Game Viewing Potential in a Multi-use Conservation Area: a Case Study of the Great Limpopo Transfrontier Park, Southern Africa

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DECLARATION

I declare that this Dissertation is my own, unaided work. It is being submitted for the Degree of Master of Science at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

(Signature of candidate)

Signed on ______________________2014 in Johannesburg

ABSTRACT

Three key objectives of transfrontier conservation are biodiversity conservation, local economic development and the promotion of peace and cooperation across international borders (Ramutsindela, 2004). Transfrontier Conservation Areas (TFCA's) may incorporate a variety of conservation land uses, and comprise of both consumptive and non-consumptive uses of wildlife (Hanks, 2003). It is critical that this mosaic of land uses is well managed and integrated in order to meet the conservation and socio-economic goals of TFCA's. One challenge is that different conservation land use areas may have varying effects on wildlife. This study aims to further our understanding of these effects in the Great Limpopo Transfrontier Park of South Africa and Mozambique.

The research uses the behavioural responses of wildlife as a way of determining the tolerance of wildlife to potentially disturbing activities. Four different conservation land use areas, namely trophy hunting, communal land, photographic tourism and exclusive photographic tourism were studied and compared in and around the Great Limpopo Transfrontier Park, southern Africa. The aim of this study was to firstly establish the diversity of mammals and the frequency of mammal sightings within each conservation land use area, and secondly, assess the response behaviour of five mammal species to an approaching vehicle. K-means cluster analysis was used on both the mammal sightings data and the response behaviour data in order to determine key influencing variables.

Throughout the study period, the mammal diversity and frequency of mammal sightings were the highest in the private ecotourism concession, followed by the national park, and then the trophy hunting reserve and lastly communal land. The behavioural responses displayed by the five study mammals (African elephant, African buffalo, impala, chacma baboon and Burchell's zebra) also varied considerably between the four conservation land use areas. The lowest response indexes and least number of flight responses occurred in the national park, followed by the private ecotourism concession, and conversely, a higher average initial response index and a greater occurrence of flight responses occurring in the trophy hunting reserve and communal land. According to the findings from the cluster analyses, the type of conservation land use impacts on the sighting potential and sighting quality of mammals, but so do

topographical differences and seasons. These results can help in the management of each conservation land use area on its own and as an integrated part of a TFCA.

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CBNRM	Community Based Natural Resource Management
DEM	Digital Elevation Model
FD	Flight Distance
GLTP	Great Limpopo Transfrontier Park
IFI	International Financial Institution
IRD	Initial Response Distance
IRI	Initial Response Index
IUCN	The International Union for the Conservation of Nature
KNP	Kruger National Park
LEDET	Department of Local Economic Development, Environment and Tourism
LNP	Limpopo National Park
LTP	Limpopo Tourism and Parks
NGO	Non-Governmental Organisation
SANParks	South African National Parks
TFCA	Transfrontier Conservation Area
USGS	United States Geological Survey

CHAPTER 1: INTRODUCTION

1.1 Background to the Study

Ecosystems provide human societies with essential goods and services that have great ecological, socio-cultural and economic value (Lagabrielle *et al*., 2010). In Africa, the majority of people are dependent on natural resources and the environment for their livelihoods. This, together with population growth and poverty, has placed these natural resources under increasing pressure, leading to over-exploitation and environmental degradation (Katerere *et al*., 2001). There is a critical need for development in such rural areas that not only has income earning potential, but also offers alternatives that do not threaten the continued protection of natural habitats and associated resources. Careful multifunctional landscape planning is thus required in order to meet the demand of society while integrating biodiversity conservation (Lagabrielle *et al*., 2010). One of the major challenges facing this kind of land use planning in Africa is planning conservation areas that are intermixed with human land use (Miller, 2007). Gardner *et al*. (2009), proposes that blanket solutions must be avoided when dealing with multifunctional landscapes, and suggests a more pragmatic approach whereby landscapes are designed to achieve multiple objectives, including biodiversity conservation, the maintenance of ecosystem services and improved human well-being. To this end, ecotourism activities, such as photo-tourism and recreational hunting, are being introduced into rural areas as a strategy to create income earning opportunities and to incentivise biodiversity conservation.

Transfrontier conservation refers to the management of relatively large tracts of land that straddle the frontiers of two or more countries, through co-operation between neighbouring states (Hanks, 2003; Duffy, 2006). In southern Africa, transfrontier conservation has become very popular in recent years, with both great potential and problems associated with it (Duffy, 2006). Three key objectives used to promote transfrontier conservation are the re-establishment of natural systems, tourism and local economic development (Ramutsindela, 2004). Transfrontier Conservation Areas (TFCA's) may incorporate national parks, game reserves, private land, communal land, forest reserves and wildlife management areas, and comprise of both consumptive and non-consumptive uses of wildlife (Hanks, 2003). It is critical that this mosaic of land uses is well managed and integrated in order to meet the conservation and socio-economic goals of TFCA's. Different conservation land use areas may have varying negative impacts on wildlife, and understanding these effects is not only important for managing each conservation land use area on its own but also for managing each as an integrated part of a TFCA (Tarlow and Blumstein, 2007). There are various methods of measuring the implications of human activities on wildlife. Breeding success, for example, is an important measure of human impacts as this ultimately determines the survivorship of a species (Tarlow and Blumstein, 2007). However, even if no direct effects of human activities are evident when studying population densities, more subtle effects of human disturbances may be evident in the behaviour of a population, and ultimately the group structure/composition or the social organisation (Averbeck *et al*., 2009). Studying the behavioural responses of wildlife is an important way of determining the tolerance of wildlife to potentially disturbing activities. Animals may be exposed to a range of stimuli; the characteristics of which will influence the responses of wildlife. Animals may respond to a stimulus such as human presence by fleeing, hiding or defending; thus affecting their spacial use patterns. Taylor and Knight (2003a) believe that wildlife response distances such as flight distances can be used to predict the energetic consequences of animals responding to human activities by expending more energy on being alert or even avoiding certain areas. In cases where there is constant non-threatening exposure, an animal may become habituated whereby they no longer react to a stimulus.

Numerous studies have shown that hunting pressure may have various negative impacts on the density, distribution, and social behaviour of vertebrates. For instance, studies on the social behaviour of *Loxodonta africana* (African elephant) have shown that hunting pressure has resulted in the movement of elephant from hunting areas into protected areas (Verdade, 1996). Verdade (1996) also recorded a decrease in the reproductive performance in *Aepyceros melampus* (impala); consequence of an imbalance in the sex ratio in hunting areas. A further study which investigated the flight distances of white-tailed deer in northern New York, firstly demonstrated that the deer in the hunting area had significantly longer flight distances than those in the un-hunted area, and there were far fewer observations of deer in the hunting area compared to the un-hunted area (Bahrend and Lubeck, 1968). Studies examining the implications of various conservation land use areas on the social behaviour of vertebrates, have been limited to hunting activities, with studies having compared the response behaviour of a specific species in a hunting area to that of the same species in an un-hunted area (Bahrend and Lubeck, 1968; Manor and Saltz, 2003; Matson *et al*., 2005; Setsaas *et al*., 2007).

This dissertation aims to extend this limited knowledge by focusing on five mammal species that differ in social behaviour, and which may thus be variably impacted by human activities. Furthermore, four different conservation land use areas; namely trophy hunting, communal land, photographic tourism (national park) and exclusive photographic tourism (private ecotourism concession), that are integrated into one transfrontier conservation area, are studied and compared. These four conservation land use areas fall within and around the Great Limpopo Transfrontier Park (GLTP) and are thought to represent two scales: one of decreasing negative disturbances and one of increasing benign disturbances that habituate game to approaching vehicles.

The current work aims to firstly study the diversity of mammals and the frequency of mammal sightings within each conservation land use area, and secondly to assess the response behaviour of five mammal species, namely the elephant, buffalo, impala, baboon and Burchell's zebra, in the four different conservation land use areas present in the GLTP. These mammals have been primarily selected as the focal animals for this study as they are known to commonly occur throughout the GLTP and its surrounds. Elephant and buffalo have always been popular targets for trophy hunting and, in the past, were uncontrollably hunted for various motives including the ivory trade. Given that these animals are intelligent with complex social structures, the implications of past human activities may still be evident in the behavioural responses of elephant, generations later, as a result of behaviour being learnt and passed down to the next generation (Lee and Moss, 1999). Primates are extremely intelligent with highly complex social systems and are often victims of human wildlife conflicts given their opportunistic and scavenging nature (Naughton-Treves *et al*., 1998). Impala and zebra are common residents in these areas and are easily habituated to human presence where they are not exposed to threatening human activities. Common threatening activities include hunting by both subsistence and trophy hunters. This study intends to quantify some short-term effects of various conservation land use areas using these five mammals as an indication. The value of such a study is that it may, in future, be repeated over time to determine whether animals recover from certain disturbances, such as trophy hunting, and help to determine the potential or limitations for game viewing as an income earner in multi-use conservation areas.

1.2 Aim and Objectives

The aim of this study is to investigate the game viewing potential within various conservation land uses in the northern portion of the Great Limpopo Transfrontier Park (GLTP). The first objective will be to compare the diversity and frequency of mammal sightings between the different land use areas. Secondly, the response behaviour of five mammals (known to occur throughout the GLTP) will be compared between the four land use areas and between different seasons which relate to resource availability and hunting.

1.3 Hypotheses and Questions

For this study, it is hypothesised that the mammal response index ratings will be lower and flight distances will be shorter in the land use zones with the least perceived negative impacts (ecotourism), than in the zones with the most perceived negative impacts (trophy hunting and communal lands). This difference will vary depending on spatial and temporal distances from hunting and community activities. Furthermore, it is also hypothesised that there will be a greater diversity and frequency of mammal sightings in areas of wildlife tourism than in areas of trophy hunting and communal lands. The underpinning assumption is that these differences make some areas more suitable for wildlife viewing than others, illustrating the need for careful planning when selecting areas for ecotourism (photographic and wildlife viewing based tourism). Through the study of relationships between land uses and animal behaviour, this study aims to answer the following questions:

- How does the sighting frequency and diversity of mammals differ between areas with similar resource availability but different land uses?
- How are spatial and temporal variations in benign human activities influencing the behavioural responses of elephant, buffalo, baboon, impala and zebra?
- How are temporal and spatial variations in hunting influencing the diversity and abundance of mammals as well as the response behaviour of the five mammals mentioned?
- How are seasonal fluctuations in resource availability influencing the response behaviour of these mammals?
- How is the proximity to the breeding season influencing the response behaviour of these mammals?

- Finally, does the Great Limpopo Transfrontier Park function as a multi-use conservation area, or do the land use zones with more perceived negative impacts, such as trophy hunting and communal lands, negatively impact the wildlife viewing potential of the land use zones primarily based on photographic and wildlife viewing tourism?

CHAPTER 2: STUDY AREA

The GLTP was proclaimed in 2002 and is managed as an integrated unit across three international boundaries (South Africa, Mozambique and Zimbabwe; **Figure 2.1**). Three key objectives of transfrontier conservation are biodiversity conservation, local economic development and the promotion of peace and cooperation across international borders (Ramutsindela, 2004). Due to the multifaceted nature of the Great Limpopo Transfrontier Park (GLTP) surrounding transboundary conservation, it uniquely offers a variety of conservation land use areas, with associated activities and management practices, which may be studied and compared. In light of the proposals to further develop photo tourism in this transboundary park, the study aims to explore how conducive such activities and management practices may be for photo tourism.

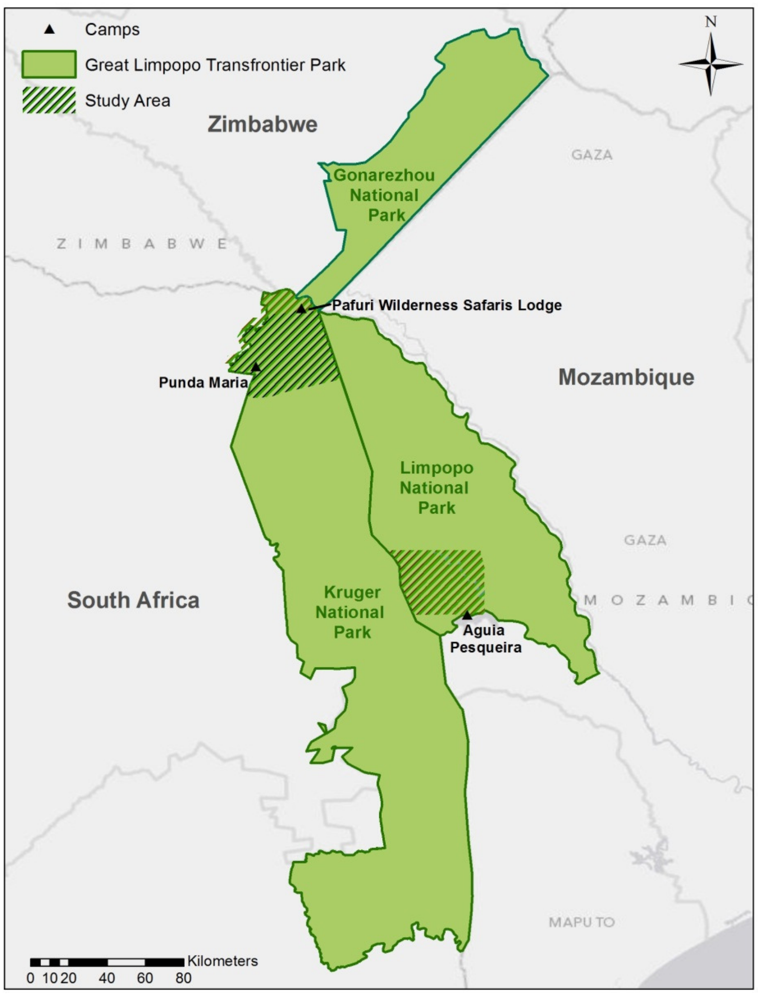

Figure 2.1: Focal area for the study within the GLTP

The primary economic activity in the GLTP is nature-based, photographic ecotourism, currently with the Kruger National Park (KNP) as the major component from an ecotourism development perspective, and the goal is to use this component as a springboard to increase ecotourism throughout the GLTP. This transfrontier park, like many others, incorporates various conservation land uses with varying impacts on wildlife. The three major establishments that make up the GLTP are the Kruger National Park, which has been established as a major tourist attraction for over 100 years, the Limpopo National Park (LNP), which is still in the development process of becoming a tourist attraction whilst also inhabited by Shangaan people who live off the resources of the land, and the Gonarezhou National Park in Zimbabwe (SANParks, 2012).

In order to compare different conservation land uses, the northern section of the KNP was chosen, as this is where the private ecotourism concession and trophy hunting reserve is located, and it was preferable for the various study areas to occur in close proximity to one another so that the environmental conditions were as similar as possible. On the other hand, the adjoining southern section of the LNP was chosen, as this was where a large section of the fence had been taken down between the KNP and LNP, and animals had been introduced into this section. There was thus a higher probability of seeing mammals in this section, thus favouring the study of their response behaviour.

This study focused on four different conservation land use areas, listed in **Table 2.1**, which vary from the land uses with the least perceived impacts to the most negative perceived impacts. For ease of reference, the term “national park” is used throughout this study to refer to the Punda Maria section of the Kruger National Park, and represents the conservation land use primarily based on photographic tourism and wildlife viewing. These four areas are thought to represent two scales: one of decreasing negative disturbances and one of increasing benign disturbances that habituate game to approaching vehicles (**Figure 2.2**). This transfrontier park mostly comprises lowland savannah with an average rainfall of 550 mm per year, which can be temporally and spatially variable (www.sanparks.org). The tropical and sub-tropical north receives an average of 400 mm of rain per annum during the summer months, from October to March, while April to September is dry (Mabunda *et al*., 2003). The KNP is split geologically, with the undulating western half underlain by granite and the more level east underlain by basalt. The northern-most section, northeast of Punda Maria Camp (**Figure 2.1**), comprises sandstone hills, with diverse geological parent material, hosting distinctive associated biota (Mabunda *et al*., 2003). There are five major river systems that cross the ecoregion in a generally west-east direction. The northern portions are dominated by mopane woodlands and shrubland, the southern half by mixed bushveld, and the south-eastern portions in Mozambique are dominated by sandveld communities (www.sanparks.org). According to Mabunda *et al*. (2003), there are eight major vegetation zones across the Kruger, and vegetation structure varies from open plains with low shrubs to closed gallery forests. Undulating open low woodland savanna, dense shrubland and sparsely vegetated broken shrubland dotted with baobab trees also occur in this diverse landscape. Consequently, this ecoregion supports a diverse selection of species, including 147 mammals, 505 birds, 119 reptiles, 34 amphibians, 49 fishes, 1,980 plants, and many thousands of invertebrates (Mabunda *et al*., 2003).

Table 2.1: Establishment details of the four conservation land use areas

Conservation Land Use	Level of Disturbance	Establishment	Road Accessibility
Private Ecotourism Concession	Low density game drives	15 Years	Off-road driving
National Park	High density public vehicles	87 Years	No off-road driving
Trophy Hunting Reserve	Low density public game drives, trophy hunting	8 Years	No off-road driving
Communal Land	Multi-use communal area	11 Years	Off-road driving

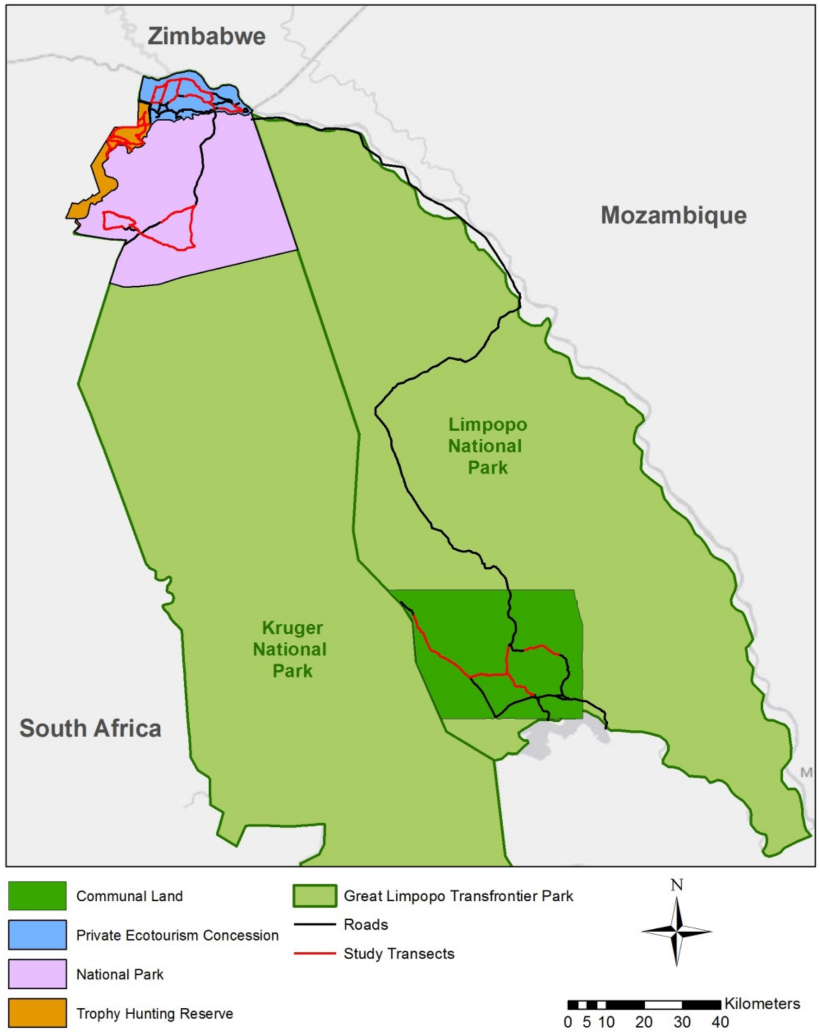

Figure 2.2: Four conservation land use areas situated in and around the GLTP

2.1 Private Ecotourism Concession

The Makuleke Contractual Park is situated in the northern section of the Kruger National Park (KNP) and is approximately 20,000 ha in extent. This region contains the majority of the KNP's biodiversity and it represents one of the major biodiversity hot spots in South Africa (Reid, 2001). The Makuleke community were victims of apartheid and were forcibly relocated from the KNP in 1969. In 1996, the Land Claims Court restored the land to the community with the condition that the land be used for conservation purposes. This region has since been co-managed by the community and South African National Parks (SANParks). The Park contains two concessionaries, Wilderness Safaris and Outpost Lodges, who aim to develop exclusive photographic safaris to the mid-upper market tourists. Road access in this area is limited exclusively to park management and the two lodges, which offer guided game drives and walks (Reid, 2001; Robins and Van der Waal, 2008). Other than the main tar road that links this area to other parts of the KNP, the majority of roads that are off limits to the public are dirt roads, ranging from well managed roads in the eastern section to roads that are only accessible by four wheel drive vehicles in the west. Data received from SANParks (2012) indicated that an average of 830 vehicles enter Pafuri Gate monthly, either as day visitors or as overnight guests. These guests primarily use the main tar road that extends along the southern section of this study area.

According to Viljoen *et al*. (in prep), the terrain of the western section of this study area is characterised by low mountains and hills, resulting from the presence of fault-bounded blocks of resistant, generally quartzitic rocks of the Soutpansberg Group. To the east of the Soutpansberg is low lying terrain, underlain by sedimentary successions of the Karoo Supergroup. Also featured in this area are fault bounded blocks of resistant uppermost Clarens Formation sandstones (Viljoen *et al*., in prep). The Makuleke area is bordered by two major rivers (Limpopo and Levuvhu Rivers), and consists of extensive areas of floodplain alluvium along these rivers in the eastern section (Viljoen *et al*., in prep). The underlying materials of the low lying areas in the east are thus alluvium that has been deposited over a number of years. These alluvial wetland floodplains, as classified by Viljoen *et al*. (in prep), comprise of a variety of landscape features, such as riverine forest, riparian floodplain forest, floodplain grassland, river channels and pans. A network of 31 seasonally flooded pans provide a good source of water for wildlife, particularly with the pans along the Limpopo Floodplain holding water well into the dry season, thereby also providing important refuge areas for wildlife during the drier months (Viljoen *et al*., in prep). In this otherwise dry landscape, a mixture of riverine forest and floodplain grassland communities occur on both the Limpopo and Levuvhu floodplains, which were designated as a Ramsar Site on 22 May 2007 (Environmental Resources Management, 2011). The large, broad canopied trees of the riverine forest provide very important habitat and shelter for a large variety of wildlife (Viljoen *et al*., in prep). Although this landscape supports the largest population of nyalas in the KNP, the rich diversity of game also include bushbuck, duiker, buffalo, kudu, waterbuck, impala, elephant bulls, vervet monkeys and baboons (Gertenbach, 1983). Conversely, shallow and calcareous soils of the western section of this study area are dominated by mopane tree savanna. This landscape does not support a high density of game and the most common mammals include zebra, kudu, steenbok, Sharpe’s grysbok, nyala, eland and elephant (Gertenbach, 1983).

According to Reid (2001), this region represents a major biodiversity "hot-spot" in South Africa, and is considered one of the most significant areas in the KNP, showing a high variability in landscapes, vegetation and associated species (Environmental Resources Management, 2011). Although poaching was uncontrolled in this area in the past, this has largely been controlled over the last ten years due to improved anti-poaching activities, resulting in a greater game density (Environmental Resources Management, 2011).

2.2 National Park

Punda Maria Camp is located near the north-western boundary of the Kruger National Park (**Figure 2.1**) and is a quieter section of the park with regards to tourist traffic. According to SANParks (2012), an average of 2,000 vehicles enter Punda Maria Gate monthly, with only about 15% of visitors staying overnight. As with other parts of the KNP, photo-tourism is the primary ecotourism activity that takes place. Road infrastructure varies from main tar roads that connect the Punda Maria Camp to other camps in the park and to the entrance gates, to less used gravel roads around the Punda Maria Camp, primarily used by tourists staying overnight at the camp.

Due to the low average annual rainfall (532 mm), this area is scarce in natural sources of water, and what does exist is ephemeral and relies on local rainfall events (Smit *et al*., 2007a). As part of the KNP water stabilisation programme that began in the 1930's, 365 boreholes and 50 dams were constructed throughout the KNP by 1995, with a focus on the northern section of the KNP (Smit *et al*., 2007a; Cain *et al*., 2012). The aim of the water stabilisation programme was to expand the distribution of herbivores / use of forage resources and to stabilise populations during droughts (Cain *et al*., 2012). According to Smit *et al*. (2007a), the programme gained particular momentum in the 1960's, after the construction of the western boundary fence which blocked the migration routes of certain herbivores, particularly blue wildebeest and zebra. Management needed to provide water and "year round habitat" in order to mitigate for the loss of dry season range for these water dependent species (Smit and Grant, 2009). Despite the initial success through the creation of borehole-associated waterholes, rare antelope species unexpectedly declined after 1986 and it was argued that the dense waterhole network was responsible for reducing herbivore diversity, by expanding the distribution of common water dependent species like zebra and blue wildebeest (and concomitantly lion), at the expense of rare herbivores (Smit *et al*., 2007a). The KNP consequently reviewed the water provision policy and about 132 of the 283 boreholes were recommended for closure (Smit and Grant, 2009). Consequently, the main source of water for the surrounding wildlife in this study area is the waterholes that have remained operational.

Sandveld communities cover the western half of this study area on Cave Sandstone of the Clarens Formation. According to Gertenbach (1983), this 'Cave Sandstone' forms prominent koppies that accommodate unique vegetation, including many rare species. The soil pattern of this landscape is dominated by lithosols, with soils of the Clovelly or Fernwood Forms present on the plateaus and bottomlands (Gertenbach, 1983). The herbaceous layer of the community is sparse and a tall shrub savanna occurs on the deep sandy soils, which are dominated by *Terminalia sericea* and *Dichrostachys cinerea*. Gertenbach (1983) further describes this landscape as relatively poor, as far as numbers of large mammals is concerned. Elephant and buffalo are common with kudu and impala omnipresent. Steenbok, grysbok and nyala are also regularly found in the region (Gertenbach, 1983). Conversely, the eastern half of the study area consists of flat to concave plains with the geological rock formations upon which this landscape developed being basalt (Gertenbach, 1983). Gertenbach (1983) describes the mopane shrubveld as the largest and most homogenous landscape in the KNP. The woody vegetation of this landscape is dominated by multi-stemmed mopane shrubs of between one and two meters in height, with other woody species being relatively scarce. Gertenbach (1983) further describes this landscape as being of major importance to the rare game species such as tsessebe, sable, roan antelope and eland; however, zebra and buffalo are present in the largest numbers.

2.3 Trophy Hunting Reserve

Makuya Nature Reserve borders the Kruger National Park on the north-western boundary below Pafuri Gate (**Figure 2.2**). This reserve is managed through a strategic partnership between Limpopo Provincial Government (Department of Local Economic Development, Environment and Tourism (LEDET)), Limpopo Tourism and Parks (LTP) and the traditional authorities of Makuya, Mutele and Mphaphuli. Such a partnership means that the community receives loyalties from the government for the lease of the land while LEDET and LTP co-manage the park with the land owners (Funke *et al*., 2011).

The park comprises 16,000 ha and is situated on high ground in the north-western side of the Kruger National Park (KNP), with which it shares a fenceless border and is separated by the Luvuvhu River

(Cadman, 2009). Located alongside the northern-most section of the KNP, the geology is similar to that of the north-western section, with resistant quartzitic rock of the Soutpansberg Group, resulting in a mountainous landscape with shallow, sandy soils. The herbaceous layer of the community is sparse and a tall shrub savanna dominates, comprising mostly arid mountain bushveld. This landscape is dominated by mopane savannah, lebombo ironwood groves and baobabs, and does not support a high density of game (Mostert, 2009). Soutpansberg Arid Mountain Bushveld plant communities are driven by abiotic environmental factors such as frequent droughts, exposure to desiccation and unpredictable rainfall events (Mostert *et al*., 2009). The topography in this reserve varies substantially from flatter areas along the river to high lying steep slopes in the northern section of the study area. The terrain is generally very rocky, especially along the steep slopes. Mammals from the KNP easily cross into Makuya Nature Reserve, which was opened to big game trophy hunting in October 2008, advertising hunting for lion, leopard, elephant and buffalo as well as a variety of plains game (www.huntingreport.com). According to Animal Rights Africa (2010), Makuya, for the 2008/2009 period, had a hunting 'off-take' detailed in **Table 2.2**.

Table 2.2: Summary of proposed hunting 'off-take' by Makuya Nature Reserve for the 2008 / 2009 period (Animal Rights Africa 2010)

Species	Quota allocated
Elephant	5
Buffalo	10
Impala	20
Kudu	5

2.4 Communal Land

The Limpopo National Park (LNP) is located in Mozambique with the western perimeter of the park adjoining the border with the KNP (South Africa), and the eastern boundary is represented by the Limpopo River. This park was formerly a hunting concession but now forms part of the Great Limpopo Transfrontier Park with the aim of becoming a world-class eco-tourism destination. The park was officially opened to the public in 2005 and the aim is for the park to be divided into a tourist zone, a wilderness zone and a resource utilization zone where the communities live off the resources of the park. Currently, however, although some communities have been resettled outside the park, many have formed enclave communities and are distributed throughout the park with their cattle and goats roaming freely. Human/wildlife conflict remains a threat to the development of ecotourism in this park, where animals are hunted by the villagers or killed as a result of crops being trampled. In order to control and avoid human/wildlife conflicts, the plan is to develop corridors along the Limpopo River to allow animals to drink while communal areas will be fenced off (Knehtl, 2009). Since the establishment of the Great Limpopo Transfrontier Park, the development of infrastructure, tourism facilities and park management facilities has increased and about 50 km of fence between the LNP and KNP has been removed. Further removal of the fence will only take place once the resettlement of communities has been completed, in order to protect these communities located close to the border of KNP and thus avoid human/wildlife conflict (Peace Parks Foundation, 2011). In addition, almost 5,000 animals were translocated from the KNP to the southern section of the LNP (Parque Nacional do Limpopo, 2010; and Peace Parks Foundation, 2013). An aerial census that was undertaken in 2010 showed a healthy growth in Sable antelope and over a thousand elephant and buffalo in the Park (Peace Parks Foundation, 2013). Research projects conducted have also identified viable populations of lion, cheetah, hyena and smaller carnivores in the Park (van der Lende and Viljoen, 2013). Poaching in this park, however, has remained a concern and although 1000 elephants and 300 rhinos were initially relocated, only 15 rhino remained at the beginning of 2013 (Becker, 2013). It is believed that the rhino are now extinct from the LNP as a result of poaching, and that poachers have now turned their attention to the remaining elephant population (Becker, 2013). Tourism in this part of the GLTP is still in the early phases of development and is mostly only accessible to 4X4 vehicles. Nonetheless, a variety of wilderness experiences are offered, including game walks, a hiking trail, a backpacking and fishing experience, and a canoeing and 4X4 trail (van der Lende and Viljoen, 2013). Many tourists use the Goriyondo and Massingiri Border Gates to travel from South Africa to Mozambique. With an average of 380 vehicles entering the Goriyondo Gate monthly (SANParks, 2012), the main road between these two gates is travelled on more frequently than other roads connecting the villages, which are estimated to have less than 30 passing vehicles monthly.

The LNP receives about 500 mm of rainfall annually, and forms part of the eastern clayey basaltic and rhyolitic section of the KNP, covered by sands of Quaternary origin (International Conservation Services, 2008). Soils range from shallow to deep and are mostly infertile (International Conservation Services, 2008). Mopane shrubland dominates the western section of the study area, while mopane tree savanna dominates the mid to eastern section, with sandveld communities in large areas (www.peaceparks.org). Soils are derived from volcanic rock zones in the west, and from a sedimentary basin to the east (www.peaceparks.org). The main river flowing through the southern section of the park is the Shingwedzi, which has a network of tributaries that feed into it.

CHAPTER 3: LITERATURE REVIEW

3.1 Land Use Planning and Biodiversity Conservation

The world's ecosystems provide many benefits to human society in the way of great ecological, socio-cultural and economic value. These benefits consist of a mix of goods and services that are poorly understood, scarcely monitored and are often undergoing rapid degradation and depletion. Multi-functional landscapes are being converted into more simple, often single function land use types such as urban and agricultural. One major problem is that it is difficult to express the monetary value of these goods and services and therefore natural and semi-natural landscapes continue to be under-valued (Daily *et al*., 2000; De Groot, 2006). When analysing the various planning and management alternatives for such multi-functional landscapes, many alternatives need to be considered. De Groot (2006) provides a framework on how to go about environmental planning, management and decision making (**Figure 3.1**). Three important steps involved in decision making include the identification of possible alternatives, identification and measurement of the impacts of each alternative, and finally a valuation of consequences, taking the impact on human well-being into account (Daily *et al*., 2000). Land use planning guides the organisation of landscapes in a way that meets the demands of a society. Only recently have land use planners started to integrate biodiversity conservation as an explicit goal (Lagabrielle *et al*., 2010). Integrating biodiversity conservation in human modified landscapes requires the recognition that societal trade-offs between competing land uses are unavoidable. Distinct landscapes need to be designed to achieve multiple objectives, including biodiversity conservation, the maintenance of ecosystem services and improved human well-being (Gardner *et al*., 2009).

Protected areas (national parks and wildlife reserves) have long been recognised as playing an important role in conserving biological diversity (Wells and Brandon, 1993). Although in the past, protected area management largely excluded people and human activities, over the past few decades there has been a considerable shift towards a much more inclusive approach. This is illustrated by the addition of two IUCN protected area categories that encompass transformed and multi-use wilderness areas (Alexander, 2008). Conservation managers have recognised the importance of involving and considering the interests of stakeholders, particularly local communities. Furthermore, it has been recognised that local stakeholders can make significant contributions in the way of local knowledge and traditional skills (Alexander, 2008). However, there are still concerns around community marginalisation and inter-state inequity in the distribution of benefits.

