Drivers of farmer-African wild dog *(Lycaon pictus)* conflict in the Waterberg Biosphere Reserve, South Africa

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I, Lungelo Dube declare that the thesis, which I hereby submit for the degree Master of Science in Environment and Society at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at this or any other tertiary institution.

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ABSTRACT

African wild dogs *(Lycaon pictus)* are the most endangered large carnivore in Southern Africa. There are as little as 5,000 individuals globally and less than 450 African wild dogs in South Africa alone. African wild dogs are listed as endangered by the International Union for Conservation of Nature (IUCN) Red List. Therefore, the time has never been more crucial to conserve the species. With increased human encroachment and inhabitation in and around protected areas, so are increased conflicts between humans and carnivores. Human-wild dog conflict is likely to rise where a common resource is found. Human-carnivore conflicts have often been induced by the uncomfortably close inhabitation of humans in areas predominantly occupied by large carnivores. For this reason, it is becoming vital to establish a harmonious relationship between carnivores and humans. This research investigated the extent and causes of human-carnivore conflict specific to private landowners and the African wild dog in the Waterberg Biosphere Reserve, Limpopo Province, South Africa between April 2018 and January 2019. The causes of conflict in the Waterberg and levels of tolerance by the farmers for African wild dogs were investigated. The methodology was two-fold, using spatial analyses and an online survey. Three African wild dogs from the same pack were collared using telemetry collars (Tag 2651, Tag 2953 and Tag 3017). These data were used for the spatial analysis part of the research, using Geographic Information System (GIS) to determine the African wild dogs' home ranges, movement patterns, and proximities to commonalities with humans and preferred land use. The private landowners possibly experiencing human-carnivore conflict were surveyed using an online survey *(n = 81)*, and this information was used to determine the extent of conflict and tolerance of African wild dogs amongst the farmers in the Waterberg. The information gathered will be used by the Endangered Wildlife Trust to develop an early warning system for private landowners affected by the presence of free-roaming African wild dogs in the area. In general, English speaking farmers in the Waterberg Biosphere Reserve were more tolerant of African wild dogs compared with Afrikaans speaking farmers. Results also showed that areas near food and water sources are high potential conflict hotspots. The results also showed that African wild dog movement patterns in Waterberg Biosphere Reserve have an influence on conflict hotspot areas during denning season, wet and dry months, different phases of the moon and overall hunting patterns of African wild dogs. This research facilitated an understanding of aspects of utilisation, persecution and how to mitigate conflict between humans and African wild dogs within the Waterberg Biosphere Reserve.

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List of Acronyms and Abbreviations

Acronym	Meaning
CSUS	Charcoal Stratigraphy Units
EWT	Endangered Wildlife Trust
GLTFCA	Great Limpopo Transfronteir Conservation Area
GPS	Global Positioning System
HWC	Human-Wildlife Conflict
HCC	Human-carnivore conflict
IR- SAT Tag	Inferred Radiometric Satellite Tag
KNP	Kruger National Park
KAZA	Kavango Zambezi
LGD	Livestock Guarding Dogs
MDM	Maximum Distance Moved
NGI SA	National Geospatial Information of South Africa
NRF	National Research Foundation
SADC	Southern African Development Community
SANBI	South African National Biodiversity Institute
SLC	Snow Leopard Conservation
TFCA	Transfronteir Conservation Area
TOPS	Threatened or Protected Species
UP GGM	University of Pretoria, Geography, Geoinformatics and Meteorology
UD	Utilisation Distribution
WBR	Waterberg Biosphere Reserve

CHAPTER 1: Background and Research Questions

GENERAL INTRODUCTION

(Image used with the permission of Derek van der Merwe, 2019)

1.1 Background

In previous years, the Endangered Wildlife Trust's Carnivore Conservation Program (CCP) has focused on addressing community engagement related to carnivore conservation in the Waterberg Biosphere Reserve, where there are many carnivore species of high value (Endangered Wildlife Trust, 2014). Communities of predominately white commercial game farmers have been the main communities targeted for the studies done thus far (Endangered Wildlife Trust, 2014).

The Waterberg Biosphere Reserve is in the northern part of Limpopo Province, South Africa. Some of the most important landforms and nature reserves in South Africa are hosted in the province (Hogan, et al., 2006). A home for the iconic "Big Five" and other important range of mammalian species including impala *(Aepyceros melampus*), kudu *(Tragelaphus strepsiceros),* klipspringer *(Oreotragus oreotragus*) and blue wildebeest *(Connochaetes taurinus)* (Department of Environmental Affairs, 2018). Various rivers that cut through Waterberg are associated with riparian zones, which offer habitat for birds, reptiles and mammals that require more water than plateau species (Hogan, et al., 2006).

Other mammals in the area include giraffe *(Giraffa camelopardalis),* white rhinoceros (*Ceratotherium simus)* and warthog *(Phacochoerus africanus*). Predators include the leopard *(Panthera pardus),* lion *(Panthera leo)* and hyena *(Hyaenidae)*. Top predators such as carnivores, are essential for maintaining the ecosystem as they limit the numbers of prey species, and functioning as conservation surrogates for less charismatic sensitive species (Dalerum, et al., 2008). In so doing, they can alter the structure and function of the entire ecosystems (Terborgh, et al., 2002; Ruiz-García & Shostell, 2012)

With increasingly fragmented habitat and expanding human populations in both protected and outside of protected areas, a threat is posed to populations of carnivores such as the African wild dog (*Lycaon pictus*) (Waterberg Nature Conservency, 2019). In 2018, the Endangered Wildlife Trust (hereafter EWT) successfully collared the last free-roaming pack of African wild dogs in the Waterberg Biosphere Reserve. This gave the EWT an opportunity to monitor the pack and the possibility to explore African wild dog-related eco-tourism opportunities in the Waterberg (EWT, 2018).

The collaring of the African wild dogs meant that the geographical locations, as well as all movements made by the carnivores were always tracked and monitored. This monitoring took place in the Melkrivier area of the Waterberg for a pack of 11 individuals. The EWT is also working with landowners in the region to increase the possibilities of co-existence with these endangered and valuable animals (Endangered Wildlife Trust, 2014). My research will, therefore contribute to understanding the attitudes of landowners towards African wild dogs and investigate their tolerance levels of these within the Waterberg. This, in turn, will increase a co-existence with both the endangered African wild dogs and all other valuable animals in the area. This information will facilitate the EWT to create an early warning system for the African wild dogs. From the information gathered from the farmers, conservation measures for the African wild dogs will also be suggested.

1.2 Study area

The Waterberg Biosphere Reserve *(Thaba Meetse*), was named a biosphere reserve by UNESCO and is situated at 23°10' to -24°40'S; 27°30' to -28°40'E in the Limpopo Province (Figure 1) (Department of Environmental Affairs, 2018). The Waterberg Mountain ranges are an average of 600 m.a.s.l, with few peaks around the area peaking higher than 2000 m (Department of Environmental Affairs, 2018). It is a relatively area with large conservation areas, including a National Park and privately owned nature reserves.

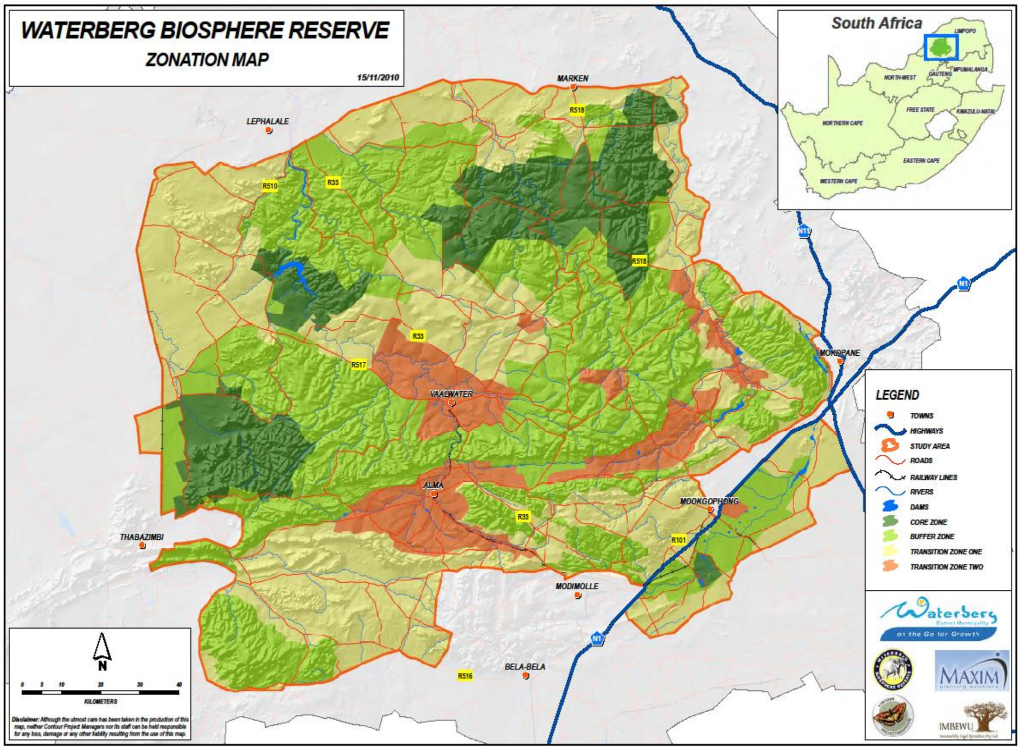

Figure 1 The Waterberg Biosphere Reserve located in the northern part of the Limpopo province, South Africa.

Human-wild conflict is prevalent in the Waterberg Biosphere Reserve, more especially when large predators predate on livestock (van der Merwe & Marnewick, 2014). Although leopards are high value predators for protected areas, livestock farmers suffering losses of cattle (*Bos taurus*), goats *(Capra aegagrus hircus)* and sheep *(Ovis aries)* regard them as problem animals. In some cases wildlife species such as the black impala *(Aepyceros m. melampus)* which have high financial value (worth up to R250 000) to the game farmers (van der Merwe & Marnewick, 2014) are of particular concern.

As an effort to alleviate the existing conflict between humans and predators in the Waterberg Biosphere Reserve, the EWT is running The Wildlife Conflict Mitigation Programme. The Wildlife Conflict Mitigation Programme is an effort to mitigate livestock damage caused by predators. Predators such as cheetahs *(Acinonyx jubatus)*, leopards, African wild dogs, the brown hyena *(Hyaena brunnea)* and spotted hyenas *(Crocuta crocuta)*, have been the primary predators casing livestock predation (Endangered Wildlife Trust, 2014). The programme uses the livestock guardian dogs (*Canis lupus familiaris*) breed in the Waterberg Biosphere Reserve (Whitehouse-Tedd, et al., 2019).

The Waterberg serves as a 40,000 km^2 water reservoir, which consists of four main river catchment areas for this arid region (Department of Environmental Affairs, 2018). Riparian zones are associated with various rivers that cut through the Waterberg (Taylor, et al., 2003). All these rivers drain to the Limpopo River, which flows easterly to discharge into the Indian Ocean (Taylor, et al., 2003).

With low mountain ranges, poor soil quality and low economic activity, on the banks of the Palala River in the Waterberg region of Limpopo Province is a protected area comprising ~44 500 ha (Lapalala Wilderness, 2018). Lapalala Wilderness is one of the largest private reserves in southern Africa (Lapalala Wilderness, 2018). It hosts a vast array of wildlife. There is a low density of humans around the area, and great-unspoiled wilderness and open spaces dominate the Waterberg (Department of Environmental Affairs, 2018).

The Waterberg Biosphere Reserve covers an area of 654,033 ha of land, and an approximate 80,000 people reside in this reserve (Department of Environmental Affairs, 2018). The concept of a biosphere reserve has ensured a balance between the pressure generated by the tourist industry, direct benefits for local communities and the conservation of natural resources (Department of Environmental Affairs, 2018). In addition, the Lapalala Wilderness School has implemented a series of action plans that involve environmental education programmes in all local communities (Department of Environmental Affairs, 2018).

1.2.1 Climate

The Waterberg is an area that has a warm climate (South African Weather Services, 2019). The mean average temperatures range from a minimum and maximum of 12.5°C and 30.7°C in the year 2007 (South African Weather Services, 2019).

1.2.2 Vegetation

The vegetation of the Waterberg Biosphere as two major ecosystem types, namely Tropical grasslands and savannas (Department of Environmental Affairs, 2018). The area also has a vast variety of habitats and land cover types (Department of Environmental Affairs, 2018). It is dominated mainly by sour bushveld, mixed bushveld and Waterberg moist bushveld (Department of Environmental Affairs, 2018). Sour bushveld characterised by Transvaal beech (*Faurea saligna*), common hookthorn (*Acacia caffra*), wild seringa (*Burkea africana*), sliver cluster-leaf (*Terminalia sericea*) and African wattle (*Peltophorum africanum*) on the deep sandy areas (Department of

Environmental Affairs, 2018). The steep slopes with cliffs and bare rock with trees including the same tree species as mentioned above and with paperbark false-thorn (*Albizia tanganyicensis*) and velvet bushwillow (*Combretum molle*) (Department of Environmental Affairs, 2018). The riverbanks and freshwater habitats including wetlands are characterised by Transvaal red milkwood (*Mimusops zeyheri*), tinderwood (*Clerodendrum glabrum*), and common wild fig (*Ficus thonningii*) (Department of Environmental Affairs, 2018).

The savanna consists of rolling grasslands and a semi-deciduous forest, with trees such as mountain syringa *(Syringa vulgaris),* silver cluster-leaf *(Terminalia sericea*) and lavender tree *(Lavandula angustifolia)* (Taylor, et al., 2003). The canopy is mostly leafless during the dry winter (Department of Environmental Affairs, 2018). Native grasses include signal grass *(Brachiaria decumbens Stapf)*, goose grass *(Eleusine indica)* and heather-topped grass *(Calluna vulgaris)* (Department of Environmental Affairs, 2018). Indigenous grasses provide graze to support native species including impala, kudu, klipspringer and blue wildebeest (Taylor, et al., 2003).

A considerable amount of the southern Africa area of savanna biome is represented in the Waterberg Biosphere Reserve (Department of Environmental Affairs, 2018). The area contains many Red Data and orange listed species of conservation concern, as well as many endemic species and high level of biological diversity (Department of Environmental Affairs, 2018). High biodiversity is maintained through the sufficiently represented habitats in Waterberg (Department of Environmental Affairs, 2018). Whilst the main characteristics of the Waterberg being vast areas of unspoiled wilderness and open spaces made possible by the low human density (Department of Environmental Affairs, 2018). The North- Eastern Mountain Sourveld is located in the south central and highest parts of Waterberg and is the most threatened veld types in Limpopo (Department of Environmental Affairs, 2018). Due to the extensive historic riverine erosion in Waterberg, vegetation cliff habitats are abundant in the area (Taylor, et al., 2003).

1.2.3 Topography and geology

The geology of the Waterberg was formed from a precursor island approximately 2.7 billion years ago and is characterised by the Kaapvaal Craton in the underlying rock formation (Taylor, et al., 2003). Through the Kaapvaal Craton, the Waterberg geology was further transformed by upward intrusion of igneous rocks (Taylor, et al., 2003). The initial rock up thrust involved, which was also referred to as the Waterberg Supergroup, is an estimated 250,000 km^2 (Taylor, et al., 2003). The extruded rocks are called the Bushveld Igneous Complex, and contained minerals such as vanadium and platinum (Taylor, et al., 2003).

Figure 2.1: Extensive mountain range that stretch up to 5000 km^2 and steep terrains in Waterberg make it a pristine tourist destination.

The oxygenation of the atmosphere two billion years ago gave rise to the oxidation of granite rocks which eroded and weathered, yielding a mosaic of red and purple coarse sands which had a high concentration content of manganese and iron (Hogan, et al., 2010). These sands were then transported as eroded bed load material through to the lower complex networks of slender streams, to build the sedimentary strata seen in the Waterberg today (Hogan, et al., 2006). About 1.5 billion years ago, sedimentary deposits were made from rivers crossing the Waterberg (Taylor, et al., 2003). The Kaapvaal craton collided with the supercontinent Gondwana and split Gondwana into its modern-day continents, 250 million years ago (Taylor, et al., 2003). Today, the Waterberg contains some cliffs that stand up to 550 m above plains, with multi-coloured sandstone(Figure 2.1 and 2.2 (Taylor, et al., 2003).

Figure 2.2: Multi-coloured sandstone on rock formations are some of the most common features seen on mountain ranges in the Waterberg.

Approximately twenty million years ago, there were a sudden uplifts that reversed the erosion and produced uplifted Waterberg Massif elevations that peak at up to 500 m higher than the recent uplifts 20 million BC landform that occurred prior (Taylor, et al., 2003). There are exceptions of exposed cliff faces towers that are 550 meters above plains, exposed and manifesting the ancient colourful horizontally layered hard sandstone (Hogan, et al., 2010). Today, the Waterberg has become the core if geomorphic change, presenting mesas, buttes and occasional koppie granitic outcroppings (Hogan, et al., 2006).

1.2.4 Land use

As of the year 2010, approximately 80,000 people lived in Waterberg (Department of Environmental Affairs, 2018). The reserve covers approximately 650,000 ha with a rich historical heritage of some of the most primitive and important San Rock Art areas in South Africa (Department of Environmental Affairs, 2018). The Waterberg is a significant site of anthropogenic interest. There are many Archaeology/Paleontology, capacity building, cultural aspects, small business initiatives, social/socio-economic aspects, wildlife-based tourism, hunting tourism and community tourism (Department of Environmental Affairs, 2018). Although the people of the area do also practice cattle farming, crop production, as well as game farming for eco-tourism and trophy hunting (Department of Environmental Affairs, 2018); tourism is by far, the major income source in the area (as seen in figure 3) (Department of Environmental Affairs, 2018).

Figure 3: Signage for a site of interest in the Waterberg Biosphere Reserve. Tourism and Environmental Education play very important roles for conservation in Waterberg. People are made more aware for their surroundings and are taught on how to protect the planet, while also establishing an appreciation for wildlife.

1.3 Purpose of research

This study identified drivers of farmer-African wild dog conflict within the Waterberg Biosphere Reserve area and suggested the appropriate interventions to reduce conflict. Furthermore, the study determined the tolerance levels of the farmers within the area for African wild dogs and suggested solutions to mitigate existing conflict and to avoid potential future conflicts. The results of this research are to be used by EWT and the Waterberg Biosphere Reserve to manage the land for people and carnivores effectively. Moreover, to develop an early warning system for landowners, to alert them if there is a pack of African wild dogs around the area where their farm is located.

1.4 Research problem

The Waterberg Biosphere Reserve has a problem of HWC specific to private land owners and the African wild dogs predating on valuable game in the area. The area also needs solutions of how HWC can be reduced in the area as well as suggestions of how to better manage the issue of HWC.

1.5 Aim

To investigate the drivers of human-African wild dog conflict and determine the tolerance levels of African wild dog by private landowners in the Waterberg Biosphere Reserve.

1.6 Objectives

i. To characterise the key areas affected by human-African wild dog conflict in the Waterberg area.
ii. To spatially track and monitor the movement patterns of the African wild dogs in this area.
iii. To identify the drivers of the human-wild dog conflict in Waterberg Biosphere Reserve.
iv. Determine the tolerance levels of the private landowners for the African wild dogs in the Waterberg Biosphere Reserve
v. Suggest mitigation and conservation measures to enable a harmonious relationship between African wild dogs and the farmers.

1.7 Research questions

This research will investigate and answer the following questions:

i. What is the extent of HWC in the study area?
ii. Which areas are potential conflict for HWC?

1.6 Proposed layout of the study

Chapter 1: Background and Study area

Chapter 1 provides a general background on this type of study and study area. This chapter also contains the research problem, aims and objectives, research questions, and purpose of the research.

Chapter 2: **literature review**

This chapter outlines the literature exploration with regard to the information on human-carnivore conflict, the different types of human wildlife conflict, the African wild dog, as well as existing strategies used across the world and literature on mitigation strategies that deals with human-carnivore conflict.

Chapter 3: Research methodology

The third chapter describes the research process in depth, including the design and analysis followed in the study.

Chapter 4: Results

Chapter 4 presented results in accordance with the stated objectives, after analysing the data and the findings of the study.

Chapter 5: Discussion

Chapter 5 will give the discussion from results presented in Chapter 4.

Chapter 6: Recommendations and Conclusion

This chapter gives recommendations on how the study area can better mitigate the current conflict with African wild dogs, as well as suggestions on conservation measures the farmers can adopt for these in the area. The chapter will also summarise the results of the study and presents conclusions drawn from the study. Limitations and recommendations for additional research are also discussed.

CHAPTER 2: Literature Review

(Image used with permission from Derek van der Merwe, 2019)

2.1 Human Wildlife Conflict (HWC)

Human-wildlife conflict (HWC) is described as a conflict that occurs between people and wildlife (Woodroffe, et al., 2005). It can be further defined as any negative impact on either humans and/ or wildlife involved as a result of any direct or indirect interaction between people and wildlife (Pettigrew, et al., 2012). One of the most direct impacts of HWC is the injury and death of humans (Nyhus, 2016). Wildlife directly attacking humans, through bites and other defence mechanisms, can cause humans to sustain serious injuries and sometimes death (Nyhus, 2016). Indirect interactions, such as collisions involving wildlife and automobiles such as cars, ships, trains, boats and planes, can also initiate HWC (Nyhus, 2016). The transmission of zoonotic diseases and parasites can also be a trigger for HWC (Conover 2002, Nyhus 2016). HWC occurs when the needs and behaviour of wildlife affect negatively on the goals of humans, or when the goals of humans negatively influence the needs of wildlife (Madden, 2004).

Wildlife is valuable, and although the value may range from species to species, the value of wildlife may change altogether when HWC is discussed (Elsner, 2008). The value of a wildlife species is associated with its existence, society's knowledge of the species, and beneficial economic returns (Elsner, 2008). Negative values of wildlife are associated with physical and economic damage inflicted by wildlife on agriculture and society (Elsner, 2008). The suite of potential impacts to humans consists of three broad categories: economic, health and safety, and psychological (Decker, et al., 2002).

HWC can cause direct economic damage to game species, livestock, property and crops (Gittleman *et al.* 2001; Woodroffe et al., 2005; Linnell et al., 2010; Loveridge et al., 2010). It can also have indirect impacts, which, in most cases, are a bit more difficult to measure (Nyhus, 2016). These include crops or livestock opportunity loss for farmers and rangers, reduced psychological wellbeing, food insecurity and disruption (Gittleman et al., 2001; Woodroffe *et al.*, 2005; Linnell *et al.*, 2010; Dickerman *et al.*, 2011; Hoare, 2012; Barua et al., 2013). Loss of human life, in addition to, loss of crops and livestock, are the primary catalysts for HWC (Dickerman, et al., 2011). HWC incidences are a result that arises when the interests of humans and wildlife- real or perceived not to coincide (Mwangi, 2015). HWC has been on the rise in recent years; it is a global problem that has likely existed for as long as humans and wildlife have coexisted and shared the same resources and landscapes (Lamarque et al., 2008; Mbaiwa et al., 2008; Mwangi, 2015). The most extreme biological impact of HWC is extinction (Nyhus, 2016), hence the need for conservation and mitigation measures.

Several influences have the potential to trigger conflict between humans and wildlife. Influences such as the spatial overlapping of humans and wildlife, an overlap in resource usage and expanding populations of both humans and livestock (Treves & Karanth, 2003; Lamarque et al., 2008). Other factors such as dwindling natural habitats, an increase in the transmission of diseases between domestic animals and wildlife, and increase of tourism (Treves & Karanth, 2003; Lamarque et al., 2008; Madden, 2008; Goodrich et al., 2011). The increasing suburban development, overabundance among adaptable species, and a shift in public attitudes from utilitarian views of wildlife to those concerned with animal welfare and rights also cause HWC (Bruggers, et al., 2002). Increased media interest in wildlife issues, and advances in wildlife science and technology that enable recovery of previously low-density wildlife populations, can trigger human-carnivore conflict (Bruggers, et al., 2002).

India generally has more HCC tigers and leopards were responsible for 78% and 22% of attacks, respectively (Dhanwatey, et al., 2013). In China, escalating HWC is a result of increased human populations, the decline of wild prey species and intensified encroachment on wildlife (Cai, et al., 2011). The occurrences of HWC in China are generally in or around the vicinity of either a protected area or remote mountainous areas (Li, 2011).

Around the world, some of the most common incidences of HWC have shown that this is a global issue (Mwangi, 2015). Examples include baboons *(Papio* spp.*)* in Namibia attacking young cattle, one-horned rhino *(Rhinocerotidae)* in Nepal (Asia) destroying crops (Mwangi, 2015), European bears *(Ursus arctos)* and wolves (*Canis lupus*) killing livestock in Europe, Rocky Mountain elk *(Cervus elephus nelsoni*) attacking people in the US (North America) (Mwangi, 2015), jaguars (*Panthera onca*) predating on livestock in Brazil (South America), and attacks by Australian Magpies *(Cracticus tibicen)* on humans (Mwangi, 2015). In China, the takin *(Budorcus taxicolor*) and the elephant *(Elephas maximus*) are the most common species in most cases of HWC (Pettigrew, et al., 2012). In Africa, large herbivores like (elephants, buffaloes *(Syncerus caffer*), and hippopotamus (*Hippopotamus amphibius*) are common in conflict incidences with humans (Mwangi, 2015). Large mammalian carnivores include lions, leopards, cheetahs, spotted hyenas, and African wild dogs (Mwangi, 2015). Crocodiles *(Crocodylinae)* are the main large reptile species most likely to be involved in human- carnivore conflict (Mwangi, 2015).

2.2 Human- carnivore conflict

With the increase in human populations residing in previously protected areas, a threat is posed to the carnivores living within these protected areas because of the competition of space, resources and territory (Wittemyer, et al., 2008). Anthropogenic activities have resulted in a significant decline in large carnivore numbers (Ripple, et al., 2014). Therefore, human-carnivore conflict is a primary driver of carnivore decline worldwide (Woodroffe, et al., 2005). Therefore, resolving and mitigating these conflicts is of primary concern to carnivore conservation and human livelihoods.

The great overlap of humans in spaces occupied by carnivores that occupy large home ranges because of widespread anthropogenic destruction and fragmentation of carnivore habitat is by far the core root of the conflict (Treves & Karanth, 2003; Dechner, et al., 2018). Due to their enormous home ranges, dietary requirements and physical size, felids and canids are the most susceptible to interacting with humans, thus increasing the probability of conflicting with humans (Macdonalad & Sillero-Zubiri, 2004; Macdonald & Loveridge, 2010; Ofstad, et al., 2016). Prey availability has an influence on predator abundance in a given area (Carbone & Gittleman, 2002; Wszola, et al., 2019) . With an average of 75% of the world's population of felid species being affected by HWC, the rigorousness of conflict increases with felid body mass (Inskip & Zimmermann, 2009; Seoraj-Pillai & Pillay, 2017). In most cases, prey for carnivores are animals (e.g. livestock or game species) that have economic, nutritional or recreational value (Graham, et al., 2005). Feeding habits of the large carnivores, paired with the carnivore's high dietary protein requirements are the key determinant of habitation and type of prey (Treves & Karanth, 2003; Yuan, et al., 2018). This often poses a threat to livestock and humans living around that chosen habitat (Packer, et al., 2005; Yuan, et al., 2018). As a result, conflict arises between humans and carnivores. In most reported cases, humans kill the large carnivores, and this has resulted in the local extirpation of many carnivore species (Treves & Karanth, 2003; Seoraj-Pillai & Pillay, 2017). Moreover, carnivores are usually the most victimised party in 'human-carnivore conflict" and experience harsh killings by humans (Graham, et al., 2005; Dechner, et al., 2018).

In subsistence farming, predation does not only cause the loss of valuable livestock and game for farmers, but it may also hinder rural development and threaten food security (Graham, et al., 2005). Therefore, it is always important to consider that carnivore conservation approaches that ignore such issues are unlikely to be supported by local people and cannot practically be enforced in remote areas (Lindsey, et al., 2009).

Carnivores, particularly top predators, fill vital roles in ecosystems such as contributing to the maintenance of biodiversity, they also limit the numbers of prey species, and functioning as conservation surrogates for less charismatic sensitive species (Dalerum, et al., 2008). In so doing, they maintain the structure and function of natural ecosystems (Schaller, 1972; Terborgh, et al., 2002). Being in the top trophic level, carnivores usually occur in low densities, need large areas to thrive and generally have low reproduction rates (Singh & Kamboj, 1996). This makes them even more vulnerable to pressures from commercial hunting, habitat reduction and extermination by humans (Nijhawan, 2008).

Carnivores prey on livestock and wild game (Pettigrew, et al., 2012). Prey depredated the most is livestock and valuable game belonging to humans (Nijhawan, 2008). In turn, this depredation evokes strong responses from humans who either own livestock or live in the community where the depredation by carnivores occurs (Pettigrew, et al., 2012). Retaliation in the form of elimination by the local people is the major contributor to diminishing populations of the large carnivores (Miquelle et al., 2005; Thirgood et al. 2005; Nijhawan, 2008; Maclennan et al. 2009; Dickman et al. 2014). Dwindling wild prey populations have further intensified attacks on domestic livestock by carnivores (Nijhawan, 2008). In many places, the real reasons for the conflict are unknown; hence, appropriate actions cannot be taken to alleviate it (Nijhawan, 2008). Conflict can have meaningful negative impacts detrimental to conservation efforts and people and animals (Elsner, 2008).

2.3 African wild dogs in South Africa

Historically, African wild dogs ranged throughout most of sub-Saharan Africa, but because of continued persecution by a growing human population, decreased prey availability, disease and interspecific competition, their numbers have been reduced to as little as 5,000 individuals (Fanshawe, et al., 1997). The African wild dog’s low population densities and foranging range make it susceptible to habitat fragmentation (Woodroffe, et al., 1998). Ultimately, the low population density makes this species susceptible to extinction (Potgieter, et al., 2012). Today, African wild dogs only exist in countries with low human population densities (Potgieter, et al., 2012). Southern Africa still has the largest populations of African wild dogs, mostly in northern Botswana and southern part of East Africa (particularly Tanzania) (Creel & Creel, 2002). In South Africa, free-roaming packs reside in eastern Mpumalanga, northern, western and eastern Limpopo, the Waterberg region of Limpopo and seldom in KwaZulu-Natal (Davies-Mostert, et al., 2016).

In 1998, the South African wild dog meta-population was established (Mills, et al., 1998). A meta-population is defined as a set of discrete, geographically isolated populations of the same species that may exchange individuals through dispersal, migration or, when implemented as a management strategy, or human-controlled movement (Potgieter, et al., 2012). Meta-population reserves are seen in in the eastern parts of Northern Cape, western and northern North West, occasionally in south of Werda North West, Botswana border and alongside the eastern border of Khamab Kalahari Reserve (Power 2014; Davies-Mostert, et al. 2016). In the South African wild dog meta-population management strategy, individuals are moved between the reserves in an attempt to mimic natural dispersal patterns and to manage gene flow and maintain genetic integrity (Davies-Mostert, et al., 2009). The goal of the African wild dog meta-population programme is not only to ensure the long-term survival and conservation of the African wild dog in South Africa, but also to encourage biodiversity conservation (Potgieter, et al., 2012).

