The feasibility of reintroducing African wild dogs (*Lycaon pictus)* into the Great Fish River Nature Reserve, Eastern Cape, South Africa.

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By

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Abstract

With a declining population of roughly 3000-5000 individuals in Africa, African wild dogs (*Lycaon pictus*) are one of the most endangered carnivores in the world. As the global human population expands, it is becoming increasingly unlikely that large portions of land will be set aside for conservation, especially in developing countries. Thus, recent wild dog conservation efforts in South Africa have concentrated on establishing a managed metapopulation. A metapopulation is a group of geographically isolated subpopulations of a species that are managed (using supplementation and harvesting) to mimic natural gene flow. The Great Fish River Nature Reserve (GFRNR) in the Eastern Cape Province of South Africa has been identified as a potential reserve to become part of the national wild dog metapopulation. My research aimed to conduct a feasibility assessment of the long-term (~ 25 years) success of a wild dog reintroduction into the GFRNR. This assessment included biological modelling of wild dogs and their expected prey, and determining the potential anthropogenic threats to wild dogs on the private and communal land surrounding the reserve. I used VORTEX population modelling and determined that the GFRNR is likely to have a wild dog carrying capacity of ~22 individuals. Using a 25-year modelling simulation, the most appropriate wild dog reintroduction scenario would be to reintroduce six females and four males initially and supplement the population with one female and two males in years 3, 10, 15 and 23. In addition, the harvesting/removal of one male and one female in years 10 and 20 would be required to ensure 100% population persistence and adequate genetic diversity. Kudu (*Tragelaphus strepsiceros*) and bushbuck (*Tragelaphus scriptus*) are expected to be the two most important prey species for reintroduced wild dogs in the GFRNR. Furthermore, wild dogs are likely to prefer the north-western and south-western sectors of the reserve because of the relatively high prey densities in these areas. However, regular monitoring of both the potential prey and the wild dog populations is essential to ensure persistence of the wild dogs and to prevent prey populations decreasing precipitously. Using structured questionnaire interviews (n = 128), I found that while neighbouring land owners and local communities were generally positive about the potential wild dog reintroduction (56 % of all respondents), several threats to wild dogs were identified along the reserve boundary and on the adjoining unprotected land. Some private landowners and members of rural communities around the reserve (34 %) stated that they would kill any wild dogs that dispersed onto their land. In addition, some respondents (8 %) admitted to believing in traditional uses for wild dog products (e.g. fur) which could result in the illegal killing of wild dogs outside of the GFRNR for traditional purposes. Poaching and the presence of unvaccinated domestic dogs on neighbouring land were also identified as being potential threats to a reintroduced wild dog population. However, such anthropogenic threats appear to be localised to the western and southern boundaries of the reserve. Therefore, by implementing preventative measures (such as anti-snare collars, anti-poaching patrols and vaccination against rabies and canine distemper) the likelihood of such threats occurring can be reduced. I conclude that the GFRNR can sustain a population of wild dogs and successfully contribute to South Africa's national metapopulation. An additional reserve will benefit the country's metapopulation by increasing the number of wild dogs available for translocation, thereby increasing genetic diversity and overall resilience (to environmental change, disease etc.) of South Africa's wild dog population. This will contribute towards the future conservation of this endangered species.

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CHAPTER 1: General Introduction

1.1. Physical description

African wild dogs (*Lycaon pictus*), also known as the painted hunting dog, are medium-sized, slightly-built carnivores, averaging 67 -78 cm in shoulder height and weighing approximately 20-25 kg (Vucetich & Creel 1999; Creel & Creel 2002). Males are generally three to seven percent heavier than their female counterparts (Creel & Creel 2002). They have several features which make them distinguishable from other African carnivores (Figure 1.1). Firstly, wild dogs have large, round, black ears which gives them excellent hearing and assists in thermoregulation (Estes 1993). Secondly, their coat patterns are individually unique, allowing them to differentiate easily between members of their pack. Their coats are a combination of mottled black, white and tan (Estes 1993; Creel & Creel 2002). Thirdly, their faces are a black and brown, with a black line extending up the face and along the sagittal crest and there is no white on the head (Estes 1993). Finally, their tails are bushy and are predominantly white. This is suggested to assist with maintaining visual contact within the pack (Creel & Creel 2002).

Figure 1.1: African wild dogs (*Lycaon pictus*) have unique physical features which make them easy to distinguish from other African carnivores. (Photo: Chad Cocking)

1.2. Taxonomy

The scientific name means ‘painted wolf’ (*Lycaon:* wolfish, from the Greek *lykaios*; *pictus* meaning painted, from the Latin *picta*) which is a reference to their tri-coloured coats (Creel & Creel 2002). Wild dogs are therefore often referred to as “painted hunting dogs”. They belong to the Order Carnivora and the Family Canidae (Creel & Creel 2002).

Wild dogs were originally described by C. J. Temmick in 1820, from an individual collected in coastal Mozambique (Creel & Creel 2002). The specimen was originally thought to be a type of hyena and was classified as *Hyena picta* (Creel & Creel 2002; Skinner & Chimimba 2005). In 1930, Matthew placed this specimen in the subfamily Canidae (Creel & Creel 2002). However, wild dogs are now considered to be a monotypic genus, but are still placed in the Family Canidae and are the only remaining representatives in the genus *Lycaon* (Mills *et al.* 1998; Creel & Creel 2002; Davies-Mostert *et al.* 2009; Davies-Mostert 2010).

DNA sequence data suggest that wild dogs are phylogenetically distinct from other wolf-like canids (wolves, jackals, *Canis* spp., and coyotes, *C. latrans*), justifying their current placement in a monotypic genus (Creel & Creel 2002). Considerable research indicates some regional differences, but this is not widely accepted as it is likely that genetic exchange occurred between populations (Creel & Creel 2002). Their overall body shape resembles the general canid body plan, but according to Creel and Creel (2002) over the past three million years there have been various significant changes in the body form of wild dogs. Firstly, wild dogs have only four toes, having lost the fifth toe that persists as a vestigial dewclaw in most canids (Creel & Creel 2002). In addition to lacking dew claws on the front limbs, the pads on the second and third toes are usually partially fused (Creel & Creel 2002). This canid is lean and tall with large round ears, rather than having the bulky build and pointed ears of other canids, such as wolves and coyotes (Creel & Creel 2002). Finally, the body structure is leaner than that of most other canids, allowing them to reach speeds of up to 60 km/h and increasing their distance of dispersal in a shorter period of time than would otherwise be possible (Creel & Creel 2002).

1.3. Dispersal behaviour

Female wild dogs are more likely than males to disperse to find new packs on an annual basis (Creel & Creel 2002). Dispersing of individuals generally occurs within the first year of sexual maturity (~2 years of age) (Girman *et al.* 2001; Creel & Creel 2002). Dispersing packs are formed from same- sex individuals (usually siblings) leaving their natal pack and joining with an unrelated dispersing pack of the opposite sex (Mills & Gorman 1997; Creel & Creel 2002). On average, two females or three males make up a dispersing pack (Creel & Creel 2002). Factors such as natal pack composition, food availability and breeding opportunities probably influence the rate and composition of dispersing groups (Fuller *et al.* 1992; Whittington-Jones 2011). According to Fuller *et al.* (1992), dispersing groups have been recorded to travel up to 250 km before they join an appropriate group to form a pack. This newly formed pack will then establish a territory (Fuller *et al.* 1992). There is much debate about the average home range size of wild dogs (Mills *et al.* 1998; Creel & Creel 1998; Vucetich & Creel 1999; Creel & Creel 2002; Lindsey *et al.* 2004a, 2005). Home range size depends factors such as intra-guild interactions, prey availability, pack size and reserve size (Vucetich & Creel 1999; Girman *et al.* 2001; Lindsey *et al.* 2004a). A study by Lindsey *et al.* (2004a) estimates that the area requirement of five wild dogs is about 65km^2 in northern areas of South Africa, 72km^2 in eastern and 147km^2 in north-eastern South Africa.

1.4. Social behaviour

Like most canids, wild dogs are intensely social animals, living in groups of up to 20 adults and their dependent offspring (Vucetich & Creel 1999; Courchamp & Macdonald 2001). Sex ratio in packs seems to be male-biased as mortality among females is high (Mills *et al.* 1998). Generally, it is only the dominant or alpha pair that breeds within the pack, with the assistance of helpers (Vucetich & Creel 1999). The helpers are the subordinate individuals of the pack, distinguished by a ranking system which occurs in both females and males (Creel & Creel 1995). The dominant female is generally the oldest in the pack (Creel & Creel). However, it is usually a more prime-aged male that is the alpha as males will decrease in rank to younger, fitter males (Creel & Creel 2002). This social system is known as cooperative breeding (Courchamp & Macdonald 2001).

Courchamp and Macdonald (2001) suggest that there are three reasons for this type of social structure in wild dogs: (1) foraging, (2) breeding and (3) survival. Wild dogs hunt cooperatively, as several individuals can hunt more effectively than pairs or individuals (Courchamp & Macdonald 2001). They work together to isolate prey, launch simultaneous attacks, distract mother from calf, and together pull prey down and restrain it while it is being killed (Creel & Creel 1995; Courchamp & Macdonald 2001). By hunting together, the likelihood of injury from large or well-armed prey is reduced (Vucetich & Creel 1999; Courchamp & Macdonald 2001). Another benefit of hunting in groups is that it extends the range of prey species that a pack will be able to bring down (Courchamp & Macdonald 2001). Larger packs are also able to retain kills from kleptoparasites such as spotted hyenas (*Crocuta crocuta*) and lions (*Panthera leo*) which regularly scavenge food off other predatory species (Creel & Creel 1995).

Cooperation is also important in the raising of the alpha's offspring (Estes 1993). Wild dogs are able to regurgitate large amounts of meat, and this is done for pups and "babysitters" as well as for sick or injured members of the pack that remain at the den during the hunt (Estes 1993). According to Courchamp and Macdonald (2001), adults give pups priority of access to food when it is scarce. This helping behaviour allows larger litter sizes, and the relationship between large pack sizes and large litter sizes has been known to correlate positively (Vucetich & Creel 1999). The final advantage of cooperative breeding in wild dogs is survival (Courchamp & Macdonald 2001). Wild dogs have not been known to aggressively defend kills, but they will mob potential predators if they threaten the survival of the pups (Courchamp & Macdonald 2001). The aggressiveness with which they attack has been known to drive off spotted hyenas, jackals and lions (Estes 1993). Success in driving off predators is higher when pack sizes are larger.

1.5. Reproduction

Wild dogs generally breed throughout the year, with a slight peak after the rainy (February/March) season when prey is abundant (Creel *et al.* 1992; Estes 1993). Mating lasts for 3 to 7 days, but oestrous behaviour builds slowly over several weeks, leading up to mating (Creel *et al.* 1992). Gestation is between 69 and 73 days, with an interval of up to one year between litters (Creel *et al.* 1992; Estes 1993). Females give birth in dens which are often old hyena dens, or on the sides of river valleys amongst rocks (Leigh 2002). Litter sizes are the largest of any canid, averaging about 15 pups, with a maximum of 21 having been recorded (Courchamp & Macdonald 2001). When members of the pack go hunting, some remain behind to defend the den against predators (Mills *et al.* 1998). Pups are born in the den, where they remain for up to three months (Mills *et al.*1998). During this time the alpha female is confined to the den and subordinate members feed her by regurgitation (Mills *et al.* 1998). After this three month period, the pups will be fed by other members of the pack in the same way (Mills *et al.* 1998; Courchamp & Macdonald 2001). Mortality among wild dog pups is high, but is significantly reduced when there are many helpers in the pack (Mills & Gorman 1997; Mills *et al.* 1998; Woodroffe *et al.* 2007). Pup mortality is roughly 50 % in most wild populations (Woodroffe *et al.* 2007; Bach *et al.* 2010).

By living in packs, wild dogs have increased their breeding success (Gusset & Macdonald 2010). Canids (with the exception of maned wolves, *Chrysocyon brachyurus*) are considered to be obligate monogamous breeders. This description refers to the obligate need for care from helpers within the pack (Bekoff *et al.* 1984; Gusset *et al.* 2010). While cooperative breeding is not essential for the successful rearing of pups it is positively correlated with pup survival (Bekoff *et al.* 1984; Vucetich & Creel 1999; Gusset & Macdonald 2010). Courchamp and Macdonald (2001) hypothesized that a pack below a critical size can become caught in a positive feedback loop: fewer helpers leading to a decrease in pup survival, which further reduces pack size, culminating in the collapse of the whole pack. The pack is therefore generally defined as the basic unit of the population as females, or even pairs, cannot successfully rear pups without assistance (Mills *et al.* 1998).

The only member of the pack assured of becoming pregnant is the alpha female (Creel *et al.* 1992). In the Kruger National Park (South Africa), alpha females produced 81 % of the 85 litters in the park, and in the Serengeti National Park, 75 % of the litters belonged to an alpha pair (Creel *et al.* 1992). If a subordinate female produces her own litter, her pups are usually born several days after the alpha’s (Creel *et al.* 1992). Often, the subordinate’s pups are killed by the dominant pair or they may be “adopted” as part of the alpha’s litter (Creel *et al.* 1992).

1.6. Conservation status

Although the global population of about 5000 wild dogs is estimated to be decreasing (Woodroffe & Sillero-Zubiri 2012), policy change and management aimed at wild dogs has resulted in improved conservation of this canid in recent decades. Wild dogs are currently listed as “Endangered” according to the 2012 IUCN Red List of Threatened Species, indicating that this species faces a high risk of extinction in the wild in the near future as there is ongoing decline of their populations (Gusset *et al.* 2006; Woodroffe *et al.* 2007). Between 1986 and 1988 wild dogs were listed as Vulnerable, but in 1994 they were upgraded to Endangered (IUCN 2012). There are an estimated 3000 – 5000 wild dogs left in Africa, 420 of which are in South Africa (IUCN 2012; Woodroffe & Sillero-Zubiri 2012).

Management and utilization of wild dogs in South Africa is governed by the National Environmental Management: Biodiversity Act (Act No. 10 of 2004) and by the Threatened or Protected Species (TOPS) regulations (Lindsey & Davies-Mostert 2009). TOPS regulations control hunting and captive breeding of species with a designation of threatened or endangered (Lindsey & Davies-Mostert 2009). Wild dogs are listed as Endangered according to the TOPS regulations.

1.7. Wild dog history in Africa and causes for their decline

Wild dogs historically inhabited most of sub-Saharan Africa, with the exception of desert and tropical rainforests in Northern Africa (Figure 1.2; Maddock & Mills 1994; Mills *et al.* 1998; Vucetich & Creel 1999; Creel & Creel 2002). They now have a patchy distribution and are largely confined to protected areas (Figure 1.2; Mills *et al.*1998). They are the most endangered carnivore in southern Africa (Mills & Gorman 1997). Of the 39 African countries where wild dogs were previously found, they are extinct in 25, and viable populations are believed only to exist in six countries (Figure 1.2 and 1.3; Maddock & Mills 1994; Courchamp & Macdonald 2001; Woodroffe *et al.* 2005). These viable populations occur in the Kruger National Park (South Africa), Hwange National Park (Zimbabwe), Selous National Park (Tanzania), the Zambezi National Park (Zimbabwe) and the Okavango region (Botswana).

Negative perceptions of wild dogs led to legal persecution through the 18th and 19th centuries across their natural range, as is evident in the writings of some of the early travellers (Childes 1988; Courchamp & Macdonald 2000; Creel & Creel 2002; Woodroffe *et al.* 2005; Gusset *et al.* 2008a):

> "Let us consider for a while the abomination – that blot upon the interesting wild things... the murderous wild dog. It will be an excellent day for African game and its preservation when means can be devised for this unnecessary creature's complete extermination" (Written by Maugham in his book Wild *game in Zambezia* in 1914, as quoted by Mills 1985).
>
> "Wild dogs hunt in packs, killing wantonly far more than they need for food and by methods of the utmost cruelty" (Bere 1956).
>
> "Wild dogs were present in small numbers and were destroyed whenever possible" (1960-61 Annual Report of the Department of Wild Life Conservation, Zimbabwe, as quoted by Childes 1988).

There are two very broad reasons for this intense dislike. The first is because of the way wild dogs kill their prey (Creel & Creel 2002). Most carnivores have a specialized killing bite but because wild dogs are relatively small compared to their prey, they kill by chasing the prey down and disemboweling it (Creel & Creel 2002). Second is the misconception that wild dogs have a more negative effect on prey populations than do other African carnivores (Creel & Creel 2002).

In Zimbabwe, wild dogs were known as stock killers and were classified as vermin in 1916. Under the subsequent Parks and Wildlife Conservation Act the wild dog was included as a "Problem Animal" (Childes 1988). As a result, farmers received monetary rewards for the removal of wild dogs (Childes 1988; Creel & Creel 2002; Davies & du Toit 2004). Between 1916 and 1975, over 3400 wild dogs were killed in Zimbabwe under the pretext of vermin control (Davies & du Toit 2004), and in Namibia, 156 wild dogs were killed over 19 months between 1965 and 1966 (Creel & Creel 2002). Wild dog populations have been severely impacted due to the increasing pressure from expanding human populations and agriculture, which has reduced the amount of available habitat for them and their prey populations (Maddock & Mills 1994).

By 1986, the legal conservation status of wild dogs became “Vulnerable Game” after a study by Cumming (1976) indicated that wild dog populations had become significantly reduced (Childes 1988). In light of Cumming’s (1976) findings, wild dogs became protected outside protected areas through a “Restriction on Hunting Notice” (Childes 1988).

By the mid 1980s, wild dogs became legally protected in six countries (Botswana, Kenya, South African, Tanzania, Zambia and Zimbabwe) (Creel & Creel 2002). In South Africa, wild dogs are confined to protected areas and there are very few free-roaming packs (Graf *et al.* 2006). Although the government-funded persecutions ended decades ago, mortality caused by humans due to perceived conflict with livestock is still an important threat to wild dogs (Courchamp & Macdonald 2000; Davies & du Toit 2004; Lindsey & Mills 2004).

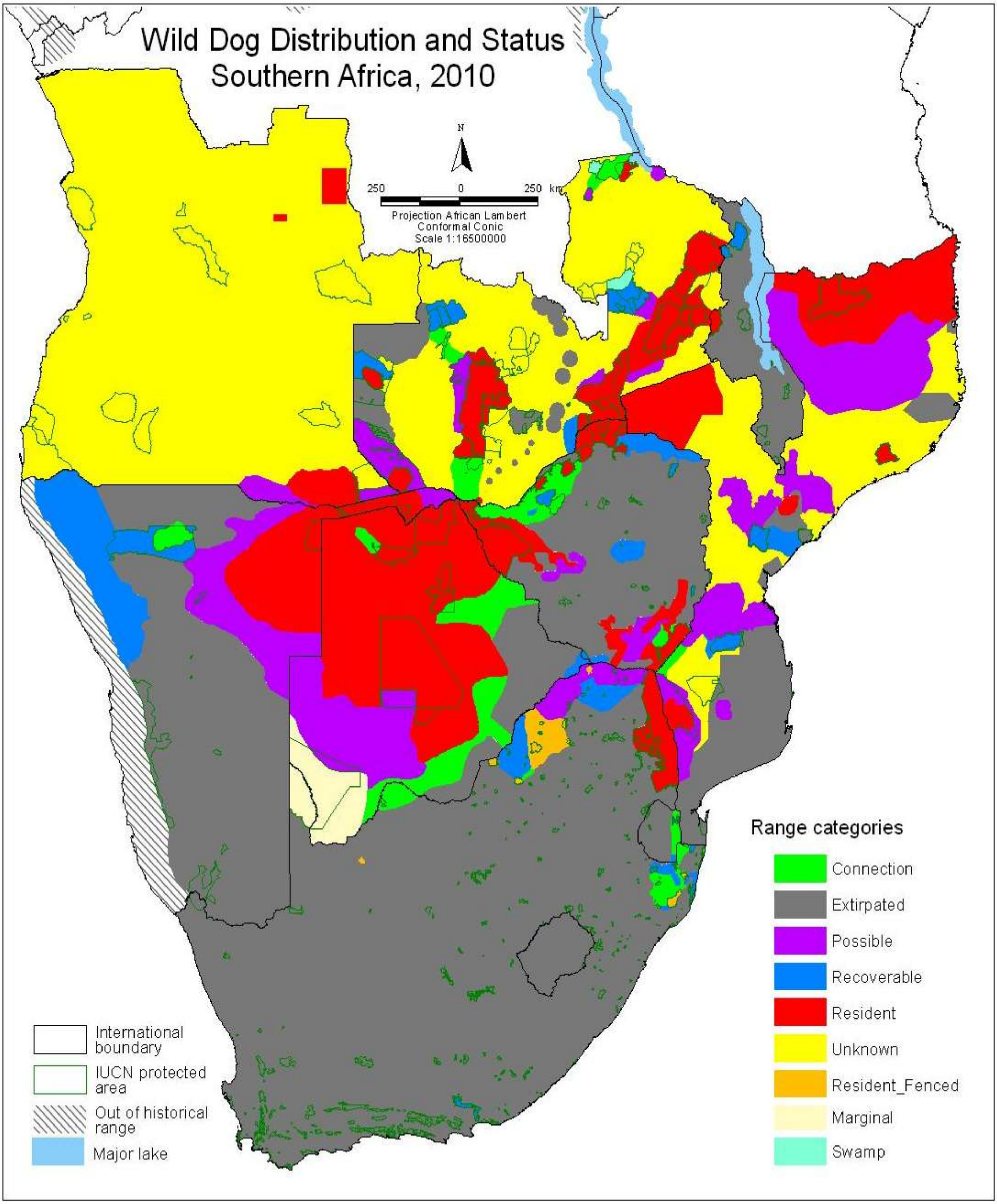

Figure 1.2: Distribution of wild dogs in Africa (African Mammal Databank 2013). Of the 39 countries where wild dogs were previously found in Africa, they are extinct in 25, very rare in seven and have low population densities in the remaining seven.

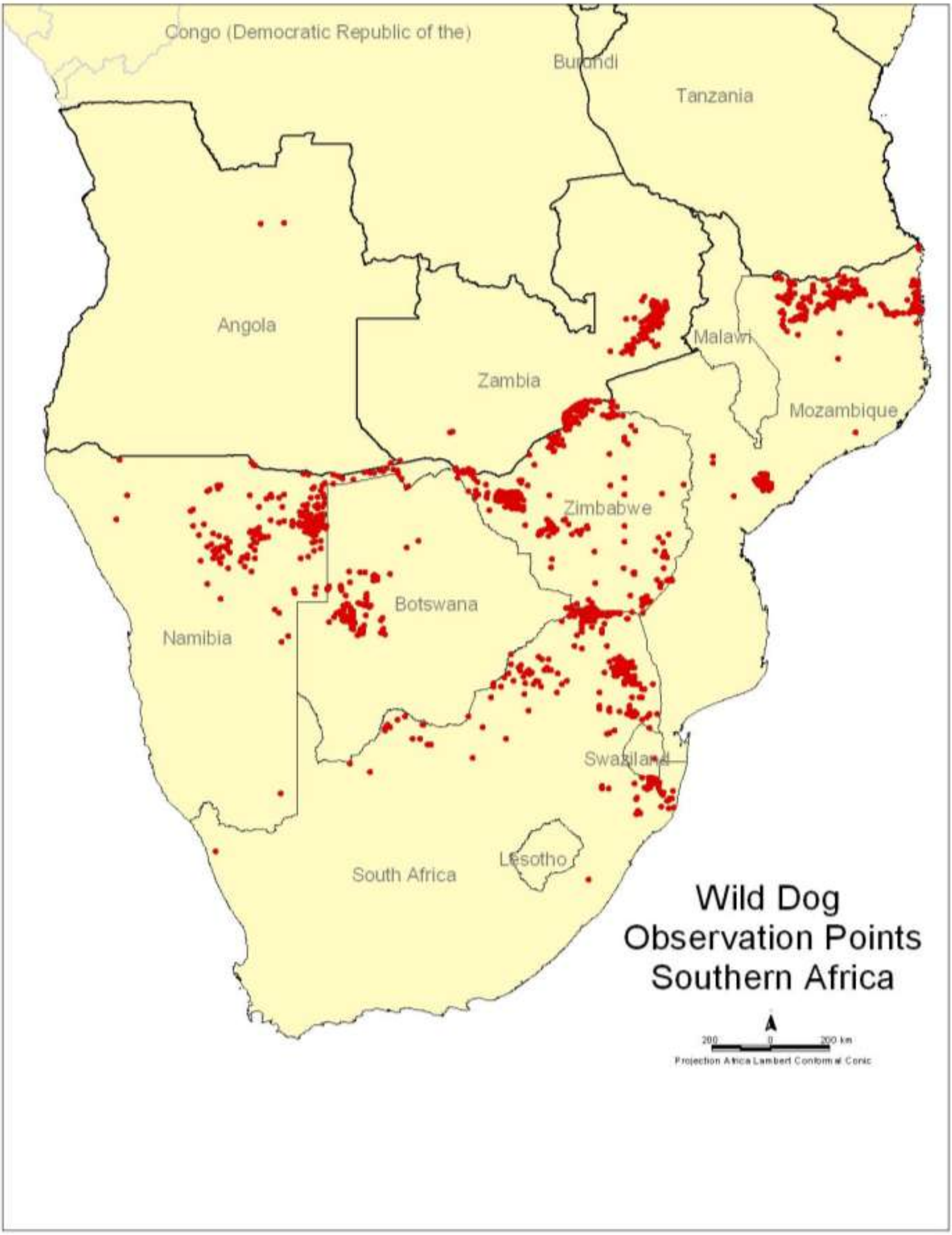

Figure 1.3: Location points in Southern Africa where wild dogs have been observed before 2010 (http://www.cheetahandwilddog.org).

1.8. The managed metapopulation conservation strategy

Viable wild dog populations are limited to approximately six of the 39 countries where they historically occurred (Lindsey *et al.* 2004b). A viable population is defined as a population which has more than eight self-sustaining packs (packs that can survive without human intervention; Mills *et al.* 1998). Currently, the only viable population of wild dogs in South Africa is located in the Kruger National Park, Limpopo Province (Mills *et al*. 1998). Because there are no additional protected areas in South Africa that are large enough to sustain viable wild dog populations, recent wild dog conservation efforts have concentrated on establishing a managed metapopulation (Lindsey *et al.* 2004a; Davies-Mostert *et al.* 2009).

To increase population numbers, subpopulations of wild dogs are managed in several small (< 1000 km^2), geographically isolated conservation areas as a linked, single metapopulation (Figure 1.4; Gusset *et al.* 2008b). This management approach involves the periodic translocation of individuals among packs from different reserves to mimic natural dispersal and to promote gene flow (Gusset *et al.* 2006; Gusset *et al.* 2008b; Davies-Mostert 2010). The concept of the metapopulation strategy was to release wild dogs of the local genotype into a network of small reserves to increase the numbers of wild dogs in South Africa (Davies-Mostert *et al.* 2009). The introduced packs are collectively and intensively managed in aspects such as disease control and artificial genetic and demographic exchange between reserves to maintain genetic diversity (Gusset *et al.* 2008b; Davies-Mostert *et al.* 2009). The reintroductions of wild dogs into several small conservation areas in South Africa have, so far, been successful, with high survival rates of both the released packs and their offspring (Gusset *et al.* 2008b). There are currently 17 wild dog packs in the national metapopulation in eight metapopulation reserves (Figure 1.4; WAG-SA Minutes 2013).

The Wild Dog Advisory Group of South Africa (WAG-SA) (which comprises scientists, protected area managers, provincial and national conservation representatives and non-governmental organizations) was established in 1997 to guide and implement the metapopulation strategy (Davies-Mostert *et al.* 2009). The metapopulation project commenced with the goal of having nine wildlife reserves reintroducing wild dogs within the decade (Davies-Mostert *et al.* 2009). At the beginning of 1998, two reserves had already reintroduced wild dogs; Hluhulwe-iMfolozi Park (KwaZulu-Natal Province) and Madikwe

Game Reserve (North-West Province) (Davies-Mostert *et al.* 2009). Six additional subpopulations were established between 1998 and 2012: Pilanesberg National Park (North West Province), Tembe National Elephant Park (KwaZulu-Natal Province), Mkhuze Game Reserve (KwaZulu-Natal Province), Tswalu Kalahari Reserve (Northern Cape Province) Zimanga Private Game Reserve (KwaZulu-Natal Province) and Khamab Kalahari Reserve (North-West Province) (Figure 1.4; Davies-Mostert *et al.* 2009; WAG-SA Minutes 2013). The metapopulation approach has resulted in the most extensive and successful reintroduction efforts of the wild dog in South Africa (Hayward *et al.* 2007b). Small, scattered populations of wild dogs are known to occur outside formally protected areas, although these populations are limited to the Limpopo and Mpumalanga Provinces (Mills *et al.* 1998; Lindsey *et al.* 2004a).

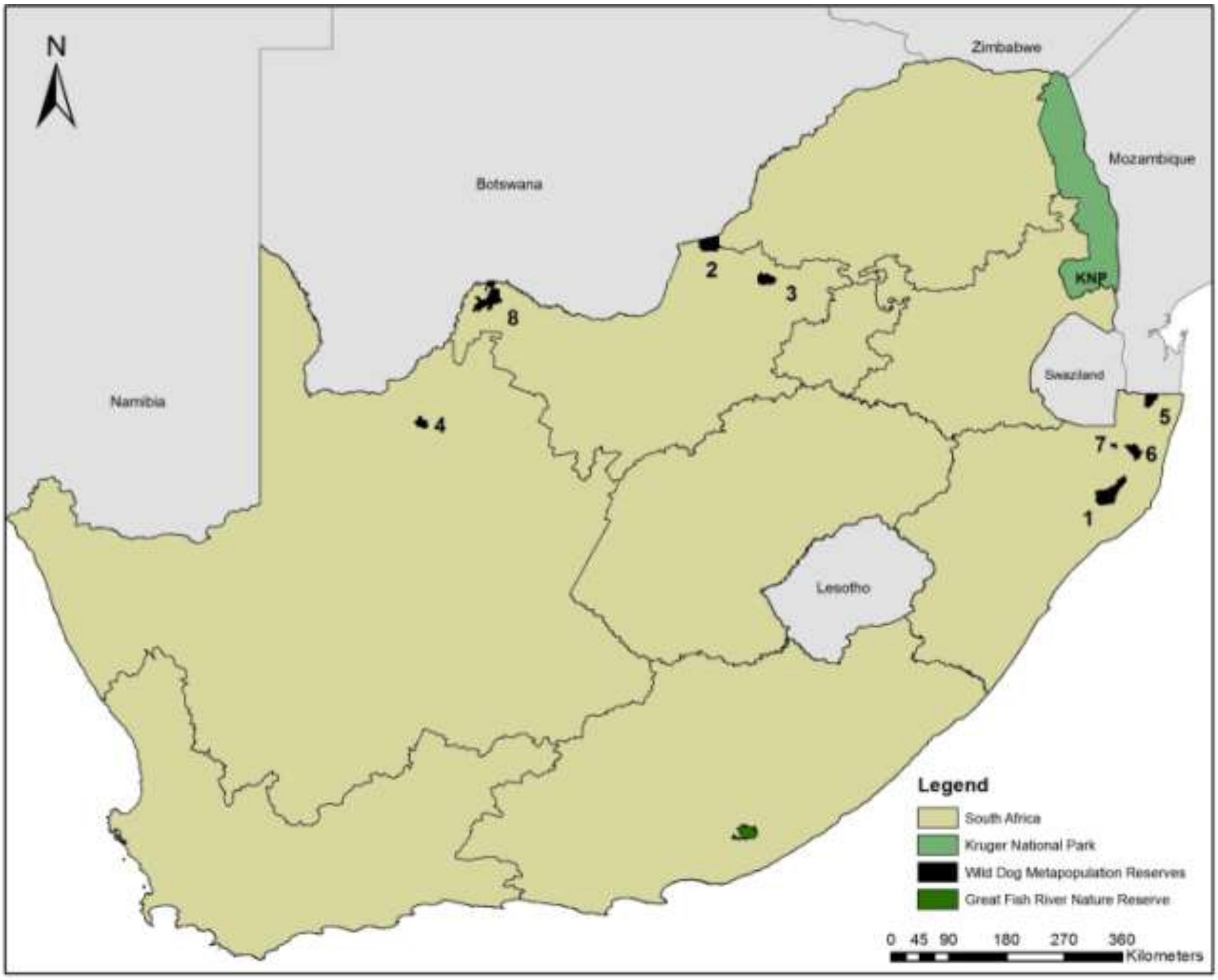

Figure 1.4: Wild dog metapopulation reserves in South Africa. 1.Hluhluwe-iMfolozi Park; 2. Madikwe Game Reserve; 3. Pilanesberg National Park; 4. Tswalu Kalahari Reserve 5. Tembe National Elephant Park; 6. Mkhuze Game Reserve; 7. Zimanga Private Game Reserve; 8. Khamab Kalahari Reserve (Davies-Mostert *et al.* 2009; WAG-SA Minutes 2013).

1.9. Wild dogs in the Eastern Cape Province

The Eastern Cape Province is the poorest of the nine South African provinces (Hayward *et al.* 2007a, c). However, large areas of marginal pastoral land have recently been converted to game farming, ecotourism ventures and conservation areas, because such land uses are more economically viable (Hayward *et al.* 2007c). This change in land use has resulted in numerous species being reintroduced (Hayward *et al.* 2007b). In total, 11 conservation areas have been established since 1996 in the Eastern Cape and most have reintroduced large predators to restore ecological integrity, to conserve threatened species and to maximize ecotourism (Hayward *et al.* 2007b).

Historically, wild dogs occurred throughout the Eastern Cape Province (Hayward *et al.* 2007b; Skead 2007; Davies-Mostert 2010), but they were completely extirpated from the region in the 1920s (Stuart *et al.* 1985). Since their extirpation there have been several unsuccessful wild dog reintroductions in the Eastern Cape that attempted to re-establish this canid species in the Province (Hayward *et al.* 2007a; Gusset *et al.* 2008b). The first reintroduction of wild dogs in the Eastern Cape was a founder population of five animals into Shamwari Private Game Reserve in 2003 (Hayward *et al.* 2007c). By 2005 this pack had increased to 10 (Hayward *et al.* 2007c). However, the pack was removed in 2010 due to levels of prey consumption deemed undesirable by reserve management (Hayward *et al.* 2007c). Wild dogs were also reintroduced into Kwandwe Private Game Reserve in 2004 with a founder population of six individuals (Bissett 2004). In 2006, canine distemper killed the pack, leaving only the alpha pair. The alpha pair was later bonded with four female dogs which were later removed in mid-2007. This pack was removed from Kwandwe as the pack learnt to use the fence-line to capture prey, resulting in more successful kills of larger, more valuable prey (Bissett 2004).

Currently, the Eastern Cape does not have a wild dog population, but multiple reserves have successfully reintroduced other large carnivores such as lions, brown hyenas (*Hyaena brunnea*), leopards (*Panthera pardus*), spotted hyenas and cheetahs (*Acinonyx jubatus*) (Bissett 2004; Hayward *et al.* 2007b; Hayward *et al.* 2007c).

1.10. Motivation for the study

Through the metapopulation approach, reintroductions of wild dogs into reserves within former wild dog range have resulted in wild dog population growth within the highly fragmented landscape of South Africa (Davies-Mostert *et al.* 2009). In an effort to increase the size of South Africa's wild dog metapopulation and to influence ecological integrity, the Great Fish River Nature Reserve in the Eastern Cape Province has included wild dogs in their reintroduction plan (D.M. Peinke, 2013, pers. comm.). To facilitate a potentially successful reintroduction, a population viability assessment (PVA) needs to be carried out as well as a study to determine the threats around the reserve from local land owners.

My research aimed to conduct a full PVA, studying the carrying capacity of the Great Fish River Nature Reserve, wild dog habitat suitability, prey base, suitable area requirements for prey to be sustained and wild dog population modelling. Population modelling was undertaken to determine a potentially suitable reintroduction plan for wild dogs. This included the pack structure (age and sexes) of the founder pack to be reintroduced and management plans for supplementation and harvesting of individuals over a 25 year period for the reserve. The threat landscape around the reserve was determined by interviewing people from rural communal areas and commercial private properties within a 12 km radius around the reserve. This process addressed aspects such as hunting practices, livestock husbandry, levels of poaching and snaring, current behaviour towards predators and property characteristics. Information of human tolerance of predators and the anthropogenic threats around the Great Fish River Nature Reserve were determined via these questionnaires.

CHAPTER 2: Study Area

2.1. Location

The Great Fish River Nature Reserve (GFRNR) is situated in the Eastern Cape Province of South Africa in the Fish River valley between 32° 55’’ S, 26° 37’’ E and 33° 08’’ S 26° 58’’ E (Figure 2.1.; Trollope *et al.* 2004). The reserve is located within the steep river valleys and inter-basin ridges of the Great Fish River catchment area (ECPTA 2012). The reserve is characterized by dense, semi-succulent thicket with variations in topography and elevation (Lent & Fike 2003; ECPTA 2012). It is approximately 40 km northeast of Grahamstown and 32 km south of Alice (Lent & Fike 2003; Ganqa *et al.* 2005). The reserve is 429 km^2 in size and roughly 24 km from north to south, with an average width of 24.2 km (Mzazi *et al.* 2011). The reserve is an amalgamation of the former Sam Knott Nature Reserve (15 500ha), the Andries Vosloo Kudu Reserve (6500 ha) and the Double Drift Nature Reserve (23 500 ha) (Trollope *et al.* 2004; Fike 2011). Two permanent rivers flow through the GFRNR, the Great Fish River (which flows for 75.3 km) and the Kat River (which flows for 21.3 km) (Figure 2.1.; Fike 2011). The Keiskamma River forms a section of the north-eastern boundary of the Nature Reserve, but it is mostly fenced out of the reserve (Fike 2011).