The majority of people in rural southern Africa are dependent on natural resources and the environment for their livelihoods. Natural resources are being placed under increasing pressure, leading to over-exploitation and degradation. This situation is further complicated by a history of civil war and destabilisation, whereby families have been displaced and, at times, forced into refugee camps in neighbouring countries (Katerere *et al*., 2001). Thus, there is a critical need for development in these rural areas that not only has income earning potential, but also offers alternatives that do not threaten the continued protection of wildlife. In order to meet these objectives, careful planning of land usage is required around important wildlife areas, particularly in transfrontier parks that connect communal and multi-use areas with strict wildlife areas. Such is the case in the Great Limpopo Transfrontier Park, the focus of this study.

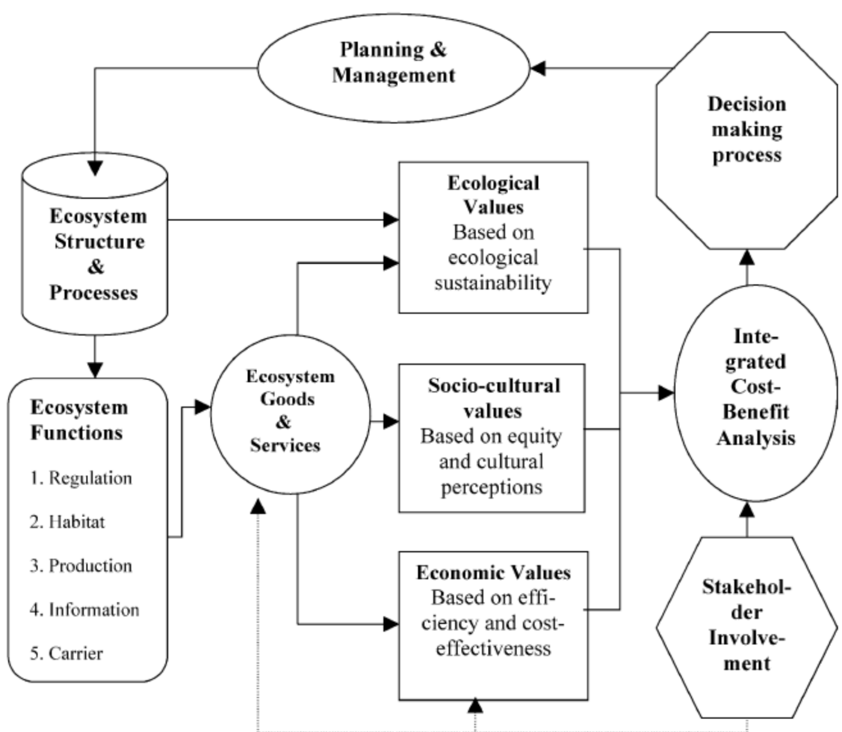

Figure 3.1: Framework for integrated analysis of landscape functions and values (after De Groot, 2006)

3.2 Transboundary Conservation

The transboundary nature of environmental issues has played a major role in promoting global environmental governance. Landscape level conservation refers to the belief that conserving biodiversity and managing wilderness is best achieved over greater ecological scales whereby biological corridors can be opened up in order to re-establish connectivity and ecosystem functions. Duffy (2006) emphasises the importance of cooperation between neighbouring states as a vital component of environmental protection and conservation. This has received much enthusiasm and financial backing from multiple interest groups such as Non-Governmental Organisations (NGO's) and International Financial Institutions (IFI's) (Wolmer, 2003; Duffy, 2006). According to Munthali (2007), TFCA's are eco-regions that straddle the borders between two or more countries. They are characterised by one or more protected areas as well as multiple-resource areas for the use of communities and private landowners, and managed for the sustainable use of natural resources.

Three key points used to promote transfrontier conservation are the re-establishment of natural systems, tourism, and local economic development (Ramutsindela, 2004). Southern Africa, together with the rest of the African continent, continually faces the challenge of alleviating severe poverty, especially in rural areas. Transfrontier Conservation Areas (TFCA's) have been developed in southern Africa with the anticipation of achieving multiple objectives, mostly relating to biodiversity conservation, local economic development and the promotion of peace and cooperation across international borders (Munthali, 2007; Suich, 2008). Due to the fact that TFCA's may encompass one or more protected areas, Hanks (2003) describes them as also encompassing varying mosaics of land use. TFCA's may incorporate national parks, game reserves, private land, communal land, forest reserves and wildlife management areas, and may even comprise consumptive use of wildlife (Hanks, 2003). One of the main drivers of TFCA's is conservation. Large protected areas are essential for biodiversity conservation as they support important ecological processes, meet the habitat requirements of keystone and indicator species, maintain diverse and large gene pools, and encompass migratory ranges necessary for large mammals and birds. This is also supported by the metapopulation theory whereby systems are buffered against extinction by gene flow between local populations, rescue effects or recolonisation after local extinction (Katerere *et al*., 2001; Wolmer, 2003; Baguette, 2004).

3.3 Rural Communities in Conservation Regions

In southern Africa, emphasis has been placed on communities as playing a key role in making TFCA's successful. This has resulted in a shift toward Community Based Natural Resource Management (CBNRM), whereby communities participate in TFCA management and receive some of the benefits, such as tourism revenues and resources from the TFCA (Duffy, 2006). As part of CBNRM, rural communities are often persuaded to relocate and reconvert agricultural land to wildlife habitat and rather buy food and products from the income derived from ecotourism (Katerere *et al*., 2001; Wolmer, 2003). Many local residents perceive protected areas as restricting their ability to earn a living and consequently continue their land-use practices that are often unsustainable, illegal and destructive (Wells and Brandon, 1993). The everyday subsistence use of resources involves hunting and collecting plants for food and medicinal purposes (Duffy, 2006). Furthermore, there is the growing problem of human-wildlife conflict as community members kill wildlife to reduce the risk of damage to crops, livestock and human lives (Woodroffe *et al*., 2005). This may jeopardise the conservation of species which may, in turn, negatively affect tourism opportunities and, in so doing, revenues earned.

A study was carried out in the western Dja Reserve in Cameroon where the spatial distribution of hunting by villagers was established to evaluate the effects hunting has on mammal populations (Muchaal and Ngandjui, 1999). Subsistence hunting and poaching mostly involved the use of cable snares and firearms. Surveys on mammalian game species across strata of human disturbed and less disturbed areas were conducted. It was found that mammal abundance increased with distance from the village. This study also indicated that certain animals adopted behavioural strategies, such as developing nocturnal habits or avoiding areas of human disturbance, to reduce their detection by humans (Muchaal and Ngandjui, 1999).

In order for CBNRM to successfully make wildlife conservation part of rural development, initiatives must be financially attractive for the community, economically efficient for the country and financially viable for donors and the government. One of the main aims of CBNRM is for communities to become self-sufficient, allowing for donor inputs to be gradually replaced by income from natural resource use. According to Barnes *et al*. (2002), the potential for income generation from natural resources is dominated by non-consumptive tourism, followed by safari hunting tourism and other less significant activities such as thatch-grass harvesting, fishing, pole and fuel-wood harvesting etc. The argument behind CBNRM is that if communities benefit directly from the use of natural resources, they will then have an incentive to invest in and conserve those resources. The positive returns communities should receive include utilization of wildlife through joint-venture agreements, grants from donors (investing in CBNRM programmes), capacity building and empowerment, cultural and aesthetic values, and more secure livelihoods (Barnes *et al*., 2002). Ecotourism and, to a lesser extent, trophy hunting, have played an important role in successful CBNRM. There are three main goals of ecotourism which include the following (Robinson and Jamal, 2009):

1. Minimize the negative environmental, economic and social impacts associated with tourism.

2. Deliver a net positive contribution to environmental conservation.

3. Improve the livelihoods of local people.

The first of these goals is often perceived as being in conflict with trophy hunting. Although trophy hunting is known for its consumptive use of wildlife, it has the potential to be an important income generator for local people through joint-venture arrangements (Robinson and Jamal, 2009). Barnes *et al*. (2002) believe that successful conservancies/protected areas are those with several different economic and conservation purposes, dominated by non-consumptive tourism.

3.4 Trophy Hunting

In the past, trophy hunting in Africa was uncontrolled and had negative implications on wildlife populations with animals even becoming extinct in some areas (Lindsey *et al*., 2007). Trophy hunting can be described as hunting by paying tourists, typically with the objective of selecting individuals with exceptional physical attributes. This usually takes place in the company of a professional hunting guide. Although this conservation land use is a highly controversial topic, it has been acknowledged by many that trophy hunting, when properly managed, has the potential to promote conservation with the revenues earned. According to Lindsey *et al*. (2007), this has been the case in several African countries where there was a gradual alignment of trophy hunting industries with conservation and development policies. Low off-takes and high prices mean that trophy hunting can play a key role in creating incentives for the conservation of threatened species. Furthermore, such conservation land use areas may generate revenue for conservation in areas which may not be suitable for photographic tourism. This may include some countries experiencing political instability or some areas that are too altered by other land uses (Lindsey *et al*, 2007). In Zambia, trophy hunting is currently generating significant economic benefits for residents of game management areas. This is because the revenues from the trophy hunting are directed to local wildlife management and community development projects. Furthermore, in Zambia, an administrative programme monitors the allocation and operation of hunting concessions (Lewis and Alpert, 2010).

Conversely, the consumptive use of wildlife has been debated on both ethical and pragmatic levels. Verdade (1996) highlights the necessity of valuing wildlife for commercial, recreational, scientific, aesthetic and/or spiritual reasons as an essential part of conserving wildlife. Hunting pressure may affect the distribution, density and social behaviour of a particular species. Wildlife often exhibit short term behavioural responses in reaction to short duration hunting events. Numerous studies have shown that such behavioural responses may involve the following (Verdade, 1996; Burke *et al*., 2008):

- Decrease in maternal behaviour
- Increase in territoriality
- Breakdown or increase in reproductive behaviour
- Decrease in reproductive success
- Distributional shifts
- Changes in diet
- Greater use of vegetative cover
- Shifts in core area use within the home range

Hunted species react differently to hunting pressure and it is therefore critical to understand the background of the hunting pressure in a particular area, as well as the social behaviour of a particular species (Verdade, 1996). According to Burke *et al*. (2008), another factor to consider concerning species with a complex social system, such as elephant, is the psychosocial stressors that result from hunting activity. A study in Pilanesberg (South Africa) focussed on ethical concerns of hunting male elephant and found that both short and long term physiological stress responses were evident throughout the elephant population after only one hunt (Burke *et al*., 2008). This indicated communication amongst individuals and potentially represented the reaction of elephants to each other's suffering, highlighting the need to understand the social complexity of a species when considering the implications of such activities (Burke *et al*., 2008).

Owing to the immense diversity and abundance of habitats and animals, and a highly developed hunting industry, South Africa is one of the most popular destinations for trophy hunting (Lindsey *et al*., 2007). There is much controversy around trophy hunting, some sections of society believe that it is ethically objectionable, while others see it as a sustainable exercise that benefits South Africa's economy and has the potential to boost conservation efforts. Publicized problems associated with trophy hunting include ethical, biological and social problems. It has been recognised that there is an urgent need for more scientific information regarding the scale and nature of the industry, as well as more efficient monitoring of the practices (Damm, 2005; Lindsey *et al*., 2007).

Various studies have been carried out on the impacts of hunting on the population biology and behaviour of mammals. In a study carried out in New York, examining the flight responses of white-tailed deer, the flight distances were compared between two areas of similar size and habitat (one including hunting and one excluding hunting) (Bahrend and Lubeck, 1968). This study firstly demonstrated a greater number of observations of deer in the un-hunted area, and secondly, that the mean flight distance of the deer in the hunting area was significantly longer than in the un-hunted area, thus showing that the deer were more sensitive to disturbances in the hunting area. This suggested that hunting could negatively affect the viewing potential of fauna for recreational purposes (Bahrend and Lubeck, 1968). Another study used impala, and compared their density, demography and behaviour between a protected area (Serengeti National Park) and partially protected areas (surrounding game reserves and an open area; Setsaas *et al*., 2007). Significantly lower densities of impala were found in the surrounding areas compared to the national park, and they showed higher alertness levels and longer flight distances to an approaching human (Setsaas *et al*., 2007). Other previous studies have similarly shown that the intensity of hunting by humans influence the flight behaviour of various ungulates (Matson *et al*., 2005; Burke *et al*., 2008; Stankowich, 2008).

3.5 Ecotourism

Ecotourism has been promoted for its potential to allow sustainable development of ecosystems and provide incentives to preserve these areas. According to Isaacs (2000), the demand for travel and tourism is on the increase and is reportedly the fastest growing industry. This has been paired with an increased demand for environmental quality, which has led to the growth of ecotourism (Isaacs, 2000).

Ecotourism prioritizes minimal human impact on ecosystems and cultures, and aims to raise the public's awareness of the environment and sensitize travellers to nature (Isaacs, 2000). Tourism is often assumed to be environmentally friendly, since tourists generally empathize with conservation and animal welfare issues. However, tourism is increasingly being seen and studied to show that outdoor recreation has the potential to disturb wildlife and have a range of negative effects (short and long term). Some short term effects may relate to the behaviour and physiology of individual mammals. Animals may become more nocturnal or more arboreal, or even avoid areas and roads where humans are likely to travel. Long term effects may include increased mortality, reduced breeding success and impacts at the ecosystem level (Griffiths and van Schaik, 1993; Taylor and Knight, 2003b; Green and Giese, 2004). Manor and Saltz (2003) add that even though tourism is often regarded as a nuisance disturbance, it may alter an animal's space use patterns and foraging efficiency, and consequently its fitness. A study on the vigilant behaviour of sable antelope, based in Hwange National Park (Zimbabwe), showed that tourism significantly increased the time the sable spent vigilant, thereby decreasing the time they spent foraging and drinking (Kamanda *et al*., 2008). In areas where human presence is common but harassment is scarce, habituation may occur, whereby animals are not as negatively affected (Manor and Saltz, 2003). However, Isaacs (2000) states that the long term effects of increased human presence may be similar to that of hunting, thus influencing the community structure. This is as a consequence of animals varying in their sensitivity to human presence, causing some species to change their behaviour while others remain unaffected or become habituated. Community structure may thus change as a result of habituated species increasing in number and predation intensity decreasing (Isaacs, 2000). It is therefore critical to effectively manage wildlife tourism in order for it to be sustainable and have minimal impacts on animals and their supporting ecosystems (Green and Giese, 2004). Isaacs (2000) advises that tourism traffic should be designated to certain areas, such as trails, whilst other areas should be left as wildlife refuges. Furthermore, to ensure sustainability of the wildlife resource, some species and situations may even need to be precluded from tourism altogether (Higginbottom, 2004).

In Africa, there has been a growing interest in the potential for ecotourism to offset costs associated with conservation. Ecotourism is a rapidly growing industry, and a study carried out by Lindsey *et al*. (2005) on the African Wild Dog in the Kruger National Park, demonstrated that there is potential for ecotourism benefits to offset the costs of conserving endangered species such as the wild dog. The key challenge is for biodiversity to pay for itself by generating economic benefits without harming the wildlife that the industry depends on (Lindsey *et al*., 2005).

3.6 Implications of Land Use Practices on Wildlife

As shown in the previous sections on the various land use practices (communal land, trophy hunting, wildlife tourism), human activities have a variety of direct and indirect impacts on wildlife (Tarlow and Blumstein, 2007). Some human activities have a greater negative impact than others; these impacts range from short-term (response behaviour, foraging and maternal behaviour) to long term behavioural patterns (distribution, mother-offspring behaviour patterns, activity patterns and habituation). The species biology of a population may be impacted in the way of physiology, reproduction and physical health, and ultimately, resulting in population declines. It is, however, unknown how relevant the disturbance effects are from one species or population to another (Anderson, 1995; Isaacs, 2000; Stankowich, 2008).

There are various methods of measuring the implications of human activities on wildlife. Breeding success is an important measure of human impacts as this ultimately determines the survivorship of a species. Other methods may involve the study of life tables and population viability analyses (Tarlow and Blumstein, 2007). However, even if no direct effects of human activities is evident when studying population densities, more subtle effects of human disturbances may be evident in the behaviour of a population, and ultimately the group structure/composition or the social organisation (Averbeck *et al*., 2009). The study of behavioural responses of wildlife measures the energetic consequences of human activity. For example, human activities may lead to reduced foraging due to increased vigilance; individuals may also form larger groups for the purpose of increased vigilance. These behavioural changes may in turn affect the reproductive success of a population (Taylor and Knight, 2003b; Averbeck *et al*., 2009). Animals may be exposed to a range of stimuli; the characteristics of which will influence the responses of wildlife. Animals may respond to a stimulus such as human presence by fleeing, hiding or defending, thus affecting their space use patterns. They may even permanently avoid otherwise suitable habitat. This is because animals have to make a trade-off between maximising energy intake and access to mates, and minimizing their exposure to risk. In cases where there is constant non-threatening exposure, an animal may become habituated whereby they no longer react to a stimulus (Green and Giese, 2004; Manor and Saltz, 2005).

The way in which wildlife populations react to human activities is not only dependent on their social background and the physical environment, but also on past and present human experiences (Verdade, 1996). A study, based on the differential effects of hunting on mixed herds and bachelor herds of impala, compared a protected area in Uganda to its surrounds where hunting took place on a regular basis (Averbeck *et al.*, 2009). This study found a greater number of calves in the protected area compared to the hunting area. This may have been due to hunting pressure increasing the energy expenditure of females associated with flight and alertness, thus affecting the female's physical condition and negatively affecting birth rates and neonatal survival. The group sizes of mixed herds decreased in the hunting area while the size of bachelor herds increased, potentially as a result of increasing the level of vigilance in the hunting area. This study further showed that hunting pressure resulted in different behavioural responses in the mixed herds compared to the bachelor herds (Averbeck *et al.*, 2009). The following factors need to be considered when studying the severity of negative effects of various activities on wildlife (Taylor and Knight, 2003a; Green and Giese, 2004; Manor and Saltz, 2005):

- species
- age
- sex
- physical condition
- stage of breeding
- habitat
- surrounding animals
- previous encounters with human activity

It is important to measure the behavioural responses of wildlife to human activities so that the tolerance of wildlife to different land use types can be factored into land use decision making. Taylor and Knight (2003b) believe that such data can be used to inform wildlife managers on the necessary buffers from harmful activities. It is important to note that the study of behavioural responses may not be the most accurate way of measuring the exact effects of land uses on wildlife. However, for this study, it is a useful tool for measuring the approachability of animals considering that the areas to be studied have the potential to become ecotourism destinations. Furthermore, it is a rapid way of determining how behaviour changes in relation to seasonal trophy hunting and subsistence hunting.

3.7 Managing Multi use Conservation Areas

Understanding levels and patterns of biodiversity in human modified landscapes is vital for current and future biodiversity conservation (Chazdon *et al*., 2009). Chazdon *et al*. (2009) also stress the importance of understanding how biodiversity patterns are affected by different human practices along a gradient of landscape modification, from small holder agriculture to industrial commodity production. The fate of biodiversity in protected areas is intimately linked to that of surrounding landscapes, as protected areas are commonly embedded within a matrix of heterogeneous landscapes (Chazdon *et al*., 2009). Managing such landscapes thus needs to occur at the scale of entire landscapes, rather than focussing on separate entities (Gardner *et al*., 2009). Although many surrounding land uses are harmful to biodiversity conservation, certain human practices may actually support biodiversity (Chazdon *et al*., 2009). Chazdon *et al*. (2009) also believe that incorporating such "biodiversity friendly land uses into actively managed buffer zones or biological corridors can contribute to the long term conservation value of protected areas". Although trade-offs are unavoidable, an integrated approach to conservation within human modified landscapes is needed, through the implementation of adaptive management, which can serve as a tool to integrate conservation with sustainability of rural livelihoods (Chazdon *et al*., 2009). According to Rogers (2003), the KNP has implemented adaptive ecosystem management, described as management by experiment, whereby ecologists seek manipulative, ecosystem-level experiments as solutions to management problems. This means learning by doing, as knowledge is gained through experimentation when dealing with complex adaptive systems and heterogeneity (Rogers, 2003).

CHAPTER 4: METHODOLOGY

4.1 Study Species

The sightings of all larger mammals (including hoofed mammals, carnivores and primates) were recorded in order to measure the diversity of mammals in each conservation land use area and to establish the frequency of sightings from a tourism perspective. The study on behavioural responses, however, concentrated on five mammal species that are known to commonly occur throughout the GLTP and its surrounds.

4.1.1 *Loxodonta africana* (African elephant)

The elephant is the largest land mammal and can subsist in any environment that provides adequate quantities of food and water. Elephants are found throughout Africa south of the Sahara, but human induced factors are the primary limiting factor to their numbers and distribution. This species has always been highly sought after for its large tusks and a rise in the price of ivory in the late 1980's resulted in an inundation of poachers and hunters, causing populations to plummet throughout the continent and by 80% in eastern Africa (Laursen and Bekoff, 1978; Estes, 1991). Although this situation of uncontrolled hunting and poaching improved during the 1990's, poaching levels have been on the rise over the last few years once again (Estes, 1991; IUCN, 2013). Elephant remain victims of land use pressure, habitat loss, human elephant conflict and illegal killing for both meat and ivory (IUCN, 2013). As a member of the 'big 5' species, and due to their size, danger and drama, the elephant has been described as a charismatic species of high touristic value (Burke *et al.*, 2008). This is a social animal with matriarchal clans made up of 2 - 24 sisters and daughters. Males are separate in herds or alone and rank is ordered by seniority and reproductive condition. Populations are nomadic/migratory within large home ranges and they do not have a mating season, although most mating and birthing takes place in the rainy season (Estes, 1991). The use of habitats by elephants are not random, especially in the dry season. In a study conducted on the resource utilization of elephant in the Kruger National Park, Smit *et al.* (2007b) found there to be sex and age related differences in feeding patterns and habitat use. The results of this study showed that, in the dry season, mixed herds occurred more frequently in areas with abundant tree cover and in close proximity to rivers. This is because mixed herds have a greater requirement for shade, cover and higher quality browsing, especially when young elephants are present. In comparison, bulls with a wider tolerance for low quality food, had much larger home ranges and could occur on open grassy plains in the dry season. Distribution of bulls were primarily determined by water resources, not by forage (Smit *et al*., 2007b). The family structure forms a fissure-fusion society whereby small family groups frequently gather into larger groups on a temporary basis. Such a structure has implications for learning in the social context. Information about new foods in the area, where and when to forage and how to avoid dangers is acquired by the young by social learning. Elephant brains are large and complex and their neuroanatomy suggests that they have highly developed memory, communication and coordination (Lee and Moss, 1999; Kiley-Worthington, 2011). Bradshaw and Schore (2006) state that elephants show highly complex behaviours, as an outcome of optimal attachment bonding and right brain development. According to Kiley-Worthington (2011), social learning primarily relates to emotional cues, if the older animal is frightened by a particular situation, the younger elephant is likely to take her cue and be frightened in that situation as well. This behaviour will then follow onto the next generation, even once the disturbance that initially caused the behaviour has ceased (Kiley-Worthington, 2011). The implications of past human activities may thus still be evident in the behavioural responses of elephant generations later. Furthermore, Bradshaw and Schore (2006) explain that mammalian brain development is experience dependent on and highly sensitive to environmental change. Transactions between elephant mothers and their offspring, together with the autonomic nervous system, govern the behaviour of the offspring throughout their life. Stressors that diminish parent-infant transactions, or cause parental energy to divert from infant care, include ecotourism, noise and perceived threats by hunters. Some examples of stress related behaviour include neglectful, stressed or abusive maternal behaviour, hyper aggression and exaggerated fearfulness (Bradshaw and Schore, 2006). Most elephant react to human disturbance by fleeing, silently or in noisy disarray. Disturbed elephants may perform displacement behaviour in between threat displays by holding their head up high with their ears extended outwards. While elephant bulls rarely follow through with their charges, unless injured and suffering, breeding herds with young are generally very aggressive towards any predators (including people) (Estes, 1991). From puberty, or about the age of twelve years, bull elephants go through periods of musth, whereby they enter a state of elevated testosterone levels and become relatively aggressive as they go in search of an oestrus cow to mate with. During musth, bulls impulsively travel long distances and challenge any other bull that they may encounter, this may also include large vehicles that they come accross(Emmett, 2012).

4.1.2 *Syncerus caffer* (African buffalo)

Buffalo are highly gregarious and non-territorial mammals with fission fusion patterns commonly observed in the group dynamics. Considered one of the most successful mammals in Africa in terms of their range, abundance and biomass, buffalo are distributed in discrete population units which remain in separate traditional home ranges. Foraging and grouping dynamics is complex and strongly influenced from bottom up, whereby group sizes are adjusted to accommodate variation in forage distribution (Ryan *et al*., 2006; Winnie *et al*., 2008). Ryan *et al*. (2006) further describe the seasonal social ecology of buffalo as they aggregate into large mixed herds during the breeding season, late in summer, and then sub-divide into smaller mixed herds and bachelor groups for the remainder of the year. Buffalo have always been popular choices as trophies for subsistence and trophy hunters due to their bulky size and formidable nature (Winnie *et al*., 2008). They are considered the most dangerous of the big five to hunt and have excellent senses, especially their sense of smell (Emmett, 2012). In addition to their dangerously moody temperament, buffalo are inquisitive and will approach sources of interest (Emmett, 2012). Buffalo were selected for this study, given their recent history of being hunted in the Makuleke area and in the Limpopo National Park, as also their on-going situation of being hunted in Makuya Nature Reserve. When buffalo are disturbed and feel threatened, they assume an alert posture with their head raised high, their back arched and their tale base is lifted into an arc. If the disturbance, such as human presence, is visible, buffalo lift their chin and stare fixedly at the disturbance and may even approach. Usually buffalo flee from perceived danger and take refuge in dense cover. Certain situations, however, may trigger a mobbing response whereby the herd confronts the disturbance with large males in front and calves at the back where they are protected (Estes, 1991). It is this formidable nature that allows one to recognise and distinguish their response behaviour patterns.

4.1.3 *Aepyceros melampus* (Impala)

The impala is a highly gregarious antelope, with herds reaching up to 200 individuals (Averbeck *et al*., 2009). Impala are very common in the Lowveld region of South Africa and it is the most abundant ungulate species in the GLTP. Mature males are territorial, especially during rutting season when males fight for dominance in order to gain the right to mate with females in his territory. Males without territories form bachelor herds (Averbeck *et al*., 2009). Impala are mixed feeders, eating a variety of grasses, forbes, shrubs and trees, with a preference for grazing. Increased browsing takes place in the dry season when the quality and quantity of grazing resources is limited

(Wronski, 2002). This southern savannah antelope may achieve very high densities in areas that provide both grazing and a varied diet of browse (Estes, 1991). Leading a sedentary existence, impala remain close to water and cover, preferring woodland areas, especially *Acacia* and mopane woodland. The gestation period is about 6.5 months and females give birth early in the rainy season (Emmett, 2012). This species shows distinct behavioural responses when frightened or startled and they are extremely alert and are quick to take flight (Averbeck *et al*., 2009). When startled, impala assume an alert posture and may stare at an object they can't identify while moving their head up and down and sideways to get a better look. Alarm snorting signals danger, and when they take flight, the herd leaps about in different directions in order to confuse their pursuer (Estes, 1991; Averbeck *et al*., 2009).

4.1.4 ***Papio cynocephalus ursinus*** **(Chacma baboon)**

Baboon have been described as a large terrestrial primate that is widely distributed throughout savanna and arid biomes where water and cliffs are present. These omnivores live in non-territorial, multi-male troops, typically numbering between 30-40 individuals and home ranges vary significantly in size and overlap with neighbouring troops (Estes, 1991). Baboons are highly water dependent and remain close to water sources as they need to drink daily (Emmett, 2012). The social organisation is highly complex and groups are virtually permanent with only males moving from one group to another at sexual maturity, where they compete to attain a high dominance rank. Some males do, however, remain in their natal groups for their entire lives and occasionally achieve alpha position (Beehner *et al*., 2006). The alpha male generally monopolizes mating access to females, unless there is more than one female in the periovulatory period, in which case the second highest ranking male may monopolize that female, thus a dominance hierarchy acts as a queue for mating opportunities (Beehner *et al*., 2006). Females form linear dominance hierarchies that usually remain stable with strongly differentiated grooming networks and alliances and daughters acquiring ranks similar to that of their mother (Altmann, 1974; Barton *et al*., 1996; Engh *et al*., 2006). Male offspring are subordinate to their mothers until adolescence when they become bigger than and dominant over all females (Estes, 1991). Baboons do not have a particular mating season, with mating opportunities occurring throughout the year. However, Beehner *et al*. (2006) claim that there is a birth peak between July and October. Predation is a major source of stress for baboon and the way in which they respond to predators is dependent on its identity and on the circumstances. When alerted to danger, baboon sound off alarm barks and adult males move in the direction of the disturbance. A sudden disturbance may provoke a barrage of loud barking and stampede for cover to confuse any potential predators. When a troop takes flight, the males form a rear guard and will go on the offensive if necessary (Estes, 1991; and Engh *et al*., 2006). Although not a common choice for trophy hunters, the intelligence of these primates may still make them vulnerable to the negative effects of hunting (Naughton-Treves *et al*., 1998). In addition, primates dominate the lists of pests that damage crops around African Parks, resulting in serious conflicts with farmers. Primates, such as baboons, are notorious for their cooperative behaviour, opportunistic lifestyle, and non-specialized and omnivorous dietary tendencies, making them highly adaptable for living alongside humans in rural or urban settings (Hill, 2000). Furthermore, baboons are highly adaptive, and have the ability to learn rapidly and change their behaviour accordingly, making them very successful and potentially troublesome. These perceived pests are thus often hunted along with all other crop-raiding animals (Naughton-Treves *et al*., 1998; Hill, 2000).

4.1.5 *Equus burchellii* (Burchell's zebra)

The Burchell's zebra is well adapted to the savanna biome and can utilise a broad range of habitats from treeless short grasses to tall grassland and open woodland (Kummerfeldt, 2012). Primarily grazers, zebra cope well with high fibre and coarser grasses, and do not show a high selectivity for grass quality. However, they do prefer short grass, shorter than 35 cm (Treydte *et al*., 2011). This water dependent grazer is nomadic, occasionally browsing on herbs and burnt twigs of mopane and kiaat when there is little else available (McNaughton and Georgiadis, 1986; Emmett, 2012). According to Ncube *et al*. (2011), although the Burchell's zebra is widely distributed throughout East and Southern Africa, they have been extirpated from certain parts of their range as a result of habitat loss. Furthermore, little is known of their population dynamics, and survival and reproductive rates (Ncube *et al*., 2011). Adult females are monandrous and live in fixed membership groups that are nonterritorial, associating with only one stallion that remains the head of the herd. As long as he is fit, a stallion that is head of a harem (up to five to six females) is rarely challenged. When another male takes over a harem, infanticide of the dependent foals may take place as a reproductive strategy, so that the mares invest only in his offspring. Bachelor herds are quite stable with an average of three to six individuals and rank is based on age (Pluhacek *et al*., 2006; Emmett, 2012). Zebra are very sociable ungulates and are often found in large herds with other herbivores (Kummerfeldt, 2012). Although there is no strict breeding season, most birthing takes place during the rainy season. When threatened, a female with young will hide behind the other family members as they cooperate and stay close together to protect any threatened members. The stallion will actively and aggressively defend his group (Emmett, 2012).

4.2 Data Collection

The main objectives of this study were to firstly compare the sighting frequency and species diversity between the various conservation land use areas, and secondly, to compare the response behaviour of the five study mammals between these land use areas. All observations and measurements were made from a vehicle. Six 10 km transects were delineated along accessible road networks within each land use area and distributed at varying distances from human presence/disturbance (**Figures 4.1 to 4.4**). The same six transects were carried out four times throughout the year in order to take seasonality (breeding and hunting seasons) into account. This study was carried out using one driver and two observers (one on either side of the vehicle), who were the same observers throughout the study to ensure consistency. A consistent speed of between 20 and 30 km/h was kept for all transects, which were carried out in the early morning (between 6h00 and 9h30) and late afternoon (between 14h30 and 18h00) when mammals were most active.