African wild dogs occupy three unique population segments in South Africa (Davies-Mostert, et al., 2016). Firstly, in the Kruger National Park, there is a protected population of African wild dogs. Secondly, in the northern part of Limpopo, northern parts of KwaZulu-Natal, northern and western parts of North West and Mpumalanga, and eastern parts of Northern Cape, reside wild free-roaming populations in protected areas and traversing land outside of those protected areas (Davies-Mostert, et al., 2016). Lastly, several private and public reserves intensively protect and manage a meta-population (Davies-Mostert, et al., 2016).

Hluhluwe-iMfolozi Park in KwaZulu-Natal Province (900 km^2) and the Madikwe Game Reserve in the Northwest Province (600 km^2), were the two reserves with reintroduced populations of African wild dogs in 1998 (Davies-Mostert, et al., 2009). By 2000, Pilanesburg National Park also participated in African wild dog metapopulation management (Davies-Mostert, et al., 2016). In June 2005, meta-population for African wild dogs in numbers was higher than that of Kruger National Park (Kemp & Mills, 2005). Between March 2000 until January 2016, the number of protected areas increased from 3 to 11 (Davies-Mostert, et al., 2016). This was an increase in surface area from 2,082 km^2 to 4,570 km^2 for land under African wild dog meta-population management (Davies-Mostert, et al., 2016).

The number of viable breeding packs of African wild dogs increased from an estimated 34 to 37 packs, between 2000 and 2016 (Davies-Mostert, et al., 2016). Pack numbers are seen to be more robust viable population indicators as opposed to the number of mature individuals (Davies-Mostert, et al., 2016). Mature African wild dog individuals are animals capable of reproduction within breeding season (Davies-Mostert, et al., 2016). Over the last 15 years, an increase from 9-73% of mature individuals was documented; this was up to five-fold of growth (Davies-Mostert, et al., 2009; Davies-Mostert, et al., 2016). Much of this success was accredited to the managed meta-population, which recorded the population over the past three generations (Davies-Mostert, et al., 2009; Davies-Mostert, et al., 2016). The growth in population numbers to date is significant. However, African wild dogs are still listed as Endangered as population numbers are still in low (<250 mature individuals) (Davies-Mostert, et al., 2016).

African wild dogs have always existed in low densities and are crepuscular carnivores seen relatively infrequently (Creel & Creel, 1996). With an estimated two-thirds of potential African wild dog range falling outside of protected areas, distribution range outside of protected areas is poorly understood (IUCN/SSC 2007, Davies-Mostert *et al.* 2016). This makes African wild dogs vulnerable to conflict with farmers over livestock and stocked game, road incident mortality, snaring and disease (Gusset, et al., 2008). Therefore, investigating farmer–African wild dog conflict is a necessary step towards establishing appropriate conflict mitigation strategies (Fraser-Celin, et al., 2017).

2.4 The African wild dog

African wild dogs also known as the painted hunting dog or Cape hunting dog, are a relatively large (16 – 28 kg) carnivore that preys mainly on ungulates and not only live but also hunts in a pack (Vucetich & Creel, 1999). The Latin name *Lycaon pictus* means painted wolf; it refers to the unique pattern on each dog's coat (Estes, 1993). Each unique coat is irregular and mottled, with brown, black, red, yellow and white features, (Figure 4) (Estes, 1993). They have an extremely powerful bite and have big round ears, that aid in heightening their hearing (Estes 1993; Creel & Creel 2002). African wild dogs might have strong senses in hearing, but they also have excellent smell and sight, too (Creel & Creel, 2002). They are unique from the rest of the members from the dog family *(Canidae)* as they only have four toes per foot (Estes, 1993).

Figure 4: A photograph showing an African wild dog *Lycaon pictus* which grow up to 76-102 cm long, and have a white bushy tail that grows up to 31-60 cm long (Creel & Creel, 2002).

African wild dogs *(Lycaon pictus)* are social canids, recognised by their unique features (Creel & Creel, 1996). Their social structure typically includes four to eight adults, with one adult breeding pair, non-breeding male and female adults as well as their dependent juvenile pups, an average of 10 pups per litter (Fraser-Celin, et al., 2017). During the denning season (May–August), wild dogs tend to remain in one location within their home range (Fanshawe, et al., 1991).

2.4.1 Breeding

In most instances, only the alpha female African wild dog gives birth to the pups in the entire pack (Courchamp & Macdonald, 2001). The alpha female is generally the oldest female in the pack (Creel & Creel, 1995). She, together with the alpha male who is normally a more prime-aged male, are the alpha pair in the pack (Mills *et al.* 1998; Creel & Creel 2002). The alpha female generally gives birth to a large litter averaging between 10-11 pups but can reach up to 20 pups (Fuller, et al., 1992). She is responsible for giving birth to the pups and nursing the litter (Courchamp & Macdonald, 2001). The litter is, however, raised by the pack as a whole, through the assistance of subordinates which are also known as 'helpers' (Creel & Creel, 1995). The subordinate individuals in the pack are both male and female, and distinguished using a ranking system which decreases with age (Creel & Creel, 1995).

In southern Africa, African wild dogs breed during one seasonal reproductive cycle (Courchamp & Macdonald, 2001). Denning season takes place usually in May to September. During this time, an abundance of weak prey, from the exhausted male impala following the rutting season is made easily available to African wild dogs to prey on and feed pups (Estes, 1993). The alpha female commonly gives birth in old, abandoned, underground dens that once belonged to either hyenas, warthogs, Cape porcupines (*Hystrix africaeaustralis)* and aardvark (*Orycteropus afer*) (Leigh 2002, African Conservation Experience 2017, SANBI 2019).

In the event of a subordinate female also breeding, the alpha pair can either kill or adopt this litter (Africa Geographic, 2015). When the alpha female adopts the litter, she can take over the litter and feed the combined litters (Burrows, 1995). However, in most cases, both females share the responsibility of feeding the litters and may even take turns in nursing the offspring at the denning site (Burrows 1995; Fuller *et al.* 1992; Kühme 1965). This can give the mothers an opportunity to participate in hunts sooner after birth (Malcolm & Marten, 1982). Therefore, cooperation is crucial for African wild dog pup rearing (Courchamp & Macdonald, 2001).

The system of cooperative breeding also involves the other African wild dog 'helpers' within the pack in hunting, feeding, and raising the pups (Courchamp & Macdonald, 2001). Firstly, the pack hunts together and eats together (Estes, 1993). All meat from the hunt is shared by the pack, with priority given to the pups (Estes & Goddard, 1967). Secondly, African wild dogs have an ability to ingest then regurgitate large quantities of meat after a full meal (Kühme 1965; Malcom 1979; Fuller & Kat 1990). The pack goes out to hunt for food, ingests it, and then regurgitate it at the denning site for the alpha female and pups to also eat (Creel & Creel, 2002). They feed the pups for up to 2-3 months (Estes & Goddard 1967; Malcolm & Marten 1982). Lastly, cooperative breeding facilitates in decreasing the mortality rate of the pups (Mills & Gorman 1997; Mills *et al.* 1998; Woodroffee 2007). A mortality rate of about 50% is a norm in the wild for pups (Woodroffee 2007; Bach *et al*. 2010). Pup survival is influenced by the number of adults in the pack and food availability (Fuller, et al., 1992).

2.4.2 Habitat and ecology

Demographic research on African wild dogs has shown that their territorial propensity is related to the habitat structure, temporal distribution and prey density (Fuller, et al., 1992). Historically, African wild dogs inhabited most of sub-Saharan Africa, except for deserts and tropical forests (Fuller, et al., 1992). African wild dogs are known to occupy a large variety of habitats such as the savannahs, short-grass plains and upland forests (Dickerman, et al., 2011).

African wild dogs have the ability to survive in most habitat types, provided that the habitat provides them a large home range area, has sufficient,suitable prey, and does not have direct threats such as deliberate persecution and accidents (Davies-Mostert, et al., 2016). Earlier studies done in Serengeti National Park showed that African wild dogs use open plains (Frame, et al., 1979). Recent studies conducted in Mana Pools National Park (Zimbabwe), Selous Game Reserve (Tanzania), and northern Botswana, showed that it is in thicker bushes where African wild dogs reached their highest densities (Creel & Creel, 2002). They also occur in open grasslands, thickest- type vegetation found specifically in Eastern Cape and in the Lowveld (Skead, 2007).

2.4.3 Prey

African wild dogs feed predominately on medium-sized ungulates (Hayward, et al., 2006). They primarily prey on the most abundant prey species ranging from 15-200 kg body mass (Hayward, et al., 2006). They prefer the most abundant prey that will also pose little threat and injury to them (Hayward, et al., 2006). Their diet consists chiefly of impala (Davies-Mostert, et al., 2016). They also prey on kudu common duiker *(Sylvicapra grimmia*), and/or the nyala (*Tragelaphus angasi*) (Estes & Goddard 1967; Creel & Creel 1995). They also prey on blue wildebeest, warthogs, scrub hares *(Lepus saxitilus)*, bushbuck *(Tragelaphus scriptus)*, waterbuck (*Kobus ellipsiprymnus)* and sometimes juvenile African buffalo (Estes & Goddard 1967; Creel & Creel 1995; Mills & Gorman 1997; Lindsey et al. 2004; Butler 2004; Hayward et al. 2006; Page 2014).

African wild dogs typically target weak animals in poor condition from prey populations (Pole, 2000). Therefore, by eliminating the weakest animals from the population, they play a role in regulating the ecosystem (Davies-Mostert, et al., 2016). However, patterns for African wild dogs prey selection have shifted because of human interferences such as the habitat fragmentation, fencing and roads (Davies- Mostert, et al., 2013). This alteration in the habitat structure has the potential to undermine benefits associated with African wild dog’s preference in prey species because of availability of prey (Davies- Mostert, et al., 2013).

2.4.4 Hunting

African wild dogs are endurance hunters, characterised by their long legs, rapid muscle recovery, and lean build (Estes, 1993). Their lean body structure allows them to reach speeds up to 60 km/h (Creel & Creel, 2002). These canines live in packs of up to 20 adults, and typically roam in open plains of bare woodlands of sub-Saharan Africa (Childes 1988, Vucetich & Creel 1999).

African wild dogs are cooperative hunters that hunt as a pack of 7-10 dogs (Fanshawe & FitzGibbon, 1993). Not only does hunting in a bigger pack sizes decreases the distance covered per hunt, it also increases the chances of successful kill per hunt. Also, it allows for greater masses of prey to be hunted (Creel & Creel, 1995). Sociality in lions is not favoured by the African wild dog's cooperative hunting (Packer, et al., 1990). Hunting in packs enables wild dogs to retain killed prey longer, as it creates a stronger defence against kleptoparasites such spotted hyaenas and lions which generally compete and steal the kills of African wild dogs (Estes & Goddard 1967; Malcolm & Marten 1982; Fanshawe & FitzGibbon 1993; Creel & Creel 1996; McNutt 1996; Carbone et al. 1997; Gorman et al. 1998).

African wild dogs are communal hunters, which explains their sociality (Creel & Creel, 1995). The African wild dog's strong sense of community facilitates in acquiring more hunts that are successful and hunting larger prey (Schaller 1972; Kruuk 1975). Although it is not universal, it is common for carnivores to associate and hunt in larger groups when hunting larger prey (Gittleman, 1989). Larger prey is more vulnerable to a large hunting group (Creel & Creel, 1995). Therefore, it is far more beneficial to hunt larger prey in a larger group (Creel & Creel, 1995).

2.4.5 Overall conservation status of African wild dogs

African wild dogs are the second most threatened carnivore in Africa and the most endangered carnivores in southern Africa (Fraser-Celin, et al., 2017; Endangered Wildlife Trust, 2018). As of 2016, South Africa's entire population of African wild dogs is estimated at less than 450 dogs (Classen, 2014). The Management Diversity Act (Act of 2004) and Threatened or Protected Species (TOPS Regulations in 2007) has governed the IUCN and has classified the wild dog as endangered (Waterberg Nature Conservency, 2019). African wild dogs are listed as 'endangered' by the International Union for Conservation of Nature (IUCN) Red List, with the current population estimated at 6600, of which 1400 are considered mature individuals (Woodroffe & Sillero-Zubiri, 2012). Previously the only remaining, naturally occurring, viable, contiguous population of African wild dogs resided in the Kruger National Park (Potgieter, et al., 2012).

Anthropogenic factors constitute the major reason for the mortality of African wild dogs (Fuller et al., 1992; Fanshawe et al., 1997). A dramatic decrease over the past 30 years, shows the disappearance of African wild dog populations from 25 of the 39 countries formally recorded to have African wild dog species (Fanshawe, et al., 1997). This sharp and steady decrease in population numbers may lead to the local extinction of African wild dogs in a relatively short time (Fuller, et al., 1992). African wild dog populations have declined continent-wide to endangered status (Fuller, et al., 1992). Fragmented habitat exposes them to threats like accidental snaring, killing in retaliation for predation on livestock and farmed game, road accidents, and domestic dog diseases (Woodroffee, 2007). African wild dogs occupy relatively large home ranges, and this increases their interactions with humans and human activities, thus heightening their susceptibility to local extinction (Woodroffee & Ginsberg, 1998)

The relative vulnerability of this species has been attributed variously to its disproportionate exposure to anthropogenic threats, limitation by larger competing predators, and Allee effects caused by obligate cooperative breeding (Woodroffee, 2011). According to Drake and Kramer (2011), a population in which there is a positive association between some fitness component (e.g., viability, juvenile survivorship, fecundity) and population size exhibits is known as the Allee effects.

In northern Kenya, potential population constraints of African wild dogs were implemented for those living on private and community land (Woodroffee, 2011). Within 10 years, the population of African wild dogs had risen from near- extinction to be the 6th largest population of the species in the world (Woodroffee, 2011). Despite inhabiting human-dominated landscapes, African wild dogs can recover population numbers relatively rapidly (Woodroffee, 2011).

2.5 Mitigation and conservation measures towards a harmonious relationship between humans and carnivores

Various efforts have been made in a bid to reduce human-wildlife conflicts (HWC) (Mwangi, 2015). Often resources to mitigate conflicts are limited and should be focused on areas of highest priority; therefore, it is important to efficiently implement and apply measures to counteract or mitigate the human-carnivore conflict (Broekhuis, et al., 2017). In Kenya, the Draft Wildlife policy identifies HWC as an issue of national concern and these policy objectives include land-use zoning to reduce

HWC, erection of barriers, community participation, and translocation of problem animals and also compensation of affected persons (Kenya Wildlife Policy, 2011).

There are various measures used to reduce human-carnivore conflict around the world (Pettigrew, et al., 2012). From preventative measures that stop the conflict before it happens, to interventions that sought to mediate on-going conflict, and mitigation measures that can be applied to reduce the impact of conflict after it has occurred (Goodrich, 2010). Mitigation measures used to combat HWC include programmes such as compensation, insurance programmes and incentive programmes (Pettigrew, et al., 2012). Different methods work for different scenarios. Although mitigation measures are the most commonly used in most countries, like China and India; preventive measures tend to be the most effective for reducing conflict (Pettigrew, et al., 2012).

Preventive measures are by far the most effective measure to reduce human-carnivore conflict (Treves & Karanth, 2003; Goodrich, 2010). Some successful and common preventive measures used to combat human-carnivore conflict include improved livestock management carnivore injury reduction and increasing wild prey (Rabinowitz, 1986; Charudutt, 1997; Frank et al., 2005; Breitenmoser, et al., 2005; Pettigrew, et al., 2012; van Eeden, et al., 2018). Avoiding carnivore habitat and conflict hot spots are effective in reducing depredation by large carnivores (Breitenmoser *et al.* 2005; Karanth & Gopal 2005; Miquelle *et al.* 2005; Miller, et al., 2016).

Zoning and land-use patterns that influence human-carnivore can be minimised through either completely removing all conflict activities, or managing these conflict activities (such as better livestock grazing) (Woodroffe, et al., 2005). Zoning facilitates with the separation of humans and carnivores by separating livestock from critical movement corridors and carnivore habitat (Pettigrew, et al., 2012). The separation can also be in the form of fencing.

2.5.1 Fencing

In wildlife, conservation fences have always been a double edged sword (Ferguson & Hanks, 2010). Fences represent an omnipresent and increasingly important key ‘anthropologically created barrier’ (ACB) that sub-divides and fragments the ‘natural’ from the ‘human-derived’ landscapes in Africa and more specifically separates wildlife from livestock production areas and human settlements (Ferguson & Hanks, 2010; Brondízio & Moran, 2013).Pervious fences allow a flow rate of large mammals that leads to problems associated with the primary intended functions of the fence (Ferguson & Hanks, 2010). This, in turn, creates room for indirect HWC such as the blocking of wildlife-livestock disease transmission pathways (Boone & Hobbs, 2004; Ferguson & Hanks, 2010). Fences help to mitigate HWC in protected areas with high human encroachment, human settlements, grazing and factors that can trigger conflict (Ferguson & Hanks, 2010). Veterinary cordon, park and private fences play an important physical feature are not only the environment, but also the social sphere as they serve to separate wildlife from livestock and people (Ferguson & Hanks, 2010).

Transfronteir wildlife corridors will always play a relatively important role in regional conservation activities for large mammals especially during migration and dispersal seasons (Ferguson & Hanks, 2010). This holds as the transfrontier wildlife corridors present consolidated opportunities for large mammals to move freely between international borders (Ferguson & Hanks, 2010; Mogotsi, et al., 2016). A greater need for safer corridors between protected areas is gaining importance for large mammals such as the elephants from Botswana moving up to Zambia and Angola (Ferguson & Hanks, 2010; Eekin, 2017). The corridor created for the elephants in these regions has to some extent facilitated with the reduction of social and environmental pressures associated with the overabundance of elephants in countries such as Botswana and Namibia (Ferguson & Hanks, 2010; (Eekin, 2017). New relatively safe corridors such as transfrontier wildlife corridors will ensure that it is not only humans that benefit from this, but also the animals as this is an opportunity to disperse in previously unoccupied areas (Ferguson & Hanks, 2010).

Through the effective communication on impacts affecting livestock and conservation, there are concerns over the compatibility of the fences with the vision of the Transfrontier Conservation Area (TFCA) (Ferguson & Hanks, 2010). The conservation and developmental success of the Great Limpopo TFCA and Transfrontier Park (GLTFCA / GLTP) and the Kavango-Zambezi (KAZA) TFCA will depend upon a solid understanding of the complex issues surrounding approaches to the permissible mobility of wildlife and livestock. Park and veterinary cordon fences in southern Africa have since the 1950s been a part of the delimitation of wild areas and the diseases that may be contained therein (Ferguson & Hanks, 2010). A Transfrontier Conservation Area (TFCA) is a relatively new conservation paradigm (Ferguson & Hanks, 2010). It is defined by the Southern African Development Community's (SADC) Protocol on Wildlife Conservation and Law Enforcement as *"the area or a component of a large ecological region that straddles the boundaries of two or more countries, encompassing one or more protected areas as well as multiple resources use areas"* (Southern Africa Development Community, 1999). The 14 Member countries of SADC is a great initiative to bring together a complex and diverse mosaic of land uses under one management authority, including national parks and game reserves, forest reserves, wildlife and game management areas, communal land and private land (Ferguson & Hanks, 2010). It has taken the lead in the formal designation, establishment, and political recognition of TFCAs in Africa (Ferguson & Hanks, 2010).

2.5.2 People and fences

Historically, fences enclosed the majority of the protected areas in southern Africa, but some years ago, such fences were removed in several areas to restore natural migrations of animals (Nijhawan, 2008). There have been some deep-seated feelings of antagonism and distrust between wildlife authorities and local populations living in and nearby wildlife areas (Anderson & Grove, 1987).Fences have always been relatively popular in wildlife conservation because they served to protect the wildlife and to keep it separate from the people outside the fences (Hulme & Murphree, 2001). Fences create a physical barrier between wildlife and humans, excluding local communities from wildlife areas (Adams & Hulme, 2001). A strong preference of barbed wire in protected areas has been preferred as “barbed wire always been perceived as functioned in that paradoxical zone, between protection and division” (Krell, 2002). The idea of barbed wire is taken from the thornbushes, which were used protection and to deter outsiders (Krell, 2002).

Most international conservation organisations have embraced the concept of TFCAs (Wolmer, 2003). Which is a recent trend focused on bringing down the fences between countries to create TFCAs (Aberly, 1999; Berglund, 2015). Boundaries of ecosystems rarely overlap with those of national and political boundaries, so it is through that rationale that they embraced the concept of the TFCA (Chapin, 2004; Shongwe, 2006). Notwithstanding, global threats to interconnected ecosystems and migrating species requires a more large-scale international effort typically to tackling the issue (Chapin, 2004; Meretsky, et al., 2011). Economic growth through tourism development in southern Africa, has been made possible through the adoption and effective implementation of the TFCA (Wolmer, 2003). Allowing locals to be beneficiaries of the TFCAs, has shown positive economic growth (Ferguson & Hanks, 2010).

The policy of ‘fines and fences approach’ or rather ‘fortress conservation’ is categorised as the banning of locals from hunting animals in protected areas and labelling them as ‘poachers’, and fining them should they get caught (Brockington, 2002). This wildlife conservation strategy was introduced in the late nineteenth century and early twentieth century in protected areas/ national parks, as a result of a decrease and scarcity in larger game animals (Beinart, 1987), especially in southern African. During the World Parks Congress held in Durban in 2003, themed 'Benefits Beyond Boundaries', it became a requirement for communities to be co-operative partners in wildlife protected areas (Ferguson & Hanks, 2010). This was after groundbreaking 'beyond the fences/boundaries' projects such as ADMADE in Zambia, and LIFE in Namibia and CAMPFIRE in Zimbabwe (Kiss, 1990; Gibson, 1991).

Fences help protect wildlife in protected areas by restricting the movement of wildlife (Netz, 2004). However, through the restriction of wildlife, particularly larger wildlife like elephants, the confinement of mammals often leads to conflict (Venter, et al., 2008). It is for this reason that conservationists argue that the conservation of wildlife should not be confined to only fenced and protected places, but should stretch beyond that (Ferguson & Hanks, 2010). Studies of natural resource use at the wildlife/livestock interface found that fences have denied some communities access to natural resources, marginalising natural resource-based livelihoods and escalating resource conflicts (Mbaiwa, et al., 2008). The Great Limpopo Transfrontier Conservation Area (GLTFCA) "funders and park planners hoped that through the use of participatory approaches local people would feel that they have a real stake in protecting wildlife" (Duffy, 2000).

2.5.3 Mitigation measures for HWC

There are several mitigation measures for HWC that have been implemented across the world. Modern agriculture's development and expansion in the 20th Century gave rise to the exploitation and the diminished interaction with wildlife species, it is here that conflicts between humans and wildlife started to occur more frequently than in the past (Mwangi, 2015). Mitigation measures used to combat HWC include programmes such as compensation, insurance programmes and incentive programmes (Pettigrew, et al., 2012).

Compensational payments have worked for livestock loss, medical expenses, injuries, and helping out families of those who lost their lives because of human-carnivore conflict (Treves *et al.* 2009; Agarwala *et al.* 2010; Dickerman *et al.* 2011; Bauer, et al., 2015). This method is most preferred by Conservation Authorities to address any financial losses incurred because of HWC (Pettigrew, et al., 2012; Anyango-van Zwieten, et al., 2015). This method aids in increasing the tolerance for wildlife, by alleviating financial losses because of HWC (Pettigrew, et al., 2012; Karanth, et al., 2018). Better mitigation of loss of human life and reducing losses of endangered species involved, fewer retaliation killings and poaching are just some results of improved attitudes for human-wildlife interaction. This increase will improve the willingness of humans to conserve endangered species (Pettigrew, et al., 2012).

Wildlife compensation is a mitigation technique that has been tried and tested successfully around the world (Fourli 1999; Butle & Rondeau 2007; Agarwala *et al.* 2010; Boitani *et al*. 2010). This has been implemented successfully in Botswana (Nijhawan, 2008). Botswana is the only member of the SADC to employ a state-funded compensation system for losses because of wild animals (Nijhawan, 2008). A key aspect for successful compensation schemes is linking compatible land-use practices with conservation (i.e. grazing in fenced zones rather than free grazing) (Pettigrew, et al., 2012). A holistic, integrative approach can be a powerful tool for managing the risk of conflict, particularly if the approach is spatially explicit to allow the prediction of when and where conflict is most likely to occur (Pettigrew, et al., 2012).

Successful compensation schemes that have problem-solving mechanisms for all problems that can be encountered, in addition to good monitoring of wildlife, will yield success (Nyhus, et al., 2003). Wildlife compensation schemes need to be linked to a prevention measure (i.e. improved livestock management), as compensation alone has little impact on encouraging the protection of wildlife (Nyhus, et al., 2003; Wilson-Holt & Steele, 2019) . In fact, compensation measures might even promote the opposite to what they are trying to achieve (Nyhus, et al., 2003; Upadhyay, 2013). People might kill wildlife and fake injury so that they can claim from compensation schemes. Pastoralists might see compensation as opportunities to receive easy money, thus reducing their efforts to take care and selling of livestock (Nyhus, et al., 2003; Rondeau & Bulte, 2007; (Shilongo, et al., 2018).

Insurance programmes are similar to compensation schemes and do share similar difficulties (Pettigrew, et al., 2012). However, through the backing of private companies that ensure reasonable rates, more sustainable mechanisms for depredation compensations can be achieved (Pettigrew, et al., 2012). In Russia and Laos, people lacking interest in this type of scheme challenge it, and in addition, there is a lack of trust with insurance companies by the people (Miquelle *et al.* 2005; Nyhus *et al.* 2005; Johnson *et al.* 2006). India harbours around 23% of the world's carnivore species in approximately 2.3% of the global land area; however, few studies have undertaken ecological assessments or evaluated their conservation requirements in shared habitats dominated by human activities (Srivathsa, et al., 2019). HWC studies in places like India can aid with solutions to mitigate the potential for conflict between wild canids and humans, such assessments could benefit both people and predators (Srivathsa, et al., 2019). In China, communities affected by human-carnivore conflict expressed their interest in participating in community self-financed insurance programmes (Pettigrew, et al., 2012). This specific insurance type is excellent as it reduces the burden on government organisations that fund wildlife compensation programmes (Pettigrew, et al., 2012). Ultimately, the overall success of insurance programmes is relatively low, especially in areas where depredation is low (Miquelle, et al., 2005).

Incentive programmes provide an alternative income source on 'conservation-friendly' practices, such as improved livestock management (Pettigrew, et al., 2012). Unfortunately, market failure harshly affects local communities the most, when the drastic decline of global resources is affected by a lack of carnivore conservation incentives at local levels (Dickerman, et al., 2011). Hence, the provision of incentives at local levels is adopted as proactive, rather than reactive as a means to improve conservation outcomes (Dickerman, et al., 2011). In Mexico, locals are given incentives of $50 and $300 for any evidence in the form of camera trap records for live jaguars (*Panthera onca*) (Nistler, 2007). This initiative places more value in the jaguar alive than dead (Nistler, 2007). At the outset, incentive programmes are subsidised, and become self-sustaining over time (Pettigrew, et al., 2012).

An alternative incentive is revenue-sharing, which is aimed at protecting conservation (Pettigrew, et al., 2012). Through sharing potential revenue with the local community members via ecotourism and wildlife hunting, the burden caused by the presence of felonious wildlife becomes a shared responsibility for both Conservation Authorities and locals (Dickerman, et al., 2011). In Uganda, revenue generated by communities surrounding national parks helped build 21 schools, four clinics, one road and a bridge (Pettigrew, et al., 2012). Moreover, interviews with locals revealed that 72% of respondents had an improved attitude towards protected areas prior to the revenue-sharing (Archabald & Naughton- Treves, 2001). Conversely, comparable to compensation programmes, revenue- sharing programmes have the probability of distributing funds unevenly especially in remote locations, leaving the poorest the most exploited and unfairly treated (Dickerman, et al., 2011).

2.5.4 Policy

An increase in stricter law enforcement in protected areas is crucial for decreasing human disturbances in prime carnivore habitat, as this can reduce encounters that result in conflict (Pettigrew, et al., 2012). Carnivores are relatively safe in protected areas; it is outside the boundaries where substantial conflict happens (Hemson, 2002). It is difficult to restrict carnivores within the bounds of protected areas as they require large home ranges (Hemson, 2002; Ofstad, et al., 2016). Hence, it is imperative to devise land-use policies such that development does not encroach on carnivore-rich habitats (Nijhawan, 2008; Kaim, et al., 2019). Such policies should partition resources between people and carnivores so that it reduces clashes (Nijhawan, 2008; Ferguson & Hanks, 2010). Any sound policy should be rooted in science and based on thorough research while incorporating social sentiment and community attitudes (Nijhawan, 2008).

2.5.5 Initiatives

An existing intervention currently employed in the Waterberg Biosphere Reserve is the *Livestock Guarding Dog Project* (van der Merwe & Marnewick, 2014). The Endangered Wildlife Trust places livestock guarding dogs on livestock farms within the cheetah distribution range in South Africa (Endangered Wildlife Trust, 2014). Livestock guarding dogs provide a long-term solution to livestock predation that allows compatible livestock production despite the presence of carnivores (van der Merwe & Marnewick, 2014). EWT trialled the Africanis "Maluti" livestock guarding dog, an indigenous African breed of dog used to guard livestock in Lesotho, the Waterberg Biosphere Reserve, Chrissiesmeer, Amersfoort, Wakkerstroom and Lunesburg area in Mpumalanga to assist farmers as an alternative to indiscriminate predator control methods (van der Merwe & Marnewick, 2014). The EWT's Carnivore Conservation Programme and African Crane Conservation Programme have joined forces to initiate this programme to aid with decreasing human-carnivore conflict (Endangered Wildlife Trust, 2014).

Similar to the approached employed by the EWT, the Snow Leopard Conservation (SLC) programme also involves communities in working together to help solve a common problem (Jackson, et al., 2005). For the conservation and stewardship of snow leopard (*Panthera uncia*) in countries like Nepal, India, Pakistan, Mongolia, and Tajikistan, the SLC program was employed to engage with rural communities (Jackson, et al., 2005). Conservation of this endangered wild cat hinges upon equitable involvement and decision-making by local communities, as formulated through village-based, community designed incentive programs that simultaneously address human-wildlife conflicts, especially loss of livestock (Jackson, et al., 2005).

Such initiatives require strong linkages between the rationale for offering incentives, the benefits they may bring to stakeholders, and the community's vested responsibilities for protecting snow leopards and other biodiversity (Jackson, 2005). Such projects should be well-grounded in "Best

Practices" design and operational criteria, along with clearly articulating each stakeholder's conservation responsibilities. The specific arrangements for reciprocal financing and/or in-kind support, imbedded with mechanisms enabling participatory planning and action, and with well-targeted evaluation and collaborative monitoring to better ensure compliance with agreed-to rules, conditions, outputs and associated benefits (Jackson & Wangchuk, 2004).

