mkhuze River which forms the northern boundary and the Msunduze River which flows through the southern section (Figure 2.6; Mulqueeny 2005). Although there is usually no flow in the Mkhuze River during the winter months, the summer months regularly see the river overflowing onto the surrounding floodplains (Patrick & Ellery 2007) . Seasonal streams feed the 2.5km^2 Nsumu and smaller Nhlonhlela pans and the lower Mkhuze floodplain, and several seasonal pans occur throughout the reserve.

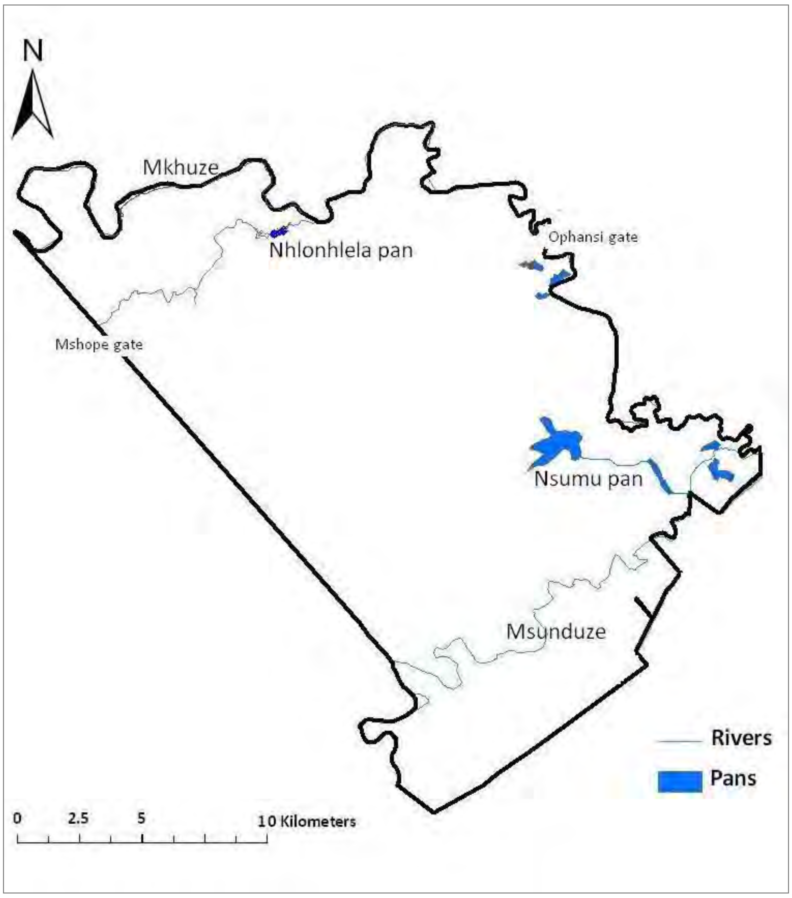

Figure 2.6: The primary river courses of Mkhuze Game Reserve.

Fauna

Among the herbivores in MGR both white rhinoceros and giraffe *Giraffa camelopardalis* are considered to have been introduced as historical records suggest they did not previously occur in the area (Mulqueeny 2005). However, elephants *Loxodonta africana* and buffaloes *Syncerus caffer* were reintroduced into the reserve in 1994 and 2006 respectively (Table 2.2; Mulqueeny 2005; White & Goodman 2009). Leopards, spotted hyaenas and brown hyaenas persisted in the reserve despite previous persecution, while cheetahs were reintroduced in 2006.

An initial wild dog pack of five males, bonded over several months to an adult female and her seven six-month old pups, was released into the reserve in early 2005. Despite several fatal snaring incidents and the loss of individuals through single-sex dispersals and encounters with competing predators, the pack persisted until 2008. In 2008 the remaining six wild dogs were further reduced to a pair due to snaring, predators and a vehicle collision. The remaining two animals included a yearling female which had in 2008 dispersed from TPGR to MGR and an adult male. This pair was placed in the holding boma facility at the Hlambanyathi Private Game Reserve and plans were initiated to source wild dogs for an introduction of two packs into MGR. This process is currently underway and wild dogs are being bonded in the MGR boma.

Topography and geology

The altitude of the reserve varies from 30m a.s.l. in the south-east to 480 m at the foot hills of the Lebombo Mountains in the north-west (Smith & Goodman 1986). Complex geological formations, tectonic movements and erosion processes have resulted in a high variety of soil forms (Greyling & Huntley 1984). The trend is for soil depth and clay content to increase from the higher lying western regions to the lower valleys and plains in the East (Goodman 1990; Mulqueeny 2005). Eight simplified geological types have been classified in MGR; marsh, young alluvium, old alluvium, orange to red dune cordon sand, siltstone and sandstone, glauconitic marine sandstone, conglomerates and rhyolite (Goodman 1990; Mulqueeny 2005).

Table 2.2: Predator and prey population numbers for Mkhuze Game Reserve (2010). Black and White rhinoceros numbers are excluded for security reasons (MGR Game Census 2010).

Species	Total
Black rhinoceros	*
Buffalo	280
Cheetah	12
Elephant	75
Giraffe	55
Grey duiker	200
Hippopotamus	84
Impala	9 050
Kudu	300
Leopard	40
Nyala	5 850
Red duiker	1 200
Spotted hyaena	60
Steenbok	50
Suni	350
Warthog	1 000
Waterbuck	50
White rhinoceros	*
Wild dog	17
Wildebeest	1 550
Zebra	850

Rainfall

Climatic data were taken from published and unpublished reports generated by MGR management. Long-term rainfall data (1951-2005) indicate a seasonal, summer rainfall pattern with a peak in February and a low in July (Figure 2.7; Mantuma Climate Summary 2010). Over the period of this study (2006-2009) however, mean monthly rainfall peaked in November (Figure 2.7). Mean annual rainfall is 628 – 671mm (Greyling & Huntley 1984; Mulqueeny 2005). Annual rainfall shows a gradient with the higher lying western area receiving marginally more precipitation than the lower lying valleys in the east (Mulqueeny 2005).

Temperature

The mean annual temperature in MGR is 23°C (Mantuma Climate Summary 2010). January is the hottest month with a mean maximum of 31°C although temperatures can exceed 41°C (Figure 2.8). Although July is the coldest month with a mean minimum of 12°C, it is still relatively warm with a mean temperature of 19°C. Temperatures have on occasion dropped to 6°C in June, July and August. No temperature data were available for Mantuma camp over the study period of 2006 – 2009.

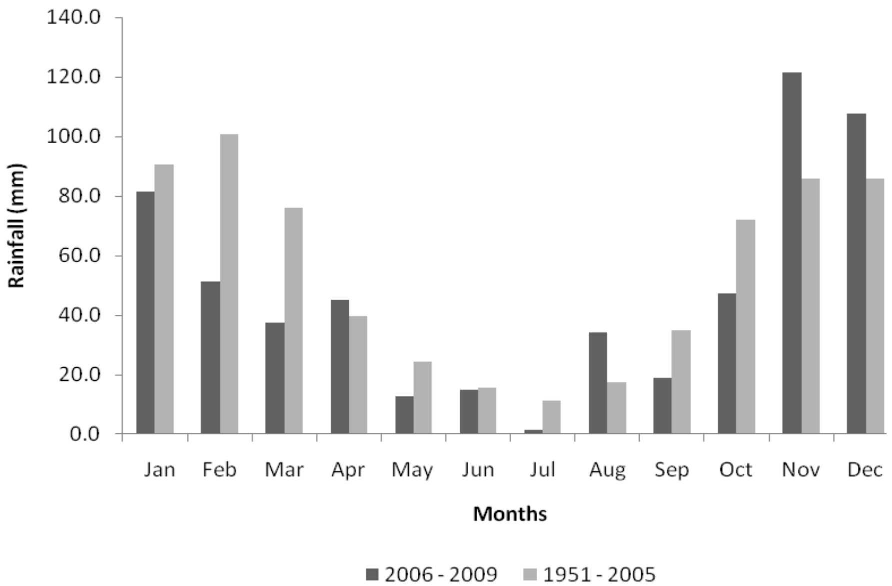

Figure 2.7: The mean monthly rainfall for Mantuma Camp, Mkhuze Game Reserve, over the study period of 2006 - 2009 and long-term 1951-2005 (Mantuma Climate Summary 2010).

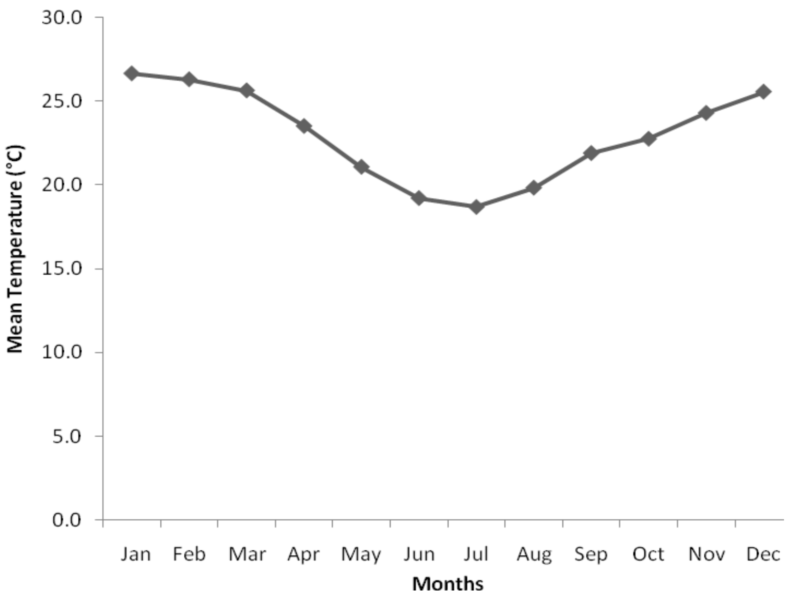

Figure 2.8: The mean monthly temperature for Mantuma Camp, Mkhuze Game Reserve, for the period 1980 – 2000 (Mantuma Climate Summary 2010).

Vegetation

The reserve is situated in the southern African savannah biome and as a result of the complex variety of geology and soils, is characterized by high habitat diversity. Mkhuze Game Reserve is classified into nine broad vegetation types; Southern Lebombo Bushveld and Western Maputaland Sandy Bushveld dominated by *Terminalia sericea*, *A. nilotica*, *A. tortillis*, *A. nigrescens and Combretum apiculatum;* Makatini Clay Thicket, Western Maputaland Clay Thicket dominated by *A. luederitzii* and *Euclea divinorum*; Lowveld Riverine Forest and Sand Forest dominated by *Ficus sycomorus* and *A. xanthophloea*; Subtropical Freshwater Wetlands; Maputaland Coastal Belt and Subtropical Salt Pans (Figure 2.9; Mucina & Rutherford 2006). Dominant grasses are *T. triandra*, *Bothriachloa insculpta* and *Aristida congesta* (Greyling & Huntley 1984).

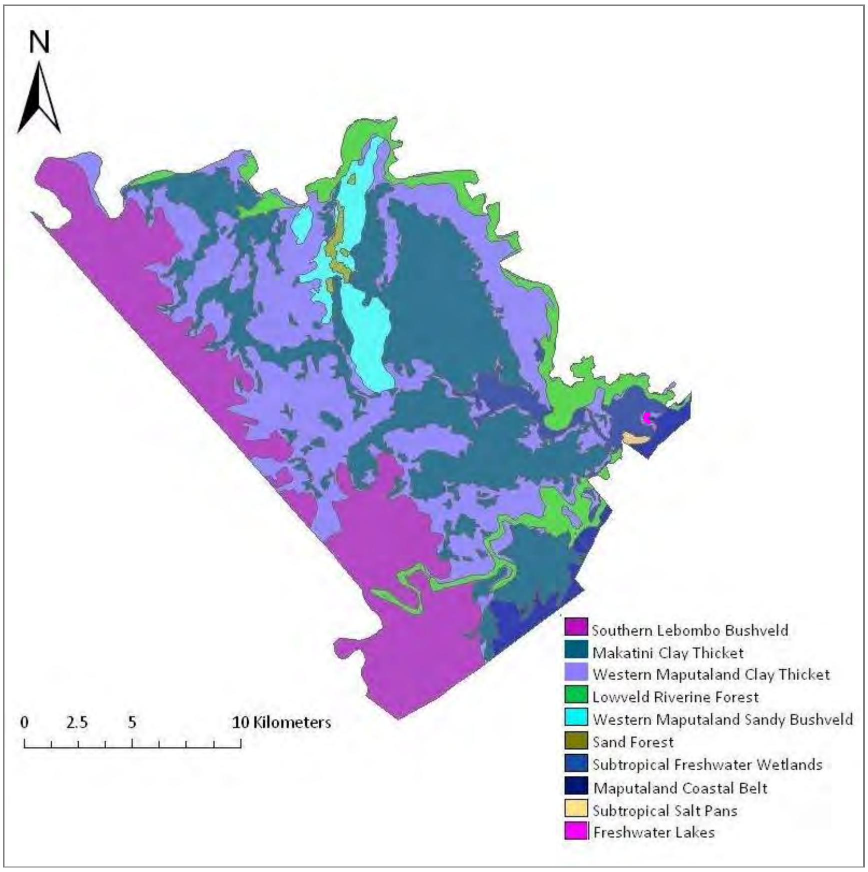

Figure 2.9: Vegetation map of Mkhuze Game Reserve (Mucina & Rutherford 2006).

2.5 Additional conservation areas of importance

Game reserves

The study area also incorporates a combination of government, private and community owned game reserves; several of which hold significance for the creation of contiguous wild dog dispersal linkages (Figure 2.1; Table 2.3). Although these are only a selection of all the conservation areas found in the northern KwaZulu-Natal region, they are game reserves through which dispersing dogs have either passed or resided temporarily between 2006 and 2009. Within this selection of reserves, TPGR currently has a resident pack of wild dogs as a result of a single-sex dispersal event from HiP in 2004 followed by subsequent supplementary introductions of two males and females from HiP and Venetia-Limpopo Game Reserve respectively in 2006. The population has fluctuated as a result of successful breeding, dispersal events and sporadic depredation by lions (KZNWDMG 2007). The pack currently comprises three adults and four pups (KZNWDMG 2010).

Tribal Authorities

Tribal authorities are areas which fall under historically traditional leadership of a king and chief. Although they are dependent on state support and occur within provincial wards, they are distinct from democratically appointed local government which manages the administrative and logistical bureaucracy of the area (Van Kessel 1997). Ten tribal authorities; Hlabisa, Mhlana, Mpukunyoni, Mdletshe, Mpembeni, Mandlakazi, Obuka, Somopho, Ximba and Zungu border HiP (Table 2.4; See Chapter 4). Two tribal authorities border MGR, Jobe to the north-east and Ngwenya to the south-west. Mandlakazi is spatially the largest tribal authority although it is divided into two parts, the majority of which is isolated from the reserve by the Hlabisa, Mdletshe and Mpembeni tribal authorities. Tribal authority land is comprised of a matrix of vegetation patches used for livestock grazing and hunting, subsistence agriculture, clustered or sparse rural dwellings, urban development, small-scale commercial sugar cane and forestry plantations.

Zululand Lowveld is the predominant vegetation type within all of the tribal authorities although Ngongoni Veld, Northern Zululand Sourveld, Maputaland Coastal Belt, Makatini Clay Thicket, Sand Forest, Scarp Forest, Southern Lebombo Bushveld, Subtropical Freshwater Wetlands, Tembe Sandy Bushveld, and Western Maputaland Clay Bushveld are all represented within tribal authority land.

Table 2.3: Game reserves in northern KwaZulu-Natal of importance for the creation of contiguous wild dog dispersal linkages.

Property name	Size (km²)	Annual rainfall (mm)	Vegetation classification (Mucina & Rutherford 2006)	Location
Emakhosini-Opathe	280	685	Ngongoni Veld, Northern Zululand Sourveld, Zululand Lowveld	Ulundi
Hlambanyathi	58	670	Northern Zululand Sourveld, Zululand Lowveld	Mkuze
isiMangaliso Wetland Park (excl. MGR)	1 900	700 -1 500	Lowveld Riverine Forest, Maputaland Coastal Belt, Maputaland Wooded Grassland, Mangrove Forest, Northern Coastal Forest, Subtropical Coastal Lagoons, Subtropical Freshwater Wetlands, Subtropical Salt Pans, Subtropical Seashore Vegetation, Swamp Forest, Tembe Sandy Bushveld	Hluhluwe
Ithala	258	791	Ithala Quartzite Sourveld, Northern Zululand Mistbelt Grassland, Northern Zululand Sourveld, Swaziland Sour Bushveld, Zululand Lowveld	Louwsburg
Munyawana	226	769	Lowveld Riverine Forest, Maputaland Coastal Belt, Sand Forest, Southern Lebombo Bushveld, Western Maputaland Clay Bushveld, Zululand Lowveld	Mkuze
Somkhanda	160	626	Northern Zululand Sourveld, Zululand Lowveld	Mkuze
Thanda	67	610	Zululand Lowveld	Hluhluwe
Zululand Rhino Reserve	230	600	Zululand Lowveld	Mkuze

Table 2.4: Tribal authorities bordering HiP and MGR.

Tribal authority	Size (km²)	Neighbouring protected area	Vegetation classification (Mucina & Rutherford 2006)
Hlabisa	132	HiP	Northern Zululand Sourveld, Scarp Forest, Zululand Lowveld
Mandlakazi	1 308	HiP	Zululand Lowveld
Mdletshe	373	HiP	Northern Zululand Sourveld, Scarp Forest, Zululand Lowveld
Mhlana	517	HiP	Maputaland Coastal Belt, Northern Zululand Sourveld, Zululand Coastal Thornveld, Zululand Lowveld
Mpembeni	111	HiP	Maputaland Coastal Belt, Northern Zululand Sourveld, Zululand Coastal Thornveld, Zululand Lowveld
Mpukunyoni	804	HiP	Northern Zululand Sourveld, Scarp Forest, Zululand Lowveld
Obuka	507	HiP	Ngongoni Veld, Northern Zululand Sourveld, Zululand Lowveld
Somopho	99	HiP	Northern Zululand Sourveld, Scarp Forest, Zululand Lowveld
Ximba	297	HiP	Northern Zululand Sourveld, Zululand Lowveld
Zungu	319	HiP	Northern Zululand Sourveld, Zululand Lowveld
Jobe	100	MGR	Lowveld Riverine Forest, Maputaland Coastal Belt, Sand Forest, Subtropical Freshwater Wetlands, Subtropical Salt Pans, Tembe Sandy Bushveld, Western Maputaland Clay Bushveld
Ngwenya	131	MGR	Southern Lebombo Bushveld, Western Maputaland Clay Bushveld, Zululand Lowveld

CHAPTER 3. Factors influencing potential dispersal routes of African Wild Dogs in northern KwaZulu-Natal

3.1 Introduction

Predation by large carnivores has a profound structuring influence on ecosystems (Terborgh 1992; Treves & Karanth 2003), and the loss of top predators can have important consequences for the survival of other species within the carnivore's habitat (Terborgh 1992; Treves & Karanth 2003; Ripple & Beschta 2004). Predators not only consume prey species, but can also change the spatial and temporal behaviour, and physiology of potential victims (Schneider 2001). Competition for resources, perceived or realized threat, and negative influences on economic security can all lead to conflicts between humans and carnivores (Sillero-Zubriri & Macdonald 1997; Breitenmoser 1998; Berg 2001; Linnell *et al.* 2001; Conforti & de Azevedo 2003). Due to comparatively low population densities and narrow trophic niche requirements (Layman *et al.* 2007), predators are often among the elements of biodiversity most vulnerable to persecution, reduced food availability and habitat fragmentation (Terborgh 1992; Treves & Karanth 2003; Ripple & Beschta 2004; Layman *et al.* 2007).

Because of the large area requirements of wide-ranging carnivores such as wild dogs, cougars *Puma concolor*, Iberian lynx *Lynx pardinus* and wolves *Canis lupus*, habitat fragmentation is one of the most significant threats to the persistence of these species (Beier 1995; Woodroffe & Ginsberg 1998; Sweanor *et al*. 2000; Tigas *et al.* 2002; Ogada *et al.* 2003; Woodroffe 2010). Habitat fragmentation occurs primarily as a result of urbanization or transformation of rural landscapes through agriculture (Palomares *et al.* 2000; Sweanor *et al.* 2000; Dickson & Beier 2002; Maehr *et al.* 2002; Tigas *et al.* 2002). Carnivores are also increasingly exposed to anthropogenic threats such as vehicle collisions, snares and direct persecution as they disperse beyond natal home ranges, within fragmented landscapes (Woodroffe & Ginsberg 1998; Palomares *et al.* 2000; Sweanor *et al.* 2000; Dickson & Beier 2002; Tigas *et al.* 2002; Ogada *et al.*

2003; Woodroffe 2010). Thus, to conserve carnivores within heterogeneous landscapes, spatial attribute selection and threats which can influence successful long-range dispersals beyond resident protected areas must be identified and understood (Beier 1995; Palomares *et al.* 2000; Sweanor *et al.* 2000; Chavez & Gese 2006). Furthermore, an understanding of the influence of these variables on dispersal can be used to develop pragmatic strategies for the management of contiguous landscapes linking core populations of large carnivores (Simberloff & Cox 1987; Palomares *et al.* 2000; Sweanor *et al.* 2000; Dickson & Beier 2002; Tigas *et al.* 2002). Additionally, a deterioration of the suitability of connective landscapes can isolate sub-populations and reduce viability, thereby increasing the risk of carnivore sub-population extinctions (Sweanor *et al.* 2000).

Dispersal is defined as the movement of an animal from its natal range upon reaching independence (Bekoff 1989; Beier 1995; Thompson & Jenks 2005) and the route taken is a function of interacting ecological features, and environmental and social pressures (Palomares *et al.* 2000; Sweanor *et al.* 2000; Dickson & Beier 2002; Tigas *et al.* 2002). Such a route may include habitat characteristics and resources found within ideal home range landscapes but may also include a matrix of unsuitable habitat patches (e.g. croplands) or artificial features such as multiple-lane highways and culverts which would not ordinarily be found or used within a resident range (Harrison 1992; Sweanor *et al.* 2000; Maehr *et al.* 2002; Tigas *et al.* 2002; Mitchell & Powell 2008). The direction of dispersal routes may be influenced by artificial barriers such as fences, roads and railways, although this would depend on whether such barriers could cause dispersal interruption, or are semi-permeable to a particular species (Sanchez-Prieto *et al.* 2010). Natural barriers which have the potential to induce complete isolation for populations or block dispersing carnivores include rivers, mountain ranges and deserts (Beier 1995; Palomares *et al.* 2000; Sweanor *et al.* 2000; Maehr *et al.* 2002; Tigas *et al.* 2002; Sanchez-Prieto *et al.* 2010). Additionally, artificial barriers such as dams, canals and cities can also isolate populations (Maehr *et al.* 2002; Tigas *et al.* 2002; Sanchez-Prieto *et al.* 2010).

While habitats with resident populations will need to supply enough resources to sustain these populations, habitats used during dispersal need only provide the ecological resources to enable the dispersing animals to be transient (Palomares *et al.* 2000). When considering the recolonization of suitable habitat by dispersing groups or individuals, as was the case with wolves from south-eastern Canada into the north-eastern United States of America (USA), factors such as distance from the source population, habitat conditions *en route*, human attitudes and hunting quotas were all considered to be important (Wydeven *et al.* 1998).

Dispersal and recolonization from expanding, resident carnivore populations can have negative consequences for both the species and agricultural operations as the likelihood for conflict with livestock can increase (Wydeven *et al.* 1998; Maehr *et al.* 2002; Marucco & McIntire 2010). In the Italian Alps, wolf dispersals occurred through unfavourable habitat and on occasion resulted in packs setting up residence in larger expanses of higher quality habitats where livestock farming was prevalent (Marucco & McIntire 2010).