Environmental data such as weather and vegetation data were collected electronically through various sources and placed into a geographic information system (GIS) for spatial analysis. SANParks provided GIS data such as weather data (temperature and rainfall), vegetation maps and water source data. Owing to weather data only being available for Punda Maria and Makuleke, the Punda Maria weather station was used to extrapolate data for the trophy hunting reserve, as this is in close proximity to the Punda Maria area. Similarly, weather data for Letaba were used to extrapolate data for the communal land study area due to its close proximity. In the same way, vegetation data for the trophy hunting reserve was extrapolated from the data provided by SANParks. While in the field, the type of vegetation cover was recorded at each mammal sighting, based on observations, with particular reference to the ratio of broad land cover categories such as wooded vegetation to bare areas or grass-like vegetation. These data were then overlaid onto Google Earth, and vegetation cover maps were generated, classifying the vegetation cover into the following:

- Bare (mostly lacking vegetative cover of any kind)
- Low vegetation/grasses (high proportion of low vegetation such as grasses or shrubs with a low proportion of wooded vegetation)
- Mixed wooded and grass vegetation

- Woodland

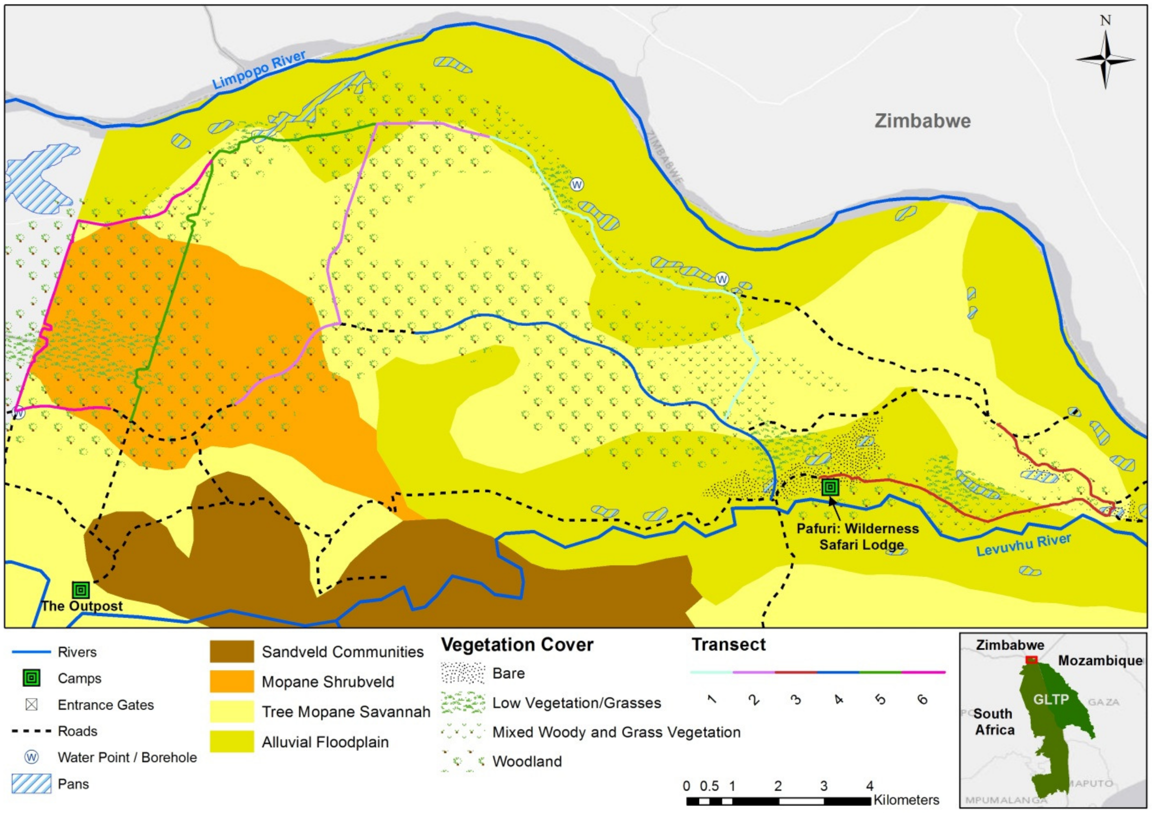

Figure 4.1: The six delineated transects within the private ecotourism concession

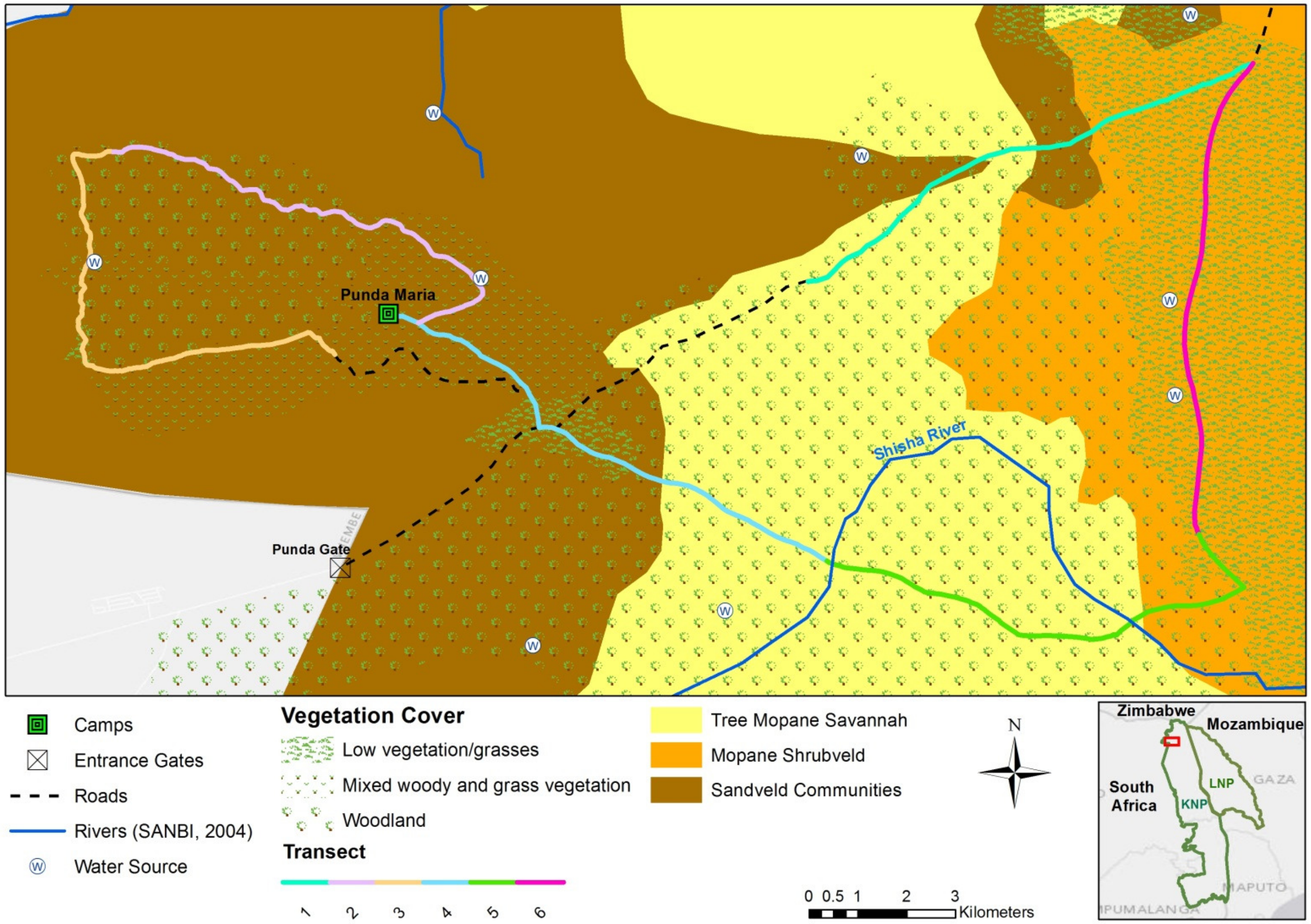

Figure 4.2: The six delineated transects within the national park

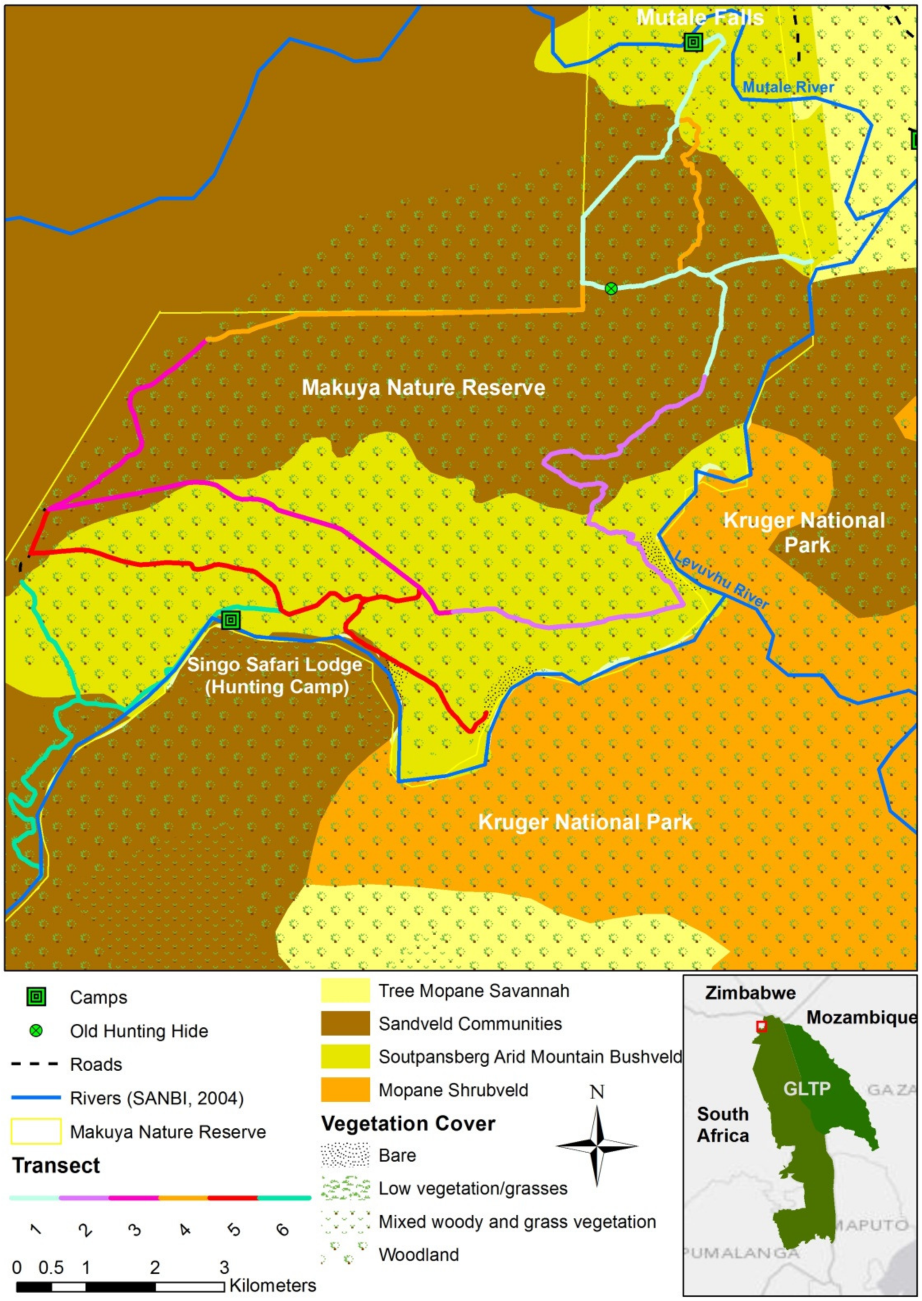

Figure 4.3: The six delineated transects within the trophy hunting reserve

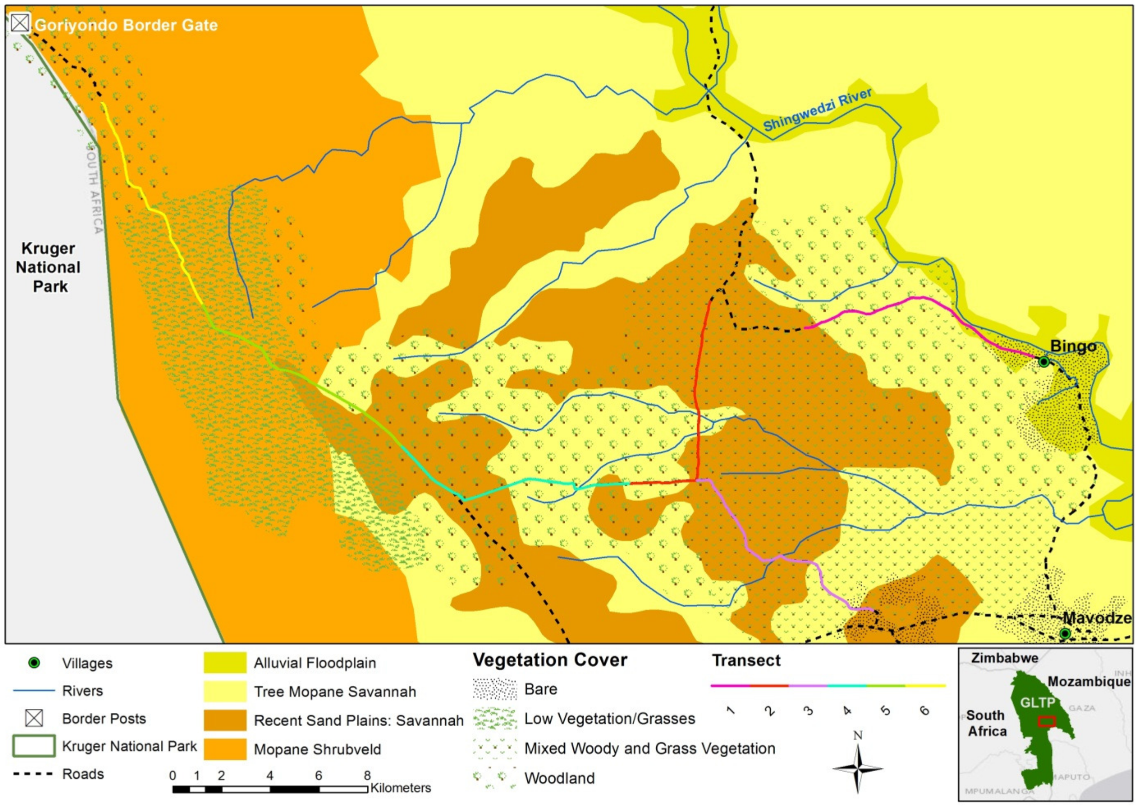

Figure 4.4: The six delineated transects within the communal area

4.3 Species Diversity and Sighting Frequency

In order to compare the frequency of sightings and species diversity between the various land use areas, all mammal sightings, sighted by the two observers along the transects, were recorded. At each sighting the GPS location of the sighting, as well as the species, number of individuals and group dynamics were recorded. While in the field, once a sighting had been recorded, any other sightings of that species were ignored for 200 m to avoid individuals from the same herd being counted as a separate sighting.

4.4 Measuring the Behavioural Responses of Wildlife

Flight distances are defined as the distance to which an animal may be approached before it flees. This may be in respect to being on foot or in a vehicle (Bahrend and Lubeck, 1968). Tarlow and Blumstein (2007) describe the method of evaluating flight distances as one of the easiest methods for quantifying anthropogenic stressors. Moreover, flight distance studies are effective for comparing areas with varying extents of human disturbance (Matson *et al*., 2005). In addition to measuring the flight responses of the five mammal species, the use of an initial response index (IRI) was also included. This technique was adopted from a system being used to monitor elephants in this area (pers. comm). The IRI measures a mammal's initial response to the approaching vehicle with the use of a ranking system. The aim of this technique is to assess and quantify how calm/stressed a mammal or group of mammals is with the approaching vehicle in a consistent way, so as to be able to compare the response behaviour between the various land use areas. The advantage of this technique is that data could be gathered with every sighting of the study mammals and was not reliant on them fleeing. The initial response was ranked between 1 and 4, as detailed in **Table 4.1.** In addition to the IRI being recorded, the initial response distance (IRD) was also measured; this was defined as the distance between the vehicle and the mammal at which the IRI was recorded. The IRD was measured in order to provide an indication of how close the mammals would be from the vehicle when they responded in a certain way. For example, the aim was to determine whether mammals had a calmer response at closer distances to the vehicle in the private ecotourism concession and national park than in the trophy hunting reserve and communal land.

Table 4.1: A description of each ranked response rating

Response Rating	Description
1	Continued activities without changing behaviour
2	A curious response where indivual/s are more alert to vehicle
3	A distressed response where individual/s show alertness and stop their normal activities
4	Immediate flight or fight response

The IRD's and flight distances were measured and recorded from a vehicle using two range finders, one for each observer on either side of the vehicle. For consistency, the same two observers measured the response behaviour throughout the study. The response behaviour measurements were part of the six transects also used for the species diversity and sighting frequency recordings. These same six transects were carried out four times throughout the year for seasonal consideration. Due to the many factors that would influence the behavioural response of the mammals, the following information was recorded at each sighting:

- Social organization (group dynamics)
- Number of individuals
- **T**ime of day (Morning or afternoon)
- Approach of vehicle towards the mammals (Tangential or Direct)

In some cases it was evident that the response behaviour was influenced by factors other than the presence of the approaching vehicle, and these sightings were not included in the analysis. These included predator related behaviour where mammals were alert to the potential presence of predators. In cases where two species of study mammals were sighted together, the response behaviour of only one was recorded. This was to avoid bias in the data as the one species may influence the behaviour of the other one. In addition, in order to avoid measuring the flight distance and IRI of the same herd twice (satellite herd), no measurements were recorded for a particular species within 200 m of that species being observed. The behavioural responses were measured at sunrise and sunset, avoiding mid-day when temperatures were high and mammals remained inactive. During summer, this was between 6am and 9am, and between 3:30pm and 6:30pm. During the winter period, this was between 7am and 10am, and between 2:30pm and 5:30pm.

4.5 Data Analysis

K-means cluster analysis was used for both the mammal sightings data and the response behaviour data to sort the observations into similar groups. This statistical technique groups variables in a way that minimizes the statistical variance among elements grouped together, while mazimizing between group variance. The advantage of cluster analysis for this kind of study, involving so many influencing variables, is that it permits the inclusion of multiple variables into the analysis (Ketchen and Shook, 1996). The purpose of grouping the data into meaningful structures was to highlight any trends in the data and influencing variables. According to Yongming *et al.* (2006), cluster analysis, along with principle component analysis, are the most common multivariate statistical methods used in environmental studies. For example, it has been used for linking animal behaviour to processes, such as dispersal, population dynamics and habitat selection (Moorter *et al*., 2010). The k-means analysis was replicated a number of times in order to investigate the effect of variable inclusion and choice of the number of groupings. Based on this, certain variables that did not play an important role in the outcome of the study were omitted from the analysis. The number of clusters or groupings was chosen once a number of options were thoroughly investigated and the most meaningful set of clusters, highlighting the main trends in the data, was recognized. Clustan Graphics 7 (1995) software was used for the k-means cluster analysis.

The IRI, IRD and visibility data were kriged using Surfer Version 10.0.500 (64-bit) Surface Mapping System, Golden Software, Inc. (2011). This geostatistical gridding method was useful for expressing trends in the response behaviour by interpolating irregularly spaced data into visually appealing contour maps. This is a very flexible gridding method that has proven useful in many fields (Yang *et al*., 2004). Surfer was also used to produce the height contour maps from Digital Elevation Models (DEM) downloaded from US Geological Survey (USGS).

CHAPTER 5: RESULTS

5.1 Frequency and Diversity of Mammal Sightings

The number of mammal sightings, being the number of times an individual or group of individuals was spotted, varied substantially in the various land use areas, both temporally and spatially. **Figure 5.1** displays the seasonal changes in the number of sightings recorded in the four land use areas per kilometre (km). As can be seen in **Figure 5.1**, it is evident that there were many more sightings recorded per kilometre in the private ecotourism concession and national park (KNP) than in the trophy hunting game reserve and communal land (LNP). The private ecotourism concession had an average of 31% more mammal sightings recorded when compared to the national park, and an average of 10% more sightings were recorded in the national park than in the trophy hunting reserve. Slightly more sightings (average of 3%) were recorded in the trophy hunting reserve than in the communal area. These differences in mammal sightings between the various conservation land use areas could be due to several factors, both spatial and temporal. The following sections consider a number of influencing factors and analyse for the importance of each factor.

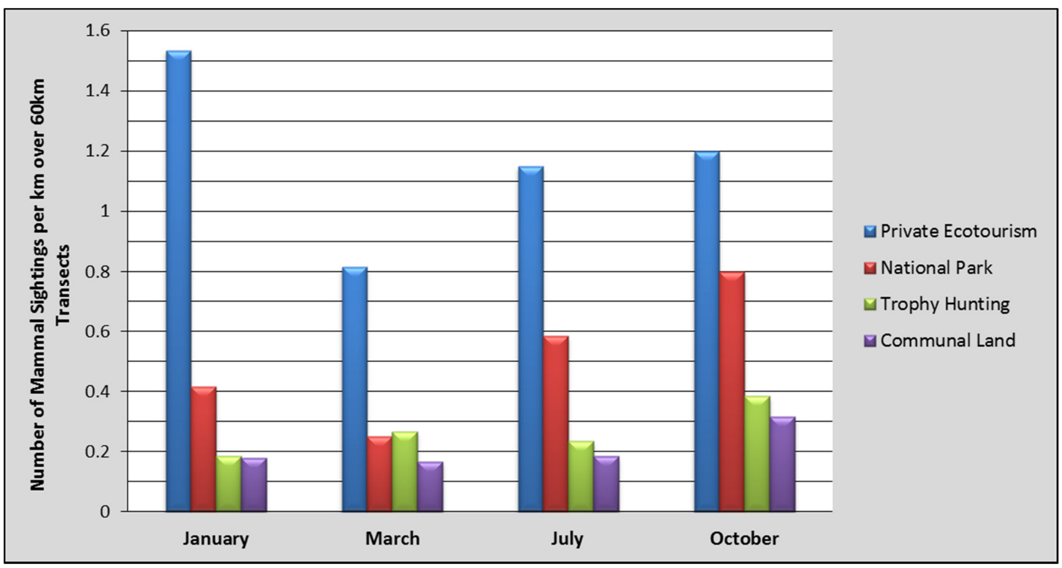

Figure 5.1: Number of mammal sightings/km recorded each season per conservation land use area

A similar seasonal pattern of mammal sightings is evident among the four land use areas, with a decline in the number of sightings recorded between January and March, and then an increase further into the dry season. **Tables 5.1 to 5.3** summarise the monthly temperatures and rainfall in the four conservation land use areas for the year 2011, being the period of time that this study took place. Although **Table 5.2** shows the average maximum temperatures to be higher in January than March, with the exception of the private ecotourism concession, the actual maximum daily temperatures experienced during the March study were substantially higher than those experienced during the January study. For instance, the average daily maximum temperature recorded for the private ecotourism concession for the January study period was 33.6°C, while that of March/April was 40.7°C. Despite the transects being carried out in the early mornings and late afternoons, temperatures remained very high in March, which most likely resulted in mammals being inactive and remaining in shaded areas, in an attempt to preserve energy. This would result in these mammals being less visible and may explain the substantial decline in sightings recorded during this period. Moreover, the northern section of the Kruger National Park receives most of its rainfall later on in summer from December onwards (See **Table 5.3**). With more water being available in the area, fewer sightings recorded in March may also be the result of mammals being less dependent on water sources such as rivers and pans/waterholes. Conversely, more sightings being recorded during the dry season are likely due to both an increased visibility when vegetation is not as dense, and as a result of animals congregating around water sources.

Table 5.1: Average daily minimum temperatures for the four conservation land use areas for the year 2011 (Wilderness Safaris, 2011; SANParks, 2011)

Average Daily Minimum Temperatures (°C)				
Month (2011)	**Private Ecotourism**	**National Park**	**Trophy Hunting**	**Communal Land**
January	**23.4**	**20.8**	**20.8**	**22**
February	21.1	20.7	20.7	21.5
March	**21.7**	**19.9**	**19.9**	20.5
April	18.6	17.8	17.8	**17.1**
May	13	14.8	14.8	12
June	7.2	12.2	12.2	7.8
July	**7.1**	**12.3**	**12.3**	**8.5**
August	9.3	13.5	13.5	10.8
September	13.4	15.7	15.7	14.6
October	19.5	**17.7**	**17.7**	**17.3**
November	21.6	19	19	19.4
December	-	20.2	20.2	21
Note: Trophy Hunting data extracted from SANParks weather data (Punda Maria) Communal Land data extracted from SANParks weather data (Letaba)				

Table 5.2: Average daily maximum temperatures for the four conservation land use areas for the year 2011 (Wilderness Safaris, 2011; SANParks, 2011)

Average Daily Maximum Temperatures (°C)				
Month (2011)	**Private Ecotourism**	**National Park**	**Trophy Hunting**	**Communal Land**
January	**36.5**	**32.3**	**32.3**	**34.1**
February	36.8	32	32	33.5
March	**39.4**	**31.5**	**31.5**	32.6
April	35.3	29.6	29.6	**30.5**
May	32.4	27.3	27.3	28.5
June	27.8	25.2	25.2	26.1
July	**25.2**	**24.9**	**24.9**	**26.4**
August	28.2	26.5	26.5	28.1
September	33.8	28.8	28.8	30.3
October	34.3	**29.7**	**29.7**	**30.3**
November	35.6	31.5	31.5	32
December	-	31.6	31.6	33.3
Note: Trophy Hunting data extracted from SANParks weather data (Punda Maria) Communal Land data extracted from SANParks weather data (Letaba)				

Table 5.3: Monthly rainfall data for the four conservation land use areas (Wilderness Safaris, 2011; SANParks, 2011)

Total Rainfall (mm)				
Month (2011)	**Private Ecotourism**	**National Park**	**Trophy Hunting**	**Communal Land**
January	**169.5**	***112**	***112**	**164.5**
February	70	*101	*101	5.2
March	**15**	**10.5**	**10.5**	4
April	25	37.9	37.9	**42.3**
May	33	*10	*10	*10
June	8.2	*6	*6	2.5
July	**1.7**	***5**	***5**	**3.3**
August	0	4.2	4.2	10.8
September	0	*13	*13	*15
October	**22.1**	***29**	***29**	***31**
November	42.7	*68	*68	46.1
December	27	*92	*92	24
Note: - Trophy Hunting data extracted from SANParks weather data - Communal Land data extracted from SANParks weather data (Letaba)				
* Average rainfall over a period of at least 15 years due to missing data for this month				

5.1.1 Seasonal Variation per Conservation Land Use Area

Private Ecotourism Concession

The six transects chosen for this study area were located in areas characterised by different traffic volumes (categorized as low, medium and high), since tourist operators tend to use some routes more regularly than others, based on access to water sources and previous experience with mammal sightings (**Figure 5.2**).

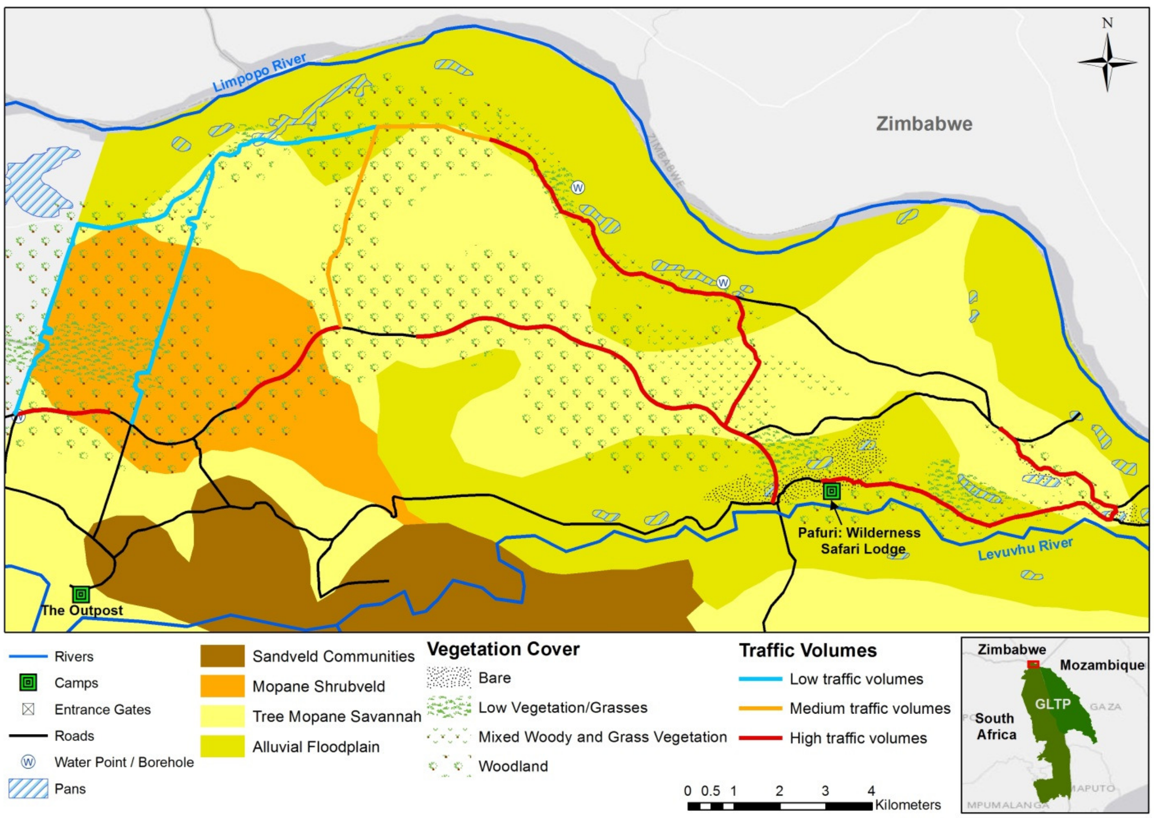

Figure 5.2: The traffic volume rankings of the six transects located in the private ecotourism concession

Figure 5.3 shows the numbers of mammal sightings per season for each transect carried out in the private ecotourism concession. Again, there was an overall decrease in mammal sightings (average of seven less mammal sightings per transect throughout the six transects) recorded between January and March, and then an increase into the dry season. As mentioned, the lowest number of sightings recorded in March may be the result of a number of factors. Firstly, visibility may have been reduced as a result of increased vegetation cover at the end of the rainy season, and secondly, mammals may remain further away from roads and water sources at this time when there is widespread water from rains. Moreover, extremely high temperatures were experienced during the two week study period (average minimum temperature of 23°C and average maximum of 41°C), resulting in mammals seeking cover for longer periods during the day to preserve energy. Transects 1 to 3, which both run in close proximity to the Limpopo and Levuvhu Rivers and various pans, contained the highest number of mammal sightings, with an average of about 12 more sightings per season than the remaining transects. This is most likely due to mammals, and especially water dependent species such as buffalo, favouring these areas close to water; not just for easy access to water, but also where forage quality is better. These two transects also show a definite increase in mammal sightings between March and July, with an average of seven more sightings recorded. Transect 1 then remained the same in the number of sightings but Transect 3 further increased by another seven sightings in October. Being in the Limpopo and Levuvhu Floodplains, as mentioned previously, the riverine vegetation offers good forage quality and provides an important refuge for wildlife during the drier months (Viljoen *et al*., in prep), hence the increase in sightings over the dry season. The remaining four transects showed a slight decrease in mammal sightings between July and October by one less sighting per transect. The Limpopo River dries up to a large extent during the dry season, leaving a dry river bed with a few scattered pools of water, while the Levuvhu River flows throughout the year. This may explain the high number of mammal sightings throughout the year and the increase during the dry period along Transect 3, which runs along the Levuvhu River. The high number of sightings recorded along Tranect 1 may primarily be as a result of the extensive alluvial floodplain of the Limpopo River, with associated vegetation and rich pan network (some of these pans are also fed by boreholes; **Figure 5.3**). Both Transects 2 and 4 showed the highest number of sightings recorded in January (11 and 17 respectively), with a substantial drop in sightings in March (2 and 5 respectively), averaging 10 less sightings (**Figure 5.3**). Although Transect 4 sightings show to be distributed all along the transect, a higher concentration of sightings was evident closer to the Levuvhu River. Transect 4 showed a slight increase of two more sightings recorded in July, which remained the same in October, as animals remained in the same area, close to water. There was an evident increase in sightings recorded along Transect 2 between March and July (5 more sightings recorded). Similarly, Transects 5 and 6 showed an average decrease of 4 sightings recorded between January and March, a slight increase of one sighting recorded in July and then one less sighting recorded in October.

National Park

In the same way in which the Makuleke transects were chosen, the six transects selected for this study area were characterised by different traffic volumes, ranging from low to high traffic volumes (**Figure 5.4**). The two transects with the highest number of sightings recorded were Transects 2 and 3, ranging from 3 to 15 sightings recorded per season (**Figure 5.5**). These transects are characterised by low traffic volumes, primarily used by overnight guests on game drives along the Mahonie route, just behind Punda Maria Camp (**Figure 5.4**). These transects revealed a very similar seasonal pattern regarding the number of mammal sightings, with a consistent increase in sightings recorded over the dry season. In addition to the low traffic volumes, the vegetation covering these transects and about half of Transect 4 belongs to the sandveld communities, supporting a more diverse range of mammals than the mopane shrubland and woodland present in the eastern sections of the Punda Maria area. Furthermore, there are two operating waterholes along Transects 2 and 3, most likely explaining the increase in concentration of game during the dry season along these transects.

The remaining transects are driven along more frequently as they are also used by people passing between Punda Maria Camp and the entrance gate, and other parts of the KNP (**Figure 5.4**). Moreover, it was evident while undertaking the study, that the roads between the Punda Maria and Pafuri entrance gates were frequently used as a thoroughfare for people living outside the KNP to commute between villages, as the roads between these villages outside the KNP are inadequate. Consequently, it was observed that several road users along roads with medium and high traffic volumes, generally drove at higher speeds and did not slow down when approaching sightings of wildlife. This could result in animals being more skittish and avoiding these road networks, consequently decreasing the number of animals sighted along these transects. Transect 6 displayed a similar seasonal pattern to that of Transects 2 and 3, with a greater number of sightings being recorded over the dry season, most likely as a result of animals concentrating around the waterholes during the dry season.