2.5.6 Ecotourism

Travel and tourism is the fastest growing industry in the world (Ferguson & Hanks, 2010). It is the foremost job creator of all industries within the SADC region (Ferguson & Hanks, 2010). It creates an alternative source of employment in areas seeking to maximise foreign exchange earnings, within high levels of unemployment and relative unskilled labour-force (Ferguson & Hanks, 2010; Sofronov, 2018). Using plant and wildlife resources to benefit human populations not only removes incentives to develop the land for arable purposes or livestock herds, but also benefits biodiversity conservation (Ferguson & Hanks, 2010; Masanja, 2014). African wild dogs can bring significant economic opportunities through specialised initiatives like wildlife viewing (Lindsey, et al., 2005). This holds especially during denning season, as it peaks the interest of African wild dog lovers and ecotourists.

CHAPTER 3: Methods

(Image used with permission from Derek van der Merwe, 2019)

To fully understand the extent of human-carnivore conflict in the Waterberg, specific to private farmers and African wild dogs (*Lycaon pictus*), both a quantitative and qualitative approach was taken. Firstly, quantitative spatial analyses were conducted using home range estimates from secondary data (telemetry data of African wild dog global positioning system (GPS) collar fixes, hereafter *fixes*). Secondly, attitudes and tolerance levels of the farmers for African wild dogs was conducted using online surveys (primary data) shown in Annexure D and Annexure E. Details for the collaring of the African wild dogs are presented elsewhere.

3.1.1 Home range estimates

The area in which an animal lives and moves over a given period is defined as the home range (Burt, 1943). This is a method used to calculate a utilisation distribution describing the relative intensity of an animal's use of areas within a defined space (Van Winkle, 1975). The utilisation distribution (UD) is used to measure how much an animal uses an area in a given space (van Winkle, 1975). The contour encompassing total space used (selected in percentage), specifies the home range boundary (Anderson, 1982). An approach that can be applied to analyse the interior of the home range is the core area (Kaufmann, 1962).

Core area

Core areas are defined as areas used most intensely by animals as compared with other areas that encompass a cluster of dependable food sources, home sites and refuges (Burt, 1943) These clusters are composed of three or more locations daily, in half of the average distance of a daily move for that animal (Samuel, et al., 1985). The importance of core areas is that they aid in identifying the critical habitat for the species studied; they also help establish habitat requirements in the environment of the species (Samuel, et al., 1985).

Although home ranges can overlap, core areas typically do not (Samuel, et al., 1985). Core areas are useful in investigating the territorial behaviour and habitat usage of carnivores (Samuel, et al., 1985). High-volume location data from global positioning system (GPS) technology provide researchers the opportunity to identify various intensities of use within home ranges, typically quantified through UDs (Samuel, et al., 1985). Isopleths, or contours of the UDs, can also be used to determine core ranges (Beorger, et al., 2006). Isopleths are typically defined at 50% (core home range) and 95% (total home range extent) levels (Ostfeld, 1986).

Point density was used to calculate the core areas affected by African wild dogs in this study (Krisp & Špatenková, 2010). To measure the density of fixes per farm, the number of fixes per square kilometre was studied using the farm point density (fix per square km) (ESRI, 2018). The farm density (fixes per square km) was calculated using a point in polygon analysis using the software ArcMap 10.6 spatial join functionality to determine the number of African wild dog fixes falling within each farm (ESRI, 2018). The completion of the polygon analysis made it easy to calculate the geometric area of all farms in the projection of the World Geodetic System 1984 (WGS84) using the ArcMap 10.6 software (ESRI, 2018). A new field of density for each farm was calculated by dividing the count of fixes over the area of the farm (km^2) (ESRI, 2018). The following formula was used to achieve the new field of density:

$$Density\ per\ farm = \frac{count\ of\ fixes}{area\ (km2)}$$

Telemetry collars

African wild dogs were tracked by satellites through the use of Infrared Radiometric Satellite Tags/collars (supplier: Africa Wildlife Tracking, http://www.awt.co.za, Pretoria, South Africa). The collar fixes record their geographic location using the Africa Wildlife Tracking software (Africa Wildlife Tracking, 2018). In this study there were three (IR-SAT 2651, IR-SAT 2953 and IR-SAT 3017) collared female African wild dogs which were tracked on a daily basis from April 2018 up until January 2019. These GPS fixes were used to calculate the home range estimates and to map and analyse the movement patterns of the African wild dogs.

The GPS telemetry data from the three-collared African wild dogs were used to find the proximity to private farms in which they passed. These distances calculated led to the creation of buffers, which served as a proxy for home ranges (Grant, 2012). An average of the fixes was used to find the centre point of the range and aid with calculating the buffer area (Grant, 2012). The furthest point from the core was the maximum distance moved (MDM) and the average of the three GPS telemetry collars used to calculate buffer distance (Grant, 2012).

The accumulation of 95% of the African wild dog GPS positions was used to determine its home range and core area (White & Garrot, 1990). Core area estimates are essential as they identify the area with the highest extent of usage, they also identify the most important habitat preference and requirements for the African wild dogs (Samuel, et al., 1985). The relative amount of time African wild dogs spent in different areas of their range were determined using the kernel UD. This method utilises the probability estimations and calculates home range (Warton, 1989).

The software ArcMap 10.6 was used to determine the 95% UD probabilities (van de Vyver, 2016). This was achieved through calculating the home range estimates, core areas occupied by African wild dogs from April 2018 to January 2019 (Darnell, et al., 2014). These isopleth polygons of 95% for the home ranges and the core areas were assigned a probability density (kernel) to each GPS location, which was placed into a rectangular grid (Seaman & Powell, 1996). Through this process, a kernel density was created, and this density was used to establish the concentration of fixes at a given area (Darnell, et al., 2014). The UDs were used to establish how the pack of African wild dogs occupied the Waterberg Biosphere Reserve, the core areas they used, as well as how long they occupied the space at a time (van de Vyver, 2016).

Habitat use

The habitat used by African wild dogs was determined by determining the proportion of each home range covered by each vegetation unit (Creel & Creel, 2002). Using ArcMap 10.6 the proportion of GPS fixes for each African wild dog that fell into each vegetation unit within a particular African wild dog's home range, was calculated to establish the habitat use for each (van de Vyver, 2016). This showed how the African wild dogs used the habitat acoss the landscape in the Waterberg Biosphere Reserve (van de Vyver, 2016). Influences for habitat selection such as habitat with prey abundance, were then deduced from this information (van de Vyver, 2016).

Telemetry data were analysed using a simple distribution map of points classified by African wild dogs overlaid over SANBI 2011 vegetation using ArcMap 10.6. The respective habitat type use was calculated by multiplying the total number of fixes by the percentage of each vegetation unit occurring in the 95% UD for each African wild dog (van de Vyver, 2016).

Proximities

The shapefiles were sourced from the University of Pretoria, Geography, Geoinformatics and Meteorology (UP- GGM) server using the map codes of 2328 and 2428. Each pair of shapefiles was merged into one main topic shapefile; each shapefile was then selected by attribute to determine proximities to common features (ESRI, 2018). All shapefiles were projected to a projected coordinate system (PCS) coordinate system within meter (m) units (ESRI, 2018). A nearest feature distance analysis was done to determine the proximities of the dogs to feature such as houses, rivers, farms etc. An input of the African wild dog geographic location data, with the nearest theme shapefiles, was done using a geodesic measurement (ESRI, 2018). The results, where an addition of a near distance column exported and opened as shapefiles in QGIS 3.10.2, were then converted to CSUS (ESRI, 2018). The near-distance columns from all CSUS were carefully merged manually to one shapefile (ESRI, 2018). The near- distance in the shapefile was then converted to km by dividing the distance by 1000 (distance/1000) (ESRI, 2018). The results of nearest distance to features for all the African wild dogs were then grouped to each individual's telemetry collar, by creating a new sheet on QGIS 3.10.2, and selecting by attribute for each telemetry collar tag and the average distance on a daily basis to common features (ESRI, 2018). These sheets were used to calculate the average near-distance per African wild dog on a daily basis to each feature that could increase the probability of conflict (ESRI, 2018). The same method was applied to calculate the nearest distance to common features for all the dogs (ESRI, 2018). These results were then tabulated.

3.1.2 Tolerance levels

Human wildlife conflicts (HWC) is a type of biodiversity conflict consisting of two components: (i) impacts that arise from direct interactions between humans and wildlife species and (ii) conflicts between humans themselves over how to manage the impacts between humans and wildlife (Young et al. 2010; Game et al. 2014). HWC as a complex conservation problem that requires multidisciplinary and trans-disciplinary approaches (Game, et al., 2014). HWC is distinct from typical biological parameters (e.g. animal behaviour, population dynamics, or species richness) in that it is as much a sociological phenomenon as it is a biological phenomenon (Atwood & Breck, 2012). Thus, people with differing beliefs and attitudes towards wildlife and the actions of wildlife can influence the perception of what is or is not deemed conflict (Atwood & Breck, 2012). Understanding the attitudes of stakeholders that are directly affected or living in close proximity to wildlife are crucial in gathering information needed to manage wildlife better and devising interventions to alleviate HWC (Manfredo et al. 2009, Decker et al. 2012).

Attitudes are defined as dispositions or tendencies to respond with some degree of favourableness or lack of, to a psychological object (the psychological object being any discernible aspect of an individual's world, including an object, a person, an issue or a behaviour) (Fishbein & Ajzen, 2010). The attitude construct is dominant in both social psychology and environmental psychology, because of the importance of evaluating one's environment as a core of human's existence (Allport 1935; Clayton 2012; Heberlein 2012; Fiske & Taylor 2013; Kansky & Knight 2014).

Attitude research in HWC gives insight in terms of what participants prefer /tolerate relating to diverse population management options, desired support related to species population sizes, the extent of damage tolerable by stakeholders, and desirability of different species on private and commercial land (Manfredo et al. 2009; Kansky 2014). This information is useful for conservation managers as it guides them in designing and predicting interventions that will be supported and accepted by the stakeholders (Kansky & Knight, 2014). Thus, reducing and preventing potential conflict in future (Kansky & Knight, 2014). Moreover, interventions can be more tailor-made for the convenience of the stakeholders when their preferences are better understood (Heberlein, 2012).

For the effective reduction HWC and the successful implementation of conservation outcomes, democracy in wildlife management is needed (Decker, et al., 2012). The perceptions of the humans affected by this type of conflict are relatively important, as it shapes how they will treat the animal they conflict with (Kansky & Knight, 2014). The acceptance or lack of acceptance (tolerance/intolerance) of the animal will influence the reaction of the human towards the animal (Kansky & Knight, 2014). Determining the extent of stakeholder tolerance and the factors driving this tolerance is important as individuals differ widely in their attitudes and tolerance towards wildlife (Treves & Bruskotter, 2014). Within a culture, some individuals have greater tolerance than others; thus, understanding this dynamic is critical for implementing effective conservation policy (Atwood & Breck, 2012). Consequently, obtaining a wider range of stakeholder views is particularly important so that those heard are not only the powerful individuals and those with extreme views, or institutions and specialised interest groups that are unrepresentative of stakeholders (Kansky, et al., 2016).

In most instances, HWC results in the financial loss for farmers and land owners who have either livestock, game, property or crops (Dickerman, et al., 2011). The result of such financial loss, particularly in developing countries and rural communities in poverty, is little tolerance for wildlife as well as negative attitudes for the conservation of wildlife (Dickerman, et al., 2011; Gemeda & Meles, 2018). In contrast, some cultures have a greater tolerance for the presence of animals (e.g., Hindu) than others (Atwood & Breck, 2012).

Research on stakeholder attitudes to living with wildlife is on the rise (Kansky & Knight, 2014). The present research aimed to understand factors explaining attitudes and tolerant behaviour specific to the African wild dogs as determined for other species (Kansky, 2014). Consequently, determining the extent of stakeholder attitudes and tolerance and the factors driving this tolerance are, therefore, critical (Treves & Bruskotter, 2014).

The African wild dog symbolises the necessity for unbroken and wild landscapes and is a flagship species for the African continent (Davies-Mostert, et al., 2016). There is minimal use or trade of the African wild dog, this is seen with majority of their geographical distribution range; local trade in the form of traditional medicine, commercial use and international trade (traditional medicine and zoos) (Davies-Mostert, et al., 2016). Although medicinal uses of African wild dogs are non-existent to date, especially in South African traditional cultures, it is still believed that smoking their fur facilitates a person to sleep, and to cure illness like headaches (Page, et al., 2015).

Determining the extent of tolerance amongst the stakeholders as well as factors influencing human-carnivore conflict in the Waterberg Biosphere Reserve is crucial. To address all questions raised throughout this research pertaining the level of tolerance and extent of human-carnivore conflict, quantitative randomised surveys were the best data collection methods to test the attitudes towards the African wild dogs (Kansky, et al., 2016).

SURVEYS

Sociological research on wildlife conflict typically focuses on problem identification, formulation of mitigation strategies, and evaluation of the success of management actions (Treves, et al., 2006). Much of the sociological research relies on the analysis of survey data collected from stakeholders designed to elicit information on relevant attitudes and perceptions (Kobus, 2015). This information can then be correlated with stakeholder behaviours and, if correlations are strong, used to indirectly predict future behaviour (Manfredo, 2008). Influences of socioeconomic factors in wildlife conservation have been studied extensively in the past (Kolowski & Holekamp, 2005). For this research project, data were obtained using an online survey.

The surveys were electronically collected using Survey Monkey over a period of three months (May-July 2019). The main purpose of the survey was to understand the tolerance levels of the farmers affected by the African wild dog's migration in the Waterberg Biosphere Reserve. A sample size of 81 farmers was used in the survey. People interviewed were private farmers and landowners with valuable game, as well as livestock, and had expressed their willingness to participate in this study as they have had some form of interaction/ experience with wild dogs. The online survey had an option of English or Afrikaans as that is the most commonly used languages in the study area by private landowners. In prior interactions with the farmers, a willingness to partake in research of this nature was indicated. The landowners were comfortable with being interviewed in English and Afrikaans. For the purpose of this research, it was important to know the farmer's tolerance for African wild dogs. This together with accompanying positive/ negative perceptions and beliefs towards the African wild dogs was used to determine what happens when they interact with the farmer.

The electronic surveys were used to:

1. Determine the farmer's tolerance levels towards the African wild dogs
2. Determine the cause of conflict between the farmers and African wild dogs.

The online survey took 15-20 min. to complete. A set of predetermined close-ended questions were used, and participants were encouraged to share their experiences and views regarding human-carnivore conflicts using a set of options provided (Greef, 2002). The online survey consisted of 24 questions in total. A series of systematic differential questions were asked in the online survey (Zimmermann, et al., 2005). There were 19 multiple-choice questions, and five open questions. The structure online survey and answers to the survey are available on Annexure D and Annexure E, respectively.

African wild dogs are a difficult species to conserve because of their relatively large home ranges and wide ranging behaviour (Fuller *et al.* 1992; Estes 1993; Thorn *et al.* 2012). Therefore, the information garnered was important to understand the perceptions of the farmers regarding African wild dogs and suggest measures that they deem necessary to keep the species from their farms. Information extracted from the online survey was transcribed and processed using SPSS Statistical software to quantify the results as seen in Chapter 4.

3.2 Data analyses

This research followed the analysing of two different data sets; the quantitative data and the qualitative data. The quantitative data was analysed in a spatial analysis. The data collected through the various methods abovementioned, was analysed using the following procedures in Table 1 below:

Table 1: the research was conducted using five objectives, which had individual desired outcomes. Each outcome from the objectives constituted to the results presented in Chapter 4.

Data Analysis	**Procedure followed**
Spatial analysis	*Home ranges:* - The Utilisation Distribution at 95% of wild dog fixes were calculated by finding the probability estimates on ArcMap 10.6. This was done by creating an isopleth polygon at 95% fixes and placing the fixes on a rectangular grid to find areas of extensive usage. - A similar, simpler method was used on ArcMap 10.6 to calculate the fix density per km^2 and point density per km^2. This method used telemetry collar fixes of the wild dogs on the ArcMap 10.6 software. - Results from the UD and fix and point density were compared, and the researcher decided to work with the fix and point per density results as they were easier to interpret. - Results of the fix density per km^2 were also used to establish how much time the wild dogs spent in a given area at a time (over wet/ dry months) *Core areas:* - On the software ArcMap 106, the point density per farm (km^2) was calculated to establish the number of fixes on the farms during the period of April 2018- January 2019. - A point in polygon analysis on ArcMap 10.6 was done. - The results of the point in polygon analysis were then converted into a heat map to get the point density per square km for core areas of conflict. - Results were presented in the form of a map.

	Proximities: - Buffers (at 3km, 2km, and 1 km) between the average wild dog fixes per day and proximities to common features (i.e. houses, ruins, rivers, roads, etc) were calculated on QGIS 3.10.2 software. - These buffers served as proxies for home ranges (Grant, 2012). - The African wild dog fixes shapefile was selected by attribute to find proximities to common features on the dataset on ArcMap 10.6; the nearest feature distance was calculated. - Results obtained were used to compile the nearest feature distance and a criteria for areas with high interactions with wild dogs. - Results were presented in Table. *Habitat use:* - Wild dog fixes were overlaid over SANBI vegetation shapefile as a base map, and a total number of fixes by the vegetation within 95% of the UD for each dog over the study period was calculated. - Results were presented in a Figure 7.
Tolerance levels	*Online survey:* - The online survey was conducted on Survey monkey with a sample size of 81 respondents. - The results from the survey were analysed and quantified using the SPSS statistical software. - Results of this were presented in Tables and Figures.

3.3 Ethical Considerations

According to the Helsinki Declaration of 1972, it is imperative to obtain clearance from an ethics committee when human (or animal) subjects are involved in any kind of research of an empirical nature. It is essential that throughout the research process, the researcher follows and abides by ethical guidelines (Kobus, 2015). When working with individuals it is essential to understand and pay attention to the following ethical principles:

3.3.1 Informed consent and voluntary participation

A local meeting for the private landowners in the Waterberg Biosphere Reserve was be conducted to inform the participants of the research that the researcher conducted. The researcher together with the EWT, stated the purpose of the research and requested for interested parties to indicate their willingness to partake in the online survey. After a clear indication of participation from the landowners, a consent letter was then given to them as written proof of the research online survey to be sent to them via a link that was shared to them on a Whatsapp group created by the EWT. In the online survey, it was clearly stated that participants are free to withdraw at any point should they wish to.

3.3.2 Protection from harm

As the researcher it is important to ensure that participants are not exposed to any undue physical or psychological harm (Leedy & Omrod, 2001). Therefore, the option of an online survey was the safest as participants could do it in the comfort of their own home, on a secure link only sent to them to answer. The option of an online survey also meant that the risks of physical and psychological harm were reduced significantly.

3.3.3 Privacy, confidentiality and anonymity

Both the researcher and the participants should have a clear understanding regarding the confidentiality of the results and findings of this study (Burns, 2000). All participants' information and responses shared during the study will be kept private and the results presented in an anonymous manner, the information given will be treated with respect, as a measure to protect their identities.

Additionally, the researcher continuously conducted the research according to the Ethics and Research Statement provided by the Faculty of Natural Science and Agriculture of the University of Pretoria. For this research, the University of Pretoria's Ethical committee granted human ethical clearance (As seen in Annexure C); an ethical clearance number of NAS143/2019 was granted.

3.3.4 Protection from harm

Throughout the course of the research, the researcher was honest, respectful and empathetic towards all the participants. A debriefing session prior to sending out online surveys was done. All necessary referrals to a professional from EWT who can provide such a service were also available (Kobus, 2015).

CHAPTER 4: Results

(Image by Keith Jones, used with permission from Derek van de Merwe, 2019)

4.1 Spatial analyses

4.1.1 Spatial tracking and monitoring movement patterns of African wild dogs

Using the tracking data from the African wild dog pack individuals in the Waterberg Biosphere Reserve for 2018-2019, the key areas potentially affected by African wild dog conflict were identified (Figure 5.1). Only areas that had African wild dog presence from April 2018-January 2019 are shown. The farm parcels showed the fixes density per square km. Farm parcels 205 and 207 were core areas as they have the highest African wild dog presence with a density of 202 fixes per km^2 and 183 fixes per km^2 respectively. Other farms with a high number of fixes per square km were farm parcel 796 and farm parcel 59, with a fixes density of no more than 51 fixes km^2 each. This pack of African wild dogs has three collared individuals from the same pack: Tag 2651, Tag 2093, and Tag 3017; thus, the results shown were for all during the study period (Figure 5.1).

Figure 5.1: Overall presence of African wild dogs in the Waterberg Biosphere Reserve during the present study. This illustrates the farm parcels with African wild dog presence Parcels 205 and 207 had the highest number of fixes per square km with 202 fixes per square km, and 183 fixes per square km respectively.

The extent of African wild dog presence is shown more in detail in Figure 5.2. Since there were three telemetered individuals, the results were divided into four parts. Key areas affected by all individuals (Figure 5.2(I)), Tag 2651 only *(Figure 5.2(II)),* Tag 2953 only (Figure 5.2 (III)), and Tag 3017 (Figure 5.2 (IV)). The farms density per square km and farm point density per square km were calculated and shown. The results of the point density (Figure 5.1 and 5.2) showed that farm parcels 205 and 207 were the most affected areas by African wild dogs as their density per square km were high and red in colour, thus core areas of habitat use and of potential conflict.

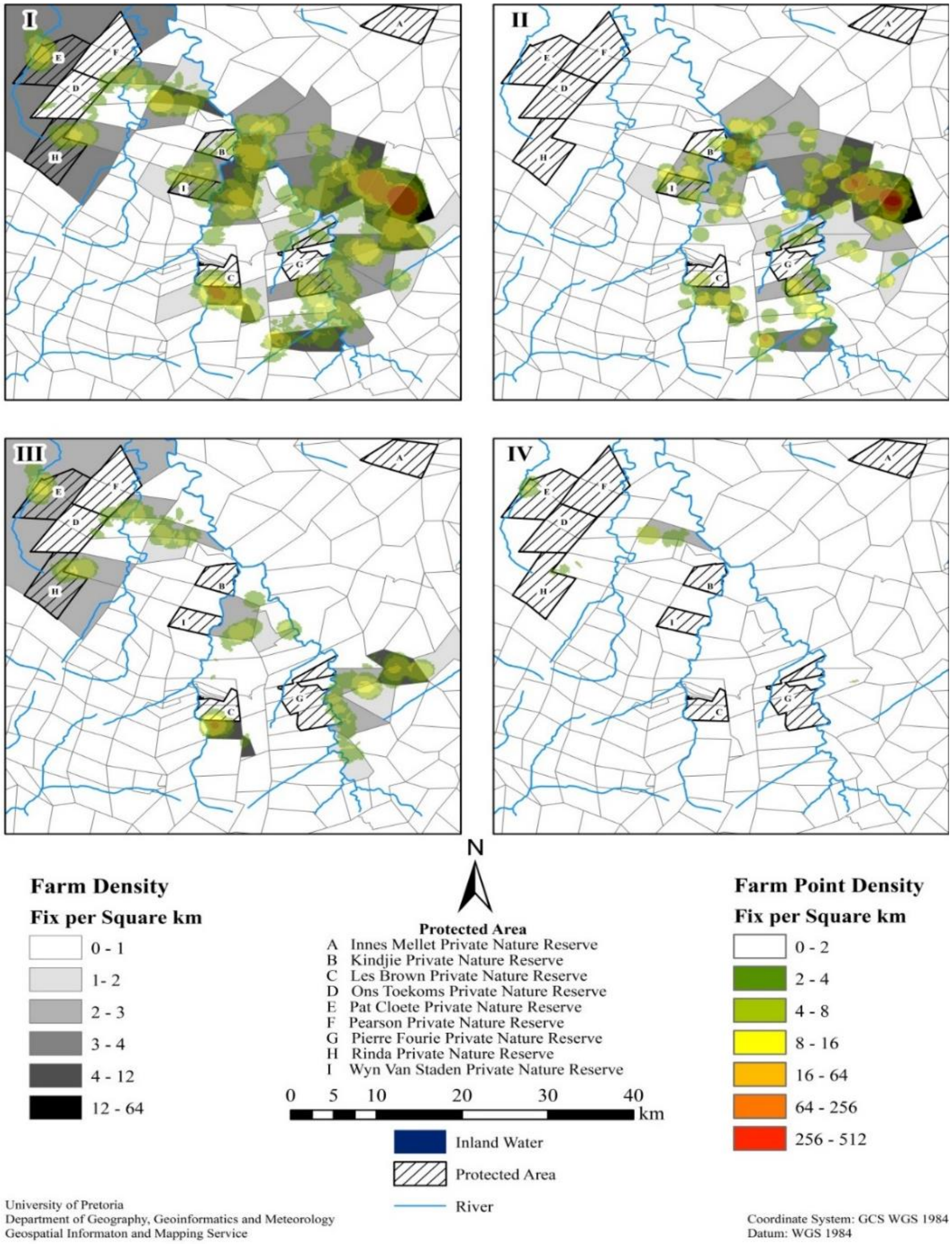

Figure 5.2: Key areas affected by potential farmer-wild dog conflict are shown based on telemetry data showing the presence of African wild dogs in the Waterberg Biosphere Reserve in the present study. The core areas affected, potential conflict hot spots and distribution of the telemetered individuals (April 2018- January 2019) are shown. (I) All individuals; (II) Tag 2651; (III) Tag 2953; and (IV) Tag 3017.

Once the field of density was established for all telemetered individuals, the point density analysis in ArcMap 10.6 was done to separate shape files for each. These separated shape files were then classified in the same intervals across all individuals to consistently show the core areas covered by the points, as well as hotspots for potential conflict formed by each. It was important to separate shapefiles for each and not only show the combined core areas for all. Tag 2651 was the alpha female, and the other two were subordinate dogs. The different individuals showed different types of presence information between the seasons.

There was a clear pattern of a high concentration of fixes close to rivers and water bodies (Figures 5.2 (I), (II), (III), and (IV)). The presence patterns of Tag 2651 (Figure 5.2 (II)) and Tag 2953 (Figure 5.2 (III)) showed an average of 2-16 fixes per km^2 along rivers. The African wild dogs also shared commonalities with regards to specific farms they were present in. Tag 2651 and Tag 2953 shared the following groups of parcels: Parcel 52, 59; Parcel 36, 37, 654; Parcel 44, 210 (Figures 5.1 and 5.2). There were more fixes per km^2 near protected areas for Tag 2953 (Figure 5.2 (III

Elevation

It was through a Digital Elevation Model (DEM) (Figure 5.3) that showed the elevation of the study area that gave further insight into African wild dog presence. On average, the dogs individuals used low to moderate elevations close to rivers (Figure 5.2). Farm parcel 43 (Figure 5.1), which was located next to the denning site, was at a relatively steep elevation. This was the reason why the individuals did not pass through there since collared. Other farms where the individuals did not pass were farm parcels 46, 48, 76 and 49 (Figures 5.1 and 5.3). With closer inspection using the DEM (Figure 5.3), these were at steep elevations. The African wild dogs typically hunt for food on generally flat lands where they can run and roam freely. Relatively steep slopes make it difficult for them to climb and hunt, so it is easier to go around. This pack moved on medium to high elevations with gentle slopes (Figure 5.3) and were typically roaming where it was most convenient to get food, water and enough home range.The denning site appeared to be at a on low elevation.

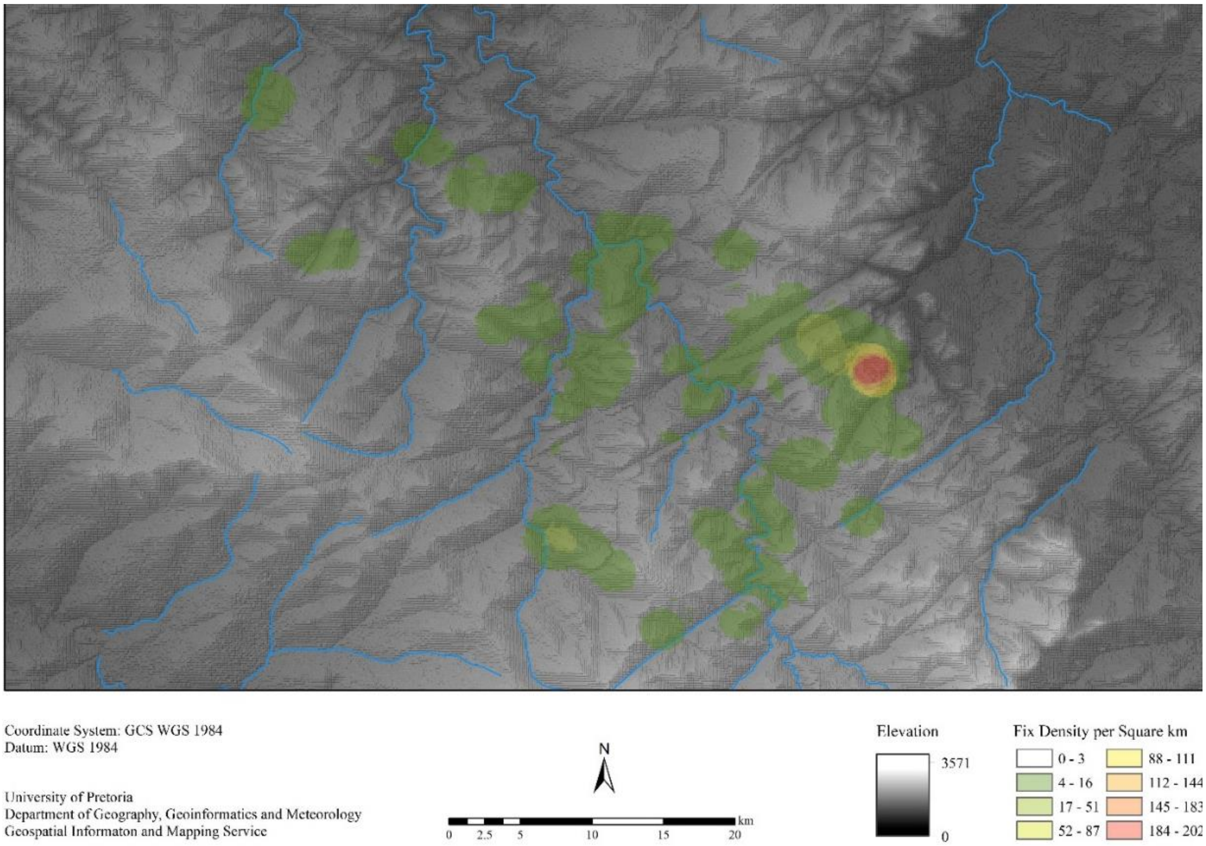

Figure 5.3: A Digital Elevation Model (DEM) showing elevation, habitat areas used and potential conflict hot spots in the Waterberg Biosphere Reserve for all telemetered African wild dogs (Tag 2651, Tag 3017 and Tag 2953). On average, the individuals used low to moderate elevations close to rivers.

A clear contrast in concentration of points on different sides of the study area showed a difference in habitat use for two of the telemetered individuals. This was explained when wet and dry months presence data were compared.

Wet and dry seasonal patterns

In the Waterberg Biosphere Reserve, the seasonal presence patterns of telemetered African wild dog individuals are shown for the dry season (Figure 6.1 (I) and (II)) and wet season (Figure 6.1 (III) and (IV)). Their seasonal presence patterns (Figures 6.1 and 6.2) showed a particular pattern used by the individuals in different seasons of the year. During the dry season (Figure 6.1 (I)), the seasonal point data showed presence was dispersed across the study area. There was high activity and much movement across the Waterberg Biosphere Reserve. This trend changed between July-September 2018 (Figure 6.1 (II)), when the level of movement decreased rapidly. During this time, farm 205 (Figure 5.1) had a farm seasonal density of 54 fixes per km^2. This was a dramatic increase from just 2-3 fixes per km^2 for the seasonal farm density, for months April- June 2018. A possible explanation is that this is denning season and the dogs tend to have relatively restricted movements.