Linkages, or corridors, are narrow pieces of habitat that connect and increase the movement of fauna and flora between suitable habitat patches, when compared to general non-habitat matrices (Gilbert-Norton *et al.* 2010). Dispersals and immigrations can result in recruitment for new or existing populations; they can increase overall population size, allow for buffering against stochastic events and reduce inbreeding which maintains the population viability (Stratman *et al.* 2001; Dickson & Beier 2002; Maehr *et al.* 2002). Restoring and/or facilitating the persistence of natural dispersal linkages can therefore reduce the need for intensive metapopulation management currently required to maintain viability of some isolated or fragmented carnivore populations (Palomares *et al.* 2000; Dickson & Beier 2002; Maehr *et al.* 2002; Tigas *et al.* 2002; Davies-Mostert *et al.* 2009). Such intensive metapopulation management can be both financially and logistically costly; particularly when it relates to capture and transport of animals (Lindsey *et al.* 2005c). Establishment and maintenance of landscape linkages can however also incur management costs through land purchases, fencing or overpass construction which may supersede that of animal transfer (Simberloff & Cox 1987). Furthermore, such linkages may have negative side-effects which reduce source-population viability by diluting population-characteristic genotypes, facilitating the spread of potentially contagious diseases and fires and exposing wild animals to domestic animals; or vice versa (Simberloff & Cox 1987; Fahrig & Merriam 1994).

In South Africa, most wild dog populations occur on game reserves with largely unmodified land cover and low human densities (Lindsey *et al.* 2004b). The Kruger National Park is currently the only reserve in the country considered sufficiently large enough to maintain a viable population of wild dogs (Mills *et al.* 1998). The remaining wild dogs within protected areas in South Africa are collectively managed as a metapopulation; an arrangement of isolated subpopulations (Mills *et al.* 1998; Lindsey *et al.* 2004b; Lindsey *et al.* 2005c; Akçakaya *et al.* 2007; Davies-Mostert 2010). In KwaZulu-Natal, resident wild dog populations currently occur in HiP, MGR and TPGR all of which are bordered by a matrix of natural habitats and human settlements. Land outside these protected areas could be utilized to expand wild dog distribution and provide connectivity between existing resident populations of wild dogs within KwaZulu-Natal (Lindsey *et al.* 2004b). Wild dogs are considered endangered primarily due to the threats they encounter as a result of their wide-ranging behaviour (Woodroffe & Ginsberg 1999a; Woodroffe 2010). These threats, including human persecution and diseases carried by domestic dogs, are similar to those already outlined to be facing large carnivores elsewhere in the world (Harrison 1992; Sweanor *et al.* 2000; Maehr *et al.* 2002; Tigas *et al.* 2002; Mitchell & Powell 2008).

Wild dog packs are usually formed when same-sex dispersing groups (usually siblings) leave their natal pack and join with dispersing, unrelated, groups of the opposite sex (Malcom & Marten 1982; Fuller *et al.* 1992a; Maddock & Mills 1994; Courchamp & MacDonald 2001; McCreery & Robbins 2001; Woodroffe *et al.* 2004; Davies-Mostert 2010). Contradictory information exists regarding sex-biased dispersal trends among wild dogs (Frame & Frame 1976; Fuller *et al.* 1992a; McNutt 1996a). Frame & Frame (1976) demonstrated female-biased dispersal in the Serengeti, Tanzania. However, McNutt (1996a) showed that wild dogs in northern Botswana had male-biased dispersal and Fuller *et al.* (1992a) found populations in East and southern Africa where both males and females dispersed without any particular bias. It is suggested that when no mating opportunities exist within the natal home range, both sexes will disperse (McNutt 1996a; Davies-Mostert 2010). Nevertheless, males tend to delay dispersal longer, disperse in larger groups, and further, than females (McNutt 1996a). Similar trends of males dispersing further have also been found in cougars (Sweanor *et al.* 2000; Maehr *et al.* 2002) and black bears *Ursus americanus* (Hellgren *et al.* 2005). Among male wild dogs this may be as a result of a male-biased adult sex ratio, along with delayed dispersal, which allows for larger dispersing male units and greater survival over longer distances than for dispersing females (McNutt 1996a; Davies-Mostert 2010).

Although dispersal distance can vary according to numerous factors including habitat suitability, temporal mate acquisition or physical barriers, dispersing wild dog groups have been recorded travelling more than 300 km before finding appropriate mates and forming a new pack (Fuller *et al.* 1992a; Fuller *et al.* 1992b; McNutt 1996a; Davies-Mostert 2010; Appendix A).

Despite several studies on the social dynamics and feeding ecology of wild dogs within protected areas in KwaZulu-Natal (Maddock 1999; Krüger *et al.* 1999; Lindsey *et al.* 2004a; Hayward *et al.* 2006; Spiering *et al.* 2010) there is a lack of information on the spatial ecology of wild dogs outside protected areas within KwaZulu-Natal. There is a need to characterize habitat niche selection outside of resident reserves to determine potential linkages between current populations, and between proposed future reintroduction sites. Once potential linkages have been identified based on habitat suitability, the feasibility of incorporating such areas into regional wild dog conservation initiatives or of funding targeted advocacy and education programs can then be investigated. Significantly, research in Kenya has indicated that despite anthropogenic threats, the potential for conflict with livestock and the depletion of large natural prey, wild dogs have persisted, and at times even increased in population density outside of protected areas (Woodroffe *et al.* 2005; Woodroffe 2010). However, it has been reported that livestock depredation can increase in human dominated landscapes where large wild prey is seriously depleted (Woodroffe *et al.* 2005).

The low density of roads in parts of the study area, and the infrequent occurrence and highly mobile nature of dispersing wild dogs outside protected areas combine to make direct observation difficult. Since only a small proportion of dispersing wild dogs are fitted with tracking collars in KwaZulu-Natal, radio tracking activities often focus on a sub-sample of all wild dogs that may leave a protected area. Therefore, recorded location data is only a sample of actual spatial utilization during dispersal. In addition, sightings reports from members of the public only reveal sporadic, *ad hoc* location data; which is frequently linked to the road network. Consequently, and in the absence of presence/absence data for dispersing wild dogs, a modelling technique which can assist with understanding environmental influences on dispersal routes, based on presence-only data, is believed to be the most appropriate for my study (Phillips *et al.* 2006; Pearson *et al.* 2007; Phillips & Dudik 2008; Wisz *et al.* 2008; Levine *et al.* 2009; Monterosso *et al.* 2009). To characterize habitat niche selection I used Maximum Entropy Modelling (Maxent) version 3.3.1 (http://www.cs.princeton.edu/~schapire/maxent).

In comparison with other presence-only models, Maxent appeared to be superior in its ability not only to predict habitat suitability, but to also perform well with small sample sizes and distinguish between grades of habitat suitability (Phillips *et al.* 2006; Wisz *et al.* 2008). Furthermore, Maxent is able to use both continuous and categorical habitat data and produce finer scale predictions than those models it was evaluated against (Phillips *et al.* 2006). Using known occurrences, Maxent predicts distribution by generating pseudoabsence data and using the probability of the suitability of environmental features at sample locations (Phillips *et al.* 2006; Tinoco *et al.* 2009).

A concern of presence only data is that it is unlikely to be entirely representative of a complete population and should therefore be carefully evaluated (Monterosso *et al.* 2009). Since such a model interprets a realized niche based on suitability of ecological data, and projects it in geographical space, it may produce results which are only a portion of the fundamental niche of the species (Phillips *et al.* 2006). In KwaZulu-Natal, points of dispersal for wild dogs are a product of populations which have been reintroduced following extirpation, and will consequently not be entirely representative of historical range nor all suitable habitats for dispersal within the region. Additional complications, which may also be a disadvantage for presence-absence data modelling, are a potential lack of environmental data to sufficiently describe a fundamental niche and sampling bias resulting from discrepancies in sampling intensity or methods (Phillips *et al.* 2006). To limit sampling intensity bias generated in this study, data was rarefied to individual location recordings per day. The absence of favoured prey species occurrence data, outside of protected areas, was a limiting factor when determining fundamental niches.

The specific aims for this chapter were to:

- Determine the natural and anthropogenic environmental variables that have influenced dispersal routes and the occurrence of wild dogs outside of protected areas containing resident populations.
- Identify potential dispersal linkages between protected areas with resident populations of wild dogs.
- Predict habitats and areas which will likely be selected by wild dogs during dispersals from regional protected areas in the future.

3.2 Materials and methods

Data collection

Radio tracking

Wild dog management policy in KwaZulu-Natal dictates that an individual wild dog from each pack in the province should be radio collared. From 2006 until 2009 at least one wild dog within each of the packs (mean number of packs = 6 ± 3) in HiP, and the one pack in each of MGR and TPGR were routinely fitted with VHF tracking collars (frequency range 148 – 151 MHz) from either Sirtrack (Havelock North, New Zealand) or Africa Wildlife Tracking (AWT – Pretoria North, South Africa). In order to fit the radio collars, the wild dogs were lured to a bait (a culled impala or nyala) and free-darted by an authorized EKZNW veterinarian/staff member using a Dan-inject CO_2 rifle to propel a 1.5ml dart with 0.8 ml, 100mg/ml Zoletil® (Virbac). Where possible, single-sex groups anticipated to disperse from a natal pack were also fitted with at least one VHF collar. In addition, four GPS/GSM remote-download collars from AWT were also deployed on wild dogs within HiP which were predicted likely to disperse. Only one of the individuals fitted with a GPS/GSM collar dispersed out of its resident protected area.

Collared animals were located by signal biangulation or triangulation (Andreka *et al.* 1999) using a VHF antenna (Telonics RA-14K) and portable receiver (R 1000 Communication Specialist). Coordinates of point locations were determined using either a handheld Global Positioning System (GPS - Garmin, E-Trex Legend) or Google Earth based on observed landmarks where location access was restricted. Where the location of a collared wild dog could be determined within 350m precision, a distance which delivered an acceptable degree of accuracy for wild dog location data (Mills & Gorman 1997), a maximum of two points were collected for each day to represent each of the daily activity cycles. On these occasions one location was recorded during each of the early morning and late afternoon activity cycles. On occasions when public reports were used to assist with locating collar signals during a tracking event, the reported location points would also be recorded. The majority (131) of the total number of location points (186) used in this study were determined using collar data.

Reported sightings

In addition to radio collar data, *ad hoc* sightings reports were also used to determine wild dog location points outside of protected areas. Reports were investigated using identification pages which comprised a series of photographs of locally occurring predators (brown hyaena, black-backed jackal *Canis mesomelas*, side-striped jackal *Canis adustus*, spotted hyaena and wild dog) which the witness used to indicate which species they had seen. Additional questions were asked about the physical characteristics and behaviour of the reported animal(s), any social or hunting interaction which may have been noted, the time of day or night the animal was seen, the prevalence of domestic dogs in the area, and the previous experience of the reporting individual in identifying wild dogs. Where possible, photographs of the reported animal were inspected and spoor and scat at reported locations were investigated. Using this information a decision was made on the validity of the report based on the body of evidence. Only reports considered to be confirmed wild dog sightings, and where a precise location point could be determined, were recorded. The remaining 55 of the 186 location points were determined in this manner.

Autocorrelation of point data may lead to false inferences of habitat use and spatial behaviour (Cagnacci *et al.* 2010). With the exception of the denning period, wild dogs are extremely mobile and move to new resting locations daily (Fuller *et al.* 1992a; Andreka *et al.* 1999). The distance between these resting periods appears to be, in part, due to prey availability and habitat density (Schaller 1972; Fuller *et al.* 1992a; Mills & Gorman 1997; Andreka *et al.* 1999). To reduce the effect of temporal or spatial autocorrelation which may have resulted from a higher frequency of point observations within a particular area or on a particular day, due to observer bias, the location points were rarefied to one recorded point per day (Cagnacci *et al.* 2010; Dray *et al.* 2010). In cases where multiple points had been recorded for a day, the earliest recorded point was used in the final analysis. This resulted in 132 location points, from 40 groups or individual dispersing wild dogs, being extracted from the original 186 over the four year study period.

All location data were downloaded into ArcMap® 9.3 (ESRI, California, USA) for analysis and Maxent (Version 3.3.1; Phillips *et al.* 2006) was used to develop a dispersal habitat suitability model in relation to current KwaZulu-Natal metapopulation reserves.

Distribution Modelling

Environmental predictor variables

All data layers used in the distribution modelling were developed by conversion from either vector datasets or varying scale raster datasets, to 100m x 90m pixel size raster format using ArcMap® 9.3 (Costanza & Maxwell 1994). This was carried out to develop uniform scale data layers based on the most precise scale of topographic classification available for KwaZulu-Natal. Data layers were converted from raster format to ASCII format for modelling in Maxent. When using presence-only data for species distribution modelling, appropriate selection of background data is important for model parameterization and accuracy of model prediction (Van der Wal *et al*. 2009b). Model performance has been shown to be lower when pseudoabsence points have been taken from either a too restricted or too broad an area (Van der Wal *et al*. 2009b).

Eight predictor variables were considered when developing the distribution model (Table 3.1). Exploratory runs of the modelling program indicated the digital elevation model (DEM) to be an important variable influencing wild dog movement. If a background size from which Maxent would determine pseudoabsences for model prediction is too large, the number of predictor variables which dominate habitat suitability decrease (Van der Wal *et al.* 2009). Predictive models can be dominated by variables that coarsely categorize regional conditions with a reduced ability to define localised niche parameters (Van der Wal *et al.* 2009). A background of 100-200km from the data points was determined to yield the most accurate models (Van der Wal *et al.* 2009). This raised concerns that the DEM may dominate this model due to the coarse scale of the background (>200km) and great variation in altitude between where current wild dog populations are located, close to sea level, and the highest point in the province at 3 450m; which was further than 200km from the dispersal points. However, it was decided that since this altitude fluctuation occurred within a radius distance from HiP which wild dogs were recorded to be able to traverse, 305 km (based on the minimum recorded travelling distance of a dispersal group from HiP over a period of 55 days in 2009) that no reduction in background data scale should occur. In addition, the majority of KwaZulu-Natal for which management recommendations are being developed occurs within the 305km radius. Therefore all predictor variables for this study were considered at the scale of the KwaZulu-Natal province.

Table 3.1: Variables used to determine dispersal routes for wild dogs in KwaZulu-Natal.

Variable	Source	Data	Abbreviation
Digital elevation model	EKZNW*	Continuous	DEM
Topographic classification	EKZNW	Categorical	TOPO
Land cover classification	Calculated from EKZNW	Categorical	LCRECLASS
Distance to river courses	Calculated from rivers – DTLGA**	Continuous	DISTRIVERS
Human density	Calculated from SPOT - Eskom	Continuous	KZNDENSITY
Road density	Calculated from roads - DTLGA	Continuous	ROADDEN
Distance to roads	Calculated from roads - DTLGA	Continuous	DISTROADS
Existing wild dog populations	Calculated from EKZNW	Continuous	EXIST

**= EKZNW 2010; **=Department of Traditional and Local Government Affairs*

Digital Elevation Model

A 20m pixel DEM in raster format used elevation levels ranging from sea level to 3 450m. The DEM was converted to the 100m x 90m pixel size by pixel averaging. This adjusted the maximum height of the data layer to 3 417m.

Topographic classification

A topographic land form map was derived from the 90m pixel DEM (Version 4; EKZNW 2010). Conversion of the raster data set to ASCII format using ArcMap® 9.3 resulted in symbol allocation to categorical topographic classifications (Table 3.2).

Table 3.2: Topographic classifications used for distribution modelling.

Variable symbol	Topographic classification
1	Canyons, deeply incised streams
2	Mid-slope drainages & shallow valleys
3	Upland drainage & headwaters
4	U-shaped valleys
5	Plains
6	Open slopes
7	Upper slopes & mesas
8	Local ridges & hills in valleys
9	Mid-slope ridges & small hills in plains
10	Mountain tops & high ridges

Land cover classification

The KwaZulu-Natal land cover dataset (EKZNW 2005) was reclassified from 39 land cover classes to eleven appropriate classes. This was done by aggregating components which were deemed closely related in function yet left distinct enough categories to determine habitat suitability for dispersing wild dogs (Table 3.3). This was scaled at a 100m x 90m pixel size. Conversion of the raster data set to ASCII format using ArcMap® 9.3 resulted in symbol allocation to categorical land cover classifications (Table 3.3). Degraded categories were included in the respective vegetation classifications since they were understood to sufficiently fulfil the ecological function of the particular classification. Old cultivated fields were included in the degraded classification since the extent of their return to relevant ecological classification, grassland or bushland was unknown.

Table 3.3: Land cover classifications used for distribution modelling.

Variable symbol	Land cover classification	Classification components
0	Outside KZN	Outside KZN
1	Water	Natural fresh water; wetlands; wetlands-mangrove; dams; estuarine water; marine water
2	Plantations	Plantation; plantation clear felled
3	Agriculture	Permanent orchards irrigated; permanent orchards dryland; permanent pineapples; sugarcane commercial; sugarcane emerging farmer; annual commercial crops dryland; annual commercial crops irrigated
4	Highly modified	Mines and quarries; urban; golf courses; rural dwellings; subsistence; smallholdings; erosion
5	Forest	Forest; degraded forest
6	Dense bush (70 -100 % cell cover)	Dense bush
7	Bushland (<70 % cell cover)	Bushland; degraded bushland
8	Woodland	Woodland
9	Grassland	Grassland/bush clump mix; grassland; degraded grassland; alpine grass-heath
10	Disturbed	Bare sand; coastal sand and rock; old cultivated fields - grassland; old cultivated fields - bushland
11	Roads	National roads; main and district roads

Distance to river courses

The distribution of browsers and mixed-feeders appears to be positively associated with river courses, an observation which may be more relative to the higher quality and availability of riparian forage, than a dependency on surface water (Redfern *et al.* 2003; Smit *et al.* 2007). In the protected areas of KwaZulu-Natal, wild dogs feed primarily on nyala, a browsing species, and impala, a mixed feeder (Krüger *et al.* 1999; Lindsey *et al.* 2004a). The distribution and density of these species outside of protected areas in KwaZulu-Natal is unknown, however it is presumed that the association of mixed-feeders and browsers with riparian areas, and thus potentially available prey for wild dogs, will hold for the rest of the study area. Furthermore, an association with this habitat may also be linked to lower numbers of dwellings. Euclidean distance to all river courses in KwaZulu-Natal, perennial and nonperennial was determined using ArcMap® 9.3.

Human density

Increased human activities and dwelling densities, particularly in fragmented habitats have been shown to result in varying degrees of spatial or temporal avoidance by dispersing cougars, bobcats *Felis rufus,* wild dogs and coyotes *Canis latrans* (Beier 1995; Dickson & Beier 2002; Tigas *et al.* 2002; Woodroffe 2010). Dwelling density (SPOT building count, ESKOM 2007) was used as a proxy to reflect human densities within KwaZulu-Natal. The vector layer was converted to a point density layer using ArcMap® 9.3 at a unit scale of dwellings/km^2.

Road density

As with dwelling density, road density affects movement patterns of resident and transient carnivores (Beier 1995; Dickson & Beier 2002; Maehr *et al.* 2002; Tigas *et al.* 2002; Henschel 2009). Vehicle strikes are a significant cause of mortalities among dispersing carnivores (Beier 1995; Dickson & Beier 2002; Maehr *et al.* 2002; Tigas *et al.* 2002; Woodroffe 2010). Whereas research has indicated a tendency by cougars to avoid some areas of higher road density (Dickson & Beier 2002), wild dogs are attracted to roads which may provide easier travelling and hunting opportunities (Woodroffe 2010). Road density was calculated using ArcMap® 9.3 line density function at a scale of kilometres of road/km².

Distance to roads

To determine whether distance to roads may influence movements of wild dogs which have left their resident reserves, as was indicated by Woodroffe (2010), euclidean distance to all roads in KwaZulu-Natal, was determined using ArcMap® 9.3.

Existing populations of wild dogs

Euclidean distance was determined from the three reserves which had resident populations of wild dogs at the time of the study using ArcMap® 9.3. This was done to determine whether dispersing wild dogs were influenced by proximity to reserves with resident populations. Caution should be exercised when interpreting results for this variable however, since areas under conservation which surround these particular resident reserves may correlate strongly with other variables being tested such as human and road density. Another concern with testing these data in such a manner is that the point data do not indicate direction of movement, and in some cases the source reserve of the animals reported was not known.

Maxent model evaluation

Maxent is a machine learning model which uses algorithms to estimate the most uniform probability distribution of a species based on environmental suitability (Phillips *et al.* 2006). Suitability is determined by the recorded occurrence data of the species, the background grid cells within the study area and the constraints imposed by a series of environmental variables (Phillips *et al.* 2006). The exponential probability of presence estimate, of the species occurring within a particular output grid cell, varies from 0 to 1, where 0 represents the lowest probability and 1 the highest (Phillips *et al.* 2006).

Maxent requires predictor variables to be in ASCII format and the point locations in CSV file format. The input data (predictor variables and location data) were georeferenced to the same coordinate system in ArcMap® 9.3. Default parameters in Maxent (version 3.3.1) were used to produce models: feature selection = automatic; regularization multiplier = 1; maximum iterations = 500; convergence threshold = 10^{-5} (Jackson & Robertson 2010). The models were set to select a random sample of 25% of the occurrence points, to be used as a test sample for comparison against the model output (Phillips & Dudik 2008). The model used 10 000 points (background points and presence points) to determine Maxent distribution. The overall fit of the Maxent model was evaluated using the receiver operating characteristic (ROC) curve where the model's sensitivity versus 1-specificity is plotted (Phillips *et al*. 2006). Sensitivity represents a fraction of positive occurrences (Phillips *et al*. 2006). Since no absence data were recorded when using Maxent, 1-specificity represents a fraction of the study area within which the species is predicted present (Phillips & Dudik 2008). The area under the ROC curve (AUC) was calculated by the model. An AUC = 1 represents the best fit, an AUC value > 0.5 indicates the model is performing better than random at predicting a species presence while AUC values > 0.75 are considered useful predictors of distribution (Elith *et al.* 2006). An AUC > 0.9 is considered outstanding (Hosmer & Lemeshow 2000; Van Gils & Kayijamahe 2010). Maxent also performs a jackknife analysis to evaluate the importance of each predictor variable in explaining the observed species distribution (Phillips *et al*. 2006; Monterosso *et al*. 2009; Van Gils & Kayijamahe 2010). The response of wild dogs to each variable was then analyzed by interpreting response curves representing the dependence of predicted suitability on each selected variable (Phillips *et al.* 2006; Monterosso *et al*. 2009). The results were used to demonstrate the importance of each variable when determining potential dispersal routes.

The logistic probability of occurrence ASCII output generated by Maxent was imported into ArcMap® 9.3 software and converted to raster grid format. The map, a representation of habitat suitability, was used to identify potential dispersal routes within KwaZulu-Natal based on currently resident wild dog populations (Phillips *et al*. 2006; Van Gils & Kayijamahe 2010).

3.3 Results

Wild dogs outside of resident reserves selected lower lying terrain with a preference for woodland land cover. Wild dogs showed a tendency to avoid areas with higher densities of people, and were recorded most frequently in areas with a road density of approximately 0.7 km/km². The model with the seven predictor variables (excluding proximity to resident populations) had an AUC of 0.96 (SD = 0.02). The 25% test sample data ran with an AUC of 0.91 (Figure 3.1). Four variables were, in combination, most influential in determining habitat suitability for dispersing wild dogs: elevation, road density, land cover and human density with relative gain contributions of 43%, 16%, 16% and 15% respectively.