2.2. Surrounding land use

Kwandwe Private Game Reserve lies adjacent to the GFRNR in the southwest, but the two protected areas are separated by the Great Fish River, a road and are separately fenced (Figure 2.1). The area around GFRNR comprises communal rangeland, commercial agriculture and hunting safari land. The communal land areas are to the north and east of the reserve (i.e. Sheshego Fingo and Kamas Location), whereas the areas to the south and west of the reserve are generally made up of private land (Figure 2.1). Private land use varies from international hunting to stock ranching; whereas communal areas are largely small-scale stock ranching and subsistence crop farming. Notwithstanding differences in land use, the areas surrounding the GFRNR are generally characterised by a low population density (72 people/km^2 in communal land and 7 people/km^2 for privately owned land), and high levels (>50 %) of unemployment, especially in communal areas (Lent & Fike 2003; ECPTA 2012).

The communal areas consist of approximately 25 rural communities, 17 of which were surveyed for this study (Figure 2.2). The land owners and community leaders within 12 km of the reserve were asked to participate in the questionnaire surveys (Figure 2.1 & 2.2). This 12 km buffer around the reserve was identified as the survey study area for this research (see chapter 4 methods for justification).

2.3. Site description and history

The GFRNR was established in incremental phases between 1973 and 1987 (ECPTA 2012). The Andries Vosloo Kudu Reserve (AVKR), named after a former administrator of the Eastern Cape, is located in the south-western part of the reserve and was established in 1973 and is approximately 65 km^2 (Lent & Fike 2003). The Sam Knott Nature Reserve (SKNR) was created in 1987, when the late Sam Knott bequeathed several farms to the Southern African Nature Foundation (more recently known as the WWF-SA) under an agreement that the area would be managed by the Cape Provincial Administration (now the Provincial Administration of the Eastern Cape) (Lent & Fike 2003). The SKNR is approximately 145km^2 is size and lies between the Double Drift Nature Reserve (DDNR) and the AVKR (Figure 2.1). The 230km^2 Double Drift Nature Reserve (DDNR) was established in the former Ciskei homeland in 1983. The three reserves now form a single ecological entity: the Great Fish River Nature Reserve (Fike 2011). Since 2005, the ECPTA have purchased a number of properties adjacent to the reserve but these have not yet been formally incorporated into the greater reserve (D.M. Peinke, 2013, pers. comm).

In a recent land claim settlement, the Double Drift community (consisting of 1151 households) was awarded ownership of approximately half of the former Double Drift Nature Reserve (D.M. Peinke, 2013, pers. comm.). In terms of the settlement agreement the land use of this area will not change, but in future this area will be co-managed (D.M. Peinke, 2013, pers. comm*)*. These ~2000 community members are represented by approximately 30 people who form part of the Community Property Association (CPA; D.M. Peinke, 2013, pers. comm.).

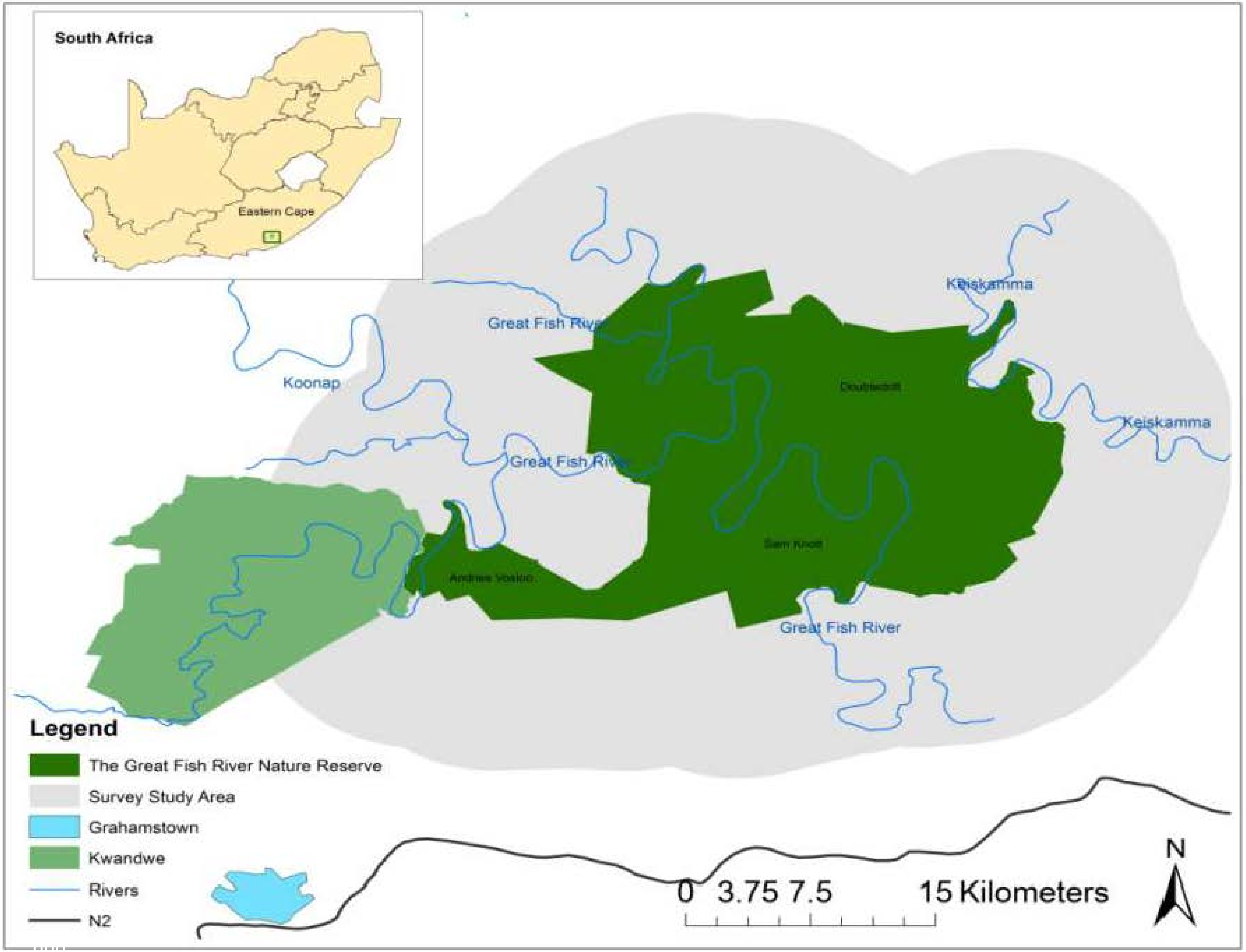

Figure 2.1: The location of the Great Fish River Nature Reserve and the study area within South Africa (ArcGIS 10.1; projected: Transverse-Mercator, spheroid WGS84, central meridian 27; map units: kilometers).

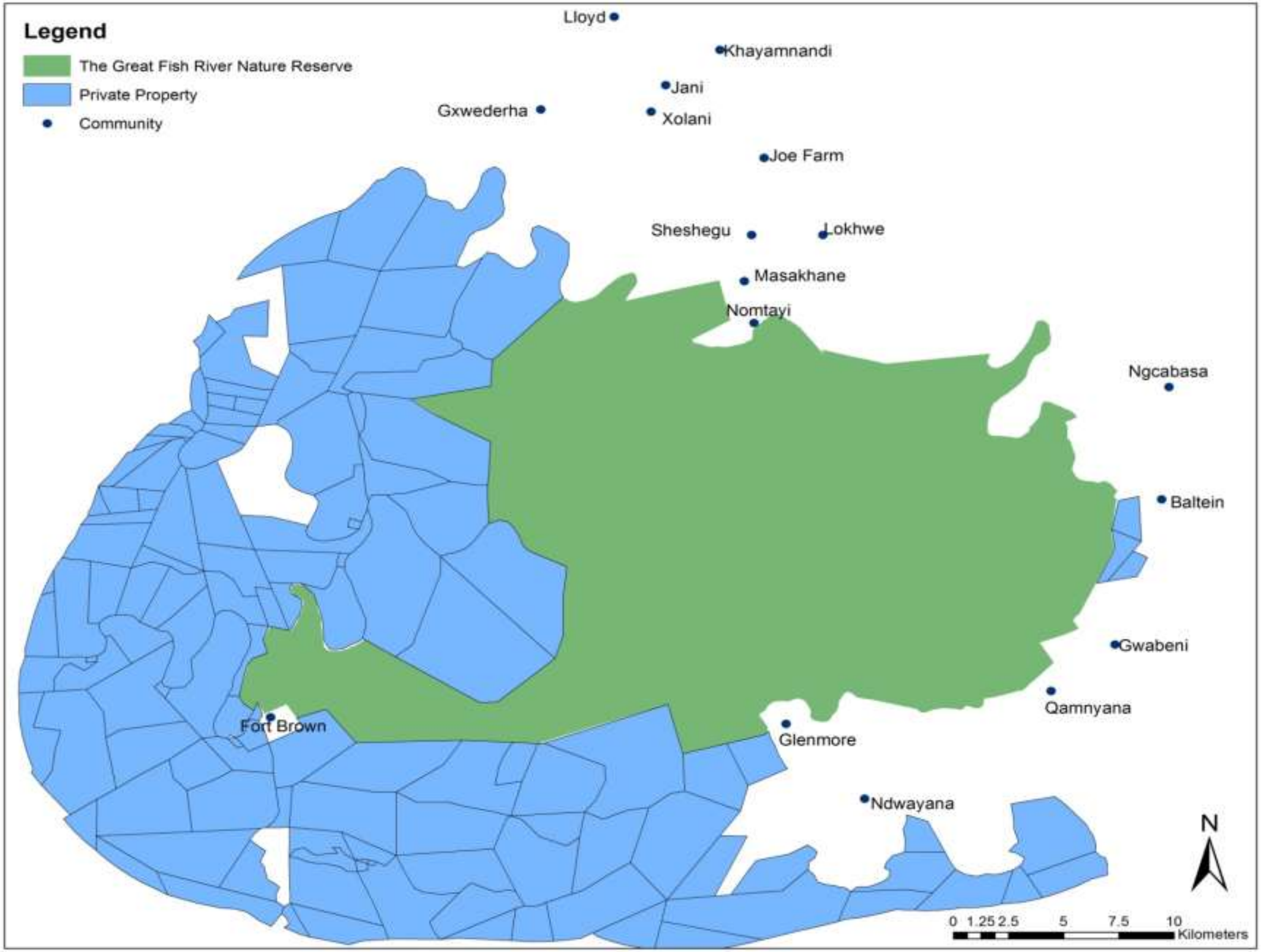

Figure 2.2: The private properties and the communities surveyed within a 12 km study area around the Great Fish River Nature Reserve Africa (ArcGIS 10.1; projected: Transverse-Mercator, spheroid WGS84; map units: kilometers).

2.4. Topography and geography

The geology of the GFRNR is predominantly grey and red mudstone of the Middleton formation (Adelaide subgroup of the Beaufort Group, Karoo Super Group), with sandstone dominating (Evans *et al.* 1997; Ganqa *et al.* 2005; Fike 2011). Soils are generally yellow/brown, apedal and are either sandy-clay loams or clay loams (Evans *et al.* 1997). Clayey soils occur throughout the reserve and surrounding area, except for the areas close to rivers where alluvial silt is deposited (Lent & Fike 2003). Soil fertility in the reserve is good, however, soils in the western sectors are composed of shale banks, and are therefore predisposed to being thin and easily eroded (Lent & Fike 2003).

The region is topographically complex, creating a complex climatic environment (Figure 2.3) (Evans *et al.* 1997). The landscape consists of fairly steep river valleys with inter-basin ridges; with more resistant sandstones along such ridges (Figure 2.3; Fike 2011). The altitude in the reserve ranges from 95 to 561 m above sea level.

The Great Fish River follows a highly convoluted course through the reserve (Figure 2.3; Lent & Fike 2003). The Koonap River is another major watercourse in the area and forms a confluence with the Great Fish River outside the western boundary (Figure 2.1). Small waterfalls (some reaching 4 m in height) have formed in places where dolerite dykes have been exposed (Fike 2011). Tributaries to the main rivers are ephemeral and subject to rapid drainage after heavy rainfall (Evans *et al.* 1997). During the mid-1970s, the Orange-Fish inter-basin transfer scheme was completed and water from the Orange River began to flow down the Fish (Evans *et al.* 1997). This changed the Fish River from being a seasonally flowing system to a perennial system (Fike 2011).

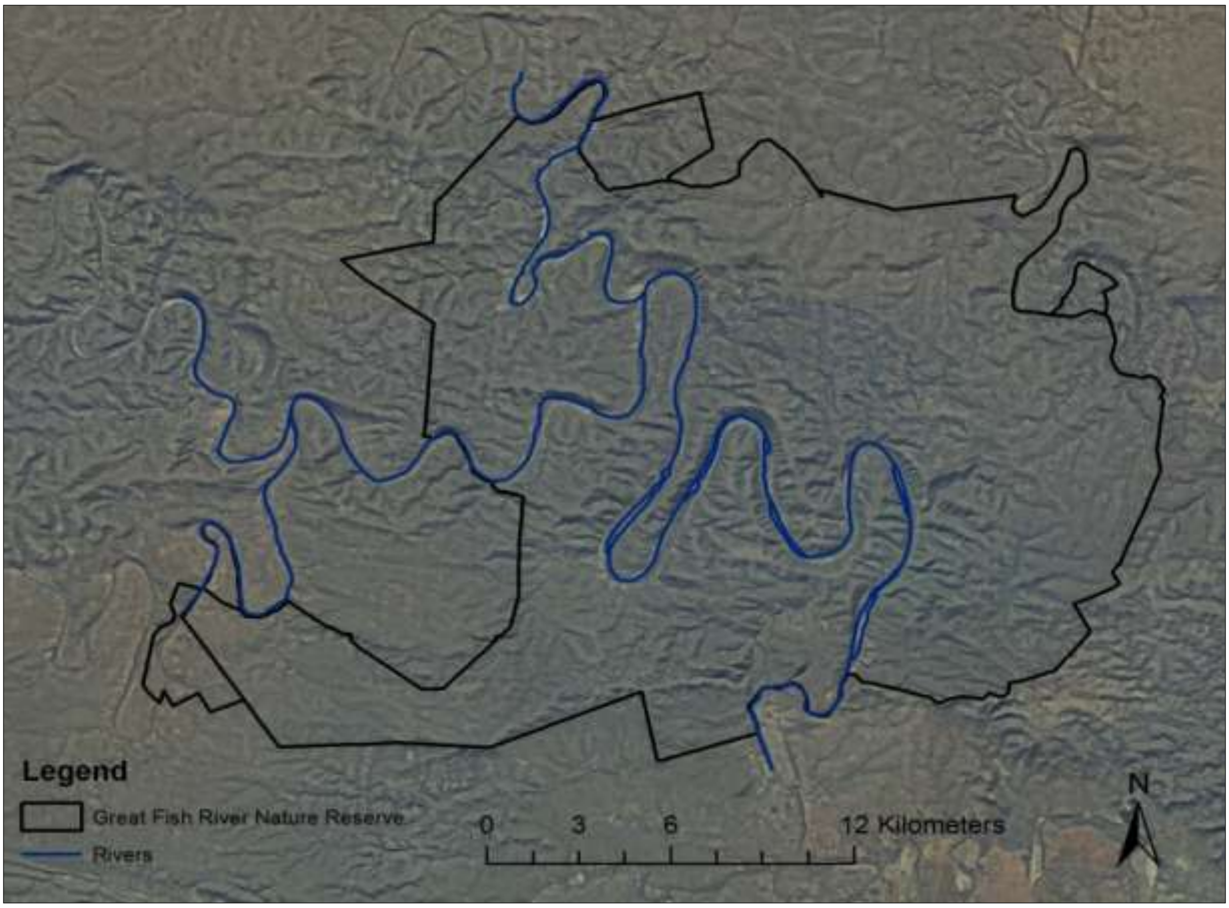

Figure 2.3: The topography of the Great Fish River Nature Reserve is complex. Shown above is the main river in the reserve: the Great Fish River. (ArcGIS 10.1; projected: Transverse-Mercator, spheroid WGS84; map units: kilometers).

2.5. General climate

The Fish River Valley can be broadly described as having a semi-arid climate (Ganqa *et al.* 2005). According to Trollope *et al.* (2011), the climatic conditions are moderately wide-ranging due to the variations in elevation, aspect and slope through the reserve. The southern slopes generally experience cooler and moister conditions, whereas the north-facing slopes generally experience warmer and drier conditions (Trollope *et al.* 2011). The average temperature of the reserve ranges greatly and the maximum temperature in summer can exceed 40°C, while temperatures in winter can reach below 0°C (Figure 2.4.; Evans *et al.* 1997).

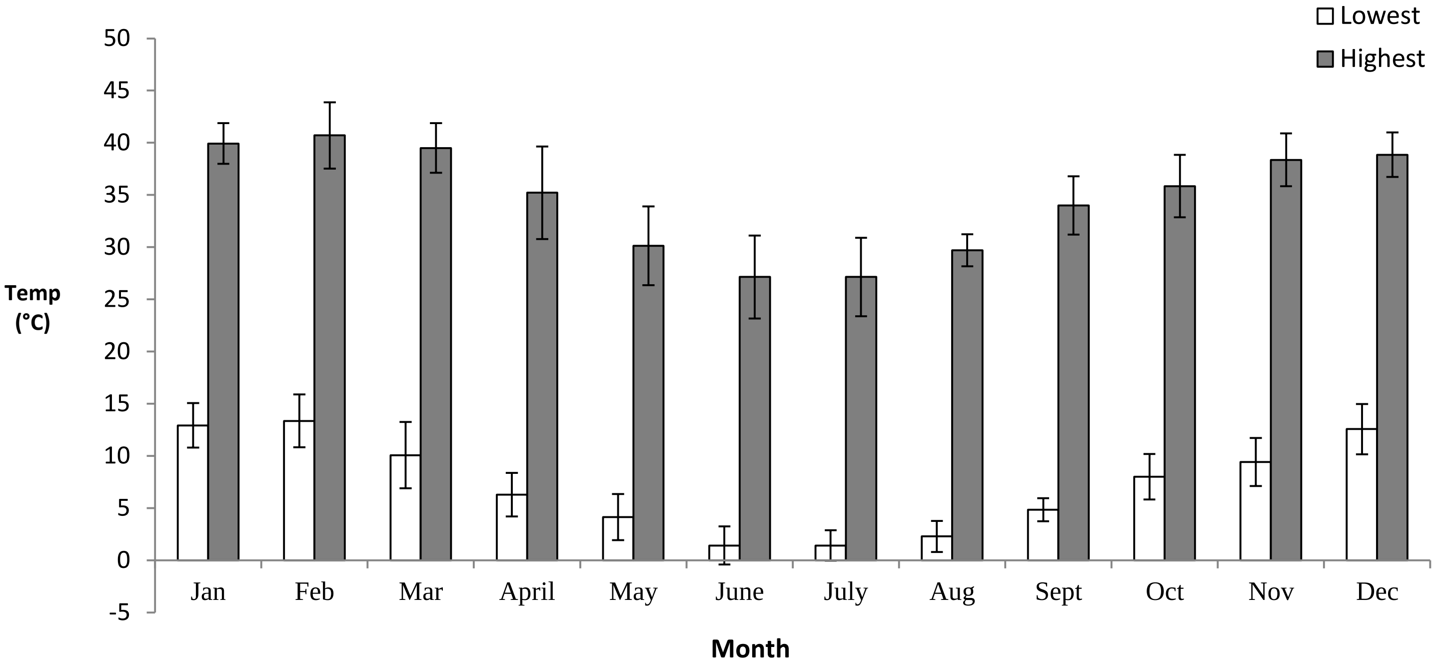

Figure 2.4: Mean monthly maximum and minimum temperatures (°C) of the Great Fish River Nature Reserve for the period between 1999 to 2012. Data are means ±1SD. (ECPTA 2012; Recorded from weather stations within the reserve).

The reserve is located between the spring and autumn-dominant rainfall regions of the province (Ganqa *et al.* 2005; Trollope *et al.* 2011). Thus, the area experiences bimodal rainfall, with the highest occurrence between January and April and September and November (Evans *et al.* 1997; Ganqa *et al.* 2005). Rainfall is highly variable within the reserve annually and among seasons (Figure 2.5). The annual rainfall ranges from 434 mm in the dryer south to 617 mm in the northern, wetter areas (Ganqa *et al.* 2005; Trollope *et al.* 2011).

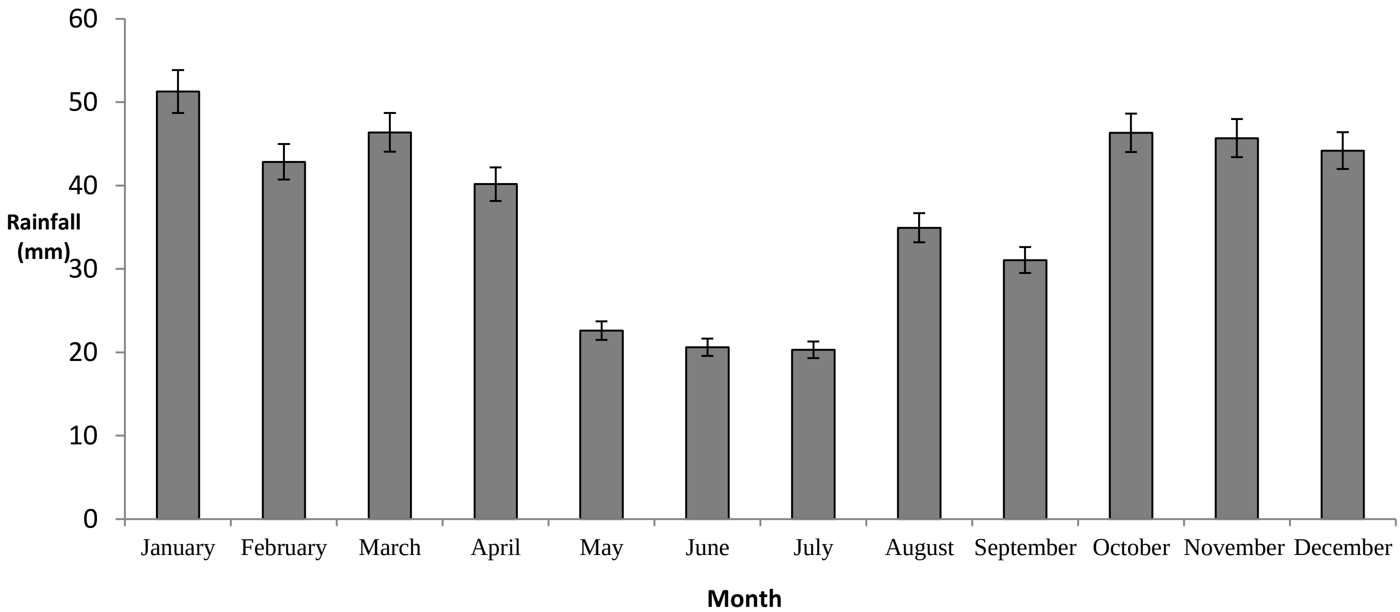

Figure 2.5: Mean monthly rainfall (mm) of the Great Fish River Nature Reserve for the period 1999 to 2012. Data are means ±1SD. (ECPTA 2012; Recorded from weather stations within the reserve).

Rainfall is usually highest in October (spring) and in March (autumn) (Figure 2.5). Rainfall in the province is non-seasonal, due to the fact that it is in the transitional zone of climatic types (Evans *et al.* 1997). The Eastern Cape Province lies directly between the subtropical conditions associated with the KwaZulu-Natal Province summer rains and the Mediterranean conditions, with winter rains, of the Western Cape Province (Evans *et al.* 1997; Ganqa *et al.* 2005).

2.6. Vegetation units

Due to topographical and climatic variations the reserve has a significant level of plant diversity, with high occurrence of plant endemism (Evans *et al.* 1997). The reserve falls within the Albany Thicket Biome which is characterised by impenetrable shrubland, with indistinguishable strata and no herbaceous cover, and is dominated by evergreen, spiny or succulent trees and shrubs (Mucina & Rutherford 2006). The majority of the woody species produce seeds contained within edible fruits which offer a rich source of nutrients to birds and mammals (Evans *et al.* 1997; Mucina & Rutherford 2006). The vegetation at higher altitudes is dominated by grass species, whereas the vegetation of the lower lying areas is either tall, dense, thornless shrub-land or short, sparse, thorny and/or succulent shrub-land (Evans *et al.* 1997; Mucina & Rutherford 2006). During unusually dry periods, the grass component disappears and dwarf, unpalatable shrubs increase in number (Evans *et al.* 1997). By comparison, during years of above-average rainfall the vegetation contains large amounts of grass and shrubs (Evans *et al.* 1997).

Classification, according to Mucina and Rutherford (2006), shows that the GFRNR's vegetation is grouped into three broad categories: Great Fish Thicket, Great Fish Noorsveld and Bhisho Thornveld (Figure 2.6). A small area of Great Fish Noorsveld occurs in the southern and south eastern parts of the reserve. This vegetation type consists of *Portulacaria afra* (Spekboom), while the sloping plateaus support low to medium height succulent thicket which is dominated by *Euphorbia bothae* and other *Euphorbia* species, sclerophylous bush clumps, succulent shrubs, rhizomatous herbs and numerous grass species (Evans *et al.* 2005; Mucina & Rutherford 2006). The Great Fish Noorsveld also has a variety of succulent trees (such as *Aloe africana* and *Aloe ferox*) and small trees (such as *Schotia afra*, *Acacia karroo* and *Boscia oleoides*). This vegetation unit is currently listed as least threatened and it holds biogeographically important taxa such as *Drimia acarophylla* (Mucina & Rutherford 2006).

Great Fish Thicket covers most of the reserve and is composed of small, medium and tall thicket types with numerous spinescent shrubs. These are dominated by *P. afra*¸ which in more arid areas is replaced by *Euphorbia bothae* or by other woody species and tall emergent *Euphorbia tetragona* and *E. triangularis* in the moister areas (Evans *et al.* 1997; Mucina & Rutherford 2006). In the northern area of the reserve a small section of Bhisho Thornveld occurs, this vegetation consisting mostly of open savanna with small *Acacia natalitia* trees and dense, grassy undergrowth dominated (Mucina & Rutherford 2006).

Figure 2.6: The vegetation units in Great Fish River Nature Reserve (Eastern Cape), according to Mucina and Rutherford (2006). (ArcGIS 10.1; projected: Transverse-Mercator, spheroid WGS84; map units: kilometers).

According to the Subtropical Thicket Ecosystem Project (STEP), the reserve is made up of Bedford Savanna Thicket (the smallest vegetation type in the reserve), Crossroads Grassland Thicket, Doubledrift Karroid Thicket, Fish Noorsveld, Fish Spekboom Thicket (making up a large portion of the reserve), Fish Thicket and Fish Valley Thicket (Figure 2.7).

Trollope *et al.* (2004) categorized the vegetation units of the reserve and identified twelve specific vegetation units which are based on the structure and dominant species (Figure 2.7). *Acacia* Savanna is characterised by open thornveld dominated by *A. karroo* trees and shrubs (Trollope *et al.* 2004). Bushclump Karroid Thicket (or Doubledrift Karroid Thicket) is characterised by *Rhus* spp., *Euphorbia undulata*, and *Gymnosporia polyacantha* tree species and *Pentzia incana*, a karroid herbaceous layer made up of characteristic grass species such as *Setaria neglecta* and *Digitaria eriantha* (Trollope *et al.* 2004). Bushclump Savanna Thicket is found on flatter areas at higher altitudes and is characterised by dense thornveld largely composed of *Chrysocoma ciliata*, *Rhus* spp, *Olea europaea*, *Cussonia spicata*, *Fluggea verucossa*, *Psydrax ovata*, *Ptaeroxylon obliquum* and *Scutia myrtina* bushclumps, interspersed with patches of grassland. Characteristic grass species of this vegetation unit include *D. eriantha*, *S. neglecta* and *Eustachys paspaloides* (Trollope *et al.* 2004). The Dry Forest (or Fish Thicket), is characterised by tall-growing species such as *Schotia latifolia*, *Viperus undulata* and *Harpephylum caffrum* trees and shrubs (Trollope *et al.* 2004). The Grassland vegetation type is characterised by open grassland consisting of one of the following vegetation: *Themeda triandra*, *Sporobolus fimbriatus* and *D. eriantha* (Trollope *et al.* 2004). Medium *Portulacaria* Thicket (or Fish Spekboom Thicket) is characterised by *P. afra*, has a bare under-storey and is interspersed with *Pappea capensis* trees (Trollope *et al.* 2004). Riverine *Acacia* Thicket is characterised by dense *A. karroo* tree communities. Short *Euphorbia* Thicket (or Fish Noorsveld) is dominated by *E. bothae* and *Euphorbia corulescens* and in some areas the woody communities include *P. afra*, *P. capensis*, *Rhigozum obovatum* and *Maytenus capitata.* Grass species include *D. eriantha*, *T. triandra* and *Aristida* spp. (Trollope *et al.* 2004).

Tall *Euphorbia* Thicket (or Fish Valley Thicket) is dominated by a continuous assemblage of *E. tetragona* and *E. triangularis*, with *Maytenus undata*, *Elaeodendron zeyheri* and *C. spicata* tree species. The under-storey is dominated by *Panicum deustem* and *P. maximum* grass species and this vegetation unit is generally found on steep slopes (Trollope *et al.* 2004). Succulent aloe Shrubland is characterised by *Aloe* spp. and is found mostly in the northern sector of the reserve. Areas identified as degraded/bare soil are areas that were previously cultivated fields (Trollope *et al.* 2004).

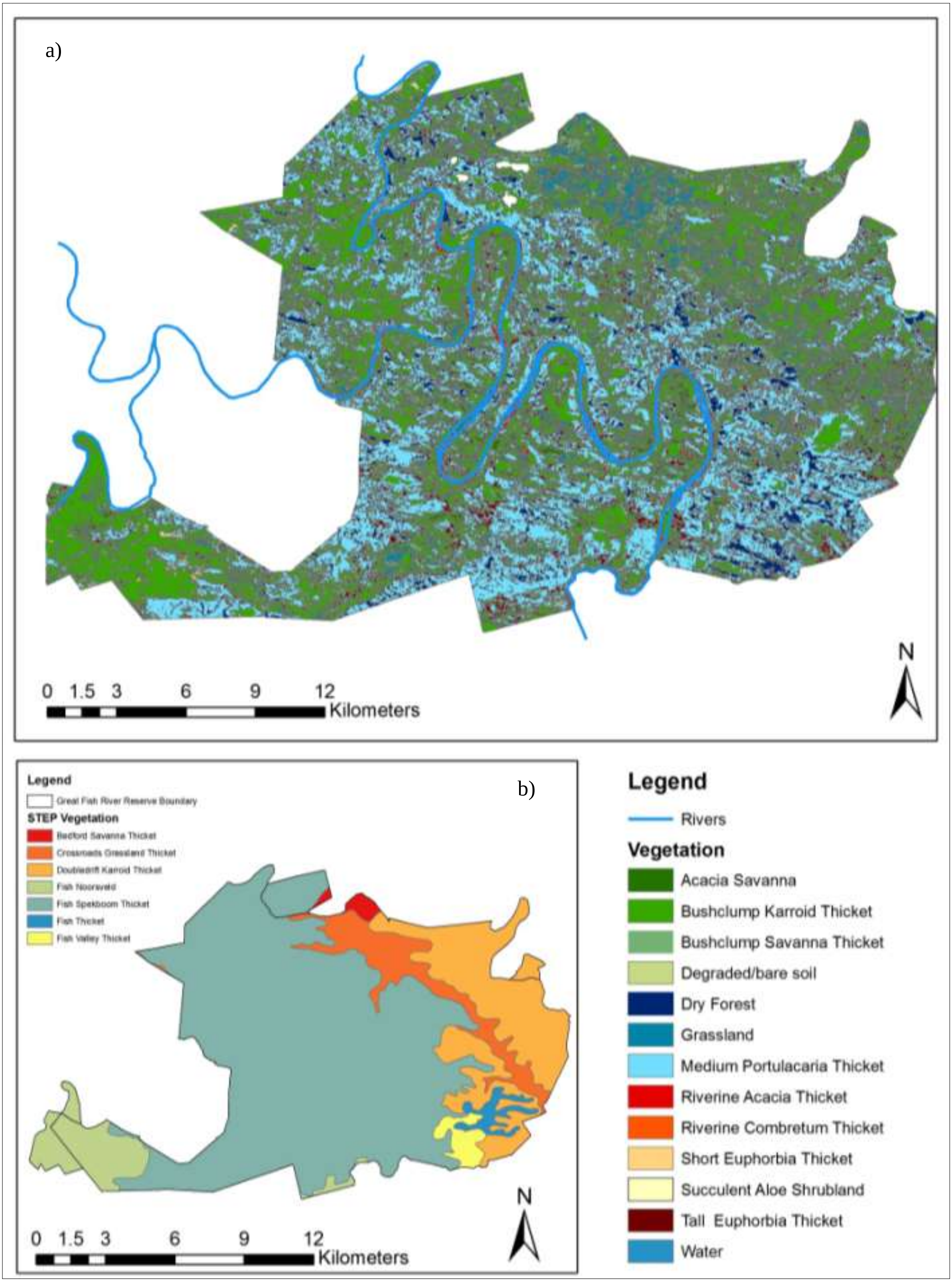

Figure 2.7: A) Distribution of the 12 vegetation types within the Great Fish River Nature Reserve (Eastern Cape) according to Trollope *et al.* (2004) and B) The STEP vegetation units that occur in the reserve. (ArcGIS 10.1; projected: Transverse-Mercator, spheroid WGS84; map units: kilometers).

2.7. Predator and prey populations

The GFRNR has ~73 mammalian species on the reserve, including the larger species (Orders: Carnivora, Perissodactyla, Proboscidea, Suiformes, Wippomorpha, Ruminantia; Table 2.1; Skead 2007). Six predatory species are found within the reserve: honey badger (*Mellivora capensis*), black-backed jackal (*Canis mesomelas*), caracal (*Caracal caracal*) and Cape clawless otter (*Aonyx capensis*). Although the GFRNR lacks apex predators: brown hyaena (*Hyaena brunnea*) and leopards (*Panthera pardus*) have been known to occur sporadically in the area. Historically wild dogs (*Lycaon pictus*), brown hyenas, spotted hyenas (*Crocuta crocuta*) and lions (*Panthera leo*) would have occurred within the region (Skead 2007).

Table 2.1: Aerial game count data for the Great Fish River Nature Reserve (*Black rhinoceros numbers are excluded for security reasons). Extra-limital species are shown in bold. Unknown = present.

Species		Total 2009	Total 2012
Aardwolf	*Proteles cristata*	Unknown	Unknown
Aardvark	*Orycteropus afer*	Unknown	Unknown
Black rhinoceros	*Diceros bicornis*	*	*
Black-backed jackal	*Canis mesomelas*	71	66
Blue wildebeest	*Connochaetes taurinus*	6	1
Bushbuck	*Tragelaphus scriptus*	154	142
Bushpig	*Potamochoerus porcus*	Unknown	Unknown
Cape buffalo	*Syncerus caffer*	215	316
Cape clawless otter	*Aonyx capensis*	Unknown	Unknown
Caracal	*Caracal caracal*	Unknown	Unknown
Common Reedbuck	*Redunca arundinum*	0	4
Eland	*Tragelaphus oryx*	624	614
Elephant	*Loxodonta africana*	2	2
Grey duiker	*Sylvicapra grimmia*	Unknown	55
Hippopotamus	*Hippopotamus amphibious*	9	17
Honey Badger	*Mellivora capensis*	Unknown	Unknown
Kudu	*Tragelaphus strepsiceros*	1758	2418
Mountain Reedbuck	*Redunca fulvorufula*	9	19
Nyala	*Tragelaphus angasii*	18	10
Plains Zebra	*Equus quagga*	135	192
Red Hartebeest	*Alcelaphus buselaphus caama*	425	329
Steenbok	*Raphicerus campestris*	54	74
Warthog	*Phacochoerus africanus*	860	547
Waterbuck	*Kobus ellipsiprymnus*	16	21

Smithers (1983) states that wild dogs were found in the Addo district as early as 1906, and in the Albany and Bedford districts in 1925. Wild dogs were listed as vermin by the South African government and a bounty offered for their persecution in the early 1900s (Smithers 1983; Stuart *et al.* 1985). Thus, by 1925, wild dogs were rare in the province compared with the mid-1800s.

Population trends of preferred wild dog prey species in the Great Fish River Nature Reserve are generally increasing within the reserve, or show relatively stable populations (Table 2.1.). It is expected that species such as kudu, plains zebra, eland, bushbuck and red hartebeest will be the preferred prey species of this canid (Hayward *et al.* 2007c). Kudu numbers, in particular, are increasing rapidly and the reserve has adopted regular culling to simulate predation in order to prevent vegetation degradation by this ungulate species (Table 2.3) (D.M. Peinke, 2013, pers. comm.).

2.8. Management of the GFRNR

After the democratic elections in 1994, management of the GFRNR was assigned to the Eastern Cape Tourism Board and subsequently in 2004 to the Eastern Cape Parks Board, now the ECPTA (ECPTA 2012). The reserve is managed according to an approved management plan which includes the reintroduction of naturally occurring species.

ECPTA's large mammal management is guided by the large mammal management policy (ECPTA 2012). The ECPTA aims to eradicate (or where not possible to control) extralimital species and wherever possible to re-establish or simulate natural ecological processes such as predation, competition for resources, plant herbivore interactions, movement of genes and the maintenance natural social structures (Peinke, 2013. *Pers. comm.*). The reintroduction of indigenous predators is an important component of this strategy and includes reintroducing top-order predators such as lions and wild dogs (ECPTA 2012). The re-introduction of wild dogs has been included in the ECPTA's 5 year reintroduction plan for large mammals (D.M. Peinke, 2013, pers. comm.).