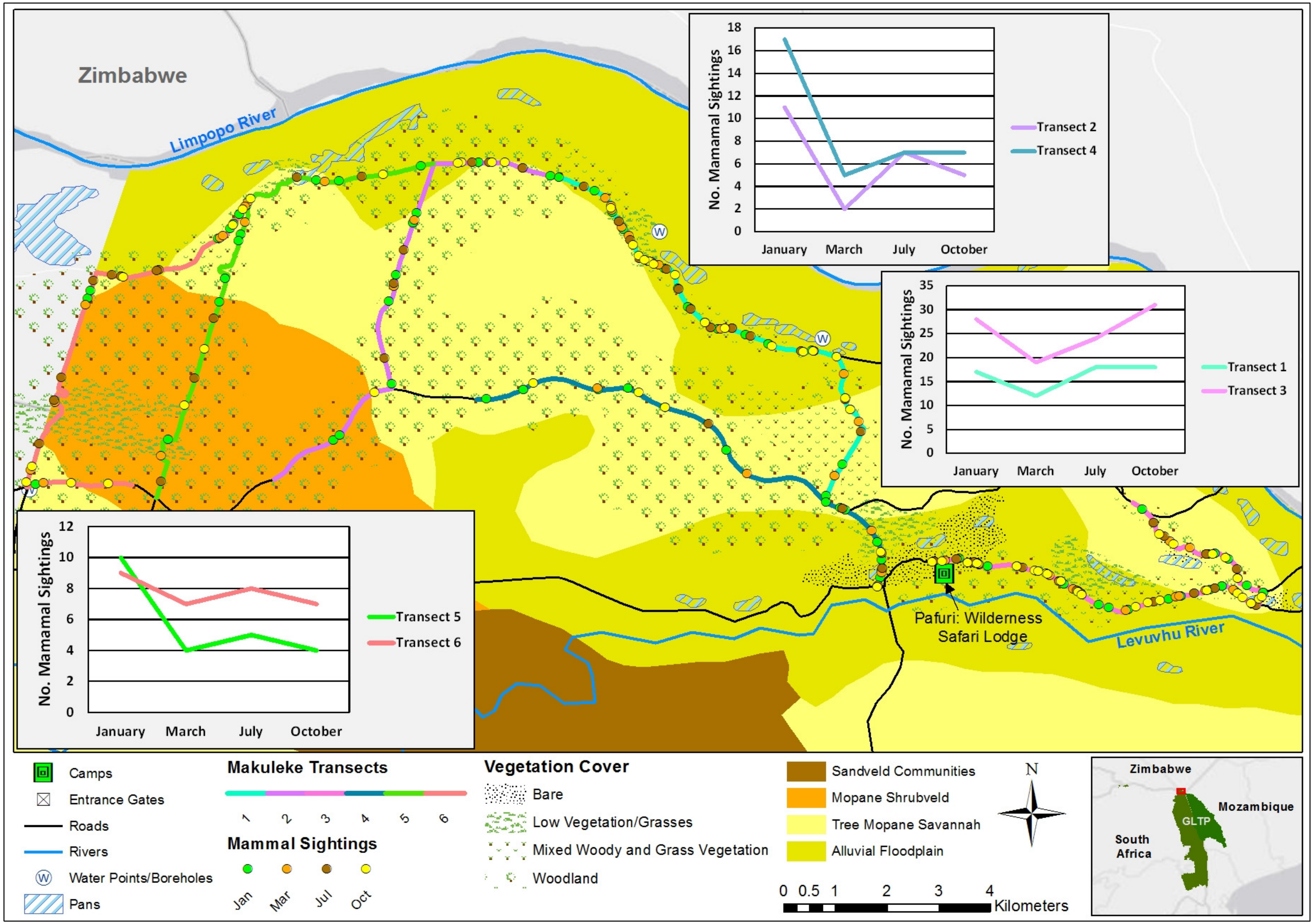

Figure 5.3: Seasonal changes in the number of mammal sightings per transect in the private ecotourism concession

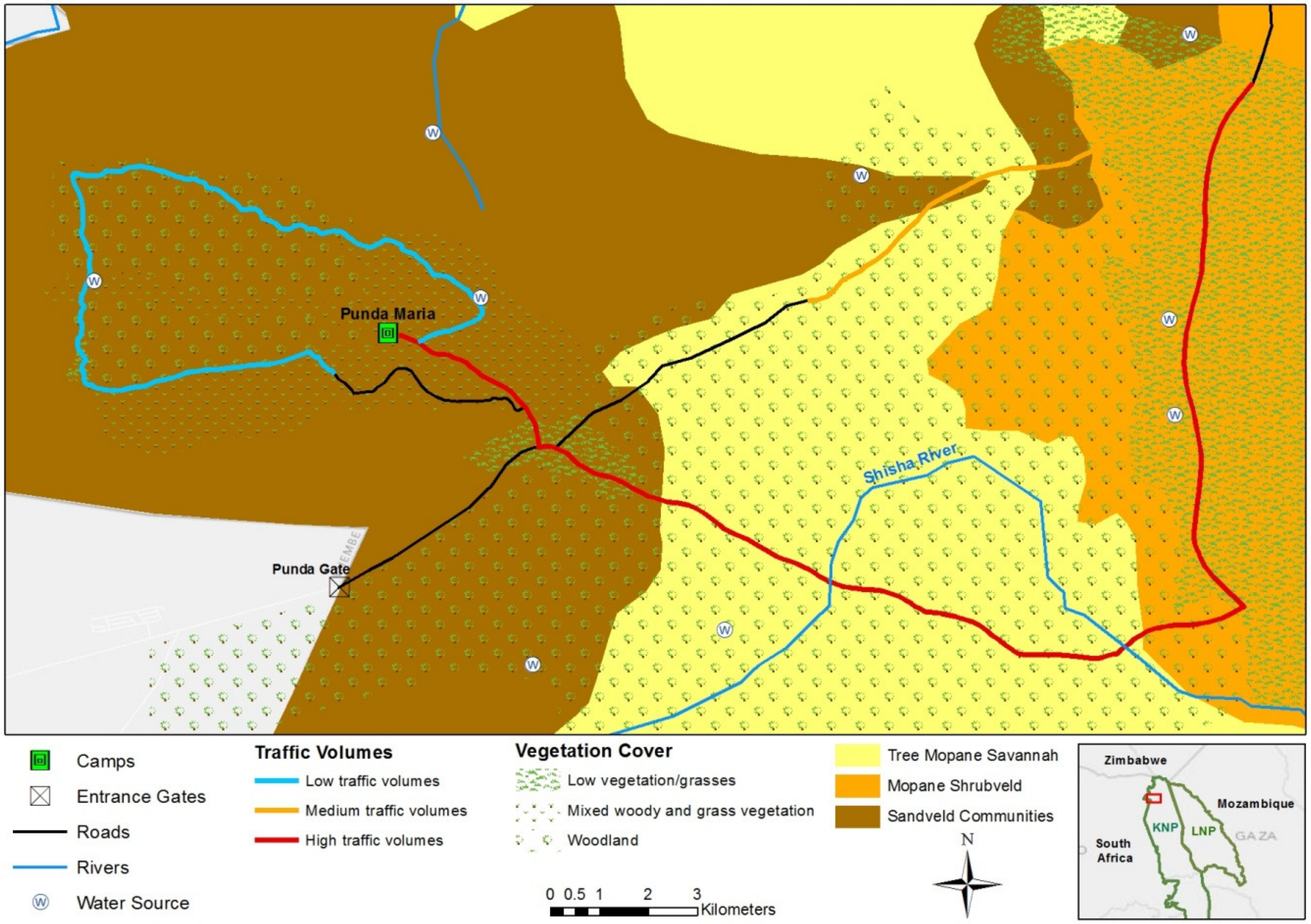

Figure 5.4: The traffic volume rankings of the six transects located in the national park

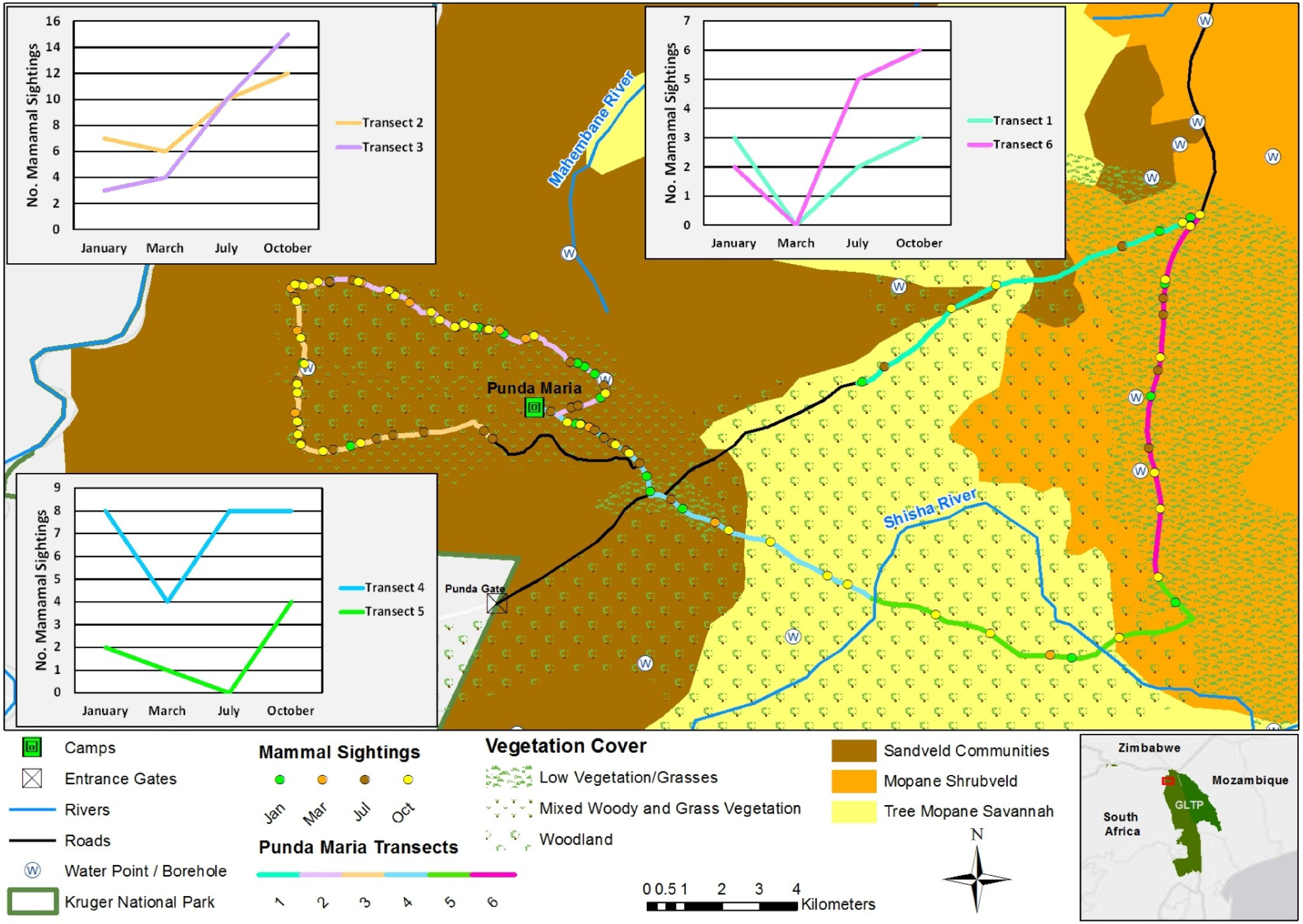

Figure 5.5: Seasonal changes in the number of mammal sightings per transect in the national park

Trophy Hunting

The six transects conducted in this area were all located in the northern section of the reserve, in the vicinity of the two tourist camps, Mutale Falls and Singo Safari Lodge. The transects were once again rated as having low, medium and high traffic volumes **(Figure 5.6)**. The majority of Makuya Nature Reserve is densely wooded with only a few patches close to the Levuvhu River that consist of bare areas and areas with mixed wooded vegetation and grasses.

Although there were very few sightings recorded in Makuya, it is evident that most of these were recorded in close proximity to the Levuvhu River **(Figure 5.7)**. This is most likely as a result of animals moving across the river from the Kruger National Park and congregating around the water source, as the Mutale and Levuvhu Rivers are the only sources of water in this water scarce environment. The majority of mammal sightings were recorded during the dry season with 15.6% more sightings recorded in July and October than January and March. This is in contrast to what was hypothesized for this study, as hunting primarily takes place during the dry season, so it was expected that mammal sightings would decrease over the dry season and increase into the wet season. On the other hand, the dry season forces animals, especially water dependent ones like zebra, buffalo and elephant, to congregate around reliable water sources such as rivers, regardless of hunting pressure. Furthermore, the dry season forces animals to travel further for food as resources easily become depleted in favourable areas forcing them to go in search of food in unfavourable environments where the vegetation is not necessarily as palatable, and where there may be hunting pressure. This would explain the overall increase in animals present in the trophy hunting reserve during the dry season.

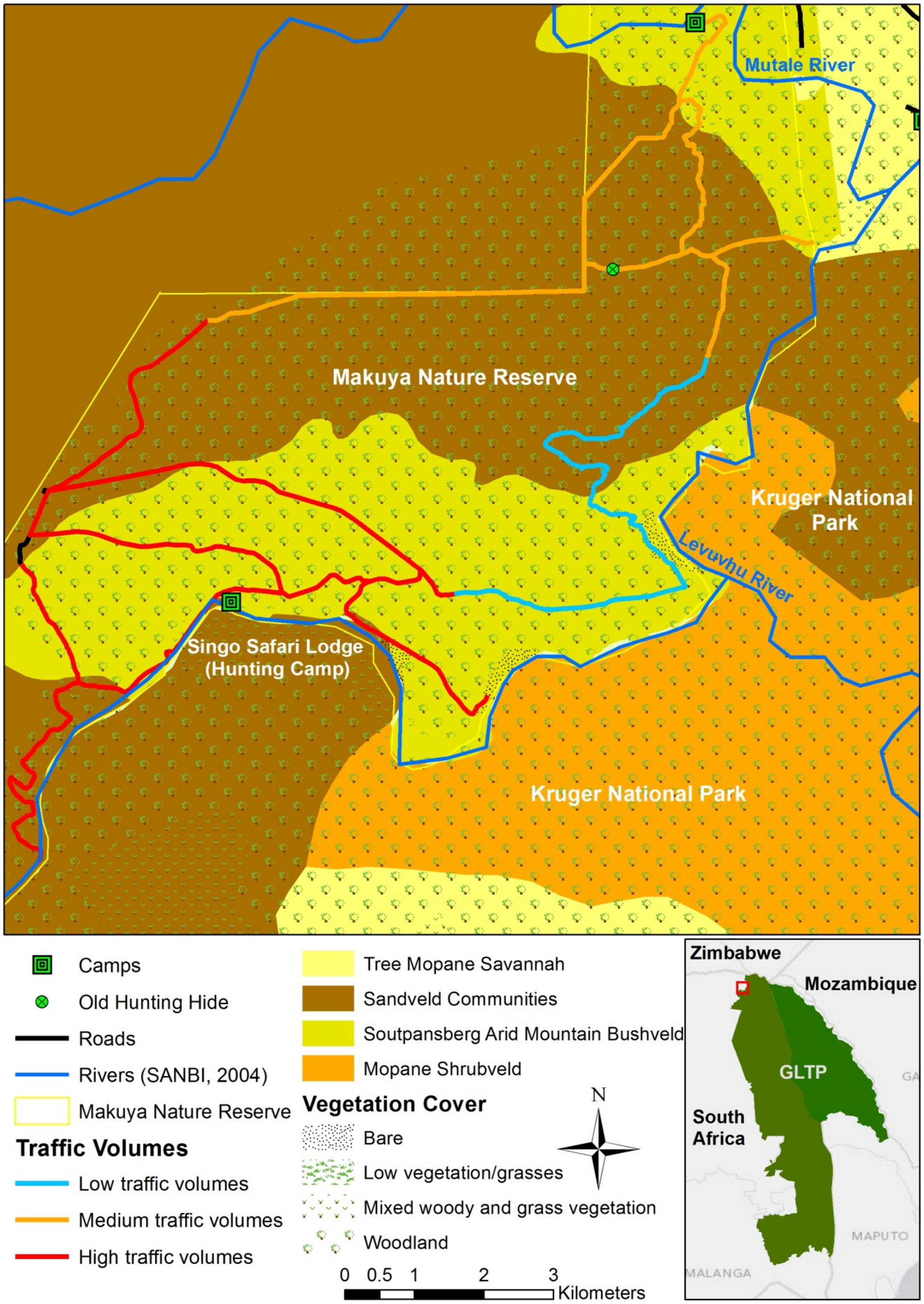

Figure 5.6: The traffic volume rankings of the six transects located in the trophy hunting nature reserve

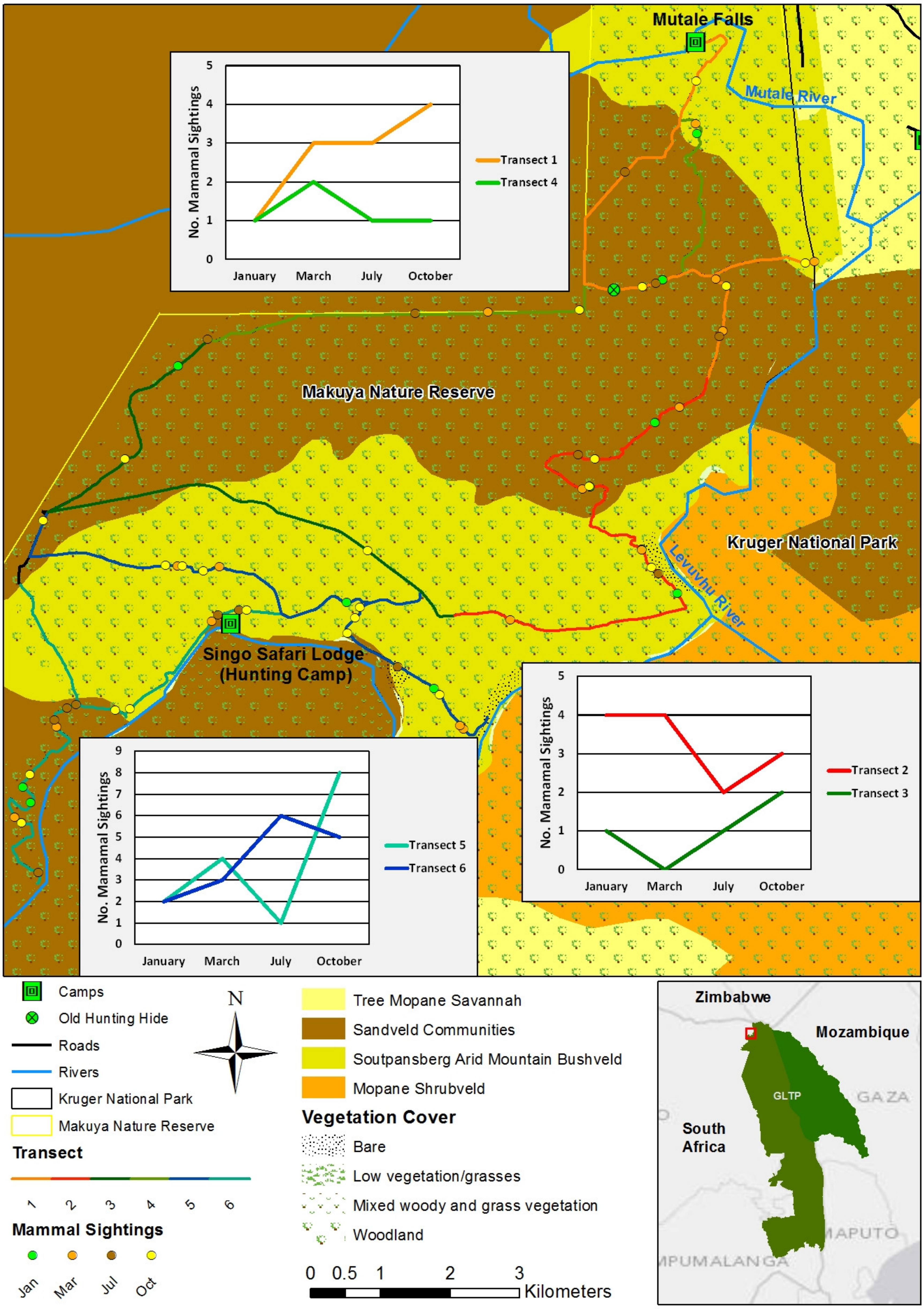

Figure 5.7: Seasonal changes in the number of mammal sightings per transect in the trophy hunting reserve

Communal Land

The six transects for this study area were carried out in the southern section of the Limpopo Park where, although there are some human settlements, this part of the park also has a large area that is uninhabited by humans and is where many of the animal translocations took place. The transects were located at varying distances from the villages in order to determine the distance from the villages at which mammals would be sighted **(Figure 5.8)**. The roads around the villages consisted of low to moderate traffic volumes, whereas the roads going from the Goriyondo Border Gate to Massingiri Dam were travelled on frequently by both villagers and many tourists using this route as a thoroughfare to get from South Africa to Mozambique.

Overall, the frequency of mammal sightings was very low with an average of 12 sightings per season, in total for the area **(Figure 5.9)**. Substantially more sightings were recorded along Transects 5 and 6, which are in closer proximity to the Kruger National Park. Conversely, Transect 1 displayed the lowest number of mammal sightings, with only one sighting recorded throughout the seasons. It must be noted, however, that this transect was not completed in January due to the roads being too wet and thus inaccessible due to it being in such close proximity to the Shingwedzi River. Transects 1 and 3 both displayed a very low number of sightings compared to the other transects and these two transects were in closest proximity to the Bingo and Mavodzo Villages. It was evident that the areas in and around the villages were largely overgrazed as a result of goats and cattle belonging to the villages, and many trees had been cut down for firewood and building material. Consequently, grazing potential for wildlife is decreased and may thus explain the absence of wildlife along these transects. In addition, subsistence hunting and human wildlife conflict is also likely to have resulted in mammals keeping their distance or remaining out of human sight. The occurrence of wildlife conflict around the villages was evident, with thorn bush and tree constructed barriers around crop fields and pens to safely keep livestock during the night. Previous interviews with community members also revealed that many villagers were unhappy about the development of the Transfrontier Park, resulting in the movement of wildlife into the area, and they thus threatened to kill mammals such as elephant seen close to their village (Kruger to Canyons, 2005). This may indicate that animals are moving across from the Kruger National Park but are still keeping a distance from the communities to avoid conflict. Transects 2, 3 and 4 showed an increase in the frequency of sightings recorded in October, from no sightings recorded during previous months to between 3 and 4 sightings. Visibility during this time was far improved as a result of vegetation not being as dense, thus allowing for better sighting potential, especially of smaller mammals such as steenbok.

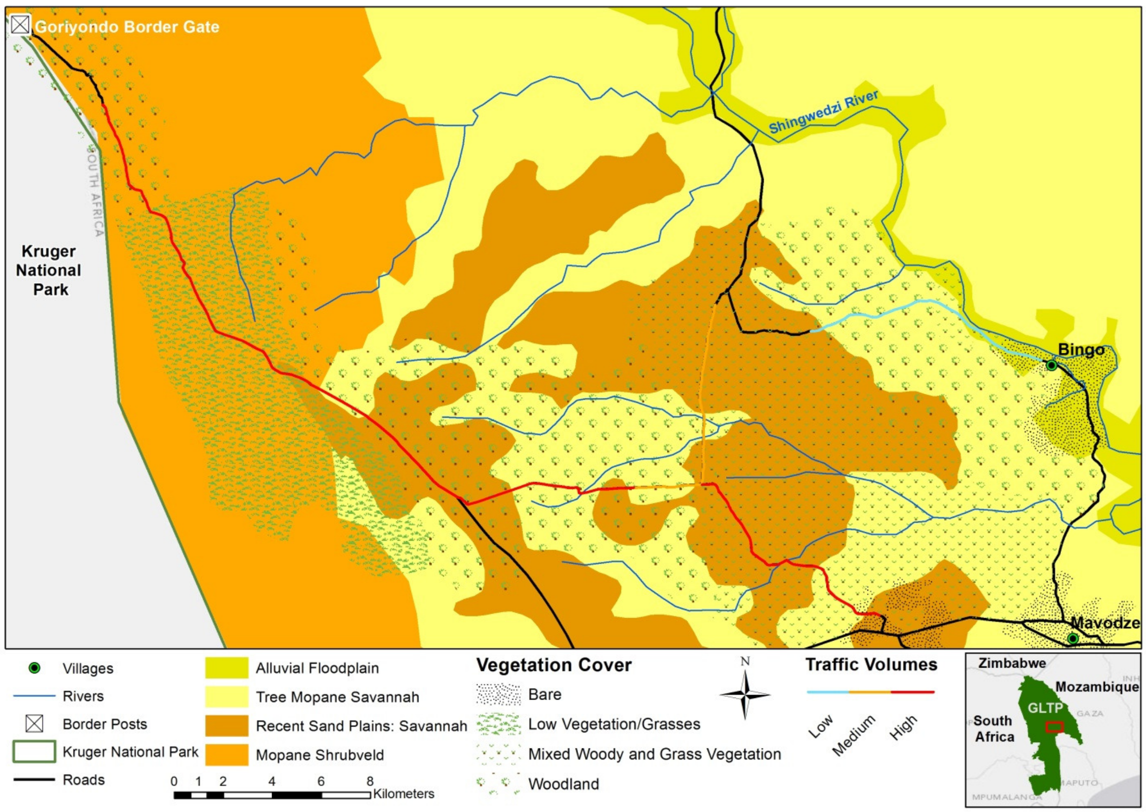

Figure 5.8: The traffic volume rankings of the six transects located in the communal land

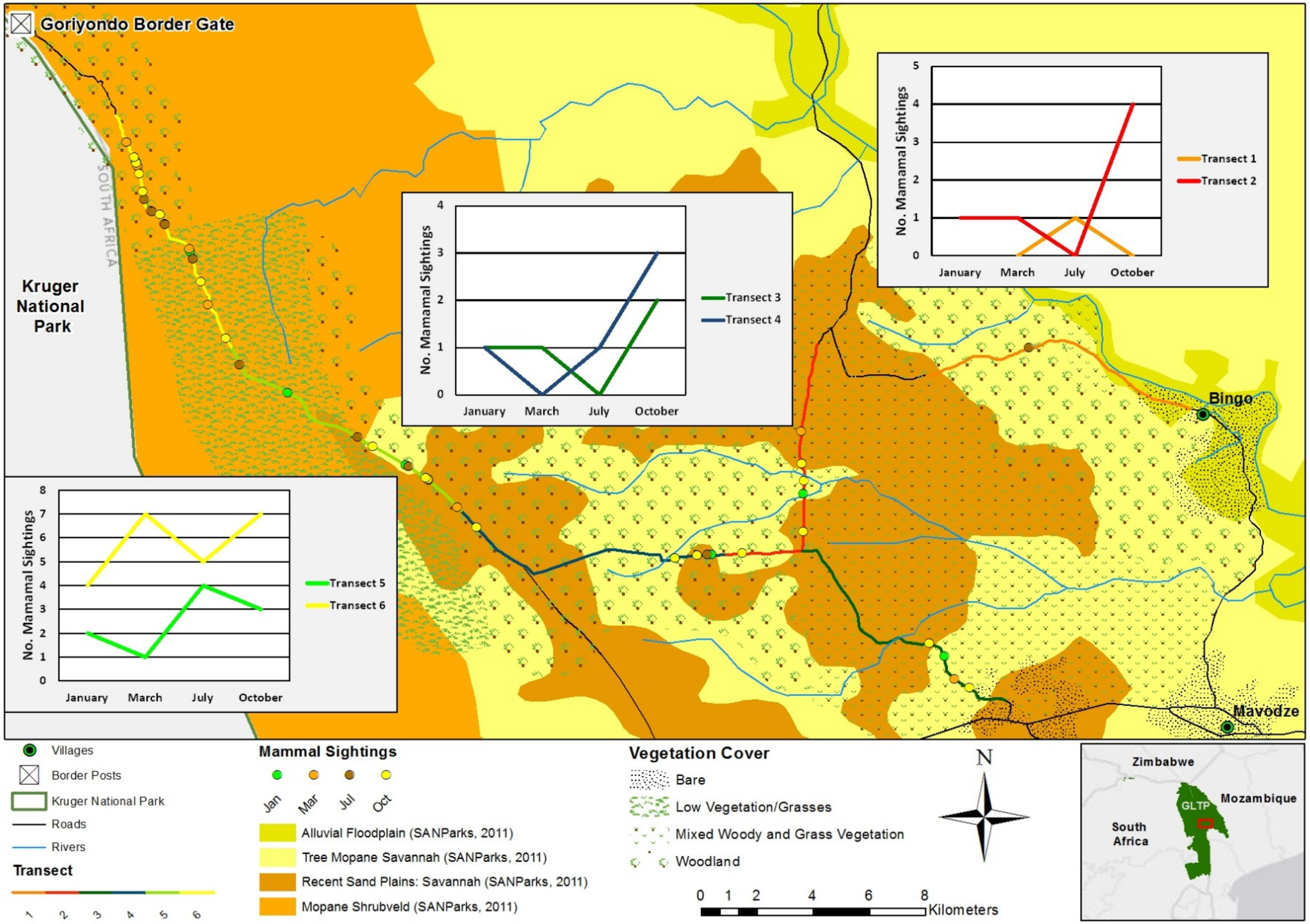

Figure 5.9: Seasonal changes in the number of mammal sightings per transect in the communal land

5.1.2 Cluster Analysis

As shown in **Section 5.1.1**, the abundance and distribution of mammals varied considerably, both temporally and spatially across the four study areas. K means cluster analysis was performed on the mammal sighting data in order to determine the relevance of the various factors; these include conservation land use area, vegetation, season and species; so as to explore the main determinants of why animals were found in certain locations at specific times. After exploring a number of cluster combinations, the data were grouped into 15 clusters, which highlighted major trends in the data, as well as teased out the subtle effects of less major variables such as species. **Table 5.4** summarises the results from the cluster analysis, showing the proportion make up of each variable in each cluster. What is evident from this summary table is that the cluster analysis primarily grouped the data according to the conservation land use area and vegetation type, considering most of the clusters were dominated by these particular variables. This shows that the land use and type of vegetation were the most important factors determining the distribution of mammals across the entire study area. Once grouped according to land use area and vegetation, it is evident that the data were then grouped according to the season and then lastly, some of the clusters were separated by a dominant species. **Figure 5.10** shows the percentage make-up of season for each cluster. The following section details the cluster analysis findings in line with these outcomes.

Table 5.4: Summary table of cluster analysis showing proportions of each variable (blue rows represent clusters dominated by private ecotourism, purple represents the national park, orange represents the trophy hunting reserve and green represents the communal land)

Cluster	No. of Observations	Ecotype (%)				Vegetation (%)						Season (%)			
		Private Ecotourism	National Park	Trophy Hunting	Communal Land	Alluvial Floodplain	Mopane Shrubveld	Soutpansberg Arid Mountain Bushveld	Sandveld Communities	Tree Mopane Savannah	Recent Sand Plains	January	March	July	October
1	27	0	0	0	100	0	52	0	0	19	30	33	19	30	19
2	29	0	0	100	0	0	0	100	0	0	0	17	28	14	41
3	21	95	5	0	0	0	0	0	0	100	0	0	43	57	0
4	39	100	0	0	0	100	0	0	0	0	0	0	0	0	100
5	18	0	83	0	17	0	33	0	0	67	0	11	6	0	83
6	30	100	0	0	0	0	0	0	0	100	0	0	37	63	0
7	39	100	0	0	0	100	0	0	0	0	0	100	0	0	0
8	48	100	0	0	0	0	0	0	0	100	0	100	0	0	0
9	35	0	0	100	0	0	0	0	100	0	0	17	23	29	31
10	34	100	0	0	0	100	0	0	0	0	0	0	0	100	0
11	26	100	0	0	0	100	0	0	0	0	0	0	100	0	0
12	19	0	0	0	100	0	63	0	0	16	21	0	26	16	58
13	30	53	47	0	0	0	100	0	0	0	0	33	10	37	20
14	30	100	0	0	0	0	0	0	0	100	0	0	0	0	100
15	93	0	100	0	0	0	0	0	100	0	0	19	15	30	35

Cluster	Species (%)																		
	Baboon	Buffalo	Bushbuck	Common Duiker	Eland	Elephant	Giraffe	Impala	Klipspringer	Kudu	Leopard	Lion	Nyala	Sharpe's Grysbok	Steenbok	Vervet Monkey	Warthog	Waterbuck	Wildebeest	Zebra
1	0	0	0	19	0	0	0	67	0	0	0	0	0	0	0	4	4	0	0	7
2	10	0	0	3	0	3	0	21	10	10	0	3	21	7	3	3	0	3	0	0
3	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0
4	13	10	3	0	0	8	0	33	0	13	0	0	5	0	0	3	10	0	0	3
5	0	0	0	17	0	17	6	0	0	6	0	0	11	11	22	0	6	0	0	6
6	17	3	0	3	7	3	0	0	0	20	0	0	17	3	0	0	7	0	0	20
7	3	0	3	0	3	3	0	46	0	3	0	3	26	0	0	0	8	0	3	3
8	6	2	0	2	0	0	0	60	0	8	0	0	8	0	0	0	8	0	0	4
9	6	9	3	3	0	9	0	11	17	3	0	0	14	17	9	0	0	0	0	0
10	6	9	0	0	0	6	0	41	0	12	0	3	6	0	0	3	6	0	0	9
11	15	0	0	0	0	0	0	35	0	15	4	0	8	0	0	8	8	0	0	8
12	0	0	0	0	0	0	0	0	0	5	0	0	0	0	95	0	0	0	0	0
13	0	3	0	3	0	17	0	43	0	0	0	0	13	3	3	0	0	0	3	10
14	10	3	0	7	3	3	0	40	0	7	0	0	3	3	7	0	3	0	0	10
15	2	1	1	11	0	11	0	29	0	14	0	0	10	9	3	0	2	0	0	8

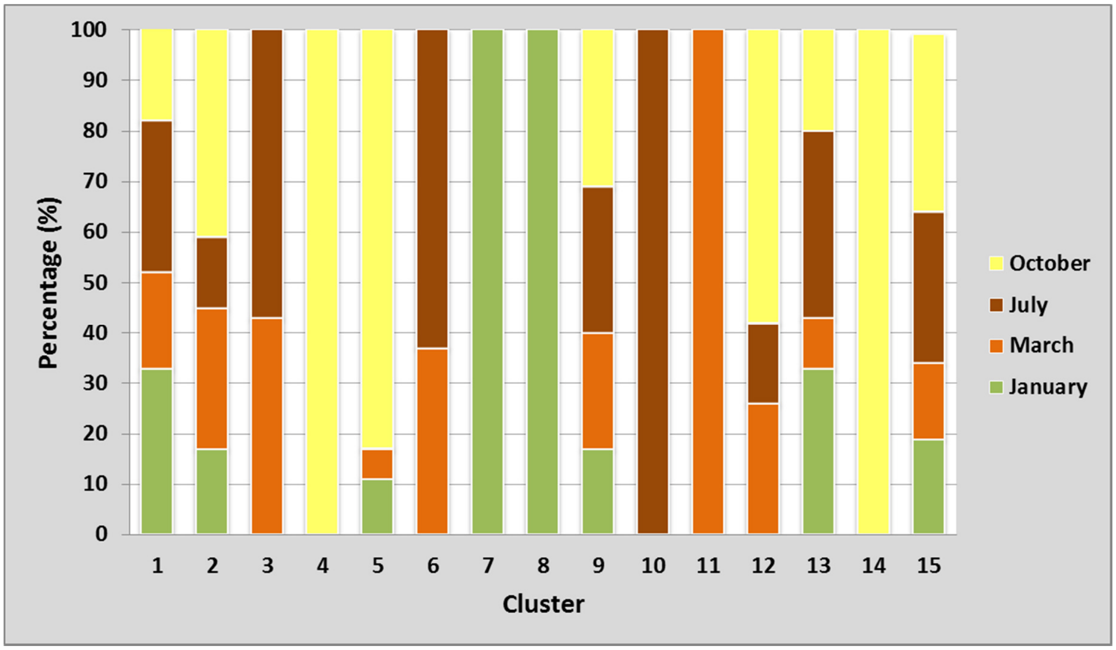

Figure 5.10: Seasonal make-up of the various clusters

5.1.2.1 Private Ecotourism

According to the cluster analysis, the private ecotourism study area (blue clusters; **Table 5.4**) was primarily grouped into two main vegetation types, being tree mopane savannah and alluvial floodplain. Tree mopane savannah dominated Clusters 3, 6, 8 and 14, while the alluvial floodplain vegetation type dominated Clusters 4, 7, 10 and 11. These clusters were then grouped according to seasonal variation and species types.