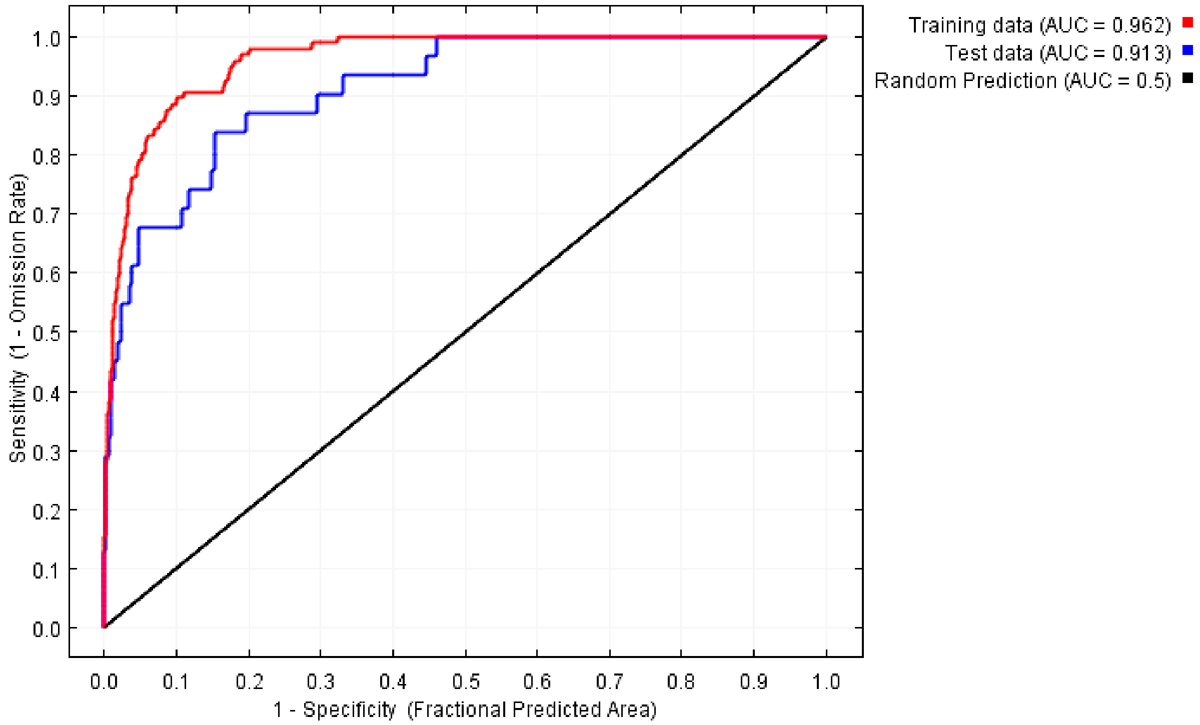

Figure 3.1: The receiver operating characteristic (ROC) curve for training and test data. The straight line represents random prediction (AUC = 0.5).

The Maxent jackknife AUC outputs for each predictor variable, run independently of all other variables, were used to show how habitat suitability responded to each predictor variable. The DEM was the single most effective variable at predicting the probability of wild dog habitat suitability (Figure 3.2). It was also the variable which, when excluded, reduced the AUC value the most, indicating that it contributed the most unique information to the overall model when compared to the other variables. According to the jackknife test the other useful predictor of habitat suitability was land cover with an AUC > 0.75. All other variables, according to jackknife testing were considered to be individually better than random (AUC > 0.5).

When the model was run to include proximity to resident populations the AUC value increased to 0.97 (SD = 0.02). This variable contributed strongly (64%) to speculative model estimates, and substantially reduced all other variable contributions to the model, for example elevation, road density, land cover and human density contributions were reduced to 2%, 7%, 10%, 8% respectively . The relative prevailing jackknife trend of predictor variable importance was however not greatly influenced despite the strong performance of the existing population variable (Figure 3.3).

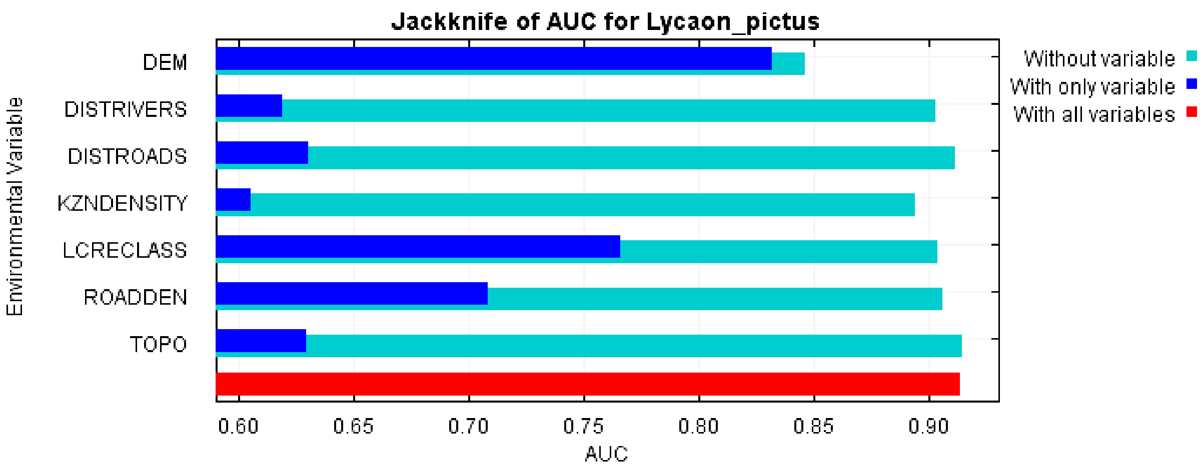

Figure 3.2: Results of the jackknife evaluations of relative importance of each variable contribution when run independently of other variables; excluding resident wild dog populations. DEM = Digital elevation model; TOPO = Topographic classification; LCRECLASS = Land cover classification; DISTRIVERS = Distance to river courses; KZNDENSITY = Human density; ROADDEN = Road density; DISTROADS = Distance to roads; EXIST = Existing wild dog populations.

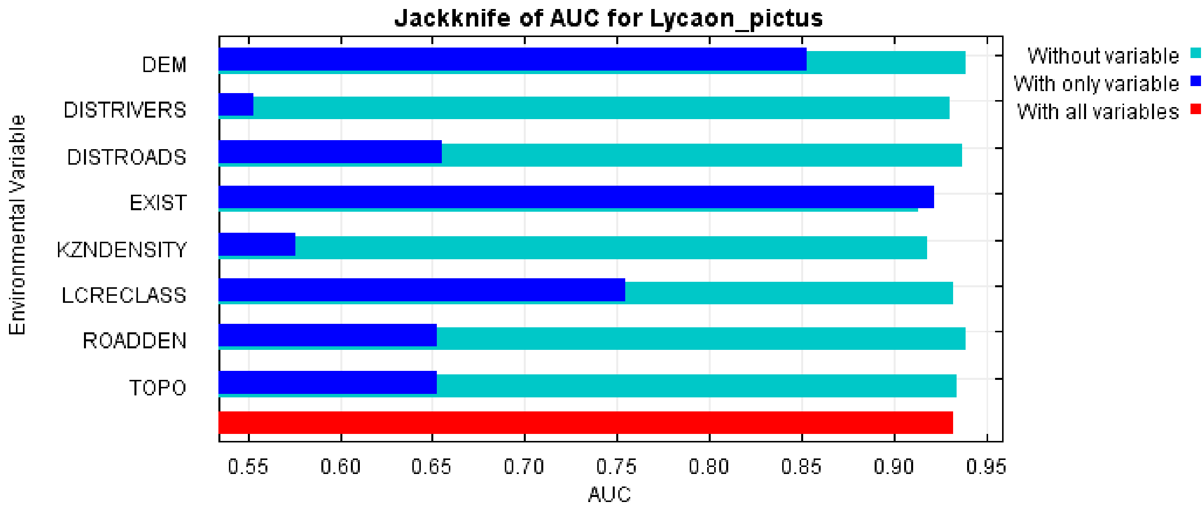

Figure 3.3: Results of the jackknife evaluations of relative importance of each variable contribution when run independently of other variables; including resident wild dog populations.DEM = Digital elevation model; TOPO = Topographic classification; LCRECLASS = Land cover classification; DISTRIVERS = Distance to river courses; KZNDENSITY = Human density; ROADDEN = Road density; DISTROADS = Distance to roads; EXIST = Existing wild dog populations.

The elevation response curve indicated a higher probability of presence for dispersing wild dogs in lower lying locations, peaking at approximately 200 – 300m a.s.l (Figure 3.4). Probability of presence peaked between 0.5km and 1.5km from river courses and approximately 20m from roads (Figure 4). Wild dogs showed a definite preference for areas of lower human density and appeared to have a highest probability of presence at road densities of approximately 0.7km/km^2 (Figure 3.4).

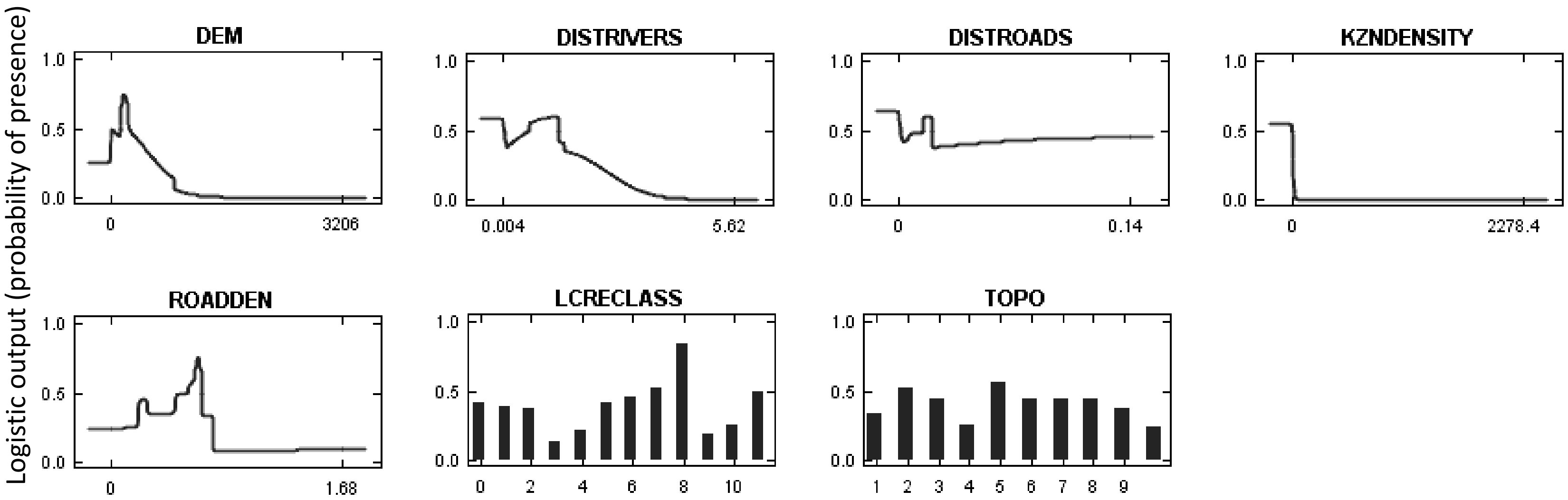

Figure 3.4: The response of individual variables when the Maxent model was created using only the corresponding variable. Units: DEM = m; DISTRIVERS = km; DISTROADS = km; KZNDENSITY = dwellings/km^2; ROADDEN = km/km^2; LCRECLASS = classifications as per Table 3.3; TOPO = classifications as per Table 3.2.

Upon visual inspection of recorded wild dog locations overlaid on the point density projection developed in ArcMap® 9.3, there was a clear preference for wild dogs in northern KwaZulu-Natal to stay in areas of lower human density (Figure 3.5).

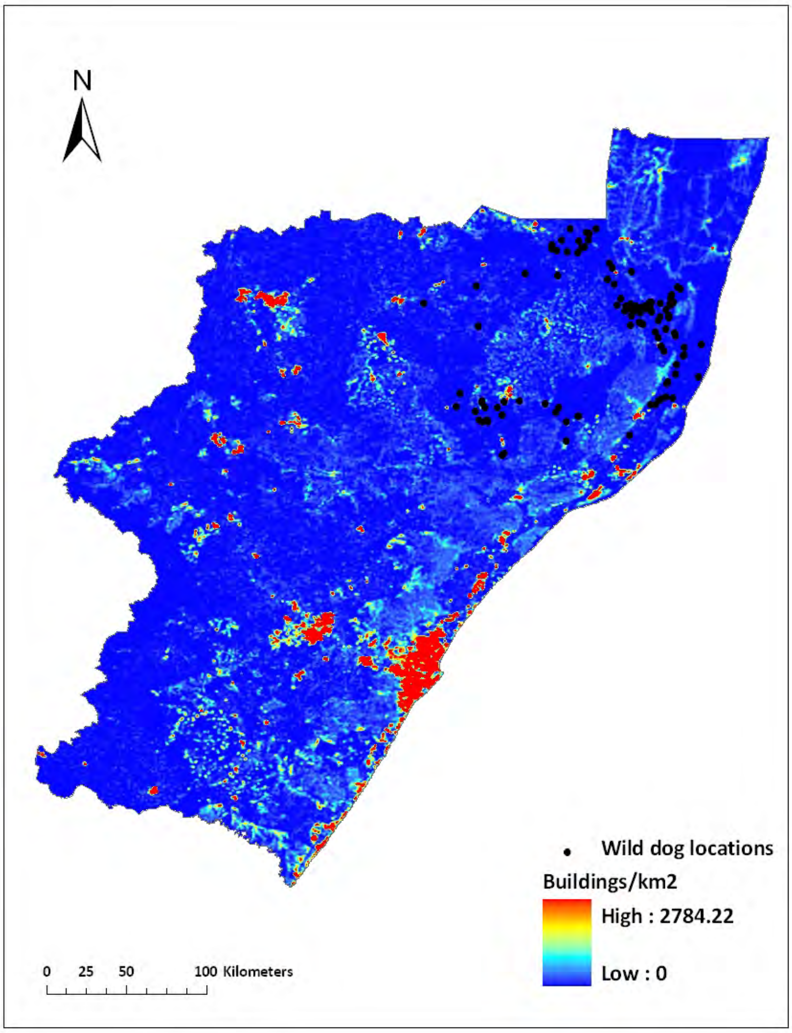

Figure 3.5: Wild dog location recordings viewed on a provincial map indicating human density (buildings/km^2).

Wild dogs in northern KwaZulu-Natal showed a strong preference for woodland habitat (category 8) with a logistic probability of presence output of > 0.8. Bushland (< 70% cell cover- category 7) was the only other land cover class which showed a presence probability of greater than random (i.e. 0.5 < 0.6). Among topographical classification, both plains and mid-slope drainages/shallow valleys had a probability of presence between 0.50 and 0.60. All other classifications performed no better than random.

Logistical output maps with predicted dispersal habitat suitability reflected a clear preference for habitats in the northern areas of KwaZulu-Natal, particularly those close to the protected areas where wild dogs are already resident (Figure 3.6). Reserves towards and within the Thukela Biosphere in the central and western region of the province also appeared to contain suitable habitat (Figure 3.6). When including existing resident populations into the Maxent model, the predicted area of suitable habitat was reduced considerably, with an anticipated concentration around resident, reintroduced populations (Figure 3.7). Importantly, the more marginal areas in the province with a lower probability of presence were excluded by this model (Figure 3.7).

Visual inspection of all existing wild dog populations (Figure 3.8) and conservation areas (including government and private game reserves, game farms and registered conservancies) in northern KwaZulu-Natal, overlaid on the habitat suitability map, shows a considerable proportion of the higher probability landscape falling within the contiguous conservation areas (Figure 3.9). The central, lighter area of lower habitat suitability, encircled by the area of higher suitability probability, reflects the town of Nongoma and neighbouring areas of subsistence agriculture and grasslands (Figure 3.9).

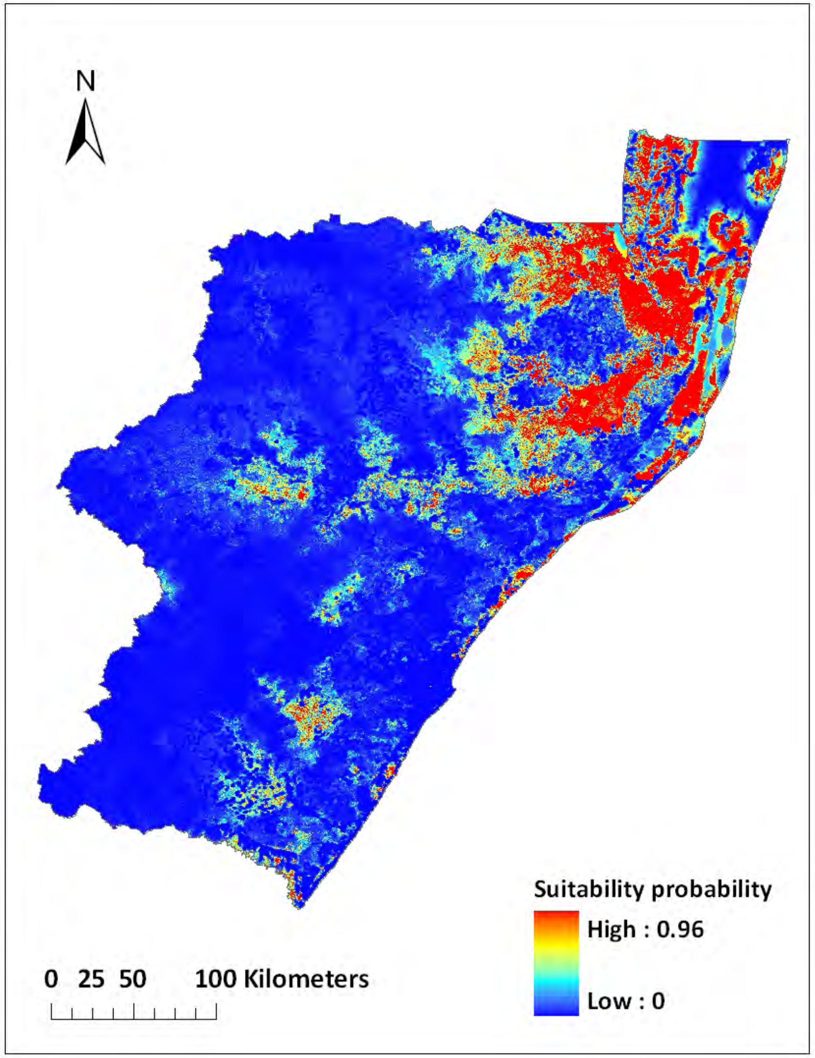

Figure 3.6: The suitability of habitat as represented by the logistic map using predictor variables excluding existing wild dog populations in KwaZulu-Natal.

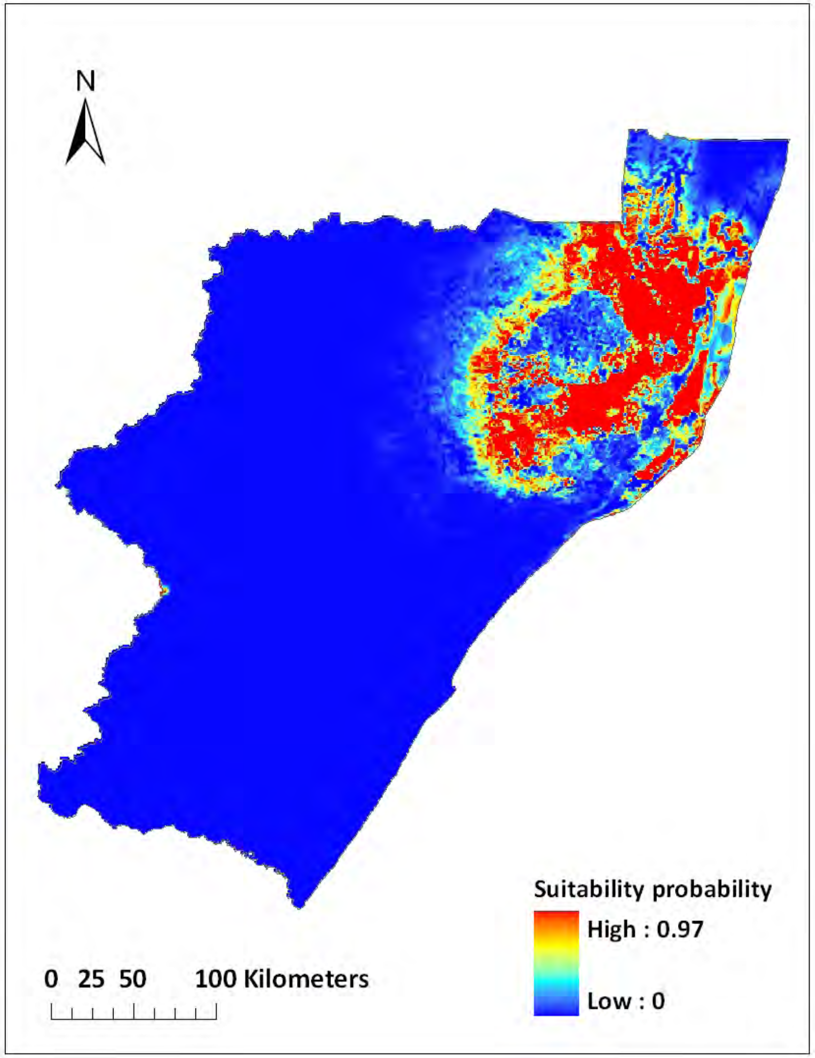

Figure 3.7: The suitability of habitat as represented by the logistic map using predictor variables including existing wild dog populations in KwaZulu-Natal.

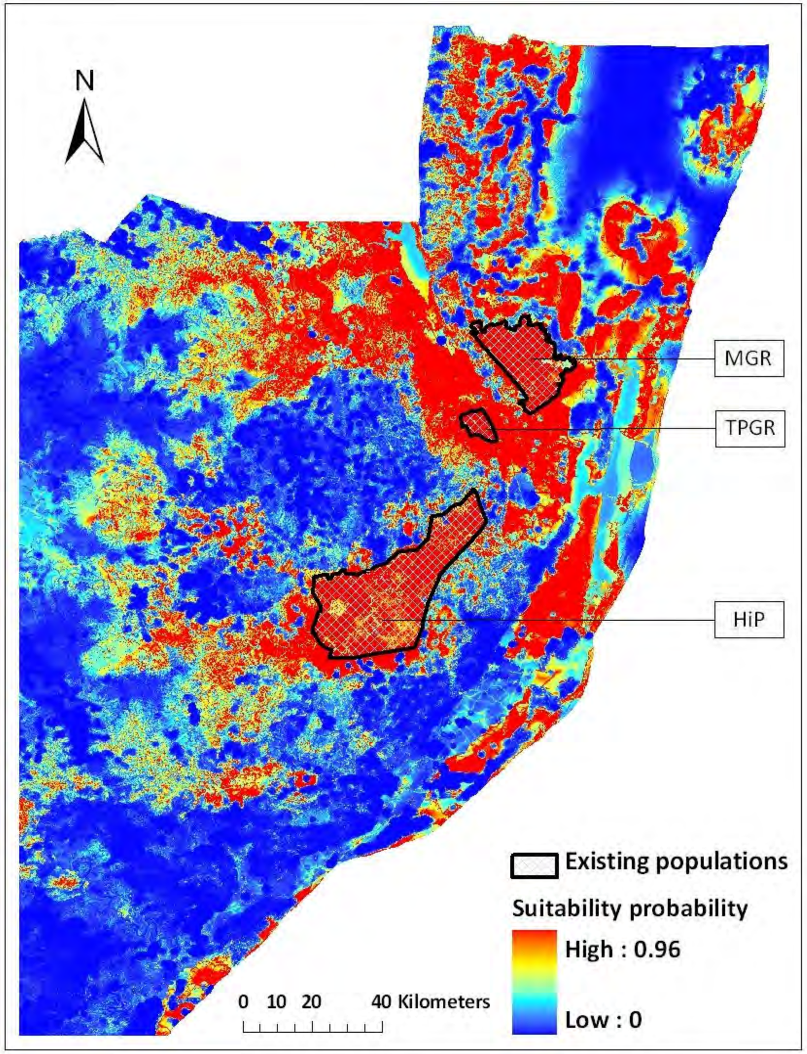

Figure 3.8: The suitability of habitat in northern KwaZulu-Natal as represented by the logistic map, overlaid by existing wild dog population reserves. HiP = Hluhluwe-iMfolozi Park, TPGR = Thanda Private Game Reserve, MGR = Mkhuze Game Reserve.