CHAPTER 3: The biological pre-requisites for an African wild dog reintroduction into the Great Fish River Nature Reserve, Eastern Cape, South Africa

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3.1. Introduction

Reintroductions have been used successfully as a management tool in assisted migrations, to recover declining animal populations or restore populations that have been completely extirpated (Lindsey *et al.* 2004a,b; Hayward *et al.* 2006; Mills *et al.* 2006; Gusset *et al.* 2006; Davies-Mostert *et al.* 2009). Eurasian lynx (*Lynx lynx*) populations in Europe have been steadily increasing due to reintroduction programs aimed to bring the population back from near extinction (this was the first real reintroduction programme to target felines) (Linnell *et al.* 2009). Local extinctions of grizzly bears (*Ursus arctos*) and wolves (*Canis lupis*) from the southern Yellowstone ecosystem, USA, were caused before 1940 by persecution from adjacent land owners (Berger *et al.* 2001). Recently these predators have been reintroduced into their native range, and their populations are growing (Berger *et al.* 2001).

The success of efforts to re-establish mammalian carnivores within their historical distribution is reliant upon the biological pre-requisites of the target species, among other key factors (such as threats in the area, reintroduction techniques etc.) (Hunter *et al.* 2001; Price & Soorae 2003; Hayward *et al.* 2007b; IUCN 2012). These biological requirements include a suitable prey base that will be sustainable under predation, and support a population (or populations) of carnivores (Hayward *et al.* 2006, 2007a; Niemann 2010). Cheetahs (*Acinonyx jubatus*) in the Suikersbosrand Nature Reserve (Gauteng Province, South Africa) were removed two years after reintroduction due to prey populations being insufficient to sustain them (Hayward *et al.* 2007d; Niemann 2010). In addition, an African wild dog (*Lycaon pictus,* hereafter referred to as wild dog) reintroduction to Kwandwe Private Game Reserve (Eastern Cape, South Africa) resulted in the kudu (*Tragelaphus strepsiceros*) population decreasing. As a result the wild dogs were removed three years after reintroduction (Bissett 2004; A. Sholto-Douglas, 2013. pers. comm.).

For a wild dog reintroduction to be sustained in the long term, there must be a sustainable prey base, limited conflict with humans and other carnivores, and the site itself must be adequate to support prey and predator populations (Lindsey *et al.* 2004a, b; Hayward *et al.* 2006; Mills & Doncaster 2006; Gusset *et al.* 2006; Davies-Mostert 2010). Several models have been released that examine carnivore prey preferences, carrying capacity and the minimum prey populations required to sustain a reintroduction (Carbone & Gittleman 2002; Lindsey *et al.* 2004a; Hayward *et al.* 2006, 2007a). These models allow researchers and protected area managers to plan reintroductions that are well suited for both the species in question and for the reserve (Price & Soorae 2003; Niemann 2010).

Prey availability is a fundamental biological constraint for the survival of a carnivore species (Estes & Goddard 1967; Mills & Gorman 1997). If reserves are small, they often will not have sufficient prey densities to sustain a carnivore population (Lindsey *et al.* 2004a). It is important to establish feeding strategies, potential diet (species and numbers killed per year) and impact on prey populations of the reintroduced carnivores prior to a reintroduction (Creel & Creel 1998; Lindsey *et al.* 2004a; Hayward *et al.* 2006). These types of data can be used to predict the number of predators an area is able to sustain: a value known as carrying capacity (Carbone & Gittleman 2002; Hayward *et al.* 2007a; Hayward & Somers 2009; Niemann 2010).

For their size (17-30 kg), wild dogs span the 21.5 kg threshold considered necessary for obligate carnivory (Creel & Creel 1991, 2002; Skinner & Chimimba 2005; Oxford 2005; Hayward *et al.* 2006). An obligate carnivore is a species which survives on a diet consisting only of meat and does not possess the physiology to digest plant matter (Oxford 2005). For their size, wild dogs consume more meat per day (3.04 kg per day) than any other carnivore (Mills & Harvey 2001), and this is due to their high metabolic demands (Creel & Creel 1995; Gorman *et al.* 1998; Lindsey *et al.* 2004a). Extremely high rates of daily energetic expenditure by wild dogs result in this high daily food requirement (Gorman *et al.* 1998; Lindsey *et al.* 2004a). To meet this demand, wild dogs are required to hunt almost daily (Creel & Creel 2002; Hayward *et al.* 2006; S. Dell, 2013, pers. comm.). Wild dogs kill their prey by tearing it apart, grabbing it from all sides and pulling against one another (Estes 1993; Courchamp & Macdonald 2001). Their digestive tracts are specialized to allow rapid ingestion of large amounts of meat, and the regurgitation of chunks later on to feed pups

(Courchamp & Macdonald 2001). This swift killing and rapid consumption decreases the time that the carcass is available to kleptoparasites, such as spotted hyenas (*Crocuta crocuta*) and lions (*Panthera leo*) (Courchamp & Macdonald 2001). A wild dog's stomach can carry approximately three days' worth of food, which is roughly 4.4 kg of meat (Estes 1993; Courchamp & Macdonald 2001).

Wild dogs have been recorded preying on a range of species from scrub hares (*Lepus saxitilus*) to juvenile African buffalo (*Syncerus caffer*) (Creel & Creel 1995; Hayward *et al.* 2006, 2007b,c). They are efficient hunters and usually prey on the most abundant medium- to large-sized prey (Creel & Creel 1995). According to Hayward *et al.* (2007a), there is a highly significant relationship between predator density and the biomass of their preferred prey: areas with higher prey densities generally have a higher number of predators (Estes & Goddard 1967; Hayward *et al.* 2007a). However, wild dogs favour prey within a bimodal body mass range of 16-32 kg and 120-140 kg (Hayward *et al.* 2006, 2007a). Prey within these ranges is generally abundant and unlikely to injure wild dogs (Hayward *et al.* 2006). Kudu and impala (*Aepyceros melampus*) are killed by wild dogs wherever wild dogs and these two ungulates coexist, and they are significantly preferred over other ungulate species (Hayward *et al.* 2006). Other prey species for which wild dogs have shown a preference include bushbuck (*Tragelaphus scriptus*) and waterbuck (*Kobus ellipsiprymnus*) (Estes & Goddard 1967; Mills & Gorman 1997; Lindsey *et al.* 2004a; Butler 2004).

It has been observed in smaller (< 500 km^2) reserves where wild dogs have been reintroduced that wild dogs adapt to use electrified fences in their hunting strategies (van Dyk & Slotow 2003). This results in higher hunting success and larger than normal prey such as adult male kudus (*Tragelaphus strepsiceros*) and eland (*Tragelaphus oryx*) being killed (van Dyk & Slotow 2003). The presence of fences can therefore increase the ecological impact of wild dogs on other prey species that are not generally hunted (van Dyk & Slotow 2003; Niemann 2010).

The second biological aspect to consider prior to a reintroduction is whether the habitat is suitable for the reintroduced species (Durant *et al.* 2010). Reintroductions of a species should primarily be within the species' former natural habitat and range (IUCN 2012). IUCN (2012) reintroduction guidelines require that reintroductions only take place where the habitat and landscape requirements of the species are fulfilled, and are expected to be sustained for the foreseeable future. Home ranges and area requirements of wild dogs have been found to vary greatly across African ecosystems (Lindsey *et al.* 2004a). The average home range of wild dogs in the Kruger National Park, South Africa, is 537 km^2, whereas in the Serengeti home ranges are between 1500 and 2000 km^2 (Creel & Creel 2002; Lindsey *et al.* 2004a). Multiple explanations have been offered for why wild dogs have such varying home range sizes (Mills & Gorman 1997; Vucetich & Creel 1999; Creel & Creel 2002; Lindsey *et al.* 2004a; Hayward *et al.* 2007c; Niemann 2010).

Firstly, wild dogs may have large home ranges to avoid competitors (Vucetich & Creel 1999; Lindsey *et al.* 2004a; Hayward *et al.* 2007d; Niemann 2010). In natural systems (ones without human intervention), there is an observed negative correlation between wild dog density and that of lions and spotted hyenas (Mills & Gorman 1997, Lindsey *et al.* 2004a). Areas with large populations of superior predators are likely to have lower densities of wild dogs (Niemann 2010). Lions are a major cause of dog mortality, being responsible for 43 % of adult dog mortality in the Kruger National Park (Mills & Gorman 1997). Secondly, wild dogs have complex pack structures (Vucetich & Creel 1999; Courchamp & Macdonald 2001). Like most canids, wild dogs are social animals, living in groups of up to 20 adults and their dependent offspring (Vucetich & Creel 1999; Courchamp & Macdonald 2001). Generally, it is only the dominant or alpha pair that breed within the pack with the assistance of helpers. The helpers are the subordinate individuals of the pack and there is ranking system in both the females and males (Creel & Creel 1995). This social system is known as cooperative breeding (Courchamp & Macdonald 2001), and such large pack sizes require large and suitable territories for the pack to roam in search of suitable denning sites and prey (Creel & Creel 1995; Courchamp & Macdonald 2001; Gusset *et al.* 2006)

However, recent studies have found that wild dogs actually require smaller areas than previously thought (Mills & Gorman 1997; Lindsey *et al.* 2004a). A minimum area requirements model, developed by Lindsey *et al.* (2004a), is based on the minimum area required to sustain a suitable population of the most important prey species in the diet of a pack of wild dogs (Lindsey *et al.* 2004a). Lindsey *et al.*'s (2004a) study suggests that high prey density areas (e.g. northern South Africa) can accommodate wild dogs in protected areas as small as 131 km^2, as these areas are predicted to support a small (< 12) pack of dogs and one year's offspring (Lindsey *et al.* 2004a). This suggests that if prey in a reserve is abundant (and in the absence of other factors such as competitors), smaller areas than those previously considered necessary for successful wild dog reintroductions could provide enough prey to support a reintroduction (Lindsey *et al.* 2004a).

It is crucial that the prey populations are large enough to sustain a population of wild dogs. If populations are not adequate it is highly likely that dispersal of the population will occur in search of more suitable, prey-abundant areas (Creel & Creel 2002). This dispersal can easily occur if fences are not regularly maintained. Such dispersal events can result in wild dogs occurring on unprotected land where other threats (persecution, vehicle collisions and snaring) are much higher (Mills *et al.* 1998, Lindsey *et al.* 2004b; Woodroffe *et al.* 2007).

Currently, the only viable population of wild dogs in South Africa is located in the Kruger National Park, Limpopo Province (Mills *et al.* 1998; Lindsey *et al.* 2004b). Thus, recent conservation efforts have concentrated on establishing a managed metapopulation (Lindsey *et al.* 2004a; Davies-Mostert *et al.* 2009). This management approach involves the periodic translocation of individuals among packs across reserves in South Africa to mimic natural dispersal and to promote gene flow (Gusset *et al.* 2006; Gusset *et al.* 2008b). Implementation of the metapopulation strategy involves releasing wild dogs of the local genotype into a network of small (< 500 km^2) reserves to increase the number of wild dogs in South Africa (Davies-*Mostert et al.* 2009). The introduced packs are collectively and intensively managed in aspects such as fencing, disease control, and artificial genetic and demographic exchange between reserves (Gusset *et al.* 2008; Davies-Mostert *et al.* 2009). This method of conserving a species has proved to be successful for other endangered species (such as grizzly bears (Berger *et al.* 2001), American bison, *Bison bison* (Fischer & Lindenmeyer 2000), wolves (Berger *et al.* 2001)). Reintroduction of wild dogs into several small conservation areas in South Africa has, so far, been successful, with high survival rates of both the released packs and their offspring (Gusset *et al.* 2008b).

Biodiversity has become increasingly threatened due to anthropogenic mortalities and habitat fragmentation, and a search for tools to evaluate extinction risk has resulted in the theoretical development of population viability analysis (PVA; Soule 1987; Lacy 1993; Soule *et al.* 2003, 2005). This is a quantitative approach, which has increasingly been used in recent decades to assess the future viability of wildlife populations (Lacy 1993, 2013; Mills *et al.*

1998; Cross & Beissinger 2001). PVAs also consider the factors influencing the persistence of a population (Lacy 1993, 2013; Mills *et al.* 1998; Cross & Beissinger 2001; Davies-Mostert 2010; Bach *et al.* 2010; Pe'er *et al.* 2013). This analytical tool has become a popular approach in biological conservation research and reintroduction biology/management (Soule *et al.* 2003). PVAs identify significant environmental and population variables and evaluate their possible interactions with the target species (Mills *et al.* 1998; Soule *et al.* 2003). This assists in providing guidance and direction of management strategies for the long-term management of a reintroduced species (Mills *et al.* 1998).

The Great Fish River Nature Reserve (GFRNR), Eastern Cape, is a 429 km^2 protected area situated in the Fish River valley (Trollope *et al.* 2004; Ganqa *et al.* 2005). The reserve, which currently does not have any apex predators except for the occasional nomadic leopard (*Panthera pardus*), has incorporated a wild dog reintroduction project into its five-year plan (D.M. Peinke, 2013, pers comm.). The aims of this research chapter were to conduct a feasibility study using a PVA approach to assess the potential of the GFRNR to sustain wild dogs by studying the biological aspects of wild dogs and the reserve. More specifically, I aimed to:

- confirm the historical occurrence of wild dogs in the Eastern Cape Province;
- determine the potential prey species of wild dogs in the reserve using predicted prey preferences;
- establish the minimum prey population required to be sustained under predation by wild dogs;
- determine habitat suitability for wild dogs in the GFRNR by assessing prey population distribution;
- determine the carrying capacity of the GFRNR for wild dogs; and
- using VORTEX software, determine the most suitable founder wild dog population size and structure, and determine the most suitable management approach for supplementation and/or harvest of individuals to ensure long-term persistence.

3.2. Methods

Historical occurrence of wild dogs in the Eastern Cape Province

A brief literature review was conducted to confirm the natural occurrence of wild dogs in the Eastern Cape Province, South Africa, specifically the area incorporating the GFRNR (Fitzsimons 1919; The Albany Museum 1931; Roberts 1951; Smithers 1983; Skead 2007).

Carrying capacity

Carrying capacity can be briefly defined as the maximum number of individuals a site can support without causing its deterioration (Hayward *et al.* 2007a). Deterioration being a state in which the ecosystem has become degraded (Hayward *et al.* 2007a). Two methods were used to calculate wild dog carrying capacity within the GFRNR. The Hayward model was used to calculate the expected wild dog carrying capacity based on the available prey densities in the reserve (Hayward *et al.* 2007a). This approach uses a regression equation and information about prey choice to predict the number of wild dogs an area can support (Hayward *et al.* 2007a). The regression equation used was (Hayward *et al.* 2007a):

$$y = -3.012 + 0.494\,x$$

where *y* is the density of wild dogs per km^2 and x is the $\log_{10}$ of suitable prey biomass density ($kg.km^{-2}$) (Hayward *et al.* 2007a). This equation uses only species falling within the preferred weight range of wild dogs - between 16-32 kg and 120-140 kg (Hayward *et al.* 2006, 2007a; Niemann 2010). Six potential prey species fall within this preferred weight category at GFRNR (Table 1). However, wild dogs may also eat impala, common duiker (*Sylvicapra grimmia*) and warthog (*Phacochoerus africanus*) (Estes & Goddard 1967; Bissett 2004; Radloff & Du Toit 2004; Hayward *et al.* 2006; Niemann 2010).

Potential prey biomass for wild dogs was calculated as the proportion of each prey species available. Prey biomass density was then calculated by dividing total prey biomass by the reserve area. This was logged to obtain x.

Table 3.1: Abundance of suitable wild dog prey species within the Great Fish River Nature Reserve for wild dogs based on the 2012 aerial census data. Wild dogs prefer prey that falls between 16 - 32 kg and 120 -140 kg (Hayward *et al.* 2006). Prey biomass values were obtained from Skinner and Chimimba (2005).

Suitable Prey Species		**3/4 of Adult Female Mass (kg)**	**2012 Aerial Census**
Blue wildebeest	*Connochaetes taurinus*	135	1
Common duiker	*Sylvicapra grimmia*	16	55
Impala	*Aepyceros melampus*	30	18
Kudu	*Tragelaphus strepsiceros*	135	2418
Reedbuck/common	*Redunca arundinum*	32	4
Reedbuck/mountain	*Redunca fulvorufula*	23	19

The second method used to estimate wild dog carrying capacity was via the equation of Carbone and Gittleman (2002). Relationships between predator and prey density apply across all carnivores, where, according to Carbone and Gittleman, 10 000 kg of prey supports approximately 90 kg of a given carnivore species. This equation differs from that of Hayward *et al.* (2007a) as Carbone and Gittleman based the relationship between predator density and prey biomass on the body mass of the predator, as follows:

$$y = (94.54x^{-1.03}) \times \frac{z}{10000}$$

where y is the density of wild dogs per km^2, x is predator body mass (25 kg for wild dogs) and z is prey (within the preferred weight range) biomass. Prey biomass was calculated by multiplying species density by ¾ of female body mass (Table 3.1; Carbone & Gittleman 2002). This equation gave the density of wild dogs per km^2, and in order to determine the carrying capacity of the reserve this value is multiplied by the reserve size.

Habitat suitability of the GFRNR for wild dogs

The habitat requirements of wild dogs were investigated to assess whether the reserve is suitable for their reintroduction. This included determining the natural, historical occurrence of wild dogs and the potential distribution of wild dogs in the reserve based on prey availability (Mills & Gorman 1997; Lindsey *et al.* 2004a).

a) Predicted prey preferences

The following equation was used to calculate the minimum prey populations needed to sustain a pack of 12 wild dogs (Lindsey *et al.* 2004a; Niemann 2010). This equation determines the minimum area required of each prey species to persist under predation by wild dogs. Firstly, the minimum sustainable yield of each species was calculated (Caughley 1977; Lindsey *et al.* 2004a; Niemann 2010):

$$\text{MSY} = \frac{r_m K}{4}$$

Where MSY is equivalent to the number of individuals of a prey species killed per year by wild dogs (N_{prey}) and K is equivalent to N_{min} (the minimum population size required to support the predation by wild dogs of a given population size). For this study, the carrying capacity for prey (see above) was used (Lindsey *et al.* 2004a). Therefore:

$$N_{min} = \frac{4\, N_{prey}}{r_m}$$

where r_m is the intrinsic growth rate, defined as $1.5M^{-0.36}$ (Lindsey *et al.* 2004a; Hayward *et al.* 2007a; Niemann 2010) and was calculated using $\frac{3}{4}$ of the adult female body mass for each prey species (Schaller 1972; Hayward *et al.* 2007a). N_{prey} was determined by calculating the potential prey preferences of a future wild dog population in GFRNR. This was done by using the Jacobs' preference indices (Jacobs 1974) presented in Hayward *et al.* (2006) and the prey abundance data from the 2012 aerial census (Lindsey *et al.* 2004a). The predicted number of kills was solved as (Hayward *et al*. 2007d, Niemann 2010):

$$\text{R}i = \frac{\text{D}i\text{p}i + \text{p}i}{1 - \text{D}i + 2\text{D}i\,\text{p}i} \times \sum K$$

where R*i* is the predicted number of kills of a species *'i'* (Lindsey *et al.* 2004a). D*i* is Jacobs' Index value of species *'i'* calculated by Hayward *et al.* (2006) using data from 18 studies, and p*i* represents the proportional abundance of prey species '*i*' in the reserve. ∑k is used as a constant and is the total observed kills at a site. As GFRNR has no wild dogs at present, an estimate of the average number of kills per year by a pack of wild dogs was used. Generally, a pack of 12 wild dogs will kill up to 300 prey items each year (Mills *et al.* 1998; Lindsey *et al.* 2004a; Hayward *et al.* 2006; Niemann 2010; S. Dell, 2013, pers. comm.). This value was used for ∑k.

b) Prey Density

For each of the potential prey species for wild dogs, kernel density analysis was used to plot their density (Worton 1989). A map was also constructed illustrating the density of all potential prey species. This indicated which areas have a higher density of prey, and therefore a higher potential for wild dogs to occur in that area (Downs & Horner 2007). Kernel analysis is a nonparametric statistical method for estimating probability densities from a set of points or coordinates (Worton 1989). Kernel density estimation produces a smoothed, continuous intensity surface of an animal's utilization distribution based on sample point locations, in this case, GPS points from a species location from the 2012 aerial census (Worton 1989; Downs & Horner 2007). Kernel density estimators incorporate less unused space and are accurate at depicting space use patterns and densities (Silverman 1986; Benson *et al.* 2006; Downs & Homer 2007). Studies have demonstrated that kernel utilisation distribution methods provide more accurate and meaningful density estimates than other techniques such as minimum convex polygons (Worton 1989; Rodgers & Kie 2007). Kernel density spreads the known quantity of the population for each point out from the point location (Silverman 1986). The resulting surfaces surrounding each point in kernel density are based on a quadratic formula with the highest value at the centre of the surface (the point location) and diminishing to zero at the search radius distance (usually indicated by the darkest colour). The kernel utilisation distribution method places a kernel (a probability density) over each observation point and a regular grid is then superimposed on the data (Worton 1989). An estimate of the density of all the overlapping kernels in that area is then obtained for each grid intersection (Worton 1989; Benson *et al.* 2006; Rodgers & Kie 2007). A kernel probability density estimator is then calculated over the entire grid using these probability density estimates from each intersection. Thus, the density estimate was high in areas with many fixes (indicating a higher density of prey species) and low in areas with fewer fixes (indicating a lower density of prey species) and this is shown by the varying colours illustrated in the given area (Benson *et al.* 2006; Rodgers & Kie 2007). Kernel densities were mapped in ArcMap10 (ESRI, Redlands, California, USA). Due to low population numbers, impala (18), mountain reedbuck (19; *Redunca fulvorufula*), nyala (10; *Tragelaphus angasii*) and waterbuck (21) distributions were not mapped.

Population modelling.

A hypothetical wild dog population was modelled to estimate wild dog survival, population size and extinction risk and to determine the most appropriate management strategies regarding supplementation and/or harvesting of individuals into and out of the population using VORTEX version 9.99 (Lacy & Clark 1991; Lacy 1993, 2013; Mills *et al.* 1998; Bach *et al.* 2010). VORTEX was also used to determine the sex ratio (males: females) required to sustain a pack and what ages the members of the founder pack should be (adults, juveniles or pups). VORTEX was chosen because it is powerful, easily available, widely used and has been used previously to examine factors influencing the viability of wild dog populations (Lacy 1993, 2013; Mills *et al.* 1998; Davies-Mostert 2010; Bach *et al*. 2010). VORTEX is a population modelling software that allows population parameters (age and sex-specific mortality rates, frequency distribution of litter sizes, average age to first reproduction, etc.) to be defined by the user (Lacy 1993; Davies 2010). These parameters are used in a Monte Carlo simulation which models the effects of deterministic forces and stochastic (demographic, environmental and genetic) events on wildlife populations (Lacy 1993).

Scenario settings

My population modelling used demographic rates recorded between 1998 and 2007 from the South African wild dog metapopulation database (Davies-Mostert 2010) and from the literature (Table 3.3; Burrows *et al.* 1994, 1995; Mills *et al.* 1998; Vucetich & Creel 1999; Woodroffe *et al.* 2007; Bach *et al*. 2010). Each model was run for 25 years and was iterated 500 times (Table 3.3). A 25- year study period was used as it reflects a realistic time-frame for decision making (Lacy 1993; Bach *et al.* 2010; Davies-Mostert 2010). Extinction was defined as the situation when only one sex of the species remained in the population (Mills *et al.* 1998; Bach *et al.* 2010). All models were run with one pack of wild dogs as the reserve population, as this is the population trend observed in many small (< 500km^2) reserves (Mills *et al.* 1998; Lindsey *et al*. 2004a; WAG-SA Minutes 2013).

Species description

The inbreeding depression was kept in the basic model, with the lethal recessive allele model, using the default values of 3.14 lethal equivalents on juvenile mortality with 100 % of the effect of inbreeding due to recessive alleles (Table 3.3; Lacy 1993; Mills *et al.* 1998; Bach *et al.* 2010). The default setting was selected as the mechanisms and effects of inbreeding in wild dogs are unknown (Davies-Mostert 2010). According to Bach *et al.* (2010), this results in VORTEX underestimating the negative impact of inbreeding because the proportion of adults contributing to each successive generation will be greater than in natural circumstances. However, wild dogs appear to selectively outbreed in the wild, thus random assignment of mates may not be too great an overestimation of the effect of inbreeding (Bach *et al.* 2010).

Carrying capacity

The method used to estimate carrying capacity is given by Hayward *et al.* (2007a). The carrying capacity numbers achieved by the Carbone and Gittleman equation (2002) was not used in the VORTEX simulations as the numbers are unrealistic and the equation unsuitable for wild dog carrying capacity. Three carrying capacity simulations were used in VORTEX. Scenario one was run with a carrying capacity of 6. Scenario two was run with a carrying capacity of 11 (achieved using the Hayward *et al.* 2007a model described above). Scenario one's carrying capacity was half of scenario two's. Scenario three was run with a carrying capacity of 22 (double scenario two). These three simulations were selected to give a broad range of results to offer the most suitable reintroduction plan with the lowest risk for reintroduction failure (i.e. extinction of the pack).

Initial population size

The initial population size was determined by using half the number of individuals determined when calculating the carrying capacity by using the regression equation given by Hayward *et al.* (2007a)(Table 3.2). Introducing a smaller group below the carrying capacity will allow the dogs to breed and increase naturally. The age distribution varied from one to 10 years to evaluate the effects on population dynamics and survival. Numbers of males and females within each initial population size varied to determine the effect of demography on population persistence.

Table 3.2: Initial population sizes that were chosen within each carrying capacity scenario in VORTEX to model a theoretical wild dog population in the Great Fish River Nature Reserve.

Carrying Capacity Simulation	Initial Population Size Tested
6	3 and 5
11	6 and 8
22	10 and 15

Reproductive systems

Wild dogs are predominately monogamous, with only an alpha pair mating, thus the long term monogamous mating system was chosen in VORTEX. Density-dependent parameters were omitted and carrying capacity was used as a population limiting factor (Bach *et al.* 2010). The maximum number of progeny per year was 10 and the sex ratio at birth was 58.8 % males (Table 3.3; Mills *et al.* 1998; Creel & Creel 2002; Gusset *et al.* 2009).

Reproductive rates

The number of breeding females was determined by making the conservative assumption that generally only one female per pack will breed (Estes 1993; Creel & Creel 2002; Bach *et al.* 2010). There are, on average, 1.7 – 2.7 females of reproductive age in a pack (Burrows *et al.* 1994). Therefore, there may be 37 – 59 % of breeding females and 58 % was used in this baseline model (Burrows *et al.* 1994; Creel & Creel 2002; Gusset *et al.* 2009). The mean age for first reproduction was set at 3 years for both sexes (Table 3.3; Creel & Creel 2002; Bach *et al.* 2010; Davies-Mostert 2010). VORTEX assumes that all individuals will mate until they die (Lacy 2003). Within the South African metapopulation, the oldest females to produce litters were 8 years old, however this has only been observed in a few (n = 2) females (Davies-Mostert 2010). Maximum longevity was, therefore, set at 10 years (Creel & Creel 2002; Gusset *et al.* 2009; Bach *et al.* 2010). Thus the maximum breeding age was set at 10. Mean pups per litter was set at 8.6 and was assumed to be Poisson-distributed (Table 3.3; Davies-Mostert 2010).

Environmental variation in reproduction was modelled by entering a standard deviation for the percentage of females producing litters and this value was determined from the literature (Creel *et al.* 1992; Davies-Mostert 2010). VORTEX was then able to determine the percent breeding for a given year by sampling from a binomial distribution (VORTEX 2009).

Mortality rates

Juvenile mortality for both sexes was 68 % (± 20.49 %) and adult mortality for both sexes was as follows: 0 - 1 year: 32 % (± 8 %) and 1 - 2 years: 29 % (± 16 %) (Table 3.3; Davies-Mostert 2010). Females between the ages of 2 and 3 years had a mortality rate of 6 % (± 9 %), whereas males had a mortality rate of 11 % (± 13 %) (Davies-Mostert 2010). The annual rate of female mortality above the age of 3 years was 37 % (± 17 %), while males older than 3 had a mortality rate of 24 % (± 2 %) (Table 3.3; Davies-Mostert 2010). The standard deviation in mortality due to changes in the environment was determined by Davies-Mostert (2010) from annual mortality rates and corrected by removing the proportion of variation due to demographic stochasticity.

Catastrophes

Catastrophes are modelled in VORTEX as random events which occur with specified probabilities that may affect survival and reproduction (Lacy 1993). A catastrophe will occur, according to Lacy (1993), if a randomly generated number between zero and one is less than the probability of occurrence. Following the event, the chances of survival and successful breeding for that simulated year are multiplied by severity factors (Lacy 1993). The model was run with two catastrophes that are likely to occur; these were disease outbreaks and anthropogenic impacts (Table 3.3). The annual probability of a disease outbreak was set at 7 % and the negative effect on reproduction and survival was set at 34 % and 54 % respectively (Table 3.3; Bach *et al.* 2010; Davies-Mostert 2010). Anthropogenic impacts could include traffic accidents, poisoning, hunting or poaching. The annual probability of such conflict was set at 10 % with a 57 % and 80 % negative effect on reproduction and survival respectively (Table 3.3; Davies-Mostert 2010).

Natural dispersal

Natural dispersal was not considered in the VORTEX simulations. The GFRNR wild dogs were modelled as a discrete population, with no possibility of natural dispersal to other reserves. Dispersal among wild dog metapopulation reserves has been recorded, but these are rare and are generally unsuccessful (Davies-Mostert 2010; Davies-Mostert *et al.* 2012).

Harvest and supplementation

Genetic diversity within the group can be increased by removing animals from the existing group and translocating new, genetically different animals into the reserve population (Bach *et al.* 2010). This is done by periodical translocations which are carried out by reserve management. To determine the most plausible management options, a combination of individuals were supplemented to and harvested from the population. It is expected that supplementations and harvest should be carried out every five years to maintain genetic diversity (Mills *et al.* 1998).

Table 3.3: Model parameters used to develop the baseline simulation of the proposed wild dog reintroduction to the Great Fish River Nature Reserve, Eastern Cape, South Africa.

Parameter/Variable	Baseline Simulation
Number of iterations	500
Number of years	25
Extinction definition	One sex remains
Number of populations	1
Inbreeding Depression	3.14 lethal equivalents
Reproduction	
Reproductive System	Long-term monogamous
Age of first offspring for females	3
Age of first offspring for males	3
Maximum age of reproduction	10
Maximum number of broods per year	1
Maximum number of progeny per brood	15
Sex ratio at birth (proportion of males)	58.8 %
Annual reproductive rates	
Proportion of adult females breeding (and variation)	0.58 (± 0.13)
Mean litter size	8.6
Mortality rates (and annual environmental variation)	
Females age 0 -1	0.32 (± 0.08)
Females age 1 - 2	0.29 (± 0.16)
Females age 2 - 3	0.06 (± 0.09)
Females age 3+ (annual)	0.37 (± 0.17)
Male age 0 - 1	0.32 (± 0.08)
Male age 1 - 2	0.29 (± 0.16)
Male age 2 - 3	0.11 (± 0.13)

Male 3+ (annual)	0.24 (± 0.02)
Catastrophes	
Type 1: Disease	
Annual probability	0.07
Severity on reproduction, survival	0.34, 0.54
Type 2: Anthropogenic Impacts	
Annual probability	0.1
Severity on reproduction, survival	0.57, 0.80
Initial Carrying Capacity (k)	
Scenario 1	6
Scenario 2	11
Scenario 3	22
Supplementation and harvesting occurring	Yes (See Appendix A)

3.3. Results

Historical occurrence of wild dogs in the Eastern Cape

Wild dogs historically occurred in the Eastern Cape and can be traced back as early as the 1800s (Figure 3.1.; Fitzsimons 1919; The Albany Museum 1931; Roberts 1951; Smithers 1983). Smithers (1983) states that wild dogs were recordedin the Addo district in 1906 and in the Albany and Bedford districts in 1925. However, by 1925, wild dogs were rare in the province compared with the mid-1800s (Skead 2007). Wild dogs were regularly reported near Kei Road and a pair of wild dogs, thought to be a nomadic pair, were shot in King William's Town in 1925 (Skead 2007). Multiple sources recorded wild dogs as being "plentiful" in the Addo bush areas in the early 1900s (Fitzsimons 1919; Hewitt 1931; The Albany Museum 1931; Roberts 1951; Smithers 1983). F. W. Fitzsimons (1919) wrote: "In the unsettled parts of South Africa these dogs cause much loss to farmers, attacking sheep, goats, cattle and ostriches. However, they [wild dogs] are exceedingly wary, and has [*sic*] in most districts taken refuge in the forests, such for instance as the Addo bush and Port Elizabeth".

Figure 3.1: Historical occurrences of wild dogs near the Great Fish River Nature Reserve (shown in green) in the Eastern Cape, South Africa, using various literary sources.

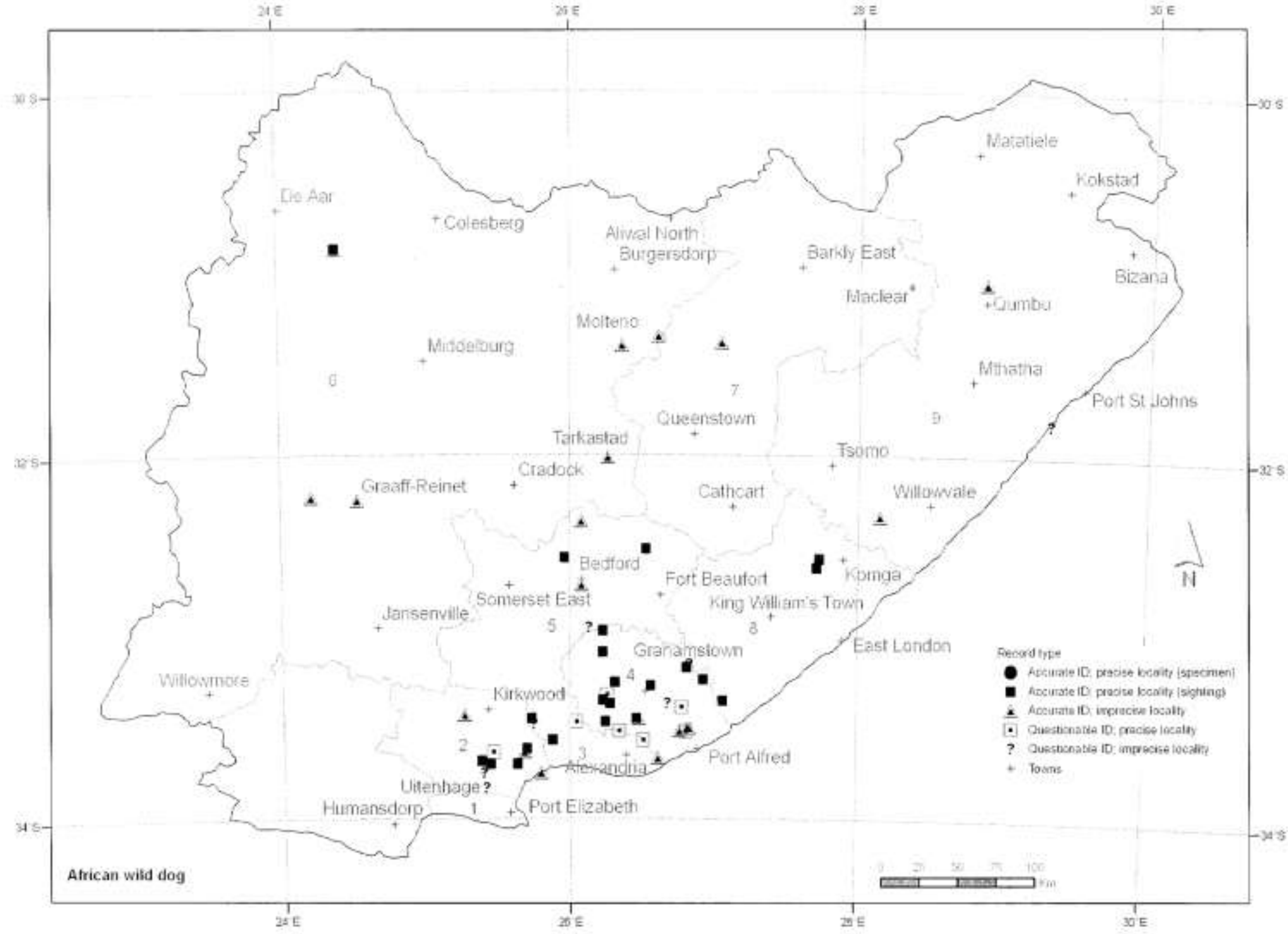

Figure 3.2: The historical distribution of wild dogs in the Eastern Cape, South Africa, according to Skead (2007). This distribution was compiled from records of sightings (solid squares) and preserved specimens (solid circles). Taken from Skead (2007).

According to Skead (2007), accurate sightings of wild dogs were abundant south-west and south of Grahamstown (Figure 3.2). At least two accurate sightings of wild dogs occurred north-east of King William's Town (Figure 3.2). The most sightings occurred in the Addo area east of Kirkwood. This area has very similar habitat to GFRNR (Mucina & Rutherford 2006; ECPTA 2012). It is assumed that the sightings of wild dogs did not occur to the west of Somerset East because that area is very dry, has poor prey availability and has sparse vegetation cover.

Carrying capacity

Using the preferred prey items of wild dogs (those species that occurred in the weight ranges 16 – 32 kg and 120 – 140 kg), it was calculated that there is 328 558 kg of available prey biomass for wild dogs and a prey density of 765.87 kg.km^{-2} (Table 3.4). This method therefore predicted a carrying capacity of 11 wild dogs for the reserve, preying on an estimated 14 379 kg of prey biomass, which would thus be removed from the reserve per annum (Table 3.4).

Table 3.4: The carrying capacity for African wild dogs (*Lycaon pictus*) in the Great Fish River Nature Reserve when using the equation determined by Hayward *et al*. (2007a).