Clustered fixes were around rivers at this time (Figure 6.1). There was a pattern that the telemetered individuals followed. They moved next to the river, went to the denning site, around farm parcel 42 and 43 (Figure 5.1), then moved either down through farm parcel 42 and 657 (Figure 5.1), or around parcel 657 and 655 down to farms 587 and 588 (Figure 5.1) to rest near the river.

In the wet season, during November – December 2018 (Figure 6.1 (III)), the wild dogs spent a lot of time on farm parcels 36 and 37; they were also present on farm parcels 59, 52 and 117 (Figures 5.1 and 6.1). These farm parcels were all close to the rivers. However, the African wild dogs avoided farm parcels 76, 49 (Figures 5.1 and 6.1) during this season. They also did not pass protected areas C and G; although, a 27-81 fixes per km^2 were observed next to protected area C. A fix per square km of 3-9 fixes (Figure 6.1 (III)) were next to the river, opposite protected area G. The patterns led back to the denning site (farm parcels 205, 207, 796) through farm parcels 206, 117, 210 and 44 (Figure 5.1). The denning site had a seasonal point density of 27-81 fixes per square km, which showed that presence increased, but movement were restricted to an extent as compared with Figure 5.2(I). Essentially, it is possible that this pattern started from the denning site (farm parcels 205, 207, 796; Figure 5.1), it went to the river through the abovementioned sequence, then up to farm parcels 587 and 588 (Figure 5.1) as seen in Figure 6.1 (III).

This pattern changed for the wet month, January 2019 (Figure 6.1 (IV)), the telemetered individuals showed a migration up north west to close to protected areas E, F, D and H (Figure 6.1). Farm parcel 205 (Figure 5.1) had gone from a seasonal farm density of 54 km^2 to 0 km^2 fixes density.

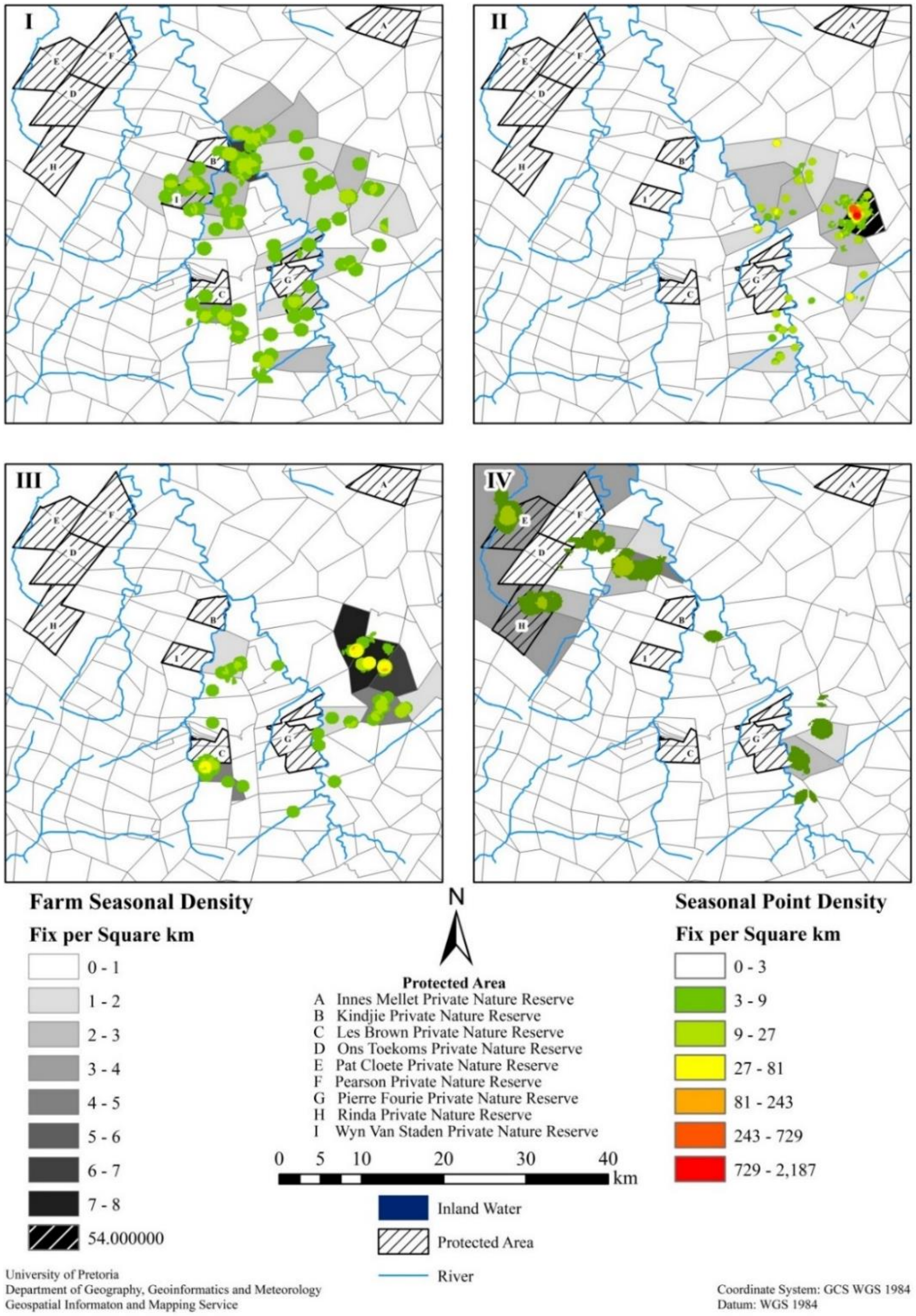

Figure 6.1: Seasonal distribution of fixes for all telemetered African wild dogs in the present study where: Dry season: (I) [April, May, June 2018] & (II) [July, August, September, October 2018]; Wet Season: (III) [November, December 2018] & (IV) Wet season [January 2019].

Further analysis showed that during the dry season (April- June 2018), Tag 2651 showed a scattered presence (Figure 6.2 (I)). However, for months July- September 2018, the same pattern followed in

Figure 6.1 (II) with a concentration of location points around the denning site and the rivers and potential food sources (Figure 6.2 (II)). During the wet season (October- December 2018), Tag 2651 was still clustered by the denning site. However, Tag 2953 was making movement from the denning site, down to the rivers to farm parcels 59 and 52, then around farm parcels 76 and 49 (Figure 5.1), and spent a lot of time on farm parcels 36 and 37 (Figure 6.2 (III)). The exact pattern was as in Figure 6.1 (III) and repeated. Tag 2651 was the alpha female and had the pups, while Tag 2953 was hunting for food to return to the denning site to feed the other dogs from the pack.

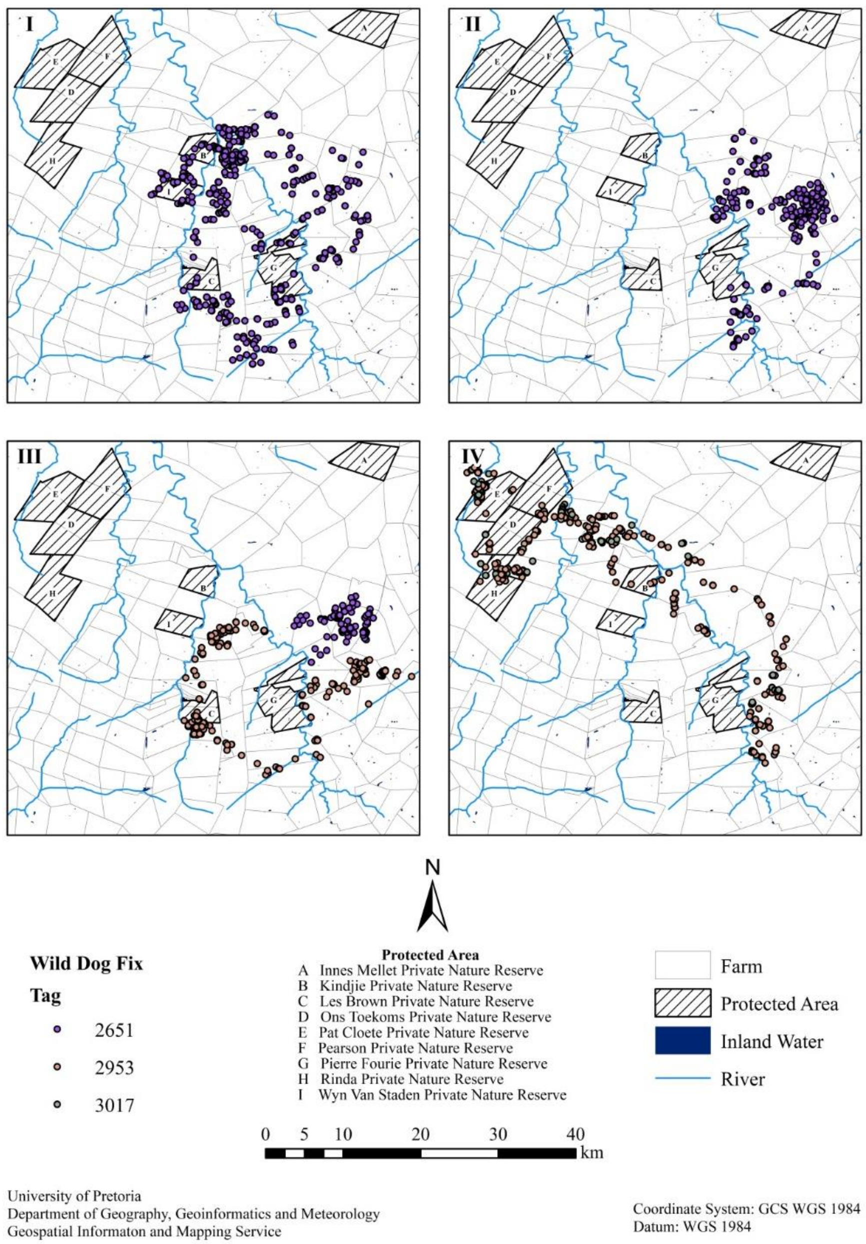

Figure 6.2: Simple individual telemetered African wild dog density maps showing their distribution and their exact point location. This map showed the seasonal distribution of the

individuals, similar to that of the seasonal point density map (Figure 10a), but showed points for each dog. Dry months: (I) Autumn [Apr, May 2018]; (II) Winter [Jun, Jul, Aug 2018]; Spring [Sept, Oct, Nov 2018]; Summer [Dec 2018, Jan 2019].

The wet month of January (Figure 6.2 (IV)), mainly showed the movement patterns of Tag 2953 and that of Tag 3017. They moved from farm 118 (Figure 2) up north, around farm 42, 43 and 657 (Figure 2). The dogs passed through protected area B and settled in protected area H and E (Figure 6.2). This showed that these African wild dogs changed habitats in different periods of the study.

Activity patterns

The telemetered African wild dogs showed change in activity and movement with time. Mean distance covered decreased in the interval 06:00- 11:59am to 103 km, before increasing again to 200 km in the interval of 12:00- 17:59pm (Table 2). Interval 18:00- 23:59pm showed the least distance travelled during April 2018- January 2019, with an average of 40 km (Table 2).

Table 2: African wild dogs activity and movement varied with time. They were crepuscular predators that were mostly active early in the morning, rested during the day, showed a high level of activity in the afternoon, and very little activity in the late evening.

Time	**Sum (km)**	**Mean (km)**	**Standard deviation**
00:00- 05:59 am	1199	200	185
06:00- 11:59 am	617	103	61
12:00- 17:59 pm	1201	200	144
18:00- 23:59 pm	241	40	12

Telemetered African wild dogs showed heightened activity in the morning at 04:00 – 05:59 (Figure 6.3), with the highest amount of activity in the 04:00-04:59 interval (Annexure A). The sharp activity was repeated in the afternoon at 15:00- 17:00, with peak activity in the 15:00-15:59 interval (Annexure A). This pack shows decreased activity early in the morning at 24:00-02:59, and 10:00-

11:59 (Annexure A and Figure 6.3). The total distance travelled by the dogs is also at its lowest 18:00- 23:59 in the evening (Annexure A and Figure 6.3).

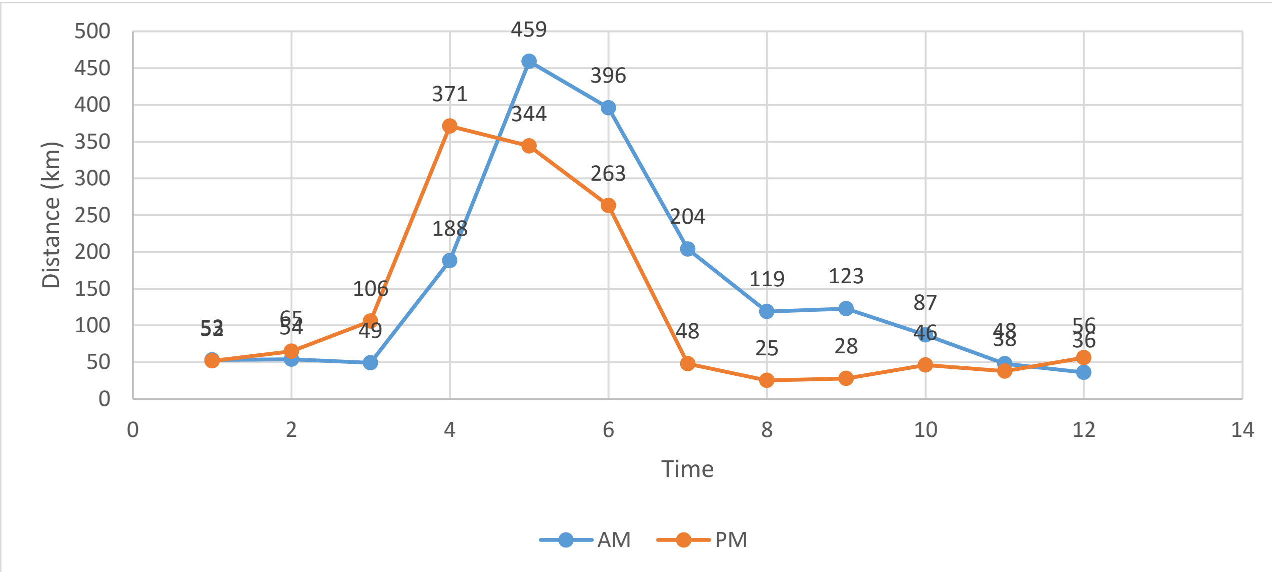

Figure 6.3: Comparison of distance moved with time for telemetered African wild dogs comparing mornings and afternoons. They were generally more active early in the morning (04:00-06:00) and again in the afternoon (15:00-17:59). Peak activity in the morning was at 05:00 and the late afternoon at 16:00.

During June the telemetered African wild dogs showed the highest amount of movement (497 km for that month alone (Annexure A). The movement of the telemetered African wild dogs decreased in the months of July and August but picked up in September. They den during this time, which explained the drop in distance travelled and overall activity as found in other studies (Creel & Creel, 2002). In addition, from November to March, the telemetered individuals were less active in terms of distance moved compared with the dry months (April to October) (Annexure A). Seasonal patterns showed how the locations of the African wild dogs were distributed across the study area for dry and wet seasons respectively. In the dry months, they travelled a total distance of 2367 km. While African wild dogs travelled a total distance of 987 kmin the wet months.

Phases of the moon

Surprisingly, the African wild dogs showed the least amount of activity on nights on a full moon (Table 3 below). They covered relatively large distances for about four days before the full moon, and three to four days after the full moon (Annexure B). Then on the night of the full moon, they travelled short distances. They travelled a mean of only 6.7 km on days with a full moon (Table 3). This could substantiate what research showed about prey being less active in during the period of full moon and behaviour of wild dogs shows similarities when compared with that of lions in this instance (Creel & Creel, 1995). Wild dogs tend to travel short distances during moonlit nights (Creel & Creel, 1995).

Table 3: The sum of distances (km) travelled by telemetered African wild dogs during the different phases of the moon in the present study.

Phase of the moon	**Sum**	**Mean**	**Mean distance 3 days prior**	**Mean distance 3 days post**
New moon	170	18.9	14.4	14.6
First Quarter	148	15.4	12.0	12.0
Full moon	60	6.7	9.9	5.6
Third Quarter	89	9.9	12.6	8.9

Three days prior a new moon, the mean distance covered by wild dogs was 14.41 km, and this held even after a new moon, as the mean distance covered three days after a new moon was a mean of 14.56 km (Table 3). Relatively vast distances were covered per day by the telemetered individuals, days leading to and after new moon (Table 3).

New moon had the highest amount of activity on the night compared with all four-moon phases (Table 3). A mean of 18.9 km was travelled by the dogs every new moon. While a mean of 15.4 km was travelled during first quarter, during the period of April 2018- January 2019. The third quarter has a mean of 9.9 km travelled during the phase, and the full moon only had 6.7 km as amean distance covered (Table 3).

The first quarter also has a substantial amount of activity on the night of the moon phase (Table 3). It was relatively similar to new moon, as the mean distance covered per day three days prior and post to the moon phase usually was lower, than on the day of the phase. The third-quarter had a decreasing mean distance covered. Three days before a third quarter, a mean of 12.59 km was covered by telemetered individuals, and a mean of 9.89 km was covered in the third quarter moon phase, and this decreased even more for three days prior the phase with a mean distance of 8.89 km after the phase (Table 3; Annexure B).

4.1.2 Identifying the drivers of the human-African wild dog potential conflict

Proximities and habitat use:

The results of the nearest feature distance (Table 4) showed the proximities of the telemetered African wild dogs to features that were the possible causes of conflict, how the dogs used the habitat and their habitat use.

Table 4: Showing the proximity of the dogs to different feature classes that could explain the causes of conflict.

		Tag 2651	**Tag 2953**	**Tag 3017**	**Mean distances for all the dogs**
Buildings	House	**1.13**	1.37	1.42	**1.20**
	Ruin	8.89	5.25	4.44	7.90
Land Cover	Cultivated Land	**1.92**	2.13	2.22	1.98
	Forest and Woodland	5.68	11.18	12.76	7.19
Transportation	Footpath	**0.25**	**0.23**	0.35	**0.25**
	Main Road	9.86	18.03	18.87	12.04
	Other Road	1.33	1.56	1.84	1.40
	Road	**0.24**	**0.22**	**0.33**	**0.24**
	Secondary Road	2.83	2.29	2.25	2.69
Barriers	Avenues	4.47	3.78	3.30	4.27
	Fences	**0.66**	**0.57**	**0.45**	**0.63**
	Furrow	13.01	12.07	10.39	12.70
	Wall	11.89	11.47	13.01	11.84
Hydrological	Dam	**1.41**	**1.56**	**1.52**	**1.45**
	Flood Bank	5.99	6.95	5.21	6.17
	Nonperennial Pan	10.03	13.82	14.98	11.07
	Nonperennial River	**0.21**	**0.23**	**0.22**	**0.21**
	Perennial River	5.01	2.90	3.58	4.48
	Reservoir	**1.76**	**1.74**	**1.67**	**1.75**

	Spring	4.70	5.05	6.20	4.84
	Vlei	6.00	9.66	11.19	7.03
	Weir	7.94	8.06	8.49	7.99
Other	Landing Strip	**2.94**	4.67	5.33	3.43
	Silo	**45.31**	42.17	44.78	44.59

Buildings

In this study, the closest location point of a telemetered individual was measured to a feature, and then averaged. The results showed that on average the fixes for all the dogs were located a mean of 1.20 km from houses. The dogs were closer to houses with people as opposed to ruins, where there a mean of 7.90 km away from ruins. This applied especially for Tag 2651, who was on average 1.13 km away from houses, the closest of the telemetered individuals.

Land cover

In terms of land cover, the telemetered individuals were on average were 1.98 km away from cultivated land, but 7.19 km away from forest and woodland. Tag 2615 moved closer to forest and woodlands compared with Tag 2953 and Tag 3017. The African wild dog pack in the Waterberg Biosphere reserve used open spaces, specifically cultivated lands as opposed to woodlands and forests.

Transportation

The telemetered African wild dogs showed a relatively close proximity to dirt roads, with an average distance of 240 m on average from secondary roads (roads supplementary to main roads i.e. gravel roads and dirt roads). Tag 2953 was the closest to these type of roads with an average of 220 m from roads. They showed relatively close proximity to secondary roads, with an average distance of 1.4 km away from these roads on a daily basis, and Tag 2651 being merely 1.33 km away from these roads on average every day (Table 4). It is clear that this African wild dog pack had a high chance of interacting with humans regularly.

The African wild dog pack also used footpaths and secondary roads (i.e. gravel roads and dirt roads), as opposed to main roads (tar roads). This was seen by their average distance of 250 m from smaller roads. However, the dogs used main roads (tar roads) less as on average they were 12.04 km away from them. Tags 2953 and Tag 3017 were on average 18.03 km and 18.07 km respectively away from main roads, while Tag 2651 was much closer to main roads with an average distance of 9.86 km daily. The telemetry data showed that the dogs like flat, open pieces of land where the can travel long distances, but avoid main roads.

Barriers

The telemetered individuals were on average 630 meters away from fences, with Tag 3017 only 450 meters from fences on average. The analysis showed that the wild dogs often moved along near fences. A possible reason for this was that the fences ran alongside roads or were barriers to further movement. Individuals stayed away from walls with 11.84 km away on average.

Hydrology

The analysis showed that on average, the telemetered individuals were 210 metres away from non-perennial rivers, and 1.45 km away from dams. For example, Tag 2651 on average was just 1.41 km away from dams. The dogs showed a close proximity to reservoirs, with an average distance 1.75 km. Tag 3017 was the dog closest to reservoirs with an average of 1.67 km away. The data showed that on average the dogs were 11.07 km away from pans, and Tag 3017 being the furthest away from the pans with an average of 14.98 km away from them on a daily basis.

Vegetation habitat use

A simple inspection showed that all the wild dog fixes fell within the Waterberg mountain bushveld, making it the only vegetation used by the dogs from April 2018- January 2019. Since the vegetation unit is only one preferred vegetation unit, a simple distribution map of points classified by dogs overlaid over SANBI 2011 vegetation sufficed (Figure 7). A polygon count was used to confirm that the only category of vegetation containing fixes was indeed the Waterberg mountain bushveld.

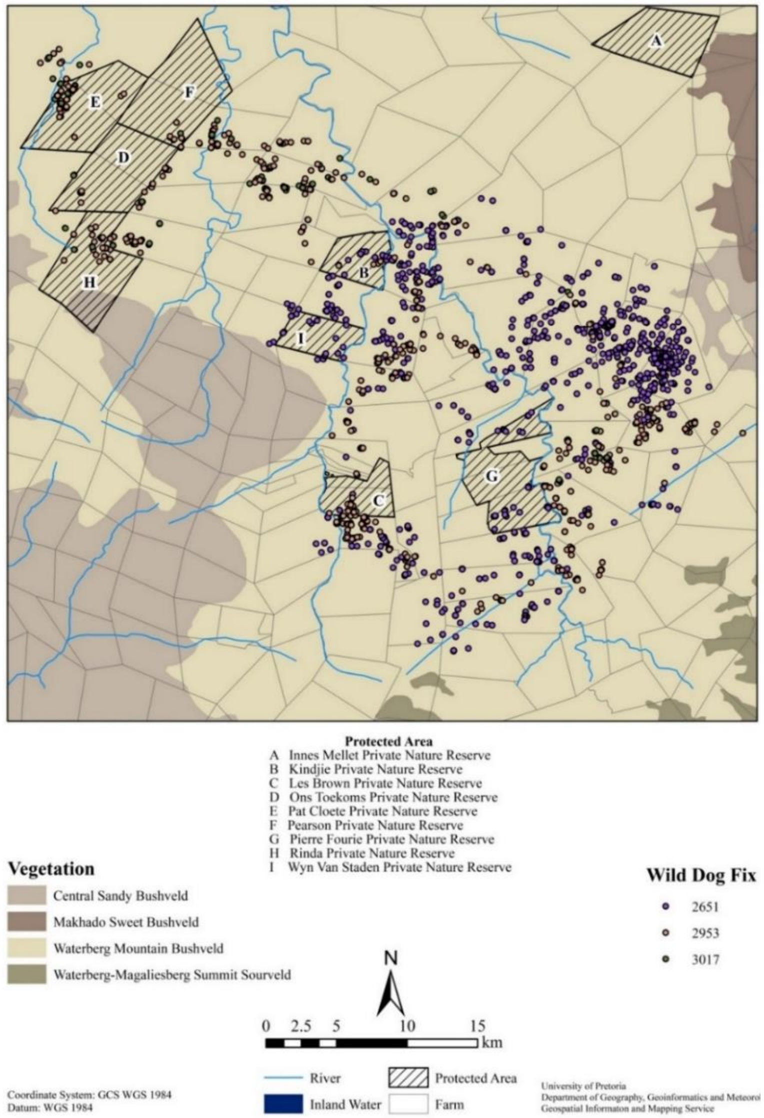

Figure 7 The vegetation type used by the telemetered African wild dogs in the Waterberg Biosphere Reserve in the present study.. All telemetry points fall within only one vegetation type.

4.2 Tolerance Levels

An initial sample size of 60 was expected for the online survey; however, because of a heightened interest in the project, 81 respondents participated in the online survey. A total of 63 respondents (77.8%) were English speaking respondents, while the other 18 (22.2%) were Afrikaans speaking respondents. Of these, 53.8% of the respondents surveyed were from Melkrivier, while 9.1% were from Vaalwater, and the remaining 36.4 % were from other areas within the Waterberg.

On average, the respondents surveyed had a secondary education as their highest level of education; although, there were exceptions of those who had a tertiary education. The participants surveyed, were in an age bracket of 21- 84 years . The average age of the respondents was 58 years as of 2019, with respondents in the age group of 66 years having the highest frequency in the sample size, and the median age being 61 years.

4.2.1 Position on farm

It was important to understand the position the respondent had on the farm in question, as this would help give different levels of information pertaining to human-carnivore conflict. An average of 69.0% of the participants interviewed were owners of their farms (Table 5.1). From this number, Afrikaans speaking respondents showed the highest number of owners with a sum of 81.8%, and 56.5% English speaking respondents.

Table 5.1 Frequency of position of respondents in terms of landowner, manager, employees or other interviewed in the Waterberg who make decisions on the farm

Choices	English speaking respondents	Afrikaans speaking respondents	Average
Owner	56.3%	81.8%	69.0%
Manager	15.6%	18.2%	6.91%
Employee	6.3%	0.00%	3.1%
Other	21.9%	0.00%	10.9%

An average of 16.9% of respondents indicated that they were managers on the farms, 3.1% indicated they were employees, while 10.9% (Table 5.1 and Figure 8.1) indicated they were affiliated as a relative to the owner, working with the owner/ manager of the farm.

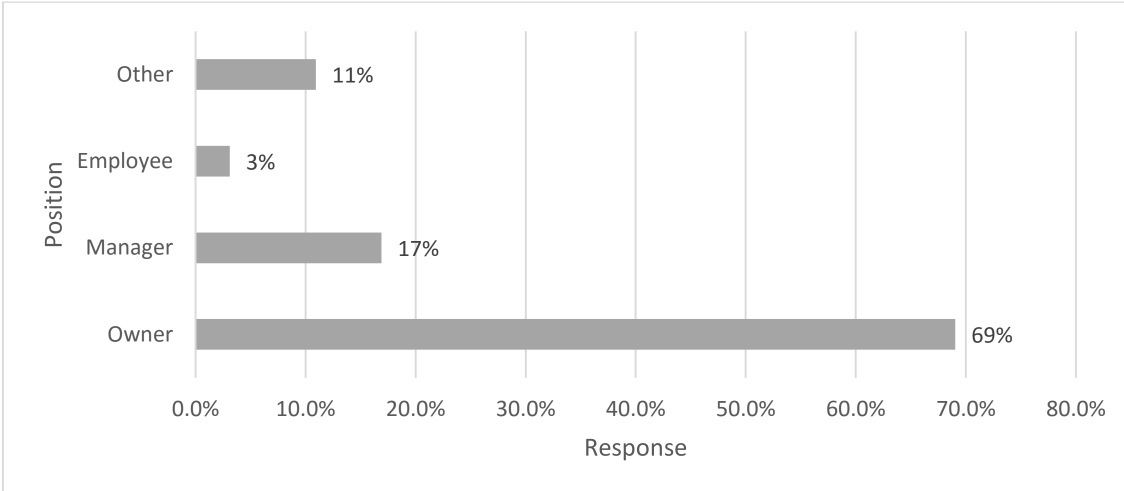

Figure 8.1 Frequency of respondents according to their position on the farm where the majority of the respondents are owners of the farms, and least of the respondents are employees on the farm

4.2.2 Purpose of the farm

An average of 27.0% of Afrikaans speaking respondents in this sample use the farms for ecotourism purposes, as compared with the 24.0% of English speaking respondents (Table 5.2). Game ranching also showed a 20.0% response for Afrikaans speaking respondents and 21.0% use for English speaking respondents. Afrikaans speaking respondents showed a 20.0% use for hunting as a farm purpose (Table 5.2).

Table 5.2 The farmers and landowners surveyed showed that they use their farms for more than one purpose and often land is used for multiple purposes. The majority of the respondents indicated that they use their farms for ecotourism and either game ranching, hunting or hospitality.

Purpose of the farm	**English respondents speaking respondents**	**Average English speaking respondents**	**Afrikaans speaking respondents**	**Average Afrikaans speaking respondents**	**Overall Average**
Ecotourism	16	24%	8	27%	25%
Livestock farming	4	6%	0	0%	3%
Game ranching	14	21%	6	20%	20%

High value game breeding	4	6%	0	0%	3%
Hunting	5	7%	6	20%	14%
Crop farming	4	6%	5	17%	11%
Hospitality	10	15%	3	10%	13%
Other	10	15%	2	6%	11%
Total	69	100%	30	100%	100

On average, ecotourism was the most common farming purpose amongst the respondents, with 25% across the whole (Figure 8.2). Since a farm could have more than one purpose, other purposes such as game ranching, hospitality, hunting and other purposes can be coupled together in one farm (Figure 8.2).