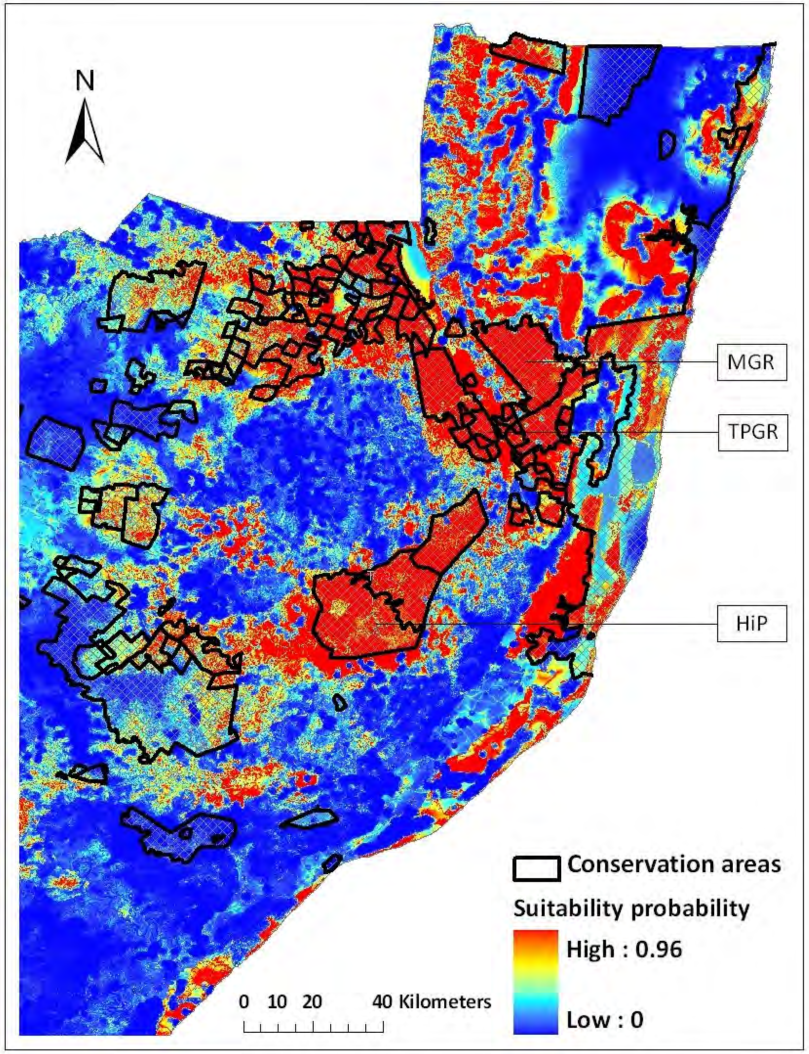

Figure 3.9: The suitability of habitat in northern KwaZulu-Natal as represented by the logistic map, overlaid by current conservation areas. HiP = Hluhluwe-iMfolozi Park, TPGR = Thanda Private Game Reserve, MGR = Mkhuze Game Reserve.

3.4 Discussion

Habitats that influence dispersal routes

The habitat preferences shown by dispersing wild dogs, or those engaging in temporary exploratory behaviour, appear consistent with the interpretation of avoiding intensive human activity (Lindsey *et al.* 2004b: Woodroffe 2010). As has been previously reported with wild dogs in northern Kenya, avoidance of human activity in this study was in part possible due to the clustering of dwellings and settlement areas, creating people-free space (Woodroffe 2010). Such avoidance also appeared possible due to the contiguous linkages of low human density areas provided by formal conservation practices, conservancies or sparsely inhabited tribal grazing lands. Although sightings were reported by members of communities neighbouring the protected areas, these were infrequent, even when transient wild dogs were known, through radio tracking, to be in the area.

Areas of high human activity pose significant threats to the survival of dispersing carnivores (Thurber *et al.* 1994; Sweanor *et al.* 2000; Dickson & Beier 2002; Tigas *et al.* 2002). Increased human densities can result in direct persecution due to perceived or realized threats posed by the carnivores (Woodroffe & Ginsberg 1998; Palomares *et al.* 2000), can lead to increased contact with domestic animals carrying potentially lethal diseases (Woodroffe & Ginsberg 1998) and can result in increased vehicle collision mortalities (Woodroffe & Ginsberg 1998; Palomares *et al.* 2000; Sweanor *et al.* 2000; Dickson & Beier 2002; Tigas *et al.* 2002; Woodroffe 2010). However, if large carnivores have dispersed from protected areas where they have had little exposure to anthropogenic threats, it is not clear whether they would avoid potentially hostile areas of human activity. Dispersing cougars (Dickson *et al.* 2005), bobcats (Tigas *et al.* 2002), coyotes (Tigas *et al.* 2002) and black bears (Hellgren *et al.* 2005) all appear to alter their behaviour to some extent; whether it is circadian rhythm, speed of movement or spatial movement patterns to include natural vegetation fragments, to avoid areas of high human activity. This may indicate an aversion to the considerably altered environment rather than the perception of threat if they have not experienced persecution (Tigas *et al.* 2002; Dickson *et al.* 2005; Hellgren *et al.* 2005).

Research in the northern USA showed that wolves were generally not present where road densities exceeded 0.6km/km^2 (Mech *et al.* 1988; Thurber *et al.* 1994; Mladenoff *et al.* 1995). In addition, road density was found to be the greatest predictor of wolf habitat suitability with wolves avoiding areas as road density increased (Mech *et al.* 1988; Thurber *et al.* 1994; Mladenoff *et al.* 1995). High road densities were suggested to be a barrier to wolf (Jensen *et al*. 1986), cougar (Beier 1995) and black bear (Hellgren *et al.* 2005) dispersal due to collisions with vehicles, disturbance and physical obstruction. Despite this, it was suggested that wolves may demonstrate less road avoidance during dispersal where the natural prey has been depleted or where human densities are low (Frederick 1991). Like wolves in south-central Alaska (Thurber *et al.* 1994)and cougars in the western USA (Dickson *et al.* 2005), it has also been proposed that low-activity roads could be attractive to wild dogs as routes for hunting and easier travel (Woodroffe 2010). This provides a likely explanation for the preference shown by wild dogs for areas with more roads in my study.

Wild dogs are habitat generalists (Fuller & Kat 1990; Andreka *et al.* 1999; Creel & Creel 2002; Woodroffe 2010) and have been described as highly visible with a strong potential to generate ecotourism based revenue (Rasmussen 1999; Lindsey *et al*. 2005a). Many of the recorded sightings in this study were reported close to roads and wild dogs were most frequently found in areas with road densities of approximately 0.7km/km^2. This would suggest that while wild dogs may show a tendency to avoid areas of high human activity, they can coexist in close proximity to humans as previously reported (Woodroffe 2010). The results of this study indicated that elevation, land cover and distance to rivers may all be of greater influence to habitat suitability of dispersing wild dogs than human density or activity.

Wild dogs in HiP spend more time hunting in woodland habitat than other vegetation types (Andreka *et al.* 1999; Krüger *et al.* 1999). Nyala, red duiker *Cephalophus natalensis* and bushbuck *Tragelaphus scriptus*, three herbivore species most closely associated with woodland habitat in KwaZulu-Natal, and impala which prefer more open habitat were modelled to be the most favoured prey species for wild dogs in the region (Krüger *et al.* 1999). In the protected areas of KwaZulu-Natal, wild dogs feed primarily on nyala and impala (Krüger *et al.* 1999; Lindsey *et al.* 2004a). Wild dogs are expected to alter prey selection based on the effort required for capture (Krüger *et al.* 1999). Although habitats with the densest vegetation in northern KwaZulu-Natal contain the highest abundance of available prey, the probability of carnivores making successful kills appears to be highest in areas of intermediate cover (Andreka *et al.* 1999; Krüger *et al.* 1999; Balme *et al.* 2007). In this Maxent model land cover played a significant role in determining the probability of presence for dispersing wild dogs. Woodland habitat, and to a lesser degree bushland, were strongly favoured by wild dogs. Observed habitat and prey preferences from within resident reserves appear to be representative of the preferences selected once outside these reserves. Woodland communities in KwaZulu-Natal tend to be found on lower lying topography or on hill slopes which appears consistent with the model preference found for wild dogs to disperse through areas of plains, mid-slope drainages and shallow valleys.

In addition, although wild dogs showed a tendency to escape from resident reserves along river courses where variable substrate levels reduced fence effectiveness; their habitat preference was not immediately along river courses. Rather, they appeared to favour areas between half a kilometre and one and a half kilometres from rivers. When interpreting land cover data along river courses west of HiP, these appeared to be primarily grassland interspersed with a matrix of woodland and bushland. Woodland and bushland habitats predominate to the north of TPGR and west of MGR (EKZNW 2005). A combination of these vegetation matrices favoured by preferred prey species (Krüger *et al.* 1999), and the distribution of browsers and mixed-feeders associated with river courses (Redfern *et al.* 2003; Smit *et al.* 2007) may have provided sufficient natural prey for these areas to be indicated as highly suitable. This prey availability may also be reflected in the low numbers of livestock reported killed by dispersing wild dogs in the region (See Chapter 4). Wild dogs have been known to kill more livestock in areas with low natural prey densities than in areas with substantial natural prey (Rasmussen 1999; Ogada *et al.* 2003; Woodroffe *et al.* 2005).

Identified dispersal linkages

Wild dogs were extirpated in KwaZulu-Natal in the 1930's and resident populations currently exist in the province as a result of a series of reintroductions which begun in 1980 (Andreka *et al.* 1999; Maddock 1999). The area of northern KwaZulu-Natal which appears most suitable for transient wild dogs include the three current resident reserves, the properties bordering TPGR and those properties which are situated north of TPGR leading up to the national border with Swaziland (Figure 2.1).

This area is comprised primarily of a contiguous matrix of private and community owned game reserves, government owned protected areas and commercial game ranches. It is clear that highly suitable habitat links both HiP and MGR to TPGR. However, the N2 national highway which heads in a north west-south east direction between TPGR and MGR is a concern due to potential vehicle collision fatalities.

TPGR is bordered to the north by the 230km^2 Zululand Rhino Reserve, which in turn is bordered to its north by the 58km^2 Hlambanyathi Private Game Reserve (HPGR). Adjoining HPGR to the west is Somkhanda Game Reserve (160km^2). All of these properties have indicated a desire to hold resident populations of wild dogs, although future conservation planning will dictate the feasibility of reintroducing resident populations into each reserve. West of these properties, in the Magudu district, several properties which, when combined, cover over 1 000km^2 have in the past been cooperative and tolerant when wild dogs traversed their properties. North of these properties in the Magudu and Mkhuze districts, contiguous conservation and subsistence agriculture areas on the northern border of South Africa link into Swaziland and Mozambique at a junction where the proposed Usuthu-Tembe-Futi Transfrontier Conservation Area will link conservation and resource-use areas.

MGR is a 400km^2 western section of the 2 300km^2 Isimangaliso Wetland Park. On the southern border of MGR is the Munyawana Game Reserve (MYGR) a 226km^2 conservation area in which dispersers from HiP, TPGR and MGR traversed between 2006 and 2009. TPGR and MYGR are linked (with the exception of the N2 highway) by a series of smaller properties which wild dogs traversed in both 2008 and 2009. Comprising shallow valleys, matrixes of grassland, bushland and woodland, these properties have been identified as highly suitable dispersal habitat.

In each of the four years of the study, wild dogs exited the south-western boundary of HiP and followed the White iMfolozi river course towards Opathe Game Reserve (OGR). This river valley is sparsely inhabited with dwellings and the vegetation composition and days spent by wild dogs in this area suggests an existing population of favoured prey. Initiatives in the past decade to secure this linkage for formal conservation have been unsuccessful yet wild dogs have continued to use this area without livestock conflict and infrequent detection by resident communities. The opportunity exists, with continued advocacy, to ensure such a route can be established as a feasible dispersal corridor for wild dogs in spite of the uncertain future over its inclusion into a formally designated conservation area. Although several high-speed roads border OGR and divide neighbouring properties, OGR is adjoined by numerous properties suitable for transient wild dogs. These properties comprise private game reserves, commercial agricultural and plantation initiatives which are managed under the Melmoth Conservancy umbrella and land which falls under the statutory heritage conservation body, Amafa/ Heritage KwaZulu Natali. The probability of suitability output also identified a patchy series of mostly contiguous areas which head north from OGR and curve to the east to link into the Black iMfolozi river valley and the Magudu district.

Conservation implications

Landscape structure restricts and influences dispersal or exploratory routes between fragmented habitats (Fahrig & Merriam 1994). Dispersal routes are comprised of matrixes of suitable fragmented habitat, susceptible to radical alteration through agricultural, infrastructural and urban development in the region (Fahrig & Merriam 1994). My results highlight the importance for potential wild dog dispersal of the numerous areas currently under some structure of conservation management in northern KwaZulu-Natal. While many of the properties within the identified areas of dispersal suitability may not be able to sustain resident wild dog packs, efforts need to persist to allow transient animals to move between resident refuges.

Despite this ecological suitability, anthropogenic factors continue to directly influence dispersal success and realized linkage suitability. Concerns remain among landowners of the perceived threat to both commercial and subsistence livestock farming, and the potential financial implications which wild dogs can pose by consumption of nyala; a species frequently traded in regional game sales (KZNWDMG unpublished). Research does however indicate that wild dog-based ecotourism has the potential, particularly in larger protected areas, to offset costs associated with wild dog conservation when calculated predation costs are low (Lindsey *et al.* 2005a). Initiatives aimed at promoting the tourism potential of the species, rapid response (should intervention be required) to sightings reports of wild dogs and integrated landscape management which could encourage additional introductions of wide-ranging species such as black rhinoceros *Diceros bicornis,* may provide financial incentives for landowners to be more tolerant of transient wild dogs.

This study suggests that suitable wild dog dispersal habitat links isolated metapopulation reserves in northern KwaZulu-Natal. However, the development of each potential linkage needs to be considered on its own merits and pragmatic management decisions will need to take into account the financial implications of promoting, creating and maintaining formal linkages (Simberloff & Cox 1987). Potential livestock conflict needs to be addressed through improved husbandry application, proactive early warning of tribal authorities should wild dogs be known to be traversing a relevant area and continued education of communities bordering metapopulation reserves. In the absence of credible depredation claim verification, compensation schemes can be unsustainable if subjected to consistent financial pressure (Boitani *et al*. 2010). Implementation of an effective compensation scheme will need to address both verification processes and accountability of claimants for reducing potential conflict scenarios (Boitani *et al.* 2010). Co-management of prey resources and wild dog populations by adjoining properties may be particularly important in allowing for home range expansion of existing metapopulations within a formal conservation framework; thereby reducing potentially lethal edge effects and potential wild dog-human conflict.

CHAPTER 4. Factors influencing the attitudes of rural communities towards African wild dogs in northern KwaZulu-Natal

4.1 Introduction

Human-wildlife conflict frequently involves free-ranging large carnivores (Gusset *et al.* 2009) and therefore carnivores are usually the first species to be lost in human-dominated ecosystems (Estes 2004). Humans have been, and continue to be, the cause of most carnivore losses either through direct or indirect persecution (Sillero-Zubriri & Macdonald 1997; Breitenmoser 1998; Berg 2001; Linnell *et al.* 2001; Conforti & de Azevedo 2003; Espuno *et al.* 2004; Zabel & Holm-Müller 2008).

Direct persecution is primarily based on the belief that carnivores threaten humans and/or economic resources such as livestock or game (Mishra 1997; Breitenmoser 1998; Conforti & de Azevedo 2003; Sillero-Zubriri *et al.* 2007; Zabel & Holm-Müller 2008; Dar *et al.* 2009). By comparison, habitat destruction and fragmentation are considered to be the most significant indirect factors affecting carnivore numbers worldwide (Woodroffe & Ginsberg 1999a; Stahl *et al.* 2001; Mattson 2004; Wilson 2004; Karanth & Chellum 2009; Inskip & Zimmerman 2009). Consequently, several conservation biologists have suggested that as human settlements further fragment existing rural landscapes and encroach on conservation land, carnivore populations will decline (Woodroffe & Ginsberg 1998; Ogada *et al.* 2003). Thus, the conservation of large carnivores depends as much on the socio-political landscape as it does on the ecological one (Treves & Karanth 2003); especially for threatened species (Inskip & Zimmerman 2009). The conservation of large carnivores is likely to depend increasingly on the resolution of human-carnivore conflict and on networks of smaller reserves, private reserves and communal lands; rather than on vast, unfragmented protected areas (Woodroffe & Ginsberg 1997; Lindsey *et al.* 2004b; Marker & Dickman 2005; Woodroffe *et al.* 2005; Kolowski

& Holekamp 2006). To effectively mitigate potential conflict on the borders of protected areas and reserves, it is of particular importance to understand the factors which determine localised community attitudes and related reactions, towards large carnivores (Newmark *et al*. 1994; Oli *et al.* 1994; Kaczensky *et al.* 2004). Tolerance of carnivore related damage for example, may be influenced by a variety of socio-economic factors such as wealth, education levels, cultural perspectives, income derivation or personal values (Zimmerman *et al.* 2005).

Persecution of carnivores occurs worldwide and impacts a diverse range of species (Oli *et al.* 1994; Landa *et al.* 1999; Harper *et al.* 2005; Virgos & Travaini 2005). Most researchers recognize that the depredation of livestock by predators including jaguars *Panthera onca* in Belize, pumas *Puma concolor* in Brazil, wolves in southern Europe, coyotes in the USA, African wild dogs in Kenya, Zimbabwe and Botswana, and dholes *Cuon alpinus* in Bhutan is a major contributing factor in exacerbating this human-wildlife conflict (Rabinowitz 1986; Kharel 1997; Ciucci & Boitani 1998; Mech *et al.* 1998; Rasmussen 1999; Vos 2000; Stahl *et al.* 2001; Odden *et al.* 2002; Conforti & Azevedo 2003; Chauhan 2003; Davies & Du Toit 2004; Swarner 2004; Woodroffe *et al.* 2005; Zimmerman *et al.* 2005; Wang & Macdonald 2006; Palmeira *et al.* 2008; Karlsson & Johansson 2010).

Zimmerman *et al.* (2005) found that despite cattle ranchers in the Brazilian Pantanal believing jaguars to be attractive animals and important to conserve, they maintained negative attitudes towards the species due to attacks on livestock. This attitude was not however attributed to the associated financial losses, but rather to individual perceptions of the species related to education, tradition and culture (Zimmerman *et al*. 2005). By contrast, Lindsey *et al.* (2005b) found that negative attitudes towards wild dogs on ranches in South Africa and Zimbabwe were generally associated with the economic costs incurred through loss of game animals or damage to fences into which wild dogs had chased larger prey. Consequently, wild dogs were considered to be the least popular predator on these ranches when compared to lions, spotted hyaenas, and cheetahs (Lindsey *et al.* 2005b). Importantly however, in communities with subsistence economies, even small losses can be economically significant since they can represent a large proportion of a scant resource (Oli *et al.* 1994; Sillero-Zubriri *et al.* 2007). By contrast, in Slovenia, it was demonstrated that negative community attitudes towards brown bears *Ursus arctos* were determined by the perceived threat of bears to humans, irrespective of damage to livestock (Kaczensky *et al.* 2004).

It is important to acknowledge that large carnivores differ in their ability to adapt to human-occupied and modified landscapes (Holmern 2007; Woodroffe 2010) and while wild dogs can sometimes move unnoticed through human inhabited landscapes (Lindsey *et al.* 2004b), they are diurnal and highly mobile which can at times make them a highly visible species (Rasmussen 1999). When it comes to apportioning blame for depredation events, which can consequently result in retributive predator persecution, culpability can be attributed more to the visibility of the carnivore than actual evidence (Rasmussen 1999). In northern Botswana, Gusset *et al*. (2009) were able to show that 33% of livestock disappearances were assumed to have been lost to predators despite a lack of any conclusive evidence. In addition, despite only two percent of 938 conflict reports in the study area being attributed to wild dogs, the majority of these wild dogs were extirpated within months of the survey being completed. Similarly, Woodroffe *et al*. (2005) reported persistently negative attitudes towards wild dogs despite livestock depredation by wild dogs in northern Kenya being rare (one attack per 1000 km^2 per year in wild dog occupied habitat). In Kibber, India, Mishra (1997) found that although snow leopards *Panthera uncia* killed substantially more livestock than wolves, wolves bore the impact of human persecution, since their dens with litters were easier to find and destroy.

Attitudes towards carnivores in rural communities are not always negative and Bruskotter *et al. (*2007) indicated that attitudes towards wolves in Utah, USA, were positive and suggested this was as a result of increased urbanization, education and increasing economic prosperity. Furthermore, it was suggested, that attitudes within a community may become more positive towards predators as a generation of people with more negative attitudes is replaced by one with more positive attitudes. Increased levels of education have also been shown to result in more positive attitudes towards predators in a diversity of rural communities' worldwide (Infield 1988; Rodriguez *et al.* 2003; Ericsson & Herbelein 2003; Lindsey *et al.* 2005a; Gusset *et al.* 2008). This is partially as a result of an improved understanding of the role of predators in an ecosystem, but can also result from indirect factors such as improved economic stability or fewer encounters with predators as more educated respondents spend less time working in subsistence agriculture (Infield 1988; Rodriguez *et al.* 2003; Bruskotter *et al.* 2007). Compensation schemes intended to mitigate the burden of, and improve tolerance towards, livestock depredation have been implemented in many countries. However the influence of such management practices on attitudes is still widely disputed (Mishra 1997; Ciucci & Boitani 1998; Berg 2001; Chauhan 2003; Hussain 2003; Madhusudan 2003; Ikeda 2004; Bulte & Rondeau 2005; Zabel & Holm-Müller 2007).

Wild dogs were once distributed through much of sub-Saharan Africa (Fanshawe *et al.* 1997), and are classified as Endangered in South Africa (Red Data Book of the Mammals of South Africa, 2004). Wild dogs are Africa's second rarest large carnivore species after the Ethiopian wolf *Canis simensis* having been extirpated from 25 of the 39 countries where they previously occurred (Fanshawe *et al.* 1997; Sillero-Zubriri & Macdonald 1997; Woodroffe *et al.* 2005). Conflict with humans has been a major cause of this decline as a result of real or perceived threat to livelihoods (Woodroffe & Ginsberg 1999a). A Population and Habitat Viability Assessment (PHVA) 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, as well as re-establishing extirpated populations into protected areas (Mills *et al.* 1998). In South Africa's KwaZulu-Natal Province wild dogs were reported to have been extirpated in the 1930's (Gusset *et al*. 2008).

Hluhluwe-iMfolozi Park and the MGR are high-priority areas suitable for wild dog packs (Woodroffe *et al.* 1997; Maddock 1999). After several successful reintroductions, beginning in 1980/1981 in HiP (Maddock 1999), a population of approximately one hundred and twenty wild dogs exists in protected areas in northern KwaZulu-Natal. This success has meant that natural dispersals of single-sex groups from natal home ranges have begun to take place (Somers 2001). Consequently, wild dogs are moving outside of designated protected areas and coming into conflict with local communities. Wild dogs have been recorded travelling up to 250km during dispersals (Fuller *et al.* 1992b) and since my project area covers approximately 7,400 km² with a human population of over 400,000 (DTLGA 2003) I predicted that future risk to wild dogs from anthropogenic threats would be high. Importantly, Gusset *et al.* (2008) showed that the majority of the Zulu community interviewed north of HiP in 2003, particularly those who had lost livestock, had negative attitudes towards wild dogs.