Calculations from Hayward *et al.* 2007a to determine wild dog carrying capacity	
Total potential wild dog prey biomass available in GFRNR	32 8558 kg
Prey biomass density in GFRNR	765.87 kg.km^{-2}
Wild dog density in GFRNR	0.03 per km^2
Carrying capacity for GFRNR	11
Prey biomass removed by wild dogs per annum	14 379 kg

Using the second carrying capacity method, the reserve was found to have a carrying capacity of 112 wild dogs (Carbone & Gittleman 2002). When all the prey species were available (regardless of weight), the equation estimated a carrying capacity of 275 wild dogs. However, this equation uses the weight of a carnivore and the biomass available. The theory behind this equation is that 10 000 kg of prey supports 90 kg of carnivore (Carbone & Gittleman 2002). This method does not take into account the high metabolic demands of wild dogs. The Carbone and Gittleman equation assumes that wild dogs, at 25 kg mass, require much less food than larger carnivores such as lions. Hence the equation allows there to be more wild dogs in the reserve than is realistic. While this method may be more accurate for larger carnivores, it is not suitable for calculating the carrying capacity for wild dogs (Carbone & Gittleman 2002; Hayward *et al.* 2006; Hayward *et al.* 2007a).

Predicted prey species

The number of potential kills for each prey species within the reserve was calculated using the 2012 game census data. Of the 17 species, 10 are likely to be preyed upon by wild dogs (Table 3.5). According to these predictions, the current population sizes of kudu and bushbuck are not adequate to support predation by a pack of wild dogs (Table 3.5).

Table 3.5: Potential prey species of the African wild dog in the Great Fish River Nature Reserve. Their Jacobs' Index value (from Hayward *et al.* 2006), their abundance based on aerial game counts, the number killed annually predicted by the model and the minimum population sizes required to sustain the population under predation (MSY) are also shown.

Prey Species	Jacobs' Index (Di) [a]	Total in GFRNR [b]	Abundance (Pi)	Predicted kills [c]	N_{MSY} [d]
Blesbok	-0.55	6	0.001	0	0
Blue wildebeest	-0.7	1	0.000	0	0
Buffalo	-0.98	432	0.088	0	0
Bushbuck	0.36	141	0.029	21	221
Bushpig	-1	9	0.002	0	0
Common duiker	0.15	55	0.011	5	36
Common reedbuck	-0.41	4	0.001	0	0
Eland	-0.71	614	0.126	8	178
Impala	0.06	18	0.004	2	18
Kudu	0.35	2418	0.494	238	3662
Mountain reedbuck	-0.77	19	0.004	0	0
Nyala	-0.48	10	0.002	0	0
Red hartebeest	-0.56	329	0.067	7	97
Steenbok	-0.34	74	0.015	3	17
Warthog	-0.52	547	0.112	14	147
Waterbuck	-0.35	21	0.004	1	17
Zebra	-0.88	192	0.039	1	17

a. Jacobs' Index from Hayward et al. *(2006)*

b. From GFRNR 2012 aerial census

c. Estimated number of individuals of a prey species killed, on average, by a pack on 12 wild dogs in a year

d. Maximum sustainable yield - number needed to sustain population under predation (Lindsey et al. *2004a)*

It is predicted that kudu, bushbuck and warthog will be the most important prey species for wild dogs in GFRNR (Table 3.5). Kudu, the most abundant prey species within the reserve, is predicted to be the most heavily preyed upon species. To sustain this level of predation, the kudu population needs to be at least 3662 animals and currently it is only 2418 (Table 3.5).

It is predicted that wild dogs will prey on 21 bushbuck each year (Table 3.5). To sustain this predation, a bushbuck population of >221 is needed; 80 more than the current population. The third most preferred prey species is warthog, with 14 estimated kills per year (Table 3.5). The current population size of warthog is adequate to support such predation. Eland, red hartebeest (*Alcelaphus buselaphus)* and common duiker are predicted to be preyed upon in small numbers and their current population sizes appear to be large enough to sustainably support wild dog predation (Table 3.5). However, when kudu and bushbuck populations become less abundant, these species may become more favoured.

There are no predicted kills of blesbok (*Damaliscus dorcas phillipsi*), blue wildebeest, common reedbuck (*Redunca arundinum*), mountain reedbuck (*Redunca fulvorufula*) or nyala (*Tragelaphus angasii*) (Table 3.5). This is possibly due to the low abundance of these species within the reserve.

Habitat utilization

Densities of potential prey species are highest in the north western part of the reserve, which may therefore be preferred by reintroduced wild dogs, especially in the absence of superior competitors (Figure 3.3). The Andries Vosloo section has a high concentration of prey species, mainly kudu and red hartebeest. Eland and bushbuck occur in low densities in this section and there are no zebra (Figure 3.3). The Sam Knott section is populated with all prey species excluding zebra. The Double Drift section is densely populated with all species but with low numbers of bushbuck (Figure 3.3).

While kudu occur throughout the GFRNR, their densities are highest along the north western boundary (Figure 3.3). Bushbuck occur in low densities in this section and in the Double Drift section. However, bushbuck densities are higher in the Sam Knott section, especially in the far north-west. Red hartebeest distribution in the reserve is somewhat patchy, occurring in all sections of the reserve in relatively low numbers (Figure 3.3). The distribution of eland in the GFRNR is concentrated in the eastern part of the reserve. Warthog are distributed evenly throughout the reserve (Figure 3.3). Zebra distribution is restricted to the eastern boundary of the reserve in the Double Drift section (Figure 3.3).

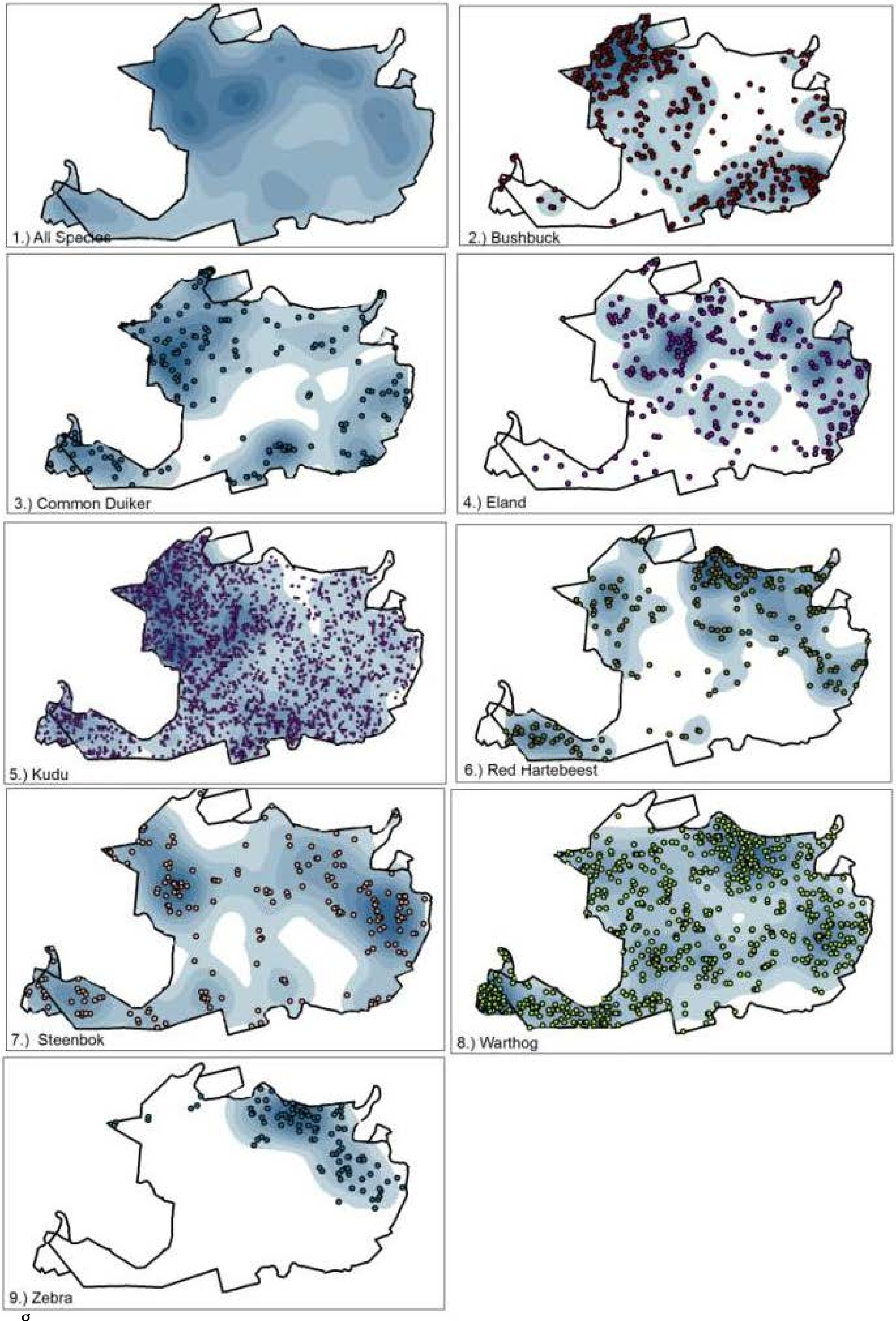

Figure 3.3: Distribution and density of eight African wild dog (*Lycaon pictus*) prey species in the Great Fish River Nature Reserve (darker colours represent higher densities). (ArcMap 10. Projected: Transverse-Mercator, spheroid WGS84, central meridian 31; map units: meters).

Carrying capacity

VORTEX simulations were run using three carrying capacities; K = 6, 11 and 22 (Figure 3.4; Table 3.6). The simulation with K = 6 went extinct within seven years and was therefore not modelled further. Generally, over the 25 year period, the other two modelled populations decreased (Figure 3.4). Without harvest and supplementation in K = 11 and K = 22, stochastic growth rate (r) was, although low, positive for all runs (Table 3.6). The growth rate was highest when K = 6 when r = 0.131 (±0.558). The mean population ranged between zero and three for all runs when no supplementation or harvesting occurred (Table 3.6). Relative genetic diversity (He) ranged from 37 % to 58 % (Table 3.6).

Table 3.6: The influence of carrying capacity on the population persistence of wild dogs in the Great Fish River Nature Reserve. Specification of the runs is shown in Appendix A. The model was run for 25 years and iterated 500times.

		r (mean(SD))	PE	Nall (mean(SD))	HE(mean(SD))
1	K = 6	0.131(0.558)	0.998	0.04(0.40)	0.479(0.029)
2	K = 11	0.039(0.515)	0.95	0.40(1.88)	0.374(0.207)
3	K = 22	0.011(0.505)	0.796	2.63(5.69)	0.5819(0.152)

* k, r, PE, N-all and He are abbreviations for carrying capacity, stochastic population growth rate, probability of extinction, average population size and genetic diversity, respectively.

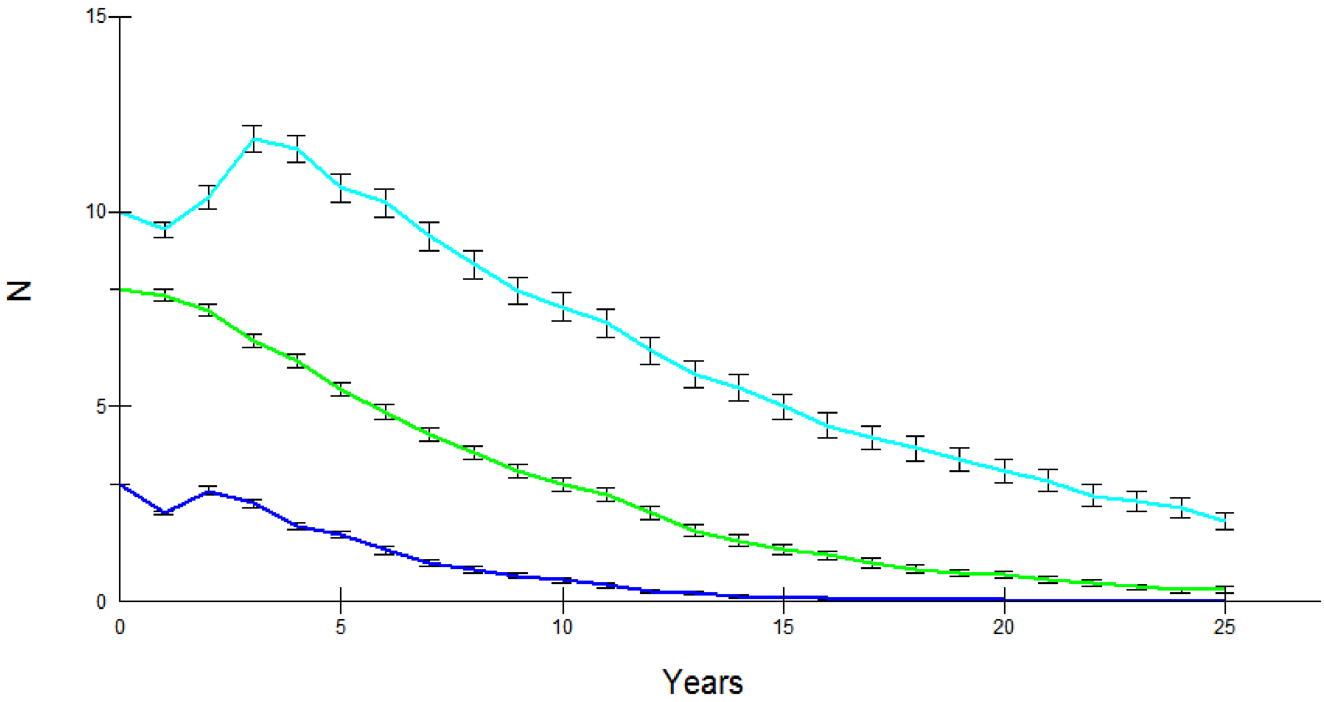

Figure 3.4: The population sizes of wild dogs over a 25 year period when testing carrying capacities of 6 (dark blue line), 11 (green line) and 22 (light blue line) in VORTEX for the Great Fish River Nature Reserve and without supplementation or harvesting occurring.

Initial population sizes and management procedures

a) When K = 11

The initial reintroduced pack size with four females and four males (run 10; Table 3.7) had the lowest probability of extinction (95 %). This run also had a high positive growth rate (0.074 ± 0.547; Table 3.7; Figure 3.5).

When the pack was supplemented with one male and one female (both aged three) in years 2, 6, 11 and 18 and one male and one female (both aged four) were removed from the pack at years 10 and 20, the long-term outcome of the pack improved (Run 20; Table 3.7; Figure 3.5). The management of individuals reduced the pack's probability of extinction to 0 % (Table 3.7; Figure 3.5) and this management approach had the highest genetic diversity of all runs (89 % ± 0.036).

Table 3.7: Population dynamics with varying initial population sizes and management plans for wild dogs in the Great Fish River Nature Reserve (K = 11). Specification of the runs is shown in Appendix A and the model was run for 25 years and iterated 500 times. Most suitable runs are shown in bold.

		r (mean(SD))	PE	Nall (mean(SD))	HE(mean(SD))
1	K = 11	0.039(0.515)	0.95	0.40(1.88)	0.374(0.207)
Initial Population Size (6 and 8)					
2	5 M; 1 F	0.042(0.495)	0.966	0.32(1.66)	0.449(0.183)
3	4M; 2 F	0.062(0.564)	0.988	0.16(1.12)	0.315(0.174)
4	3M; 3 F	0.090(0.571)	0.97	0.25(1.38)	0.479(0.161)
5	2M; 4F	0.079(0.572)	0.974	0.21(1.14)	0.397(0.268)
6	1M; 5F	0.049(0.508)	0.968	0.26(1.34)	0.369(0.234)
7	7M; 1F	-0.008(0.503)	0.978	0.20(1.24)	0.394(0.223)
8	6M; 2F	0.025(0.516)	0.968	0.22(1.11)	0.441(0.200)
9	5M; 3F	0.058(0.533)	0.956	0.34(1.62)	0.320(0.249)
10	**4M; 4F**	**0.074(0.547)**	**0.954**	**0.37(1.64)**	**0.427(0.178)**
11	3M; 5F	0.075(0.562)	0.97	0.28(1.40)	0.505(0.166)
12	2M; 6F	0.057(554)	0.97	0.26(1.37)	0.365(0.221)
13	1M; 7F	0.026(0.513)	0.976	0.20(1.16)	0.303(0.181)
Supplementation and Harvest					
14	(See Appendix A)	0.132(0.576)	0.01	5.60(3.65)	0.788(0.053)
15		0.122(0.564)	0.004	6.51(3.23)	0.800(0.045)
16		0.115(0.580)	0	8.02(2.86)	0.80(0.041)
17		0.202(0.568)	0	5.74(3.59)	0.789(0.059)
18		0.128(0.561)	0.006	6.89(3.38)	0.846(0.054)

19	0.215(0.493)	0	6.82(3.72)	0.810(0.066)
20	**0.236(0.473)**	**0**	**9.49(2.67)**	**0.889(0.036)**

* k, r, PE, N-all and HE are abbreviations for carrying capacity, stochastic population growth rate, probability of extinction, average population size and genetic diversity, respectively.

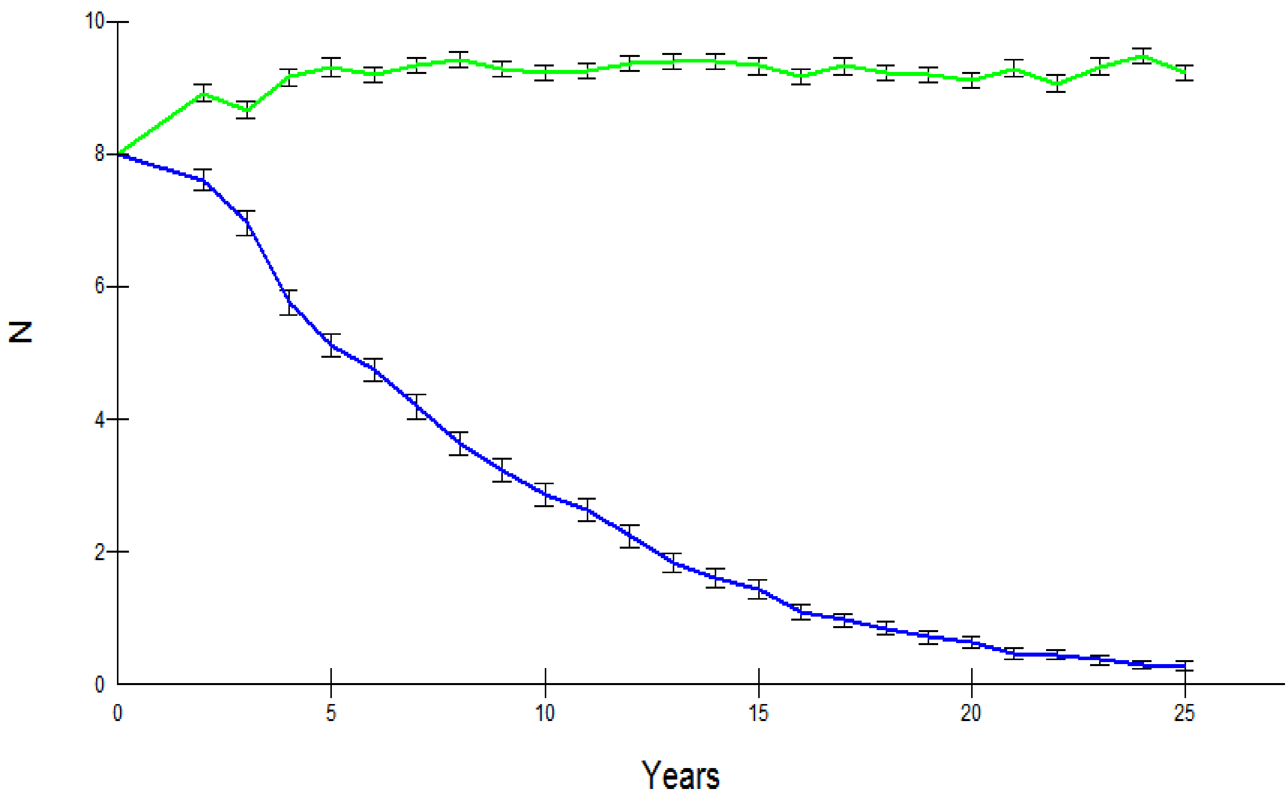

Figure 3.5: Average population size of a reintroduced wild dog pack in the Great Fish River Nature Reserve without harvesting and supplementation (blue line) and with management intervention (green line) when carrying capacity was 11.

b) When K = 22

The second group of simulations was run with a carrying capacity of 22 and this yielded a slow, yet positive growth rate (0.011 ± 0.505; Table 3.8). Initial population sizes of 10 and 15 were tested in this simulation. The pack composition of six females and four males had the lowest probability of extinction (78 %). However, when supplementing the pack with one female and two males (all aged four) in years 3, 10, 15 and 23, and harvesting one male and one female (all adults) every 10 years (run 29; Table 3.8; Figure 3.6), there was no risk of extinction. This run also resulted in the highest relative genetic diversity (93 % ± 0.02; Table 3.8). The average pack size of this run was 19 (± 5.09; Table 3.8; Figure 3.6).

Table 3.8: Population dynamics with varying initial population sizes and management plans for wild dogs in the Great Fish River Nature Reserve (K = 22). Specification of the runs is shown in Appendix A and the model was run for 25 years and iterated 500 times. Most suitable runs are shown in bold.

		r (mean(SD))	PE	Nall (mean(SD))	HE(mean(SD))
1	K = 22	0.011(0.505)	0.796	2.63(5.69)	0.5819(0.152)
		Initial Population Size (10 and 15)			
2	9M; 1F	-0.006(0.488)	0.908	1.27(4.25)	0.572(0.163)
3	8M; 2F	-0.006(0.502)	0.884	1.33(4.01)	0.492(0.173)
4	7M; 3F	0.012(0.524)	0.872	1.65(4.48)	0.533(0.172)
5	6M; 4F	0.0269(0.533)	0.822	2.54(5.86)	0.540(0.178)
6	5M; 5F	0.038(0.538)	0.844	2.06(5.17)	0.504(0.218)
7	**4M; 6F**	**0.052(0.531)**	**0.784**	**3.05(6.28)**	**0.533(0.173)**
8	3M; 7F	0.040(0.523)	0.804	2.76(6.13)	0.548(0.187)
9	2M; 8F	0.019(0.515)	0.826	2.18(5.26)	0.506(0.200)
10	1M; 9F	-0.015(0.506)	0.858	1.74(4.85)	0.549(0.158)
11	14M; 1F	-0.051(0.466)	0.924	1.01(3.74)	0.487(0.193)
12	13M; 2F	-0.023(0.496)	0.878	1.72(5.01)	0.528(0.167)
13	12M; 3F	-0.009(0.502)	0.858	1.79(4.88)	0.545(0.175)
14	11M; 4F	0.004(0.509)	0.858	1.99(5.05)	0.539(0.146)
15	10M; 5F	0.014(0.520)	0.812	2.29(5.33)	0.538(0.79)
16	9M; 6F	0.033(0.529)	0.796	2.56(5.79)	0.580(0.140)
17	8M; 7F	0.038(0.534)	0.804	2.47(5.57)	0.560(0.147)
18	7M; 8F	0.038(0.549)	0.816	2.55(5.90)	0.571(0.149)
19	6M; 9F	0.044(0.542)	0.786	2.84(5.91)	0.558(0.161)
20	5M; 10F	0.037(0.547)	0.794	2.60(5.68)	0.555(0.170)
21	4M;11F	0.034(0.538)	0.796	2.65(5.76)	0.568(0.164)
22	3M;12F	0.018(0.514)	0.808	2.44(5.58)	0.545(0.157)
23	2M; 13F	0.008(0.494)	0.808	2.75(6.12)	0.564(0.179)
24	1M; 14F	-0.036(0.502)	0.874	1.67(4.88)	0.558(0.141)
		Supplementation and Harvest			
25	(See Appendix A)	0.012(0.509)	0.848	2.08(5.39)	0.584(0.167)
26		0.012(0.509)	0.852	2.10(5.49)	0.537(0.180)
27		0.008(0.504)	0.844	2.08(5.32)	0.519(0.202)
28		0.165(0.434)	0	18.60(4.87)	0.924(0.024)
29		**0.175(0.430)**	**0**	**18.63(5.09)**	**0.925(0.022)**
30		0.16	0.03	16.81(6.40	0.902(0.033)

* k, r, PE, N-all and He are abbreviations for carrying capacity, stochastic population growth rate, probability of extinction, average population size and genetic diversity, respectively.

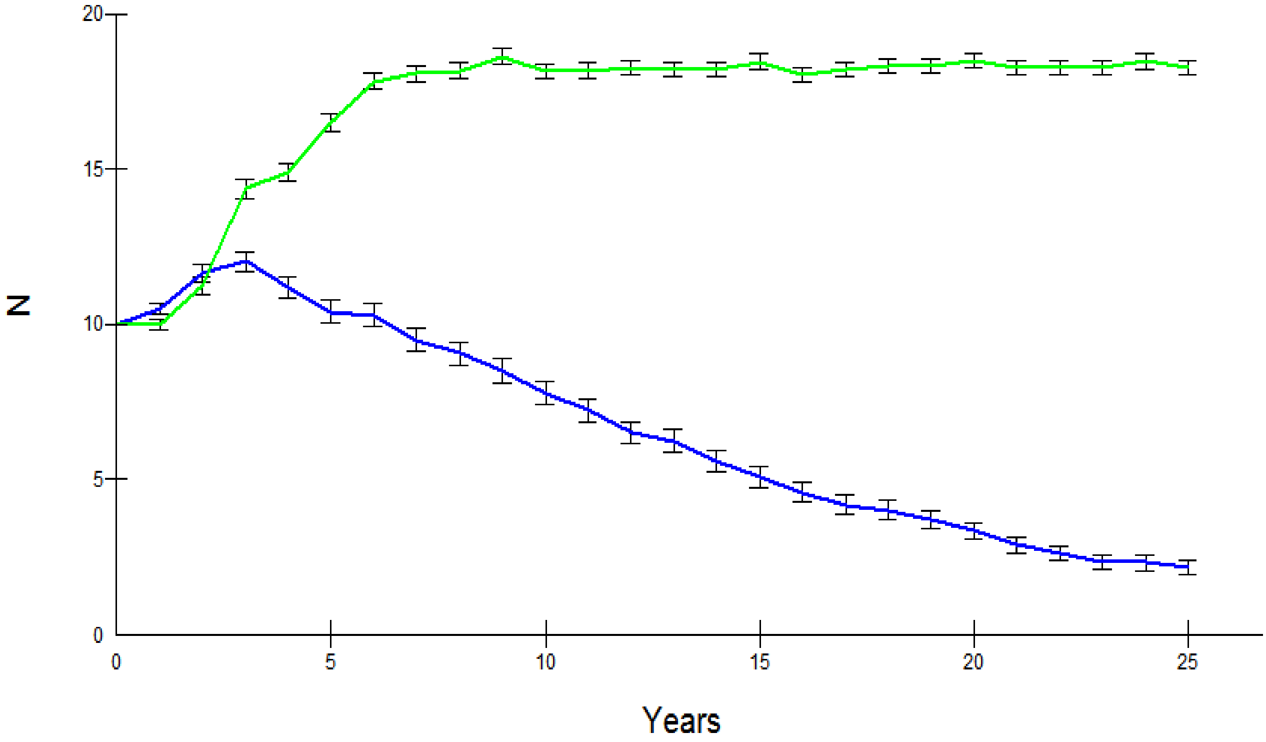

Figure 3.6: Average population size of a reintroduced wild dog pack at the Great Fish River Nature Reserve without harvesting and supplementation (blue line) and with management intervention (green line) when carrying capacity was 22.

3.4. Discussion

Reintroductions are an important tool for the conservation of species, especially those which have been extirpated from areas of their historical natural range (Price & Soorae 2003; Nilsen *et al.* 2007; Armstrong & Seddon 2008; IUCN 2012). Reintroductions can occur for various reasons or requirements (IUCN 2012). One motive behind reintroductions is to fully restore ecosystem function (Nilsen *et al.* 2007). For example, in much of the Highlands of Scotland, red deer (*Cervus elaphus*) densities have exceeded carrying capacity and are preventing reforesting and reducing bird densities (Nilsen *et al.* 2007). It has therefore been proposed to reintroduce wolves (*Canis lupus*) into the area to reduce deer populations and thus restore ecological integrity (Nilsen *et al.* 2007). Another motive can be for the purpose of economic gain through the promotion of tourism (Lindsey *et al.* 2005b; Hayward *et al.* 2007b). Nevertheless, reintroductions, for whatever reason, need to be adequately planned and studied (Niemann 2010). Reintroductions could have wide-ranging implications (e.g. loss in biodiversity (Coblentz 1978)) and it is therefore important that appropriate assessments of the ecological implications are carried out prior to release (Nilsen *et al.* 2007). This includes assessing the species' historical distribution within the area, determining their potential impacts on prey species or native fauna and determining how many individuals the area can sustain without deterioration (Price & Soorae 2003; Hayward *et al.* 2007a; Armstrong & Seddon 2008; IUCN 2012).

Any conservation translocation of a species to within their former indigenous range is termed population restoration (IUCN 2012). To restore a population, either reinforcement or reintroduction needs to occur (IUCN 2012). Population reinforcement is the translocation of a species into an existing population of conspecifics to maintain population persistence (IUCN 2012). Reintroduction is the intentional movement and release of a species into its indigenous range from which it has been absent (IUCN 2012). Wild dogs historically occurred throughout the Eastern Cape, especially around the Grahamstown and Addo areas (Fitzsimons 1919; The Albany Museum 1931; Roberts 1951; Smithers 1983; Skead 2007). However, due to the legal persecution of these predators and negative public perceptions, they were completely eradicated from the province in the early 1900s (Fitzsimons 1919; The Albany Museum 1931; Roberts 1951; Smithers 1983). This meets the IUCN reintroductions guidelines for population restoration through the use of reintroduction. Based on findings in the literature, it can be assumed that wild dogs can survive and adapt to the Eastern Cape climate, terrain, indigenous prey and Albany Thicket habitat as they once survived in the area (Roberts 1951; Smithers 1983; Mills *et al.* 1998). Thus the largest concerns of the reintroduction would lie within the biological environment of the reserve itself, rather than the suitability of the topographical area.

The ability to predict the diet and carrying capacity of predators at potential reintroduction sites can improve the success prospects of a reintroduction (Hayward & Somers 2009). This aspect of feasibility studies is fundamental to the success of a reintroduction as it enables managers to ensure an adequate prey base is available or to dismiss the potential for a reintroduction if prey is limited (Hayward & Somers 2009). Suitable management strategies can then be planned for in the event of overpopulation or negative effects of prey populations. Knowing which prey species, and how many, that predators are going to kill assists in the planning of a reintroduction (Niemann 2010). Most predators will kill prey in relation to their abundance (Hayward *et al.* 2006). My predictions of potential wild dog prey preferences at GFRNR indicated that kudu, the most abundant species, are likely to be the most heavily preyed upon species. This knowledge will allow management to manipulate kudu numbers to ensure that the population is not negatively affected (Hayward *et al.* 2007a, b, c). However, it is important to note that wild dogs do not always kill in relation to prey abundance (Rasmussen & Macdonald 2012). Wild dogs will often prey on the old and sick individuals, thereby decreasing their energetic costs by reducing the effort needed to kill prey (Rasmussen & Macdonald 2012). This method of removing weaker individuals from the population can improve the general fitness of the population (Rasmussen & Macdonald 2012).

Using the Hayward *et al.* (2007a) model, it was determined that the GFRNR can potentially sustain 11 wild dogs. However, this method does not include species which fall outside of the weight range but have been recorded as prey. This includes species such as waterbuck (Hayward *et al.* 2006; Niemann 2010), red hartebeest (Niemann 2010; Davies-Mostert *et al.* 2013), warthog (Niemann 2010) and eland (Creel & Creel 1995; Davies-Mostert *et al.* 2013). Eleven is therefore probably a conservative estimate as it is likely that if the additional species were included, the carrying capacity for wild dogs would be higher.

Bushbuck and kudu populations may decline post reintroduction and become a management concern if wild dogs are reintroduced. Should wild dogs be reintroduced, these prey populations may decrease to unsustainable levels (Hunter & Skinner 1998; Hayward *et al.* 2007d). However, it is important to note that the GFRNR management culls kudu populations annually (Table 3.9). In the last two years, the reserve has culled more kudu per year than wild dogs are estimated to remove naturally. Therefore, the kudu population may be sustainable under predation post reintroduction if culling stops before the wild dog reintroduction.

Table 3.9: The average number of kudu culled by reserve management per year in the Great Fish River Nature Reserve from 2009 to 2013 (D.M. Peinke, 2013, pers. Comm.).

Year	Kudu Culled
2013	317
2012	231
2011	216
2010	106
2009	169

The number culled each year is based on a predator simulation model which estimates how many individuals should be removed from the population each year (D.M. Peinke, 2013, pers. comm.). Without culling in the year preceding the reintroduction, kudu populations will likely increase and reach levels that could be sustained under predation (Thorn *et al.* 2012). Bushbuck numbers indicate that the reserve requires an additional 80 individuals to have a population that can persist under predation. However, it is possible that the population size of bushbuck is larger than what the aerial census data indicates (Coates & Downs 2005). Bushbuck are nocturnal, secretive animals which prefer dense vegetation (Coates & Downs 2005). This makes gaining accurate estimates of bushbuck density and abundance challenging, especially as the GFRNR is mostly thick vegetation (Coates & Downs 2005; ECPTA 2012). Bushbuck density in suitable habitat is normally one animal per 33 ha (Coates & Downs 2005), suggesting that there could be as many as 1378 bushbuck within the GFRNR. Nevertheless, bushbuck and kudu populations would need to be closely monitored post wild dog reintroduction to prevent either the dogs being removed or an unsustainable decline in prey populations leading to the local extinction of that species within the reserve.

The GFRNR currently has no apex predators (ECPTA 2012) and this may have resulted in the current prey populations becoming less vigilant and less aware of predators

(Hunter & Skinner 1998). In circumstances where ungulates have existed without predators, they are generally more predator “naïve” and less vigilant than those ungulates that have lived in reserves where predators are abundant (Hunter & Skinner 1998; Kauffman *et al.* 2007). This increases their vulnerability to predation following carnivore reintroductions (Hunter & Skinner 1998). Naïve ungulates are more susceptible to predation wherever they encounter newly reintroduced predators (Kauffman *et al.* 2007). As most native ungulates in GFRNR have lived without top predators for generations, it is likely that they will be predator naïve. Upon release of the wild dogs it is possible that populations will decrease as kill rates are far more successful due to this phenomenon (Hunter & Skinner 1998). However, the ungulates will eventually adapt and become more predator aware, resulting in fewer successful kills (Niemann 2010).

Wild dogs tend to avoid areas of high prey density which are favoured by other larger carnivores such as lions and spotted hyenas (Mills & Gorman 1997; Creel & Creel 1998; Vucetich & Creel 1999; Woodroffe *et al.* 2007). This is a survival strategy as lions are a major cause of wild dog mortality, accounting for 39 % of natural pup deaths and > 43 % of adult deaths (Mills & Gorman 1997). However, in circumstances where there are no top-order predators (such as in the GFRNR) it is assumed that wild dogs will occur in the areas where their prey is most dense (Woodroffe *et al.* 2007).

The north-west area of the Sam Knott portion of the reserve is the most prey dense area within the reserve. This area of the reserve also has the highest density of the two most preferred prey according to my predictions: kudu and bushbuck. As the Great Fish River runs through deep gorges in the central area of the reserve (ECPTA 2012), the density of ungulates is very low. Therefore it is not expected that the wild dogs will occur frequently in this area. The Andries Vosloo section (the western horn of the reserve) also has high prey abundance. This area is of special concern as it is a long narrow fenced section of the reserve. Most species demonstrate a degree of adaption to their surroundings, and wild dogs have continuously shown themselves to be highly intelligent carnivores by adjusting their behaviour to suit their environment (Leigh 2002). Wild dogs have adjusted their hunting strategies to maximize success by using reserve fences (van Dyk & Slotow 2003; Bissett 2004; Davies-Mostert *et al.* 2013). This fence-hunting behaviour is likely to influence the impact of wild dogs on prey populations by potentially enabling the hunting of larger species (van Dyk & Slotow 2003). A study by Davies-Mostert (2010) in Venetia Limpopo Nature

Reserve (370 km^2; Limpopo Province, South Africa) revealed that kills by wild dogs against the fence comprised of 40.5 % of all kills (n = 316). When compared to kills made away from the fence, fence-assisted kills comprised larger prey species (33 kg vs. 25 kg) (Davies-Mostert 2010). Fences generally contribute to the overall hunting success by enabling the pack to capture individuals against the fence that might otherwise have escaped (van Dyk & Slotow 2003; Niemann 2010). If wild dogs adopt this behaviour in GFRNR it is likely that the numbers of each species killed will increase significantly. Thus it is suggested that the hunting behaviour of the wild dogs be closely monitored and that, if possible, this behaviour be prevented. However, longer kill intervals were observed from fence-line hunting behaviour as the catch per unit increased from fence-assisted kills (27.3 kg.km-1 vs. 12.2 kg.km-1) (Davies-Mostert 2010). By enabling wild dogs to capture prey that would otherwise have escaped, fence-line hunting can reduce the compensatory nature of predation, causing shifts in predator-prey dynamics (van Dyk & Slotow 2003; Davies-Mostert 2010; Niemann 2010). This can be beneficial as this could influence the ability of small reserves to sustain predator populations in the long-term (Davies-Mostert 2010). Therefore it is crucial to monitor fence-line hunting and determine the effects on prey populations.

In my VORTEX population simulations, two management scenarios were fully modelled to offer varying management options for the wild dog population in the GFRNR to ensure long term persistence.

The first management scenario is one with a carrying capacity of 11 wild dogs. Based on this model, an initial population of 4 males and 4 females with regular supplementation and harvesting is needed to ensure the wild dog population has a 100 % chance of persistence. To maintain a genetic diversity of greater than 80 %, introduction of new individuals into the pack needs to occur every five years (Mills *et al.* 1998). With a carrying capacity of 11 dogs, supplementation needs to occur regularly to maintain a genetic diversity of 89 % and a stable pack size throughout the modelled 25 years. This supplementation strategy was adopted to correct for potential catastrophes that may decrease population numbers and to create high genetic diversity among the population. Importantly, without any management intervention, the population is likely to go extinct.