Tree Mopane Savannah

As can be seen in **Figure 5.10**, Clusters 3, 6, 8 and 14 were largely grouped according to the month during which the mammal sightings were recorded. Clusters 3 and 6, however, were both dominated by sightings recorded in March and July, thereby indicating that there must be another factor that divided these two clusters, rather than them forming one cluster. **Figure 5.11** details the species make-up of each cluster, and from this, it is evident that the species type is what divided Clusters 3 and 6, with impala exclusively making up Cluster 3 and a range of species making up Cluster 6. With the exception of Cluster 6, impala are a dominant species among the remaining three clusters, most likely due to their preference for mopane woodland, as stated by Emmett (2012). Furthermore, the remaining dominant species, highlighted in **Figure 5.11**, are largely mixed feeders and browsers (nyala, kudu, eland, common duiker), with a preference for mopane woodland (Emmett, 2012).

The spatial distribution of the four clusters reveals interesting trends (**Figure 5.12**), with mammals in Clusters 3 and 14 remaining particularly close to water sources, such as pans, while Clusters 6 and 8 show a wider distribution of mammals across the study area. In addition to most of the sightings in Cluster 3 being in the dry season (July), impala, as described by Emmett (2012), are very water dependent, explaining why these sightings were generally concentrated around water sources. Conversely, Cluster 6 comprised a wider variety of mammals, many of which are not as dependent on water, and were therefore more widely distributed throughout the mopane woodland. While zebra are primarily grazers, a particularly high proportion of them were recorded in the tree mopane savannah (Clusters 6 and 14). Considering that a large proportion of Cluster 6 and all of Cluster 14 are in the dry season, this high proportion of zebra is most likely a result of them browsing during the dry season when little else is available. According to Emmett (2012), zebra are known to occasionally browse herbs and burnt twigs of mopane woodland. Cluster 8 mammals, being more widely distributed, are most likely due to them not being as dependent on water sources during the wet season when more water is available.

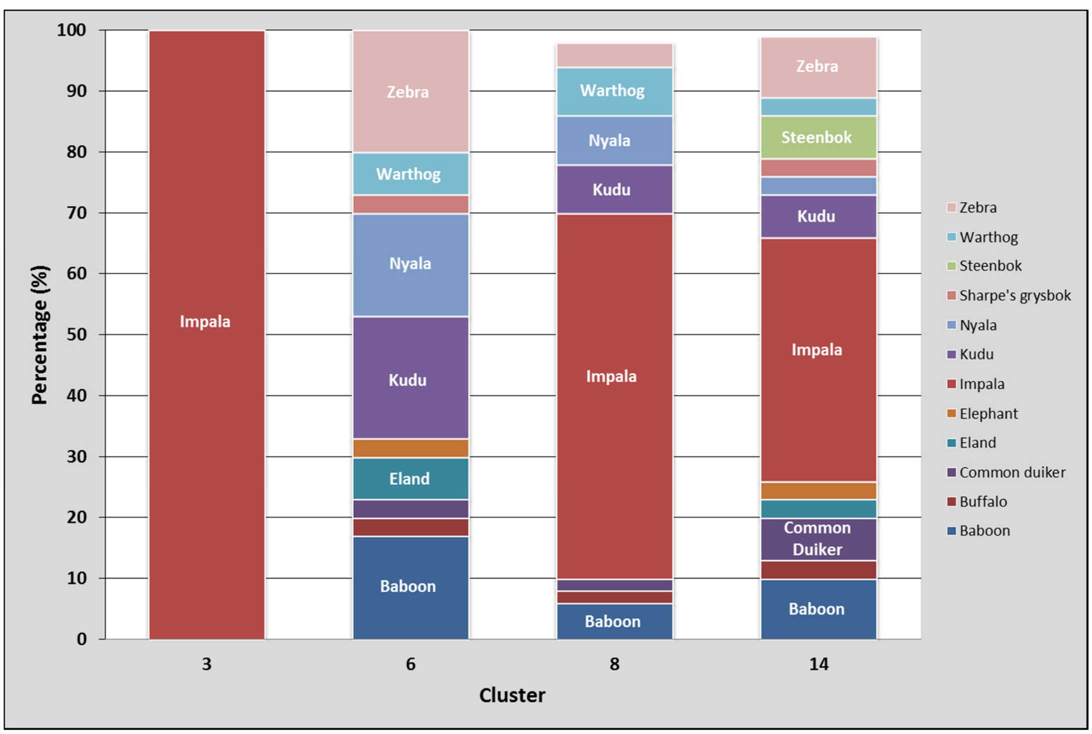

Figure 5.11: Species make-up of the tree mopane savannah clusters

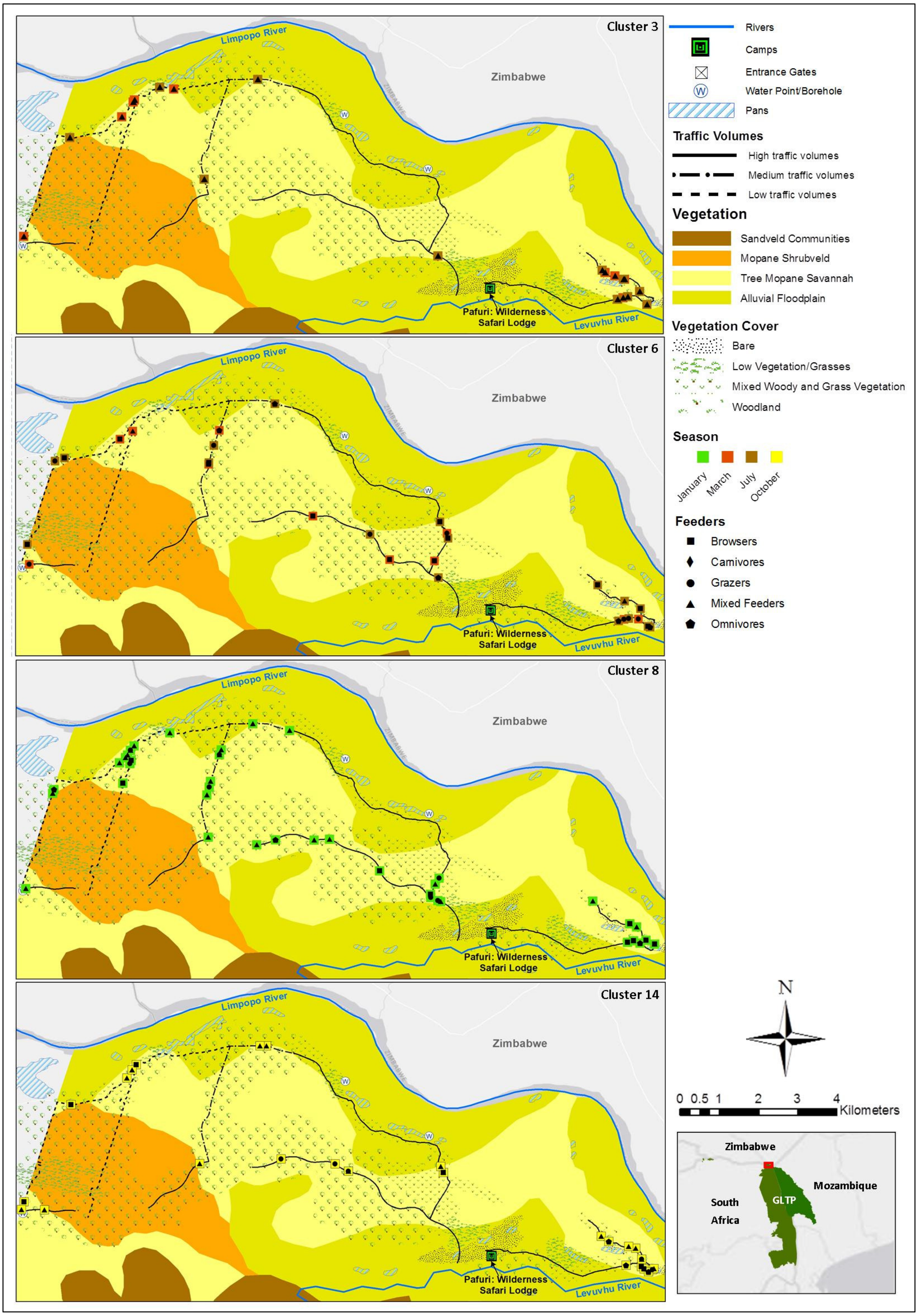

Figure 5.12: Spatial distribution of the various clusters dominated by tree mopane savannah located within the private ecotourism study area

Alluvial Floodplain

Four of the clusters (4, 7, 10 and 11) that represent 100% Alluvial Floodplain land cover had clear distinctions between the seasons containing 100% of the sightings recorded in a particular month (**Table 5.4**). Conversely, the species composition of each cluster did not differ as much, with the exception of Cluster 7, comprising a more diverse species make up, and with differing proportions of some species such as nyala (**Figure 5.13**). In general, the dominant species making up the Alluvial Floodplain clusters included baboon, elephant, impala, kudu, nyala, vervet monkey, warthog and zebra. Most of these species are water dependent, explaining their close presence to the rivers and pan network. Furthermore, as described by Viljoen *et al*. (in prep), the Limpopo and Levuvhu floodplains comprise a mixture of riverine forest and floodplain grassland, providing a refuge as well as good browsing and grazing opportunities for a variety of organisms.

Figure 5.14 displays the spatial distribution of each cluster within the alluvial floodplain. Vegetation cover along the Limpopo floodplain consisted of a small portion of mopane woodland along the western section, with the majority comprising mixed wood and grass vegetation, and large expanses of floodplain grassland. The Levuvhu floodplain, on the other hand, mostly comprises of riverine forest, with large, broadleaved trees, creating a densely wooded habitat. This is reflected in **Figure 5.14**, with mixed feeders and grazers mostly occupying the areas along the Limpopo floodplain and a larger proportion of browsers occupying the wooded areas along the Levuvhu floodplain. What is evident between the clusters in **Figure 5.14,** is how mammals are far more concentrated around the pan network during the dry season (Clusters 4 and 10), and more evenly distributed along the floodplain during January and March (Clusters 7 and 11).

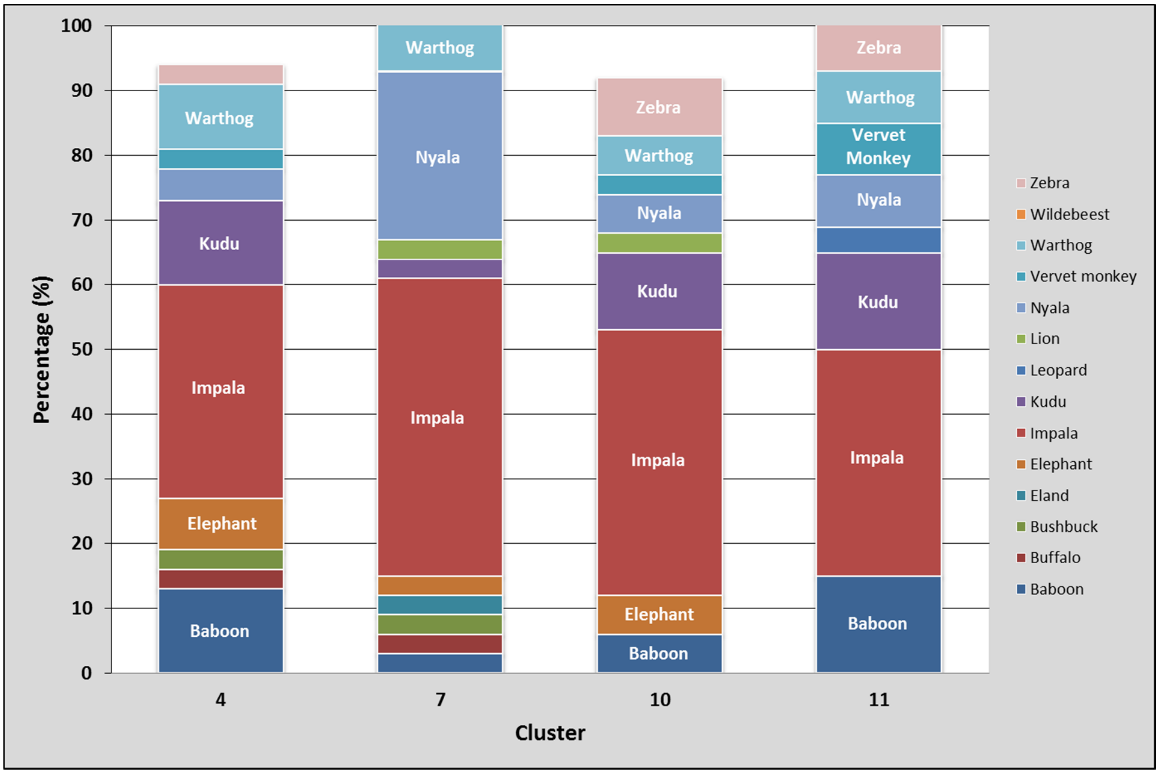

Figure 5.13: Species make-up of the Alluvial Floodplain clusters

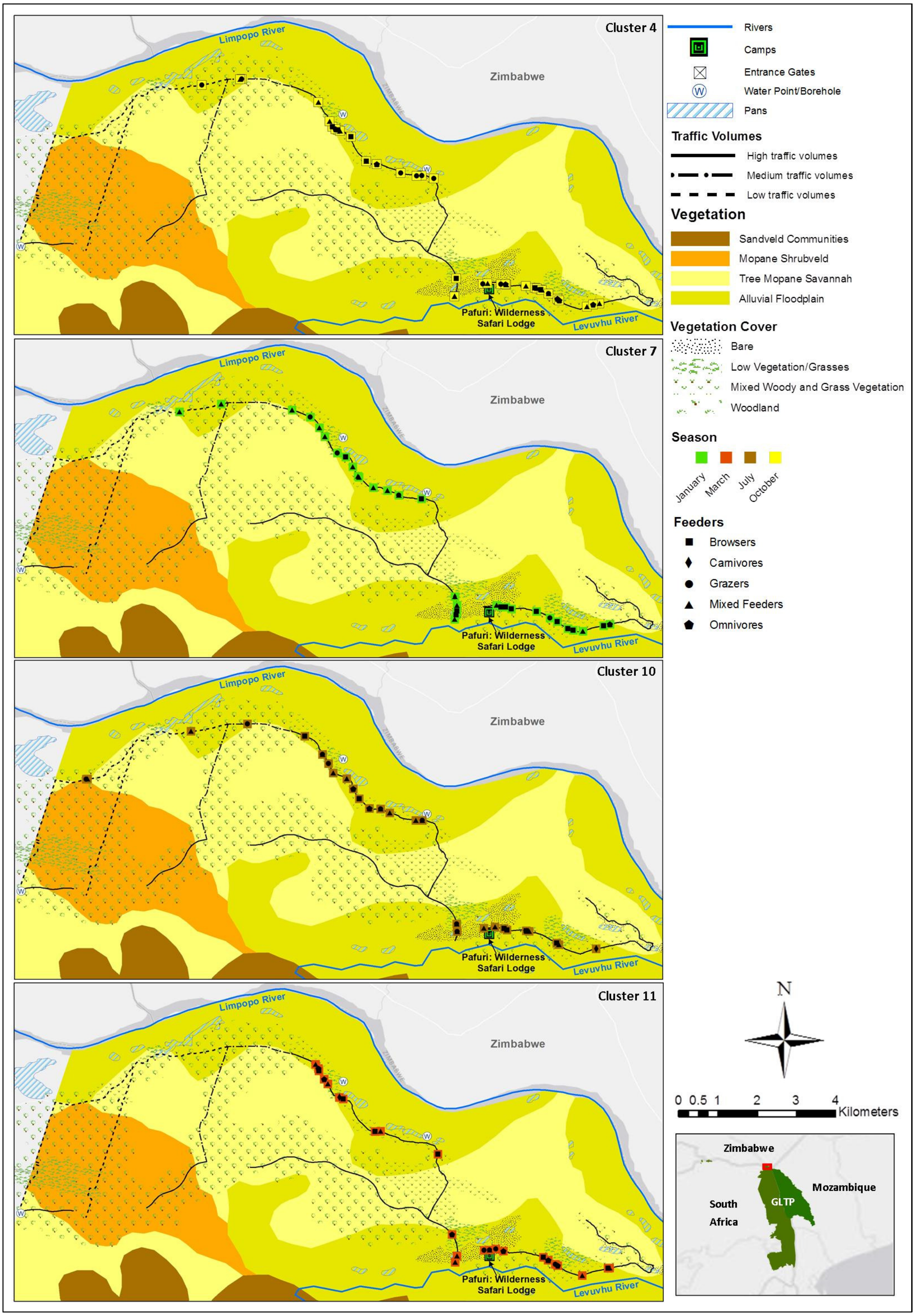

Figure 5.14: Spatial distribution of the various clusters dominated by alluvial floodplain located within the private ecotourism study area

5.1.2.2 National Park

The national park comprised of two primary clusters, namely Clusters 5 and 15, each dominated by different vegetation types (**Figure 5.15**). The seasonal make-up of these two clusters also varied considerably, with the vast majority of Cluster 5 species occurring during the late dry season (October), and Cluster 15 mammals occurring throughout the year, but also mostly during the dry season (**Figure 5.10**). Cluster 5 was dominated by browsers and contained a higher proportion of common duiker, elephant and steenbok, while Cluster 15 comprised higher proportions of impala and kudu (**Figure 5.16**). As can be seen in **Table 5.4** and **Figure 5.17**, animals were far more common in the sandveld communities (93 sightings) as opposed to the tree mopane savannah and mopane shrubveld (18 sightings). Although the tree mopane tree savannah and mopane shrubveld is decribed by Gertenbach (1983) as being of significant importance to rare antelope species and grazers such as buffalo and zebra, this landscape does not support a wide range of species, especially being a water scarce environment. The majority of the sightings occurring during the late dry season may be as a result of mammals moving into this area with not much forage being available elsewhere.

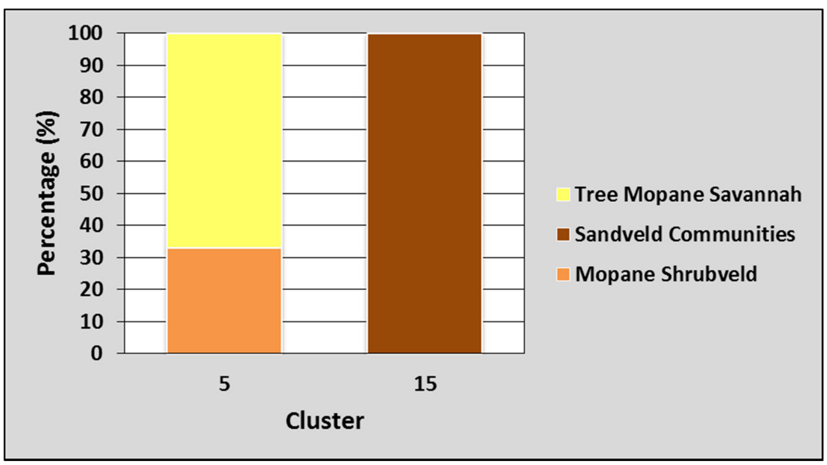

Figure 5.15: Vegetation composition of the clusters within the national park

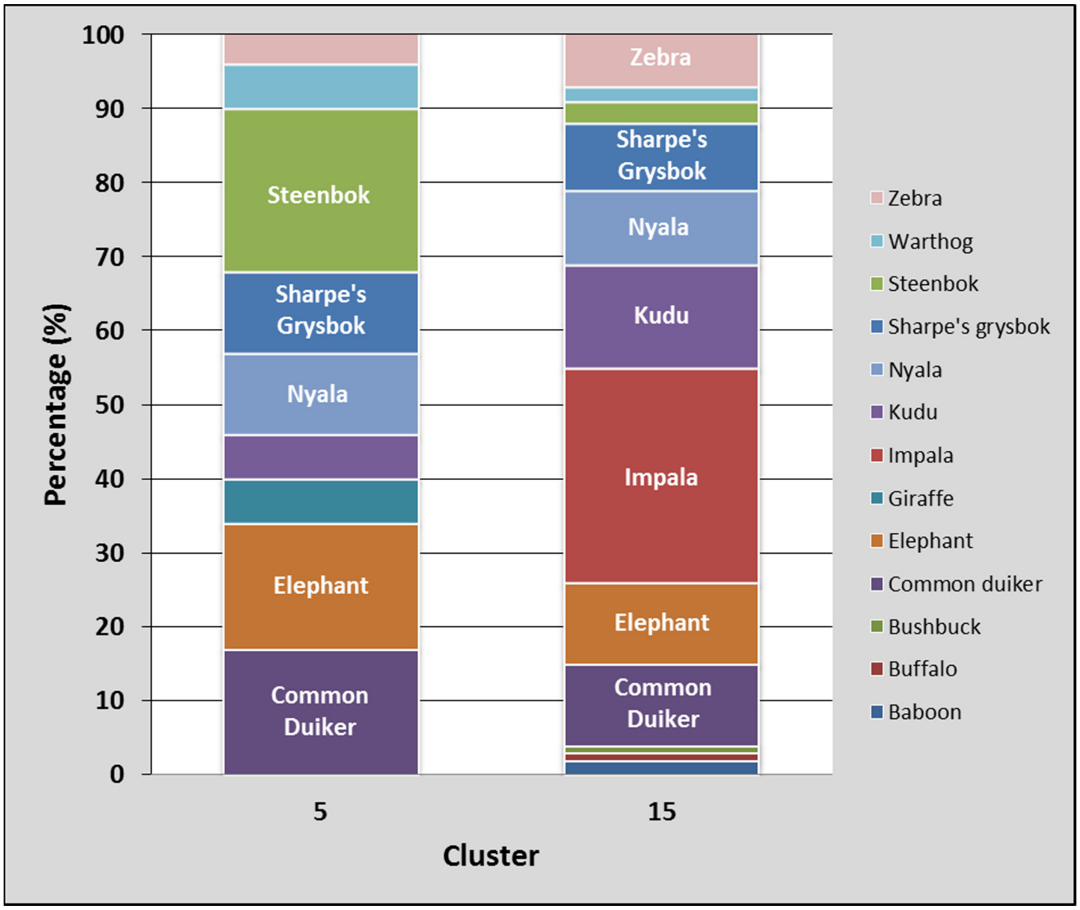

Figure 5.16: Species composition of the clusters within the national park

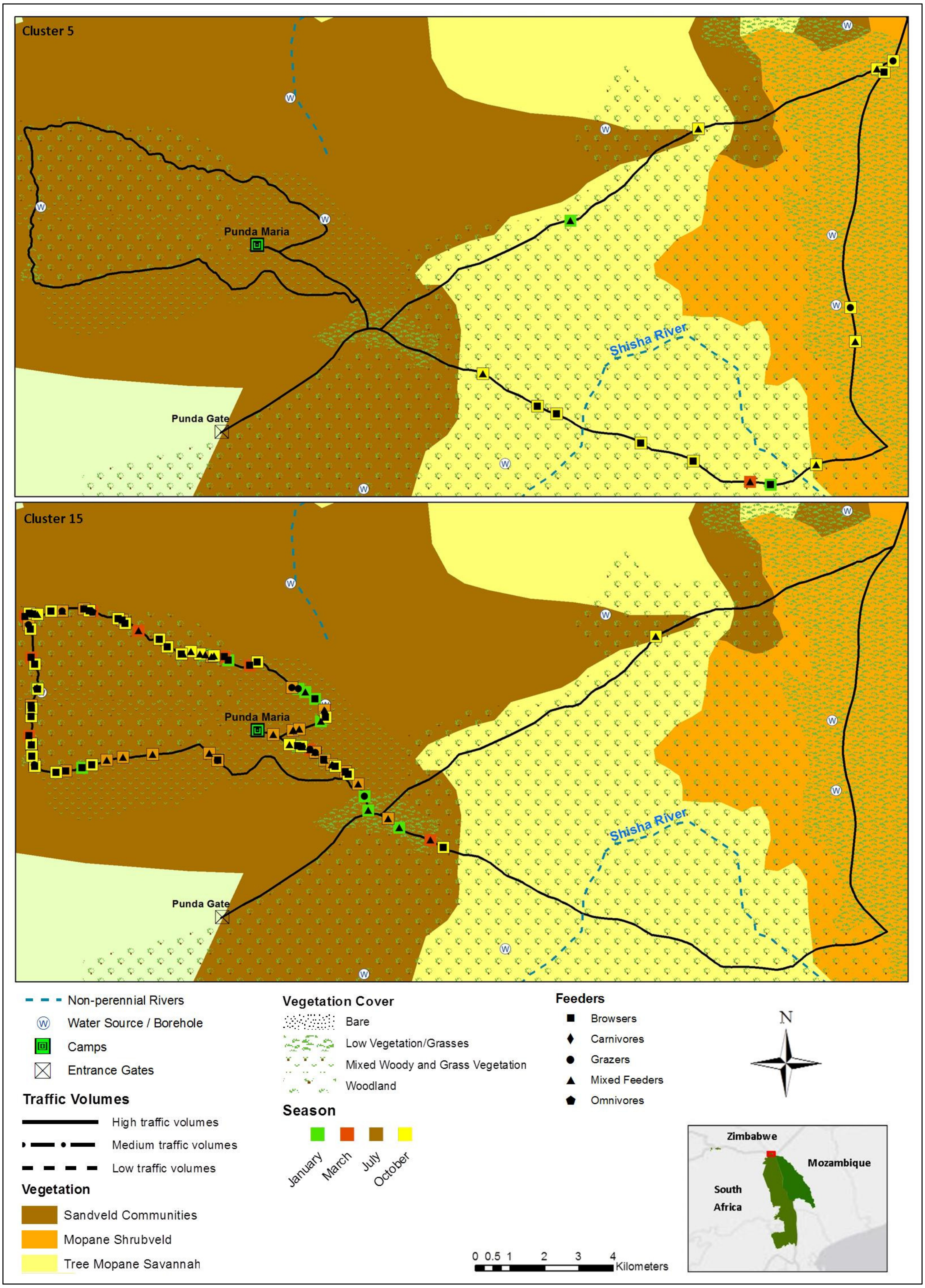

Figure 5.17: Spatial distribution of the various clusters located within the national park

5.1.2.3 Trophy Hunting

The trophy hunting reserve, according to the cluster analysis, was primarily grouped according to the vegetation type, with Cluster 2 falling exclusively within the Soutpansberg Arid Mountain Bushveld vegetation and 100% of Cluster 9 consisting of sandveld communities. Both clusters showed similar seasonal patterns, with the dry season making up more than 50% of the total sightings (**Figure 5.10**). The species composition differed slightly between the two vegetation types, with a higher proportion of small antelope, such as klipspringer, sharpe's grysbok and steenbok, occurring in the sandveld communities (Cluster 2), and larger browsers, including kudu and nyala, occurring in the Soutpansberg Arid Mountain Bushveld (Cluster 9; **Figure 5.18**).

Spatially, it was evident that, despite the season, animals across both clusters favoured the areas closer to the Levuvhu River (**Figure 5.19**). With the exception of a few bare patches along the Levuvhu River, the entire study area comprised of densely wooded vegetation, and this was reflected in the species composition of both clusters, primarily comprising browsers. A high proportion of the area, containing Soutpansberg Arid Mountain Bushveld, was characterised by mountainous topography with rocky, steep slopes. The smaller antelope, especially klipsringer, are better suited to this landscape, hence their common occurrence in these areas.

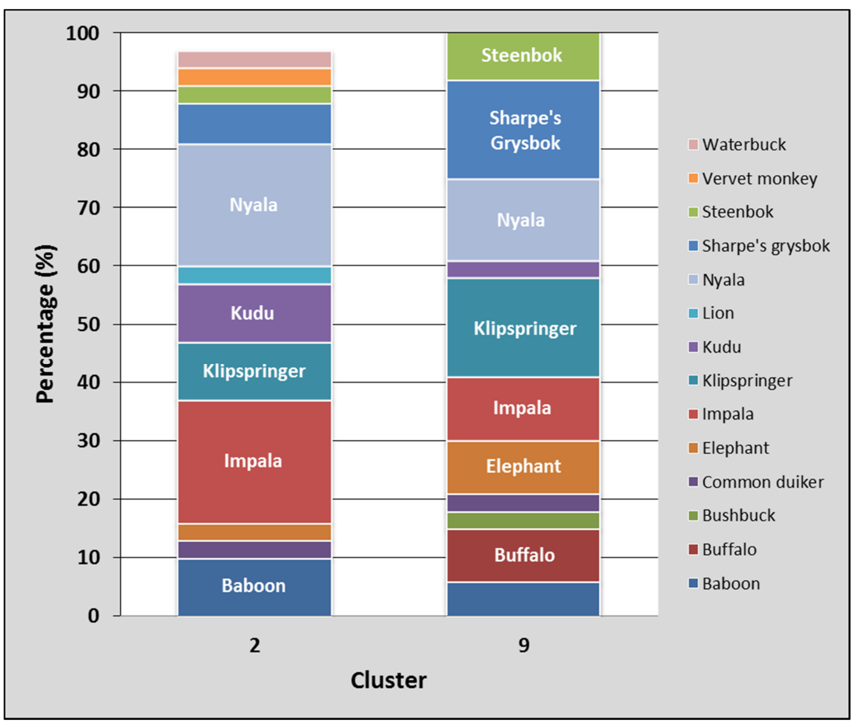

Figure 5.18: Species composition of the clusters within the trophy hunting reserve

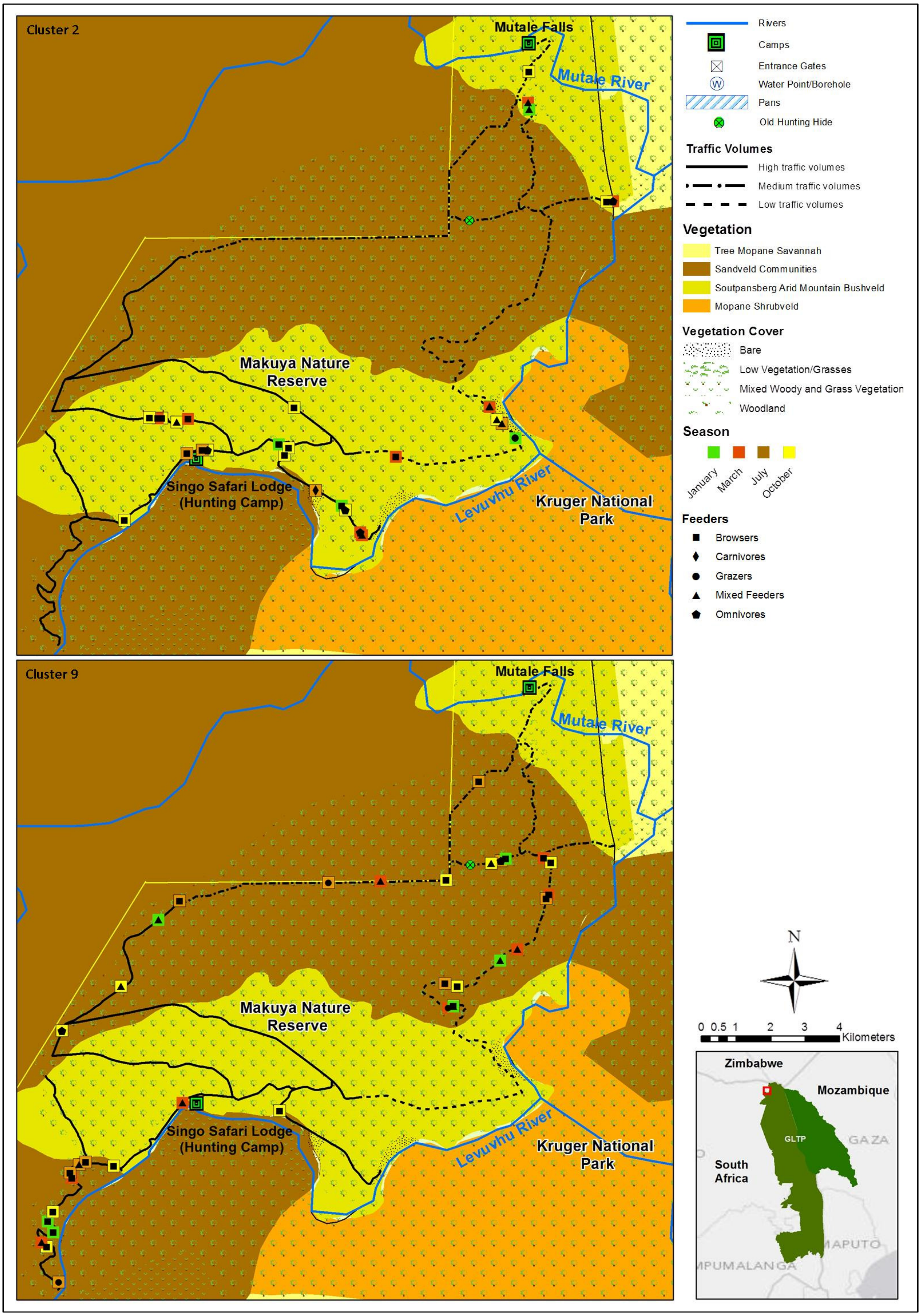

Figure 5.19: Spatial distribution of the various clusters located within the trophy hunting reserve

5.1.2.4 Communal Land

In contrast to the previous three study areas, the communal land clusters had a similar vegetation composition, and the clusters were rather separated by species composition. The majority of both Clusters 1 and 12 comprised mopane shrubveld, with smaller proportions of recent sand plains and tree mopane savannah (**Figure 5.20**). Cluster 1 sightings were distributed throughout the year, with a slight majority being in January and July, while Cluster 12 sightings mostly fell within October, and a smaller proportion in March and July (**Figure 5.10**). A big difference is evident between the two clusters in **Figure 5.21**, with Cluster 1 mostly comprising common duiker and impala and Cluster 12 primarily comprising steenbok.