The Endangered Wildlife Trust's KwaZulu-Natal Wild Dog Project (hereafter referred to as the KZN Wild Dog Project) has conducted community liaison work, in all tribal authorities surrounding HiP and MGR, facilitated wild dog education camps and maintained a media profile in the area from 2006 until 2009. To understand the effectiveness of such liaison work in influencing local people's perceptions towards wild dogs and to determine successful conflict mitigation strategies, extensive community surveys were conducted. The specific aims of the study were to:

- Determine whether wild dog-specific education influenced:
    1) Respondents' attitudes towards wild dogs and other large carnivores;
    2) The attitude towards stock loss;
    3) The respondents' ability to identify wild dogs;
    4) The respondents' understanding of wild dog behaviour and;
    5) The respondents' understanding of the livestock husbandry methods required to minimize livestock depredation by wild dogs beyond protected areas;
- Using questions from the survey that addressed the respondent's attitude towards wild dogs and other large mammalian carnivores, to develop an attitude index and test the effect of selected demographic variables (age, gender, community density, employment status, household size and formal education level)on this index;
- Assess the attitude of respondents to stock loss through depredation and test how this attitude was affected by stock losses, the livestock numbers and the expectation of compensation;

- Using questions from the survey that addressed the respondent's knowledge of wild dogs and other mammalian carnivores, to develop a knowledge index and to examine the relationship between the knowledge index and various variables (age, gender, level of formal education and received wild dog education);
- Using questions from the survey that addressed the respondent's approach to livestock husbandry to develop an index for livestock husbandry and to test the effect of various variables (number of livestock, formal education level, received wild dog education, gender and age) on livestock husbandry;
- Determine whether distance from a protected area influenced depredation frequency, community attitudes towards wild dogs and other large carnivores and the effectiveness of wild dog specific education.

4.2 Methods

4.2.1 Data Collection

A structured questionnaire survey (Appendix B) was conducted in areas bordering two protected areas, HiP and MGR of KwaZulu-Natal from November 2008 to April 2009 (Figure 4.1). These two protected areas were selected since, at the time of surveying, they were the only two provincial game reserves in KwaZulu-Natal to have resident populations of wild dogs. Interviews (n=247) were conducted among rural communities in six tribal authorities, Ximba, Zungu, Mdletshe, Mandlakazi, Nyawo and Jobe (Figure 4.1). The surveys were conducted in a series of four predefined transects each 18 km long and 3 km wide located in areas where wild dogs had in the past 10 years been sighted (Figure 4.2). Each transect was further sub-divided into three, namely "Near" (0-6 km), "Medium" (6-12 km) and "Far" (12-18 km) relating to their proximity to the respective protected area (Figure 4.2). The maximum length and width of transects was chosen to avoid the potentially confounding effect of proximity to other protected areas or private game reserves (Figure 4.2). A minimum of twenty surveys were conducted in each transect category (i.e. near, medium and far) for a power of 0.94 at the 0.05 level of significance.

Questionnaires were conducted one-on-one, in isiZulu, to ensure maximum completion and understanding of questions. Answers were transcribed in English by the interviewer for ease of analysis and interpretation. The questionnaires comprised a series of open- and close-ended questions, and those scaled on the 5-point Likert scale (White *et al*. 2005; Zimmerman *et al.* 2005). Trichotomous questions (yes/ no/ maybe answers) were conducted as a series of statements upon which the interviewee could comment (Walpole & Goodwin 2001). Questionnaires were divided into four sections aimed at determining social demographics, attitudes towards predators (specifically wild dogs), livestock husbandry and knowledge of wild dogs. A pilot questionnaire of 10 surveys was conducted to identify ambiguous questions or questions which did not translate effectively. Eight questions were modified which resolved confusion among both the interviewer and respondent. Pilot surveys were not included in the final total of completed questionnaires to ensure a standardized questionnaire for all respondents.

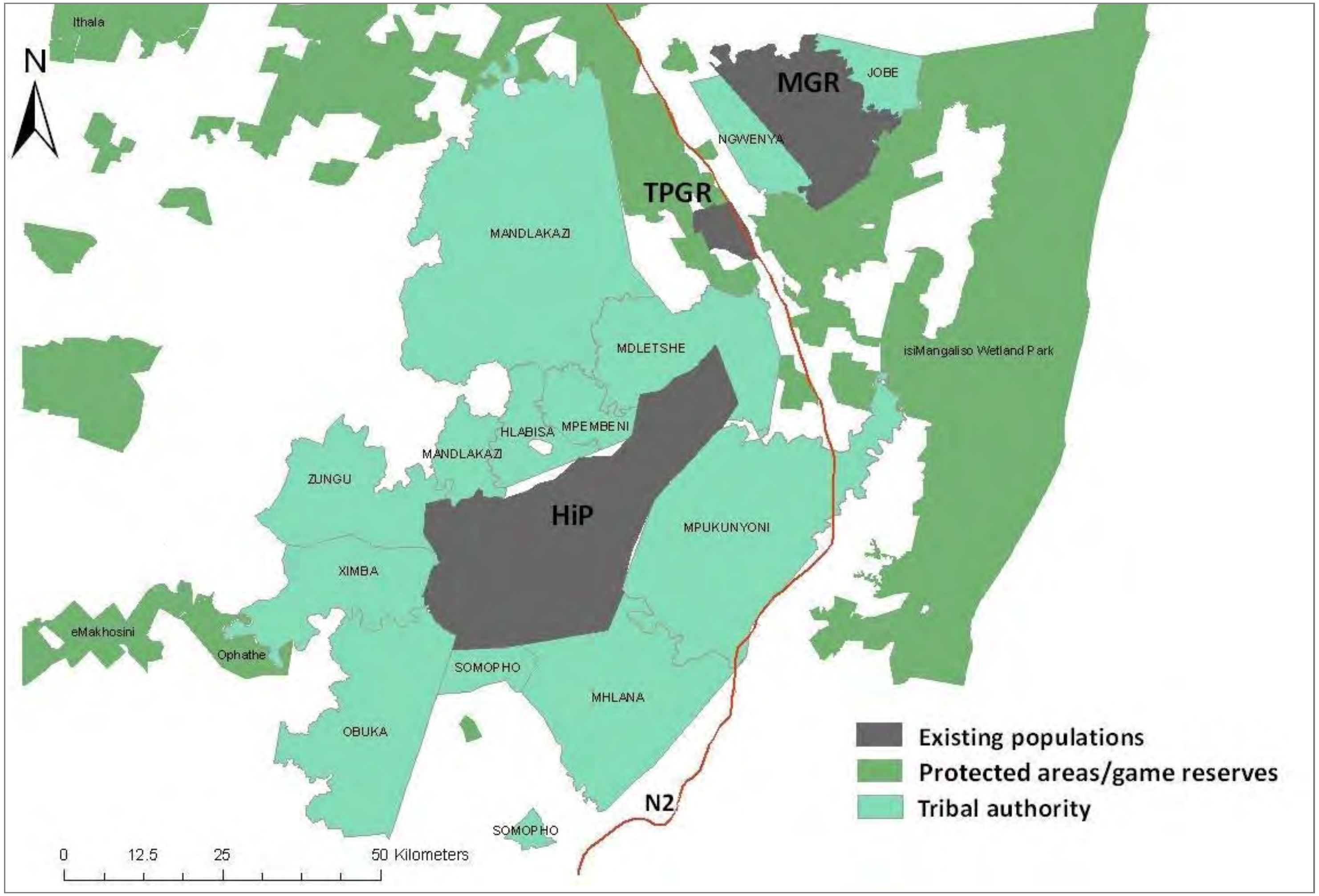

Figure 4.1: Map of study area in northern KwaZulu-Natal with tribal authorities and current resident wild dog populations indicated.

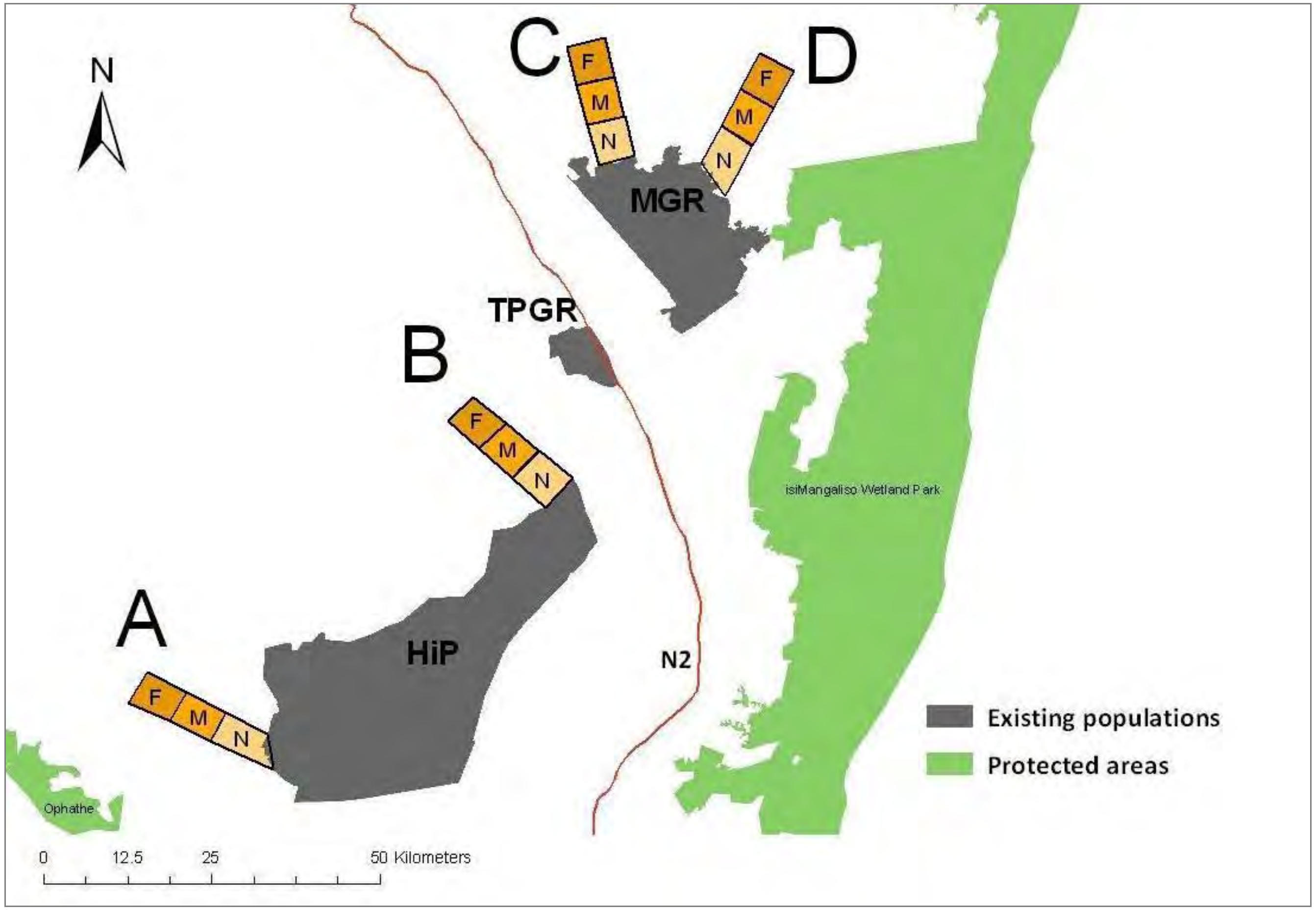

Figure 4.2: Map of study area in northern KwaZulu-Natal with survey transects A, B, C and D indicated. Transect divisions of near (N; 0-6 km), medium (M; 6-12 km) and far (F; 12-18 km) are indicated.

Interviews were conducted by a Community Liaison Officer from the KZN Wild Dog Project and two assistants. Despite the project's community liaison work having been conducted for two years before the commencement of the surveys, it was still made clear to respondents that the surveys were in no way being conducted by provincial conservation officials, and that information given during the interviews would not be used against those in the community. I attempted to interview an equal number of males and females and a maximum of six youths (defined as being a learner at primary or secondary school) from each transect category. This was in order to assess the influence of gender and age on respondents' answers. Within these parameters individuals were selected for interview by walking or driving through a community and asking individuals outside dwellings or stores if they would be willing to be interviewed. In areas where the population was sparse, but where there were congregations of more than an individual, a respondent was isolated for an interview before another respondent was consulted.

Socio-demographic and socio-economic questions (Appendix B) were used to determine age, gender, education level, employment status, number of occupants per relative household and density of communities. These were followed by a series of questions to gather information on livestock numbers and the threats perceived to be the most significant to the livestock of individuals or communities. If a respondent lived in the same house as another respondent, a livestock total was only considered for one of the respondents and not duplicated in calculations. Further questions explored husbandry efforts and the perceived or actual limitations, which can reduce effective care and management of livestock.

Respondents were shown identification pages, each with images of a series of locally occurring prey species (bushpig *Potamochoerus larvatus*, grey duiker *Sylvicapra grimmia*, guinea fowl *Numida meleagris*, scrub hare *Lepus saxatilis*, impala, kudu *Tragelaphus strepsiceros*, nyala, and common reedbuck *Redunca arundinum*) and predators (brown hyaena, caracal *Caracal caracal*, honey badger *Mellivora capensis*, black-backed jackal, side-striped jackal, leopard, lion, serval *Leptailurus serval*, spotted hyaena and wild dog) and asked to indicate which species they knew and the perceived status and population trends of those particular species. Questions relating to the perceived abundance of prey species were asked to ascertain the potential, localised, availability of indigenous prey for predators outside of protected areas. Knowledge of predator identification is important to gauge the ability of community members to correctly identify animals which may be a threat to, or have killed livestock. Certain questions were also asked in order to identify hunting trends, perceived frequency of hunting in a community and methods which may be favoured by particular communities.

Detailed accounts of conflict with predators were recorded to determine the procedures followed upon the location of a livestock carcass, the accuracy with which the predator(s) were determined and the most widely accused predator(s). Individuals who have experienced livestock losses may exaggerate future losses (Rasmussen 1999, Romanach *et al.* 2007). It was therefore made clear to respondents that answers of any sort would not lead to compensation or other financial benefits (Kolowski & Holekamp 2006). A further five questions pertaining to livestock husbandry were asked to determine management recommendations which may have allowed for a reduction, actual or perceived, in predator/human conflict. Attitudes towards predators were investigated through a series of questions or described scenarios to which responses were recorded (Appendix B). These were followed by a series of statements to determine respondents' opinions on a range of misconceptions which the KZN Wild Dog Project has regularly encountered, for example, that wild dogs regularly attack humans or feed exclusively on livestock.

Three indices were created (attitude, knowledge and husbandry) to measure the influence of attitudes towards predators, knowledge about wild dogs and conflict mitigation, and husbandry effectiveness (Walpole & Goodwin 2001; Marker *et al.* 2003; Zimmerman *et al.* 2005; Appendix C; Appendix D; Appendix E). Index scores were calculated by allocating values of between -2 and 2 to a series of questions according to the positive, neutral or negative attitude to predators, the accuracy of answers about wild dog behaviour and perceptions, and general husbandry effectiveness (Marker *et al.* 2003; Zimmerman *et al.* 2005). The value for each index (i.e. attitude) for each respondent was calculated as the sum of the scores for each question. For attitude and knowledge indices all respondents (n=247) were counted while husbandry index scores were calculated for those respondents (n=162) with, or who had recently owned (within 2 years) livestock.

4.2.2 Data Analysis

Percentages were used as descriptive statistics to illustrate a variety of answers for questions when statistical testing was not appropriate. Statistical significance was set at $P < 0.05$ and all data were analyzed using STATISTICA 8.0 software (Statsoft, Tulsa, OK).

Two-sample t-tests were conducted to test the effect of the wild dog education on attitude index, knowledge index and husbandry index and to test whether respondents were hunters or not, had lost livestock or not, or had heard of wild dogs in traditional stories or not, affected attitude index. Data were log transformed to achieve normality where appropriate. Where this was not possible a Mann-Whitney U-test was conducted. A correlation was run to test the relationship between the attitude index scores and knowledge index scores.

The effect of demographic variables on attitude index

A logistic regression was used to determine which variables, when tested in combination, best predicted attitude index. Six predictor variables were used in the analysis, of which four were continuous variables (education level, household size, age and community density); and two categorical (gender and employment status). The Akaike Information Criterion (AIC) was used to select the best model from these variables (Archibald *et al.* 2005). Models with a Δ AIC < 4 were considered acceptable predictors (Archibald *et al.* 2005).

A one-way analysis of variance (ANOVA) was used to analyze the relationship in mean attitude index scores between genders, and respondents' answers to close-ended questions on compensation, predator conflict, whether wild dogs attack humans (an additional Scheffes Test was also conducted to test significance, $P < 0.05$, for this variable) and distance from the park.

Multiple regressions were conducted to understand the significance of relationships between attitude index scores and formal education levels of respondents, household size of respondents and livestock numbers owned by respondents or their households.

Factors affecting attitude towards loss of livestock to predators

A logistic regression was performed to determine which variables best predicted attitude towards stock loss. Three predictor variables were used in the analysis, of which two were continuous variables (livestock numbers and number of livestock lost to predators); and one categorical (expectation of compensation). The AIC was used to select the best model from these variables (Archibald *et al.* 2005). A Kruskal-Wallis test was used to test for differences between respondents who would likely, possibly or not have their attitudes influenced by the expectation of compensation.

Factors affecting knowledge of wild dogs and other large carnivores

A logistic regression was performed to determine which variables best predicted the knowledge index. Five predictor variables were used in the analysis, of which four were continuous variables (age, formal education level and livestock numbers); and two categorical (gender and whether have received wild dog education). The AIC was used to select the best model from these variables (Archibald *et al.* 2005). A Kruskal-Wallis test was used to test for differences in knowledge index between respondents, who believed they would definitely, might be or would not be attacked by wild dogs.

Factors affecting husbandry methods (husbandry index)

A logistic regression was performed to determine which variables best predicted the husbandry index. Five predictor variables were used in the analysis, of which three were continuous variables (age, formal education level and livestock numbers); and two categorical (gender and whether have received wild dog education). The AIC was used to select the best model from these variables (Archibald *et al.* 2005).

The influence of distance from protected areas

A one way ANOVA was used to test the effect of distance on the number of livestock lost and two way ANOVAs were used to test distance and wild dog education, on the attitude and knowledge indices.

4.3 Results

General

Demographics of respondents

Of the 247 respondents, 52% were male, 48% female and the average age was 26 years old. Only one male respondent refused to be interviewed beyond giving his age and name. The majority of respondents were either learners at school (38%) or unemployed (34%; Table 4.1). Thirty nine percent of households relied on government issued pensions or child grants as the principal source of income and other important sources of income were an employed family member (26%) or subsistence agriculture (21%; Table 4.1). Sixty four percent of respondents had some secondary education while 25% had ceased schooling at a junior school level (Table 4.1). On average, each household contained 9 individuals with 4 adults and 5 children and housing density was 10.7 ± 5.9 homes per 200m radius.

Table 4.1: The occupations, primary sources of income and education levels of all respondents (n=247).

Occupation	%	Primary source of household income	%	Education level	%
Learner	38	Pension	30	No education	5
Unemployed	34	Relative works	26	Primary education	25
Employed	18	Agriculture	21	Secondary education	64
Temporary work	4	Child grant	9	Tertiary education	4
Agriculture	2	Employed	9	No response	2
Student	<1	No response	5		
Community leader	<1				
No response	2				

Livestock management and predation on livestock

Sixty two percent of the 247 respondents owned domestic livestock, of which goats (55%) and cattle (40%) were most common with sheep, donkeys and pigs comprising the remainder (Table 4.2). Forty nine (20%) respondents claimed to have lost a total of 134 livestock to predators in 51 separate incidents (Table 4.2). The majority of animals killed were goats (81%) with far fewer cattle being lost to predators. Spotted hyaenas were most frequently blamed for depredation events (62%) and no attacks were attributed to wild dogs (Table 4.2). The identification of predators responsible for depredation events was through evidence at the carcass or identified predator spoor (67% of respondents) or based on hearing a call at night (18%). Eighty percent of the 51 alleged depredation events occurred at night despite 98% of all respondents indicating that they kept livestock in an enclosure at night. Moreover, no livestock were reportedly killed in enclosures. All respondents who lost livestock at night subsequently indicated these attacks had occurred when they had failed to return livestock to enclosures on these particular evenings. Ten percent of attacks reportedly occurred during the day; however, only one attack was witnessed. The dominant perception amongst respondents was that conflict between livestock and predators was increasing (70%) with 17% believing that conflict was decreasing.

Theft (34%), drought (30%) and disease (14%) were ranked as the greatest problems facing livestock owners while predators were ranked as the greatest problem by only 4% of respondents (Table 4.3).

Table 4.2: The composition of livestock owned at the time of the survey and livestock losses attributed to 51 depredation attacks since 2007.

	Livestock					Total
	Goats	Cattle	Sheep	Donkeys	Pigs	
Livestock owned	2094	1477	117	57	8	3753
Total livestock lost	108	26	0	0	0	134
Losses attributed to predators:						
Spotted hyaena	68	15	0	0	0	83
Leopard	10	11	0	0	0	21
Cheetah	24	0	0	0	0	24
Jackal	1	0	0	0	0	1
Serval	5	0	0	0	0	5
Wild dogs	0	0	0	0	0	0

Table 4.3: The most important perceived threats to livestock management as reported by 247 respondents. Data are the percentage of respondents who identified each threat as being the most important.

Threats to livestock	% Respondents
Theft	34
Drought	30
Disease	14
Predators	4
Poor grazing	3
Infertility	3
Hit by vehicle	2
No herder	2
Unreliable market	1
No response	7

Attitude towards predators and the attitude index

The questions on attitude towards wild dogs generated some contradictory answers. Although wild dogs held no importance to 66% of respondents, 83% of respondents believed efforts to protect wild dogs should continue; 53% believed that wild dogs were an important part of Zululand's natural heritage and 58% had a positive opinion of wild dogs (Table 4.4). A small majority (52%) would accept a wild dog introduction onto a neighbouring property and 69% believed that wild dogs could benefit tourism in some way, but 48% believed there were too many wild dogs in the region. Seventy three percent stated they would cooperate to reduce wild dog-human conflict, 66% said that they would actively assist with wild dog protection and 94% agreed it was important to educate people on how to respond when they saw a wild dog (Table 4.4). Seventy three percent of respondents were concerned for Zululand's wildlife, yet 33% indicated they would be happy to have all predators removed from the landscape and 4% of respondents claimed to have successfully removed a predator (Table 4.4). Threats to wild dogs from medicinal trade appeared to be low with only 5% believing wild dogs could be used for traditional medicine.

When these data were summed for each respondent's answer, they combined to form the attitude index, which had a potential maximum of 24 and a minimum of -24 points. The mean score for all respondents was 6.7 points with a standard deviation of 6 points. The highest score by a respondent was 20 while the lowest was -10.

Table 4.4: Survey questions illustrating the attitudes of respondents towards wild dogs and other large carnivores. Data are percentages of 247 respondents.

Perception	Yes	No	Maybe	No response
Should efforts to protect wild dogs continue	83	9	6	2
Are wild dogs important to you	31	66	0	3
Are wild dogs important to Zululand’s heritage	53	30	15	2
Is your current emotion towards wild dogs positive	58	30	0	12
Would Zululand be better without wild dogs	43	49	6	2
Would you tolerate wild dogs introduced by your neighbour	52	42	4	2
Can wild dogs benefit tourism	69	15	14	2
Are there too many wild dogs	48	36	13	3
Would you actively assist with wild dog protection	66	24	9	1
Is it Important to educate people about how to react to wild dogs	94	2	2	2
Would you cooperate to reduce human/predator conflict	73	14	10	3
Are you keen to learn more about wild dogs	92	5	0	3
Are you concerned for Zululand's wildlife	73	20	5	2
Would you be happy if all predators are removed	33	60	5	2
Have you successfully removed a predator	4	93	0	3

The respondents who had received some form of wild dog education from either EWT, EKZNW or a community member, had a significantly higher attitude index than those respondents who had not received this education (*P* < 0.05, *t* = -4.81, *df* = 245; Figure 4.3).