The second scenario was run with a carrying capacity of 22 individuals. This scenario was less strict than the first, allowing for more flexibility and growth of the population. It was modelled as wild dog populations can increase very fast due to large litter sizes (Creel *et al.* 1992; Gusset & Macdonald 2010). Often, one breeding season can result in the population being at carrying capacity. An initial population of four adult males and six females results in a 22 % chance of persistence over 25 years. With regular supplementation and removal of individuals from the population, the genetic diversity increased to 93 % and the population had a 100 % chance of persistence. In this population scenario the average pack size was 18 individuals, only seven more than the carrying capacity estimated by Hayward *et al.* (2007a). Although in VORTEX, populations are constrained by carrying capacity, this simulation never reached the carrying capacity of 22, but rather remained at a stable population of 18.

As a general rule, reintroduced populations are considered demographically viable when the probability of extinction is less than 10 % (Foose 1993; IUCN 2012). Without management involvement, neither simulated population (neither K = 11 nor K = 22) would be considered demographically viable (Mills *et al.* 1998). However, with regular supplementation the chance of persistence increases to 100 %. Wild dog populations that are stable without such management intervention are known as viable populations (Mills *et al.* 1998) and currently South Africa's only viable population is in Kruger National Park (Mills *et al.* 1998; Mills & Doncaster 2006). This additional population to South Africa's metapopulation can be crucial in improving the overall genetic diversity of the population (Mills *et al.* 1998). When individuals are translocated into a new subpopulation, they bring in new genes. This increases the genetic diversity of the next generation, increasing the population's viability and making its members more resilient to disease and environmental changes (Mills *et al.* 1998; Davies-Mostert, H. 2014. pers. comm.).

Based on the modelling exercise, four key lessons were learnt. (i) Firstly, in a small population, such as the potential GFRNR population, consistent, periodic managed gene flow is needed to reduce damaging levels of inbreeding and thus increasing risks of sub-population extinction (Mills *et al.* 1998). Managing gene flow can be done effectively though translocations which involve regular supplementation and harvest of wild dogs into or from the pack. (ii) This supplementation is also crucial to maintain population size to ensure pack persistence. With a small population (< 15), without management intervention, the population will go extinct within 25 years (Mills *et al*. 1998; Bach *et al.* 2010). (iii) Catastrophic events (such as disease or persecution) have the ability to drastically reduce the population to levels which are not demographically viable (Mills *et al.* 1998). Management must, as far as possible, prevent such catastrophes from occurring through the use of vaccinations, regular monitoring, adequate fencing and awareness programmes (Alexander & Appel 1994; Kat *et al.* 1995; Mills *et al*. 1998; Leigh 2005). Although my model did not definitively measure this, the results are compatible with the conclusion that an annual anti-rabies vaccination is likely to increase the probability of persistence (Kat *et al*. 1995; Hofmeyr *et al.* 2004; Mills *et al.* 1998). (iv) Lastly, the models demonstrated that any founding group ranging in size from 10 to 15 could persist better than a founding group size of less than eight.

It is important to emphasise that ecological systems are dynamic. What is presented within this chapter are results from models and scenarios using data from mostly outside of the Eastern Cape (Hayward *et al.* 2006). What happens in reality may differ from model predictions, and management must tolerate and allow flexibility within the system. Wild dogs are intelligent animals and are capable of learning, and their predation habits are unique (Leigh 2005). Wild dogs are known to deviate from what is normal by adjusting their behaviour from past experiences (Estes & Goddard 1967; Hayward *et al.* 2006; Davies-Mostert *et al.* 2013). However, my research is an attempt to predict what the reintroduced wild dog pack may do following their release and offer a guideline on how to manage them.

In conclusion, the GFRNR is able to sustain a single wild dog pack with a maximum carrying capacity of 22. Close monitoring and management will be needed to maintain a stable population. Regular supplementation and harvesting can ensure this, as well as ensuring genetic diversity in the population. The GFRNR wild dogs can also improve the genetic diversity of the metapopulation by making more individuals available for supplementation into other metapopulation reserves.

CHAPTER 4: The socio-demographic environment surrounding the Great Fish River Nature Reserve and how this relates to a potential African wild dog reintroduction

4.1. Introduction

Most large (> 25 kg) carnivores have experienced significant declines in their worldwide populations and have suffered significant range contraction in the last century (Ginsberg *et al.* 1995; Mills *et al.* 1998; Woodroffe *et al.* 2005; Gusset *et al.* 2009). A combination of habitat fragmentation, persecution by humans, disease and decreases in prey species have contributed to the rapid decline of many predatory species (Mills *et al.* 1998; Fisher & Lindenmayer 2000; Woodroffe *et al.* 2005; Armstrong & Seddon 2007; Ripple & Beschta 2012). Habitat fragmentation results in population decline of the species which depends upon that habitat (Lindsey *et al.* 2004a; Bateman *et al.* 2010). For example, the Sumatran tiger (*Panthera tigris sumatrae*) has become critically endangered in the last few decades (IUCN 2012). This is attributed to habitat loss between 1990-2005; where approximately 59 % of the tiger's forest habitat in Malaysia, and at least 56 % of habitat in Indonesia, was replaced with oil palm plantations (Bateman *et al.* 2010). However, the most severe threat to carnivores is caused by human-wildlife conflict which often results in direct persecution (Macdonald & Sillero-Zubiri 2002; Mills *et al*. 1998).

As a direct consequence of declining animal populations across Africa, conservation and management of small, disjunct populations has become inevitable, with reintroduction and periodic translocation strategies being used as important conservation tools to support population recovery (Fisher & Lindenmayer 2000; Armstrong & Seddon 2007; Hayward *et al.* 2007a; Hayward & Somers 2009; Niemann 2010; Ripple & Beschta 2012). Reintroductions are an attempt to re-establish a species within its historical range after being previously extirpated from the area (Hayward & Somers 2009). In an effort to restore ecological integrity to an area, many protected areas are reintroducing species that had been extirpated (Ripple & Beschta 2012). Reintroductions have occurred more and more frequently in the last three decades (Fisher & Lindenmayer 2000; Seddon *et al.* 2007; Hayward & Somers 2009; Niemann 2010). It is speculated by Seddon *et al.* (2007) that the first "true" reintroduction took place in Oklahoma in 1907 and involved the release of 15 American bison (*Bison bison*). Since then, a recognizable and relatively detailed field of reintroduction biology has begun (Fisher & Lindenmayer 2000).

Before reintroductions can be carried out, careful consideration is required to determine whether the prospective release site is suitable (Niemann 2010; IUCN 2012). Guidelines for reintroductions, detailed by the IUCN RSG (International Union for Conservation of Nature Reintroduction Specialist Group; 2013), specify the evaluation of possible reintroduction sites. These guidelines are threefold and stipulate that the site must, 1) be within the species' former natural habitat and range, 2) the population must be able to be sustained for the foreseeable future, and that 3) there should be sufficient carrying capacity of the location to sustain growth of the reintroduced population (IUCN 1998; Armstrong & Seddon 2007). The IUCN reintroduction guidelines also emphasize the need to conduct a study of the availability of suitable habitat as a key component of reintroduction planning (Seddon *et al.* 2007). Sufficient research should be carried out before the reintroduction to determine whether the species historically occurred in the area to avoid harmful consequences (Seddon *et al.* 2007). For example, feral goats (*Capra hircus*) were introduced onto many oceanic islands by travellers as a source of fresh meat for future visits to the island (Coblentz 1978). These goats have caused widespread habitat destruction and the alteration of species composition on many sensitive island ecosystems (Coblentz 1978). Wild dogs (*Lycaon pictus*) were eradicated from the Eastern Cape by persecution from land owners. It is therefore important to study the anthropogenic threats around the Great Fish River Nature Reserve and establish why they would occur (IUCN 2012).

Most large carnivores, such as cougars (*Puma concolor*), wolves (*Canis lupus*), leopards (*Panthera pardus*) and wild dogs, have large home ranges and exhibit wide-ranging behaviour (Fuller *et al.* 1992; Estes 1993; Thorn *et al*. 2012). Wild dogs are among the hardest carnivore species to conserve because of such behaviour, coupled with negative human perceptions (Mills & Gorman 1997; Lindsey *et al.* 2004b; Gusset *et al.* 2008c; Davies-Mostert *et al.* 2012). Because of this behaviour, wild dogs often range beyond protected area boundaries (Mills *et al.* 1998; Davies-Mostert *et al.* 2012). Outside of formally protected areas there are a suite of anthropogenic threats that may limit wild dog persistence (Kat *et al.* 1995; Mills & Gorman 1997; Vucetich & Creel 1999; Lindsey & Davies-Mostert 2009). Mortality of wild dogs caused by humans is higher on private lands than in reserves

(Davies-Mostert *et al.* 2012). Such threats have the potential to hinder the success of any carnivore reintroduction, and therefore need to be identified and resolved before a reintroduction can occur (Price & Soorae 2003; Wato *et al*. 2006; Nilsen *et al.* 2007; Armstrong & Seddon 2008). Threats on unprotected land include poaching, direct persecution from land owners (human-wildlife conflict), disease transfer from domestic dogs (*Canis familiaris*) and vehicle collisions (Kat *et al.* 1995; Mills & Gorman 1997; Vucetich & Creel 1999; Lindsey & Davies-Mostert 2009).

Human-wildlife conflict occurs when contact between humans and wildlife occurs outside protected areas (Dickman 2010; Thorn *et al*. 2012). Humans often respond to predators through direct persecution which involves killing the species concerned (Dickman 2010). However, even in instances where direct conflict between humans and carnivores may not be evident, humans can either consciously or inadvertently cause negative impacts upon populations through habitat destruction (Dickman 2010). For example, the eastern lowland gorilla (*Gorilla beringei graueri*) has become endangered in the past few decades in the Democratic Republic of the Congo, Rwanda and Uganda (IUCN 2012). This population declined to approximately 880 individuals and is due to wars and the rapid transformation of the lowland forest into agricultural land (Kalpers *et al*. 2003). Direct persecution is widespread and the severity can vary from the occasional poisoning of lions (*Panthera leo*) by Masai pastoralists to the government sponsored eradication of gray wolves in North America (Hazzah *et al.* 2009; Ripple & Beschta 2012).

Wild dogs are predisposed to conflict with humans and direct retaliation due to the real and/or perceived risks from wild dogs (Courchamp & Macdonald 2001; Lindsey *et al.* 2004a; Inskip & Zimmermann 2008), and has been common throughout recent history (Vucetich & Creel 1999; Courchamp & Macdonald 2001; Creel & Creel 2002). For example, between 1916 and 1975, over 3400 wild dogs were killed in Zimbabwe under the pretence of vermin control (Davies & du Toit 2004). Wild dog populations have been severely impacted due to the increasing pressure from expanding human populations and agriculture, which has reduced the amount of available habitat for them and their prey populations (Maddock & Mills 1994). Although government-funded persecution ended decades ago, mortality caused by humans is still the main threat to wild dog survival (Courchamp & Macdonald 2001). As wild dogs naturally occur at low densities, typically range over large areas and because of their dispersal behaviour they are especially difficult to protect (Creel & Creel 2002; Lindsey *et al.* 2004a). In addition, long-distance dispersal of single sex groups (Creel & Creel 2002), often results in wild dogs occurring outside of formally protected areas where they are more vulnerable (Mills & Gorman 1997; Vucetich & Creel 1999; Lindsey *et al.* 2004b).

Human socio-economic and demographic factors are also very important when considering the potential threats to wild dogs outside protected areas (Bath & Buchanan 1989; Rodriguez *et al.* 2003; Lindsey *et al.* 2005; Nilsen *et al.* 2007; Anthony 2007; Schumann *et al.* 2012). This includes considering people's perceptions, tolerance and behaviour towards predators on their land (Bath & Buchanan 1989; Schumann *et al.* 2012; Thorn *et al.* 2013). As the human population continues to encroach on protected reserves, private land owners and communities will inevitably play a significant role in the conservation or demise of predators (Woodroffe *et al*. 2005; Lindsey *et al.* 2005). The extent to which land owners may tolerate wild dogs on their property is dependent on a variety of socio-demographic factors (such as economic status, education, gender, age) (Bath & Buchanan 1989; Lindsey *et al.* 2004, 2005; Nilsen *et al.* 2007; Anthony 2007; Schumann *et al.* 2012). It is therefore essential to have an understanding of the factors which may influence land owner tolerance and behaviour in order to implement the most appropriate mitigation strategies to promote the success of a reintroduction project (Mills *et al.* 1998; Anthony 2007).

However, not all attitudes towards predators are negative. A study by Lagendijk and Gusset (2008) of community members around the Kruger National Park (Limpopo Province), found that land owner attitudes towards large predators were generally positive. Respondents were proud of predators on their land and viewed them as an integral part of their natural heritage that should be perserved for future generations (Lagendijk & Gusset 2008). This was strongly influenced by respondents' education (Lagendijk & Gusset 2008). However, it is crucial to note that the acceptance of carnivores by land owners is often dependent on the degree of depredation on their livestock as well as their economic status (Lagendijk & Gusset 2008). The economic capacity of farmers to withstand the impact of predation by predators can have an effect on attitudes and tolerance levels (Schumann 2009). In poverty-stricken areas, such as rural, communal areas, farmers have a small number of livestock and even few livestock loses can have substantial negative consequences on a farmer's livelihood (Lagendijk & Gusset 2008). Therefore, they are generally less tolerant towards predators (Lagendijk & Gusset 2008). Age has also been found to be an influential demographic factor influencing land owners attittudes and behaviours towards predators (Lindsey *et al.* 2005). Younger farmers are generally more conservation-orientated and tend to have more positive attitudes towards carnivores than older individuals do (Lindsey *et al.* 2005; 2009). Older individuals can often be very inflexible when it comes to predators, whereas younger individuals are more aware of ecological processes and the importance of conservation through better/higher education (Zimmerman *et al.* 2005). Education has been repeatedly found to significantly influence the attitude and tolerance of land owners towards predators (Zimmerman *et al.* 2005; Selebatso *et al.* 2007; Lagendijk & Gusset 2008). In Namibia, farmers' attitudes towards cheetahs (*Acinonyx jubatus*) were significantly linked to educational background and positively related to the land owner's support of cheetah conservation (Selebatso *et al.* 2007).

Attitudes and perceptions towards predators can often be irrational and based on perceived levels of damage rather than actual damage (Orford 2002). When a predator is viewed as a liability it is often pre-emptively killed (Orford 2002; Zimmerman *et al.* 2005). It is therefore essential to understand the attitudes and tolerance levels of human communities surrounding protected areas, particularly where wild dogs occur (Zimmerman *et al.* 2005; Selebatso *et al.* 2007). Without the co-operation of neighbouring residents, the conservation of predators cannot be successful (Thorn *et al.* 2012; Schumann *et al.* 2012).

Contact between wild dogs and domestic animals can result in the transmission of infectious diseases which can constitute a major threat to wild dogs on unprotected land (Woodroffe & Sillero-Zubiri 2012). Wild dogs are known to be susceptible to diseases, in particular, rabies and canine distemper virus (CDV), because they are social, low density animals (Creel & Creel 1998; Gusset *et al.* 2006; Prager *et al.* 2012). Both of these diseases are contagious and are either spread by domestic dogs or other wild canids (Alexander & Appel 1994; Kat *et al.* 1995; Creel & Creel 1998). Wild dogs are especially vulnerable to extinction by "spill-over" transmission from other species which carry the viruses (Alexander & Appel 1994; Kat *et al.* 1995; Creel & Creel 1998; Woodroffe & Ginsberg 1999; Woodroffe 2000; Hofmeyr *et al*. 2004). For example, wild dogs in Madikwe Game Reserve (North-West Province; 600 km^2) were completely decimated in September 1997 from a rabies outbreak (Hofmeyr *et al.* 2004). It is assumed that the disease was transmitted from black-backed jackals (*Canis mesomelas*) which are known to be a host of rabies in the area (Hofmeyr *et al.* 2004). In the north of the Masai Mara National Reserve in Kenya, 21 out of a pack of 23 wild dogs died from rabies in 1989 (Kat *et al*. 1995). The area where the pack typically roamed was inhabited by the Masai tribe's people and it was estimated that within that area, there were over 750 domestic dogs (Kat *et al*. 1995).

Another important aspect to consider before any reintroduction of wild dogs is the potential for mortality caused by snaring and poaching (Mills *et al.* 1998; Woodroffe & Ginsberg 1999; (Davies & du Toit 2004; Wato *et al.* 2006; Lindsey & Davies-Mostert 2009). Snares are unselective; meaning they injure any species of animal which becomes trapped in it (Mills *et al.* 1998; Wato *et al.* 2006). This includes animals as large as African elephants (*Loxodonta africana*), smaller species such as springhares (*Pedetes capensis*) or game birds such as helmeted guinea-fowls (*Numida meleagris*) (Davies & du Toit 2004; Wato *et al*. 2006). Often, species like wild dogs are unintentionally caught in snares that were set up with the intention of capturing ungulates for food species (such as kudu (*Tragelaphus strepsiceros*), impala (*Aepyceros melampus*) or duikers (*Sylvicapra grimmia*)) (Woodroffe & Ginsberg 1999; Davies & du Toit 2004; Lindsey & Davies-Mostert 2009). Snaring has had a significant impact on populations of wild dogs in Zimbabwe (Lindsey & Davies-Mostert 2009) and in Mkhuze Game Reserve, KwaZulu-Natal Province, South Africa (Lindsey & Davies-Mostert 2009).

Historically, wild dogs occurred throughout the Eastern Cape Province (Hayward *et al.* 2007a; Skead 2007; Davies-Mostert 2010; Bach *et al.* 2010) and the main cause for extirpation of wild dogs in the Eastern Cape was government-funded persecution (Fitzsimons 1919; The Albany Museum 1931; Roberts 1951; Smithers 1983; Hayward *et al.* 2007a). Wild dogs were completely extirpated from the Province due to persecution from land owners and bounty hunters (Stuart *et al.*1985). While legal persecution ended decades ago, other potential risks (such as disease transmission, land owner persecution and poaching) may still exist and these risks need to be identified and assessed.

The Great Fish River Nature Reserve (GFRNR) management is considering reintroducing wild dogs to the reserve within the next three to five years (ECPTA 2012). Thus it is essential that the threat landscape of the areas bordering the reserve is fully understood. The aims of this research chapter were therefore to:

- evaluate the potential threats to wild dogs on properties neighbouring the Great Fish River Nature Reserve, Eastern Cape, South Africa. These threats included the prevalence of snaring, poaching, unvaccinated domestic dogs and land owner persecution.
- assess land owner perceptions and behaviour towards predators across the mosaic of land use types outside the Great Fish River Nature Reserve.
- develop a threat index which indicates properties that have high risks to wild dogs; and
- examine the influence of human demographic variables and property characteristics on the threat scores of respondents.

4.2. Methods

Data collection

Questionnaires are frequently used in ecology to test research hypotheses when information is required (White *et al.* 2005). The use of questionnaires can be crucial for explaining human behaviour and understanding the perceptions or attitudes towards conservation strategies (White *et al.* 2005). Significantly, questionnaire surveys have been effectively used to determine the success of the reintroduction of predators in protected areas (Nilsen *et al.* 2007; Gusset *et al*. 2008c), assess conflict between wildlife and humans (Davies & du Toit 2004) and study the distribution patterns of carnivores (Thorn *et al.* 2011). The perceptions and concerns of local land owners towards the proposed wild dog reintroduction into the GFRNR were assessed by conducting structured questionnaire interviews (Bath & Buchanan 1989; Anthony 2007; Schumann *et al.* 2012).

The questionnaires (n = 128) consisted of a total of six sections (Appendix B). In the first section, respondents were asked to answer questions based on the structural elements of their land/property (e.g. land use, details on fencing, size of property, game/livestock occurring on property and problems among their animals). The second section was designed to gain an understanding of the respondent's concerns and overall knowledge of wild dogs and their reintroduction to the GFRNR. The third section included a series of questions relating to livestock husbandry and the precautions taken against depredation (where appropriate). This third section was only completed by respondents who had domestic livestock (n = 87). The fourth section was aimed at determining whether respondents had previously visited the GFRNR and whether they may be more inclined to do so if wild dogs were reintroduced. The fifth section included questions to determine the potential threats to dispersing wild dogs. Specifically, questions focusing on snaring, poaching and current predator control/eradication were asked. This section was crucial in developing a threat index for wild dogs outside the GFRNR (see below). The final section involved gathering respondents' personal information such as age, gender, highest level of education and employment status. The sections were ordered in this fashion in an attempt to allow respondents to feel more at ease with the interviewer as the interview progressed (Anthony 2007). Therefore, all personal questions were left to the end of the interview in the hope that respondents would be more comfortable divulging such information.

Questionnaires consisted of five pages and were designed to take approximately 20 minutes to complete (White *et al.* 2005). Data were collected from April to September 2013. Generally, a pilot study is conducted to serve as a guide for the sample size required for the study (White *et al.* 2005). However, as this study surveyed all land owners within a specific area outside of the GFRNR (see chapter 2), a pilot study was deemed redundant as the questionnaire was reviewed by experts in the field from The Endangered Wildlife Trust, Rhodes University and the Eastern Cape Parks and Tourism Agency (ECPTA). The questionnaires were also constructed with strict reference to literature that used similar approaches (Mills *et al.* 1998; Davies & du Toit 2004; Lindsey *et al.* 2005a; White *et al.* 2005; Anthony 2007; Gusset *et al.* 2008c; Schumann *et al.* 2012).

Interviews were conducted face-to-face in the respondent's first language to ensure maximum completion and understanding (White *et al.* 2005; Zimmerman *et al.* 2005; Anthony 2007; Gusset *et al.* 2008). The answers were later transcribed into English (where necessary) by the interviewer for ease of analysis and interpretation. The first language of private land owners surrounding the GFRNR (n = 37) was generally English and all of the rural community members interviewed (n = 91) spoke isiXhosa. Consequently, separate workshops were held for private land owners and community members in order to conduct the interviews. The isiXhosa questionnaires were reviewed by three separate isiXhosa speakers to ensure that the questions translated correctly and to identify any ambiguous questions (Anthony 2007).

The questionnaire study was limited to all the land owners (private and communal) within a 12 km area around the reserve. The width of this buffer zone was based upon the mean daily distance moved by a pack of wild dogs and their average home range (Estes 1993; Creel & Creel 2002). The average home range size of wild dogs in eastern southern Africa is 218 km^2 and 14 km is the approximate diameter of 218 km (Lindsey *et al.* 2004a). The mean daily distance moved by wild dogs is 10 km (Creel & Creel 2002). Thus, taking an average of the two, the land owners within 12 km of the GFRNR would be the most likely candidates to be most immediately affected by dispersing wild dogs. Daily movements were considered as a 24 hour period was assumed to be the period required for reserve managers to recapture and relocate any dispersing animals (Creel & Creel 2002; D.M. Peinke, 2013, pers. comm).

Community questionnaires

Two full-day workshops were held at Nottingham Lodge in the GFRNR in May 2013 to conduct community member interviews. The first workshop was for the Community Property Association (CPA) members. The CPA consists of members of the community who were awarded a portion of the Double Drift Reserve in a land-claim dispute in 2012. In total, there are approximately 2000 CPA members, but these members are represented by 30 elected individuals. Twenty CPA members attended the workshop and were all interviewed. The second workshop was for members of the Park Forum (PF). The PF are ward/municipal leaders which represent each community around the reserve (24 communities in approximately 11 wards, see chapter 2). Twenty-one PF members attended the workshop and all were interviewed. At each workshop, a brief presentation on wild dogs, their biology and the proposed reintroduction to the GFRNR was given. The presentations were given in isiXhosa by the GFRNR community representative (Melikhaya Pongolo, ECPTA). After each presentation attendees were given an opportunity to ask questions and engage with GFRNR staff before being interviewed. The questionnaire interviews were all conducted in isiXhosa and there were a total of four interviewers who interviewed respondents, one-on-one, at each workshop.

During the interview, respondents were shown identification pages, each with images of locally occurring predator species (leopard; *Panthera pardus*, serval; *Leptailurus serval*, caracal; *Caracal caracal*, brown hyena; *Hyaena brunnea*, African wild cat; *Felis silvestris lybica*, and black-backed jackal) to prevent misidentification (Watermeyer 2012). Each community questionnaire took approximately 30 minutes to complete.

In addition to the CPA and PF workshops, four isiXhosa-speaking representatives from ECPTA visited each community within the buffer area to increase the number of community respondents between June and September 2013. The same presentation was given and this was followed by the questionnaire interviews. A further 50 respondents from 14 communities were interviewed using this approach.

In total, 91 respondents were surveyed from 17 communities around the GFRNR. Ten communities (Baltein, Fort Brown, Glenmore, Joe Farm, Khayamnandi, Xolani, Lokhwe, Ndwayana, Gxweterha and Nomtayi) willingly participated in the surveys when ECPTA representatives visited their village/community. However, there were seven communities (Masakhane, Gwabeni, Qamnyana, Jani, Zizeni, Lloyd and Sheshegu) within the study zone who were not willing to participate in the survey. Nevertheless, as some members of the CPA and PF were from those communities, a small number of respondents from those seven communities (excluding Zizeni) and twelve other communities (Baltein, Glenmore, Khayamnandi, Ngcabasa, Fort Brown, Gxwederha, Joe Farm, Lokhwe, Ndwayana, Tyhali, Xolani and Nomtayi) were interviewed.

Private land owner questionnaires

Private land owners surrounding the GFRNR were not interviewed after formal workshops due to the difficulty in setting up dates that suited all individuals but rather one-on-one on an *ad hoc* basis. Land owners were visited on their property between May and September 2013. Potential respondents were telephoned beforehand, the project was briefly explained and if they were willing to participate, a time and date was set to visit the respondent to complete the questionnaire (Lindsey *et al.* 2005). There are 41 private land owners surrounding the GFRNR and 37 agreed to participate in the study, thus the refusal rate for private land owners was 9 %. Respondents did not wish to participate as they were selling their land (n =1), they had no time (n = 2) or they did not support the reserve and its managers (n =1). Before the questionnaire began, respondents were once again informed that Rhodes University and ECPTA were conducting the project and assured that all responses would remain anonymous (Lindsey *et al.* 2005). The reason for the project and the layout of the survey, and a brief introduction on wild dogs, their biology and the possible reintroduction was also explained. The private land owner surveys took roughly 15 minutes to complete.

Threat and husbandry indices

Two indices (threat and husbandry) were derived to understand the possible threats facing wild dogs should they escape from the GFRNR and the level of husbandry occurring on properties outside the reserve (Zimmerman *et al.* 2005). The threat index was generated from a total of 16 statements, and the husbandry index from four statements (Appendix D).

The threat index comprised questions that revolved around possible threats to wild dogs on land adjacent to the GFRNR. These threats included poaching, land owner persecution, unvaccinated dogs and snaring. Semantic differential questions are used to measure respondent attitudes toward stimulus words, objects, and concepts and in this case the focus was on wild dogs (Wisco 2009). In my questionnaire, these semantic differential questions were trichotomous (yes/ no/ maybe answers) and were conducted as a series of statements upon which a respondent was asked to comment (Zimmerman *et al.* 2005). The questionnaires also made use of both closed and open ended questions (Lindsey *et al.* 2005). The latter allowed for respondents to express their opinions and concerns in their own words (Lindsey *et al.* 2005).

The answers to the trichotomous questions were assigned values in order to generate index scores (Anthony 2007). Index scores were calculated by allocating values of between 1 and -1 to the questions according to a positive (1), neutral (0) or negative (-1) response towards wild dogs and their reintroduction (Zimmerman *et al.* 2005; Anthony 2007). For example: the questionnaire asked: "I would harm wild dogs if they appear on my land". A score of +1 was given if the respondent answered no (as it indicates a positive attitude and therefore lower threat), 0 if they are unsure (as it does not necessarily indicate a positive or negative response) and -1 if they answered yes (as it indicates a negative attitude and increased the potential threat to wild dogs). The value for each index for each of the respondents was calculated as the sum of the scores of all 16 questions (Zimmermann *et al.* 2005). The maximum value that could be achieved for the threat index was 16, which indicated no or low threats in the area, while -16 was the most negative and indicated an area with many potential threats to wild dogs. Therefore, the more negative the threat index, the greater the potential threat to the persistence of wild dogs outside of the GFRNR (Anthony 2007).

Similar to the calculation of the threat index, land owners who owned domestic livestock, answered four trichotomous questions related to livestock husbandry to establish the husbandry index (Appendix D). These questions included questions concerning the precautions taken against depredation and general husbandry techniques (Gusset *et al.* 2009). The maximum husbandry score that a respondent could achieve was +4 (which indicated good husbandry) while the lowest possible score was -4 (indicating poor husbandry).

Data analysis

Descriptive analysis

Percentages were used to illustrate a variety of answers for various questions in order to provide qualitative summaries (Anthony 2007; Schumann *et al.* 2012). In addition, maps of the GFRNR and surrounding land were constructed using ArcMap 10 (ESRI, Redlands, California) as a visual representation of the different land uses of the survey respondents. Maps were also constructed to illustrate the threat index of each property, with each threat value being allocated a unique colour plotted on the map. Properties with snaring, poaching, unvaccinated dogs and those which indicated medicinal uses for wild dogs were also mapped.

Quantitative analysis

The statistical significance was set at $p < 0.05$ and all data were analyzed using Statistica 11.0 software (StatSoft inc. Tulsa, OK, USA; Motulsky 2010). Logistic regressions were completed to determine which variables best predicted the threat index (Gusset *et al.* 2008c). Nine predictor variables were used (Table 4.1) One of which was a continuous variable (age), and eight were categorical (education level (4 levels), language (3 levels), gender (2 levels), land use (4 levels), owning livestock/game (2 levels), previous problems with predators (2 levels), fear of wild dogs (2 levels) and land tenure (2 levels)).

Table 4.1: The property and human demographic variables used in the regression models to best predict the threat index of respondents.

Human demographic variables	Property Variables
Age	Land use
Gender	Land tenure (private or communal)
First language	Previous problems with predators on property
Highest level of education completed	Livestock or game on property
Fear towards African wild dogs	

The effects of the respondent’s demographic variables on their threat index

Five demographic variables were used in a multi-model analysis to determine their effect on the respondent’s threat index. One predictor variable was continuous (age) and four were categorical (education level), language, gender and fear of wild dogs; Table 4.1). The effects of these variables and the respondent’s threat index were explored using regression analysis (Burnham & Anderson 2002; Codron *et al.* 2007; Posada 2008; Rowe 2009; Symonds & Moussalli 2010). A multi-model selection was performed to determine which of these variables or combination of variables best predicted the threat index (Rowe 2009). The five variables were incorporated into a best subsets model selection procedure using Akaike’s Information Criterion (AIC; Burnham & Anderson, Rowe 2009). Each model was constructed with between one and five variables, giving a combination of 31 potential models which could explain the threat index results. The overall aim of this model selection approach was to identity which variables, when tested in combination, best predicted the threat index (Codron *et al.* 2007; Rowe 2009; Motulsky 2010; Symonds & Moussalli 2010).

As the total sample size for this study was relatively small (n = 128 respondents), models were compared using AIC with small sample adjustment (AICc), where variable significance was expressed as the difference in AICc between each model and the model with the lowest AICc value (Burnham & Anderson 2002; Thorn *et al.* 2012 & 2013). Since AICc values are not comparable in their raw form, delta AICc (ΔAICc) values and Akaike weights (w*i*) were calculated to facilitate interpretation (Burnham & Anderson 2002). The ΔAICc was calculated by taking the AICc for the model and subtracting the smallest AICc value from it; therefore the lower the AICc, the better the predictive power of the model (Burnham & Anderson 2002). The equation for calculating AICc was as follows (Burnham & Anderson 2002; Symonds & Moussalli 2010; Thorn 2012 & 2013):

$$AICc = AIC + \frac{2k\ (k+1)}{n-k-1}$$

where n is the sample size and k is the number of fitted parameters in the most complex model (Symonds & Moussalli 2010). This approach is based on Kullback–Leibler information theory systems and uses the AIC to predict the most suitable model (Johnson & Omland 2004; Codron *et al.* 2007). Each model was ranked in order of parsimony using ΔAICc and Akaike weights (Burnham & Anderson 2002; McDonald 2009; Thorn *et al.* 2012

& 2013). Akaike weights (w*i*) indicate the strength of evidence for a model and sum up to one, with higher values indicating that a model is relatively more important than the other models and therefore more likely to explain the variability in the data (Codron *et al.* 2007). A given w*i* is considered as the weight of evidence in favour of a model (Burnham & Anderson 2002).

In addition to the model-building approach, the impact factors of each individual predictor variable were calculated by summing the weights of each model which contained the specific predictor variable (Rowe 2009). Impact factors, a form of cross model validation, were calculated in order to determine a variable's relative importance in influencing the threat index (Rowe 2009). Variables with an impact factor of > 0.80 were interpreted as strong evidence for the role of the predictor variable in shaping the threat index (Rowe 2009).

General linear models were then run to test the best two candidate models for explaining the threat index (Burnham & Anderson 2002; Rowe 2009; Symonds & Moussalli 2010). The best two models (the models with the lowest ΔAICc values) were used as they generally incorporated all predictor variables.

<u>The effect of property variables on the threat index.</u>

Four property variables were also used in a multi-model selection to determine the effect on the threat index. All four variables were categorical (land use, owning livestock/game, previous problems with predators, and land tenure; Table 4.1). By using the same model-building procedure described above, the effects of the property variables on the threat index were assessed. Multiple regression models were constructed for every combination of variables as well as each variable, giving a combination of 15 potential models for explaining the threat index. General linear models were then run to test the best two candidate models for explaining the threat index (Burnham & Anderson 2002; Rowe 2009; Symonds & Moussalli 2010).

4.3. Results

Communal areas surrounding the GFRNR were more densely populated than private land (72 people per km^2 in communal land and 7 people per km^2 for privately owned land); as a result, more surveys were obtained from the surrounding communities (ECPTA 2012). In total, 128 respondents were surveyed; 37 private land owners and 91 communal area members.

Of the 128 respondents, 79 % were males and 21 % were females (Table 4.2). The majority of respondents (59 %) had some form of secondary education, 23 % of respondents had at least primary school education and 14 % had tertiary education in the form of a university degree or diploma (Table 4.2). Only 3 % of respondents had no education at all. Seventy-two percent of respondents spoke isiXhosa as their first language, 20 % spoke English and 8 % Afrikaans (Table 4.2). All of the English and Afrikaans first language speakers were private land owners, while 99 % of the isiXhosa speakers came from the communal areas to the north and east of the reserve. The average age of respondents was 47 (±14.66) years (range: 21-79; Table 4.2).

Table 4.2: A summary of the demographics of respondents surveyed within a 12 km area around the Great Fish River Nature Reserve (n = 128).

Demographics of responder	Number	%	Mean(±SD)
Gender:			
Males	101	78.9 %	
Females	27	21.1 %	
Home language:			
English	26	20.3 %	
Afrikaans	10	7.8 %	
isiXhosa	92	71.9 %	
Education:			
None	4	3.1 %	
Primary School	30	23.4 %	
High School	76	59.0 %	
Tertiary Education	18	14.1 %	
Age			47 (±14.66)

The average property size for private land owners (29 % of respondents) was 2255 ha (± 3440.37) (Table 4.3). The average property size for communal area land owners could not be determined as there are no distinct boundaries in these areas. Ninety percent of respondents had livestock or game on their property (Table 4.3).

Table 4.3: A summary of the characteristics of properties surveyed within a 12 km area around the Great Fish River Nature Reserve (n = 128).

Property characteristics	Number	%	Mean(±SD)
Farm size			2255 (± 3440.37)
Own livestock or game:			
Yes	116	90.6 %	
Livestock	87	87 %	
Game	15	13 %	
Land tenure:			
Private	37	28.9 %	
Community	91	71.1 %	

The dominant land use around GFRNR was stock ranching (Figure 4.1 & 4.2). Wildlife ranching (for the purpose of live game sales, ecotourism and hunting) was the second most important land use and was only found among private land owners (Figure 4.1 & 4.2). Subsistence crop faming was more prevalent in the communal areas. Seventeen respondents had no land use for their property (Figure 4.1 & 4.2). The only other land use occurring in the area was sand mining (Figure 4.1). As a result of communal areas not having distinctive property boundaries, their land use could not be plotted on Figure 4.2. The dominant land use on communal land was subsistence stock ranching (79 %) followed by subsistence crop farming (4 %). Seventeen percent of respondents had no economic use for their land.

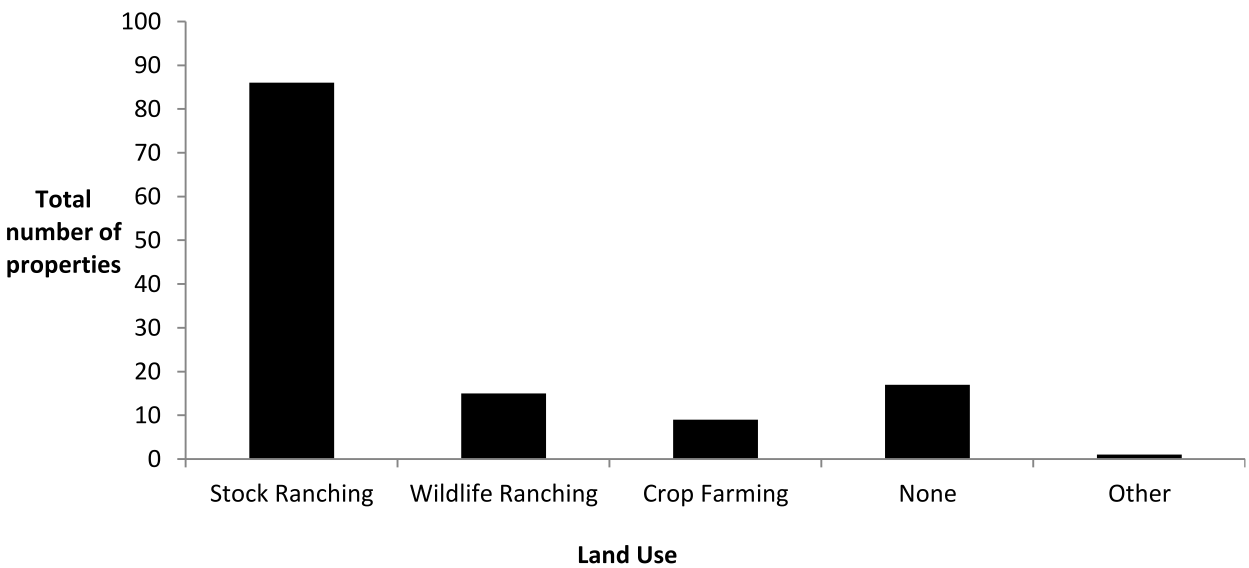

Figure 4.1: The five land use categories of private and communal area properties surveyed within a 12 km area of the Great Fish River Nature Reserve (n =128).