Spatially, there were no obvious differences in the distribution of species between the two clusters, and the majority of sightings were recorded along the main road south of the Goriyondo Border Gate (**Figure 5.22**). Perhaps the reason for sighting so many more steenbok at the end of the dry season was as a result of better visibility, due to sparser vegetation.

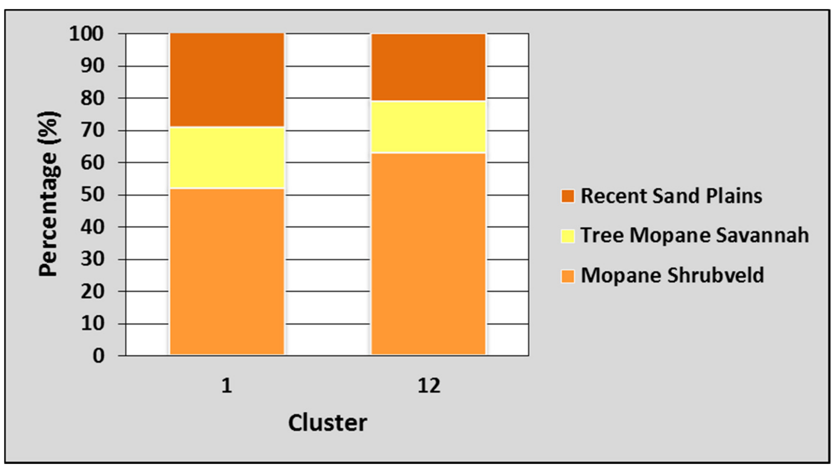

Figure 5.20: Vegetation composition of the clusters within the communal land

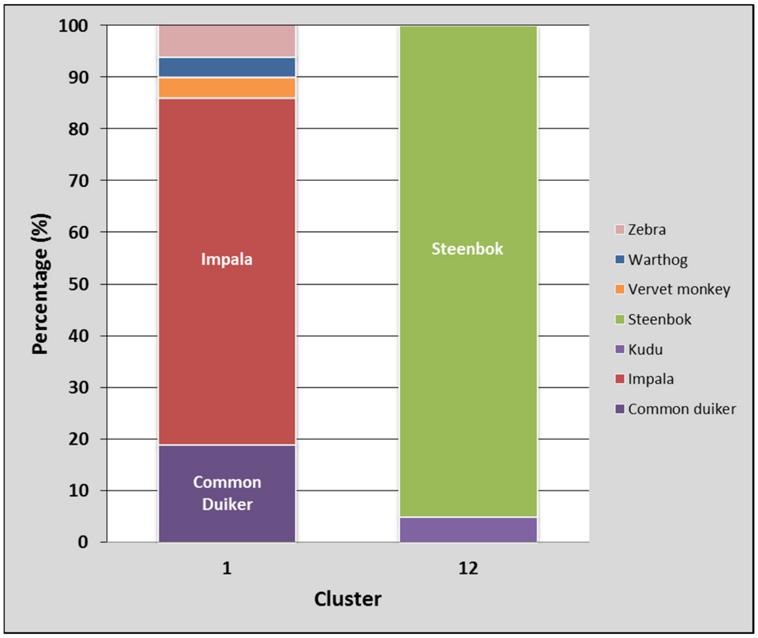

Figure 5.21: Species composition of the clusters within the communal land

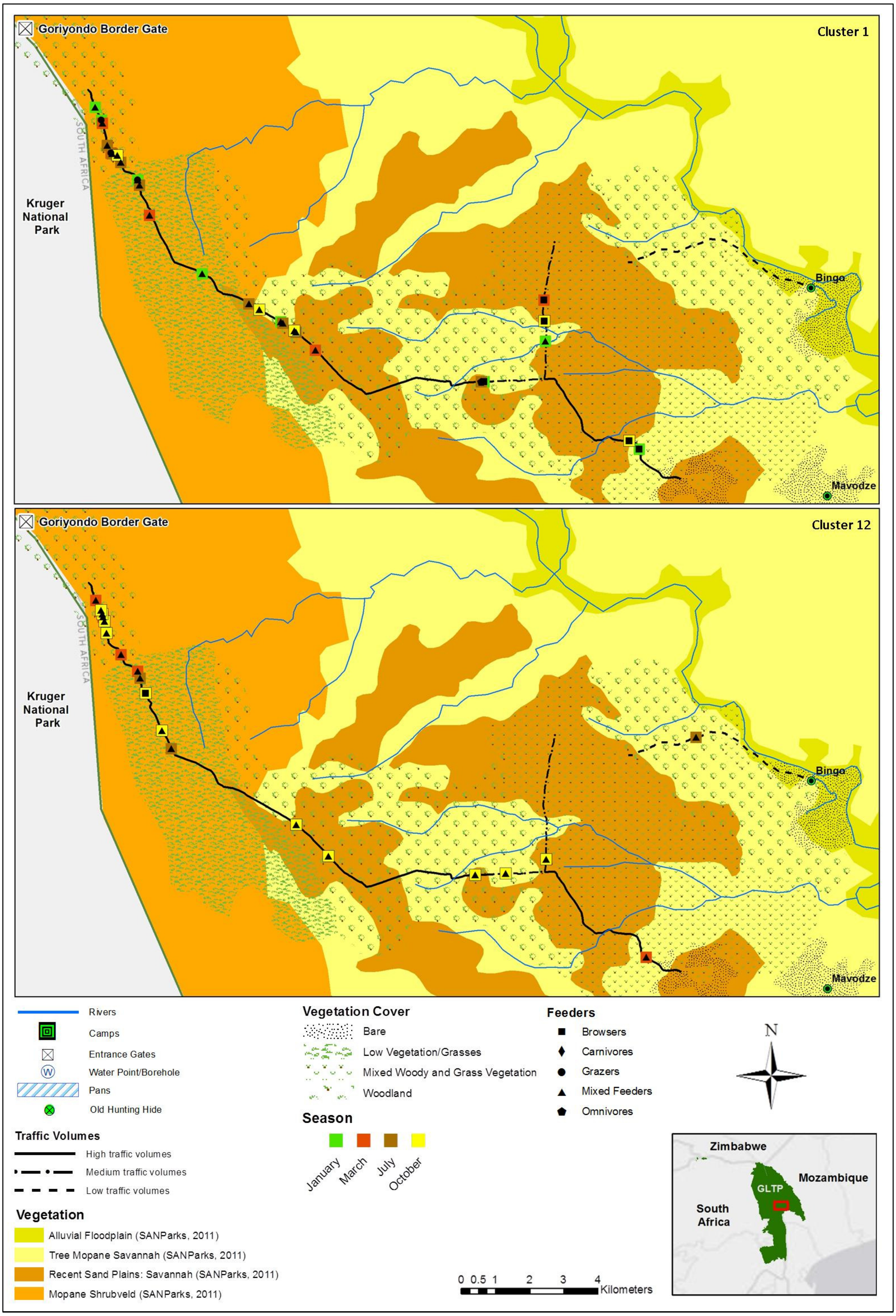

Figure 5.22: Spatial distribution of the various clusters located within the communal land

5.2 Response Behaviour

The second objective of this study was to investigate the response behaviour of the five mammal species in each conservation land use area and compare the results between the four areas as well as within each conservation land use area, between areas of varying extent of human activities. The response behaviour was observed by measuring the initial response index (IRI), from one to four, of an individual or group of individuals at every sighting of the five study species (baboon, buffalo, elephant, impala and zebra). **Table 5.5** provides a description of each response rating. The initial response distance (IRD) was recorded along with the IRI, which was the distance measured between the individual and the vehicle when the IRI value was recorded. In addition to the IRI and IRD being measured, the flight distance was recorded if the individual/s took flight. The flight distance is the distance to which an animal may be approached before it flees. While the IRI accounted for the individual/group of individuals' initial response to the approaching vehicle, and the IRD recorded the distance between the mammal/s and the vehicle at the point that the IRI was measured, the flight distance was measured at any stage if the animal/s took flight as the vehicle continued to approach them.

Table 5.5: Description of each rating of the behavioural response index

Initial Response Rating (IRI)	Description
1	Continued activities without changing behaviour
2	A curious response where individuals are more alert to vehicle
3	A distressed response where individuals show alertness and stop normal activities
4	Immediate flight or fight response

5.2.1 Flight Responses

The flight distances recorded showed considerable differences between the four study areas. Although the private ecotourism concession displayed the most number of times that mammals took flight, this only constituted 6.8% of the total response behaviour sightings. The trophy hunting reserve, on the other hand, showed a higher rate of 26.3%, and the communal land resulted in the highest rate of 33.3%. Conversely, only 5.5% of the response behaviour sightings in the national park resulted in the mammals taking flight. In the same way, the distance at which the mammals took flight differed between the four study areas, with the average flight distance of both the private ecotourism concession and the national park being 37 m, while that of the trophy hunting reserve being 56 m, and that of the communal land 45 m. This indicates that mammals in the trophy hunting reserve and communal land were considerably more anxious during human presence, taking flight more frequently with the approaching vehicle and at further distances from the vehicle than those in the national park and private ecotourism concession.

Figure 5.23 summarises the environmental conditions of the flight distance data within each study area. Impala and baboon appeared to be the most sensitive, making up a high proportion of the species composition, with a high proportion of flight responses occurring in January, mostly in the private ecotourism concession and national park. This heightened sensitivity to human presence at this time may be owing to the high presence of young, causing the herds to be more protective. A very high proportion of flight responses involved sightings with fewer than five individuals, most likely as a result of the mammals feeling more vulnerable when in fewer numbers. Even though only 20% of the response behaviour sightings were approached directly by the vehicle, as opposed to tangentially, a much higher proportion of the flight responses occurred when the mammals were approached directly (**Figure 5.23**). These mammals evidently felt more vulnerable when crossing the road ahead of the vehicle or felt more threatened with the vehicle approaching them directly.

Figure 5.24 displays the spatial distribution of the flight response data across the four conservation land use areas, representing the season, species and flight distance of each recording. The majority of the flight responses recorded in the private ecotourism concession occurred along transects in the western section of the study area, which contained low traffic volumes and steeper terrain. Mammals thus responded more anxiously in areas with less exposure to tourist vehicles, and possibly where they felt more vulnerable on steeper terrain and wooded vegetation. All of the flight responses that took place in the national park were also along transects with low traffic volumes, and during the wet season when many young were likely to be present. The flight responses within the trophy hunting reserve, on the other hand, were widely distributed across the study area and throughout the year. This is contrary to what was expected of this study area, as a higher frequency of flight responses and higher average flight distances were expected during the hunting season, which took place between April and October. Mammals thus remained more skittish around human presence throughout the year and did not recover as expected. The communal land comprised the highest proportion of mammals taking flight, which occurred throughout where mammals were sighted, indicating that these mammals were not well accustomed to passing vehicles, as they generally may avoid areas with human presence. One hundred percent of the sightings were impala, and approximately 80% of these contained less than 10 individuals per sighting. These groups of individuals may have reacted with heightened anxiety as a result of feeling vulnerable when in low numbers.

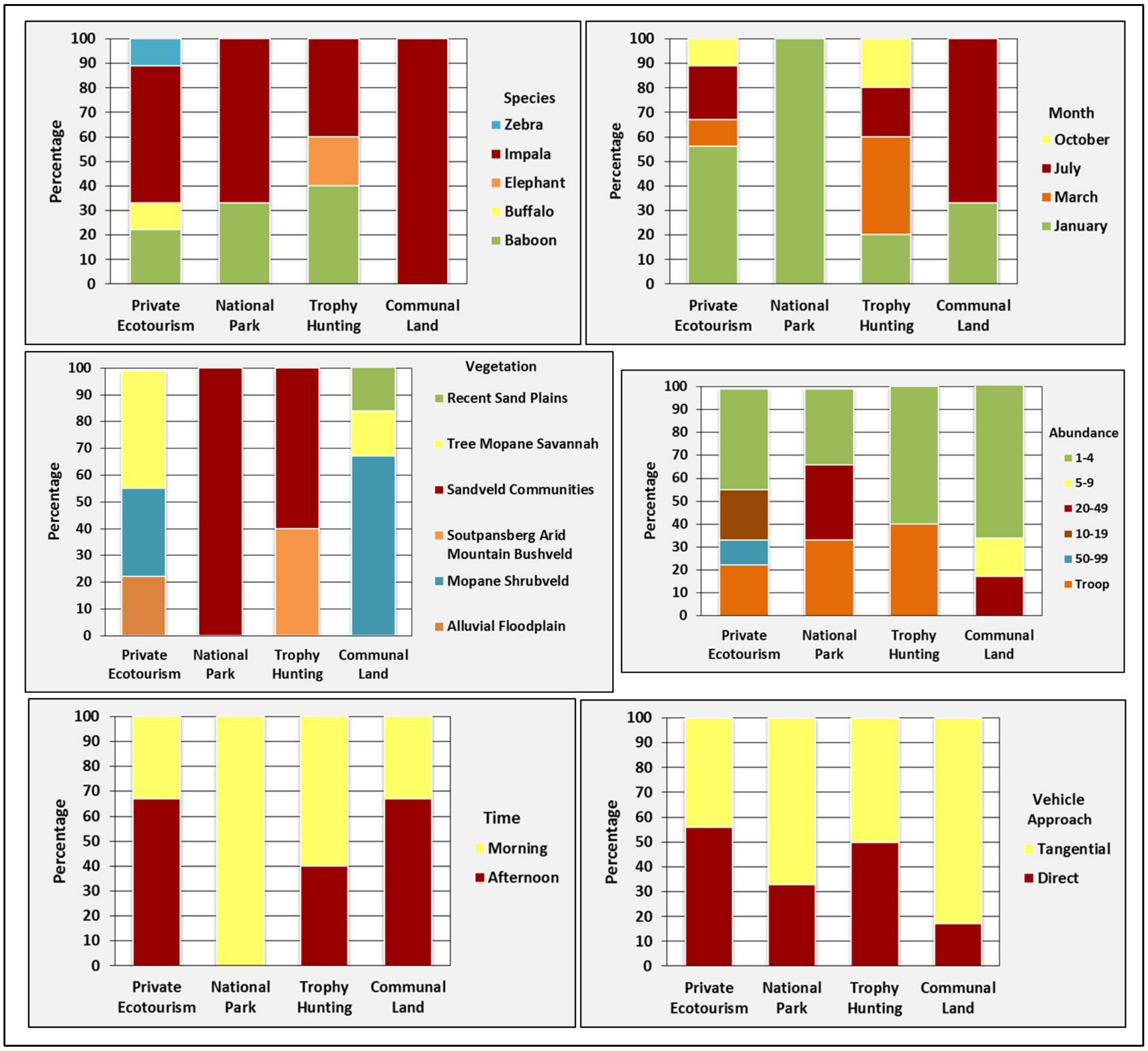

Figure 5.23: Summary graphs displaying the environmental conditions of the flight distance data within each conservation land use area

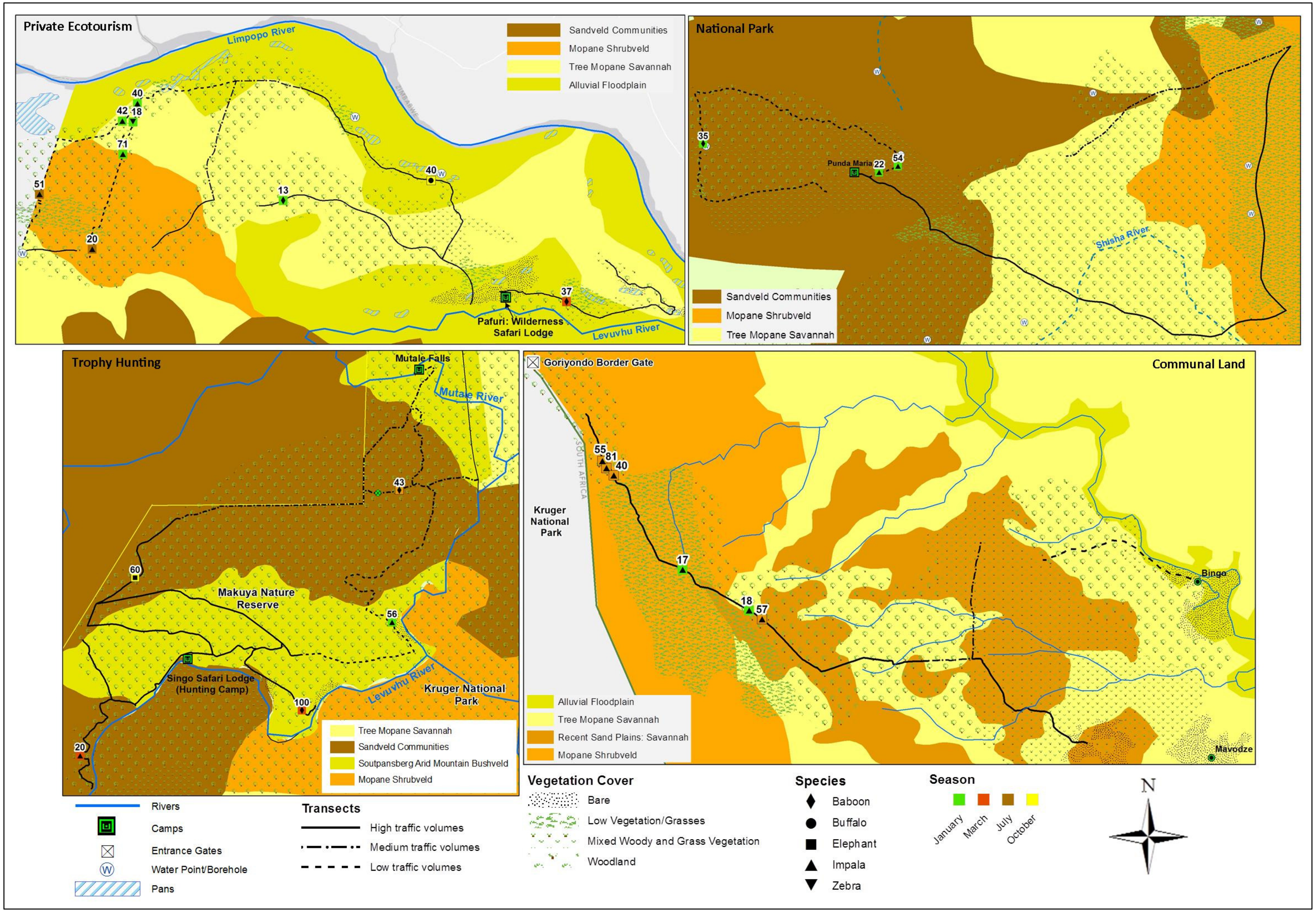

Figure 5.24: Spatial distribution of the flight responses across the four study areas

5.2.2 Gridding and Contouring

In order to compare the general response behaviour of the study species between and within the conservation land use areas, kriging of the initial response index (IRI) and initial response distance (IRD) data was undertaken, so as to investigate visible spatial trends in these values for each study area. It is important to note that because kriging smoothes the data by averaging it out over space, it is useful for highlighting general trends in the data, rather than giving an accurate account of the data. The kriging was overlaid on the topographic data for the area, in order to investigate the influence that the local topography may have had on the response behaviour of the study species. The visibility data that were recorded in the field were also kriged to establish the relationship between the topography of each area and the visibility, which would impact the sighting potential of mammals.

<u>Initial Response Index (IRI)</u>

Figures 5.25 to 5.28 show the kriging results of the IRI values for the four ecotourism areas. As predicted for the private ecotourism concession (**Figure 5.25**), lower IRI values were obtained throughout the study area, demonstrating a general well habituated state. Within the private ecotourism concession, however, there were sections that represented a slightly higher IRI value of 2, thus showing that mammals did not respond uniformly across the study area. These areas with higher IRI values were firstly characterised by changes in the topography, increasing in contour heights from east to west. This was the same area where more flight responses were evident (see **Section 5.2.1**). Steeper terrain may decrease visibility potential, thus increasing the likelihood of suddenly surprising animals with the approaching vehicle, and additionally, animals may feel more vulnerable and confined in such terrain. Furthermore, these transects with higher IRI values were mostly along transects that are seldom used by tourist operators, resulting in mammals not being as well habituated to passing vehicles.

Even though the kriging results for the national park were not as extensive as the ecotourism concession, owing to fewer sightings, the entire ecotourism area was dominated by a low IRI value of 1. This is with the exception of a small area to the north-west of the study area, which displays a slightly higher IRI value of 2 (**Figure 5.26**). These results demonstrate that mammals in the national park are far more accustomed to human presence (i.e. approaching vehicles) than the remaining study areas, even when compared to the private ecotourism concession. As is the case with the ecotourism concession, the topography in the western half of this study area is characterised by sudden changes in contour heights, as the Punda Maria Camp is situated against a hill and the transects in this area make their way around this hill. Despite a couple of higher IRI values of 2, the dominance of low IRI values illustrates that the topography of the land did not significantly impact the response behaviour.

The trophy hunting reserve, in contrast to the previous two study areas, revealed limited areas with low IRI values as low as 1, with the majority of the study area presenting IRI values of 2 and some small areas with even higher IRI values of 3, indicating a general anxious response to the approaching vehicle (**Figure 5.27**). The entire reserve is characterised by rough terrain with high lying areas, steep slopes and varied topography. However, there are a few flatter sections where the river flows between the rocky slopes. The IRI values were generally lower over these flatter sections; potentially as a result of mammals feeling less vulnerable to approaching vehicles, compared to the rocky slopes where visibility is limited. In addition, with no fences and the Kruger National Park on the eastern side of the river, animals along these stretches of the river could easily have crossed over from the national park, and thus be more accustomed to vehicles.

Data were rather limited in the communal area as a result of very few mammal sightings recorded in total; however, the colours that are illustrated from the kriging in **Figure 5.28** are nevertheless useful for comparing the general response behaviour to the other study areas. A varied response was displayed in this ecotourism area, ranging from low IRI values of 1 to very high IRI values of 4. This result indicates that the response behaviour of the mammals in the communal area, despite the limited data available, was far more sensitive to human presence, with some individuals taking flight immediately upon the vehicle approaching. No change in IRI could be observed with changes in topography, as all the kriging was displayed over the same contour height of 350 m.

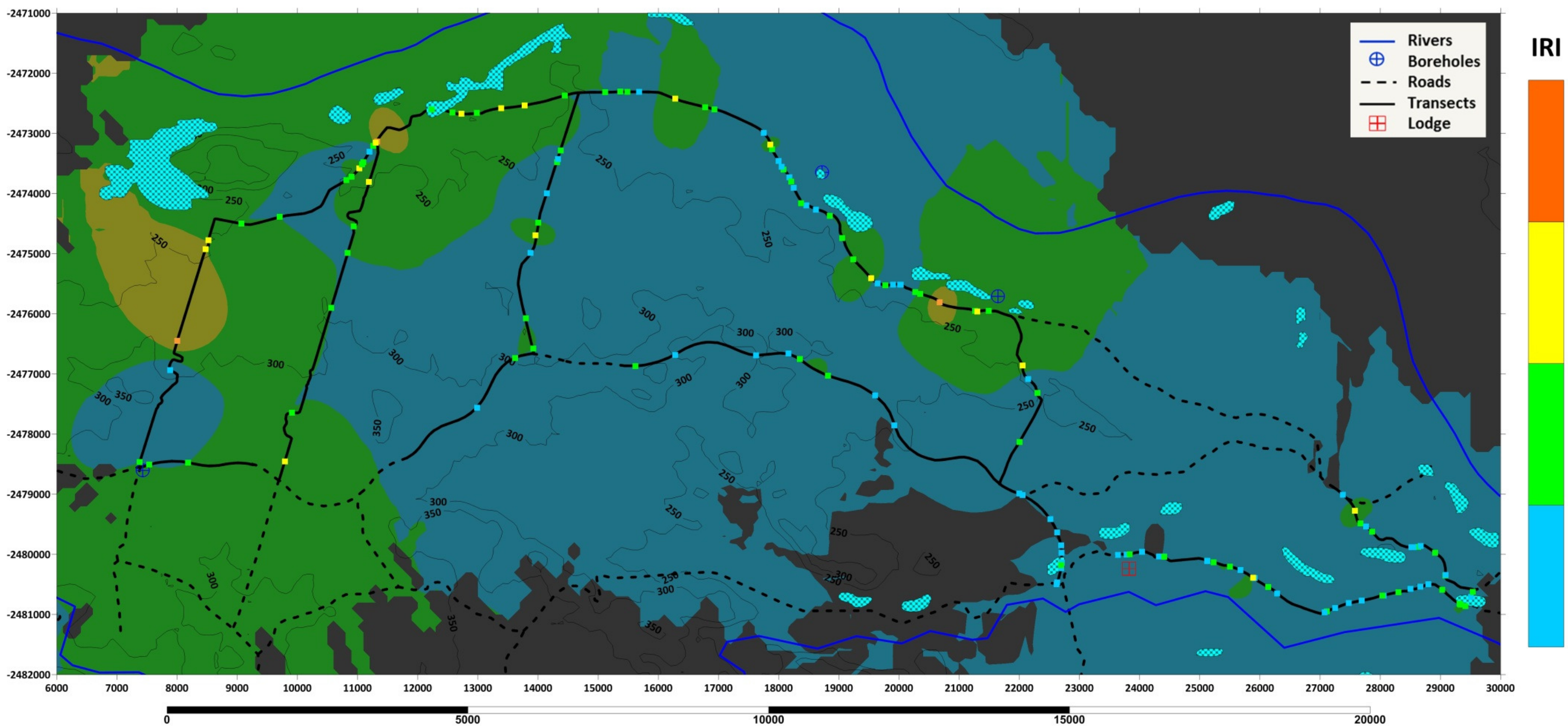

Figure 5.25: Kriging results of the Initial Response Index data of the Private Ecotourism Concession overlaid on contour data. The individual points represent the actual data

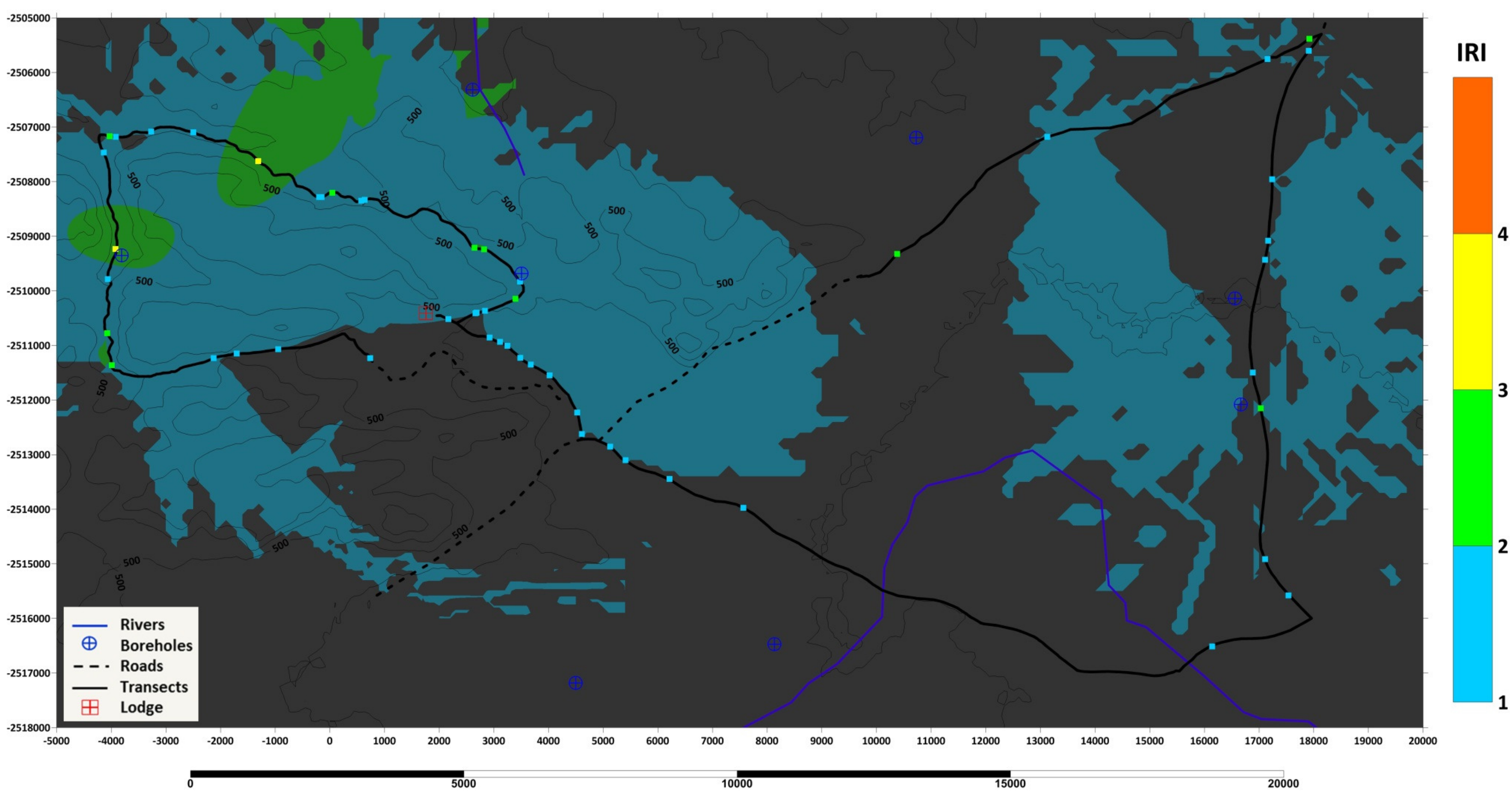

Figure 5.26: Kriging results of the Initial Response Index data of the National Park overlaid on contour data. The individual points represent the actual data