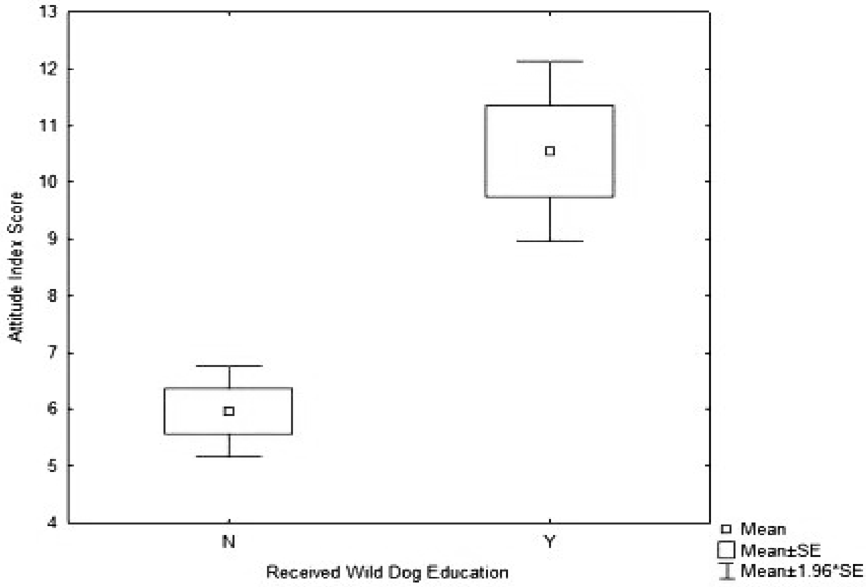

Figure 4.3: Attitude index scores for those respondents who had (Y) or had not (N) received wild dog education.

Only 13% of respondents had heard traditional stories about wild dogs; all of which had negative connotations. There was no significant effect of these stories on the attitude index (*P* > 0.05, t=-0.438, *df* = 238). There was no significant difference in the attitude index of respondents who believed that conflict was increasing, decreasing or remaining stable (*P* > 0.05, $F_{(2,229)}$= 0.87), although respondents who believed conflict was increasing had a non-significant tendency to have a lower mean attitude index (6.7) than those who believed the conflict was decreasing or stable (7.9, 7.8).

Sixty four percent of respondents (n=247) acknowledged that hunting occurred in their communities whilst only 23% said they had hunted (Table 4.5). Hunting appeared to be largely uncontrolled, and was mostly carried out for food provision. There was no significant relationship between whether respondents hunted or not and the attitude index ($P > 0.05$, $t = -0.12$, $df = 243$).

Table 4.5: Questionnaire answers outlining the hunting culture in the study area. Responses are expressed as a percentage of all answers (n=247).

Hunting query	Yes	No	No response
Is there hunting in your area	64	35	1
Have you hunted before	23	76	1
Do you need permission to hunt	15	57	28
Should community members be allowed to hunt in protected areas	5	87	8
Have you seen livestock caught in a snare	31	67	2
Reasons for hunting (%)			
Food	53		
Pleasure	12		
Money	6		
Tradition	2		
Muti	<1		
No response	26		

Using logistic regressions with six factors and AIC to identify the best models, education level, household size and age were identified as the best individual predictors (Δ AIC < 4; Archibald *et al.* 2005) of attitude index while gender, employment status and housing density had little predictive power (Δ AIC > 4; Archibald *et al.* 2005). One model including education level, household size and age was the best predictor of attitude index. When these factors were tested separately using Univariate Tests of Significance, there was a significant positive relationship between level of formal education and attitude index, but the level of formal education explained only 3% of the variation in attitude index ($P < 0.05$; $R^2 = 0.03$; $F_{(1,235)} = 10.9$; Figure 4.4). The effects of household size ($P > 0.05$, $F_{(1, 242)} = 3.4$, $R^2 = 0.01$) and age ($P > 0.05$, $F_{(1, 235)} = 2.22$) did not significantly influence attitude index. It is likely that a single household which supported 48 members (mean household size 9.11 ± 4.1) had a disproportional impact on the regression results.

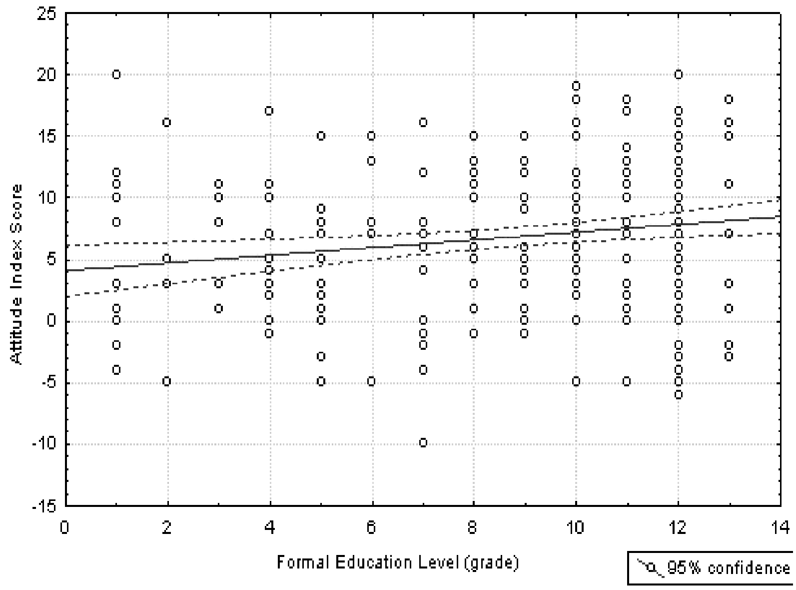

Figure 4.4: The relationship between the level of formal education of respondents and Attitude index. Dashed lines indicate a 95% confidence bands. Grade 13 on the x-axis refers to tertiary education.

Attitude towards livestock loss

Although 93% percent of respondents would not tolerate losing livestock to wild dogs, the majority (64%) would still not try kill the predator blamed for losses (Table 4.6). Seventy two percent of respondents expected financial compensation in the event of livestock loss to predators and 62% expressed that they would be more inclined to accept losses to predators if they were financially compensated (Table 4.6). Seventy five percent of respondents believed that local conservation agency EKZNW should be responsible for the payment of any compensation.

Table 4.6: The perceptions of respondents towards livestock loss.

Livestock loss perception	Response % (n=247)			
	Yes	No	Maybe	No response
Will accept livestock loss by wild dogs	2	93	3	2
Will kill a predator if lose livestock	30	64	6	0
Will accept livestock loss if compensated	62	30	8	0
Expect compensation	72	21	5	2

Using logistic regressions with three factors and the AIC to identify the most influential factors and models, livestock number was the best single predictor of attitude (Δ AIC < 4; Archibald *et al.* 2005; using attitude index scores for respondents with livestock) towards stock loss. A two factor model with livestock losses and livestock numbers best predicted attitude towards predators (Δ AIC < 4; Archibald *et al.* 2005). Respondents with a greater number of livestock had significantly higher attitude scores than those who owned less livestock ($P < 0.05$, $F_{(1,244)} = 5.7$), despite those with more livestock having lost significantly more animals ($P < 0.05$, $Z = -3.12$, $df = 239$; Figure 4.5).

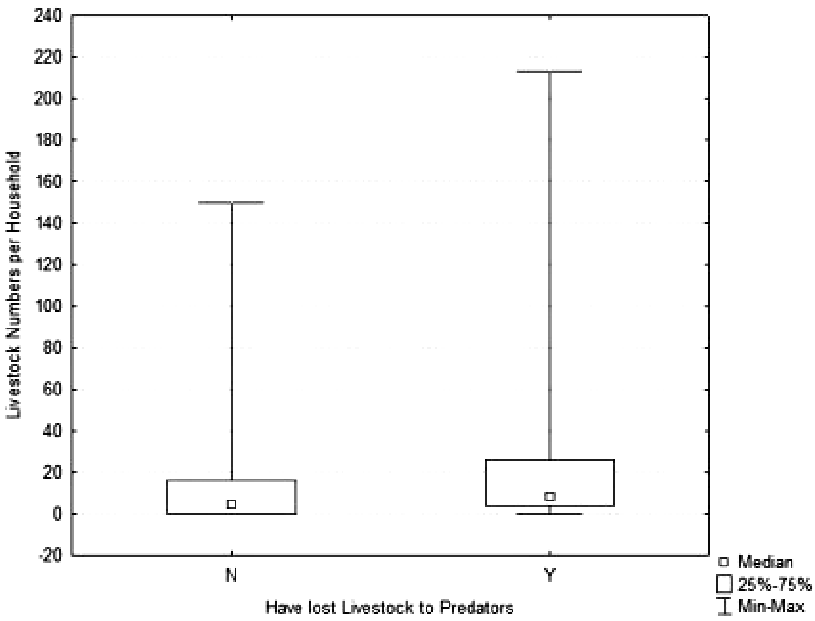

Figure 4.5: The number of livestock per household and those respondents who have either lost livestock to predators (n=49) or not (n=113) ($P < 0.05$, $Z = -3.12$, *df* = 239).

The number of livestock lost to predators losses did not significantly affect respondents' attitude towards stock loss ($P > 0.05$, $t = -1.33$, *df* = 239). None of the remaining five models were considered to be acceptable predictors (Δ AIC > 4; Archibald *et al.* 2005).

The attitude index scores were not significantly different between respondents who believed conflict with predators was increasing, decreasing or stable ($P > 0.05$, $F_{(2,229)} = 0.9$) and wild dog education did not significantly influence attitudes towards livestock losses *(P* < 0.05, Z = -3.2, *df* = 245).There was no significant relationship between the respondents' attitude towards financial compensation for stock loss and attitude index ($P > 0.05$, $H_{(2,242)} = 0.21$; Figure 4.6).

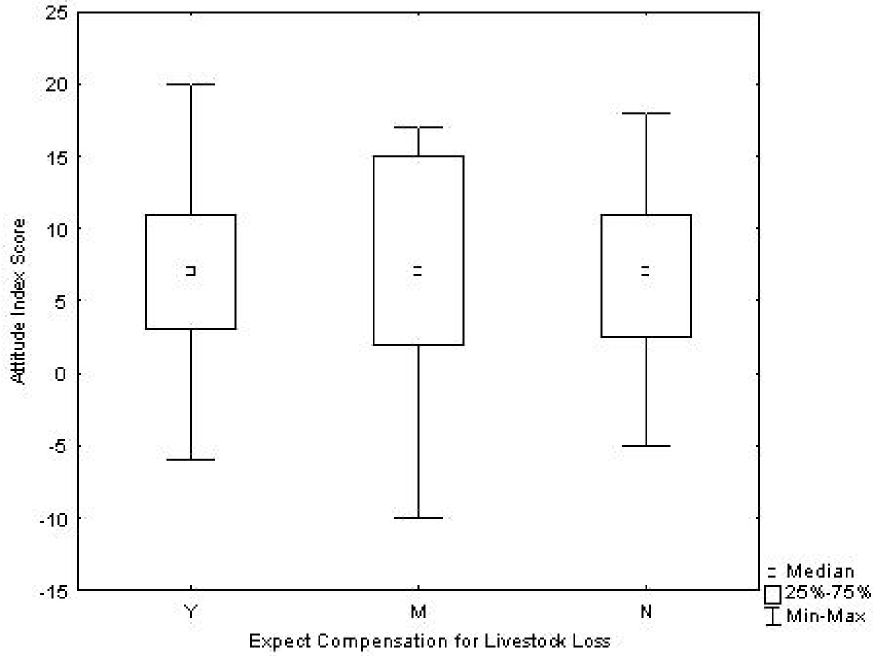

Figure 4.6: The attitude index score of respondents who expect (Y), do not expect (N), or might expect (M) compensation for livestock losses (n=247) ($P > 0.05$, $H_{(2,242)} = 0.21$).

4.3.4 Knowledge and perceptions of game (prey) availability

Knowledge of indigenous game species was generally poor, with only 55% of respondents (n=247) able to correctly identify an impala, the most common ungulate in the region (Table 4.7). Identification rates for guinea fowl (89%) and scrub hare (79%) were high while rates for all other game species were very low (Table 4.7). Among those respondents who were able to correctly identify the game species, all species were perceived to be decreasing in numbers (Table 4.7). Seventy five percent of all respondents believed that lower game densities in areas outside of protected areas will increase the likelihood of wild dogs attacking livestock.

Table 4.7: Percentage of respondents (n=247) able to correctly identify locally distributed game species, and perceptions of the local abundance of each species outside of the nearest protected area, by those respondents who could correctly identified a particular species.

	Can identify (%)			Dominant perceived trend
	Yes	*No*	*No response*	
Bushpig	53	45	2	Decrease
Duiker	35	63	2	Decrease
Guinea fowl	89	9	2	Decrease
Scrub hare	79	19	2	Decrease
Impala	55	42	3	Decrease
Kudu	38	61	1	Decrease
Nyala	28	71	1	Decrease
Reedbuck	19	80	1	Decrease

4.3.5 Knowledge of wild dogs and other predators

Less than half of the respondents could correctly identify wild dogs (Table 4.8) and this increased to 66% for those who were familiar with the KZN Wild Dog Project. By contrast, 83% could identify leopard and 79% could correctly identify lions (Table 4.8). The two species of jackal (both side-striped and black-backed), were often confused and reported as the same species in Zulu communities (with the names *inkanka* or *mpungutshe* used interchangeably) and also frequently confused with wild dogs when reported to the KZN Wild Dog Project. Despite 65% of all depredation attacks being blamed on spotted hyaenas only 43% of respondents could identify this species. There was an overwhelming perception that all predator populations were declining (Table 4.8). This was later contradicted in questions to generate the knowledge index, with 51% of survey respondents stating the provincial wild dog population was increasing.

Table 4.8: The percentage of respondents (n=247) able to correctly identify predator species, and the perceptions of local abundance outside of the nearest protected area, of those respondents who could correctly identify a particular species.

	Can identify (%)			Dominant perceived trend
	Yes	*No*	*No response*	
Brown hyaena	3	95	2	Decrease
Caracal	9	89	2	Decrease
Honey badger	34	65	1	Decrease
Jackal	49	49	2	Decrease
Leopard	83	15	2	Decrease
Lion	79	19	2	Decrease
Serval	18	80	2	Decrease
Spotted hyaena	43	55	2	Decrease
Wild dog	44	54	2	Decrease

Forty five percent of respondents believe that wild dogs do not attack humans while 37% held the opposite view and 4% believed that humans comprise a proportion of the diet of wild dogs (Table 4.9). Only one respondent believed that wild dogs feed exclusively on game animals when outside a protected area whilst the rest of the respondents, believed that livestock and poultry sustain wild dogs (Table 4.9).

Table 4.9: Survey questions indicating respondent's understanding of wild dog behaviour or ecological function. Responses displayed as a percentage (n=247).

Perception	Response (%)			
	Yes	No	Maybe	No response
Wild dogs attack humans	37	45	16	2
Wild dogs can pass communities unnoticed	39	47	12	2
Wild dogs can pass without killing livestock	24	66	7	3
Wild dogs play a role in the ecosystem	48	29	21	2
Outside protected areas wild dogs feed on (%):				
Goats only	45			
Mixed livestock	20			
Cattle only	3			
Humans & livestock	3			
Humans only	1			
Antelope only	<1			
Antelope & livestock	0			
No response	28			

The allocation of points for each respondent's answers, to questions which combined to form the knowledge index, were summed and used in statistical analysis. Knowledge index scores had potential maximum of 18 and a minimum of -17 points. The mean score for all respondents was 1 point with a standard deviation of 4.2 points. The highest score by a respondent was 11 while the lowest was -7.

Respondents who had received wild dog education through EWT or EKZNW had significantly higher knowledge index ($P < 0.05$, $Z = -7.97$, $df = 245$; Figure 4.7) when compared to those who had not received wild dog-specific education.

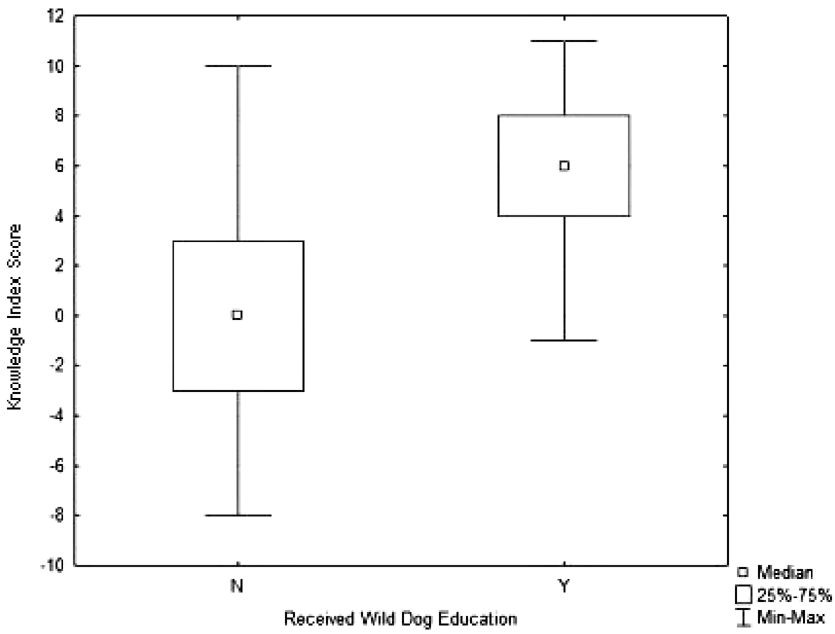

Figure 4.7: The knowledge index scores of respondents who had received wild dog education (Y) and those who had not (N) ($P < 0.05$, $Z = -7.97$, *df* = 245).

Using logistic regressions with five factors and AIC to identify the best models, received wild dog education and age were identified as the best individual predictors of knowledge index while educational level, gender and livestock numbers had little predictive power. One model including received wild dog education and age was the best predictor of husbandry index. Those respondents who received wild dog education had a significantly higher knowledge index than those that had not received wild dog education ($P < 0.05$, $F_{(1, 241)} = 11.71$). However, the relationship between age and knowledge index was not significant ($P > 0.05$, $F_{(1, 241)} = 0.78$).There was a significant positive relationship ($P < 0.05$, $r = 0.40$; Figure 4.8) between attitude index and knowledge index.

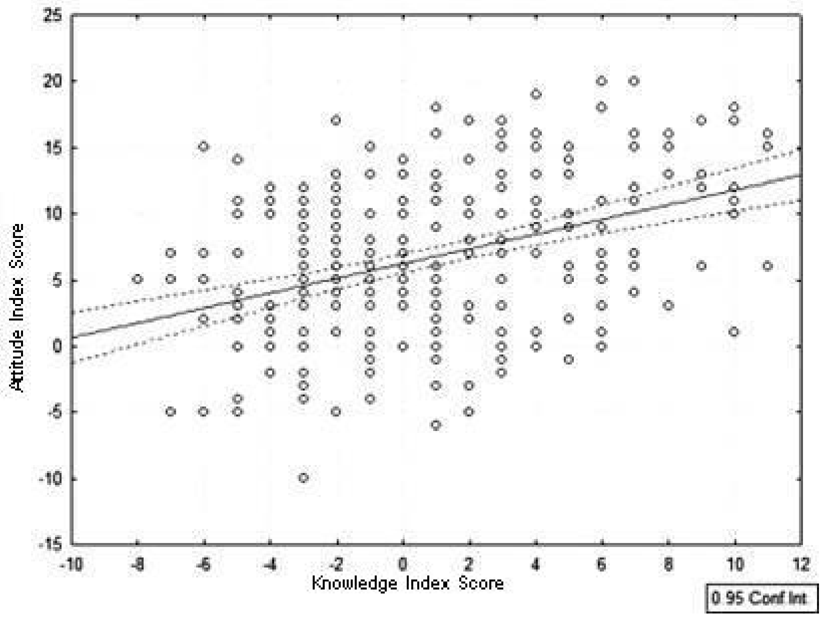

Figure 4.8: The significant relationship between attitude index score and the knowledge index score of respondents. ($P < 0.05$, $r = 0.40$). Dashed lines indicate 95% confidence bands.

There was a significant relationship between the perception of whether wild dogs attacked humans and the attitude index ($P < 0.05$, $F_{(2,238)} = 3.99$; Figure 4.9). Respondents who correctly believed that wild dogs did not attack humans had a significantly higher attitude index than those who thought they might be attacked ($P < 0.05$, $F_{(2,238)} = 3.99$).

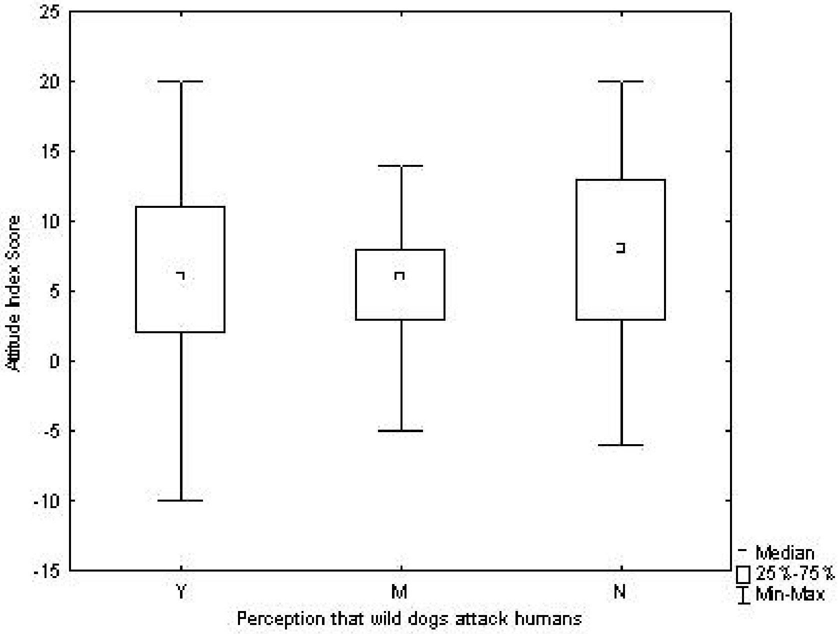

Figure 4.9: The attitude index scores of respondents and the perception that wild dogs might, or will definitely not, attack humans ($P < 0.05$, $H (2,241) = 8.0$).

4.3.6 Livestock husbandry

Grazing lands were mostly communal and mostly unfenced and nearly all respondents kept livestock in enclosures at night and allowed free roaming during the day (Table 4.10).

Table 4.10: Methods of livestock husbandry used by 152 respondents.

	%	
Livestock husbandry	Night	Day
Enclosure	96	<1
Free roaming	2	93
Guarded	0	4
Other	0	1
No response	2	2

Thirty one percent of respondents had observed livestock being caught by, or carrying, a snare and 41% reported that they had lost domestic animals for reasons other than depredation.

Only 23% of those who owned livestock employed a herder, despite 93% of all respondents with livestock rating the effectiveness of a herder positively. There was no significant impact by the KZN Wild Dog Project education program on improving livestock husbandry practices (as indicated by the husbandry index) among respondents with livestock ($P > 0.05$, $Z = -0.14$, $df = 153$). This was despite 83% of respondents acknowledging improved husbandry care would reduce potential livestock losses to wild dogs.

Using logistic regressions with five factors and AIC to identify the best models, education level and gender were identified as the best individual predictors of husbandry index while age, livestock numbers and received wild dog education had little predictive power. One model including education level and gender was the best predictor of husbandry index. Although the husbandry index was slightly higher for males compared to females, there was no significant difference between the two groups ($P > 0.05$, $F_{(1, 150)} = 0.01$).

4.3.7 The influence of distance from a protected area on respondents

Although the frequency of predator attacks did not differ with distance from the protected area, the number of livestock lost to predators in a similar frequency of attacks increased with distance ($P < 0.05$, $H_{(2, 247)} = 13.43$; Figure 4.10). This increase was gradual and no pairs were significantly different.