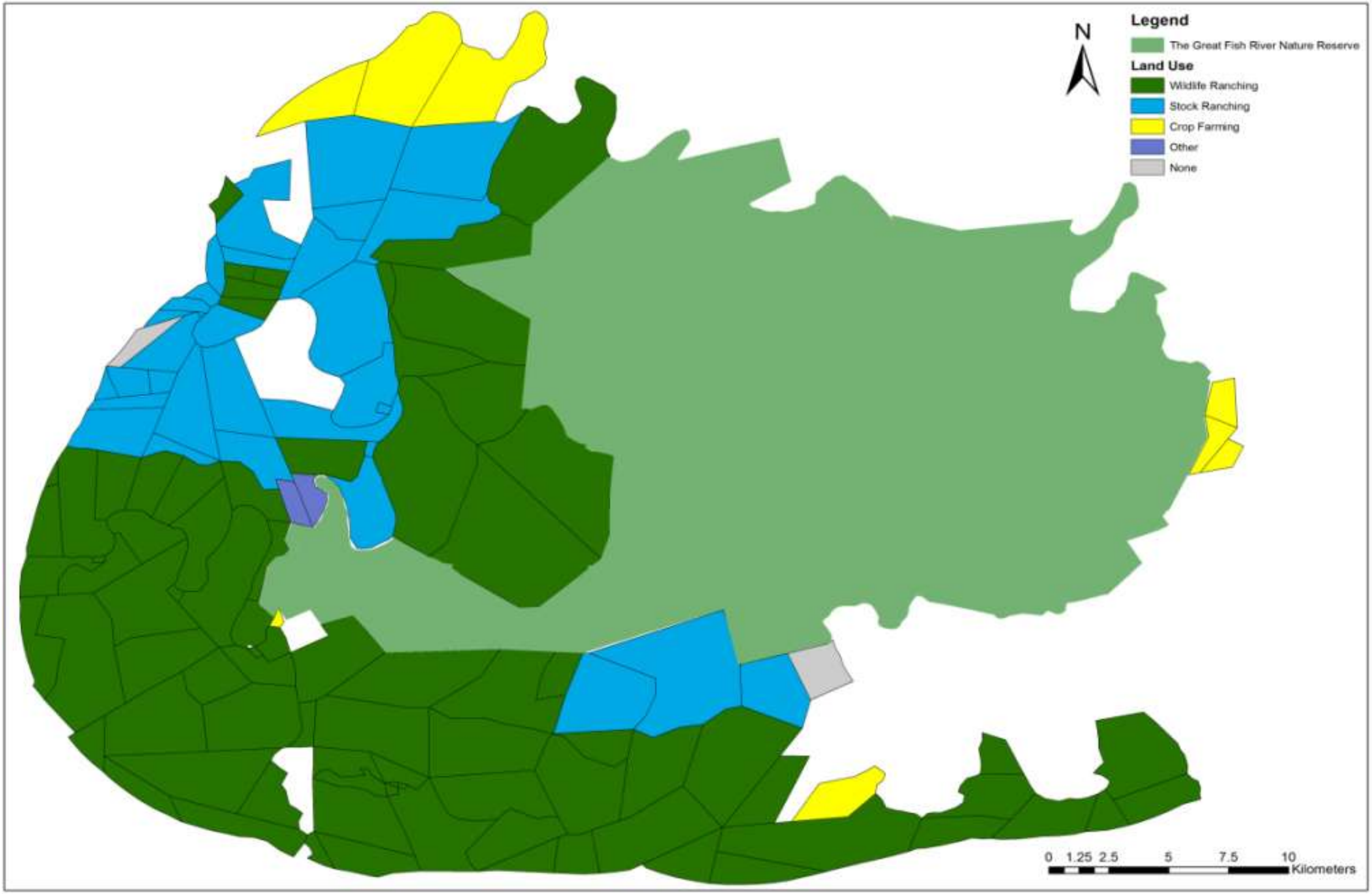

Figure 4.2: The land use practices of private land owner respondents within a 12 km area around the Great Fish River Nature Reserve. (ArcMap 10. Projected: Transverse-Mercator, spheroid WGS84, central meridian 27; map units: meters).

Current problems with predators

Most survey respondents had experienced problems with one or more predators on their land in the past year (Figure 4.3). Few respondents had problems with three or more species. The two most problematic species, according to the respondents, were the black-backed jackal (88 respondents listed jackal as a problematic species) and the caracal (55 respondents). Most respondents had experienced problems with both of these predators. Domestic dogs were the third most problematic species. Leopards and brown hyenas were also identified as problem predators, but by fewer respondents than those who experienced problems with black-backed jackal or caracal. Warthog, aardwolf and serval were identified as being problem animals by one respondent each.

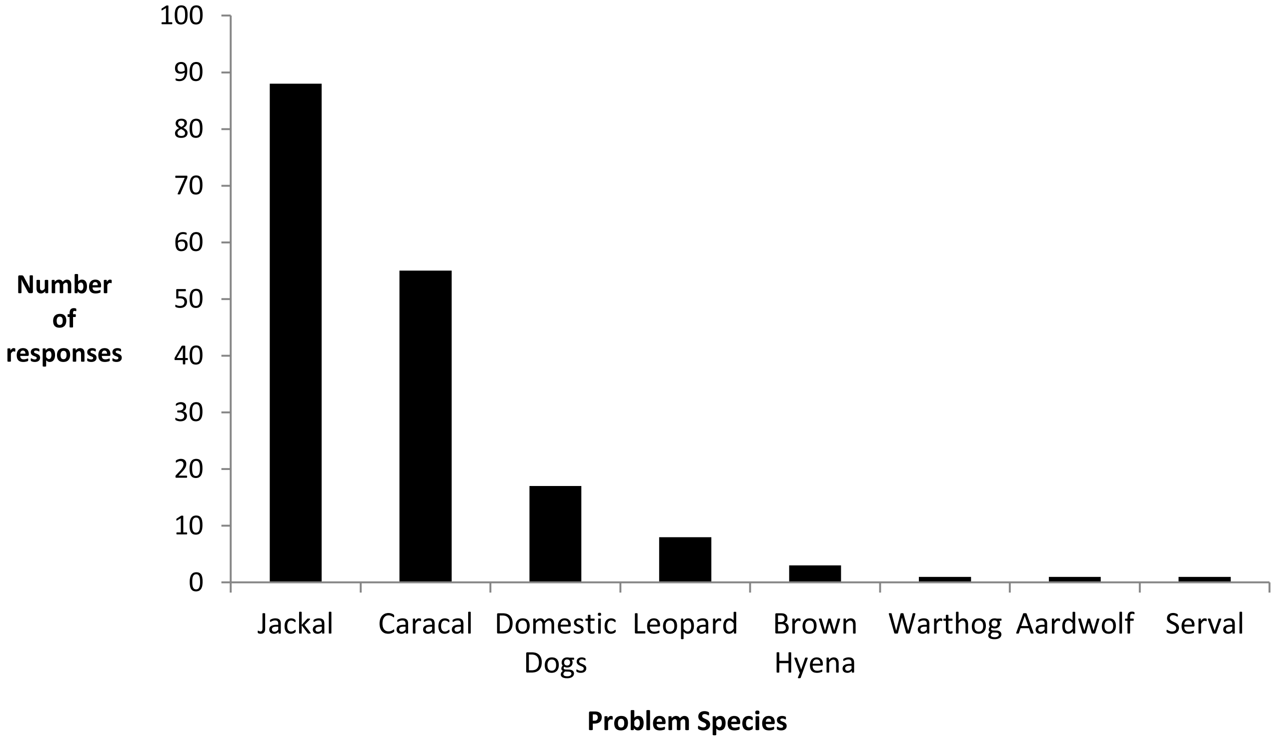

Figure 4.3: The total number of respondents within a 12 km area around the Great Fish River Nature Reserve who had experienced problems with eight different species on their property.

In general, respondents used a combination of anti-predator strategies. These included shooting and calling (n = 25), setting cage traps (n = 3), setting snares (n = 1), guard dogs (n = 40) and kraaling (enclosing livestock in a fenced area; n = 85). When asked what their reaction would be to predators on their land, 74 respondents gave positive responses (Figure 4.4). Most respondents (n = 62) said that they would call the reserve managers to remove the predators, and 12 said that they would leave the animal alone (Figure 4.4). However, 47 respondents had more negative responses (Figure 4.4). Forty respondents said that their reaction would be to kill the predator, and seven said that they would chase it away (Figure 4.4).

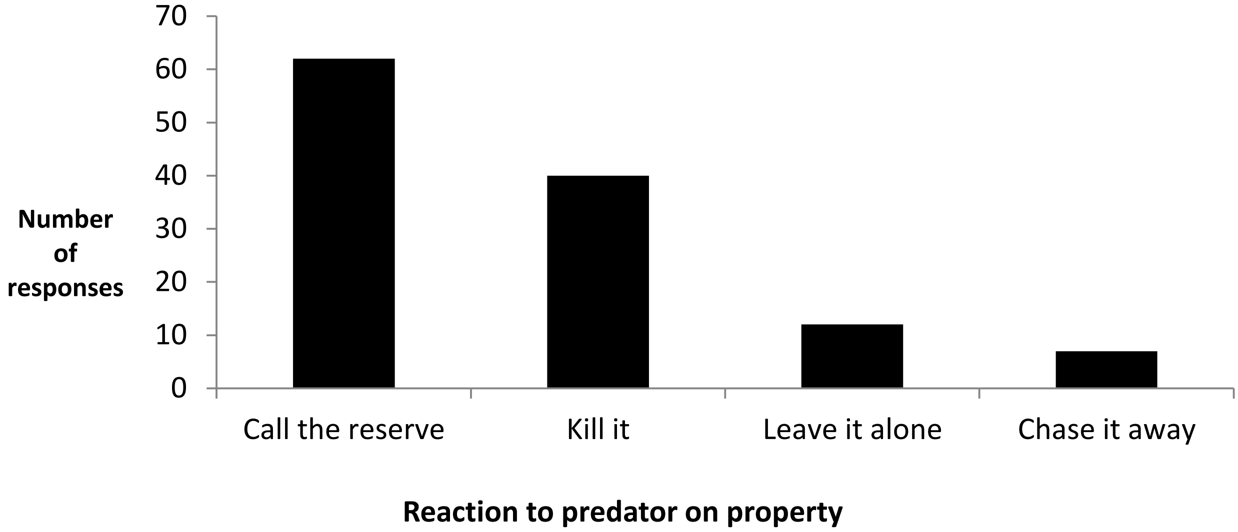

Figure 4.4: The four reaction categories of land owners to wild dogs on their properties, within a 12 km study area around the Great Fish River Nature Reserve (n = 128).

In the past year, the most heavily persecuted predator was the black-backed jackal, with 307 individuals reportedly killed by land owners around the reserve (Figure 4.5). One hundred and nineteen domestic dogs, 86 caracals and one brown hyena had also been killed in the past year (Figure 4.5). Excluding domestic dogs, these proportions are relative to the number of respondents who experienced these predators as problem species (Figure 4.3 & 4.5).

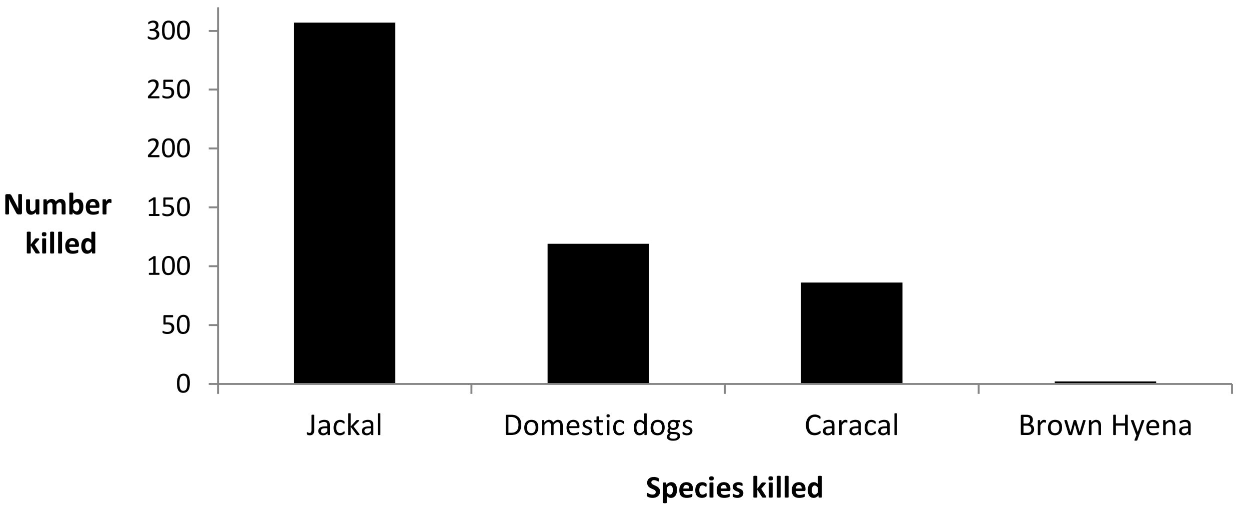

Figure 4.5: The number of predators killed by respondents within a 12 km area of the Great Fish River Nature Reserve in the past year (n = 128).

The potential for wild dog-human conflict, livestock depredation, snaring and disease.

Ninety-one percent of respondents had livestock or game on their property (Table 4.4). However, over half of the respondents (56 %) were in favour of the reintroduction of wild dogs into the GFRNR. Nevertheless, 20 % of respondents were against the reintroduction and 24 % were unsure (Table 4.4). When asked about fear towards wild dogs, 39 % of respondents expressed fear for their own lives and/or livestock and/or game (Table 4.4). Ninety-four percent of respondents felt that wild dogs should be conserved. Thirty-five percent of respondents felt that their neighbours would be in favour of the reintroduction, while 25 % felt that their neighbours would be against the reintroduction (Table 4.4). When it came to directly harming wild dogs, 9 % of respondents stated that they would harm wild dogs if they appeared on their land (Table 4.4). If wild dogs killed any of their livestock or game, this figure went up to 22 % (Table 4.4). Seventy-six percent of respondents employed some form of predator control (Table 4.4). These control measures included lethal techniques such as hunting, setting snares and poisoning, and non-lethal measures such as setting traps and using guard dogs. Eighty percent of respondents had killed predators on their land before (Figure 4.5 & Table 4.4). Forty-six percent had problems with poaching on their land and 40 % of respondents had problems with snares in their area (Table 4.4). Seventy-nine percent of respondents regularly patrolled their fence lines to search for snares and when finding a snare, 87 % of respondents removed them while the others left it in place (Table 4.4). Eighty-one percent of respondents owned dogs, but only 70 % of these dogs were vaccinated against rabies and canine distemper (Table 4.4).

Table 4.4: Threat index questions and number of responses given by private land owners and communal area members within a 12 km radius of the Great Fish River Nature Reserve (n = 128).

	Private			Communal Areas		
	Yes	No	Unsure	Yes	No	Unsure
Do you own livestock or game?	35	2	0	81	10	0
Are you in favour of the reintroduction of wild dogs into the Great Fish River Nature Reserve?	23	8	6	49	18	24
Would you be afraid of wild dogs?	7	30	0	44	37	10
Should wild dogs be protected/conserved?	32	1	4	88	1	2
Would your neighbours be in favour?	11	17	9	34	15	42

Would you harm wild dogs if they escaped from the reserve and appeared on your land?	6	28	3	6	82	3
Would you harm wild dogs if they escaped from the reserve and killed your livestock/game?	11	22	4	17	65	9
If you see a predator on your land, what is your reaction?	See Figure 4.4					
Do you employ any predator control?	23	13	1	74	15	2
Have you killed any predators on your land before?	29	8	0	73	18	0
Are there snares in your area?	19	17	1	32	48	11
Do you own dogs?	29	8	0	75	16	0
Are your dogs vaccinated for canine distemper and rabies?	25	3	1	64	9	2
Is there poaching in your area?	27	9	1	35	50	6
If you find a snare, do you remove it?	36	1	0	75	10	6
Do you routinely patrol fences?	33	4	0	68	21	2

Sixty percent of respondents had heard of wild dogs before the workshops/surveys (Table 4.5). Most of those who had not heard of wild dogs were communal area respondents. However, 85 % of respondents expected compensation if wild dogs were to disperse from the reserve and kill any of their livestock or game (Table 4.5). It was expected that either the reserve or the government should compensate for any livestock or game lost. Eight percent of respondents revealed that wild dogs had been a part of their traditional history or stories (Table 4.5).

Table 4.5: Responses given by respondents to four non-threat survey questions regarding the reintroduction of wild dogs into the Great Fish River Nature Reserve (n=128).

	Private			**Communal Areas**		
	Yes	**No**	**Unsure**	**Yes**	**No**	**Unsure**
Before today had you heard of wild dogs?	35	2	0	42	49	0
Would you be more inclined to visit the reserve if there were wild dogs?	14	21	2	79	9	3
Would you expect compensation?	26	6	5	83	8	0
Use for traditional medicine	0	0	0	10	74	7

Threat index

The mean threat index for wild dogs outside the reserve was four (± 4.17) (Figure 4.6). Private land owners had a mean threat index of two, while communal area members had an average threat index of five. This indicates that there is generally a lower threat to wild dogs on communal area land. The most negative threat index was -5, indicating potentially high threat areas to wild dogs in some places outside of the reserve. The most positive index achieved was 13 (a community respondent), indicating that several low risk areas also exist (Figure 4.6). Nevertheless, the threat indices are relatively evenly distributed across the respondent range (Figure 4.6). Seventeen respondents scored negative threat index values (indices below 0), thus indicating high threats to wild dogs on their land (Figure 4.6). The remaining respondents scored positively with a threat index of above 0, and 15 respondents scored above 10 (Figure 4.6).

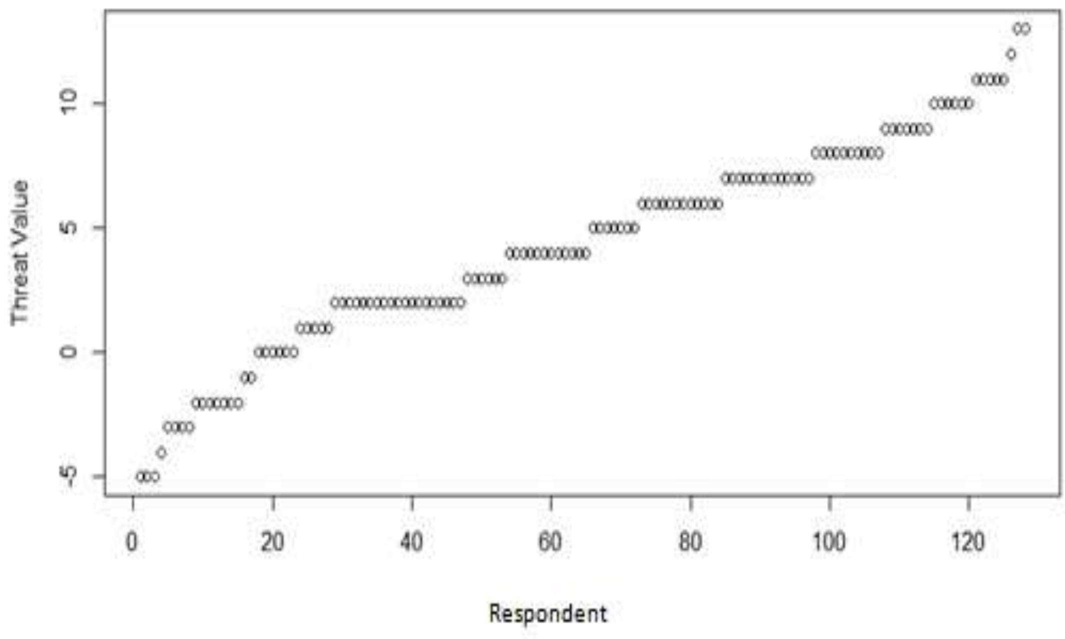

Figure 4.6: The distribution of threat indexes of each respondent within a 12 km radius of the Great Fish River Nature Reserve (n = 128).

Generally, most private properties adjacent to the reserve had positive, but low threat index values (Figure 4.7). The threat indices of these properties were influenced by poaching, snaring and the presence of unvaccinated domestic dogs (Figure 4.8). However, private properties with the most negative threat index values were not located directly adjacent to the reserve (Figure 4.7).

The total number of respondents representing each community varied (Table 4.6). This discrepancy occurred due to some communities being uncomfortable with completing questionnaires. Therefore, the plots on Figure 4.7 are the average index values of representatives from each community. This was done in order to gain a more visual representation of the potential threats in the communal areas. The most positive index value achieved was nine, while the lowest and most high risk threat index was for the Ndwayana community which scored -1 (Figure 4.7 & Table 4.6).

Table 4.6: The average threat index scores of each community and the total number of respondents representing the 18 communities surveyed around the Great Fish River Nature Reserve.

Village	Number of respondents	Average threat Index
Ndwayana	5	-1
Fort Brown	1	4
Ngcabasa	2	4
Glenmore	10	5
Gxwederha	3	5
Jani Location	6	5
Khayamnandi	9	5
Gwabeni	5	6
Masakhane	4	6
Qamnyana	4	6
Sheshegu	13	6
Xolani	4	6
Baltein	9	7
Lokhwe	5	7
Tyhali	3	7
Lloyd	3	8
Joe Farm	2	9
Nomtayi	3	9

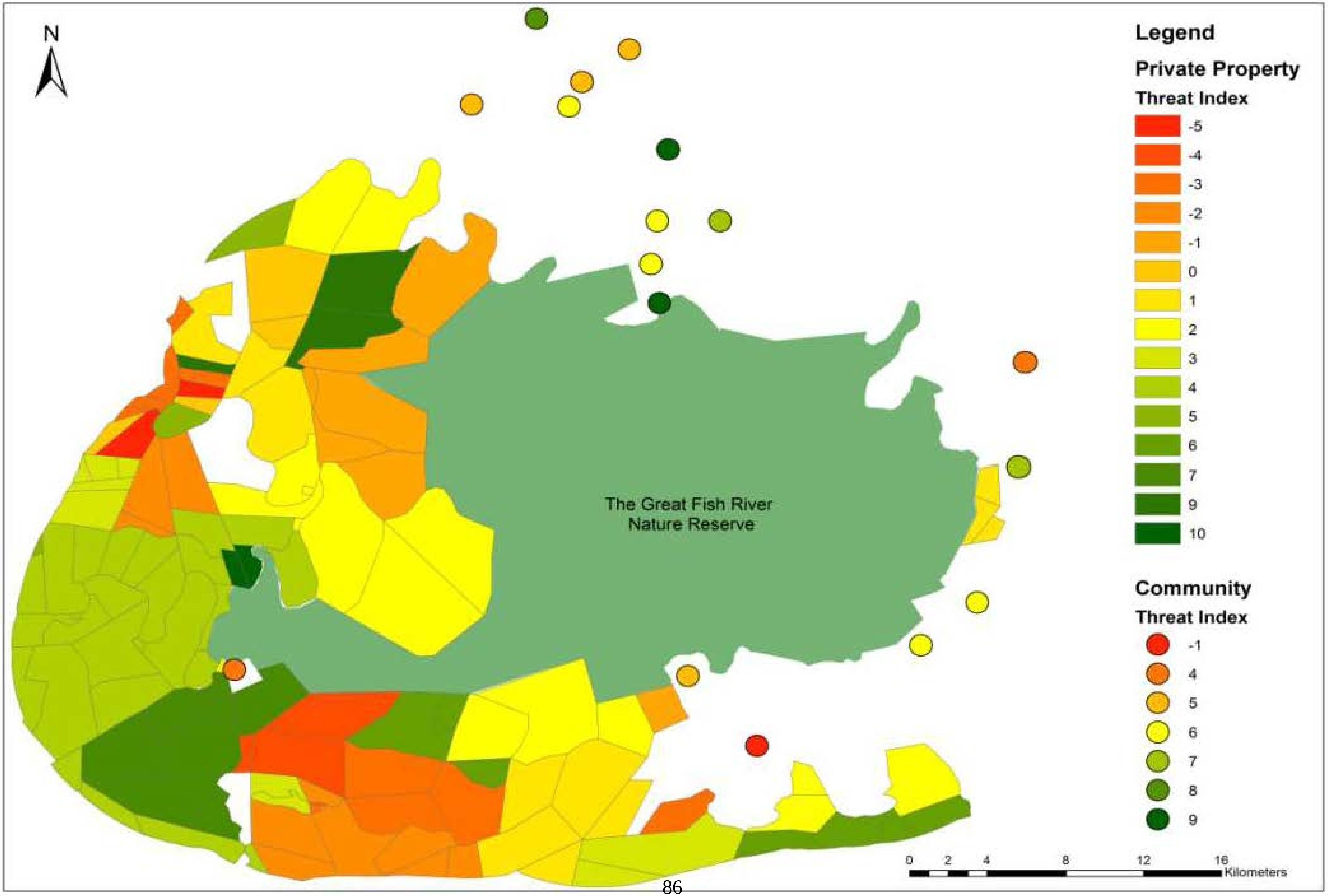

Figure 4.7: The threat index scores of the communal area and private properties surrounding the Great Fish River Nature Reserve. (Reds and oranges indicate higher threat areas while darker greens indicate low threat areas; ArcMap 10. Projected: Transverse-Mercator, spheroid WGS84, central meridian 27; map units: meters).

Fifty-six percent of all respondents were in favour of the reintroduction, but 20 % were not. There were four main reasons for respondents being against the reintroduction of wild dogs into the reserve (Table 4.7). The main motivation for respondents being against the reintroduction was the potential threat they believed wild dogs posed to their livestock. Livestock was kept by 84 % of respondents, with cattle (*Bos primigenius*), goats (*Capra aegagrus hircus*) and sheep (*Ovis aries)* being the most prevalent domestic animals. Personal fear of wild dogs was another important reason cited by respondents against the reintroduction (Table 4.7).

Table 4.7: Reasons given by respondents to justify willingness/unwillingness to reintroduce wild dogs to the Great Fish River Nature Reserve.

		Number of responses	
Attitude towards wild dog	**Reasons given to justify (un)willingness to reintroduce wild dogs**	**Private**	**Communal Areas**
Positive	Wild dogs are endangered and they need to be conserved	5	6
	Love them	3	2
	They are indigenous to the area	4	
	Will bring benefits (improve local economy, increase tourism, jobs)		21
	Not dangerous to human life		8
	To see them and have children see them		5
Negative	Scared of them		3
	Danger to livestock	2	17
	Threat to natural game inside and outside the reserve	2	
	They will break out of the reserve	1	

Respondents in favour of the reintroduction gave six statements justifying their opinion (Table 4.7). The potential benefits that the reintroduction may encourage, such as job opportunities and the potential of ecotourism which could generate money for the local economy, was the main motivation for positive feelings towards the reintroduction (Table 4.7). This was only highlighted by the communal area respondents surveyed. Respondents felt positive about the reintroduction as wild dogs are an endangered species and do not pose any significant threat to human life (Table 4.7).

Specific threats to wild dogs outside the reserve

Poaching was viewed as a direct persecution of a species through tracking and hunting, whereas snaring was considered more indirect and unspecific. Poaching was a severe problem around the reserve and was more of an issue among the private properties (Figure 4.8a). Seventy-three percent of private land owners experienced poaching, and only 38 % of communal area respondents experienced poaching. Overall, 48 % of respondents had experienced poaching on their property in the last year. One respondent (private) reported losing all livestock and game on his property to poachers.

Snaring was less of a problem on properties than poaching (Figure 4.8b). Fifty-one percent of private properties and 35 % of communal area respondents had snaring occurring on their properties (Figure 4.8b). One communal area respondent acknowledged that he personally set snares when he experienced problems with predators. Animals reported getting caught in snares included kudu, warthog, duiker (*Sylvicapra grimmia)*, steenbok (*Raphicerus campestris)*, black-backed jackal, rabbit (*Lepus spp.*), spring hares, caracal, chacma baboons (*Papio hamadryas*), brown hyena and bushbuck. Snares are non-selective, and as a result domestic livestock also gets caught in snares including goats, cattle and sheep.

Seventy-eight percent of private properties had domestic dogs, 86 % of which were vaccinated against canine distemper and rabies (Figure 4.8c). Of the private property respondents that owned dogs, there were a total of 126 dogs (13 unvaccinated on four private properties; Figure 4.8c). According to private land owner respondents, campaigns to vaccinate dogs do not occur regularly around the western and southern boundaries of the reserve. Six respondents used their dogs for hunting and most of these properties were hunting lodges. Eighty-two percent of communal area respondents owned dogs and 85 % were vaccinated (Figure 4.8c). A minimum of 179 dogs were owned by the 75 respondents; at least 27 of these dogs were unvaccinated (in four communities; Figure 4.8c). According to respondents, the Department of Agriculture visits the communities annually to vaccinate dogs. Seventy-six percent of dogs are locked up on the respondent's property. However, two respondents stated that their dogs were unvaccinated and roamed freely across several properties (Figure 4.8c). Only three communal area respondents used their dogs for hunting and most respondents used their dogs for guarding livestock. Significantly, most of the properties with unvaccinated dogs are located right next to the reserve (Figure 4.8c). In community surveys, respondents raised concerns that their dogs are often stolen by poachers and taken into the reserve as hunting dogs.

None of the respondents from private properties had any traditional uses for wild dogs (Figure 4.8d). However, 10 respondents from six communities stated that they knew of traditional uses for wild dogs (Figure 4.8d). According to one respondent, “The smoke of burning wild dog fur makes someone sleep” while another stated that “Traditional healers use them in their traditional attire and are used for many medicinal purposes”.

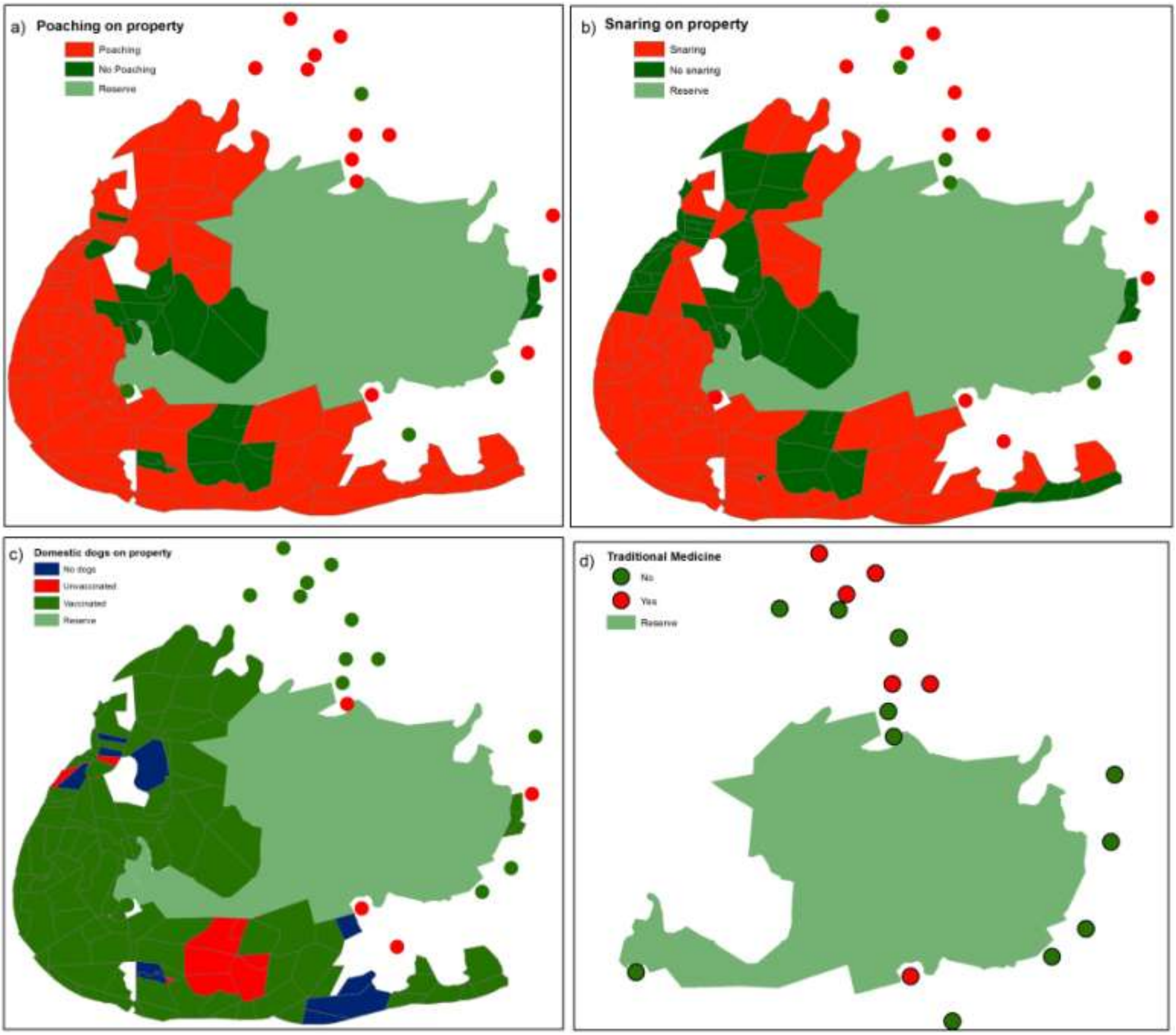

Figure 4.8: Threats to wild dogs around the Great Fish River Nature Reserve. A) Poaching, B) Snaring, C) Domestic dogs and D) Wild dogs used for traditional medicine (ArcMap 10. Projected: Transverse-Mercator, spheroid WGS84, map units: meters).

Relationship between demographic variables and threat index

Thirty-one demographic models, using five variables, were constructed to explain the respondents' threat index (Table 4.8). Two models (which included age, gender, first language and fear towards wild dogs) had the lowest ΔAICc values and were thus the most suitable models for explaining the observed variation in the threat index (Table 4.8).

Table 4.8: The Akaike information criterion (AICc) regression models investigating the effects of human socio-demographic variables on the threat index of respondents (n = 128).

	Variable 1	Variable 2	Variable 3	Variable 4	Variable 5	AICc	ΔAICc	wt
1	Age	Gender	Language			688.33	0.00	0.42
2	Age	Gender	Language	Fear		689.24	0.91	0.27
3	Age	Language				690.85	2.52	0.12
4	Age	Language	Fear			691.71	3.38	0.08
5	Age	Gender	Education	Language		693.80	5.47	0.03
6	Gender	Language				693.99	5.67	0.02
7	Age	Gender	Education	Language	Fear	694.73	6.40	0.02
8	Language					695.41	7.08	0.01
9	Age	Education	Language			695.67	7.34	0.01
10	Gender	Language	Fear			696.07	7.75	0.01
11	Age	Education	Language	Fear		696.62	8.29	0.01
12	Language	Fear				697.11	8.78	0.01
13	Gender	Education	Language			698.20	9.87	0.00
14	Gender	Education	Language	Fear		699.73	11.40	0.00
15	Education	Language				700.10	11.77	0.00
16	Education	Language	Fear			701.25	12.92	0.00
17	Age	Gender	Education			707.10	18.78	0.00
18	Gender	Education				707.24	18.91	0.00
19	Age	Gender				707.63	19.30	0.00
20	Age	Gender	Education	Fear		708.37	20.04	0.00
21	Age	Gender	Fear			708.88	20.55	0.00
22	Gender	Education	Fear			709.35	21.02	0.00
23	Gender					709.94	21.61	0.00
24	Education					711.26	22.94	0.00
25	Age	Education				711.84	23.51	0.00
26	Gender	Fear				712.52	24.19	0.00
27	Age					712.82	24.50	0.00
28	Education	Fear				713.96	25.63	0.00
29	Age	Education	Fear			714.14	25.82	0.00
30	Age	Fear				715.61	27.28	0.00
31	Fear					718.37	30.04	0.00

First language was the best individual predictor variable for the threat index (an impact score of 1.00; Table 4.9). The effect of language on the threat index was significant ($F_{(2; 118)} = 13.87$; $p < 0.05$). IsiXhosa first language speakers had the most positive threat index (an average index of five; Figure 4.9). Afrikaans speakers received an index of two and English speakers had the poorest index (an index of one; Figure 4.11). The difference in threat indices between isiXhosa and English speakers was significant (Scheffe test, $p < 0.05$). Differences between English and Afrikaans speakers and isiXhosa and Afrikaans speakers were not significant (Scheffe Test, all cases, $p > 0.05$).

Table 4.9: The individual Akaike weights (impact factors) for the human demographic variables predicting the threat index of respondents towards wild dogs in the Great Fish River Nature Reserve.