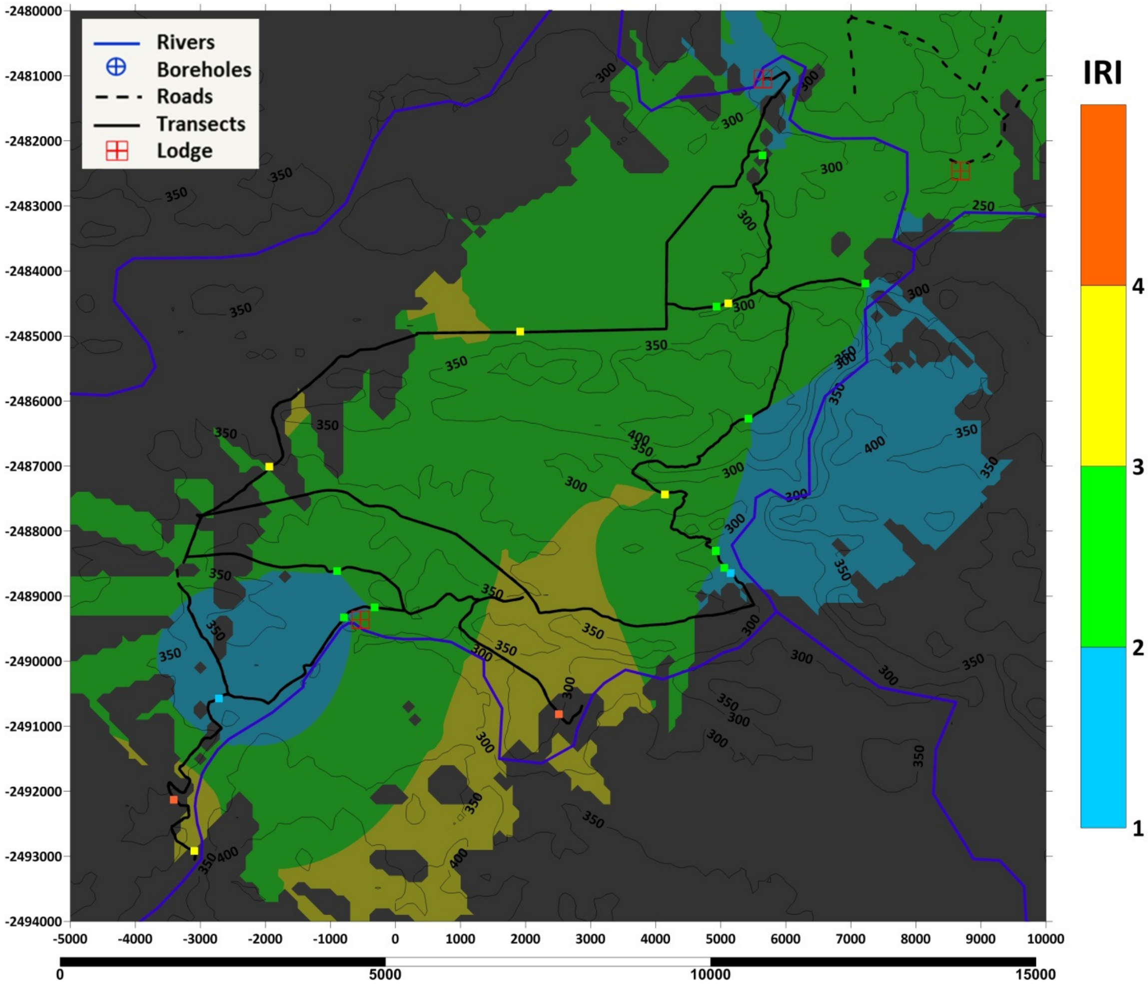

Figure 5.27: Kriging results of the Initial Response Index data of the Trophy Hunting Nature Reserve overlaid on contour data. The individual points represent the actual data

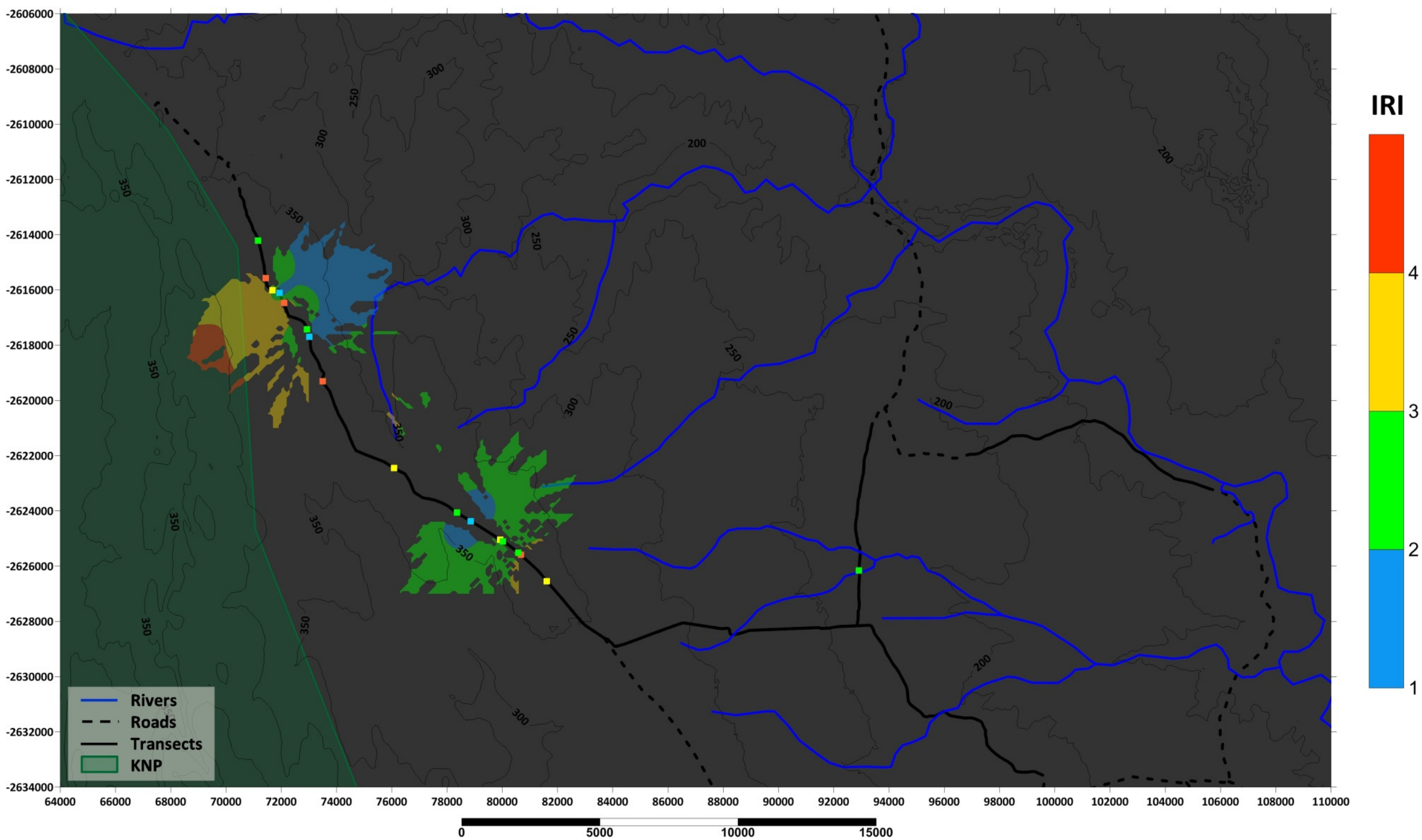

Figure 5.28: Kriging results of the Initial Response Index data of the communal area overlaid on contour data. The individual points represent the actual data

Initial Response Distance (IRD)

The IRD is the distance measurement between the observed animal and the vehicle at the point which the IRI was recorded. Considering the IRD was measured at the point where the observer could see and recognise a response from the observed animal/s, the IRD is likely to have a direct relationship with the visibility of that particular area. **Figures 5.29 and 5.30** represent the kriging results of the IRD data and the visibility consecutively for the private ecotourism concession. Although not an exact match, similar patterns can be seen between these two figures. Areas showing high IRD values and high visibility are found along the floodplain on lower, flatter topography (eastern transects) of both figures. In addition to the flatter topography, the vegetation along the floodplain consists of a lower proportion of woody vegetation with more grass/bare areas, thus resulting in higher visibility potential (refer to **Figure 5.3** for a vegetation map of this study area). Conversely, the low visibility of the western transects is likely to be a result of both a change in topography with higher lying areas and a high proportion of woody vegetation, typically tree mopane savanna and shrubveld. The IRD values also, to some extent, follow the visibility pattern of the western transects; however, generally higher IRD's were recorded than the visibility of the area. The higher IRD values, in conjunction with higher IRI values indicate once again that mammals in this area were displaying more anxious behaviour towards the vehicle.

A very similar pattern is evident between IRD values and visibility for the national park (**Figures 5.31 and 5.32**). Though the IRI values for the entire study area were low, both the IRD and visibility values varied markedly across the study area, displaying higher values along the eastern transects where the topography is low and flat, and low to intermediate values in the western transects where the topography varies with increasing contour heights. The vegetation along the eastern transects was likewise characterised by more grass and shrubbery, while the western transects consisted of more woody vegetation, thus impacting the visibility, and ultimately the IRD values recorded.

The IRD data varied from low to intermediate over the trophy hunting nature reserve (**Figure 5.33**), whereas the visibility values remained low for the entire study area (**Figure 5.34**). These low visibility values are likely a consequence of the varying topography and steep slopes, as mentioned in the previous section, as well as the high proportion of wooded vegetation throughout. The variance in response distance data, however, and higher values than that of visibility, indicate that the observed animals in this ecotourism area were not as well habituated to approaching vehicles. The areas representing high IRD values in **Figure 5.33** (yellow patches), are the same areas where high IRI values were recorded, demonstrating that mammals in this particular area were reacting anxiously from a further distance to the approaching vehicle. In addition to this, three adult lion (two females and a male) were recorded in this area over the July study period and, although their response behaviour was not recorded, as they do not form part of the five study species, it was noted that they were very distressed by the presence of the vehicle. After trying to crouch low to avoid being seen, they took flight after only a short while once the vehicle had stopped. This transect may be a popular choice for hunters during the hunting season as it is in close proximity to the camp and to the river where animals can easily cross over from the Kruger National Park, and this area is somewhat flatter than the surrounding topography, thus allowing for better visibility of animals.

As mentioned previously, data were limited in the communal area as a result of very few mammal sightings recorded. Irrespective, the kriging for the IRD and visibility data displayed very similar patterns (**Figures 5.35 and 5.36**), with higher values recorded further north and lower values further south. Considering that the vegetation cover further north was characterised by grass with a low proportion of woody vegetation, compared to a higher proportion of woody vegetation further south, the higher response distances recorded were most likely owing to visibility, as a further consequence of the vegetation cover.

5.2.3 Cluster Analysis

The response behaviour data were clustered using K-means clustering. As discussed in the previous section, a number of factors need to be taken into account when analysing the response behaviour of the five mammal species in the various ecotourism areas. The purpose of the clustering is to order the observed data into meaningful structures, so as to highlight any trends in the data and influencing variables. The data were grouped into five clusters based on the following variables:

- Species (Baboon, buffalo, elephant, impala and zebra)
- Season (January, March, July and October)
- Time of day (Morning and afternoon)
- Vegetation type (Alluvial floodplain, mopane shrubveld, sandveld communities, recent sand plains, soutpansberg arid mountain bushveld and tree mopane savannah)
- Vegetataion cover (Bare, low vegetation, mixed woody and grass vegetation and woodland)

- Initial response index (IRI)
- Initial response distance (IRD)

Table 5.6 summarises the results of the cluster analysis by providing the percentage make up of each variable for each cluster. This is with the exception of the IRI and IRD data, which provide the mean, minimum and maximum values for each cluster. This is because these two variables consisted of continuous data rather than categorical data, as is the case with all the other variables listed. **Figure 5.37** displays the percentage make up of each variable for each cluster. What is evident from the first graph in **Figure 5.37** is that the majority of each cluster falls within the private ecotourism study area, showing that this study area comprised a variety of response variables to the various influencing factors, such as vegetation type, cover and response behaviour. Similarly, impala dominated the species composition of all five clusters, making up at least 57% of each cluster, and commonly occurring throughout the various conservation land use areas, vegetation types and during all seasons. As discussed by Wronski (2002), these mammals are able to achieve high densities in different vegetation types as they have a varied diet involving grazing and browsing, although they are water dependent and generally remain close to water sources (Estes, 1991). The variables from the remaining graphs that showed a considerable difference between the five clusters included vegetation type, IRI and IRD, indicating that these were important variables in grouping the five clusters (**Figure 5.37**). The following section summarises each cluster and highlights the main trends visible.

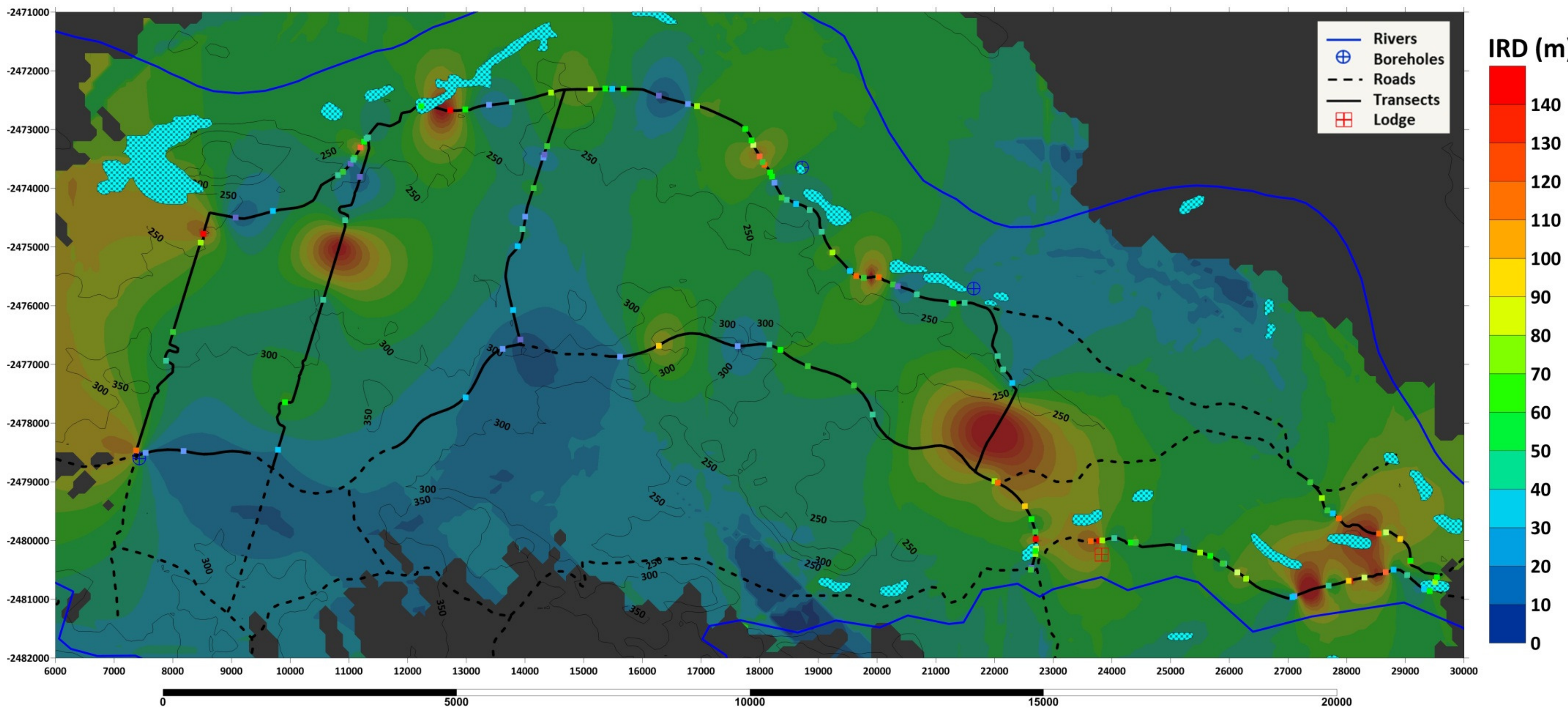

Figure 5.29: Kriging results of the Initial Response Distance data of the Private Ecotourism Concession overlaid on contour data. The individual points represent the actual data

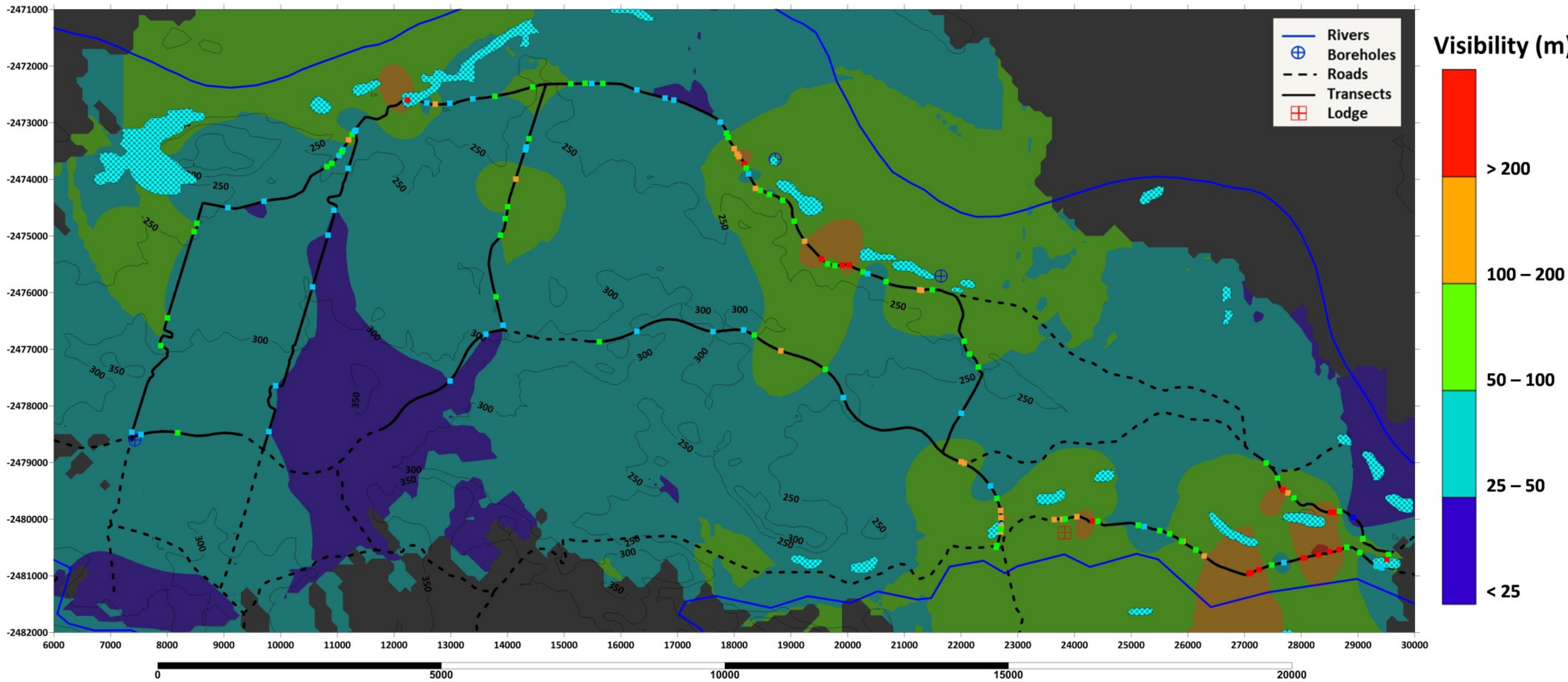

Figure 5.30: Kriging results of the visibility data of the Private Ecotourism Concession overlaid on contour data. The individual points represent the actual data

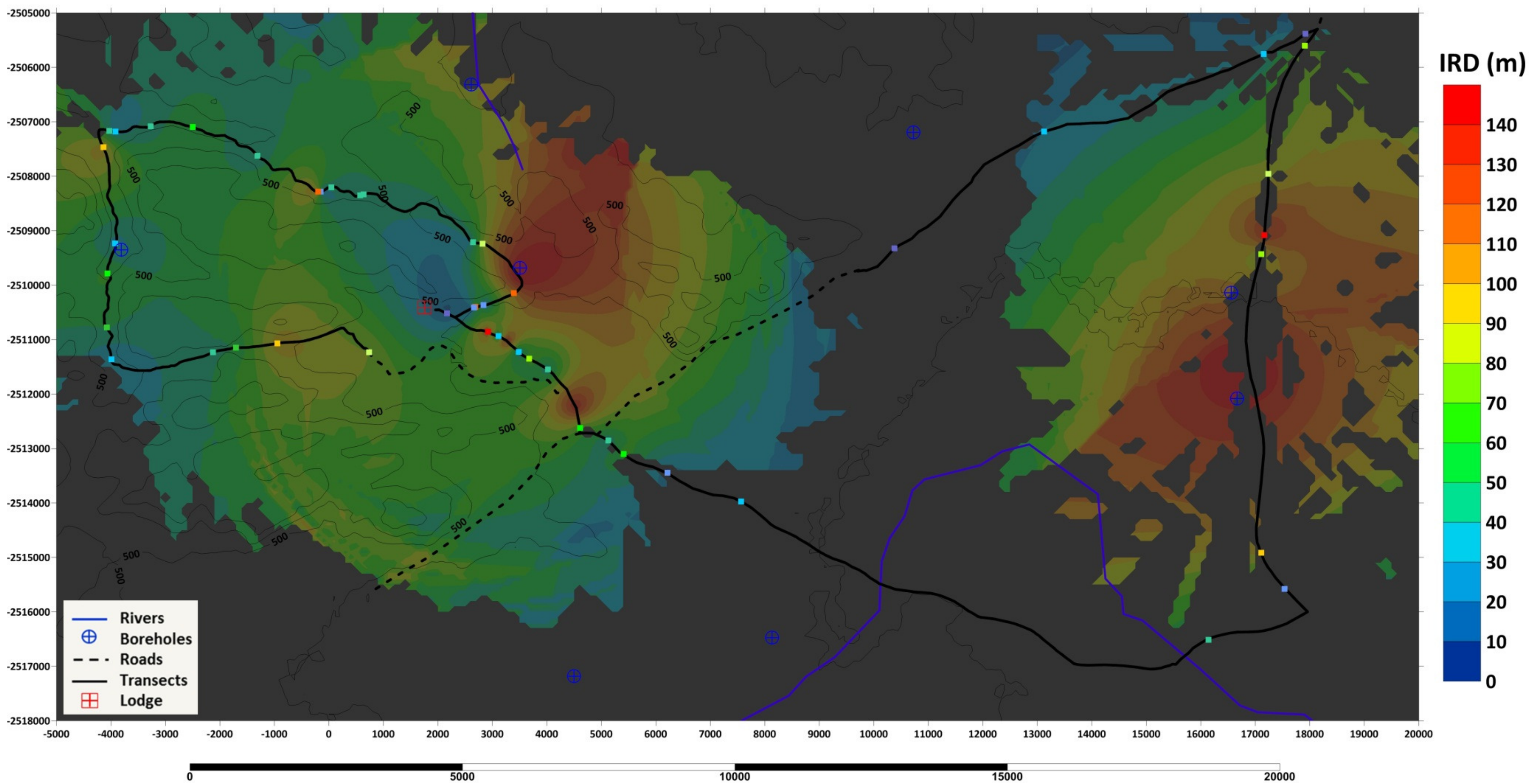

Figure 5.31: Kriging results of the Initial Response Distance data of the national park overlaid on contour data. The individual points represent the actual data

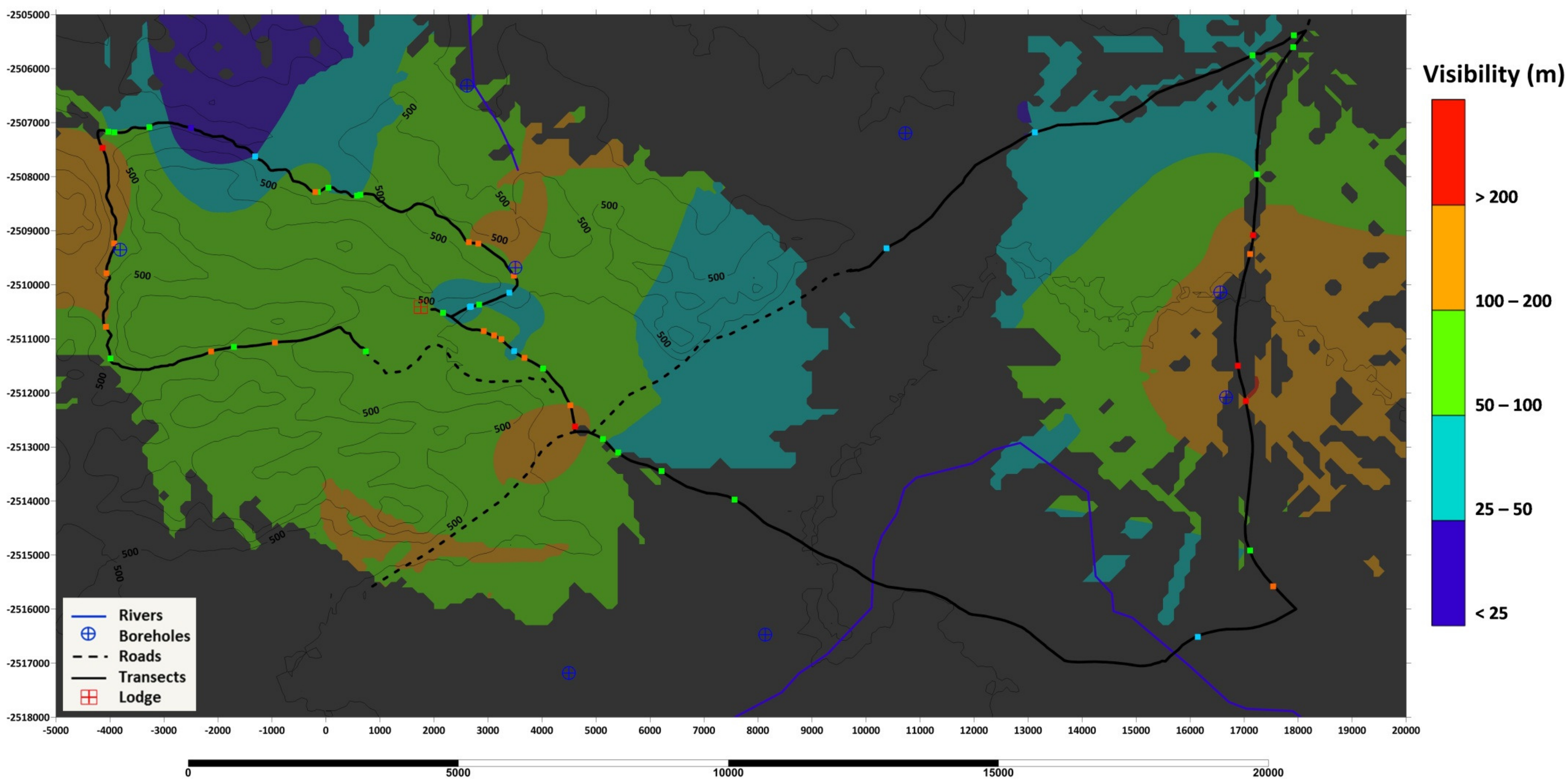

Figure 5.32: Kriging results of the visibility data of the national park overlaid on contour data. The individual points represent the actual data

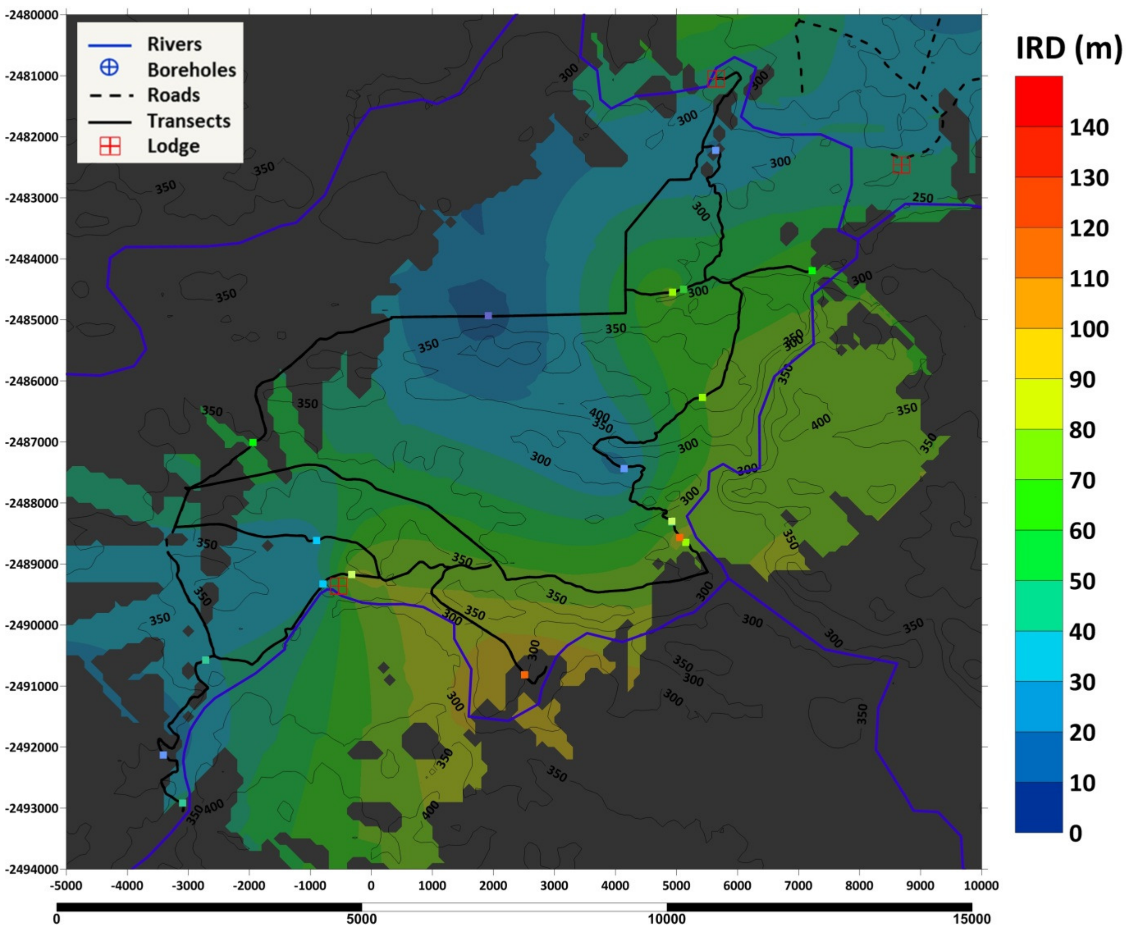

Figure 5.33: Kriging results of the Initial Response Distance data of the trophy hunting nature reserve overlaid on contour data. The individual points represent the actual data

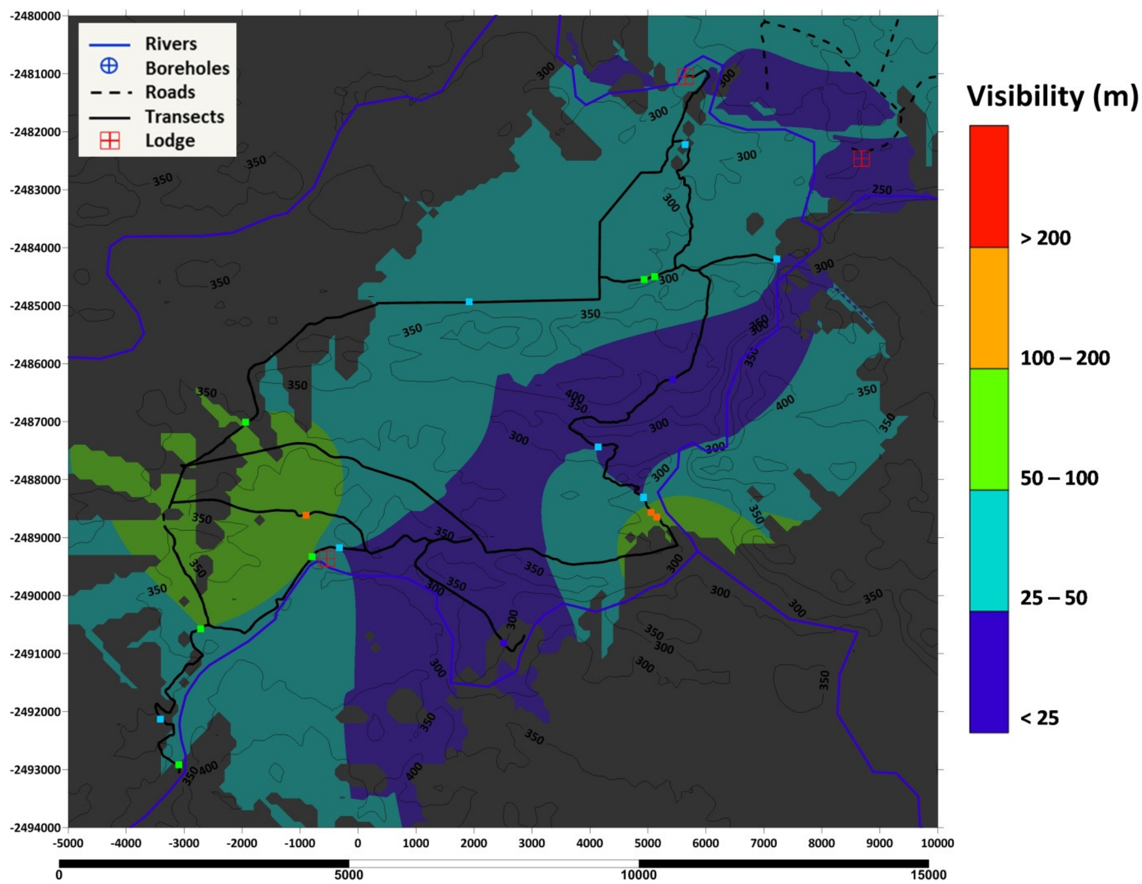

Figure 5.34: Kriging results of the visibility data of the trophy hunting nature reserve overlaid on contour data. The individual points represent the actual data