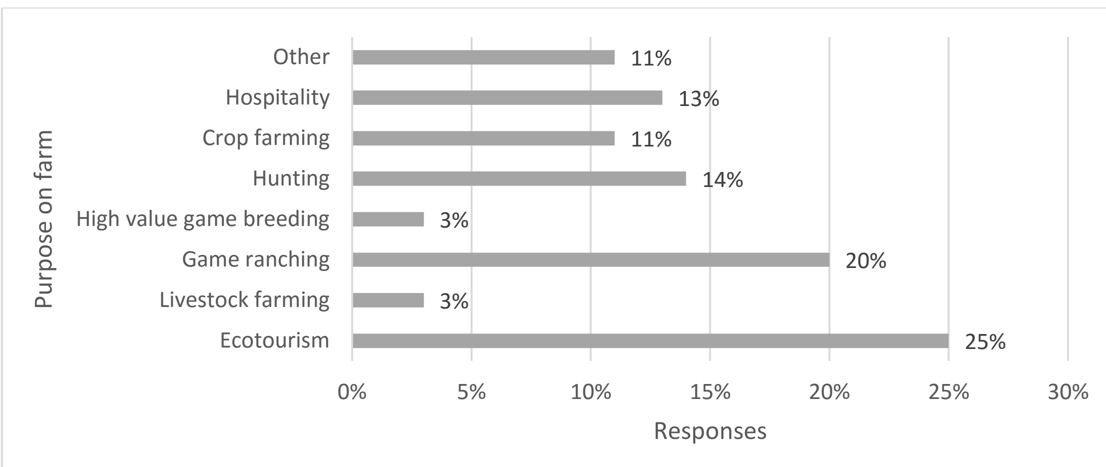

Figure 8.2 Frequency of the purpose of the farm. Respondents indicated that a farm could have more than one purpose at a time, and most farms had more than one purpose on it.

4.2.3 Species predated on by African wild dogs over the last five years

To establish the most predated species in Waterberg Biosphere Reserve, a variety of options was presented in the online survey for their selection. The results are shown in Table 5.3.

Table 5.3 The most predated species in the Waterberg for the period of 5 years according to respondents in the present study.

Animal species	**English respondents**	**Average English speaking respondents**	**Afrikaans speaking respondents**	**Afrikaans speaking respondents**	**Average**
Impala	9	18%	5	20%	19%
Kudu	6	12%	4	16%	14%
Blesbok	1	2%	1	4%	3%
Wildebeest	1	2%	2	8%	5%
Bushbuck	3	6%	2	8%	7%
Red Hartebeest	3	6%	1	4%	5%
Nyala	0	0%	2	8%	4%
Warthog	1	2%	0	0%	1%
Klipspringer	1	2%	2	8%	5%
Duiker	0	0%	0	0%	0%
Zebra	0	0%	0	0%	0%
Cattle	0	0%	0	0%	0%
Goats	0	0%	0	0%	0%
Sheep	0	0%	0	0%	0%
No species lost	21	49%	6	24%	36%
Total	46	100	25	100%	100%

A period of 5 years was used to establish if species predated the most in the Waterberg corresponds with what literature suggests. The data shows that the most predated species in the Waterberg because of African wild dogs was the impala, with an 18% response from English speaking respondents and 20% from Afrikaans speaking respondents. The second most predated species in the Waterberg for English speaking respondents was the kudu, with a response of 12%. Species like the bushbuck and red hartebeest (*Alcelaphus buselaphus caama*) had a response of 6% each from the English speaking respondents. Afrikaans speaking respondents had a response of 8% each for the bushbuck, wildebeest, nyala and klipspringer (Table 5.3).

Respondents whom the question was not applicable to, meaning they had not lost any species because of the African wild dog in the past year, or their farm did not have any species that could be predated by wild dogs, or even the fact that their farm did not have animals at all and they use the farm for purposes out of animal activity centred activities showed 43% for English speaking respondents and 20% for Afrikaans speaking respondents (Table 5.3).

On average, 19% of all the farmers interviewed in the sample size indicated that the impala was the most predated species on their farm (Figure 8.3). From the respondents that answered, 14% have lost kudu, 7% had lost bushbuck, while 5% had lost wildebeest, red hartebeest and klipspringer respectively because of African wild dog predation in the past 5 years (Figure 8.3). Species such as the duiker, zebra, cattle, goats and sheep were not been reported missing by the respondents in the survey (Figure 8.3).

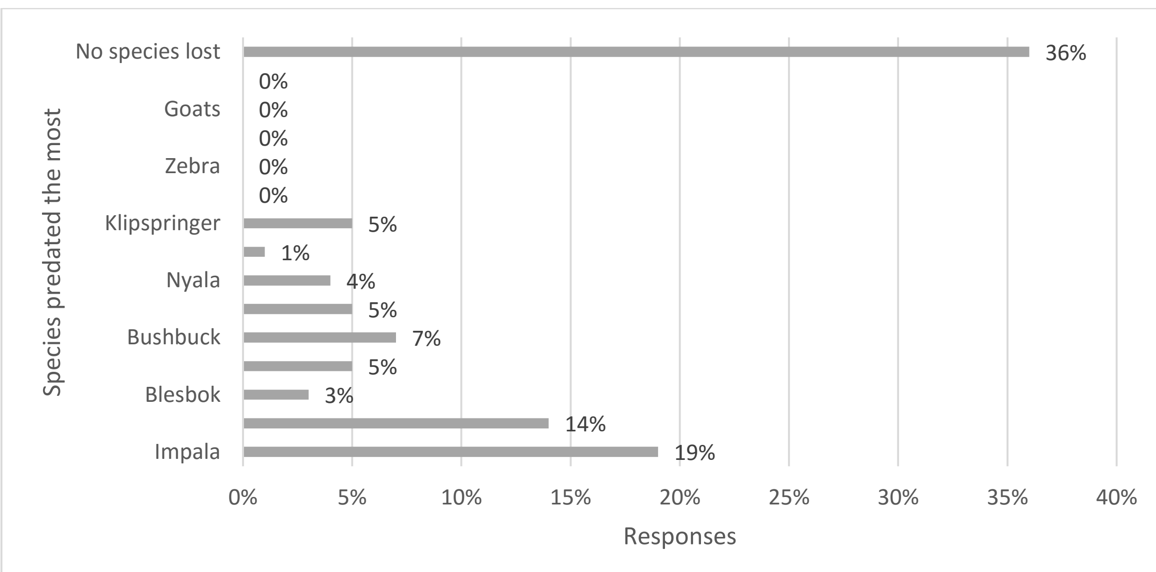

Figure 8.3 Frequency of predated prey as reported by the respondents in the present study. They showed that the impala were the most predated species in the Waterberg Biosphere Reserve.

4.2.4 Financial losses

The approximated value of losses per year was established through asking a question with price ranges of losses. The results showed that 44% of respondents had high value game species on their farms, while 56% did not have any. A response rate of 34% of Afrikaans speaking respondents indicated that they had high value game species on their farms, while 75% of English speaking respondents stated that they do not have high value game species on their farm. An average of 85% of the respondents did not have predator proof fences, which meant that it was easy for species such as African wild dogs to predate on their farms. With an average loss of 52% game losses because of African wild dogs over the past year for the respondents surveyed, it was important to know exactly how much in value was lost by the farmers, as this could have an influence on the respondents' tolerance for African wild dogs on their farms.

Table 5.4 Estimated loss among the different categories of farmers in the study area.

Approximated loss	**English speaking respondents**	**Average English respondents**	**Afrikaans speaking respondents**	**Average Afrikaans respondents**	**Overall Average losses**
<R10 000	4	13%	2	18%	15%
R10 000 to R50 000	5	16%	2	18%	17%
>R50 000	0	0%	2	18%	9%
Not Applicable	23	72%	5	46%	59%
Total	32	100%	11	100%	100%

An estimated 18% of Afrikaans speaking respondents had lost to the value of more than R50 000 because of African wild dogs in the past year alone (Table 5.4). Only 20% of high value game species were kept in breeding camps on the farms, which also made the high value game susceptible to predation. There was a higher chance of high value game interacting with predators (such as African wild dog, African hyena, the leopard or lions) when they were not protected. On average, 15% of the respondents had lost less than R10000 of value because of African wild dogs (Figure 8.4).

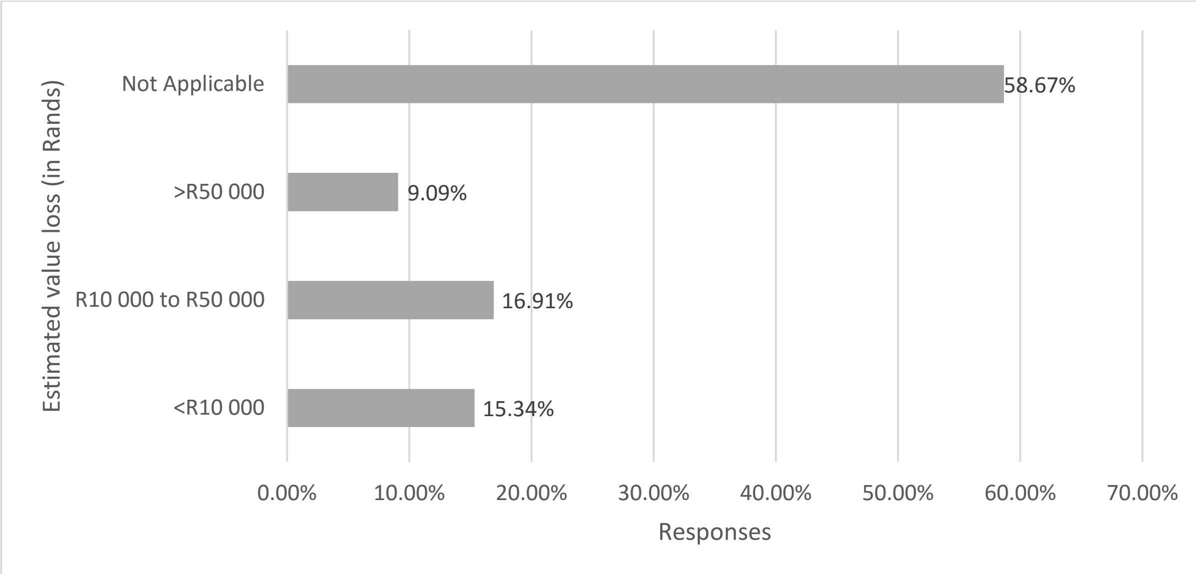

Figure 8.4: Estimated value losses in rands for farmers who participated in the survey.

4.2.5 Tolerance levels

Farmers were asked questions on their attitudes towards the African wild dogs in the Waterberg area. These questions were important as they addressed the fundamental objective of this research to understand how farmers feel about the species, measures to bring a symbiotic harmony regarding this matter, and ways to improve any negative attitudes towards African wild dogs in Waterberg. The results are shown in Table 5.5.

Table 5.5 Level of tolerance to African wild dogs among farmers in the Waterberg study area.

Level of tolerance	English speaking respondents	Average English speaking respondents	Afrikaans speaking respondents	Average Afrikaans speaking respondents	Overall Average
Wild dog friendly	21	65.63%	4	36.36%	51%
Wild dog tolerant	8	25.00%	4	36.36%	31%
Wild dog intolerant	3	9.38%	3	27.27%	18%
Total	32	100%	11	100%	100%

The results of the online survey show that 65.6% of English speaking respondents were wild dog friendly and are happy for the wild dogs to spend time on their farm (Table 5.5). While 36.4% of Afrikaans speaking respondents also expressed their friendliness towards the dogs and were happy having African wild dogs on their property for a few days at a time. An average of 25% of English speaking respondents expressed their tolerance for wild dogs on their farm, while 36.4% of Afrikaans speaking respondents expressed that they were happy for the African wild dogs to pass through as long as they did not spend any significant time on their farm (Table 5.5). On the contrary, 27.3% of Afrikaans speaking respondents stated their lack of tolerance for African wild dogs on their farms, and only 9.4% of English speaking respondents indicated that they did not want the African wild dogs to spend any time on their farm.

Generally, the farmers of Waterberg were wild dog friendly (Figure 8.5), that 51% of the respondents indicated that they like African wild dogs and did not mind having them on their farm. An average of 31% of the farmers stipulated their tolerance for wild dogs, provided the dogs only stayed on their farm for a short period (less than a week). While 18% of farmers clearly expressed their dislike for African wild dogs, and did not have any desire to have them on their farm (Figure 8.5).

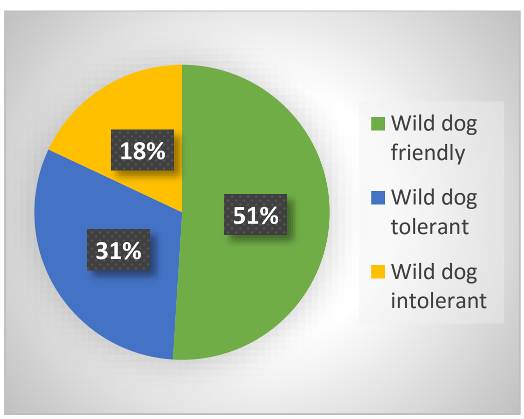

Figure 8.5: Frequency of tolerance to African wild dogs according to the respondents in the present study. The majority of farmers indicated their farms to be wild dog friendly.

Overall, the results did show that English respondents tended to more tolerant towards wild dogs compared with Afrikaans speaking respondents. This could be because of many reasons. Firstly, Afrikaans speaking respondents had indicated having more high value species as compared with English respondents Secondly, Afrikaans speaking respondents had indicated a higher financial loss as compared with English respondents (Table 5.2 and figure 8.4). Thus, this, in turn, might be the primary reason for the high intolerance towards African wild dogs as compared with English respondents.

Of the respondents who indicated that they are African wild dog friendly, an average 74% of the respondents indicated that they were willing to put up a African wild dog friendly sign outside the entrance of their farm, while 26% of the respondents said they were not willing to do this.

4.2.6 Frequency of wild dog movement over the past 5 years

A substantial number of the respondents indicated that they had only seen African wild dogs less than twice a year, if never at all. In fact, 46% of Afrikaans speaking respondents stipulated that they had seen an infrequent movement of African wild dogs over the past 5 years, seeing them only once or twice a year (Table 5.6). English respondents also indicated witnessing an infrequent movement of African wild dogs once or twice a year, with a response of 29% (Table 5.6). English respondents indicated very infrequent movement of African wild dogs over the past 5 years, with an average response of 29%. They indicated only seeing African wild dogs less than once a year over the past 5 years in Waterberg.

Table 5.6 Frequency of respondents that had seen African wild dogs. For most, the occurrence of African wild dogs in the Waterberg was a very rare one, with the majority of the farmers indicating that they had either seen a wild dog less than twice a year if ever at all.

Frequency	**No. of English speaking respondents**	**Average English speaking respondents**	**No. of Afrikaans speaking respondents**	**Average Afrikaans speaking respondents**	**Average**
Very frequently (weekly)	0	0%	3	27%	0.00%
Frequently (monthly)	2	6%	1	9%	12%
Infrequently (once or twice a year)	9	29%	5	46%	37%
Very infrequently (less than once a year)	9	29%	2	18%	19%
Never	11	36%	0	0%	31%
	31	100	11	100%	100%

A response of 35.5% of English- speaking respondents indicated that they had never seen a wild dog in the past 5 years, while 27.3% of Afrikaans speaking respondents also said they have never seen a wild dog in Waterberg during this time (Table 5.6). Creel and Creel (1996) found that African wild dogs are crepuscular predators which are seen relatively infrequently and at low densities. The present study supported what Creel and Creel (1996) said on wild dogs being animals seen rarely. However, the frequency of wild dogs on the farms of the respondents and the abovementioned attitude towards the dogs (Table 5.5; Figure 8.6) raised how 31% respondents could be African wild dog friendly, yet they have never seen wild dogs before (Figure 8.6). Respondents who might have a liking for wild dogs but have only been exposed to wild dogs through documentaries, videos, social media, magazines, media etc., did express a high eagerness to have wild dogs on their farms as they would like a first-hand wild dog experience.

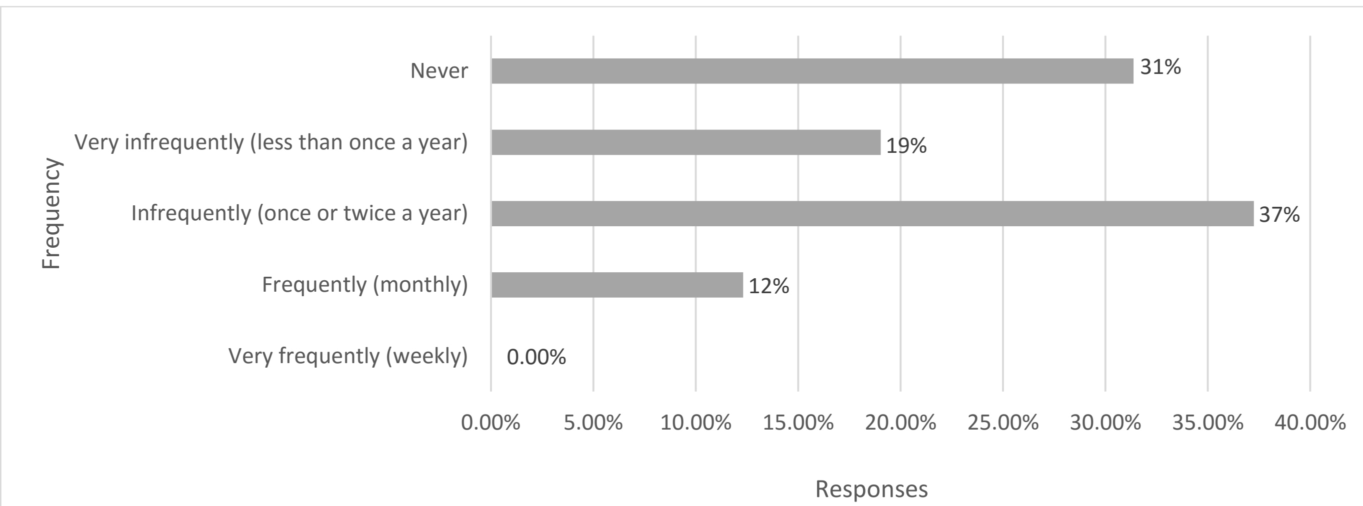

Figure 8.6: Frequencies that respondents reported they saw African wild dogs in the Waterburg Biosphere Reserve. Most saw them less than twice a year in the Waterberg Biosphere Reserve.

On average, the majority of the farmers had seen wild dogs only once or twice a year over the past 5 years, with an overall average response of 37% in the online survey (Figure 8.6). This was followed by an average of 31% of farmers surveyed, indicating that they had never seen African wild dogs over the past 5 years in the Waterberg. This number halved as an average of 19% farmers had indicated that they had seen wild dogs less than once a year over the past 5 years. While 12% of farmers indicated that, they had seen wild dogs monthly (Figure 8.6). Lastly, there were no farmers who had seen African wild dogs on a weekly basis, as a response of 0% was given.

4.2.7 Ecotourism opportunity

When asked on ecotourism opportunities with African wild dogs, 50% of the respondents expressed their interest to allow tourists on their farm, for a fee, to view African wild dogs. While 28% of the farmers had agreed to allow tourists to come to view the species on their farm for free, and 22% of the respondents stated that they would not allow for such activity on their farm. Farmers who expressed an interest in allowing tourists to come to view African wild dogs on their farm expressed the distances their willingness to drive tourists up to more than 50 km to view wild dogs. An average of 44% of English speaking respondents were willing to drive guests between 20- 50 km to go view wild dogs, while 56% of Afrikaans speaking respondents agreed to driving guests more than 50 km to view wild dogs per trip.

CHAPTER 5: Discussion

(Image by Keith Jones, used with permission from Derek van de Merwe, 2019)

A potential conflict hotspot is a geographical area with a high probability of conflict occurring. In biodiversity, hotspots are areas of significant importance where wildlife conservation and human safety is threatened, and vice versa (Shackelford, et al., 2015). According to Samuel et al. (1985), core areas facilitate in identifying critical habitat for species and establishing habitat requirements for the species. Therefore, identifying these areas is essential. This research studied areas occupied by African wild dogs and identified areas of potential conflict in the Waterberg Biosphere Reserve. The results showed that close proximity to food sources, water sources and denning sites has an influence a specific area being a potential conflict hospot. In fact, the distances covered by these African wild dogs over different seasons and moon phases, shows this.

African wild dogs are highly active and very social canids (Creel & Creel, 1996). They need vast areas to thrive and normally cover relatively long distances (Singh & Kamboj, 1996). Wild dog packs are cohesive, and members of the pack move together during hunts both in the morning and at night, with an exception for denning season (Creel & Creel, 1995). African wild dogs prefer both woodlands and savannas (Hoedspruit Endangered Species Center, 2019). Waterberg is predominantly covered in savannas, deciduous forest and tropical grasslands (Department of Environmental Affairs, 2018). Key areas preferred by African wild dogs are typically the savanna, dense woodlands and arid zones, away from forested areas (Fuller *et al.* 1992; Dickerman *et al.* 2011). Their populations are fairly low in areas where lions are most abundant. (National Geographic Wild, 2018). They hunt in a variety of terrains where their prey flourish (Dickerman, et al., 2011). African wild dogs can be seen in altitudes up to 1800 m (National Geographic Wild, 2017). Wild dogs like to roam on dirt roads (National Geographic Wild, 2018). They know that main roads are dangerous and opt to move on smaller roads and footpaths instead. They keep away from cars but are not too far from humans. They like large, flat pieces of land to run, hunt and roam freely.

African wild dogs are known to hunt mainly impala, but also prey on species such as kudu, common duiker, nyala, blue wilderbeest, klipspringer, warthogs and bushbuck (Estes & Goddard 1967; Creel & Creel 1995; Mills & Gorman 1997; Lindsey *et al.* 2004; Butler 2004; Hayward *et al.* 2006; Page 2014; Davies-Mostert *et al.* 2016). Therefore, the species being predated by the African wild dog in the present survey corresponded with what literature suggests. Contrary to literature, this pack appeared dependent on water (Hoedspruit Endangered Species Center, 2019). The distribution of key predator species of those ungulates is likely to be distributed thereof, as water sources have an indirect influence. Water is a key driver of biological diversity and population dynamics (Mills & Gorman, 1997).

African wild dogs drink relatively little water; hence where they settle is not dependant of a water source (National Geographic , 2017). In the present study, African wild dogs avoided perennial rivers and preferred non-perennial rivers as they have water flowing throughout the year. The high occurrence of wild dogs near Lapalala River, a non-perennial river, may suggest that the specific terrain influences the dispersion pattern of its prey (ter Braak & Prentice, 1988). Subsequently, the occurrence of the impalas may be the reason behind how the water sources are spread out spatially (Mbizah, et al., 2014). This explained the dense population of wild dog fixes along the Lapalala River (Figures 5.2, 6.1 and 6.2). Another reason could be that the wild dogs needed a source of drinking water for themselves (Ndaimani, et al., 2016). African wild dogs in savanna landscapes are said to be water dependent (Mills & Gorman 1997, Pole *et al.* 2004, Smit *et al.* 2007). In the savannas, African wild dogs are generally attracted to water sources. However, the they are attracted to water sources when the water resources are scarce (Ndaimani, et al., 2016). This is because their food sources are more abundant and more accessible in areas with water to drink. While surface water may directly influence the distribution of ungulates (Crosmary *et al.* 2012; Ogutu *et al.* 2014). This suggests potential food sources for the wild dogs, such as impala in the area (Dickerman, et al., 2011).

When water resources are scarce, the African wild dog's home range widens into potential ecological traps (Ndaimani, et al., 2016). This explained the high concentration of fixes on Protected areas: I, B and G, during the dry months, and the high concentration of fixes close to Protected areas: C, B, H D, E and F, in wet months. In southern Africa, dry months are normally April- October, and wet months November- March (Zijlma, 2019). Dry months are categorised by sunny and cool days, with relatively cold nights; wet months tend to be the hottest with December being the peak (Zijlma, 2019). Another ecological trap wild dogs may fall into involves kleptoparasites at common surface water locations during dry season for the same prey. A heightened interaction with competitors can threaten wild dog populations as wild dogs are mortal enemies with kleptoparasites such as lions and spotted hyenas (Mills & Gorman, 1997). Not only can wild dogs be robbed of their kills because of these kleptoparasites, but they can also lose their lives (Mills & Gorman, 1997).

In a study done by Creel & Creel (1995), African wild dogs in the Selous Game Reserve hunted in two periods, 05:00- 09:00 and 17:30- 19:30. African wild dogs in the Waterberg Biosphere Reserve showed a relatively similar trend. Fuller and Kat (1990) found African wild dogs hunting and travelling vast distances earlier in the morning, resting during the day, then hunting again in the afternoon, before resting again. African wild dogs generally tend to have brief periods of activity followed by a series of naps (Creel & Creel, 2002). They generally spend more time sleeping but wake up more frequently (Creel & Creel, 2002). They are mostly active in the mornings and evenings, with long rest periods at during the day and at night (Creel, et al., 1992). It was usual for them to settle at a day-time rest at an average of about 3 hours after initiating a hunt (Fuller & Kat, 1990). In a study done in south western Kenya, African wild dogs were most often killed 2 hours before sunrise and 1 hour after sunset (Fuller & Kat, 1990).

Wild dogs hunt at night during certain phases of the moon; however, they are mostly crepuscular resting during the day and hunting in the early morning and evening (Awdconservancy, 2018). A hunt is defined as a pursuit of prey either exceeding 50 m at a full run or ended with testing of prey at bay or a kill (Creel & Creel, 1995). The actual timespan for each phase of the moon lasts for only a brief instance; however, to the human eye, a full moon, for instance, may appear full for as long as three days (FunTrivia, 2016). Similar to the ocean and tides, animal behaviour can also be influenced by the moon as most animals have a composition of about 50 and 70 percent water in their bodies (Oak, 2012). Due to the moon's magnetic pull on the earth and amount of light available during each moon phase at night, the lunar cycle can have an influence on the hunting schedule of wildlife, its reproductive cycle and overall navigation at night during this time (Lotzof, 2019).

Phases of the moon can affect wildlife for days longer than the actual phase of the moon (Schmaltz, 2016). For example, research shows that prey tends to be less active during periods of a full moon, thus causing lions to consume less during nights with the presence of the moon (Poppick, 2013). Although lions tend to hunt at night, the occurrence of a full moon causes them to kill during the day as compensation of slow nights (Poppick, 2013). Research also revealed that the African lion tends to be more aggressive towards humans in the days right after the full moon (Parker, et al., 2011). Like the lion, African wild dogs are also carnivores and do hunt at night from time to time (Creel & Creel, 2002).

The results also showed how denning sites chosen by the African wild dogs had an influence on an area being a potential conflict hotspot. The high concentration of points of telemetry data during denning season showed that the dogs had more than one denning site during the period of June to September 2018. Estes (1993) found that African wild dogs usually den during this time and often prey on tired impala from the rutting season. African wild dogs search for suitable denning sites, and tend to have more than one option as a denning site (National Geographic Wild, 2017). In fact, they can have up to three denning sites identified before the denning season, to aid during times of danger from predators and competitors such as the hyena and lions (National Geographic Wild, 2017). Any sign of danger means that wild dogs need to change their denning site to ensure safety for the pups (National Geographic Wild, 2017). Therefore, it is not unusual for African wild dogs to change their denning site more than once during their denning season. During the denning season, wild dogs usually remain in one location within their home range; therefore, it is important for them to den in a location that will ensure safety for the pups and the pack as a whole (Fanshawe, et al., 1991). It is relatively common for the alpha female to give birth to the pups, while the rest of the pack helps raise the pups. African wild dogs use cooperative breeding as a method to help raise the pups as a team (Courchamp & Macdonald, 2001). The alpha female nurses the pups in the denning site, and the subordinate wild dogs hunt, feed and raise the pups (Courchamp & Macdonald, 2001). The denning site appeared to be at a on low elevation. This would make sense since wild dogs are said to use abandoned underground warthog and Cape porcupine dens to give birth (African Conservation Experience, 2017).

Overall, my findings suggest that to come up with mitigation and conservation measures suitable for the Waterberg Biosphere Reserve, it was essential to understand how the farmers felt about African wild dogs in the area. Understanding their attitudes towards this species will aid tailor-made solutions in the study area to help conserve the species, and help future research on how to win farmers over and overall improve the attitudes towards African wild dogs as a whole. The acceptance and lack for African wild dogs in the Waterberg will have an influence on how the dogs will be treated in the area (Kansky & Knight, 2014). Currently, the EWT is working with farmers on a project with African wild dogs in the Waterberg area (EWT, 2018). This project affords interested participants an opportunity to see African wild dogs, more especially during denning season (EWT, 2018). Interacting with farmers to find their attitudes towards the dogs will aid the EWT going forward since African wild dogs are collared and their locations are valuable information that can be used to track how much time they spend on each farm during hunts, travel, denning etc. Subsequently, this information can be used for interested farmers interested in having African wild dogs on their farms for entertainment purposes.

Mitigation methods such as compensation to improve the tolerance levels of the farmers need to be applied with caution. Compensation schemes have been tested and implemented successfully, but they do not have a big impact in conservation (Nyhus, et al., 2003). This method is the most commonly preferred to deal with financial losses caused by human-carnivore conflict; however, they should be implemented together with a preventive measure for conflict (Nyhus, et al., 2003).

CHAPTER 6: Recommendations and Conclusions

(Image used with permission from Derek van de Merwe, 2019)

5.1 Introduction

Overall my study's focus was to investigate the causes of private landowner and African wild dog conflict in the Waterberg Biosphere Reserve, through researching factors that cause conflict between the human participants and African wild dogs. The aims and objectives of this research were to investigate key areas affected by wild dog conflict in the Waterberg Biosphere Reserve. It was also to spatially track areas affected by wild dog occupation and to identify core areas for conflict in the area. The causes of conflict were to be established, as well as determining the tolerance levels of the farmers for the dogs and suggest mitigation measures on the human-carnivore conflict in the area. Results obtained in Chapter 4 are as follows:

The core areas for this pack of wild dog's home range is the denning site, situated on land parcels 205, 206, 207 and 796. Specific emphasis is placed on land parcel 205 in dry season. Not only is the denning site a denning area, it is also a conflict hotspot especially in the dry season. According to Shackelford, et al (2015), conflict hotspots are geographical area with a high probability of conflict occurring. Land parcel 117 has the potential to be a hotspot for conflict for Tag 2651. Another conflict hotspot is land parcels 59 and 52, next to protected area C in the wet months. The habitat preferred and occupied the most by this pack of dogs is most likely to cause conflict because as the dataset suggests, the dogs are relatively close to humans and areas most likely to have humans on a daily basis. What this means is that not only are the dogs at a high chance of interacting with humans that have tolerance for them, but it also opens a chance for them to interact with humans that do not have a tolerance for the dogs. Humans that do not have a tolerance for the dogs have the potential to pose harm on the dogs. Therefore, it is important to clearly establish key areas most affected by wild dogs the most, so that potential areas of conflict can be known. The researcher has been able to determine areas most preferred by wild dogs, and the areas are classified as follows:

Key areas most preferred by wild dogs in the Waterberg Biosphere Reserve during April 2018-January 2019 fall in this criterion:

1. Areas less than 300m away from: footpaths, roads, non-perennial rivers and fences.
2. Areas less than 2km away from: houses, cultivated land, secondary roads, dams and reservoirs.
3. Areas less than 3km away from: landing strips.
4. Areas on high elevation, with very gentle slopes.

The dataset also shows that wild dogs are most active early in the morning 04:00- 05:59am and late in the afternoon 15:00- 17:59pm, and the day of new moon and first quarter.

Through the spatial analysis, areas spatially tracked showed the home ranges for wild dogs, core areas of conflict, seasonal variation and movement patterns of the dogs. In summary, farm parcels 205, 207, 796, 59 and 52, show the highest concentration of wild dog fixes, subsequently, they show the highest interactions with wild dogs during April 2018 up until January 2019. There is a particular interest in Farm parcel 655 and parcel 657.