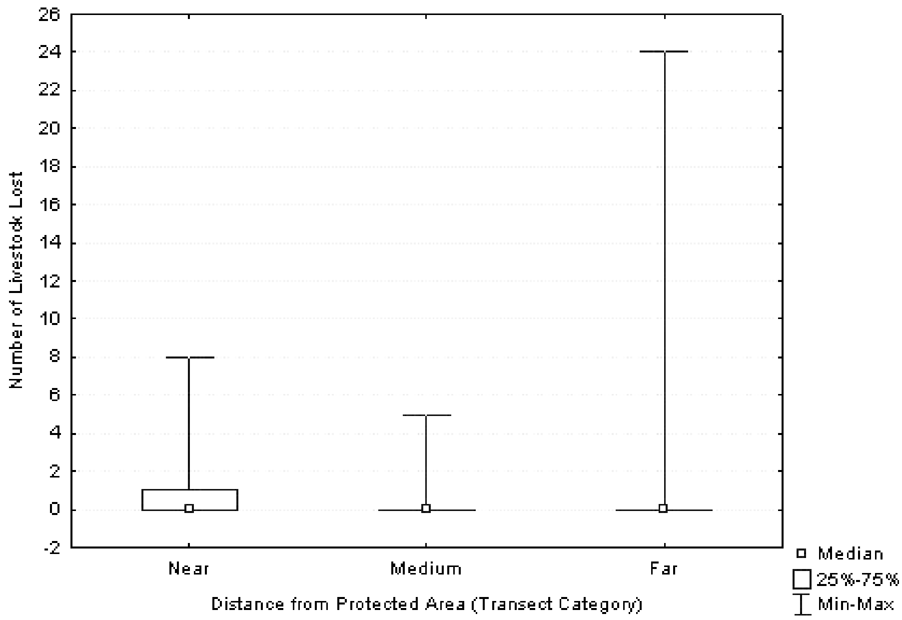

Figure 4.10: The number of livestock lost per depredation incident as distance from a protected area increases (P < 0.05, H (2, 247) = 13.43).

There was no significant effect of distance from protected area on attitude index ($P > 0.05$, F $(_{2,244})$ = 2.53) but the knowledge index of respondents closest to the protected areas was significantly greater than that of those living furthest from the protected areas ($P < 0.05$, H $(_{2,247})$ = 13.61; Figure. 4.11). It has already been shown that respondents who had received wild dog education had significantly higher knowledge index scores (Near: 2.46 ± 4.53; Medium: 0.27 ± 4.19; Far 0.15 ± 3.55) when compared to those who had not received wild dog-specific education. Of the 18% of respondents who had received wild dog-specific education 60% were nearest the protected area, 29% were in the medium proximity and 11% in the farthest category.

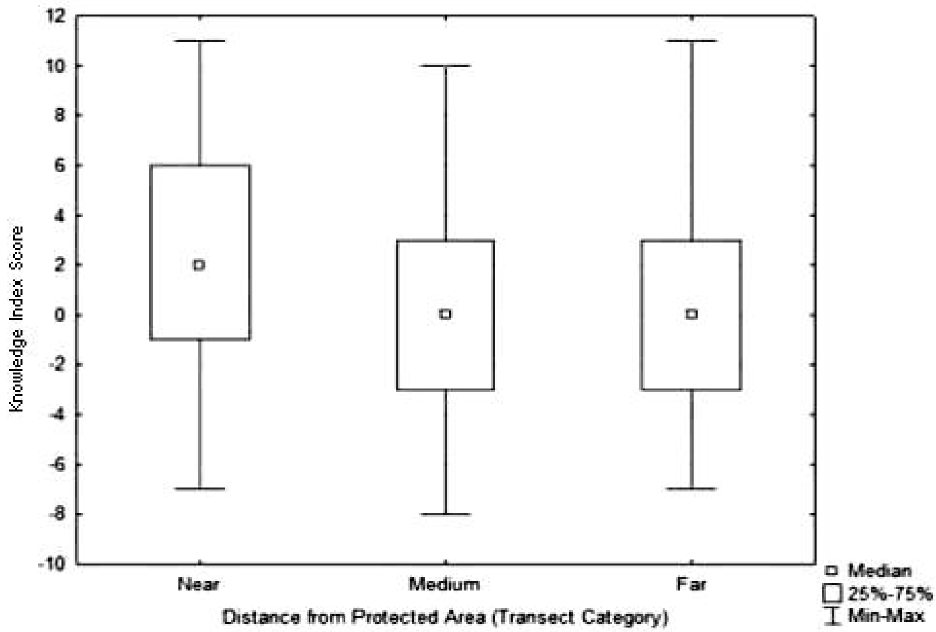

Figure 4.11: Knowledge index (Near: 2.46 ± 4.53; Medium: 0.27 ± 4.19; Far 0.15 ± 3.55) of those respondents living at different distances from a protected area.

4.4 Discussion

4.4.1 Demographics of respondents

The results indicate that the socio-demographic variables of age and gender did not significantly influence community attitudes to predators. This is in line with findings of Rodriguez *et al.* (2003) and Gusset *et al.* (2008), who found such demographics to have no significant influence on attitudes. This contrasts with studies that have found more negative attitudes among older respondents (Lindsey *et al.* 2005b; Zimmerman *et al.* 2005) and females to be more negative towards predators than males (Zimmerman *et al.* 2001). The high unemployment rate and majority dependency on government grants and subsistence agriculture is a point of concern since these economically marginal communities are more likely to have negative attitudes towards wildlife and conservation (Oli *et al.* 1994). For livestock owners with small herds, any attacks may lead to their agricultural practices becoming unsustainable (Ikeda 2004). In addition, 53% of respondents in this study indicated that hunting of game species in their areas is for food and the majority of respondents perceived game populations to be declining. A decreased prey base is likely to increase predator attacks on livestock (Fritts *et al.* 2003; Woodroffe 2005). An increase in the need for game hunting to supplement financial income or food supplies could aggravate existing conflict with predators (Lindsey *et al.* 2005b).

4.4.2 Attitude towards predators and the attitude index

The survey found that community attitudes towards predators (wild dogs in particular) were generally positive, in part, due to increased education levels of respondents when compared to prior research (Infield 1988; Gusset *et al.* 2008). This finding contradicts Gusset *et al.* (2008) who found a negative attitude towards wild dogs resulting from fear of predators and a perception that wild dogs would kill livestock. However, my results agree with the recommendations of Gusset *et al.* (2008), suggesting that education efforts needed to continue to generate a more favourable attitude to predators. The study of Gusset *et al.* (2008) showed a positive attitude to wild dogs immediately after a brief conservation education program. However, a decline in attitudes towards wild dogs followed in the three year period between their surveys when no conservation education work was carried out. Prior research found respondents living near HiP to be significantly more positive towards conservation if they had some formal education than if they had not (Infield 1988). On the boundary of Kruger National Park people with formal education were also more positive than those without (Lagendijk & Gusset 2008). When assessing public response to Mexican gray wolf *Canis lupus baleyi* relocations a positive relationship between academic qualifications and attitudes was found (Rodriguez *et al.* 2003). This was partially due to those with higher academic qualifications being less likely to own livestock, and therefore less likely to perceive wolves as a threat. In my study, 93% of respondents had some level of formal education and 18% had also received wild dog-specific education. Both formal and wild dog-specific education had significantly positive impacts on respondent's attitudes.

The results suggest that while a majority of respondents are largely ambivalent towards wild dogs and nearly half the respondents believed there are too many wild dogs in the region, the majority believe that conservation efforts to protect the species should continue. The rationale for supporting wild dog conservation may lie in the perceptions that wild dogs are an important part of Zululand's heritage and that such a rare species could act as a catalyst for tourism initiatives in the economically impoverished region (Walpole & Goodwin 2001; Andereck & Vogt 2009). It is unclear though how such perceptions will be sustained in the future as neighbouring communities currently do not receive direct financial support as an exclusive result of wild dogs existing in protected areas. Communities neighbouring EKZNW protected areas do however receive sporadic development benefits as a result of accrued community levies; a proportion of gate earnings generated by tourists entering reserves.

Whilst respondents may be hesitant to see an increase in carnivore abundance, it appears they would be willing to cooperate to ensure that a balance is established whereby livestock can be maintained in an environment with some carnivores, but without the fear of losses to predators. This attitude resembles the "jaguars deserve protection…but not on my ranch" responses frequently recorded in the Brazilian Pantanal (Zimmerman *et al.* 2005). In KwaZulu-Natal this may allow for transient single-sex dispersals outside protected areas with core wild dog populations and enable migration through linkages to other populations within the region. Provided effective conflict mitigation measures are in place it may also allow for infrequent, temporary, movement of resident wild dog packs beyond the fenced boundaries of protected areas.

4.4.3 Knowledge of wild dogs and other predators

Knowledge index scores, which represented an understanding of wild dog behaviour and human/carnivore conflict mitigation, were significantly higher among those respondents who had received wild dog education when compared to those who had not. In addition, the ability to identify wild dogs was more pronounced among respondents who had received wild dog-specific education. Since 94% of respondents felt it was important to educate communities on how to respond when wild dogs are outside a protected area, and 92% wanted to learn more about wild dogs, it is evident that the opportunity exists to stimulate more extensive positive attitudes towards carnivores through ongoing education initiatives. Increasingly positive or tolerant attitudes towards carnivores, provided they translate into carnivore tolerant behaviour, could allow for increased predator ranging beyond protected areas (Jackson *et al.* 1996; Ogada *et al.* 2003). In this context cooperation with conservationists could reduce the need for lethal carnivore-conflict mitigation measures.

Fear of predators has been shown to be negatively correlated to attitude due to the perception of the threat posed to humans (Kellert & Berry 1987; Kaczensky 2004). By contrast, in Norway, fear of wolves, and attitudes, were not always correlated (Zimmerman *et al.* 2001). Attitudes were more likely attributed to experiences related to wolf encounters rather than the perceived threat. Worldwide however, predators are a statistically insignificant source of human mortality (Ginsberg 2001). My results showed that respondents who believed they would not be attacked had significantly more positive attitudes than those uncertain as to whether they could be attacked or not. It appears that knowing wild dogs held no threat to humans substantially influences attitudes when compared to the uncertainty of not understanding the threat level posed, or the possible anxiety of not knowing how to react when wild dogs are encountered. This attitude could further be influenced by conflicting knowledge of whether wild dogs will attack humans or not, and a previous negative encounter with domestic dogs which are often considered similar to wild dogs by community members within the study area.

4.4.4 Livestock management, husbandry and depredation

It has been suggested that those communities who live in close proximity to carnivores are often those who generate low financial income (Dar *et al.* 2009). Although the authors do not explain why this is the case, it is presumed likely that this results from economically poorer rural communities expanding into areas which are less developed, perhaps unsuitable for commercial agriculture and would more likely play refuge to carnivores. In the Pantanal region of Brazil there was no significant relationship found between cattle numbers owned and attitude (Zimmerman *et al.* 2005). However, they suggested that, higher income among farmers could enable them to more likely accept depredation losses. In my study, livestock losses to predators were not found to be a direct indicator of a negative attitude. Although respondents with higher numbers of livestock had significantly higher losses they were not attacked more frequently than those with fewer livestock. Those respondents with more livestock had significantly more positive attitudes than those with less livestock. Livestock ownership is an indicator of financial wealth in Zulu culture (Dovie *et al.* 2004). Thus, respondents with more livestock are considered financially more stable and in a better position to absorb the financial impact of an attack (Zimmerman *et al.* 2005). The financial burden of livestock losses to those with fewer livestock will be perceived to be greater than for those with many livestock since any loss is a greater proportion of total financial wealth (Oli *et al.* 1994; Mertens & Promberger 2001; Romanach *et al.* 2007; Lagendijk & Gusset 2008; Dar *et al.* 2009).

Livestock losses to predators were only rated as the most significant problem by 4% of respondents in my study. This contrasted strongly with theft (34%) and drought (30%) which suggested that more effective husbandry practices, rather than an entire shift of sentiment, could reduce losses. Such findings correspond with those in Minnesota, USA, where wolves were perceived as a threat to livestock agriculture, but one which was negligible in the context of greater perceived hazards such as disease and extreme weather (Chavez *et al.* 2005). An increased vulnerability of livestock to predators where herding practices were reduced was reported in Alpine regions of Europe, despite the continuing need to graze livestock (Breitenmoser 1998). Of additional concern is that theft, losses to predators, overgrazing of particular locations, and losses of livestock by being hit by vehicles could all be reduced through the use of livestock herders (Jackson *et al.* 1996; Butler 2000; Linnell *et al.* 2001; Ogada *et al.* 2003) and 93% of all respondents with livestock agreed that herders were effective. Surprisingly, however, 77% of all livestock owners in my study area did not use a herder and only 2% of respondents believed this to be the most significant problem facing those with livestock.

It may be that factors such as the impact of HIV/AIDS on family structures (Bollinger *et al.* 1999; Barnett & Grellier 2003; Heuveline 2004; OPKZN 2006), legislation enforcing formal schooling of children (Watson 1977; Iro 1994) or financial burdens of local livestock management costs (Ogada *et al.* 2003) are eroding the tradition and prevalence of herding. Anecdotal evidence in the study area suggests that financial constraints and the need for children to be educated at school are the primary reasons for herders not being used in Zululand more frequently. However, if these are indeed the root causes of the current conduct, there appears to be little collective cooperation within communities to establish a solution. One example would be to employ a paid herder using collective monies which could be generated from the sale of livestock that may otherwise have been lost. Cattle continue to be routinely released from enclosures to roam freely, or are herded to collective grazing sites and left with minimal or no supervision (personal observation). In addition, 80% of all livestock losses occurred at night when animals had not been gathered into enclosures. Wild dogs tend to be more active and hunt in early mornings or late afternoons; times when livestock will most likely be grazing (Creel & Creel 1995; Holmern *et al.* 2007). Therefore, the implementation of more intensive herding practices and the habitual use of enclosures could mitigate potential conflict with dispersing wild dogs (Rasmussen 1999; Ogada *et al.* 2003).

The results indicate that although the mean husbandry score from the surveys was slightly positive, there was generally a lack of proactive, effective livestock management in the communities. My surveys indicated that the KZN Wild Dog Project education conducted has not significantly influenced husbandry practices or attitudes towards stock losses in the study area. Nevertheless, in the majority of cases where owners lost livestock to predators, they had subsequently implemented successful husbandry strategies to overcome a repeat of the incident. These included fetching livestock from grazing earlier in the afternoon or separating calves and kids from their mothers and keeping the vulnerable offspring in enclosures throughout the day. Similar responses were also found to be successful when managing against livestock depredation in the United States and France (Robel *et al.* 1981; O'Gara *et al.* 1983; Espuno *et al.* 2004; Mitchell & Powell 2008). Such interventions have, however, been reactive and without cohesive, proactive husbandry in the future, the conflict could continue, and potentially negatively influence community perceptions of predators (Zimmerman *et al.* 2005; Kolowski & Holekamp 2006; Wang & Macdonald 2006; Karlsson & Sjöström 2007).

To effectively manage carnivore/livestock interactions, communities also need to know which carnivores present the greatest threats. Whilst 65% of depredated livestock were blamed on spotted hyaenas, none of these events were witnessed by the respondents. In addition, the majority of these events were not reported to or investigated by a trained conservation official. Furthermore, all of them occurred at night and only 43% of all respondents could positively identify a spotted hyaena. While spotted hyaenas certainly do kill livestock (Ogada *et al.* 2003; Kolowski & Holekamp 2005) the accuracy of apportioning blame at carcasses in my study site is yet to be determined. None of the respondents blamed feral or domestic dogs for livestock attacks. However, in 38 attacks incorrectly blamed on wild dogs in tribal authorities bordering HiP and MGR (investigated by the KZN Wild Dog Project) between 2006 and 2009, 37% were positively identified as domestic dog attacks. There was a similar tendency to blame wild carnivores such as wolves or brown bears for livestock losses in central Italy, when in fact feral dogs were frequently the culprits of such attacks (Cozza *et al.* 1996). If the majority of attacks occur at night, and none were indicated to have occurred in an enclosure, it would imply that securing livestock in enclosures at night would reduce losses (Robel *et al.* 1981; Rasmussen 1999; Ogada *et al.* 2003). Moreover, if domestic dogs are found to kill livestock, effective control and management measures need to be implemented. The scavenging behaviour of domestic canids and several indigenous carnivores also needs to be considered as livestock can die from undetected illness and be consumed by scavengers, which are subsequently blamed for depredation attacks (Robel *et al.* 1981).

The suggestions that lower natural prey numbers could increase the likelihood of depredation attacks on livestock (Woodroffe *et al.* 2005) are also of concern since this could further exaggerate perceptions of increasing carnivore conflict. Competition between livestock and wild prey for food resources can reduce abundance of both the resource and the prey, and alter the distribution of wild prey (Sillero-Zubriri & Laurenson 2001). This can consequently alter the distribution or frequency of the associated carnivore depredation (Sillero-Zubriri & Laurenson 2001). The majority of respondents could not identify game species and of those that could, the majority indicated antelope species to be rare and decreasing over the past five years. Interestingly similar results were given for predators. Yet the perception was that conflict is increasing despite the trend appearing stable with 27% of alleged depredation attacks taking place in 2007 compared to 22% in 2008. It may be a case of local perceptions reflecting extremes of damage rather than the average, since the results did not support the perception of increasing conflict (Woodroffe *et al.* 2005). It could however, also reflect a decline of prey numbers at a faster rate than predators in the same area. It has also been suggested that farmers often express the most negative attitudes towards large carnivores, even when smaller carnivores or feral dogs may be the problem (Kellert 1985). These perceptions and poor knowledge of game and predator species again highlight the potential, and need, for more education focusing on identifying indigenous species and adaptively mitigating human/carnivore conflict according to the actual threats.

To induce a significant change in husbandry practice it is clear that the current methods and/or content of the program would need to be modified. Although many researchers highlight the need for education to improve livestock management practices, and thus reduce depredation losses (Oli *et al.* 1994; Rasmussen 1999; Conforti & de Azevedo 2003; Ogada *et al.* 2003; Treves & Karanth 2003; Zimmerman *et al.* 2005; Holmern *et al.* 2007), there appears to be a dearth of information on the implementation, and subsequent effectiveness of, education efforts in reducing conflict. This suggests that research is required prior to, and after husbandry changes are made, to quantify the reduction in livestock losses, and the anticipated financial gains.

Compensation is a much debated management strategy when dealing with human/carnivore conflict and often focuses on high value species or those where problems have been exacerbated by pro-carnivore government management policy (Wagner 1997). Inherent problems with such schemes are slow responses from government agencies (Mishra 1997; Stahl *et al.* 2001), false claims (Bulte & Rondeau 2005), poor husbandry encouraging additional livestock losses (Bulte & Rondeau 2005; Sillero *et al.* 2007), complicated application processes (Mishra 1997; Vos 2000) and the selection of species (both predators or depredated animal) for which compensation is paid (Rimbey *et al.* 1991; Kaczensky 1999). In practice, variations of policy can generate additional complexities. For example, in Italy, compensation for the full value of lost livestock was paid (Cozza *et al.* 1996), whereas in Indian Trans-Himalaya livestock losses were only partly compensated (Mishra 1997). The system in Italy is open to abuse as farmers may leave old sheep to be killed by predators in order to claim compensation while livestock owners in Indian Trans-Himalaya complain about partial compensation which leads to further animosity towards the predator and the compensation implementation agency (Cozza *et al.* 1996; Mishra 1997). Combinations of these diverse problems mean that compensation does not always result in recipients being more tolerant to depredation attacks, or conflict being resolved (Mishra 1997; Sillero *et al.* 2007; Gusset *et al.* 2009).

Although the majority of respondents in my study agreed that they would more likely accept losses if they were compensated, they still did not have significantly more positive attitude scores than those who would not accept losses even if compensated. This suggests that while expedient payment of compensation may temper initial aggravation at the loss of livestock by depredation, it is no guarantee of a positive perception of predators by livestock owners in the long-term. Compensation should be viewed as a management tool to be used in combination with other conflict mitigation measures such as educational programs, rapid investigation of claims and more vigilant, improved livestock husbandry practices (Oli *et al.* 1994; Ogada *et al.* 2003; Treves & Karanth 2003; Zimmerman *et al.* 2005; Holmern *et al.* 2007). The current EKZNW compensation policy only covers locally reintroduced species (e.g. lions, wild dogs, cheetahs and elephants *Loxodonta africana*). It excludes payment for damage caused by locally resident species like spotted hyaena and leopard (two species most frequently blamed for livestock depredation in my study area) which fosters animosity towards the authorities and these species. This, combined with bureaucratic delays of payments, have hampered acceptance of this policy.

4.4.5 The influence of distance from a protected area on respondents

Attack frequency on livestock by predators showed no significant difference with proximity to the protected areas. However, those further away suffered greater losses when attacks did occur. Those individuals further from the protected areas owned more livestock, and it was shown that those who owned more livestock suffered significantly greater losses than those with fewer livestock. It would therefore be reasonable to assume that while distance may indirectly influence livestock numbers through a number of undetermined variables, it does not appear to be the key factor influencing livestock losses.

In both Sweden and Norway, respondent's attitudes to wolves were more positive the greater the distance they were from wolf habitat, (Zimmerman *et al.* 2001; Karlsson & Sjöström 2007). Similar significant differences were found when comparing attitudes of residents in Austrian provinces with bears and lynxes *Lynx lynx*, to those in the capital city, Vienna (Zeiler *et al.* 1999) These studies were, however, all comparing rural and urban respondents over a landscape spanning up to 600 kilometres; essentially comparing attitudes within areas with wolves, bears and/or lynxes to those devoid of large carnivores. Despite the studies focusing on the difference of attitude over distance it is likely that factors relating to the difference between rural and urban settings could have confounded the results. My study site had predators occurring throughout and was on a transect scale of 18 km. I found that the knowledge index was significantly higher closer to the protected areas compared to further away. The KZN Wild Dog Project's education initiative has concentrated on communities in close proximity to protected areas. Since there were significantly positive knowledge scores among those respondents who had received wild dog education, this may explain to some extent the increased knowledge index scores closer to HiP and MGR. Alternatively, other factors such as direct experiences with the reserves may also have contributed to the improved knowledge closer to the reserves.

There was a significant relationship between the attitude index and the knowledge index over all transects, yet this relationship was not apparent in the transect categories closest to protected areas. Despite a higher mean attitude index and significantly higher knowledge index closer to protected areas than in categories medium and far, distance did not significantly influence attitude in my study area. Factors which I have not considered in this survey may have negatively influenced attitudes in close proximity to reserves, despite the higher knowledge index scores.

4.4.6 Conclusion

My study suggests that while wild dogs are in general viewed positively or with ambivalence, concerns over the potentially increasing threat to livestock as natural prey numbers decline and wild dogs disperse from natal packs, are manageable. There appears to be a genuine desire among all demographic sectors within communities in the study area, to cooperate to their economic and social benefit and the benefit of general conservation. There is also significant scope to encourage improved livestock husbandry to mitigate depredation losses; despite such losses being viewed as slight when compared to losses to theft and drought. Whilst wild dogs appear to rarely traverse densely inhabited land, more sparsely inhabited tribal authority grazing lands do in part border protected areas which have wild dog populations. A combination of continued advocacy, sustained education initiatives and rapid response to conflict reports will play an important role in allowing natural dispersals of wild dogs to take place between metapopulation reserves in northern KwaZulu-Natal.