Variable	Impact Factor
First language	1.00
Age	0.94
Gender	0.77
Fear towards wild dogs	0.38
Level of education	0.07

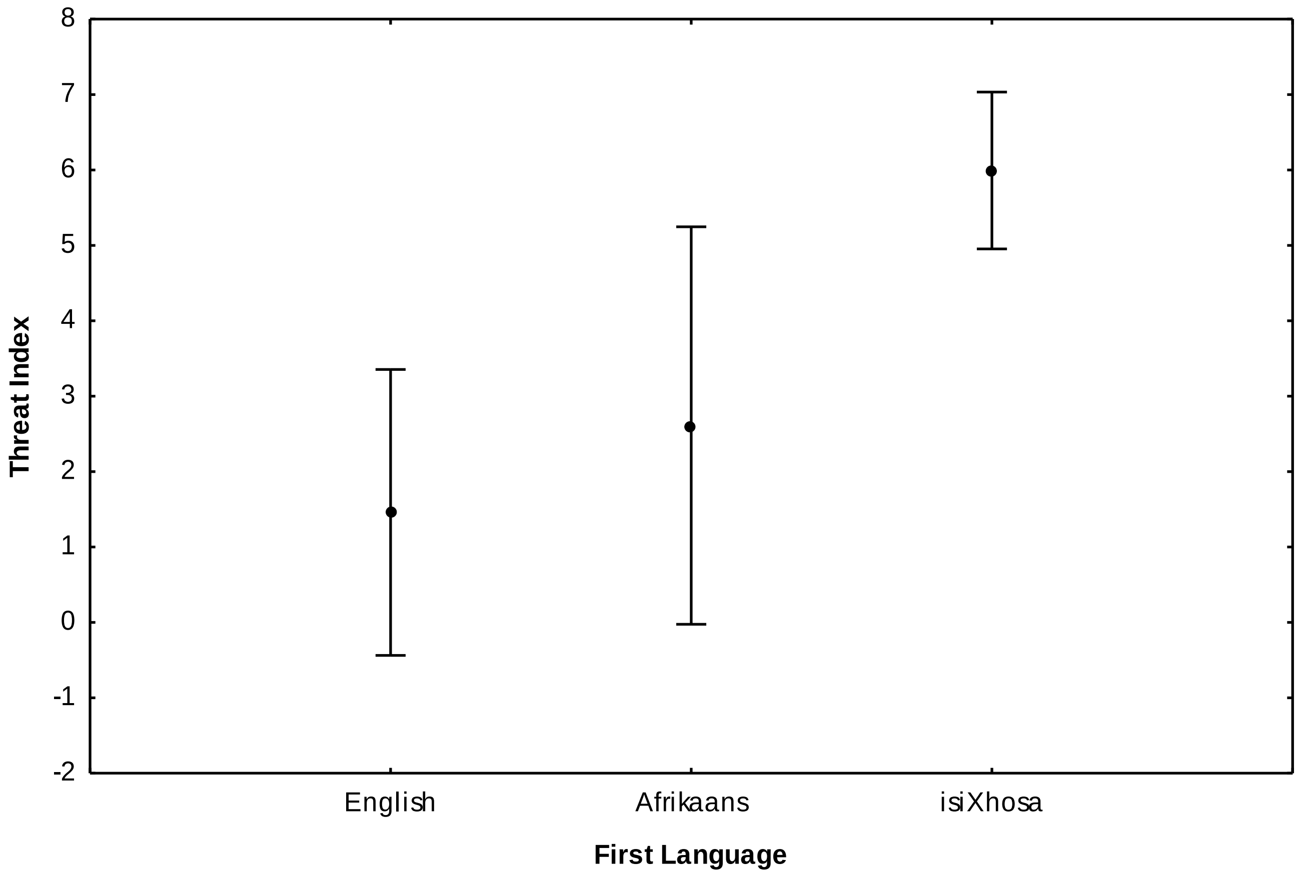

Figure 4.9: There was a significant relationship between first language of respondents around the Great Fish River Nature Reserve and threat index score ($F_{(2;118)} = 13.87$; $p < 0.05$). Vertical bars denote 0.95 confidence intervals.

Age was the second best predictor of threat index (impact score of 0.94; Table 4.9) although the effect on threat index was not significant ($F_{(1;\ 128)} = 3.58$ $p > 0.05$). Threat indices became more positive with increasing age, but they were generally randomly distributed across age groups and explained only 1 % of the variation in the threat index ($F_{(1;\ 128)} = 3.58$ $p > 0.05$; $r^2 = 0.01$).

Education of respondents was found to have a significant effect on the threat index ($F_{(3;123)} = 3.53$; $p < 0.05$; Figure 4.10). Generally, with increasing education levels, there was a decrease in the threat index of the respondent (Figure 4.10). Thus the more educated a respondent, the poorer/more negative the threat index (Figure 4.10). Respondents with tertiary education received the poorest index (an index of two), high school respondents received a mean index of four, primary school leavers an index of seven, and respondents with no education received the most positive index (an index of eight: Figure 4.10). While the level of education was significantly influenced a respondent's threat index, it had the lowest impact score of the five predictor variables (0.07; Table 4.9).

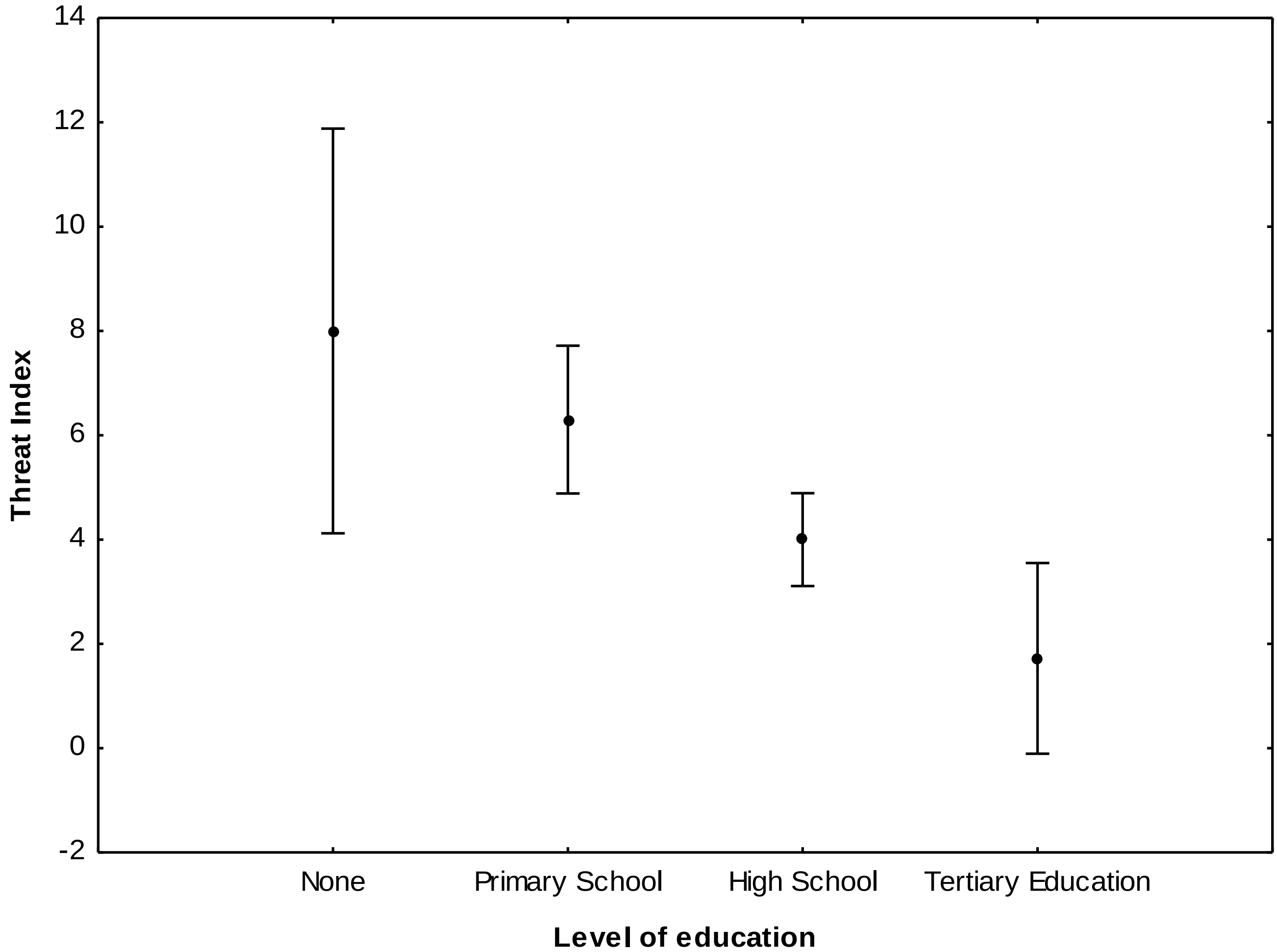

Figure 4.10: The level of education of respondents around the Great Fish River Nature Reserve was significant in influencing their threat index scores ($F_{(3;123)} = 3.53$; $p < 0.05$). Vertical bars denote 0.95 confidence intervals.

Generally, properties represented by females received more positive threat indices than males ($F_{(1; 126)} = 1.66$; $p < 0.05$; Figure 4.9). The average threat index for females was four, while males scored two. Fear towards wild dogs was not found to have a significant effect on the threat indices of respondents towards wild dogs ($F_{(1; 126)} = 3.04$; $p > 0.05$). Respondents who feared wild dogs had an average index of four while those respondents who did not fear wild dogs had a threat index of six.

Relationship between property variables and threat index

Fifteen property models, using four variables, were constructed to explain the threat index (Table 4.10). Two models (which included variables such as land tenure (community vs. private), land use and previous problems with predators) were the most suitable models for explaining the variation in threat index (Table 4.10).

Table 4.10: The Akaike information criterion (AICc) regression models investigating the effects of property variables on the threat index of respondents.

	Variable 1	Variable 2	Variable 3	Variable 4	AICc	ΔAICc	wt
1	Land tenure	Land use	Problems with preds.		697.29	0.00	0.39
2	Land tenure	Land use			698.57	1.28	0.20
3	Land tenure	Land use	Own livestock or game	Problems with preds.	698.79	1.50	0.18
4	Land tenure	Land use	Own livestock or game		700.04	2.75	0.10
5	Land tenure	Problems with preds.			701.34	4.05	0.05
6	Land tenure				701.98	4.69	0.04
7	Land tenure	Own livestock or game	Problems with preds.		703.28	5.99	0.02
8	Land tenure	Own livestock or game			703.55	6.25	0.02
9	Land use	Problems with preds.			711.56	14.27	0.00
10	Land use	Own livestock or game	Problems with preds.		713.52	16.23	0.00
11	Land use				715.33	18.03	0.00
12	Land use	Own livestock or game			717.08	19.79	0.00
13	Problems with preds.				723.30	26.00	0.00
14	Own livestock or game	Problems with preds.			725.29	28.00	0.00
15	Own livestock or game				726.99	29.70	0.00

Land tenure was the best individual predictor variable for the threat index (an impact score of 1.00; Table 4.11). There was a significant effect of land tenure on the respondent's threat indices ($F_{(1;\ 116)} = 16.44$; $p < 0.05$). Private land owners had an average index of two while communal area respondents had an average index of 5.5 (Figure 4.11).

Table 4.11: The individual Akaike weights (impact factors) for the property variables predicting the threat index of respondents towards wild dogs in the Great Fish River Nature Reserve.

Variable	Impact Factors
Land tenure	1.00
Land use	0.87
Previous problems with predators on property	0.64
Own domestic livestock or game	0.32

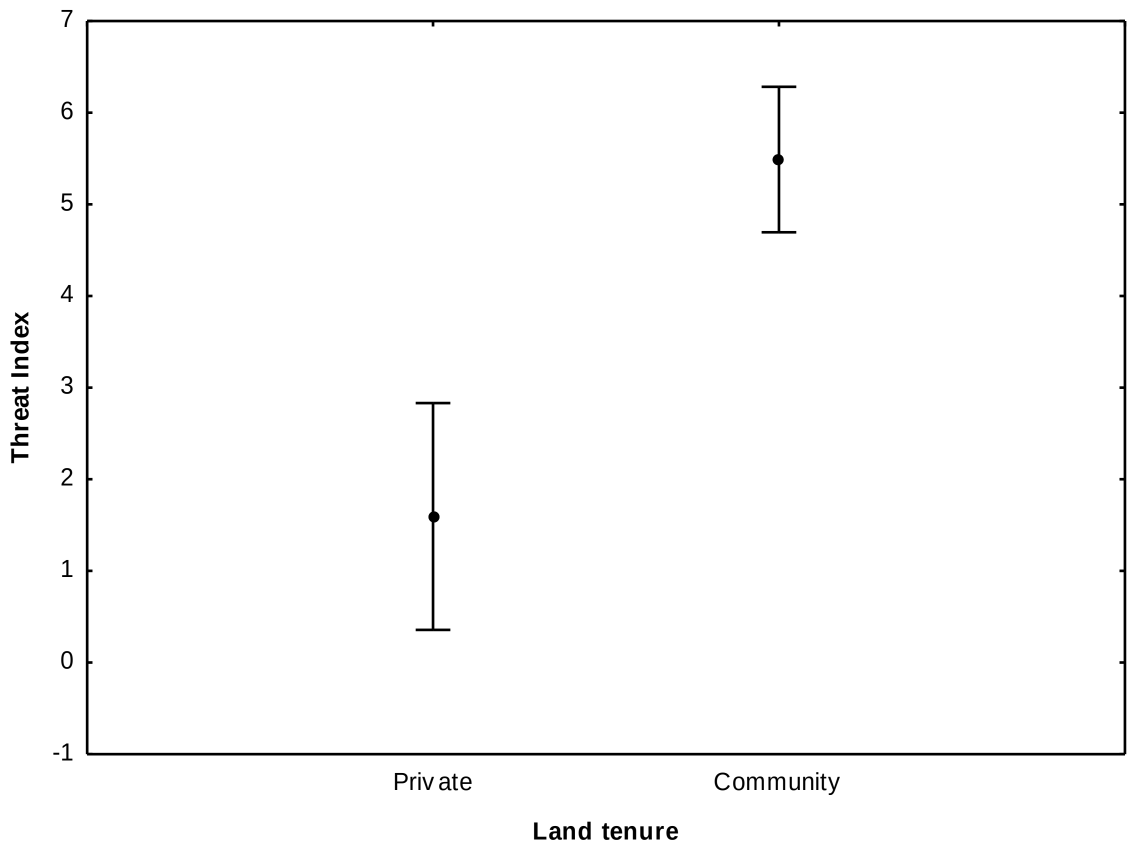

Figure 4.11: The land tenure (communal vs. private) of respondents around the Great Fish River Nature Reserve was significant in influencing their threat index scores ($F_{(1;116)} = 16.44$; $p < 0.05$). Vertical bars denote 0.95 confidence intervals.

Land use was the second-best predictor of threat index (an impact score of 0.87: Table 4.11). The effect of the land use and the respondent's threat index was significant ($F_{(3; 123)}$ = 3.75; $p < 0.05$). Properties that had no land use had the most positive index (5), followed by stock ranching properties (4.5; Figure 4.12). Crop farming properties had a threat index of two, while wildlife ranching properties had the poorest threat index (Figure 4.12). There was a significant difference in threat indices between wildlife ranching properties and those properties with no land use (Scheffe test, < 0.05). Differences between other land use types were not significant (Scheffe test, all cases, $p > 0.05$).

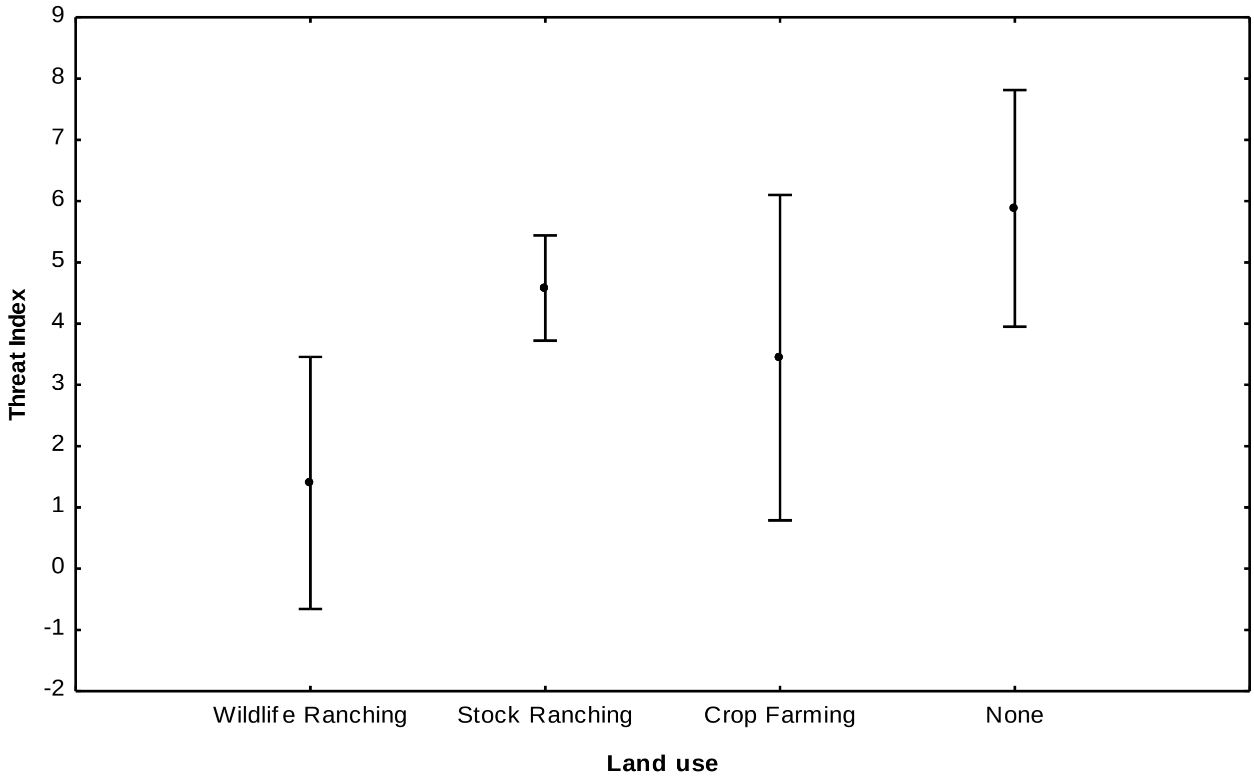

Figure 4.12: There was a significant relationship between the threat index of a respondent and the land use of their property ($F_{(3;123)}$ = 3.74; $p < 0.05$). Vertical bars denote 0.95 confidence intervals.

It was expected that if a property carried livestock or game, the respondents would have had a lower threat index than those without animals. However, despite respondents having livestock or game on their property, their threat indices were similar and the effect was insignificant ($F_{(1; 116)}$ = 0.05; $p > 0.05$). If a respondent had had previous problems with predators, their threat index tended to be more negative than those respondents who had no experience of problems with predators. However, this was not significant ($F_{(2; 116)}$ = 2.67; $p > 0.05$). Although the relationship between these variables was insignificant, their impact scores were high (Table 4.11). It was also found that if respondents experienced problems with poaching they tended to have more negative threat indices than those who had not experienced poaching ($F_{(1; 126)} = 19.82$; $p < 0.05$).

Husbandry Index

Sixteen percent of respondents do not kraal their livestock and 81 % of respondents practice kraaling. Eighty-three percent of domestic livestock owners take precautions against predators. Strategies include guard dogs (n = 45), having a full-time herder to watch them during the day (n = 52), or by using bells (n = 2). During the breeding season, 85 % of domestic livestock owners take extra precautions to protect their calves/lambs and new mothers. These methods include keeping the lambs/calves in kraals during the day and keeping the young close. Seventy-eight percent of respondents reported keeping records of all their livestock.

Respondents from communal areas generally had higher husbandry indices than private land owners, and this difference was significant ($F_{(1;115)} = 6.29$; $p < 0.05$; Figure 4.13). Private land respondents had an average index of one, while communal members had an index of three (Figure 4.13). Education levels ($F_{(1;115)} = 1.88$; $p > 0.05$), gender ($F_{(1;115)} = 0.32$; $p > 0.05$) and language ($F_{(1;115)} = 2.28$; $p > 0.05$) were not found to be significant in influencing the husbandry indices of respondents. Although husbandry indices generally increased with increasing age, they were distributed across all age groups. Age explained only 1 % of the variation in the husbandry index ($F_{(1; 128)} = 1.15$ $p > 0.05$; $r^2 = 0.013$). The threat index of a respondent did not have a significant effect on the respondent’s husbandry index, and explained only 0.02 % of the variation within the husbandry index ($F_{(1; 128)} = 0.02$ $p > 0.05$; $r^2 = 0.0002$).

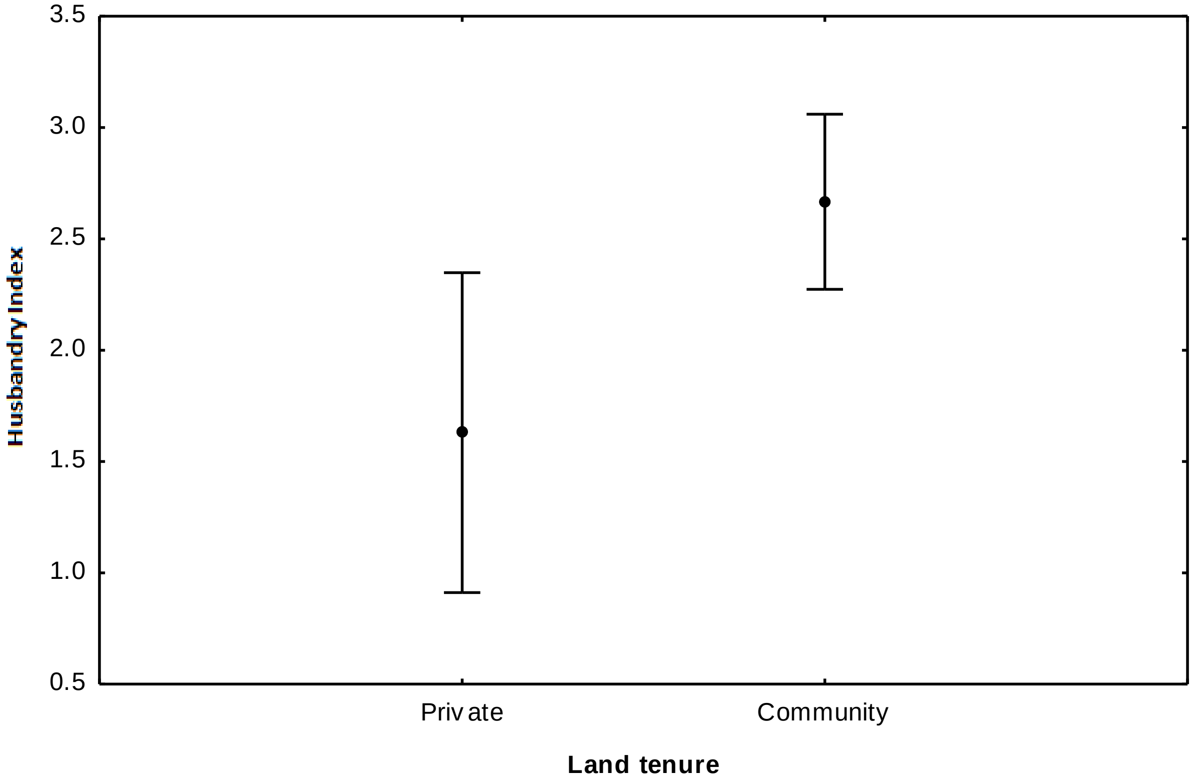

Figure 4.13: There was a significant relationship between the husbandry index of a respondent and the land tenure of their property ($F(1;115) = 6.29$; $p < 0.05$). Vertical bars denote 0.95 confidence intervals.

4.4. Discussion

4.4.1. Wild dogs and threats outside the reserve boundaries

Poaching and snaring are evidently severe problems around the reserve. This was significant in influencing a respondent's threat index: respondents who experienced snaring and poaching had more negative threat index scores. Snares are indiscriminate and are traditionally laid for bush meat (Woodroffe & Ginsberg 1999; Davies & du Toit 2004). Wild dogs are unintentionally caught in snares set on the boundaries of protected areas to capture ungulates for personal consumption or commercial sale (Woodroffe & Ginsberg 1999). For example, snaring is responsible for approximately 10 % of adult wild dog mortality in Hwange National Park, Zimbabwe (Davies & du Toit 2004). The risk of snaring events creates threats to wild dogs as the risk of mortality in snares is high (Woodroffe & Ginsberg 1999). To get into the reserve, poachers cut fence lines (Wato *et al.* 2006). This increases the likelihood of wild dogs escaping from the reserve and increasing the potential for vehicle collisions, persecution and disease transmission (Alexander & Appel 1994; Mills *et al.* 1998).

Wild dogs have had medicinal uses in many African cultures, and this can be a major threat to the survival of wild dogs in protected areas (Davies & du Toit 2004). For example, the ingesting of the teeth of wild dogs is believed to make human teeth stronger, wild dog fat treats tetanus and their faeces cure dizziness (Davies & du Toit). Ten community respondents in this study reported medicinal uses for wild dog products. Many species around the world are in rapid decline due to the preconceived notion that they are traditional medicine (Warchol *et al.* 2003). For example, the recent illegal trade in rhino horn for medicinal use in China, Japan and Vietnam has resulted in over 1000 white and black rhinos (*Ceratotherium simum* and *Diceros bicornis)* being poached in South Africa in less than a year (Warchol *et al.* 2003; IUCN 2013). While traditional uses were evident in the communal areas, poaching was localized and fairly small-scaled. As traditional uses for wild dogs were expressed by a few respondents (11 %) around the reserve, there is the possibility that deliberate snaring and poaching of wild dogs for consumptive products may occur. This constitutes an important potential threat to a reintroduced wild dog pack (Davies & du Toit 2004). While threats to wild dogs from the medicinal trade appeared to be low, there is risk that after the reintroduction occurs, this belief may grow and become a severe problem.

Another factor which may affect the persistence of wild dogs in the reserve is the risk of disease transmission (Alexander & Appel 1994; Kat *et al.* 1995). Most private and community respondents own domestic dogs. The interaction between unvaccinated domestic dogs from the communal areas and wild dogs within the reserve may be a potential threat. Four communities, all located near (< 5 km) the reserve, had respondents stating that their dogs were unvaccinated against rabies or canine distemper. As the community members often allow their dogs to roam freely, it is likely that there may be interaction between these unvaccinated dogs and reintroduced wild dogs. This increases the potential for the wild dogs to contract diseases from such interactions (Kat *et al.* 1995; Woodroffe 1999; Hofmeyr *et al.* 2004; Woodroffe *et al.* 2007). Wild dogs are known to be susceptible to diseases, particularly rabies and canine distemper virus (Creel & Creel 1998; Gusset *et al.* 2006; Prager *et al.* 2012). Both these diseases are contagious and are spread either by domestic dogs or natural canid wildlife (Alexander & Appel 1994; Kat *et al.* 1995). According to Davies and du Toit (2004) wild dog populations which are small and isolated and that occur close to human settlements (as the GFRNR population would be) are most at risk from disease outbreak.

There is a risk of persecution from respondents should wild dogs occur on their property (Lindsey *et al.* 2005; Anthony 2007). Predators are often killed pre-emptively as they are seen as liabilities to land owners, who incur financial losses when livestock is killed (Romañach *et al.* 2010). Tolerance of wild dogs among land owners seems to be positive, as only 9 % of respondents would harm wild dogs pre-emptively on their property. However, this tolerance would decrease if wild dogs harmed any livestock or game outside the reserve. Twenty-two percent of respondents would resort to killing wild dogs only after they killed livestock or game. Compensation payments do not always change livestock owners' willingness to coexist with predators (Gusset *et al.* 2009). However, most respondents in my study may be more tolerant of wild dogs occurring on their property, especially if some form of compensation was offered by the GFRNR for livestock/game lost. It is assumed that respondents would resort to persecution as they cannot afford more losses of stock as poaching and snaring is already costing income. Currently, several carnivores (such as black-backed jackal and caracal) around GFRNR are being heavily persecuted. Most respondents said that they would not do the same to wild dogs as they are endangered and need conserving whereas jackal and caracal are plentiful. However, persecution by land owners on unprotected land is the most critical threat that may face the GFRNR wild dogs should the reintroduction occur.

4.4.2. Socio demographic variables and threat index

Threats to wild dogs outside of the Great Fish River Nature Reserve appear to be relatively low (average threat index of 4; the most negative and highly threatening score would have been -16) although there are high levels of poaching and snaring. This is probably linked to the fact that tolerance of carnivores may be influenced by a variety of socio-economic factors such as education levels, age, cultural perspectives and/or personal values (Zimmerman *et al.* 2005).

My results indicate that most socio-demographic variables influenced the threat indices of respondents. However, results in this study did not concur with the literature. Education level is often found to be a highly significant predictor of attitudes and tolerance towards predators in general, with the “anti-predator” feeling decreasing with increasing education (Bath & Buchanan 1989; Anthony 2007; Schumann *et al.* 2012). Lagendijk and Gusset (2008) found that there was a strong link between education and attitudes, with better educated individuals showing a greater tolerance for human-carnivore coexistence. Bath and Buchanan (1989) found similar results, determining that increased education level positively related to willingness to restore wolves in Yellowstone National Park, USA. Higher education leads to an increased understanding of the ecological role of large carnivores and with that, an increased acceptance of predators and higher tolerance of them on their land (Zimmerman *et al.* 2005). However, while education was significant in influencing the threat index in my study, the opposite trend was observed. Educated respondents tended to have poorer threat scores and a decreased tolerance for wild dogs and other predators on their properties. In contrast to other studies (Bath & Buchanan 1989; Rodriguez *et al.* 2003; Anthony 2007), respondents with primary school education or less had the most positive threat indices. This could possibly be linked to the fact that most of these respondents came from rural communities who had not heard of wild dogs before the workshops were conducted. Therefore, it is possible that they had no preconceived misconceptions about wild dogs and were then more receptive to the potential reintroduction. Misconceptions about wild dogs could include: wild dogs kill more than they require, they terrorize their prey, they endanger human life and they will always kill livestock (Creel & Creel 2002; Lindsey *et al.* 2005; Nilsen *et al.* 2007; Anthony 2007). Increased education often results in improved knowledge of predators and because community respondents have had no prior knowledge of wild dogs, it is likely that they have no negative presumptions of these animals and were more interested in the reintroduction than more highly educated respondents (Bath & Buchanan 1989; Rodriguez *et al.* 2003; Schumann *et al.* 2012). However, the largest concern when using questionnaires is that of response bias (Gusset *et al.* 2008c). This is a type of cognitive bias where responders answer questions according to how they think the interviewer wants them to answer rather than according to their true beliefs. This problem may have probably occurred with community questionnaires and this may have lead to slightly exaggerated results where threats seem more positive than they are in reality.

The socio-demographic variables of age and gender had a significant effect on the threat indices of the respondents. Rodriguez *et al.* (2003) and Gusset *et al.* (2008c) found that these socio-demographic variables do not significantly influence attitude (and thereby tolerance and behaviour). However, Lindsey *et al.* (2005) and Zimmerman *et al.* (2005) identified that more negative attitudes and behaviour was found among older individuals and that women tended to be more negative than men. Women are generally more afraid of predator species than men, and when respondents were able to elaborate on various questions, women readily expressed more fear than men in terms of safety related to carnivores. This reflects an adaptation to an evolutionary role of females as the primary caretakers of young children who need protection against such predators (Kaltenborn *et al.* 2008). However, in my study, women tended to be more positive about the reintroduction of wild dogs to the reserve than men, but this difference was slight (men and women scored 4 and 2 respectively). Gender was assumed to be more significant but it is important to note that the sample size for males and females was skewed, with males comprising a total of 79 % of all of the respondents. Generally, men were the owners of the property and therefore elected to complete the questionnaires as they are more familiar with daily farm operations than women (Schumann *et al.* 2012).

It would have been encouraging to have observed more positive scores among younger respondents, as this would indicate that conservation and tolerance for predators might increase over time (Gusset *et al.* 2008c). This trend was evident where younger respondents tended to have more positive attitudes towards carnivores than older individuals in a study by Lindsey *et al.* (2005). However, in my study older individuals tended to be more positive about the possible reintroduction and have more positive threat indices. This could be closely tied with education levels, as younger respondents tended to have higher education levels (secondary and tertiary) and thus more negative indices and therefore less tolerance towards predators. However, this trend does highlight the importance for carnivore education/conservation programs in the area as tolerance will continue to decrease and thus create a greater threat for any possible carnivore reintroductions in the future in GFRNR (Gusset *et al.* 2008). Carnivore conservation programs can assist in improving tolerance through specific carnivore education.

Language was found to significantly influence the threat scores of respondents. IsiXhosa speakers had the most positive threat index (score of 6), followed by Afrikaans and English speakers (scoring 2 and 1 respectively). Language can be used as a proxy for culture and therefore it is apparent that the culture of the respondent may influence attitudes towards a species (Lindsey *et al.* 2005; Cocks *et al.* 2012; Schumann *et al.* 2012). Cultural beliefs and upbringing may have therefore influenced threat indices and respondents' feelings and opinions towards the possible wild dog reintroduction (Lindsey *et al.* 2005; Thorn *et al.* 2012). English and Afrikaans people, who have a long tradition with many generations of commercial farmers, tend to be less tolerant of predators on their property as they directly affect their economic livelihood (Lindsey *et al.* 2005; Thorn *et al.* 2012). A recent study by Cocks *et al.* (2012), found that isiXhosa people in the Eastern Cape have a strong sense of interconnectedness with nature, as biodiversity is linked to strong nature-based religious beliefs. For example, certain species are believed to be representatives of the ancestors while other species (such as wagtails - *Motacilla capensis*) bring luck and blessings from the ancestors (Cocks *et al.* 2012). Therefore, based on the intangible and long-standing cultural values that are attached to nature and biodiversity, isiXhosas have an innate need to conserve biodiversity and their natural surroundings (Cocks *et al.* 2012). This can allow cultural values to be incorporated into local conservation plans and in the local wild dog reintroduction.

Fear is possibly one of the single greatest factors that can influence the attitude and behaviour of people towards predators (Lagendijk & Gusset 2008). A study by Gusset *et al.* (2008c) found that misconceptions and perceptions concerning carnivores were more negative among the rural population around Hluhluwe-iMfolozi Park (KwaZulu-Natal), and were largely independent of the personal details of the participants. These misconceptions often fuel fear of a species and therefore make respondents less tolerant of predators on their land. Fear of a predator may often result in outwardly negative behaviour towards a species and may thus hinder conservation efforts (Gusset *et al.* 2008c). Nilsen *et al.* (2007) found in their study that a fear of wolves was a hindrance to reintroduction efforts as people who feared predators were more likely to disrupt the reintroduction and more readily resorted to persecution (Nilsen *et al.* 2007). Respondents fear may stem from poor knowledge of the wild dogs, their dangerous nature, responsibility for causing damage on livestock, their predatory and carnivorous nature or the possible anxiety of not knowing how to react when wild dogs are encountered (Nilsen *et al.* 2007).

4.4.3. Property variables and threat index

Land tenure (private or communal) of respondents was found to be a significant property variable influencing threat index. In general, rural communities, particularly those living adjacent to protected areas containing large carnivores, have traditionally regarded predators as a threat to their livestock or own lives (Gusset *et al.* 2008c). As a result, it was always assumed that people in rural settings have more negative attitudes and lower tolerances towards predators (Gusset *et al.* 2008c). However, this trend was not observed in my study. Private properties returned considerably more negative scores than rural community respondents (scoring 2 and 5 respectively). Rural communities are often poorly educated, have little livestock and little understanding of predators and therefore tend to have more negative behaviours and views of carnivores. While many of the communities surrounding the GFRNR have the same characteristics, their threat scores were actually lower than those of private land owners and they were more willing for the reintroduction to occur. It is likely that their lower levels of education may, in fact, have resulted in more positive scores. Because communal area respondents had not heard of wild dogs before the study and had no prior education of them, they had very few negative perceptions of them and more of an interest to reintroduce them. Communal area respondents were also more interested in seeing wild dogs than were private land owners. Land tenure also links very closely with language and culture of respondents. It was observed that all community members were isiXhosa, while private land owners were English and Afrikaans. This reinforces the possibility that culture may be playing a large role in influencing the threat index of a respondent.

Poaching, predator control and snaring strongly influenced the scores of respondents. Generally, communities around the reserve did not frequently practice predator control, and as a result this improved their scores. By contrast, most private land owners had large numbers of game or livestock and experienced poaching and snaring which resulted in more negative threat scores. Private land owners use their game or livestock for economic purposes, and coupled with levels of poaching and snaring, land owners were unwilling to risk losing more animals to a newly reintroduced predator (Nilsen *et al.* 2007). Communal area respondents were less negative about wild dogs occurring on their land. Most private land owners were likely to shoot wild dogs on their land, while community respondents would generally call reserve managers in order for them to remove the wild dogs. This reaction also influenced the threat index of respondents; those willing to cooperate had more positive scores than those respondents whose reaction would be to kill them.

Conflicts between humans and free-roaming predators are the product of socio-economic value because the resources involved (e.g. livestock) have high monetary value and can directly affect human livelihoods (Thavarajah 2008). In particular, it is thought that livestock farmers generally have more negative attitudes towards predators as they prey on their livestock and directly affect their livelihoods (Thavarajah 2008). The effect of land use on threat index was significant. Properties with no domestic livestock or wild game, had the most positive threat index (a threat index of 6) as they would not experience any impact from reintroduced wild dogs. Stock ranchers had the second lowest index (5). It was expected that stock farmers would have had more negative indices than wildlife ranchers as livestock farming is often less profitable than game ranching and thus financial impact of predation is higher (Thorn *et al*. 2012, 2013). However, livestock farmers may have been more positive as predation on livestock may be prevented by using effective husbandry techniques (such as stop collars, livestock camps; Gusset *et al.* 2008c). Livestock is also easier to manage as they can be easily contained in camps and there is limited threat of them breaking out (Gusset *et al.* 2008c). Wildlife ranchers are unable to effectively contain their game within camps as ungulates (such as kudu) are able to jump over camp fences. Wild game is also very expensive, and the loss of one individual to an unwanted prey species often has high impact (Gusset *et al.* 2008c). Thus wildlife ranchers had the most negative threat score of all the land users. Unexpectedly, crop farmers had the third most negative score. As crop farmers experience very limited losses to predation (as they generally do not have any livestock or game to lose) it was expected that they would have the lowest threat score as a wild dog reintroduction would not affect them economically. It is likely that crop farmers' threat indices were negatively affected because of fear towards wild dogs and the high levels of poaching and snaring in the area. To decrease persecution and other threats, suitable mitigation strategies can be implemented to reduce the threats to wild dogs on unprotected property.