Denning season took place during June to September 2018. This is seen when in the data set showed a higher concentration of fixes densely located in the same locations, over a long period of time (at least a month at each location). There is a possibility that the dogs changed dens during the denning season, as the concentration of fixes suggest a possibility of three dens. The first being on farm parcel 205 during June and July 2018. A potential second den on farm parcel 207, during the month of July for a brief time. Thirdly, the last den, occupied during August until September 2018, on farm parcel 796.

During denning season, the distances travelled by the subordinate dogs, contributes to the distance covered by the dogs. This happens as the other dog's hunt for food and bring it back to the den for the alpha female and the pups.

Since the three dogs being studied were collared (Tag 2651, Tag 2953 and Tag 3017), the dataset shows that the different dogs occupied the same spaces but at different times of the year. It was not clear if the dogs took turns to occupy the same spaces or were avoiding each other. Unfortunately, the collar data available did not give equal data for the same period throughout, so a question of if the dogs took turns to occupy the same farms at different times is unclear.

The travel pattern followed by the dogs shows that they travelled alongside a water source during the period they were collared. The pattern established suggests a potential food source close to the rivers and water bodies the dogs always yielded close to. The DEM model shows that the dogs prefer higher altitudes with gentle slopes and would much rather travel around steep terrain than through or across it. The travel pattern followed by the dogs during dry and wet months is completely different. This might be influenced by the pups being old enough to travel with the adult pups on hunts in the wet months, as opposed to the dry months when they are still small, and restrict the overall movements of the whole pack (National Geographic , 2017).

Wild dogs in this study prefer woodlands during dry months and during denning season. Surprisingly, they like cultivated land more during the wet months. The dogs like protected areas I, B and G during dry months, but move to Protected Areas C, B, H, D, E and F in wet months. Tag 2561 strayed closer to forest and woodlands as opposed to Tag 2953 and Tag 3017. This information holds as Tag 2561 is the alpha female, and was nursing pups during denning season, whilst the other dogs were hunting for food and feeding the pups during denning season.

The dataset shows that the dogs prefer being closer to houses where people reside, as opposed to ruins or abandoned buildings. Footpaths and dirt roads are the most preferred transportation route for the dogs. Which shows that the dogs like flat open plains to travel, away from cars and danger, but also provide easy mobility to hunt, run and roam freely. The dogs also love fences and have shown in this study that they like being in places with fences.

According to the dataset, these wild dogs have a high affinity for non-perennial rivers and reservoirs. This may be because perennial rivers and seasonal water sources only have water during certain times of the year, and this has an influence on the abundance of prey availability in an area (Ndaimani, et al., 2016). Whereas, non- perennial water sources such as the Lapalala River has a consistent supply of water throughout the different seasons of the year, meaning that prey is also available throughout the duration of the time of the study.

The dogs are also surprisingly close to a landing strip, which suggests that the land in which they are settling in is at high elevation and gentle slopes. There is a fascination around landing strips by the dogs. Results show that dogs are much closer to landing strips as opposed to other potential drivers like silos. The dogs on average are 3.43km away from landing strips. Tag 2651 is fixing relatively close to areas with landing strips, with an average distance of 2.94 km away from it. This is a close distance to humans in and around the landing strips. Landing strips are long, they are flat and have no vegetation on them. Landing strips are a very interesting discovery to the study as they are unexpected and also very close to humans who own helicopters in the Waterberg. This information will come in very handy not only in the Waterberg, but also other areas with landing strips such as Nature reserves, game reserves and biosphere reserves that may find this research interesting.

Silos for grain to feed animals have the largest distance apart from the dogs. On average, the dogs are 44.59 km away from silos. Tag 2651 shows the greatest distance away from silos with an average of 45.31 km away from them. This data suggests that the dogs do not want to be on farms where humans can shoot them easily. Lastly, the results show that the dogs hunt early in the morning between 04:00- 05:59am, and late in the afternoon between 15:00- 17:59pm.

Online survey

The data set from the online survey shows that Afrikaans speaking respondents had more farm ownership as compared with English speaking respondents. The data also suggests that most financial losses because of wild dog occupation were below R50 000. Afrikaans speaking respondents have made more losses because of wild dog occupation in the past year as compared with English speaking respondents. In general, 51% of farmers in the Waterberg are wild dog friendly. English speaking respondents are generally wild dog friendly as compared with Afrikaans speaking respondents. The data set shows that Afrikaans speaking respondents are less tolerant for wild dogs. This could be because of the fact that they have high value species, and they make greater financial losses because of high value game species, as compared with English speaking respondents in the area. However, a question of whether it is always the wild dog predating on high value game is raised as the respondents have indicated to witnessing wild dogs in Waterberg less than twice a year over the past 5 years. If there is such a low occurrence of wild dogs in the area, is it really possible that there is a high frequency of high value game and prey lost because of just wild dogs?

Majority of all farmers surveyed indicated that their farms does have ecotourism as a main purpose. This coupled with other purposes such as game ranching, hospitality and hunting on their farms. More than one farm purpose was possible as an option for a farm can perform multiple purposes. The data shows that 50% of farmers had indicated their interest in having wild dogs on their farm for guests to view the dogs. On average farmers had indicated they are willing to take guests up to 50km to view wild dogs. Farmers that had indicated their interest to partake in the ecotourism opportunity are the same ones who are wild dog tolerant and have existing ecotourism opportunities on their farms.

Wild dogs have the potential to bring in significant income through specialist wildlife- viewing initiative such as the one in De Beers Venetia Limpopo Nature Reserve and Madikwe Game Reserve (Lindsey *et al.* 2005; Davies-Mostert *et al.* 2016). Currently, the EWT is working with farmers in the Waterberg interested in this ecotourism opportunity. It runs during denning season for guests to come view wild dogs at R600 per person. Therefore, this will be a great opportunity for farmers interested in expanding ecotourism streams on their farms will make extra money.

5.2 Recommendations and Mitigation measures

Given the results obtained from this study, the following recommendations can be made for the Waterberg Biosphere Reserve going forward:

Early warning system

The phases of the moon should be used by the EWT as a guide for the development of the Early Warning System. The early warning system should take into consideration how each moon phase will influence the movement patters of the dogs. Alerts made to the farmers before each moon phase can help farmers protect their game better ahead of time. The early warning system should also be designed in manner that takes into consideration peak times for the dogs. These times can be communicated to the farmers so that they know when to be alert for wild dogs, also this will aid in protecting their game better as they can move game to a safer area within the farm before wild dogs are on the move.

Conflict hot spots

Farms with a high density of dogs (Protected areas and farm parcels identified to have the highest density of fixes) on their farms and do not want the dogs there, will have to change what is attracting the dogs to their farms per specific season. In addition, farm parcels 205, 207, 796, 59 and 52 need to be protected areas.

Mitigation and conservation measures

Increased habitat protection has potential positive conservation outcomes (Nyhus, 2016). An almost exponential growth in the world's protected areas network, particularly in less economically developed countries has been documented (Naughton-Treves, et al., 2005). In the year 2014, 15.4% of the world's terrestrial and inland water areas and 3.4% of the world's oceans were protected (Juffe-Bignoli, et al., 2014). Even though the implementation of protected areas alone do little to reduce conflict, it can help to provide protected habitat and legal protection for some species (Nyhus, 2016).

In the year 1998, there was a population size of 80 wild dogs in Waterberg (Davies-Mostert, et al., 2009). This number had dropped drastically to only 5 dogs in 2017 (EWT, 2018). However, with the introduction of the last pack of free roaming wild dogs in 2019, the population rose to 26 resident dogs (EWT, 2018). Although this increase may not be as high as in the year 1998, it does show a sharp increase in wild dogs, which shows progress in attempts to conserving the species.

A breeding centre is a suggestion to increase the number of wild dogs in Waterberg. Although this pack of wild dogs are special as it is the last free roaming pack of wild dogs, concerns of the population decreasing because of a low tolerance by farmers for the dogs, game hunters, sickness, accidents, etc. Wild dog populations are threatened by the acts of low tolerance such as killings, snaring, shootings, road kills and other threats posed to the dogs on a daily basis (see Figure 9 below). This is one relatively effective way to preserve the species, as should numbers drop suddenly (Lindsey, et al., 2004).

Figure 9: Road kills of wild dogs is an ongoing problem in the Waterberg and is threatening the population of the dogs. A breeding centre for African wild dog species might be a solution to boosting numbers of species, before releasing it back into the wild through reintroduction. **(Image used with permission from Derek van de Merve, 2019).**

The breeding centre can be used to increase the population of the dogs over a specific period, so that the desired number is achieved, they can be reintroduced into the wilderness (Lindsey, et al., 2005). The reintroduction of an African wild dog species can be monitored and studied in an on-going process.

According to Davies- Mostert *et al.* 2016, captive facilities should consider the following:

1. A breeding programme that is self- sustaining and fully functional. This programme should adhere to base the addition of new founders on sound population management principals.
2. Clearly benefiting *in-situ* population research programmes.
3. A well-developed educational programme for all *in-situ* facilities to be facilitated accordingly.

Conservation community

Another recommendation to preserve the wild dog's species will be to create some form of society in the Waterberg community united in protecting wild dog species. This society will install as sense of pride in the farmers; thus, making the farmers involved in the conservation of the dogs. This programme will be more effective as compare to putting the responsibility of conserve the species on EWT alone (Murilo, 2019).

The successful unity of Waterberg farmers working hand in hand for the betterment of the wild dogs will not only conserve the species of the wild dogs but has the potential to bring relatively positive publicity (Matheson, 2019). Not only will this put Waterberg on the map in terms of conservation, it could also have many other positive contributions to the area and be a great value add for the area and land values (Matheson, 2019).

Research

Ongoing research is also recommended for farmer- wild dog conflict as ongoing monitoring of the warning system and mitigation measures to be implemented by the Waterberg Biosphere Reserve going forward. This will be useful in tracking the success of the early warning system, ensure that the measures suggested by the farmers are being implemented, and develop more improved measures to conserve the species.

Compensation

Wildlife compensation only addresses the financial aspect of human- carnivore conflict, and lacks key drivers of HWC such as social, political and conservation problems that come with land use, poaching, declining prey densities, habitat loss and environmental education (Pettigrew, et al., 2012). However, in order to reach that goal, we first need to understand the limitations of current approaches (Atwood & Breck, 2012).

Wildlife compensation programmes have come with much criticism as they often fail to meet conservation goals of mitigating HWC (Pettigrew, et al., 2012). Failure is often linked to the programme lacking to meet one or more of the key concepts for a successful and effective programme (Pettigrew, et al., 2012). High and unsustainable payout costs, high number of false claims, delayed payments, difficulty to verify claims, and government corruption, are just some of the reasons that make this option not viable (Karanth & Gopal 2005; Dickerman *et al.* 2011; Nyhus *et al.* 2005).

Financial incentives may fail to facilitate in solving the conservation problem especially of large carnivores like African wild dogs (Pettigrew, et al., 2012). In most cases, compensation does not improve attitudes towards problematic wildlife (Naughton-Treves *et al.* 2003, Rondeau & Bulte 2007). Even if they do reduce retaliation killing, this incentive type does remain pre-emptive killing (Dickerman, et al., 2011).

Livestock owners are rarely fully compensated by this type of programme, as the compensations schemes only pay a certain portion of money, at “market value” (Pettigrew, et al., 2012). Therefore, compensation programmes are not recommended to be used alone (Pettigrew, et al., 2012). Should this measure be selected and used, a prevention measure should also be applied to reduce depredation (Pettigrew, et al., 2012).

In cases with human injury and loss of life, wildlife compensation may yield a more positive outcome on conservation as attacks on humans are rare and claims for such incidences are generally more easier to be identified (Pettigrew, et al., 2012). Incentive- based programmes need to be implemented in a manner that includes financial and cultural incentives to ensure that benefits associated with wildlife outweigh the cost of a problematic wildlife species (Pettigrew, et al., 2012). To win the support of local communities and lessen the intensity of human-carnivore conflicts, we need to foster peaceful coexistence and find appropriate ways for people to be rewarded for their tolerance towards the animals. This would ultimately lead to increased community participation in the protection of wildlife (Nijhawan, 2008). Finally, a close monitoring of revenue- sharing activities will yield a significant improvement in conservation of endangered species (Pettigrew, et al., 2012).

Illegal trading of wild dogs in the international market

Hidden trading for wild dog conservation is an issue that trades live wild animals such as wild dogs for countries such as China, for financial incentives (Hidden Trade Of Endangered African Wild Dogs, 2016). Close attention needs to be paid regarding conserving wild dog species from this type of trade and having an early warning system with farmers who have expressed their low tolerance for wild dogs may be an even bigger risk in the long run.

Fences

From the online survey, 82% of the respondents had indicated to not having predator- proof fences. Predator-proof fences around protected areas has been a successful tool for reducing human-predator conflict (van de Vyver, 2016). Conservationists have argued that the conservation of wildlife should not only be confined to fenced and protected place, but should also stretch beyond that (Ferguson & Hanks, 2010). Fences have always been relatively popular in wildlife conservation; they served to protect the wildlife and to keep it separate from the people outside the fences (Hulme & Murphree, 2001). However, for this pack of wild dogs in the Waterberg Biosphere Reserve, fences would be a bad idea. The data shows that on average, these wild dogs are 600m away from fences every day. The dogs are fond of the fences and are attracted to fences. Increasing the number of fences as a means to confine them will only lead to more problems. Problems such as the dogs digging holes and going under the fences; subsequently, leading to a lot of fences with holes for other animals to go through.

5.3 Conclusion

To conclude, farmer- wild dog conflict in the Waterberg Biosphere Reserve is an ongoing project that needs constant studying and monitoring. The limitations to this study can be improved to facilitate the next researcher to be able to look at other factors causing human- carnivore conflict in the Waterberg. Factors such as mapping the areas with the corresponding tolerance level per farm and looking at why each dog is drawn to each specific farm over the different seasons of the year. This research was also limited in measuring the degree of wild dog tolerance by respondents because of restrictions on the type of permission to information granted to the researcher. This information will aid in understanding how respondents can be wild dog friendly, yet see wild dogs relatively infrequently.

Other limitations such as funding for the project need to be catered to and proper arrangements for future researchers can be implemented to aid in the smooth running of research from an academic aspect. Limitations pertaining the availability of collared data can also be improved through affording the researcher with permission to all the data they need, as well as through the use of data recovery methods (for battery malfunctioning), to enable the researcher to have all the necessary data they may require for their analysis.

The illegal trading of wild dogs for wild dogs in the illegal international market is also something to keep a close eye on. This type of illegal trade has not been investigated thoroughly before, and the introduction of an early warning system with so much information on specific locations and other sensitive information, can cause intolerant farmers or other parties interested to put the wild dog species at risk in the area.

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ANNEXURE A: Distance Travelled (April 2018- Jan 2019)

The activity of the dogs is at its peak early in the morning when it is cool, then again later in the afternoon when it is getting cooler. In between, the dogs rest regularly during the day after peak times. Then activity of the dogs is given through giving the sum of distance (in km) covered per month at each hour interval during the day.

AM	April 2018	May 2018	June 2018	July 2018	Aug 2018	Sep 2018	Oct 2018	Nov 2018	Dec 2018	Jan 2019	Total
12:00 - 12:59	5	3	30	1	8	5	0	1	0	0	53
01:00 - 01:59	2	4	15	5	11	11	0	2	3	1	54
02:00 - 02:59	3	18	2	1	21	4	0	0	0	0	49
03:00 - 03:59	13	34	41	3	1	36	0	32	27	1	188
04:00 - 04:59	80	5	30	51	20	64	0	38	107	64	**459**
05:00 - 05:59	13	36	62	49	22	46	3	73	67	25	**396**
06:00 - 06:59	17	13	29	31	28	21	0	18	16	31	**204**
07:00 - 07:59	1	14	19	34	32	6	0	1	5	7	119
08:00 - 08:59	15	7	28	1	41	3	0	6	8	14	123
09:00 - 09:59	7	8	4	8	3	20	33	1	2	1	87
10:00 - 10:59	5	6	2	14	9	10	0	2	0	0	48
11:00 - 11:59	3	5	3	3	4	11	0	0	1	6	36
											1816
PM	**April 2018**	**May 2018**	**June 2018**	**July 2018**	**Aug 2018**	**Sep 2018**	**Oct 2018**	**Nov 2018**	**Dec 2018**	**Jan 2019**	**Total**
12:00 - 12:59	3	2	7	2	11	14	0	6	4	3	52
01:00 - 01:59	6	2	3	2	10	9	0	7	26	0	65
02:00 - 02:59	12	0	20	44	11	12	0	2	4	1	106
03:00 - 03:59	52	24	105	75	31	36	0	11	15	22	**371**
04:00 - 04:59	33	10	19	28	29	27	0	66	114	18	**344**
05:00 - 05:59	3	0	9	14	5	20	0	61	64	87	**263**
06:00 - 06:59	11	0	9	6	4	15	0	3	0	0	48
07:00 - 07:59	0	2	6	3	9	3	0	1	0	1	25
08:00 - 08:59	2	3	12	3	5	2	0	1	0	0	28

09:00 - 09:59	1	8	24	4	5	1	0	1	1	1	46
10:00 - 10:59	3	2	6	2	23	2	0	0	0	0	38
11:00 - 11:59	9	3	11	6	22	5	0	0	0	0	56
											1442

ANNEXURE B: Moon Phases

The total distance (km) travelled by the dogs per day studied with the four phases of the moon to establish a movement pattern induced by the moon phases.

Day	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan
1	-	14	7	4	24	14	-	19	1	10
2	-	10	19	5	12	12	-	3	19	12
3	-	15	16	3	0	10	-	3	0	13
4	-	6	13	3	5	15	-	21	9	28
5	-	12	34	18	13	15	-	17	2	17
6	-	14	29	13	12	6	-	17	38	17
7	-	5	9	0	31	23	-	6	15	20
8	-	19	5	11	0	28	-	23	16	5
9	1	7	3	28	6	36	-	4	5	18
10	9	17	11	32	11	27	-	15	31	39
11	2	15	31	22	20	7	-	14	6	21
12	13	7	35	17	7	12	-	10	14	16
13	26	4	33	11	16	31	-	9	12	9
14	7	3	25	24	7	3	-	9	16	22
15	16	19	24	11	5	23	-	8	13	0
16	30	17	6	23	32	12	-	2	8	6
17	20	28	31	13	0	18	-	4	9	-
18	26	5	8	18	14	13	-	8	7	-
19	14	22	1	20	8	44	-	27	12	-
20	4	33	44	38	14	25	-	20	12	-
21	6	12	10	0	20	6	-	11	24	-
22	9	9	10	16	11	1	-	9	0	-
23	15	11	19	27	11	-	-	7	2	-
24	2	9	20	12	6	-	-	11	12	-
25	1	26	30	2	7	-	-	2	4	-
26	14	28	5	4	6	-	-	5	14	-
27	28	9	3	1	9	-	-	13	48	-
28	19	18	11	0	28	-	-	3	27	-
29	5	8	2	0		-	33	22	1	-
30	27	9	30	11		-	0	10	14	-

31		26	-	0		-	3		11	-
	294	**437**	**497**	**387**	**335**	**381**	**36**	**332**	**402**	**253**

LEGEND	
Phase of the moon	
New moon	
First Quarter	
Full moon	
Third Quarter	

ANNEXURE C: Ethics Approval Letter

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Natural and Agricultural Sciences
Ethics Committee

E-mail: ethics.nas@up.ac.za

29 November 2019

ETHICS SUBMISSION: LETTER OF APPROVAL

Ms LJ Dube
Department of Zoology and Entomology
Faculty of Natural and Agricultural Science
University of Pretoria

Reference number: NAS143/2019
Project title: DRIVERS OF FARMER-WILD DOG (Lycaon pictus) CONFLICT IN THE WATERBERG BIOSPHERE RESERVE

Dear Ms LJ Dube,

We are pleased to inform you that your submission conforms to the requirements of the Faculty of Natural and Agricultural Sciences Research Ethics committee.

Please note the following about your ethics approval:

- Please use your reference number (NAS143/2019) on any documents or correspondence with the Research Ethics Committee regarding your research.
- Please note that the Research Ethics Committee may ask further questions, seek additional information, require further modification, monitor the conduct of your research, or suspend or withdraw ethics approval.
- Please note that ethical approval is granted for the duration of the research (e.g. Honours studies: 1 year, Masters studies: two years, and PhD studies: three years) and should be extended when the approval period lapses.
- The digital archiving of data is a requirement of the University of Pretoria. The data should be accessible in the event of an enquiry or further analysis of the data.

Ethics approval is subject to the following:

- The ethics approval is conditional on the research being conducted as stipulated by the details of all documents submitted to the Committee. In the event that a further need arises to change who the investigators are, the methods or any other aspect, such changes must be submitted as an Amendment for approval by the Committee.
- **Applications using Animals:** NAS ethics recommendation does not imply that AEC approval is granted. The application has been pre-screened and recommended for review by the AEC. Research may not proceed until AEC approval is granted.

Post approval submissions including application for ethics extension and amendments to the approved application should be submitted online via the Ethics work centre.

We wish you the best with your research.

Yours sincerely,

ANNEXURE D: Online Survey and Consent Form

CONSENT AND ASSENT FORMS

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Date…………………………………………….

INFORMED CONSENT TO BE READ TO POTENTIAL PARTICIPANTS

Declaration or consent information:

This survey in the Waterberg Biosphere Reserve will aid to address the problem of carnivore invasion of the African wild dogs within private farms in Waterberg. This problem is being addressed since these invasions often leads to the killing of livestock, thus, conflicting with the livestock owners. The results will be used to write a full dissertation to fulfil the requirements for M.Sc. Environment and Society thesis from the University of Pretoria. The survey takes about 10- 15 minutes. Your participation is anonymous, voluntary and can be withdrawn at any stage. If there any questions, feel free to ask. So, if I have your permission, I will continue with the survey.

For this study, I kindly request that you participate in an interview discussion using a structured questionnaire. Your participation will enable me to collect relevant information that will help me achieve the goals of the study, I therefore ask that you read the information below before you make a good decision regarding your participation in this study.

RESEARCH PROCEDURE

Title:

1. DRIVERS OF HUMAN-CARNIVORE CONFLICT IN THE KEY AREAS WITHIN LIVESTOCK COMMUNITIES OF THE WATERBERG BIOSPHERE RESERVE.

2. Main aim: The aim of this research is to understand the effect the African wild dog has had in private farms in Lapalala, Waterberg Biosphere Reserve. The aim also seeks to monitor and track the extent of wild dog invasion in the Lapalala area, while also paying close attention to the drivers of conflict in the areas affected

3. *Procedures*: Interview will be done within 10-15 minutes using structured questionnaires. Your participation in this study is entirely voluntary. You may choose not to answer particular questions. You can refuse to participate or stop at any time during the study without giving any reason. If you decide not to be in this research or if you decide to stop later, there will be no penalty or loss of benefits to which you are entitled. Once you have completed the study you have the right to access your data. All information that you give will be kept strictly private. Research reports, presentations and articles in scientific journals will not include any information that may identify you. Furthermore, with your consent, data captured during the interview will be stored for a minimum of 15 years in the Department of Geography, Geoinformatics and Meteorology at the University of Pretoria and may be used for future studies.

4. *Benefits:* This research study does not have any risks and no money benefits for the respondents. There will be no payment would be provided for the participation and this is purely for academic reasons. The findings from this study will further inform our understanding on the topic of wild dog invasion and human- carnivore conflict in Waterberg; the research will capture the voices and perspective of the private land owners and farmers. Furthermore, the research output and recommendations could provide insight for an early warning system for the EWT.

5. Please indicate your choice by ticking yes or no and initializing next to it:

	Yes	No

Use the answers given for the purpose of this research		

6. *Information and contact person*:

Lungelo Dube

Signature…………………………………….

MSc. (Environment and Society) candidate

Faculty of Natural and Agricultural Sciences University of Pretoria

Pretoria

0002

Republic of South Africa

Mobile: +27(0) 766429429

Email: u12284344@tuks.co.za

Dr Francis Nsubuga

Signature…………………………………….

Supervisor

Department of Geography, Geoinformatics and Meteorology Faculty of Natural and Agricultural Science

University of PretoriaPretoria 0002

Republic of South Africa

Tel : +27 (0)12 420 2532

francis.nsubuga@up.ac.za

CONSENT TO PARTICIPATE IN THIS STUDY

I confirm that the person (Lungelo Dube) asking my permission to take part in this study has told me about the study. I have read this form (Information Leaflet and Informed Consent) and I understood the information regarding the study. I am aware that the results of the study, including personal details, will be secretly processed into research reports. I am participating willingly. I have had time to ask questions and have no objection to participate in the study. I understand that there is no fine should I wish to stop with the study and my withdrawal will not affect me in any way.

I agree

Yes	
No	

Online Survey Questions

***Declaration or consent information*:**

My name is Lungelo Dube and I am a student doing a Master's degree in the Faculty of Natural and Agricultural sciences at the University of Pretoria. The aim of this research is to understand the effect the African wild dog has had in private farms in Lapalala, Waterberg Biosphere Reserve. This questionnaire will be used to investigate the tolerance level of farmers towards the African wild dogs in their farms. The results will be used to produce a full dissertation to fulfil the requirements for M.Sc. Environment and Society. The survey takes about 10- 15 minutes. Your participation is anonymous, voluntary and can be withdrawn at any stage. Full anonymity and confidentiality is ensured. If there are any questions, feel free to ask. So, if I have your permission, I will continue with the questionnaire. Thank you in advance

If you agree to partake in the survey from your own free will, please click below:

https://docs.google.com/forms/d/1WQW-mbMsjB6F4LL-bdJ9OCMtVsJKWXYGya8_wPF9Tag/edit

Faculty of Natural and Agricultural Sciences
Ethics Committee

E-mail: ethics.nas@up.ac.za

29 November 2019

ETHICS SUBMISSION: LETTER OF APPROVAL

Ms LJ Dube
Department of Zoology and Entomology
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We wish you the best with your research.

Yours sincerely,

Title of study:

DRIVERS OF HUMAN-CARNIVORE CONFLICT IN THE KEY AREAS WITHIN LIVESTOCK COMMUNITIES OF THE

WATERBERG BIOSPHERE RESERVE.

Afrikaans/ English

1. **English or Afrikaans**

English

Afrikaans

Landowner and Stakeholder attitudes toward African Wild Dogs in the Waterberg

2. **What is the purpose of your farm? (You can choose more than one answer)**

Ecotourism

Livestock Farming

Game Ranching

High value game breeding

Hunting

Crop Farming

Hospitality

3. **Is your perimeter fence predator proof?**

Yes

No

4. **Do you have any high value game species (eg. sable, colour variants) on your farm?**

Yes

No

5. Are your high value game species kept in breeding camps?

Yes

No

Not applicable

6. Would you classify your farm as?

7. How often have Wild Dogs traversed through your farm over the past 5 years?

Very frequently (weekly)

Frequently (monthly)

Infrequently (once or twice a year)

Very infrequently (less than once a year) Never

8. If you are Wild Dog friendly would you consider putting a Wild Dog Friendly Farm sign at your property entrance?

Yes

No

9. Have you experienced livestock or game losses to African Wild Dogs over the last year?

Yes

No

Don't know

10. What species were predated on by the Wild Dogs over the last five years?

- ☐ Impala
- ☐ Kudu
- ☐ Blesbok
- ☐ Wildebeest
- ☐ Bushbuck
- ☐ Red Hartebeest
- ☐ Nyala
- ☐ Warthog
- ☐ Klipspringer
- ☐ Duiker
- ☐ Zebra
- ☐ Cattle
- ☐ Goats
- ☐ Sheep
- ☐ Not Applicable

☐ Other (please specify)

____

11. What was the approximate value of these losses over the past year?

- ☐ <R10 000
- ☐ R10 000 to R50 000
- ☐ >R50 000
- ☐ Not Applicable

12. Would you agree to tourists viewing Wild Dogs on your property?

☐ Yes - for
☐ a Fee Yes
☐ - for Free
No

13. If you offer ecotourism on your property, would you be interested in driving your guests to another property to view/track the Wild Dogs?

☐ Yes
☐ No

14. How far would you be willing to take your guests to view the Wild Dogs?

☐ < 20km

☐ 20 - 50km

☐ > 50km

Afrikaans: Grondeienaar en belanghebbendes se houdings teenoor die pak Wildehonde in die Waterberg

35. Watse tiepe aktiwieteite word op die plaas beoefen? (Jy kan meer as een kies)

Ekotoeri
sme Vee
Boerdery
Wild
Boerdery

Jag

Gewasse
Boerdery
Gastehuis

Ander (spesifiseer asseblief)

36. Is u grensdraad roofdier bestand?

Ja

Ne

e

37. Het u enige hoe waarde wild spesies op u plaas (bv. sable swart rooibok)?

Ja

Ne

e

38. Indien Ja, word die wild in teel kampe aangehou?

Ja

Ne

e

Nie van toepassing nie

39. Sal u die plaas klassifiseer as:

40. As die plaas Wildehond vriendelik is, sal u oorweeg om n "wildehond vriendlik" teken langs die ingangshek te vertoon?

Ja

Nee

41. Hoe gereeld het wildehonde deur die plaas beweeg in die laaste 5 jaar?

NooitBaie selde (minder as een keer n jaar)

Selde (een of twee keer n jaar)

Dikwels
(maandliks)
Gereeld
(weekliks)

42. Het u al ooit vee of wild verliese gelei as gevolg van wildehonde gedurende die laaste jaar?

Ja
Ne
e

Weet nie

43. Watse spesies het die wildehonde gevang?

- ☐ Rooibo
- ☐ k Kudu
- ☐ Blesbo
- ☐ k
- ☐ Wildeb
- ☐ eest
- Bosbo
- k
- Rooi
- ☐ Hartebeest
- ☐ Nyala
- Vlakvark

- ☐ Klipspr
- ☐ inger
- ☐ Duiker
- ☐ Zebra
- ☐ Beeste
- ☐ Bokke
- ☐ Skaape
- Nie van toepassing nie

☐ Ander (specifiseer asb)

44. **Wat is die geskatte waarde van die verliese oor die laaste jaar?**

45. **Sal u bereid wees om betalende gaste toe te laat op die plaas om Wildehonde te kom sien?**

- Ja
- Nee

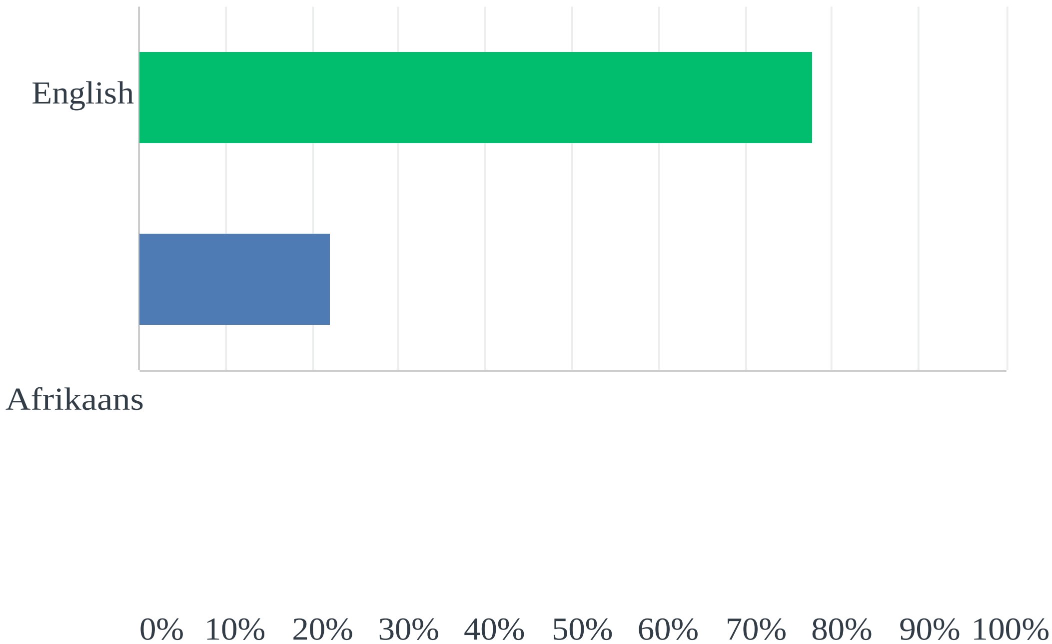
46. **Indien u alreeds betrokke is by ekotoerisme, sal u bereid wees om gaste na ander plase toe te vervoer om die wildehonde te sien?**

- Ja
- Nee

47. **Hoe ver sal u bereid wees om gaste te vervoer vir so 'n ervaring?**

ANNEXURE E Survey Answers

Q1 English or Afrikaans



Answers	Responses	No. of responses
English	78%	63
Afrikaans	22%	18
Total	100%	81

Q2 What is your first name?