CHAPTER 5. Conclusion and management implications

5.1 Wild dog population connectivity in KwaZulu-Natal

The results of the study suggest that although consolidation of contiguous landscapes linking isolated wild dog metapopulation reserves in KwaZulu-Natal remains a complex task, a considerable area of suitable habitat exists under some form of conservation management. Tribal authority areas, favoured by dispersing wild dogs, appear to have sufficient suitable habitat with low human densities, and the potential for conflict with largely subsistence livestock ventures appears manageable. The higher densities of wild dogs in national metapopulation reserves than in unmanaged populations such as Kruger National Park, and the wide ranging behaviour of wild dogs increase the likelihood of neighbouring rural communities or private reserves encountering dispersing wild dogs (Davies-Mostert *et al.* 2009; Davies-Mostert 2010). However, the constraints electrified fences impose on dispersal from natal ranges, and the susceptibility of wild dogs to lethal edge effects in fragmented habitats compound population management complexity (Ogada *et al.* 2003; Davies-Mostert *et al.* 2009; Davies-Mostert 2010; Woodroffe 2010).

Dispersals by individuals or groups, resulting in successful integration into an existing pack, or the creation of a new pack have taken place within the metapopulation reserves, yet have until now been rare among KwaZulu-Natal metapopulation reserves (Maddock 1999; Gusset *et al.* 2006). Since the reintroduction of wild dogs into the province in 1980, their persistence has relied largely upon management interventions and supplementation from other national metapopulation reserves (Maddock 1999; Gusset *et al.* 2006). The implications of landscape connectivity, and the willingness and financial capacity of stakeholders to tolerate dispersing wild dogs are important factors affecting the recovery of a viable wild dog population in northern KwaZulu-Natal.

Wild dogs showed a preference for dispersing through woodland and to a lesser degree bushland habitat. Tribal authority lands and private reserves which link the three current

KwaZulu-Natal metapopulation reserves consist of a high proportion of these habitats. However, despite this apparent spatial connectivity, dispersals between these reserves remains infrequent and often requires management intervention (KZNWDMG 2010) to mitigate concerns of landowners and to reduce the threat of wild dog mortalities as a result of snares, vehicle collisions or direct persecution.

5.2 Management considerations

Among rural communities, education and wild dog-specific knowledge levels, and the potential economic impact of wild dog depredation on livestock determine attitudes towards dispersing wild dogs. Economic considerations, in particular the regional preference of wild dogs to consume nyala (a high-value and frequently-traded game species), are the primary concern of private landowners in KwaZulu-Natal (Krüger *et al.* 1999; Lindsey *et al.* 2004b; Lindsey *et al*. 2005b). Thus, wild dog population expansion within KwaZulu-Natal is likely to continue to rely on managed core populations of perimeter-fenced metapopulation reserves with tolerant communities and landowners contributing to the connectivity of potentially isolated reserves. Generation of tolerance through conflict mitigation, continued extension education and advocacy (Oli *et al.* 1994; Ogada *et al.* 2003; Treves & Karanth 2003; Zimmerman *et al.* 2005; Holmern *et al.* 2007), and implementation of incentive schemes for adjoining private landowners to co-manage wild dog populations will need to be addressed in conjunction with traditional law enforcement and managed metapopulation practices (Ogada *et al.* 2003; Zachrisson 2004; Boitani *et al.* 2010; Davies-Mostert 2010; Goodrich *et al.* 2011; Liu *et al.* 2011).

Livestock losses to predators were rated as the most significant problem by only 4% of respondents in my study. Departure from traditional livestock husbandry practices such as herding left scope for livestock management improvement and more effective mitigation of livestock-carnivore conflict (as reflected by the husbandry index in chapter 4). Of concern is the common practice among community members to leave livestock unattended and grazing in areas of woodland and bushland; habitats which dispersing wild dogs prefer. Despite this, post-conflict implementation of successful husbandry strategies by those farmers who had incurred losses, normally prevented repeated incidents. Livestock owners regularly attribute culpability for depredation to wild carnivores such as spotted hyaenas, leopards and wild dogs. In the absence of empirical, unambiguous evidence this is a further cause for concern. Domestic dogs were responsible for 37% of livestock losses investigated by the KZN Wild Dog Project between 2006 and 2009. Liability in all of these cases was attributed to wild dogs or other indigenous carnivores. Responsible management of domestic dogs or livestock is more likely to reduce depredation incident frequency than misinformed, retributive action towards indigenous carnivores (Rasmussen 1999; Goodrich *et al.* 2011). The need for continued education to correctly identify carnivores, to understand factors influencing depredation trends and to improve livestock management practices is discussed in chapter 4 (Oli *et al.* 1994; Rasmussen 1999; Conforti & de Azevedo 2003; Ogada *et al.* 2003; Treves & Karanth 2003; Zimmerman *et al.* 2005; Holmern *et al.* 2007).

A financial compensation scheme is used in KwaZulu-Natal to reimburse complainants for livestock losses which have been clearly attributed to wild dog depredation. The strategy was adopted as a financial incentive to improve livestock farmer's attitudes towards conservation of wild dogs. This study indicates that while such a scheme does not appear to influence attitudes towards wild dogs, if it is used in conjunction with rapid incident investigation it can be effective as a management tool to mitigate aggravation at wild dog attributed stock loss. Such schemes have however been considered inadequate at mitigating conflict in other parts of the world, susceptible to false claims, expensive and counterproductive by perpetuating a permanent state of conflict (Naughton & Treves 2003; Zabel & Holm-Müller 2008; Boitani *et al.* 2010). Thus, such a scheme would appear to have limitations, both financially and as the only mechanism to mitigate carnivore attributed depredation (Boitani *et al.* 2010). It is suggested that compensation would be most positive where livestock depredation is rare and irregular, traditional conflict mitigation husbandry is practiced or when predators are not living permanently in a particular area (Boitani *et al.* 2010). Such conditions currently exist with wild dog populations in KwaZulu-Natal. However, this would mean that the expected wild dog population increase could prove problematic unless a diversity of conflict mitigation measures are adopted and adhered to. The infrequent depredation of livestock in the study area under current husbandry management suggests that a return to traditional herding practices and the early warning of neighbouring communities of wild dogs moving through areas where livestock are grazing would further reduce wild dog-livestock conflict (Rasmussen 1999; Boitani *et al.* 2010; Goodrich *et al.* 2011). Monitoring programs currently in place for wild dog packs within metapopulation reserves have enabled information regarding breakouts from these reserves to be passed on to tribal authorities.

Participants within conservancies are more likely to be positive towards wild dogs than isolated landowners (Lindsey *et al.* 2005b). In KwaZulu-Natal all wild dog metapopulation reserves are spatially isolated. Although neighbouring landowners or communities have largely expressed tolerance towards dispersing wild dogs, such cooperation is not the norm when resident packs make frequent exploratory excursions or show an inclination to settle outside of established resident reserves. Smaller, isolated properties tend towards consumptive use of game to generate profit thus increasing the likelihood of conflict with carnivores (Lindsey *et al.* 2005b). Co-management of carnivores in conservancies increases access to available prey, and reduces habitat fragmentation (Zachrisson 2004), which consequently reduces the potentially lethal edge effects experienced beyond reserves. Co-management of wild dog populations in KwaZulu-Natal could provide sufficient area to enable the current population to expand in both pack numbers and range, while limiting the pressure on prey populations and thus the financial resources of smaller, unsuitable reserves.

5.3 KwaZulu-Natal's contribution to national wild dog conservation

The vision of the South African national action plan for wild dogs is to secure viable populations, improve ecosystem vigour and facilitate coexistence with people (Lindsey & Davies-Mostert 2009). The goal of the action plan is to improve their status across a matrix of land uses of suitable habitat, within their historical range (Lindsey & Davies-Mostert 2009). Through this study suitable habitat for dispersing wild dogs has been indicated, the variables within the heterogeneous landscape which appear to influence dispersal routes have been identified, and the attitudes of communities potentially impacted by dispersing wild dogs has been interpreted. The metapopulation approach to recovery of the national wild dog population has indicated that wild dogs can successfully re-establish resident populations in areas with appropriate habitat and prey base, and adequate protection from human persecution (Davies-Mostert 2010). The subpopulation of wild dogs in northern KwaZulu-Natal can contribute significantly to the national metapopulation through pragmatically managed linkages between isolated reserves, implementation of co-management strategies to increase resident range and the mitigation of commercial concerns of relevant stakeholders.

CHAPTER 6. References

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APPENDICES

Appendix A: All recorded dispersal or exploratory events by wild dogs outside of resident reserves between 2006-2010.

Disperser ID	**Sex**		**Date left reserve**	**Source reserve**	**Approximate days out**	**Minimum estimated distance covered (km)**	**Outcome**
	Male	**Female**					
Saffron+Shadow	0	2	5/3/2006	HiP	33	-	Joined by Nero from TPGR
Saffron+Shadow+Nero	1	2	7/4/2006	HiP+TPGR	2	-	Saffron recaptured
Shadow+Nero	1	1	-	HiP+TPGR	25	-	Shadow recaptured
Nero	1	0	-	TPGR	1	-	Recaptured – moved to HiP
Aum	0	1	4/5/2006	HiP	183	-	Last seen 3/11/2006
Saffron	0	1	14/6/2006	HiP	50	-	Recaptured
Pampoen+Pinstripe+Boggom	3	0	2/7/2006	HiP	35	220	Recaptured (Boggom died)
Nambiti Males	3	0	19/8/2006	Nambiti	42	150	Last seen 1/10/2006
Baleka+Bambisa+Bhobhoza	3	0	4/9/2007	MGR	4	50	Returned to MGR
Baleka+Bhobhoza	2	0	18/4/2008	MGR	2	12	Baleka killed by vehicle on N2
Bhobhoza	1	0	19/4/2008	MGR	6	50	Returned to MGR
Bhobhoza	1	0	26/5/2008	MGR	63	80	Returned to MGR
Bekezela	0	1	12/6/2008	MGR	49	-	Returned to MGR
Croc Pack Females	0	5	14/7/2008	HiP	4	30	Returned to HiP
Bhobhoza+Bekezela	1	1	11/8/2008	MGR	4	30	Returned to MGR
Mduna	1	0	1/9/2009	TPGR	2	10	Recaptured – introduced into HiP
Bhobhoza+Bekezela	1	1	5/9/2008	MGR	20	-	Returned to MGR
Bhobhoza+Bekezela+Kanga	1	2	11/10/2008	MGR+TPGR	4	35	Returned to MGR with TPGR female
Bhobhoza+Bekezela+Kanga	1	2	13/1/2009	MGR	4	55	Returned to MGR
Bhobhoza+Bekezela+Kanga	1	2	9/2/2009	MGR	3	30	Returned to MGR
Veggie Pack	8	7	12/4/2009	HiP	1	15	Returned to HiP
Veggie Pack	8	5	27/7/2009	HiP	4	50	Returned to HiP
Veggie Pack Males	8	0	10/9/2009	HiP	55	305	Recaptured (7) - moved to MGR

Appendix B: Wild Dog Community Survey.

GENERAL

1) Date: ______________ 2) Investigator:__________________ 3) Distance to nearest PA boundary: ____________

4) Location: ________________ 5)
Coordinates of location: S ______.________________________________ º E ___. ___________ º

6) Name:____ 7) Phone Number:___________

8) Age:_____ 9) Sex:___________ 10) Job:__________________________ 11) Education Level:__

12) How many people live at your house?____ 13) Adults:_______________ Children:_______

14) How long have you lived in the area?________________ 15) Main source of family income? _

16) Total houses in 200m radius ________ 17) Have you ever joined an environmental club?

Yes	No

18) How many animals do you keep? Please indicate if you had large increases/decreases in any animals over the past 2 years and which, if any, animals receive vaccinations.

	Cattle	Sheep	Goats	Donkeys	Horses	Pigs	Poultry	Dogs	Other
quantity									
Increase/ decrease									
vaccinated									
Reason for decrease									

19) What is the role of livestock if they are not the main source of income?______________________________

20) Do you lease land from the Tribal Authority for grazing?

Yes	No

21) Is it fenced?

Yes	No

22) Are you the only user of this land for grazing?

Yes	No

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

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

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

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

25) What is the vegetation type where you keep your animals? (See explanation on last page of survey)

Grassland	Shrubland	Thicket/ Bushland	Forest /Closed Woodland	Plantation

26) What is the water source for your animals?

River/Stream	Dam/ Pan	Borehole	Spring	Tap

27) What game animals exist in your area? (Species images to be shown)

Species	Can you identify the following species? (Y/N)	Perceived Status: Absent, Rare, Common, Unknown	When was the last time you saw this species?	Trend over past 5 years: Increase, Decrease, Stable
Nyala				
Duiker				
Kudu				
Reedbuck				
Impala				
Bushpig				
Hare				
Guinea Fowl				
Other				

28) Is there hunting of game in your area?

Yes	No

29) Have you been involved in hunting?

Yes	No

30) Hunting carried out for:

Pleasure	Food	Tradition	Money	Muti	Improved Status	Other

31) If other, please explain: ______________________

32) Do you need permission to hunt on community lands?

Yes	No

33) What method of hunting is used?

Firearm	Spear	Snare	Dog	Poison	Other

34) Which method do you believe is most effective?____

35) Why do you believe this? ____

36) Does tradition in your community favour any specific method of hunting?______________________

37) Should community members be allowed to hunt in game reserves?

Yes	No

38) If snares are set, how often are they checked to see if they have caught an animal?________________

39) Have you ever seen domestic animals or livestock caught in a snare?

Yes	No

40) Do you believe snares in a game reserve could kill Wild Dogs?

Yes	No

41) Why do you believe this?____

42) How often do you hunt, or do you notice hunting?

Daily	Weekly	Monthly	Every 6 months	Once a year	Never

ATTITUDE

43) What predators have you seen, or found signs of, in your community? (Species images shown)

Species	Can you identify the following species? (Y/N)	Perceived Status: Absent, Rare, Common, Unknown	When was the last time you saw this species?	Trend over past 5 years: Increase, Decrease, Stable
Lion				
Spotted Hyaena				
Brown Hyaena				
Wild Dog				
Jackal				
Leopard				
Caracal				
Serval				
Honey Badger				

Comments: ____

44) If yes for Wild Dog:

Date	Number seen	Location	Collar (Y/N)	Time of Day	What were the Wild Dogs doing at that time?

45) Do you lose livestock to predators?

Yes	No

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

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

47) Who were the attacks reported to?

	Name	Attack investigated		Response
EKZNW		Yes	No	
EWT		Yes	No	
iNduna		Yes	No	
Other		Yes	No	
Not reported				

48) If there has been an incident involving Wild Dogs please provide witness information:

Name	
Sex	
Age (estimated)	
Number of Witnesses	
Contact information	

Response at incident	Chased predator	Killed predator	Other

Comments: ____

49) In which season have Wild Dog related incidences take place?____________________

50) If no witnesses, what would lead you to believe it was a Wild Dog attack?________________

____

51) How many cases have you had where Wild Dog has been blamed for an attack which has subsequently been proven to be the work of another predator? ________________

52) Will you accept it if Wild Dogs kill any of your livestock?	Yes	No	Maybe
53) If compensation was to be paid for Wild Dog related losses would you then accept such losses?	Yes	No	Maybe
54) Do you ***expect*** financial compensation for livestock losses to any predators?	Yes	No	Maybe
55) Are you concerned about the future of Zululand's wildlife?	Yes	No	Maybe
56) Do you believe predators receive enough protection from the law	Yes	No	Maybe
57) Do you believe you would be a happier if all predators were removed?	Yes	No	Maybe
58) Do you believe predation by Wild Dogs is a problem EKZNW must deal with?	Yes	No	Maybe
59) Do you believe you would try to kill/remove a predator in future if you lost livestock to predation?	Yes	No	Maybe
60) If you were carrying a weapon while in community land and you saw a predator do you believe you would try to kill it?	Yes	No	Maybe

61) If these circumstances in the previous question above were to occur, what other response do you believe you may have and why do you believe this? ________________________________

____

62) Who do you believe should be responsible to pay in the case of stock losses?______________

63) Do you know of any species threatened with extinction? ______________________

64) Have you ever successfully removed a predator?

Yes	No

65) If yes, explain how?

Shot	Poisoned	Live Trap	Other

LIVESTOCK HUSBANDRY

66) What husbandry protection practices are employed for your livestock?

	Free Roaming	Enclosure	Guarded by Human or Dog	Other
Day				
Night				

67) What season(s) are your livestock, poultry etc. offspring born?

Cattle	Sheep	Goats	Donkeys	Horses	Pigs	Poultry	Dogs	Other

68) During birthing seasons do you make any husbandry changes to further protect offspring or mothers?

Yes	No

69) Explain:____

70) Do you keep records of the births/ deaths?

Yes	No

71) Explain your enclosure design. If you have different enclosure types for different livestock please explain.

Livestock type	Shape	Height	Materials	Width	No Enclosure

72) How many animals does one herder guard?____________________________________

73) Is the herder a

Paid Worker	Child	Other

1=Strongly Disagree	***2=Disagree***	***3=Neither Agree nor Disagree***	***4=Agree***	***5=Strongly Agree***

Please score your opinion of the following statements based on the rating given above:

74) The herder is effective at protecting livestock?

1	2	3	4	5

75) How many animals does one dog guard?______________________________

76) The dog(s) is effective at protecting livestock?

1	2	3	4	5

77) Do people graze livestock together in one area?

Yes	No

78) Explain:____

____

79) Give details of any husbandry changes following all attacks:______________________________

____

____

80) Have your changes been successful?

Yes	No

81) Are there methods you think will be more effective at protecting livestock?

Yes	No

82) Are you considering these alternative methods in response to threats experienced or as a result of public information campaigns which have explained new options?

83) Explain:____

____

84) Why do you not use these now?____

85) Do you believe improved husbandry practices will prevent Wild Dog related losses?

Yes	No

86) Have you lost animals in the past 2 years for any reason other than predation?

Yes	No

87) If yes, please state how many and explain the cause:______________________________

88) Do you believe the conflict with predators is increasing, decreasing or stable?__________________

89) Can you give reasons why you believe this is occurring?______________________________

____

EDUCATION

90) Have you heard of the KZN Wild Dog Conservation Project?

Yes	No

91) If yes, from whom

EKZNW	EWT	iNduna	Friend	Community Member	Child	Media

92) When did you hear about the project?

< 6 Months Ago	6 months - 1 year ago	> 1 year ago

Do you believe?

93) Wild Dogs attack humans?	Yes	No	Maybe
94) Wild Dogs can pass through your land or community unseen/ unnoticed?	Yes	No	Maybe
95) Wild Dogs can live in or pass through your area without killing livestock?	Yes	No	Maybe
96) Wild Dogs in Zululand are increasing in number?	Yes	No	Maybe
97) Efforts should continue to protect Wild Dogs in Zululand?	Yes	No	Maybe
98) Wild Dogs have a role to play in the ecosystem?	Yes	No	Maybe
99) Wild Dogs are an important part of Zululand's natural heritage?	Yes	No	Maybe
100) You could tolerate Wild Dogs being introduced onto neighbouring land?	Yes	No	Maybe
101) Zululand would be a better place without Wild Dogs?	Yes	No	Maybe
102) Wild Dogs could create tourism related benefits for you or your community?	Yes	No	Maybe
103) Low game densities in an area may result in Wild Dogs killing goats?	Yes	No	Maybe
104) It is important to educate communities on how to react when they see Wild Dogs?	Yes	No	Maybe
105) There are too many Wild Dogs?	Yes	No	Maybe
106) You could actively assist Wild Dog protection efforts in some way?	Yes	No	Maybe
107) You would cooperate with conservation groups to reduce conflict with predators?	Yes	No	Maybe

108) Have you seen Wild Dogs interacting with any other species?____________________________________

109) What do Wild Dogs eat in your area?____

110) Do you know if Wild Dogs have a particular conservation status?

Common	Endangered	Protected	Problem Animal	Don't Know	Other

111) How many Wild Dogs do you think there are in KwaZulu-Natal?________________________________

112) Do Wild Dogs hold any importance for you?

Yes	No

113) If yes, explain:____

114) What is your current emotion towards Wild Dogs?

Excitement	Interest	Fear	Anger	No interest	No opinion

115) Are Wild Dogs used for traditional medicine? | Yes | No |

116) If yes, how are the products obtained?______________________________________

117) Are Wild Dogs recalled in traditional stories? | Yes | No |

118) If yes, explain:____

____

119) Would you be interested in learning more about Wild Dogs? | Yes | No |

____

Explanation of Vegetation Classification

Vegetation Classifications:	***LESS THAN***	***GREATER THAN***
Grassland	0.1% Tree/ Shrub Cover	0.1% Grass Cover
Shrubland	0.1% Tree Cover	0.1% Shrub Cover
Thicket/ Bushland		1% Tree Cover 10% Shrub Cover
Forest/Closed Woodland	10% Shrub Cover	0.1% Tree Cover
Plantation	Eucalyptus plantation	

Trees: *woody, self-supporting plants over 2m high with a definite trunk branching above ground level*

Shrubs: *woody, self-supporting plants up to 5m high, multi-stemmed or branching at/near ground level or multi-stemmed or single stemmed when less than 2m high*

Grass: *non-woody, herbaceous plants*
Edwards (1983)

Appendix C: The questions and scoring system used to determine the attitude index.

Questions	Score		
	Yes	Maybe	No
Member of an environmental club	1		-1
Will accept livestock loss by wild dogs	2	0	-1
Will accept livestock loss if compensated	1	0	-1
Do you expect compensation	-1	0	1
Concerned for Zululand's wildlife	1	0	-1
Predators are protected enough by legislation	-1	0	1
Will be happy if all predators removed	-1	0	1
Will kill a predator if lose livestock	-1	0	1
Will try kill predator if have a weapon available	-1	0	1
Have successfully removed a predator	-1	0	1
Herder is effective to safeguard livestock	1	0	-1
Efforts to protect wild dogs should continue	1	0	-1
Wild dogs are important to Zululand's heritage	1	0	-1
You would tolerate wild dogs introduced by neighbour	1	0	-1
Zululand will be better without wild dogs	-1	0	1
Wild dogs could benefit tourism	1	0	-1
Important to educate people about how to react to wild dogs	1	0	-1
There are too many wild dogs	-1	0	1
You would actively assist wild dog protection	1	0	-1
You would cooperate to reduce human/predator conflict	1	0	-1
Wild dogs are important to you	1	0	-1
Are you keen to learn more about wild dogs	1	0	-1
Primary perceived threat to livestock is predators	-1	0	1
Current emotion towards wild dogs is positive	1	0	-1

Appendix D: The questions and scoring system used to determine the education index.

Questions	Score		
	Yes	Maybe	No
Correctly identified a wild dog	1	0	-1
Correctly identified a jackal	1	0	-1
Correctly identified a spotted hyaena	1	0	-1
Snares can kill a wild dog	1	0	-1
Have heard of KZN wild dog project	1	0	-1
Heard of the KZN Wild Dog Project from EWT or EKZNW	1	0	0
Wild dogs attack humans	-1	0	1
Wild dogs can pass communities unnoticed	1	0	-1
Wild dogs can pass without killing livestock	1	0	-1
Wild dogs are increasing in Zululand	1	0	-1
Wild dogs play a role in the ecosystem	1	0	-1
Correctly identified what wild dogs eat when on tribal authority land	1	0	-1
Low game densities can result in greater predator/livestock conflict	1	0	-1
Correct ID of wild dog conservation status (Endangered/Protected = Correct)	1	0	-1
Correct estimation of wild dogs numbers in KZN (Correct total (120) ± 70)	1	0	-1

Appendix E: The questions and scoring system used to determine the husbandry index.

Questions	Score	
	Yes	No
Have you lost livestock to predators	-1	1
Have you lost livestock to predators during daylight	-2	
Have you lost livestock to predators at night	-1	
Did you report the attack to an official	1	-1
Husbandry day: Is your livestock guarded	2	-1
Husbandry night: Is your livestock protected in an enclosure	2	
Husbandry night: Is your livestock left unprotected and grazing	-2	
Do you make changes to protect mothers and offspring during birth seasons	1	-1
Do you record livestock births	1	-1
Have you made husbandry changes following predator attacks	1	-1
If yes, were your changes successful	1	0
Do more effective methods exist	1	-1
Will improved husbandry prevent wild dog depredation	1	-1
Is a herder effective	1	-1