4.4.4. Mitigation strategies to decrease threats to wild dogs and improve predator tolerance outside of the Great Fish River Nature Reserve

Gusset *et al.* (2008c) found that respondents' views of wild dogs, especially rural people, were undermined by misconceptions and fear. Therefore the first, and potentially the most crucial strategy, should be education programs that aimed at increasing land owner tolerance and acceptance of carnivores in their area (Lindsey *et al.* 2005c; Gusset *et al.* 2008c). These conservation education programs should also aim to dispel misconceptions of wild dogs, including their threats to humans and livestock and medicinal uses, address concerns of fear, monetary losses and encourage increased co-operation with reserve staff (Rodriguez *et al.* 2003; Lindsey *et al.* 2005c). It was evident from community workshops held in May, that communities are eager to learn more about wild dogs. Most community members were genuinely interested in hearing about wild dogs and were excited by the opportunity to see them. Conflict mitigation strategies should be directly aimed at increasing tolerance of carnivores and should focus on younger Afrikaans and English speakers (Thorn *et al.* 2012). These types of educational conservation programs have been successful in improving knowledge and tolerance towards wild carnivores (Gusset *et al*. 2008c; Whittington-Jones 2011). Gusset *et al.* (2008c) illustrated that the carnivore education program around Hluhluwe-iMfolozi Park created more favourable perceptions of wild dogs among respondents. However, as the program was short-term, these perceptions did not endure. Five years later, respondents were again negative towards wild dogs (Gusset *et al.* 2008c).

To reduce the risk of disease transmission from domestic to wild dogs, the reserve can encourage the Department of Agriculture to vaccinate local domestic dogs, especially those communities with dogs close to the reserve (Woodroffe 1999). The wild dogs reintroduced into the reserve should also be adequately vaccinated against diseases. While rabies may not be especially common in the Eastern Cape, canine distemper has regularly occurred (Bissett 2004; Hayward *et al.* 2007b). Kwandwe Private Game Reserve (opposite the GFRNR) reintroduced wild dogs in 2005 and by August 2006 the entire pack, except the alpha pair, had been eliminated by canine distemper virus (Bissett 2008). Multiple vaccination against rabies has proven to be effective in protecting wild dogs against rabies, as proven by the Madikwe wild dogs (Hofmeyr *et al.* 2004).

To reduce wild dog mortality caused from snaring events, wild dogs can be fitted with anti-snare collars (Leigh 2002; Davies & du Toit 2004). These collars have stainless steel plates with protruding rivets fitted to the collar (Leigh 2002). As wild dogs typically catch snares around their neck, the purpose of this collar is to trap the wire snare in the rivets on the collar, thus protecting the neck (Leigh 2002). The snare can later be removed (Leigh 2002). Each collar is custom-fitted to the appropriate neck size for each individual (Leigh 2002). Through increased anti-poaching patrols (especially on reserve boundaries), mortalities of wild dogs to poachers and snaring can be minimized (Stuart *et al.* 1985; Mills *et al.* 1998; Davies & du Toit 2004; Woodroffe *et al.* 2007). Anti-poaching teams should also regularly patrol fence lines to clear any snares that may be set along reserve boundaries (Mills *et al.* 1998; Leigh 2002; Woodroffe *et al.* 2007). This will decrease the possibility of wild dogs (and other game) being caught in them (Leigh 2002). Close monitoring of the wild dog pack will also promote early detection of snared dogs. If injured dogs can be treated and rescued sooner, it will increase survival.

Another strategy that could be implemented to reduce the potential conflict between wild dogs and land owners would be to implement a compensation scheme for wild or domestic livestock killed by wild dogs (Bath & Buchanan 1989; Rodriguez *et al.* 2003; Nilsen *et al.* 2007). Compensation schemes, if implemented correctly and effectively, have the ability to help land owners overcome losses and anger and to prevent retaliation towards predators (Nyhus *et al.* 2003; Rodriguez *et al.* 2003). A study by Rodriguez *et al.* (2003) found that 50 % of respondents who were against the relocation of wolves to Yellowstone National Park would change their opinion if a compensation program was implemented to reimburse land owners who lose stock to wolves. Implementing this strategy reduced the number of pre-emptive killing of carnivores as losses can be replaced and no economic loss will occur (Nilsen *et al*. 2007). However, compensation schemes bring many challenges (Nyhus *et al.* 2003; Rodriguez *et al.* 2003). One of the most critical compensation challenges is the lack of evidence proving a predator killed/injured private livestock/game (Nyhus *et al.* 2003). Lack of evidence supporting an individual's claim for compensation can often prevent compensation being awarded. Unjust award for stock that was not lost to predators can also prevent the success of a compensation scheme (Nyhus *et al.* 2003). It is recommended that the GFRNR wild dogs be suitably collared (preferably GPS/VHF satellite collars) and regularly tracked (Mills *et al.* 1998). If a claim for compensation is submitted, the wild dog's presence on that property can be verified by confirming their recent movements (Mills *et al.* 2002). The costs of maintaining compensation schemes are often very expensive. A non-governmental organization (NGO) in India, spends US$160 00 annually for a tiger and leopard compensation scheme, a snow leopard (*Panthera uncia*) compensation scheme in Pakistan spends US$2000 annually and in Switzerland, the government compensates for all carnivore damage and spends approximately US$30 000 annually (Nyhus *et al.* 2003). The core elements of a successful compensation scheme are: (1) quick and accurate verification, (2) prompt and fair payments, (3) sufficient and sustainable funds and (4) clear rules and guidelines (Nyhus *et al.* 2003). In addition, before the wild dogs are reintroduced, it is crucial that the reserve sets up a predator secured perimeter fence (Mills *et al.* 1998). Perimeter fences, if they are adequately constructed and maintained, could prevent wild dogs from straying onto neighbouring land and thus coming into potentially fatal contact with humans (Hayward *et al*. 2007b; Lindsey *et al*. 2005).

Implementing the aforementioned mitigation strategies has the potential to substantially reduce the severity and the number of threats to wild dogs on unprotected land and along reserve boundaries. If this occurs the likelihood of a successful reintroduction is greatly increased (Mills *et al.* 1998; Woodroffe & Ginsberg 1999; Woodroffe *et al.* 2007).

4.4.5. Conclusion

Generally, most respondents were positive towards the possible reintroduction of wild dogs and would be willing to cooperate should wild dogs disperse from the reserve. The average threat index achieved by all respondents was 4; a positive score indicating some threats to wild dogs. However; these threats do need to be addressed.

IUCN reintroduction guidelines (2012) require that before a reintroduction of a species is going to occur into their former range, the previous causes of extirpation must be identified and significantly reduced. Threats facing wild dogs on adjacent lands have now been identified and suitable mitigation to prepare for the reintroduction can now occur. While the community and private land owners could pose a threat to the GFRNR wild dogs, these threats can be addressed through mitigation before, during and after the reintroduction. These mitigation strategies could include compensation schemes (especially for poorer rural communities), annual vaccination campaigns to inoculate domestic dogs around the reserve and the reserve wild dogs themselves and upgrading fences and conducting carnivore conservation education programs (Mills *et al.* 1998; Leigh 2002; Nyhus *et al.* 2003; Hofmeyr *et al.* 2004; Gusset *et al.* 2009; Schumann *et al*. 2012).

There will always be the potential for conflict wherever humans and wildlife interact, but with suitable conservation education and increased tolerance from land owners, this conflict can be significantly reduced. Snaring, poaching and unvaccinated dogs did occur along reserve boundaries, but with suitable planning, these threats can be minimized. Although these threats for wild dogs were present around the reserve; they can be addresses with public cooperation and fostering a good relationship between reserve staff and local land owners (both private and communal). This will increase the likelihood of reintroduction of being successful.

The reintroduction of wild dogs into the GFRNR has the potential to generate income for the reserve through tourism, assist the local community by providing more jobs (trackers, rangers, wild dog monitors, anti-poaching teams) and more importantly, assist the metapopulation strategy for conserving wild dogs in South Africa.

CHAPTER 5: Synthesis

5.1. Introduction

My study was carried out to determine the long term (~25 years) feasibility of a wild dog reintroduction to the GFRNR in the Eastern Cape, South Africa. This included: i) biological modelling which determined the ability of the reserve to sustain a wild dog population and ii) determining the potential anthropogenic threats surrounding the reserve that could threaten the survival of the population. In this final chapter I summarize the key findings of my research and outline some important recommendations with respect to a wild dog reintroduction.

5.2. Biological requirements of wild dogs in the GFRNR

My results show that the GFRNR has adequate prey populations to sustain a small (< 22) wild dog population. Generally wild dogs tend to prey on animals in relation to their abundance (Estes & Goddard 1967; Hayward *et al.* 2007c). I therefore expect that kudu (*Tragelaphus strepsiceros*) and bushbuck (*Tragelaphus scriptus*) will be the most preyed upon species in the reserve. According to prey mapping, it is likely that the wild dogs will prefer areas in the north-west section of the reserve post reintroduction, as well as the Andries Vosloo section in the south-west.

According to my wild dog population modelling, two suitable management strategies can be offered to ensure the long term persistence of a reintroduced wild dog population. These strategies were offered to compensate for the dynamic nature of wild dogs, as well as their large litter sizes (Creel & Creel 1991). The first scenario was run in VORTEX with a carrying capacity of 11 wild dogs. An initial population size of four males and four females supplemented with one male and one female in years 2, 6, 11 and 18, and one male and one female being removed from the population every 10 years, resulted in a population with a 100 % chance of persistence. The same level of persistence, yet with a higher genetic diversity, was observed when the initial population consisted of six females and four males (with a carrying capacity of 22). In this scenario, supplementation of one female and two males needed to be carried out in years 3, 10, 15 and 23, and harvesting of one male and one female needed to occur at years 10 and 20. Regular supplementation and harvesting should be carried out to ensure that the wild dog population is both genetically and demographically viable (Mills *et al.*1998; Bach *et al.* 2010).

5.3. Conservation incorporating neighbouring land owners and local communities

Anthropogenic threats occurring along the GFRNR boundaries can have negative consequences for reintroduced wild dogs (Woodroffe *et al.* 2007). Threats identified around the reserve include poaching (around the reserve) and unvaccinated domestic dogs which could carry diseases (particularly along the eastern boundary). If the wild dogs manage to disperse onto adjoining land outside of the reserve, these risks are amplified (Lindsey *et al.* 2004b). Significantly, conflict between land owners and wild carnivores arises when land owners feel that either their livestock or their own lives are threatened (Gusset *et al.* 2009). When a carnivore kills livestock the land owner loses income and this often triggers the pre-emptive killing of carnivores (Butler 2004; Gusset *et al.* 2009) and this may be a potential scenario should reintroduced wild dogs disperse out of the GFRNR.

Results of my study indicate that private properties are largely in favour of the reintroduction of wild dogs. All private land owners would be willing to call the reserve and assist if the wild dogs broke out onto their property. However, most respondents from local communities would resort to killing the animal (n = 40), chasing the animal away (n = 12) or just leaving it alone (n = 7). Nevertheless, while most (n = > 80) rural community respondents had not heard of wild dogs prior to my study, all expressed interest in hearing and learning about them. Local community members were excited by the prospect of seeing these animals in a reserve so close to their homes. In addition, many expressed the desire for their children and grandchildren to get the oppourtunity to see them. However, there are still concerns on local community land. The main concerns included unintentional snaring of wild dogs (from snares intended for bushmeat), and persecution of wild dogs (Wato *et al.* 2006; Woodroffe *et al.* 2007; Gusset *et al.* 2009; Thorn *et al.* 2012). These potential threats need to be adequately managed to prevent the loss of individual wild dogs from the population.

5.4. The reintroduction into GFRNR

To ensure that the reintroduction of the wild dogs is as successful as possible, there are five aspects of the actual reintroduction that need to be considered.

Firstly, wild dogs are susceptible to diseases, in particular rabies and canine distemper virus (CDV), because they are social, low density animals (Creel & Creel 1998; Gusset *et al.* 2006; Prager *et al.* 2012). A protocol for vaccination against such diseases needs to be carried out (Kat *et al.* 1995; Mills *et al.* 1998; Hofmeyr *et al.* 2004). Wild dogs should be vaccinated at least twice, as a single vaccination is not sufficient to keep the animals protected (Hofmeyr *et al*. 2004). Multiple vaccinations against rabies have been shown to be more effective in protecting wild dogs than single vaccination techniques (Hofmeyr *et al.* 2004). The vaccine can be administered either by hand or by dart gun (Mills *et al.* 1998). The latest technique is via an oral vaccine which is effective at stimulating neutralising antibodies (Hofmeyr *et al.* 2004). A benefit of oral vaccination is that if it is done during denning it can improve the vaccination coverage of all members of pack, including pups (Hofmeyr *et al.* 2004).

The release strategy for wild dogs into the GFRNR needs to be carefully planned, and a suitable boma should be available (Mills *et al.* 1998). Release strategies are intended to facilitate acclimatisation and are often termed 'soft releases' (Armstrong & Seddon 2008). Wild dogs should be kept in the boma to familiarise the animals with the surrounding area, terrain and weather (Armstrong & Seddon 2008). The boma itself should be approximately 100 m x 100 m in size and should have areas of shade and adequate water (Lines 2004). Lines (2004) suggests erecting a corridor and corner camp inside the boma where the pack can be fed. This allows old carcasses to be removed without entering the main boma (Lines 2004). Monitoring is essential while dogs are in the boma as this is the period where dominance hierarchies will be established (Lines 2004). The success of the release depends on the establishment of a hierarchical system amongst the dogs (Mills *et al.* 1998; Courchamp & Macdonald 2001) and release should not occur until this has been established (Lines 2004). The location of the boma within the reserve also needs to be carefully considered. It is suggested that the release boma should not be within the Andries Vosloo area of the reserve as this area has high risk of fence-line hunting due to its narrow and enclosed shape. An ideal location may be nearer to the central area of the reserve where prey is abundant and away from fences.

While wild dogs are in the boma it is beneficial to condition them to a distinctive sound (the sound of a whistle or hooting of a vehicle) (Dell, S. 2013. pers. comm.). Generally, while wild dogs are in the boma, feeders should give a distinctive, recognizable sound before feeding. In the event that wild dogs disperse onto adjoining land, the same sound can be played and the wild dogs will move in the direction of the sound (Dell, S. 2013. pers. comm.). This allows relocation of dogs back into the reserve to be as efficient as possible (Dell, S. 2013. pers. comm.). This was done effectively in the Pilanesberg National Park, North-West Province (Dell, S. 2013. pers. comm.). Wild dogs should also be habituated to reserve vehicles to allow monitoring teams to get close to them (either to dart them or to monitor them; Lines 2004).

Another crucial aspect is the fencing around the reserve itself. To minimize human-wildlife conflict, wild dogs should not be allowed to disperse onto adjoining unprotected land (Thorn *et al.* 2013). Predator- proof fencing is generally made from steel, 2.4m high and folded over on the ground towards the inside for 50 cm at least (Mills *et al.* 1998; Lines 2004). To prevent animals digging out under the fence, rocks should be packed onto the folded fence (Lines 2004; Dell, S. 2013. pers. comm.). The fence should be electrified with at least three live strands on the lower half of the fence (Lines 2004).

While initial pack demographics were determined from VORTEX, it is still important to consider the source population of the reintroduced packs (Mills *et al.* 1998). Wild dogs are difficult to source from the wild because of their endangered status (Lines 2004). However, captive- bred animals may be a reliable source for reintroduction (Mills *et al*. 1998; Hofmeyr *et al.* 2004; Gusset *et al.* 2006). The introduction success prospects of wild dogs will be greatly enhanced if wild-caught animals are used in combination with captive- raised individuals (Hofmeyr *et al*. 2004). These types of pack combinations have been successful in the past. In Madikwe Game Reserve (North-West Province), for example, three captive-born females were grouped with three wild-caught males in a boma (Hofmeyr 2004). The group formed a coherent pack that, after being released, hunted and bred successfully (Hofmeyr 2004; Lines 2004).

5.6. The bigger picture: South Africa's wild dog metapopulation

A Population and Habitat Viability Assessment for wild dogs resulted in the conservation action plan for wild dogs in southern Africa, part of which included protecting and enlarging existing wildlife areas having the potential to support wild dog populations (Mills *et al.*1998). Since there are no additional protected areas in South Africa that are large enough to sustain viable wild dog populations, recent wild dog conservation efforts have concentrated on establishing a managed metapopulation (Lindsey *et al.* 2004a; Davies-Mostert *et al.* 2009). Currently, South Africa's wild dog metapopulation consists of 17 packs in eight reserves (Davies-Mostert *et al.* 2009; WAG-SA Minutes 2013). This management approach involves the periodic translocation of individuals among packs from different reserves to mimic natural dispersal and to promote gene flow (Gusset *et al.* 2006; Gusset *et al.* 2008b; Davies-Mostert 2010). Genetic bottle-necking of individuals in the sub-populations is thus prevented (Mills *et al.* 1998). The addition of the GFRNR to the metapopulation can further improve the conservation of wild dogs in South Africa by offering more individuals into the system. Currently, South Africa has approximately 420 individual wild dogs (WAG-SA Minutes 2013; 2014), and an additional reserve would increase the number of wild dogs in this wild population. An additional reserve has the potential to increase overall genetic diversity in the population (Mills *et al.* 1998). This is beneficial as it improves the overall metapopulation viability and its ability to adapt and resist to environmental changes (Mills *et al.* 1998; Soule *et al.* 2003).

The vision of the "South African National Action Plan for Wild Dogs" is to secure viable populations of wild dogs within a matrix of land uses that contribute to ecosystem integrity, which coexist with, and are valued by, the people of South Africa (Lindsey & Davies-Mostert 2009). Reintroducing wild dogs into the GFRNR can help promote this vision. As there are currently no wild dog holding reserves in the Eastern Cape, the GFRNR can serve as a platform from which to educate and create awareness in the area for this endangered carnivore.

CHAPTER 6: References

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Appendix A: Vortex Simulations for K = 11 and K = 22

Table 1: VORTEX simulations for wild dogs

	Initial Pop		Management	
	M	F	Supplementation	Harvesting
Run 1	K = 11 (Initial population sizes 6 and 8)			
Run 2	5	1	-	-
Run 3	4	2	-	-
Run 4	3	3	-	-
Run 5	2	4	-	-
Run 6	1	5	-	-
Run 7	7	1	-	-
Run 8	6	2	-	-
Run 9	5	3	-	-
Run 10	4	4	-	-
Run 11	3	5	-	-
Run 12	2	6	-	-
Run 13	1	7	-	-
Run 14	4	4	1M; 1F every 5 yrs	1M; 1F every 10 yrs
Run 15	4	4	2M; 1 F every 5 yrs	1M; 1F every 10 yrs
Run 16	4	4	1M; 1F every 5 yrs	1M; 1 F every 5 yrs
Run 17	4	4	1F every 5 yrs	1M; 1F every 5 yrs
Run 18	4	4	2M; 1 F every 5 yrs	1F every 10 yrs
Run 19	4	4	1M; 1F at yrs 3,7,10,14,16,18,24	1M; 1F every 10 yrs
Run 20	4	4	1M;1F at yrs 2,6,11,18	1M;1F every 10 yrs

	Initial Pop		Management	
	M	F	Supplementation	Harvesting
Run 1	K = 22 (Initial population sizes 10 and 15)			
Run 2	9	1		
Run 3	8	2		
Run 4	7	3		
Run 5	6	4		
Run 6	5	5		
Run 7	4	6		
Run 8	3	7		
Run 9	2	8		
Run 10	1	9		
Run 11	14	1		
Run 12	13	2		

Run 13	12	3		
Run 14	11	4		
Run 15	10	5		
Run 16	9	6		
Run 17	8	7		
Run 18	7	8		
Run 19	6	9		
Run 20	5	10		
Run 21	4	11		
Run 22	3	12		
Run 23	2	13		
Run 24	1	14	Supplementation	Harvesting
Run 25	4	6	1M; 1F every 10 years	1M; 1F every 10 years
Run 26	4	6	2M; 1F every 5 years	1F every 10 years
Run 27	4	6	1M; 1F every 5 years	None
Run 28	4	6	2M; 1F at years 3,8,12,15,18,23,25	1M; 1F every 10 years
Run 29	4	6	2M; 1F at years 3,10,15,23	1M; 1F every 10 years
Run 30	4	6	1M; 1F at years 4,8,12,16,20,24	2M; 1F every 10 years

Appendix B

GREAT FISH RIVER NATURE RESERVE WILD DOG REINTRODUCTION PROJECT

Date/ Umhla:	Time/Ixesha:	Interviewer/Oqhuba udliwano-ndlebe:
Property/farm name or community/village/: Umhlaba/igama lefama okanye ingingqi/ilali:		
Community/private: Ingingqi:		Location of interview/: Indawo ekuqhutywa kuyo udliwano-ndlebe
Please indicate your property on the map/: Nceda ubonise umhlaba wakho emephini		

Section A: Property characteristics and livestock/game information
Icandelo A: Iimpawu zomhlaba nolwazi ngemfuyo/izilwanyana zasendle

1. Land use on your property (private land) or in your immediate area (communal area) (Please circle the activity(ies) that take place on your property)/
Ukusetyenziswa komhlaba yakho (kumhlaba wabucala) okanye kwindawo ohlala kuyo (indawo yoluntu) (Nceda ubiyele okwenzeka kumhlaba wakho):

Stock ranching/ Ifama yemfuyo: [ ] Sheep/Igusha [ ] Goats/Iibokwe [ ] Cattle/Iinkomo	Crop farming (commercial)/ Ifama yezityalo (ukulungiselela urhwebo):	Wildlife ranching/ Ifama yezityalo (ukulungiselela urhwebo): [ ] Live game sales/ Intengiso yezilwanyana zasendle [ ] Culling/Uncipiso ngokuzixhela	Other/ Ezinye:
	Crop farming (subsistence)/ Ifama yezityalo (ukulungiselela ukutya/ukuziphilisa):	Hunting/ Ukuzingela: [ ] Local/ Kwimida yeli [ ] International/Kwamanye amazwe	
		Ecotourism	

2. Out of the activity(ies) listed above, which one is your main source of income (i.e. which brings in the most money)?/
Kulo msebenzi okanye kule misebenzi idweliswe ngasentla, ngowuphi ongowona uzuza kuwo (oko kukuthi owona uza nemali/nengeniso eninzi)?______________________________

3. for private land - Size of the property in hectares/ Kumhlaba wabucala – Ubungakanani bomhlaba ngokwe akile____

4. Is this property perimeter fenced? Yes:______ No:______ A combination:_______ Don't know:______
Ingaba le umhlaba ibiyelwe ngokweeperimitha? Ewe:______ Hayi:______ Zenziwe zombini:_______ Andazi:______

Please specify Nceda unike iinkcukacha:

1.4 m fence with no mesh/ Nge-1.4 m yocingo olungenamingxuma	1.4 m fence with mesh/ Nge-1.4 m yocingo olunemingxuma	2.4 m game fence without mesh/ Nge-2.4 m yocingo lwezilwanyana zasendle olungenamingxuma	2.4 m game fence with mesh/bonnox/ Nge-2.4 m yocingo lwezilwanyana zasendle olunemingxuma/BONNOX	Other: Enye:
Notes:				

Is it electrified: Yes:______ No:______ How many strands??_________________________________
Ingaba lifakwe umbane: Ewe:______ Hayi:______ Ziilayini zocingo ezingaphi?______________________

5. If you are a private land owner, have you got a certificate of adequate enclosure (CAE)?
Ukuba ungumnikazi womhlaba wabucala, ingaba unawo amaphepha mvume sokubiyela ngokufanelekileyo (certificate of adequate enclosure (CAE)?____

6. Do you own any livestock? Yes:______ No:______
Unayo imfuyo eyeyakho? Ewe:______ Hayi:______

7. If yes please specify what kinds of livestock and/or game are on your property and how many? (If numbers are unknown then just tick)
Ukuba kunjalo nceda uxele ukuba zeziphi iindidi zemfuyo kunye/okanye izilwanyana zasendle ezikumhlaba wakho kwaye zingaphi? (Ukuba

Stock Imfuyo	Cattle Iinkomo	Sheep Iigusha	Goats Iibhokhwe	Donkeys Iidonki	Horses Amahashe	Pigs Iihagu	Other Ezinye	Don't Know\ Andazi	None Ayikho

Quantity **Ubuninzi**									

Please specify what game occurs on your property (private land) or in your immediate area (communal land)

Nceda uxele ukuba zeziphi izilwanyana zasendle ezifumaneka kumhlaba wakho (kumhlaba wabucala) okanye kwindawo ohlala kuyo (kumhlaba woluntu)

Game **Izilwanyana zasendle**	Impala Impala	Kudu Iqhude	Bushbuck Imbabala	Warthog Inxakhwe	Blue Wildebeest Inkonkoni	Red Hartebeest Ixhama	Nyala
Quantity							
Game **Ubuninzi**	Waterbuck	Blesbok	Zebra Iqwarhashe	Buffalo Inyathi	Other Ezinye	Don't know Andazi	None Azikho
Quantity							

8. If you are a livestock or game farmer please rate the significance of the following factors on a scale of 1 – 5:

Score significance: 1 – 5 where: 1 = no problem, 3 = occasional problem, 5 = Major problems

Ukuba ungumfama wemfuyo okanye izilwanyana zasendle nceda ulinganise ubuninzi kwezi zinto zilandelayo kwisikali esingu-1 – 5:

Intsingiselo yamanqaku: 1 – 5 apho: 1 = akho ngxaki, 3 = ingxaki ngamaxesha athile, 5 = Iingxaki ezinkulu

Disease Isifo	Drought Imbalela	Insufficient browsing/grazing Ukungoneli kokutya	Parasites Iincukuthu	Predators Amarhamncwa	Theft Ubusela	Road kill Ukufa ezindleleni	Other Ezinye

Section B
Icandelo B

	General questions		
9. Had you heard of wild dogs before today? Wakhe weva nge Xhwili ngaphambili?	Yes	No	Maybe
10. Are you in favour of re-introducing wild dogs to GFRNR? Ingaba uyakuxhasa ukwaziswa kwezizinja zasendle kwi-GFRNR? a) What are your reasons for being in favour of re-introducing wild dogs to GFRNR? Zithini izizathu zakho zokuba uxhase oku kukwaziswa kwezinja zasendle kwi-GFRNR? Elaborate	Yes	No	Maybe

Cacisa:____ ____ ____ b) What are your reasons for being against the re-introducing of wild dogs to GFRNR? Zithini izizathu zakho ezibangela ukuba uchase ukwaziswa ngokutsha kwezinja zasendle kwi-GFRNR? Elaborate:____ Cacisa____ c)If you are against the reintroduction, is there anything that would change your mind? Ukuba uyaluchasa ulwaziso lwezizilwanyana, ingaba ikhona into engatshintsha ingqondo yakho ____			
11. Do you think the reintroduction of wild dogs into GFRNR will negatively impact you in any way? Ucinga ukuba ukwaziswa kwezinja zasendle kwi-GFRNR kuya kuba nempembelelo embi kuwe nakanjani?	Yes	No	Maybe
12. Do you think the reintroduction of wild dogs into GFRNR could benefit you in any way? Ucinga ukuba ukwaziswa kwezinja zasendle kwi-GFRNR kungakwenza uzuze nakanjani?	Yes	No	Maybe
13. Would you be afraid of wild dogs? Uyakuzoyika ezizinja zasendle?	Yes	No	Maybe
14. Would you expect compensation for damages caused by escaped wild dogs? If so, who do you expect to pay: Ingaba uyakulindela imbuyekezo ngeengozi ezenziwe zizinja zasendle? Ukuba kunjalo, ulindele ukuba kuhlawule bani:	Yes	No	Maybe
15. Do you think wild dogs should be conserved/protected? Ucinga ukuba izinja zasendle zimele kukulondolozwa/zikhuselwe?	Yes	No	Maybe
16. Do you think your neighbours will be in favour of the reintroduction? Ucinga ukuba abamelwane bakho bayakuluxhasa olu lwaziso	Yes	No	Maybe

lwezizinja.			
17. Have wild dogs have been a part of your traditional history, traditional medicine or occur in your traditional stories? Ingaba izinja zasendle zakhe zayinxalenye yembali yakho yesiNtu, amayeza esiNtu okanye zafunyaniswa kumabali wakho wesiNtu? Explain: Cacisa:	Yes	No	Maybe

Section C: Livestock Management (Livestock owners only)
Ulawo lweMfuyo (Abanikazi bemfuyo kupela)

	Livestock Only		
18. Do you kraal your animals? If so, when? Uzivalela ebuhlanti izilwanyana zakho? Uba kunjalo, nini?	Yes	No	Maybe
19. Do you take precautions to protect your livestock against predators? Uyawathatha amanyathelo ukukhusela imfuyo yakho emarhamncweni? Elaborate /Cacisa:	Yes	No	Maybe
20. Do you use extra protection methods to protect mothers and offspring during birthing seasons? Ingaba usebenzisa iindlela zokhuselo ezimandla ukukhusela oomama nenzala yabo ngamaxesha okuzala? Elaborate: Cacisa:	Yes	No	Maybe
21. Do you keep written records of the number of livestock that you have? Uyayigcina ingxelo ebhalwe phantsi yenani lemfuyo onayo?	Yes	No	Maybe

Section D: The Great Fish River Nature Reserve IcandeloD:GFRNR	**Great Fish River Nature Reserve**		
22. Have you ever visited the GFRNR? If not, why? Ingaba wakhe watyelela e-GFRNR? Ukuba akunjalo, kutheni?	Yes	No	Maybe
23. Would you be more inclined to visit the GFRNR if they had wild dogs? Bungathanda ukutyelela e-GFRNR ukuba bebenezinja zasendle?	Yes	No	Maybe
24. Do you have a good working relationship with the GFRNR Management?	Yes	No	Maybe

Unobudlelwane bokusebenza obuhle nabaLawuli base-GFRNR?			
25. Do you think it is important to have areas like the GFRNR where plants and animals are protected and conserved? Ucinga ukuba kubalulekile ukuba kubekho iindawo ezifana ne-GFRNR apho izityalo nezilwanyana zikhuselweyo kwaye zilondoloziweyo?	Yes	No	Maybe

Section E: Threats

	Threat Questions		
26. Do you currently have any problems with predators on your land? If so, which predators: Ingaba unengxaki namarhamncwa emhlabeni wakho? Ukuba kunjalo, ngawaphi la marhamncwa: (*See attached for photo card*)/*Jonga ifoto elincanyatiselweyo*	Yes	No	Maybe

Leopard Ingwe	Jackal Udyakalashe	Domestic dogs/ Izinja zasekhaya	Caracal Ingqawa	Serval Ihlosi	Brown Hyena Impisi	Oth

27. If you saw a predator on your land, what would your reaction be? Ukuba ubone irhamncwa emhlabeni wakho, uyakuthini?

Kill it Uyakulibulala	Chase it away Uyakuligxotha	Call the GFRNR authorities Uyakubiza abasemagunyeni e-GFRNR	Leave it alone Uyakuliyeka	Other: Enye

28. Do you employ predator control measures (Hunting, Trapping, etc) in your area? Ingaba zikona ezinye izinto ozisebenzisayo ukuthintela lamarha,ncwa? (Ukuzingela nokuthiya) kumhlaba wako, What methods? Zezipi?____	Yes	No	Maybe

29. Have you killed any predators on your land before?
How many in the last year?
Wakhe wabulala irhamncwa emhlabeni wakho ngaphambili?

Amangaphi kunyaka phelileyo:____
What predators?
Ngawaphi la marhamncwa?

Leopard Ingwe	Jackal Udyakalashe	Domestic dogs/ Izinja zasekhaya	Caracal Ingqawa	Serval Ihlosi	Brown Hyena Impisi	Other

Yes	No	Maybe

30. Would you harm wild dogs if they escaped from the reserve and appeared on your land?
Ungazonzakalisa izinja zasendle ukuba ziyabaleka elugcinweni ziyotsho emhlabeni wakho?

Yes	No	Maybe

31. Would you harm wild dogs if they escaped from the reserve and killed your livestock/game?
Ungazonzakalisa ezi zinja zasendle ukuba ziyabaleka elugcinweni ziyotsho emhlabeni wakho zitye zibulale imfuyo yako?

Yes	No	Maybe

32. Have you killed any predators on your land before?
Wakhe wabulala irhamncwa emhlabeni wakho ngaphambili?

How many in the last year:
Amangaphi kunyaka ophelileyo: _______________________

What predators?
Ngawapi Lomarhamncwa?

Leopard Ingwe	Jackal Udyakalashe	Domestic dogs/ Izinja zasekhaya	Caracal Ingqawa	Serval Ihlosi	Brown Hyena Impisi	Other

Yes	No	Maybe

33. Do people set snares in your area?
Ingaba abantu bayathiya imigibe kundawo ohlala kuyo?
If so,
Ukuba kunjalo,
How many: Very few:______ Quite a few:______ Many:______
Zingapi: Imbalwa Kakulu Imbalwa Mininzi
What gets caught:____
Yintoni ebhajiswayo
Who sets the snares:____
Ngubani othiya le migibe
Where (Please indicate on the map)
Phi (Nceda ubonakalise emephini)

Yes	No	Maybe

34. Do you know people who set snares in your area?
Bakhona abantu obaziyo abathiya imigibe?

Yes	No	Maybe

35. Have you seen an animal caught in a snare in the last year?
Wakhe wazibona izilwanyana zibhajiswe ngumgibe

Yes	No	Maybe

<table>
<tr><td colspan="4">What animals?
Ukuba kunjalo, zeziphi ezi zilwanyana?</td><td></td><td></td><td></td></tr>
<tr><td colspan="4">36. If you find a snare, do you remove it?
Ukuba ufumana umgibe, uyawususa?</td><td>Yes</td><td>No</td><td>Maybe</td></tr>
<tr><td colspan="4">37. Do you routinely patrol your fence line to look for snares?
Uyalujonga ungqameko locingo lwakho rhoqo ukhangela imigibe?</td><td>Yes</td><td>No</td><td>Maybe</td></tr>
<tr><td colspan="4">38. Do you own dogs?
Ingaba unazo izinja?
If so, how many?:_
Ukuba Kunjali,
Zingapi?____</td><td>Yes</td><td>No</td><td>Maybe</td></tr>
<tr><td colspan="4">39. Have your dog's been vaccinated for canine distemper and rabies?
Ingaba izinja zakho zakhe zagonyelwa na umgada?</td><td>Yes</td><td>No</td><td>Maybe</td></tr>
<tr><td colspan="4">40. Have there been any campaigns to vaccinate dogs in your area?
Ingaba izinja zakho zakhe zagonyelwa na umgada?</td><td>Yes</td><td>No</td><td>Maybe</td></tr>
<tr><td colspan="4">41. Ezi zinja zisetyenziselwa ukuzingela?
Are these dogs used for hunting?</td><td>Yes</td><td>No</td><td>Maybe</td></tr>
<tr><td colspan="4">42. Are your dogs contained?
Ingaba izinja zakho zivalelwe okanye ziyazula nje?</td><td>Yes</td><td>No</td><td>Maybe</td></tr>
<tr><td colspan="4">43. Does poaching occur in your area?
Ingaba ukuzingela ngaphandle kwemvume kukhona na kwindawo yakho?
Elaborate Cacisa:
____
____
____
_______</td><td>Yes</td><td>No</td><td>Maybe</td></tr>
<tr><td colspan="4">Communal Only Uluntu kuphela
44. Does hunting occur in your area?
Ingaba kuyazingelwa endaweni yakho?
For what purposes?
Nganjongo zithini</td><td rowspan="2">Yes</td><td rowspan="2">No</td><td rowspan="2">Maybe</td></tr>
<tr><td>Recreational
Ukuzonwabis a</td><td>Food
Ukutya</td><td>Cultural/ Ngokwenkcubeko
Elaborate/Cacisa:</td><td>Problem Anima
Izilwanyana eziyingxaki</td></tr>
</table>

What animals? Zeziphi izilwanyana? ____ *Please indicate the areas where hunting occurs on the map* *Nceda ubonise iindawo ekuzingelwa kuzo emephini*			

Section F: Personal information about respondent
Icandelo F: Iinkcukacha zophendulayo

45. Name/ Igama:
____

46. Date of birth /Umhla wokuzalwa:______________________________________

47. Gender/ Isini:

Male/Indoda	Female/Owasetyhini

48. Contact number/Iinkcukacha zoqhagamshelwano : ___________________________

Email Address Idilesi ye-imeyili:__________________________________

49. Level of education (tick applicable):
Inqanaba lemfundo (yenza uphawu kwindawo efanelekileyo):

None Ayikho	Primary School Level INqanaba lamaBanga aPhantsi	High School Level INqanaba lamaBanga aPhakamileyo	Tertiary Education Specify: iMfundo ePhakamileyo Xela:

50. First language/Ulwimi lokuqala : _____________________________________

51. Occupation/ Isikhundla :____________________________________

52. Leadership role in the community:

Community Leader	Municipal Leader	Tribal/Traditional Leader	No leadership role

Appendix C

Table 2: The statements and scoring system used to determine the threat index.

	Score		
Threat Statement	**Yes**	**Maybe**	**No**
Do you own livestock or game?	-1	0	1
Are you in favour of the reintroduction of wild dogs into the Great Fish River Nature Reserve?	1	0	-1
Would you be afraid of wild dogs?	-1	0	1
Should wild dogs be protected/conserved?	1	0	-1
Would your neighbours be in favour?	1	0	-1
Would you harm wild dogs if they escaped from the reserve and appeared on your land?	-1	0	1
Would you harm wild dogs if they escaped from the reserve and appeared on your land and killed your livestock/game?	-1	0	1
If you see a predator on your land, what is your reaction?	Chase away (0), Call the reserve (+1), Kill it (-1), Leave it alone (0)		
Do you employ any predator control?	-1	0	1
Have you killed any predators on your land before?	-1	0	1
Are there snares in your area?	-1	0	1
Do you own dogs?	-1	0	1
Are your dogs vaccinated for canine distemper and rabies?	1	0	-1
Is there poaching in your area?	-1	0	1
If you find a snare, do you remove it?	1	0	-1
Do you routinely patrol fences?	1	0	-1