Q3 What is your surname?

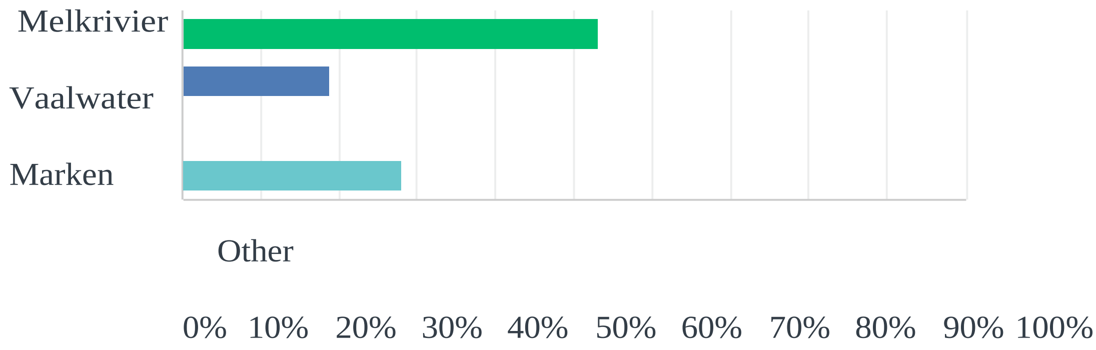
Q4 What is your email address?

Q5 Please provide a telephone number:

Q6 What is the name of your farm or farms per Title Deed? (Cadastral farm name)

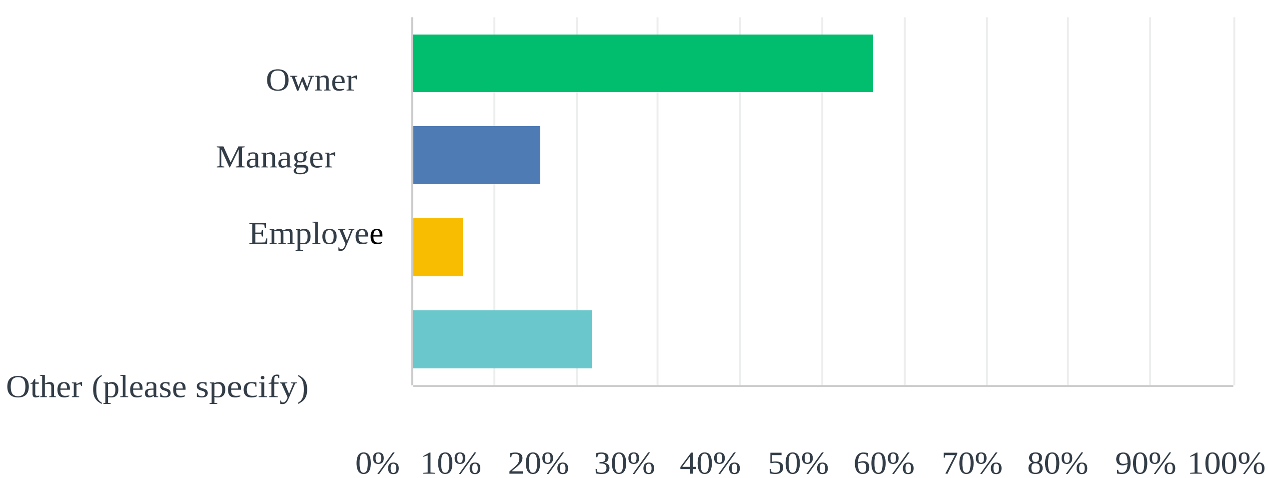
Q7 What is the common name of your farm?

Q8 In which area does your farm occur?



Answers	Responses	No. of responses
Melkrivier	53%	17
Vaalwater	19%	6
Marken	0%	0
Other	28%	9
Total	100%	32

Q9 What is your position on the farm?

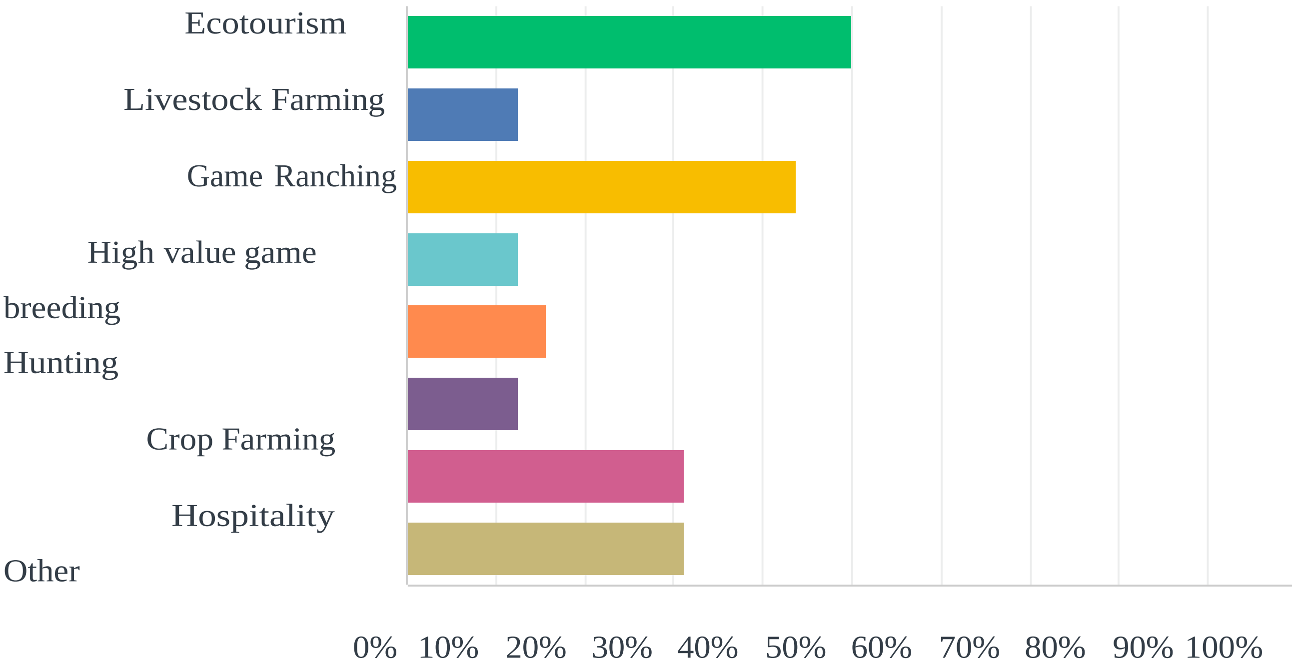


ANSWER CHOICES	RESPONSES	
Owner Manager	**56.25%**	**18**
Employee	15.63%	5
Other (please specify)	**6.25%**	**2**
	21.88%	**7**
TOTAL		**32**

Q10 Total size of the farm? (Ha) Answered: 32; Skipped: 49

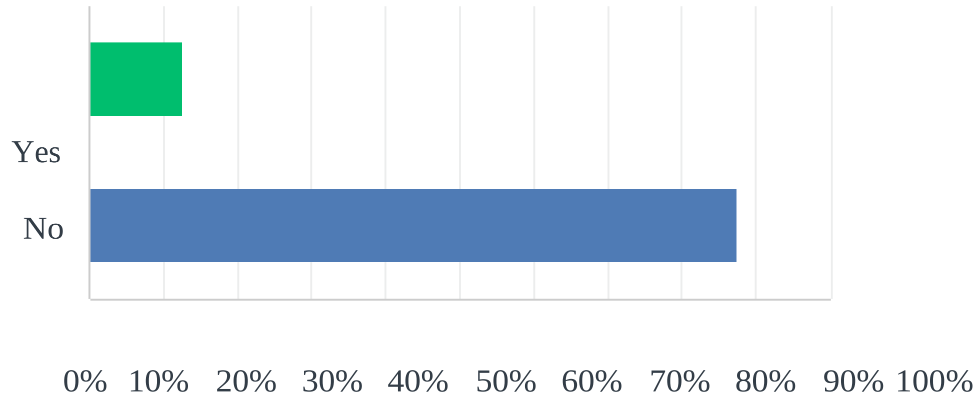
Q11 Length of time you have owned/worked on the farm? Answered: 32; Skipped: 49

Q12 What is the purpose of your farm? (You can choose more than one answer)



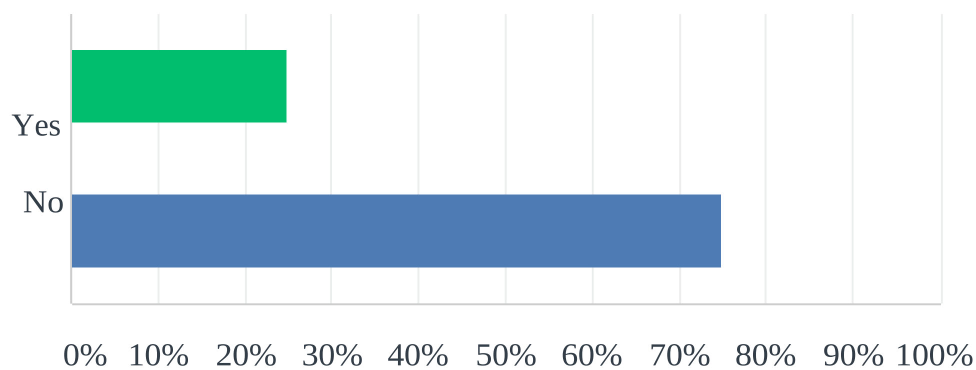
Answers	Responses	No. of responses
Ecotourism	24%	16
Livestock Farming	6%	4
Game Ranching	21%	14
High value game breeding	6%	4
Hunting	8%	5
Crop Farming	6%	4
Hospitality	10%	10
Other	15%	10
Total	100%	67

Q13 Is your perimeter fence predator proof?



ANSWER CHOICES	RESPONSE
Yes	12.50%
No	**87.50%**
TOTAL	**34**

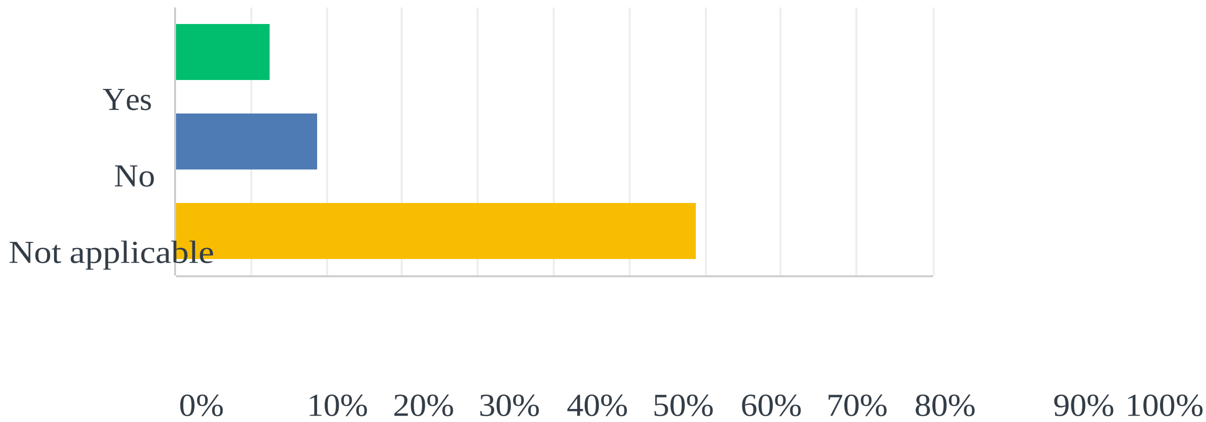
Q14 Do you have any high value game species (eg. sable, colour variants) on your farm?



ANSWER CHOICES	RESPONSES	
Yes	**25.00%**	**8**
No	**75.00%**	**24**
TOTAL		**32**

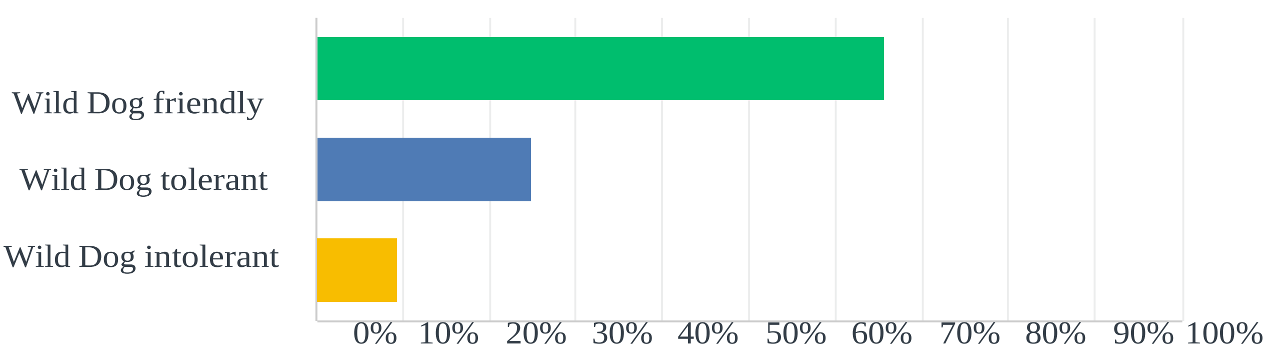
32

Q15 Are your high value game species kept in breeding camps?



ANSWER CHOICES	RESPONSES	
Yes	12.50%	
No	**18.75%**	
Not applicable	**68.75%**	**22**

Q16 Would you classify your farm as?



ANSWER CHOICES

RESPONSES

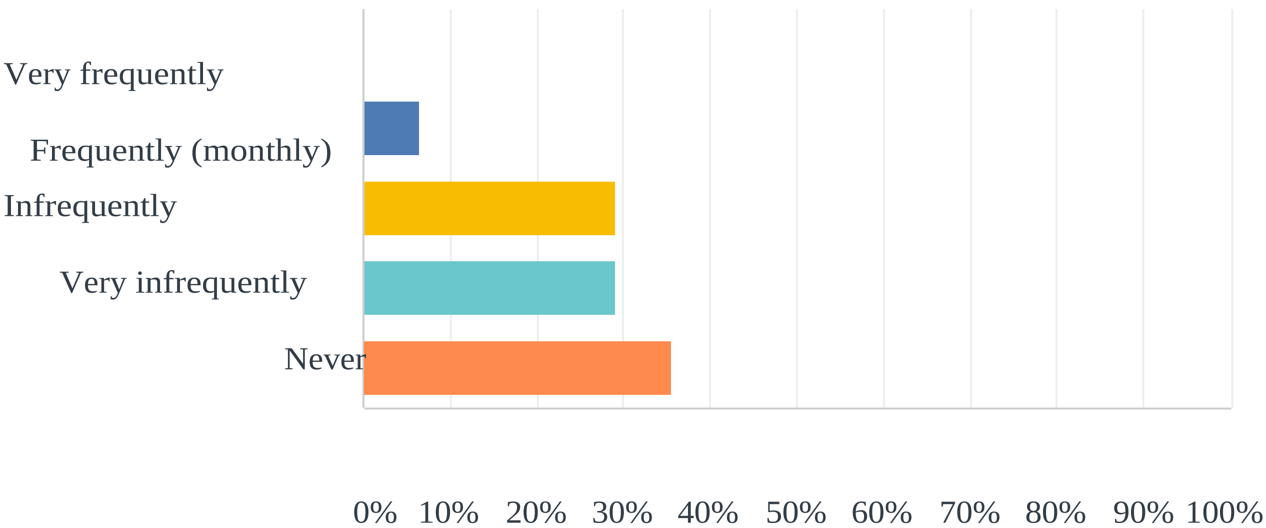
Wild Dog friendly (you are happy for the Wild Dogs to spend time on your farm)
66%

Wild Dog tolerant (you are happy for the Wild Dogs to pass through as long as they don't spend any significant time on your farm) **25%**

Wild Dog intolerant (you do not want the Wild Dogs to spend any time on your farm)
9%

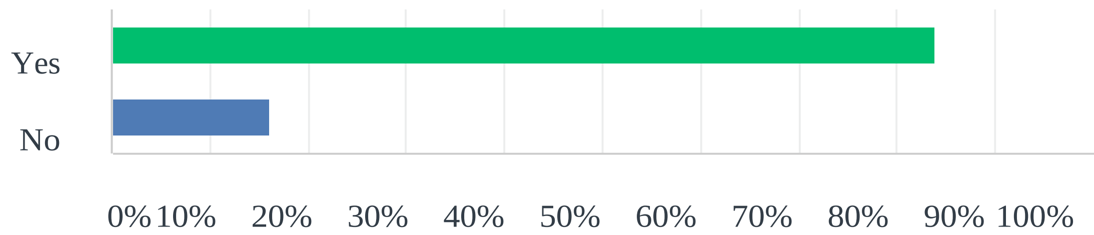
100%

Q17 How often have Wild Dogs traversed through your farm over the past 5 years?



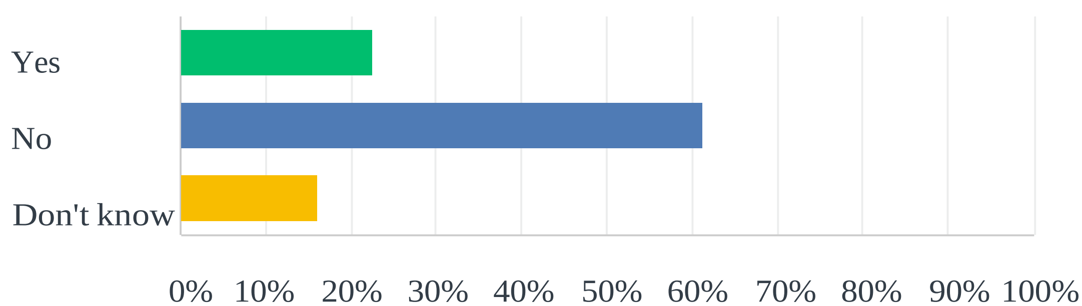
ANSWER CHOICES	RESPONSES	
Very frequently (weekly)	**0%**	**0**
Frequently (monthly)	**7%**	**2**
Infrequently (once or twice a year)	**29%**	**9**
Very infrequently (less than once a year)	**29%**	**9**
Never		11
Total Respondents: 31		

Q18 If you are Wild Dog friendly would you consider putting a Wild Dog Friendly Farm sign at your property entrance?



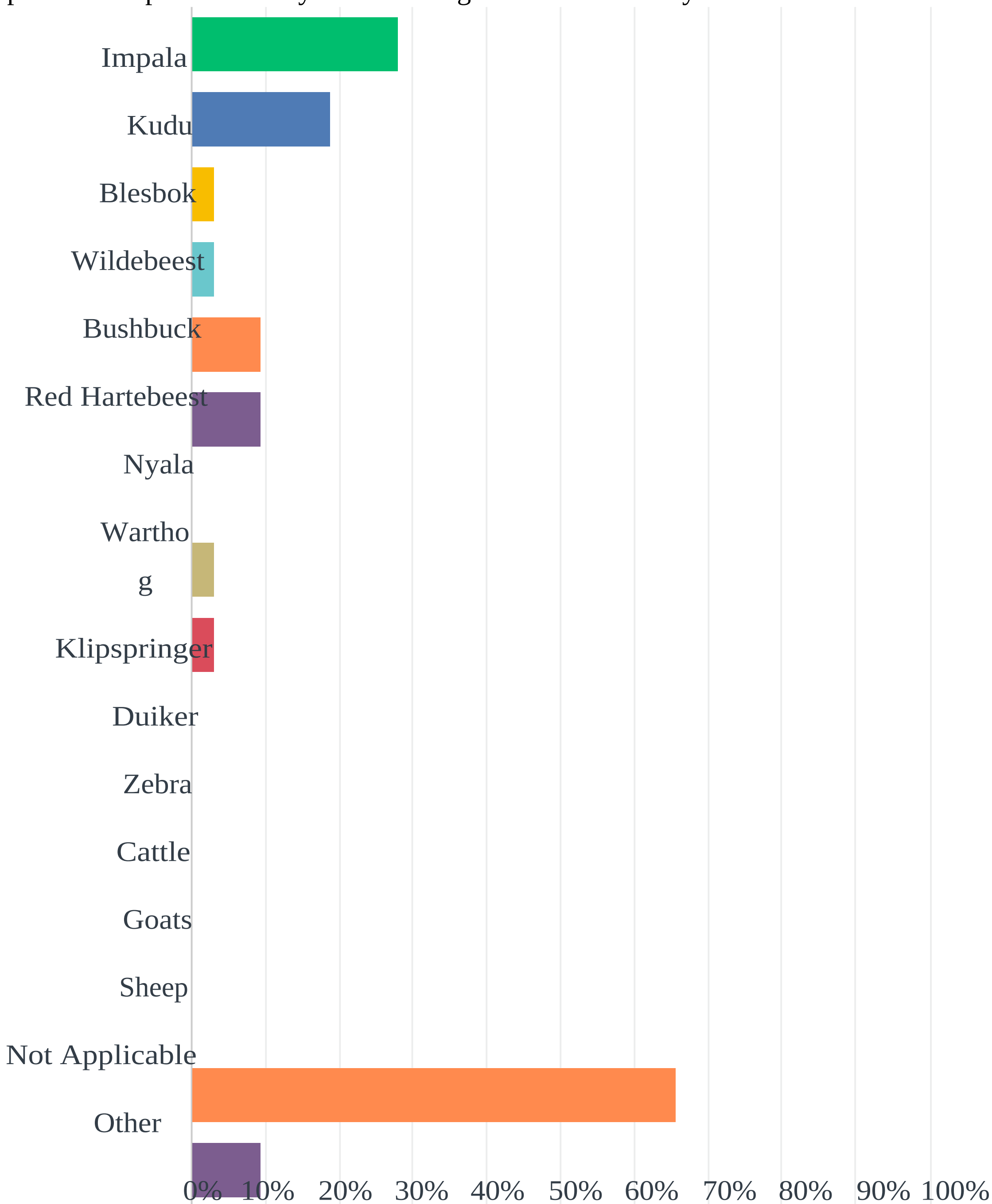
ANSWER CHOICES	RESPONSES	
Yes	83.87%	26
No	16.13%	5
TOTAL		31

Q19 Have you experienced livestock or game losses to African Wild Dogs over the last year?



ANSWER CHOICES	RESPONSES	
Yes	22.58%	7
No	61.29%	19
Don't know	16.13%	5
TOTAL		31

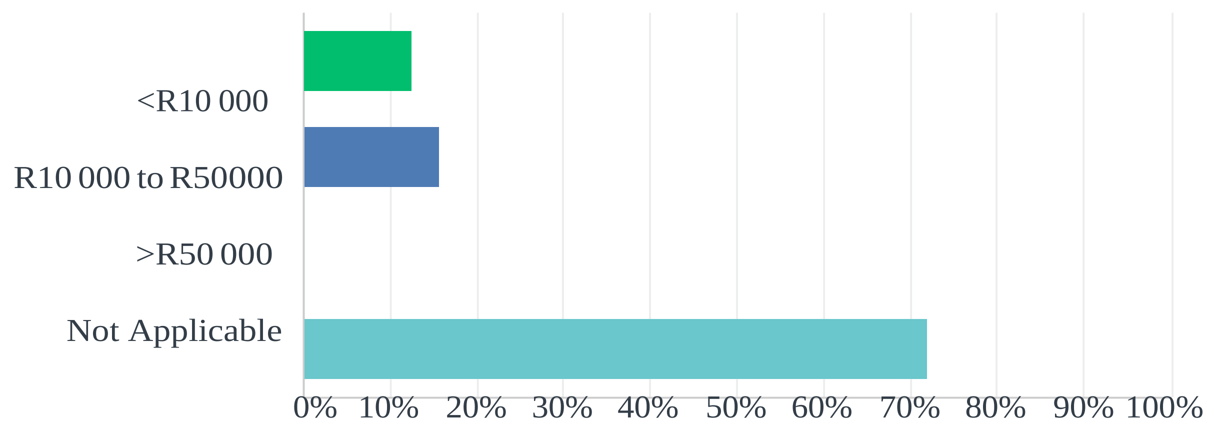
Q20 What species were predated on by the Wild Dogs over the last five years?



Species	Responses	No. of responses
Impala	18 %	9
Kudu	12%	6
Blesbok	2%	1

Wildebeest	2%	1
Bushbuck	6%	3
Red Hartebeest	6%	3
Nyala	0%	0
Warthog	2%	1
Klipspringer	2%	1
Duiker	0%	0
Zebra	0%	0
Cattle	0%	0
Goats	0%	0
Sheep	0%	0
Not Applicable	43%	21
Other	6%	3
Total	100%	49

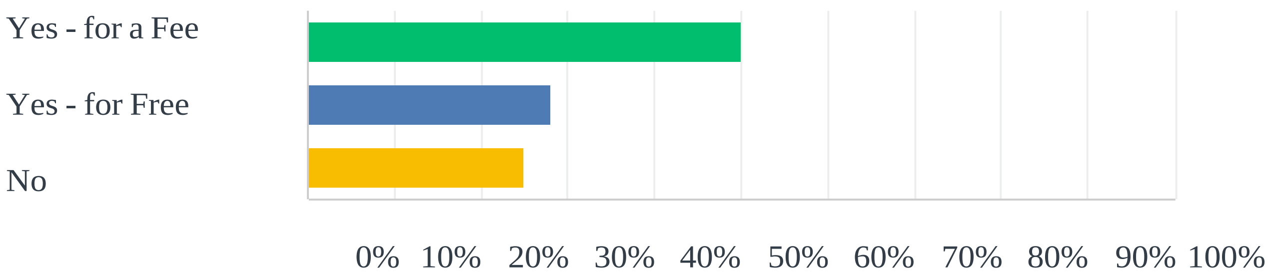
Q21 What was the approximate value of these losses over the past year?



Answer choices	Responses	No. of responses
<R10 000	13%	4
R10 000 to R50 000	16%	5
>R50 000	0%	0

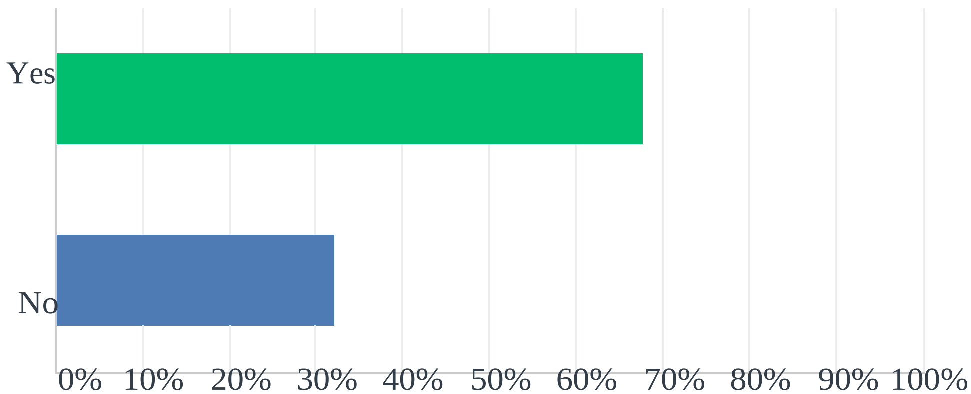
Not Applicable	72%	

Q22 Would you agree to tourists viewing Wild Dogs on your property?



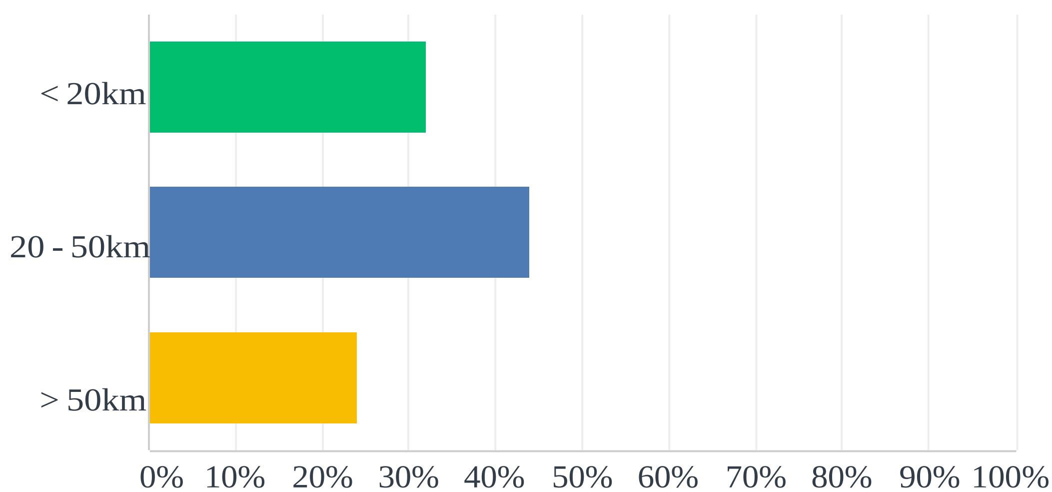
Answer choices	Responses	No. of responses
Yes- for a fee	50%	16
Yes- for free	28%	9
No	25%	8
Total		32

Q23 If you offer ecotourism on your property, would you be interested in driving your guests to another property to view/track the Wild Dogs?



Answer choices	Responses	No. of responses
Yes	68%	21
No	32%	10
Total	100%	31

Q24 How far would you be willing to take your guests to view the Wild Dogs?



Answer choices	Responses	No. of responses
< 20km	32.00%	8
20 - 50km	44.00%	11
> 50km	24.00%	6

Afrikaans Respondents

Q25 Wat is u naam?

Q26 Wat is u van?

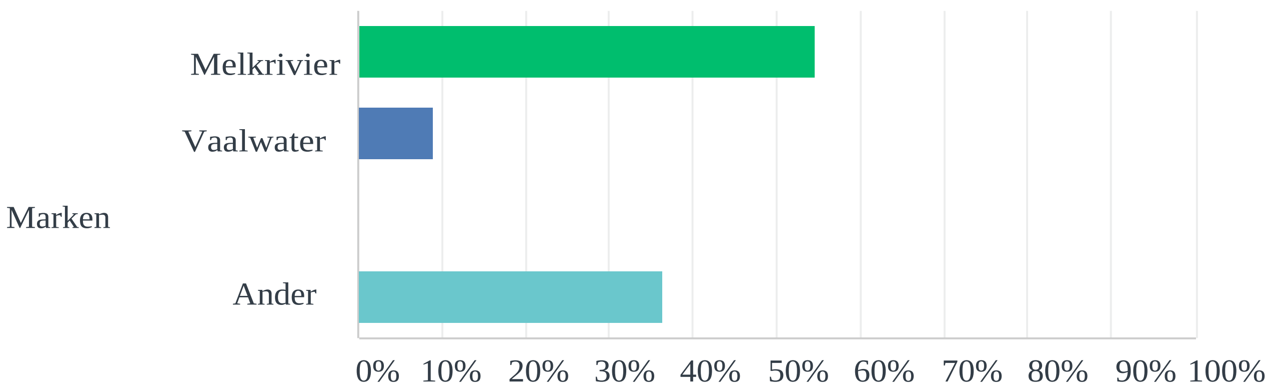
Q27 Wat is u e-pos adres?

Q28 Wat is u kontak telefoon nommer?

Q29 Wat is die naam van u plaas of plase op die titelakte? (Cadastral plaas naam)

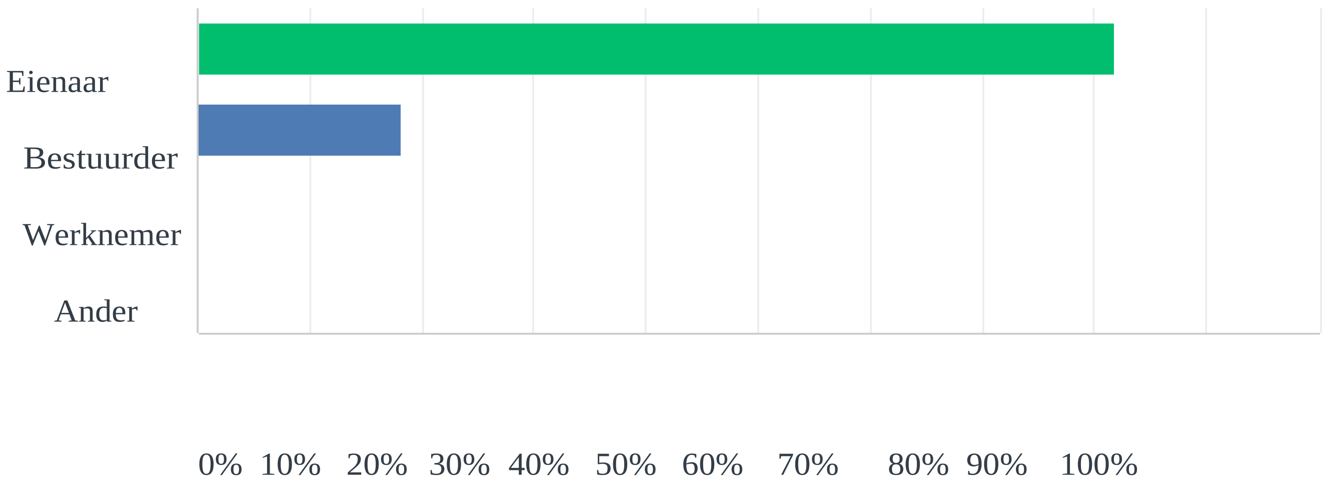
Q30 Wat is die algemene naam van jou plaas?

Q31 In watter gebied kom jou plaas voor?



Answer choices	Responses	No. of responses
Melkrivier	56%	6
Vaalwater	9%	1
Marken	0%	0
Ander	37%	4
Total	100%	11

Q32 Wat is u posisie op die plaas?

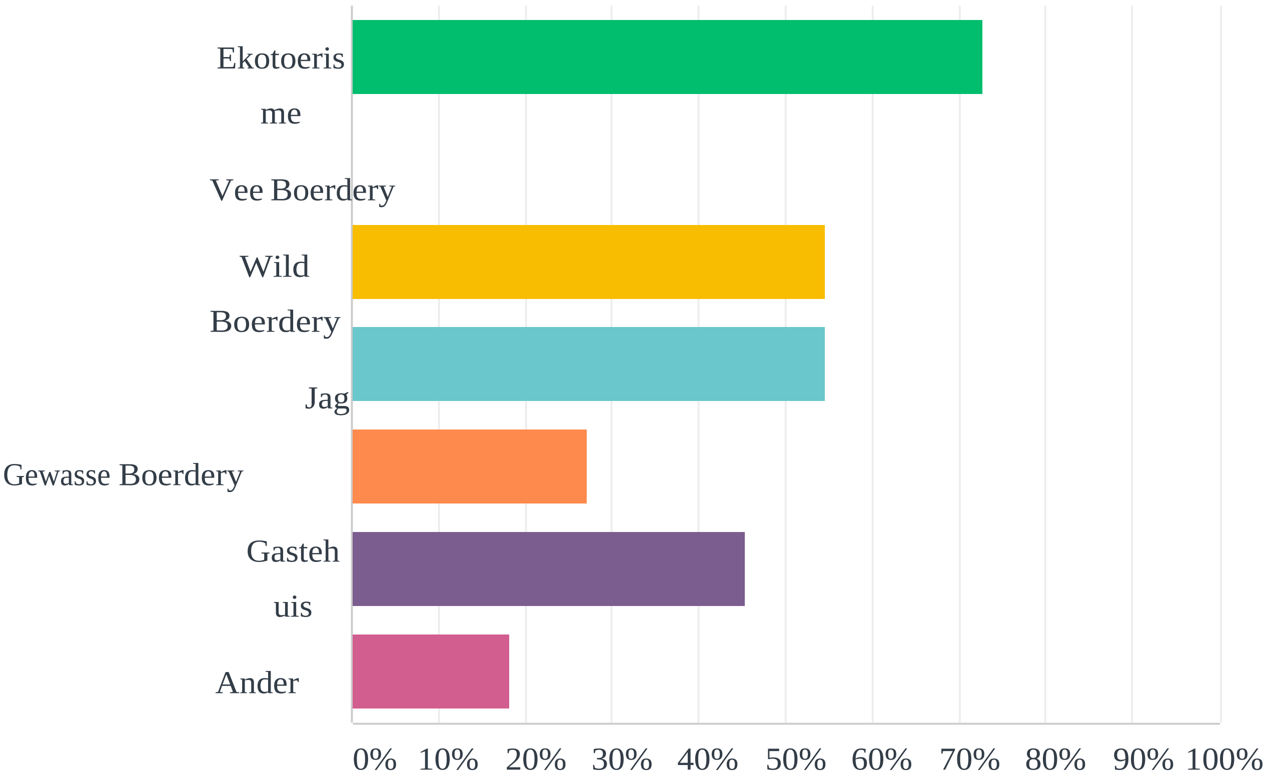


Answer choices	Responses	No. of responses
Eienaar	82%	9
Bestuurder	18%	2
Werkneer	0%	0
Ander	0%	0
Total	100%	11

Q33 Hoe groot is u plaas? (Ha)

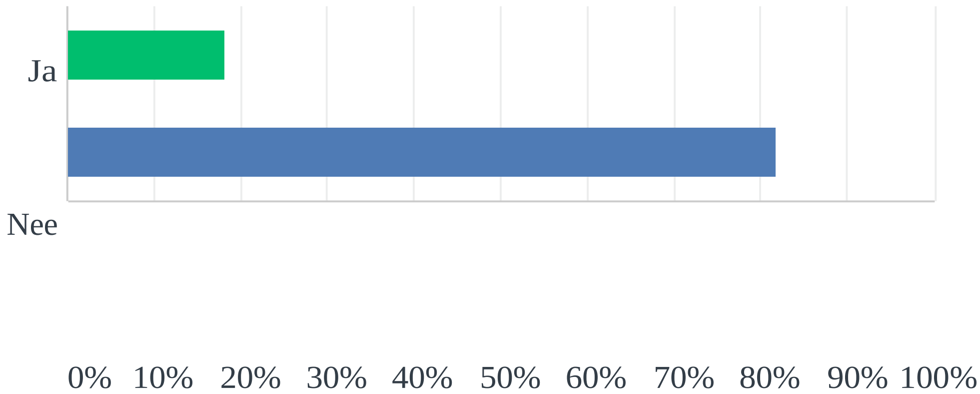
Q34 Hoe lank is u al betrokke by die plaas?

Q35 Watse tiepe aktiwieteite word op die plaas beoefen? (Jy kan meer as een kies)



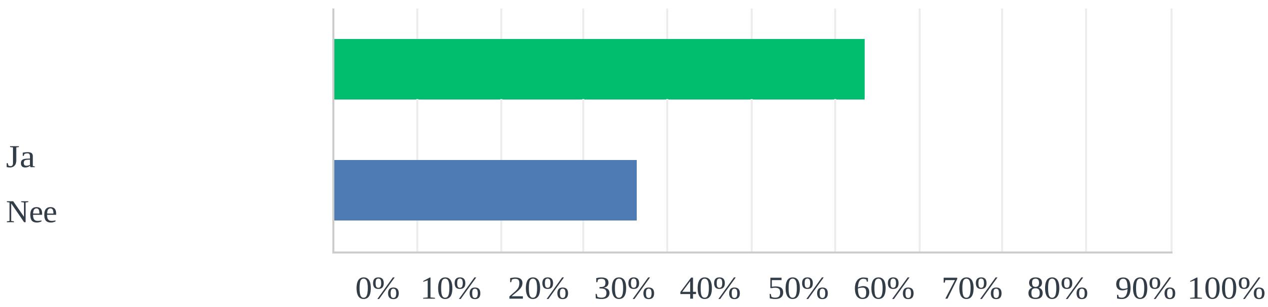
Answer choices	Responses	No. of responses
Ekotoerisme	27%	8
Vee Boerdery	0%	0
Wild Boerdery	20%	6
Jag	20%	6
Gewasse Boerdery	17%	5
Gastehuis	10%	3
Ander	7%	2
Total		30

Q36 Is u grensdraad roofdier bestand?



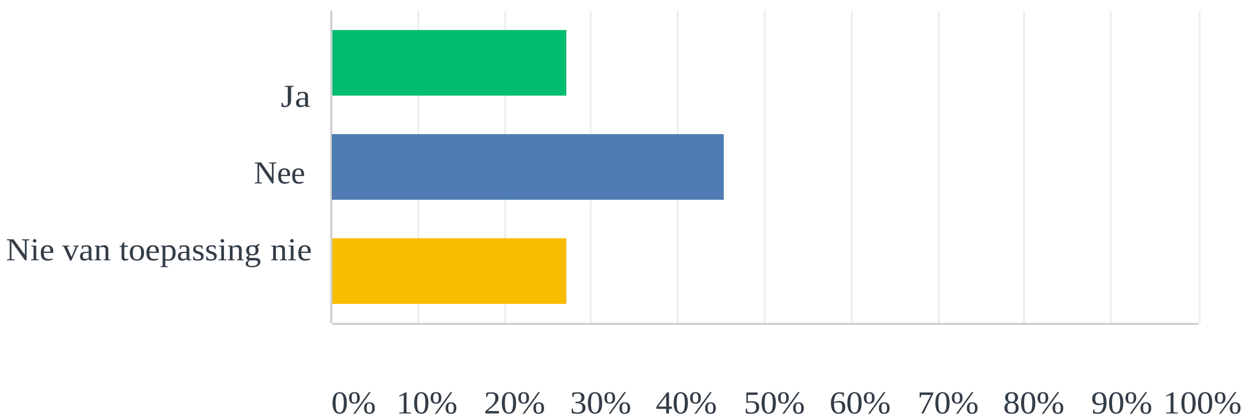
Answer	Response	No. of respondents
Yes	18%	2
No	82%	9

Q37 Het u enige hoe waarde wild spesies op u plaas (bv. sable swart rooibok)?



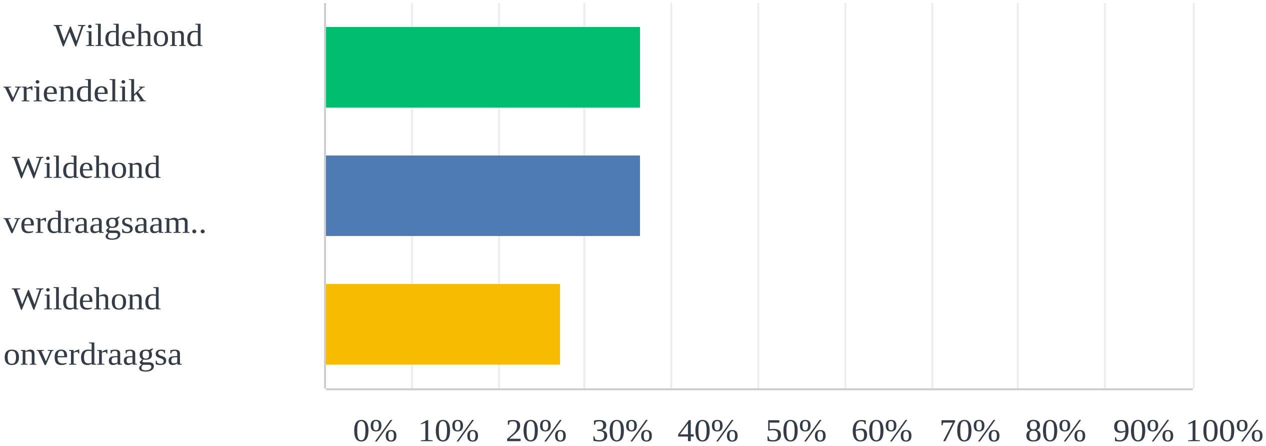
Answer	Responses	No. of responses
Ja	64%	7
Nee	36%	4
Total	100%	11

Q38 Indien Ja, word die wild in teel kampe aangehou?



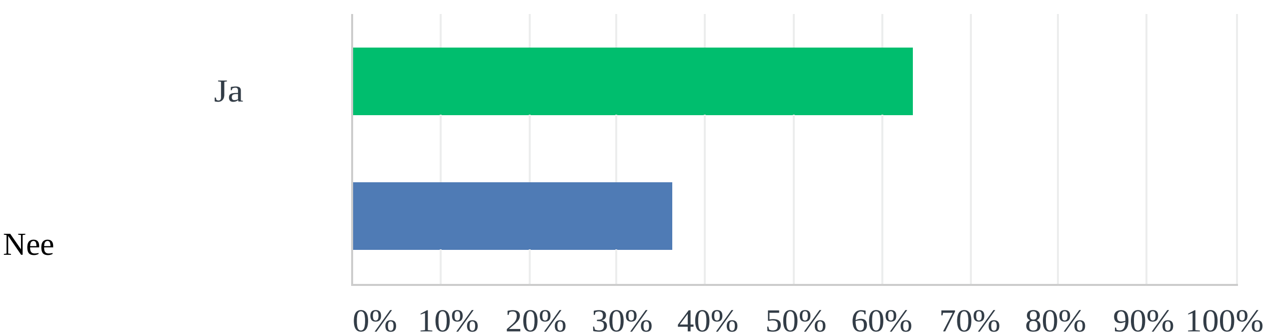
Answer	Response	No. of respondents
Ja	27%	3
Nee	46%	5
Nie van toepassing nie	27%	3
Total	100%	11

Q39 Sal u die plaas klassifiseer as:



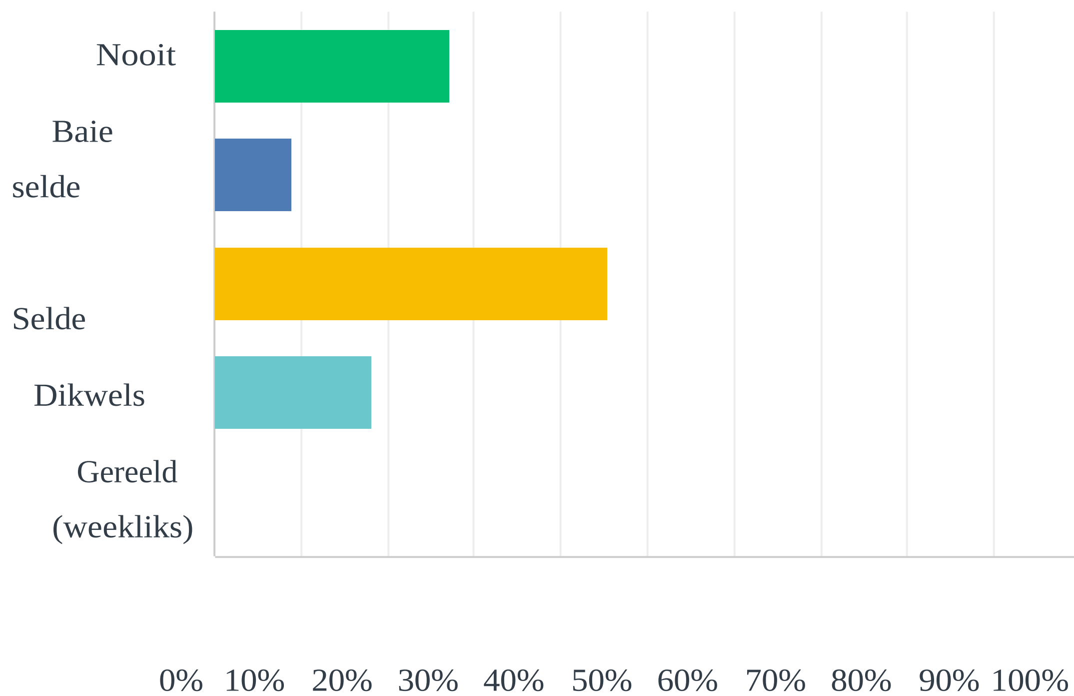
ANSWER CHOICES	Response	No. of responses
Wildehond vriendelik (Die Wildehonde is welkom op die plaas)	36%	4
Wildehond verdraagsaam (Die Wildehonde mag deur die plaas beweeg, maar mag nie daar vir n lang tyd bly nie)	36%	4
Wildehond onverdraagsaam (Die Wildehonde is glad nie welkom op die plaas nie)	27%	3
	100%	11

Q40 As die plaas Wildehond vriendelik is, sal u oorweeg om n "wildehond vriendlik" teken langs die ingangshek te vertoon?



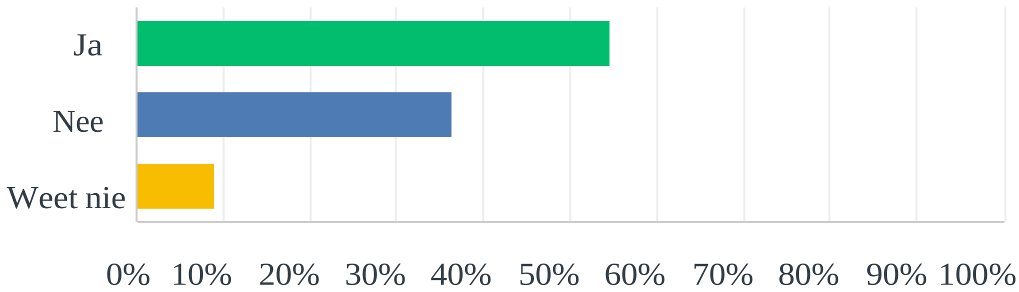
Answers	Responses	No. of responses
Ja	67%	7
Nee	33%	4
Total	100%	11

Q41 Hoe gereeld het wildehonde deur die plaas beweeg in die laaste 5 jaar?



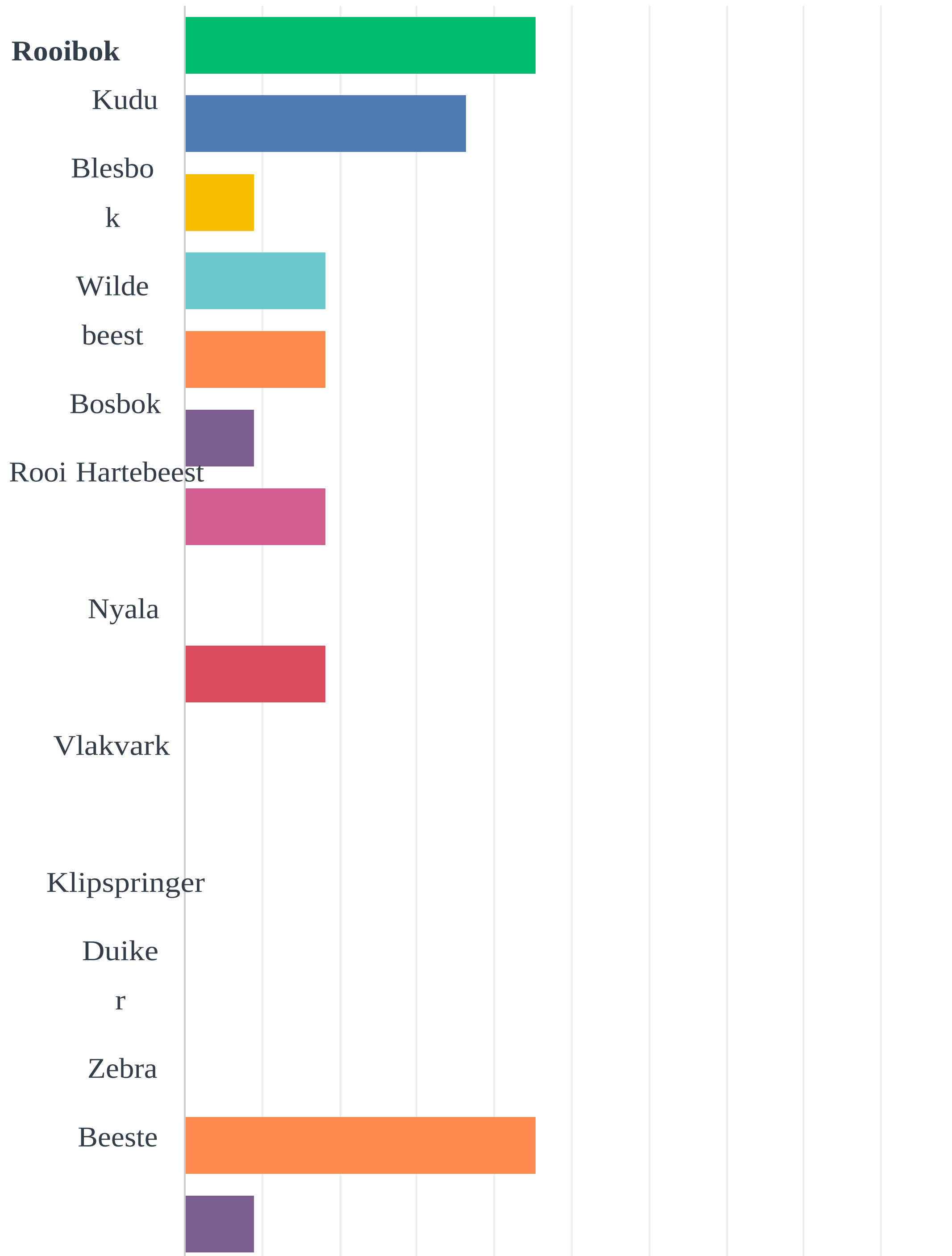
Answers	Responses	No, of responses
Nooit	27%	3
Baie selde (minder as een keer n jaar)	9%	1
Selde (een of twee keer n jaar)	46%	5
Gereeld (weekliks)	0%	2
Total	100%	11

Q42 Het u al ooit vee of wild verliese gelei as gevolg van wildehonde gedurende die laaste jaar?


Ja
Nee
Weet nie
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%

Answers	Responses	No. of responses
Ja	55%	6
Nee	36%	4
Weet nie	9%	1
Total	100 %	11

Q43 Watse spesies het die wildehonde gevang?



Bokke

Skaape

Nie van toepassing nie

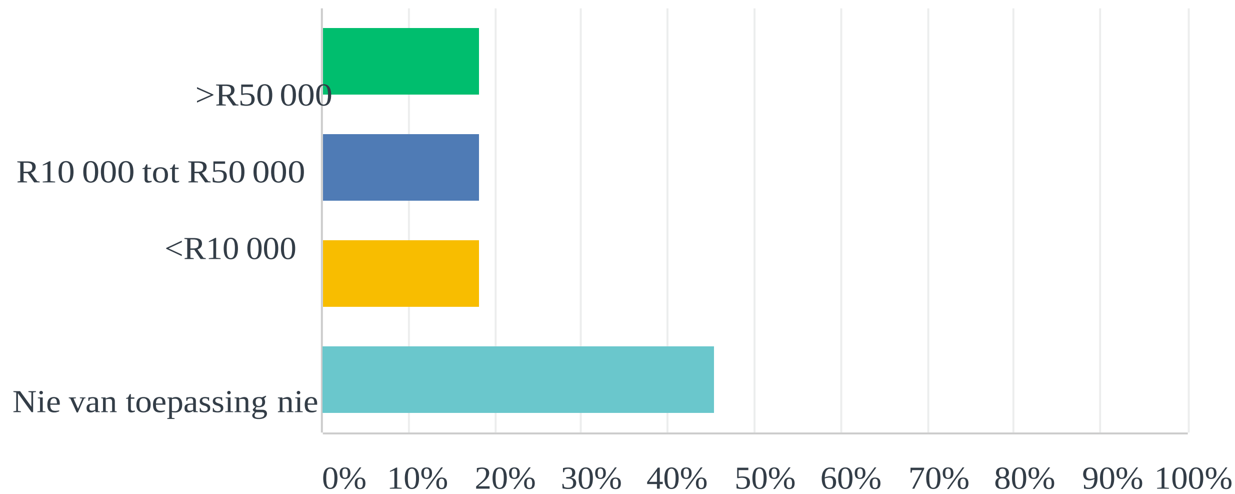
Ander (specifiseer...

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Answer	Responses	No. of responses
Rooibok	20%	5
Kudu	16%	4
Blesbok	4%	1
Wildebest	8%	2
Bosbok	8%	2
RooiHartebeet	4%	1
Nyala	8%	2
Vlakvark	0%	0
Klipspriner	0%	2
Duiker	0%	0
Zebra	0%	0
Beeste	0%	0
Bokke	0%	0
Skaape	0%	0

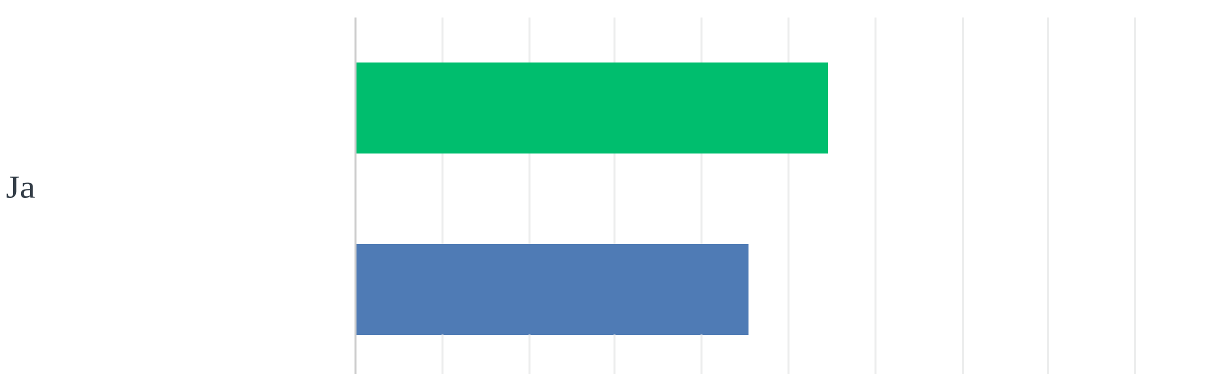
Nie van toepassing nie	20%	5
Ander	4%	1
Total	100%	25

Q44 Wat is die geskatte waarde van die verliese oor die laaste jaar?



Answer choices	Responses	No. of responses
>R50 000	18.18%	2
R10 000 tot R50 000	18.18%	2
<R10 000	18.18%	2
Nie van toepassing nie	45.45%	5
Total	100%	11

Q45 Sal u bereid wees om betalende gaste toe te laat op die plaas om Wildehonde te kom sien?

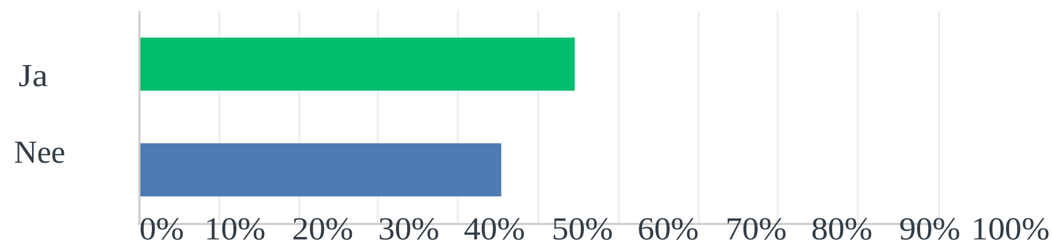


Nee

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

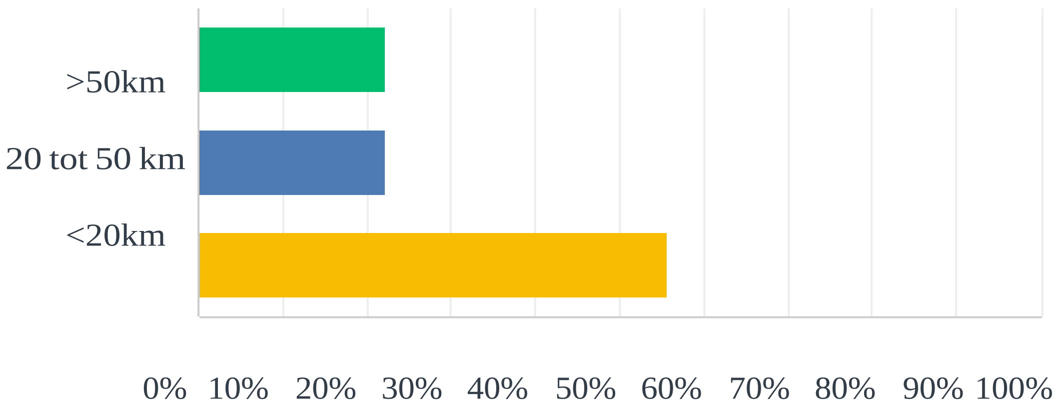
Answers	Responses	No. of responses
Ja	55%	6
Nee	45%	5
Total	100%	11

Q46 Indien u alreeds betrokke is by ekotoerisme, sal u bereid wees om gaste na ander plase toe te vervoer om die wildehonde te sien?



Answers	Responses	No. of responses
Ja	55%	6
Nee	45%	5
Total	100%	11

Q47 Hoe ver sal u bereid wees om gaste te vervoer vir so 'n ervaring?



Answers	Responses	No. of responses
>50km	22.22%	2
20 tot 50 km	22.22%	2
<20km	55.56%	5
Total	100%	9