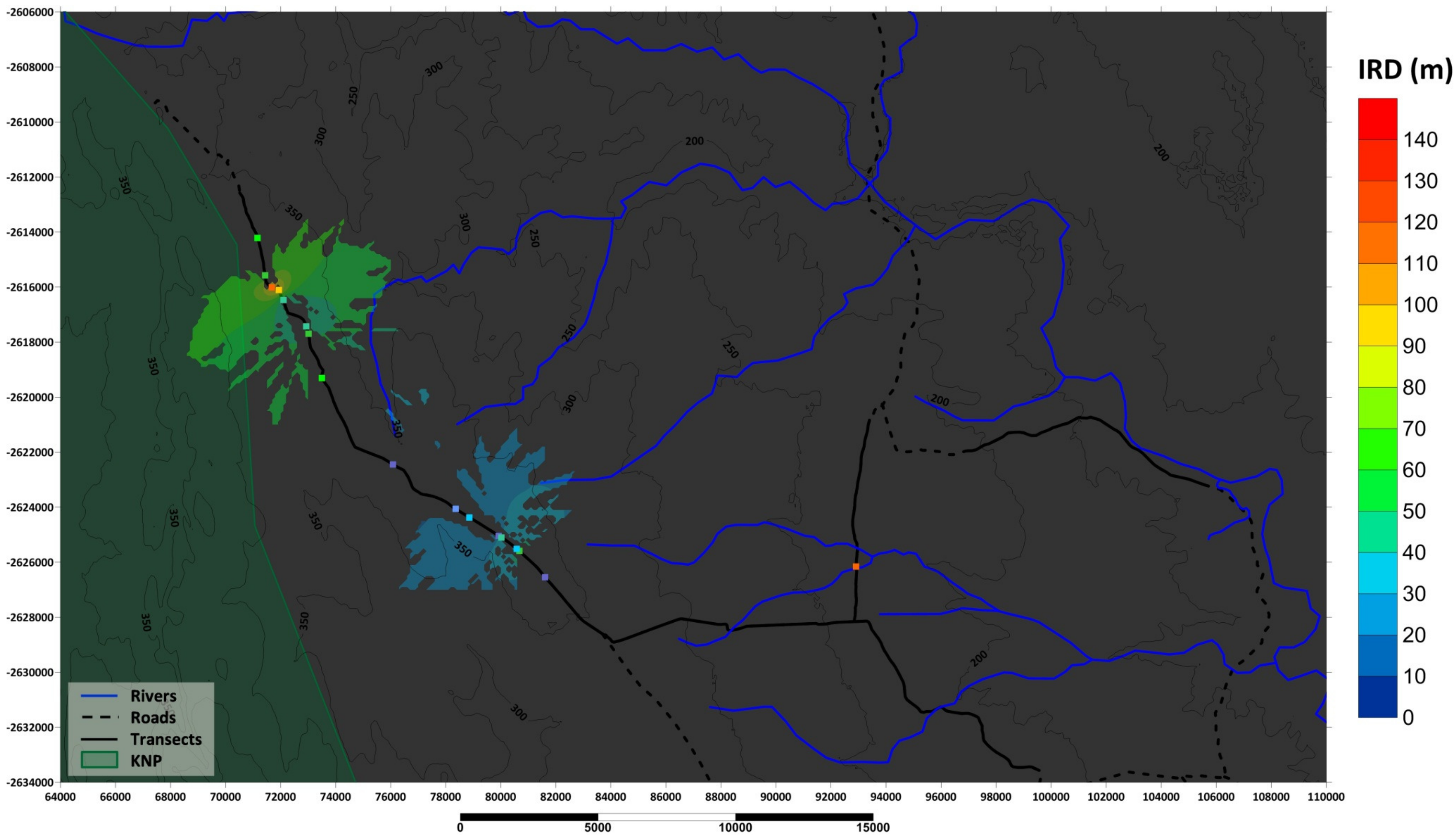

Figure 5.35: Kriging results of the Initial Response Distance data of the communal area overlaid on contour data. The individual points represent the actual data

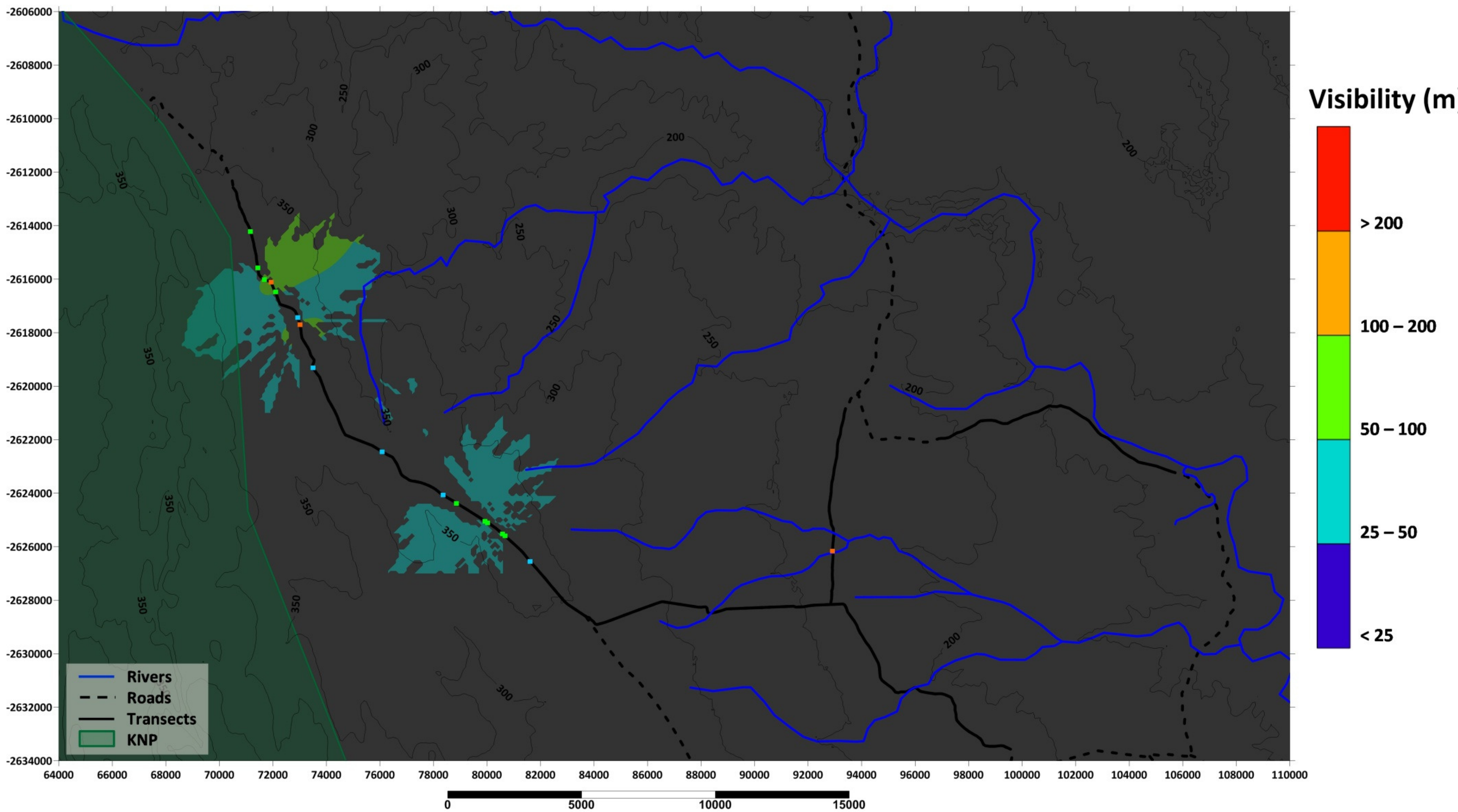

Figure 5.36: Kriging results of the visibility data of the communal area overlaid on contour data. The individual points represent the actual data

Table 5.6: Summary table of the clusters showing the percentage make up of each variable

Cluster	Size	Ecotype (%)				Species (%)					Month (%)				Time (%)	
		Private Ecotourism	National Park	Trophy Hunting	Communal Land	Baboon	Buffalo	Elephant	Impala	Zebra	January	March	July	October	Morning	Afternoon
1	68	60	12	13	15	4	9	10	65	12	29	15	35	21	60	40
2	57	56	39	2	4	7	0	19	68	5	18	21	33	28	74	26
3	14	57	43	0	0	7	0	0	57	36	29	7	29	36	36	64
4	37	59	35	3	3	16	3	14	57	11	30	11	43	16	54	46
5	56	73	5	14	7	13	4	4	70	11	43	18	14	25	55	45

Vegetation (%)						Vegetation Cover (%)				Approach (%)		IRI				IRD			
Alluvial Floodplain	Mopane Shrubveld	Soutpansburg Arid Mountain Bushveld	Sandveld Communities	Tree Mopane Savannah	Recent Sand Plains	Bare	Low	Mixed	Wood	Direct	Tangential	Means	St Dev	Min	Max	Means	St Dev	Min	Max
19	13	3	19	41	4	7	7	9	78	12	87	2.6	1	2	4	35	14	14	74
30	11	0	32	28	0	12	14	18	56	11	89	1.0	0	1	1	42	13	17	64
21	29	0	21	29	0	7	21	50	21	29	71	1.3	0	1	2	161	18	136	190
38	14	3	24	22	0	30	22	27	22	14	86	1.0	0	1	1	91	18	63	126
36	7	11	9	38	0	14	13	32	41	39	61	2.1	0	2	4	74	21	40	129

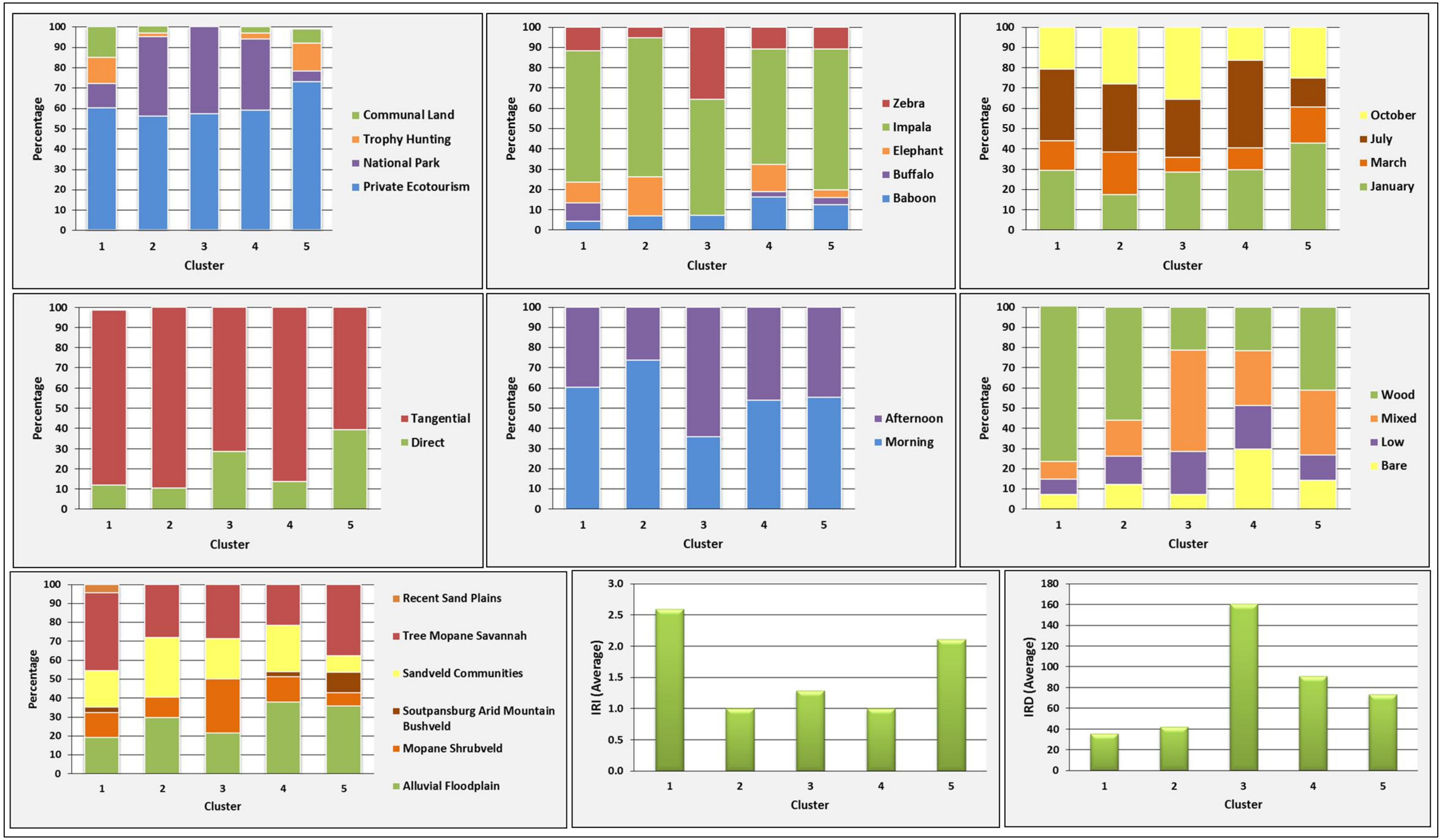

Figure 5.37: Summary graphs showing the composition of each cluster of the various influencing factors

Cluster 1

Cluster 1 consisted of the highest average IRI value of 2.6 (**Figure 5.37**), representing an anxious response behaviour towards human presence. **Figure 5.38** displays the distribution of Cluster 1 sightings across the four study areas. This cluster consisted of a higher proportion of sightings located in the communal land study area, where mammals are not as well habituated to approaching ecotourism vehicles, and to a lesser extent, the trophy hunting reserve. Mammals were mostly distributed along transects in the communal land that comprised high traffic volumes, where tourists travel between the Kruger National Park (Goriyondo Border Gate) and Massingiri Border Gate. This area where animals were located is at the greatest distance from villages and closer to the Kruger National Park. The distribution of sightings within the private ecotourism concession were largely along transects with medium to low traffic volumes, where mammals were not as accustomed to the presence of vehicles. Furthermore, as explained in **Section 5.2.2**, the topography of the western portion of this study area is characterised by steeper terrain and more densely wooded vegetation. Mammals may have thus reacted more anxiously to the vehicle as a result of feeling more vulnerable on the steeper slopes and due to the higher likelihood of being suddenly approached with limited warning of the approaching vehicle. This is supported by the vegetation cover and IRD graph in **Figure 5.37**, showing a very high proportion of wooded vegetation and a low average IRD of 35.5 m.

Cluster 2

A large proportion of Cluster 2 occurred in the national park, with very few sightings recorded in the trophy hunting reserve and communal land (**Figure 5.37**). What stands out about this cluster is the very low IRI of 1, along with a very low average IRD of 41.9 m. This shows well habituated behaviour at closer proximity to the approaching vehicle. Similar to Cluster 1, a large proportion of the vegetation cover was densely wooded (56%), most likely a causal factor of the low IRD. As can be seen in **Figure 5.39**, the distribution of sightings within the national park are largely in close proximity to the Punda Maria Camp, and along the transects mostly used by overnight guests on game drives (as explained in **Section 5.1.1**). It was expected for mammals along these particular transects to be better habituated when compared to the remaining transects, as the latter transects are often used by guests that are using these roads as a thoroughfare between villages outside of the KNP. They generally drive at faster speeds and are less concerned for the surrounding wildlife. Furthermore, the majority of sightings in this cluster were recorded during the dry season, so animals may have been concentrating around this area for better forage quality and where more waterholes are located (**Figure 5.39**). Likewise, the distribution of mammals within the private ecotourism study area was largely concentrated along the Levuvhu River and the floodplain pan network (**Figure 5.39**).

What is also evident from the distribution of mammals in the private ecotourism concession, is that they were mostly found along the transects characterised by high traffic volumes, showing that these mammals that are more accustomed to game drive vehicles, display a calm response behaviour towards human presence.

Cluster 3

Cluster 3 was characterised by a very low number of sightings (14) and none were recorded in the trophy hunting reserve or communal land. This cluster showed to have a much larger proportion of zebra sightings compared to the other clusters and, like Clusters 2 and 4, contained a high proportion of sightings in the national park (**Figure 5.37**). These mammals were mostly recorded in areas with mixed vegetation cover containing both wooded vegetation and grass, and largely in the dry and especially the late dry season. As can be seen in **Figure 5.40**, mammals concentrated around the water holes during the dry season. Although this Cluster displayed a relatively low IRI of 1.3, the average IRD was the highest at 161 m, distinguishing this cluster from the others. The higher proportion of mixed wood and grass vegetation may have resulted in better visibility, and therefore a higher IRD.

Cluster 4

Similar to Clusters 2 and 3, this cluster contained a high proportion of sightings in the national park, second to the private ecotourism concession, with very few sightings recorded in the trophy hunting reserve and communal land. Sixty percent of Cluster 4 sightings were recorded in the dry season and a large proportion (30%) of sightings were recorded along the alluvial floodplain, closer to water and better forage (**Figure 5.41**). Although mammals in Cluster 4 displayed well habituated behaviour, with a low average IRI of 1, the average IRD was relatively high (91 m). This is most likely due to increased visibility as a result of the vegetation being sparser during the dry season, as well as the vegetation along the alluvial floodplain comprising a high proportion of bare areas.

Cluster 5

Cluster 5 consisted of the second highest average IRI rating of 2.1, demonstrating more anxious response behaviour. Although 73% of this cluster occurred in the private ecotourism concession, a higher proportion of sightings were located in the trophy hunting reserve (14%), with a very small proportion located in the national park (5%). Furthermore, the average IRD of the mammals in this cluster was relatively high (74 m), showing that these mammals responded anxiously to the approaching vehicle from a relatively far distance away. This type of response was anticipated from the trophy hunting reserve, as a result of these mammals being exposed to hunting. As was the case with Cluster 1, a higher proportion of sightings within the private ecotourism concession were distributed along transects with lower traffic volumes, and the rest were concentrated around the rivers and pan network (**Figure 5.42**). Once again, these mammals along the transects with lower traffic volumes were not as well habituated to human presence, and the rocky and steep terrain may have resulted in animals feeling more vulnerable, as they are not able to escape as easily on such terrain, thus resulting in more anxious behaviour. The majority of sightings were recorded during the wet season (January), as well as the late dry season (October). Since many antelope, such as impala, give birth to their young in the early wet season (between November and December), October is a time when they give birth, and January is a time when many young lambs are present. This may have contributed to the higher IRI's at higher IRD's, as these mammals are more cautious and protective at this time when their young are very vulnerable to predators.

5.2.3.1 Study Species

With 151 sightings in total, impala dominated the sightings across all the clusters. This high sample size is an advantage as it allows for a more accurate representation of the population. Even though they dominated the sightings across all the clusters, they were most dominant in Clusters 1 and 2. Impala were most commonly sighted in January in mopane tree savannah and along the alluvial floodplains, and similarly, in thick wooded areas and bare areas. Impala varied in their response behaviour, showing well habituated response behaviour in Cluster 2, as opposed to more anxious responses seen in Cluster 1.

Baboons predominantly occurred in the private ecotourism concession and were absent from the communal land. They showed a preference for the wooded areas such as the tree mopane savannah, but were also common along alluvial floodplains in bare areas close to water. Baboons were most dominant in Clusters 4 and 5. They varied in their response behaviour from being well habituated in Cluster 4 along well used tourist roads in the ecotourism concession, to a highly anxious and suspicious awareness of vehicles in Cluster 5, mostly occurring in the trophy hunting reserve.

Buffalo made up a small percentage of the sightings with only nine sightings in total (less than 4%). They were most common in the private ecotourism concession and trophy hunting reserve, with 77.8% of the sightings during the dry season. Buffalo were most commonly found in wooded areas such as tree mopane savannah, but were also common along alluvial floodplains. The general response behaviour of these mammals was one of nervousness towards human presence. The majority (55.6%) of response index ratings were 3 and the average response distance measurement was 55 m. As described by Emmett (2012), these mammals are known for their formidable and inquisitive nature, suspiciously responding to any approaching object, such as a vehicle. In addition, a high proportion of the sightings were recorded in the trophy hunting reserve where they are targeted by hunters.

Elephant were predominantly sighted in the private ecotourism area and the national park, but were not common in the trophy hunting reserve or the communal area. This mammal was most dominant in Clusters 2 and 4, and predominantly occurred during the dry season with 80% of the total elephant sightings being recorded between July and October. Elephants were commonly sighted in the national park and responded calmly to the approaching vehicle throughout, displaying IRI's of 1 at a moderate average response distance of 53.4 m. However, as mentioned previously, Cluster 1 individuals displayed an anxious response with IRI's of 3 and 4, and an average response distance of 35 m. Cluster 1 elephant mostly occurred in the private ecotourism concession along roads with high traffic volumes. Although Cluster 1 did not make up a large percentage of the total elephant sightings, this was an unusual finding for the private ecotourism concession, as the general trend for this area showed calm and well habituated behaviour. The low average response distance may indicate that these individuals were not well aware of the approaching vehicle and may have been suddenly surprised and thus reacted anxiously. Additionally, as stated previously, the Makuleke Concession borders both Zimbabwe and Mozambique where poaching is less controlled. Elephants frequently wander beyond the Kruger National Park boundaries in search of better resources and then wander back, sometimes injured from snares or land mines. Experiences they might have had in the past may still affect their behaviour towards human presence. Further to this, the group dynamics of all elephant sightings that were recorded along transects in the private ecotourism concession and trophy hunting reserve were bachelors and no breeding herds were recorded. This is despite the presence of large perennial rivers in both of these ecotourism areas. This may indicate that the breeding herds were more shy and preferred to stay out of human sight. This could be owing to past experiences with humans in this area, and the behaviour being learnt and passed down between generations, or from more recent interactions in and around the area.

Zebra occurred throughout most of the clusters in small proportions, with the exception of Cluster 3 which contained a higher proportion, and they mostly occurred in low lying areas close to water sources. Although the response behaviour of this mammal seemed relatively well habituated with IRI's of 1 and 2, the response distance was generally quite far (average of 156 m), most likely as a result of the flat low lying areas having a high visibility potential. Zebra were most common in the private ecotourism concession and the national park, but not common in the communal land and did not occur in the trophy hunting reserve.

This may be due to the high gradient and steep slopes of the hunting reserve, which is not ideal for this grazing mammal.

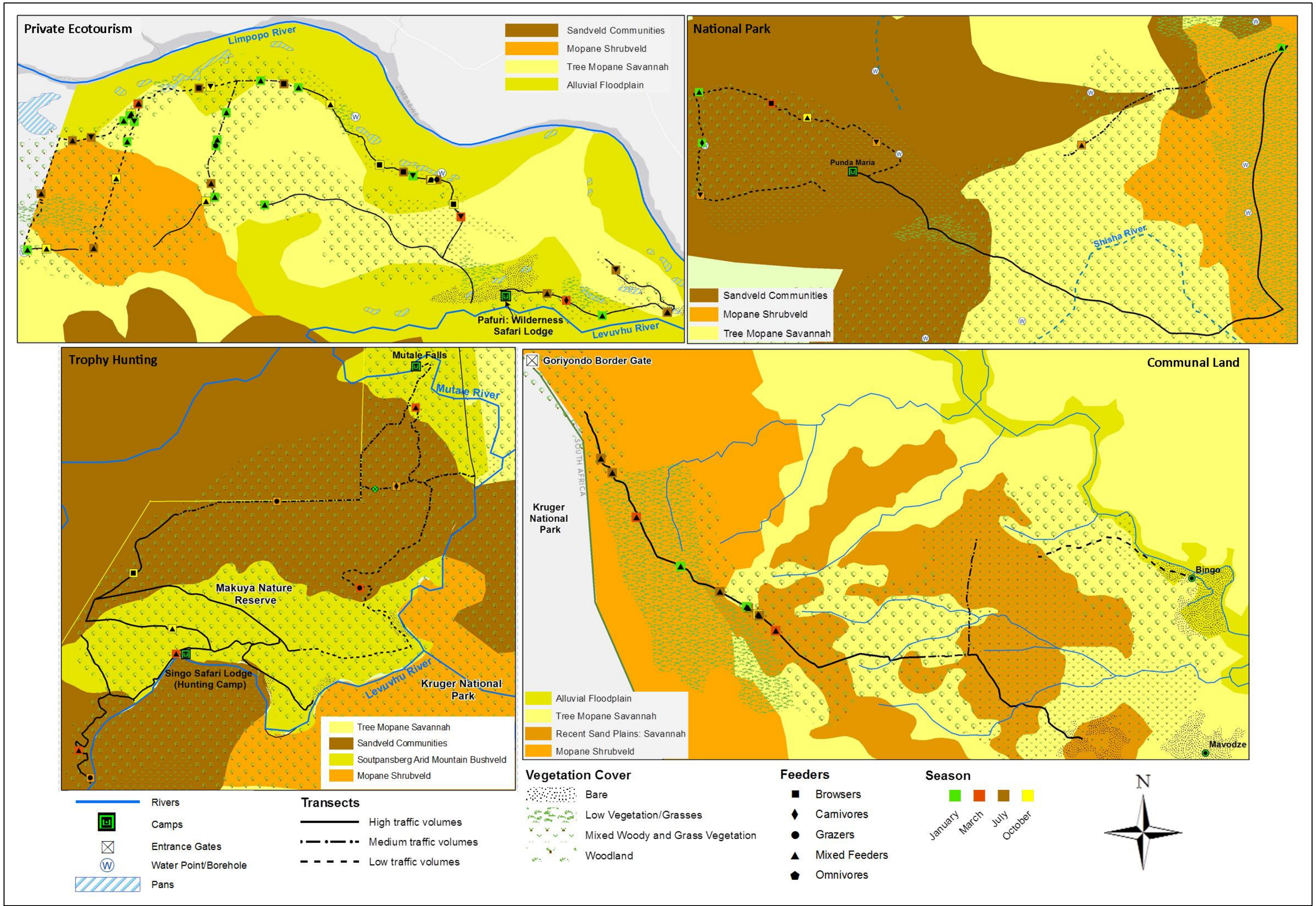

Figure 5.38: Cluster 1 summary maps showing the distribution of sightings across the four study areas

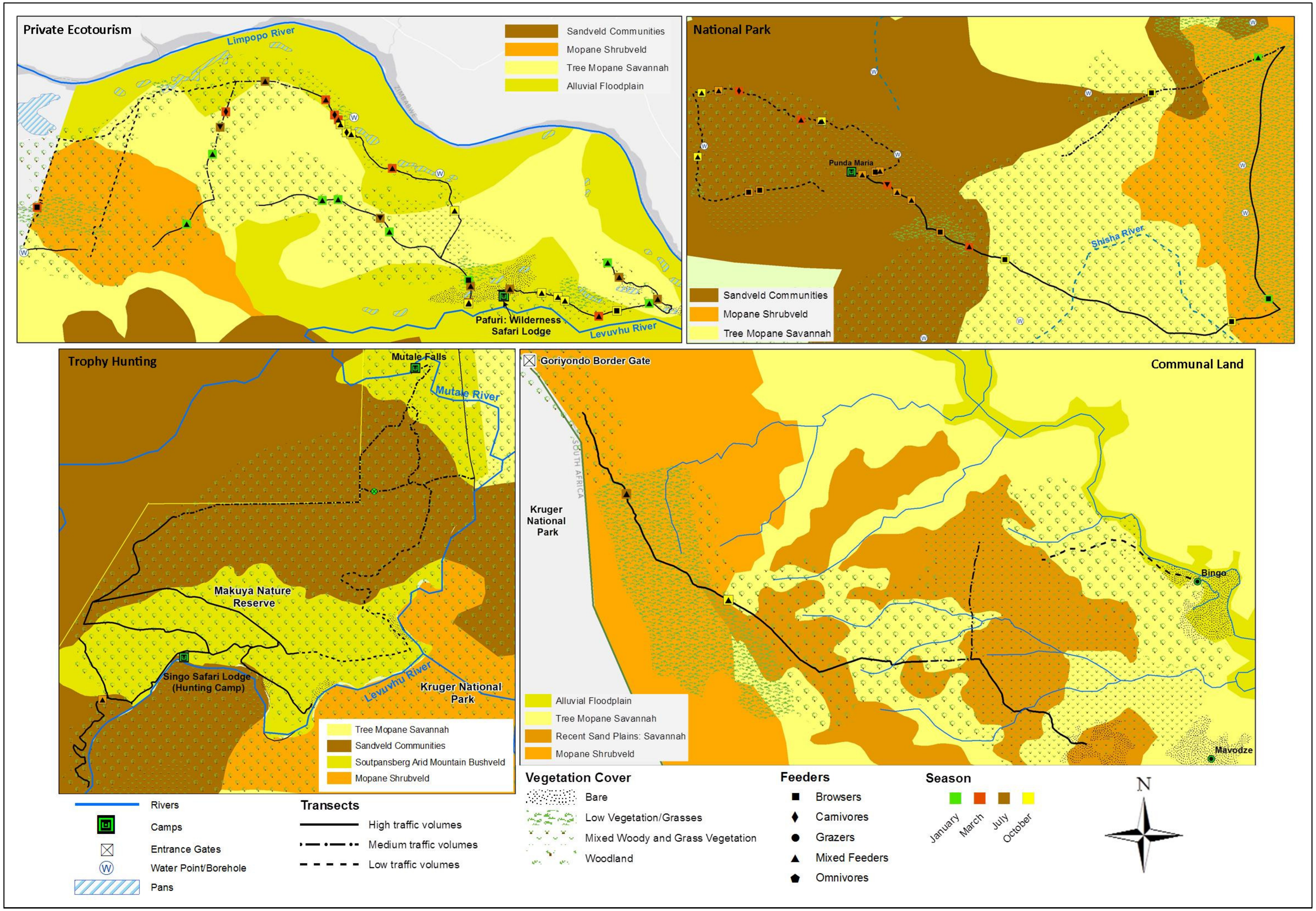

Figure 5.39: Cluster 2 summary maps showing the distribution of sightings across the four study areas

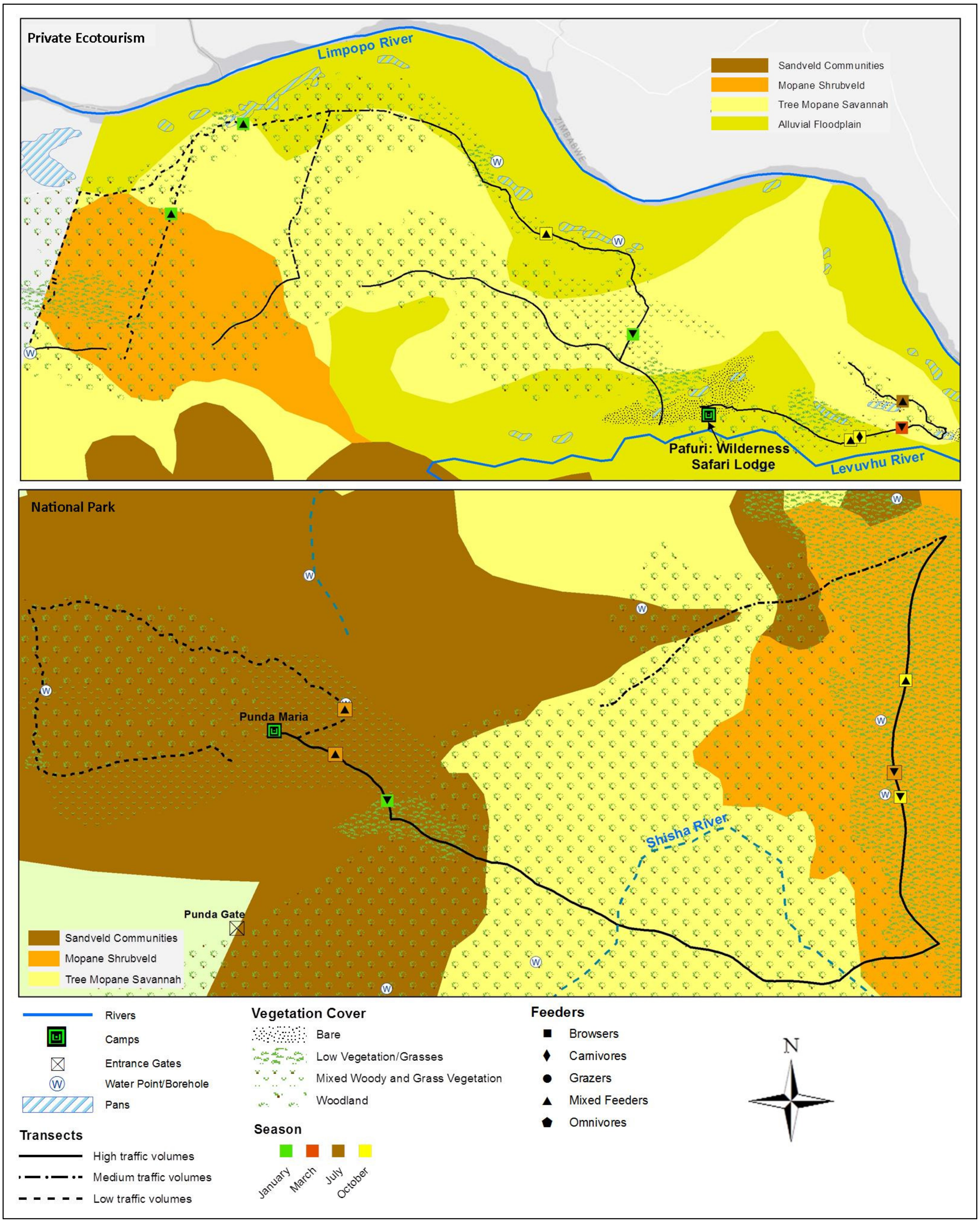

Figure 5.40: Cluster 3 summary maps showing the distribution of sightings across the four study areas

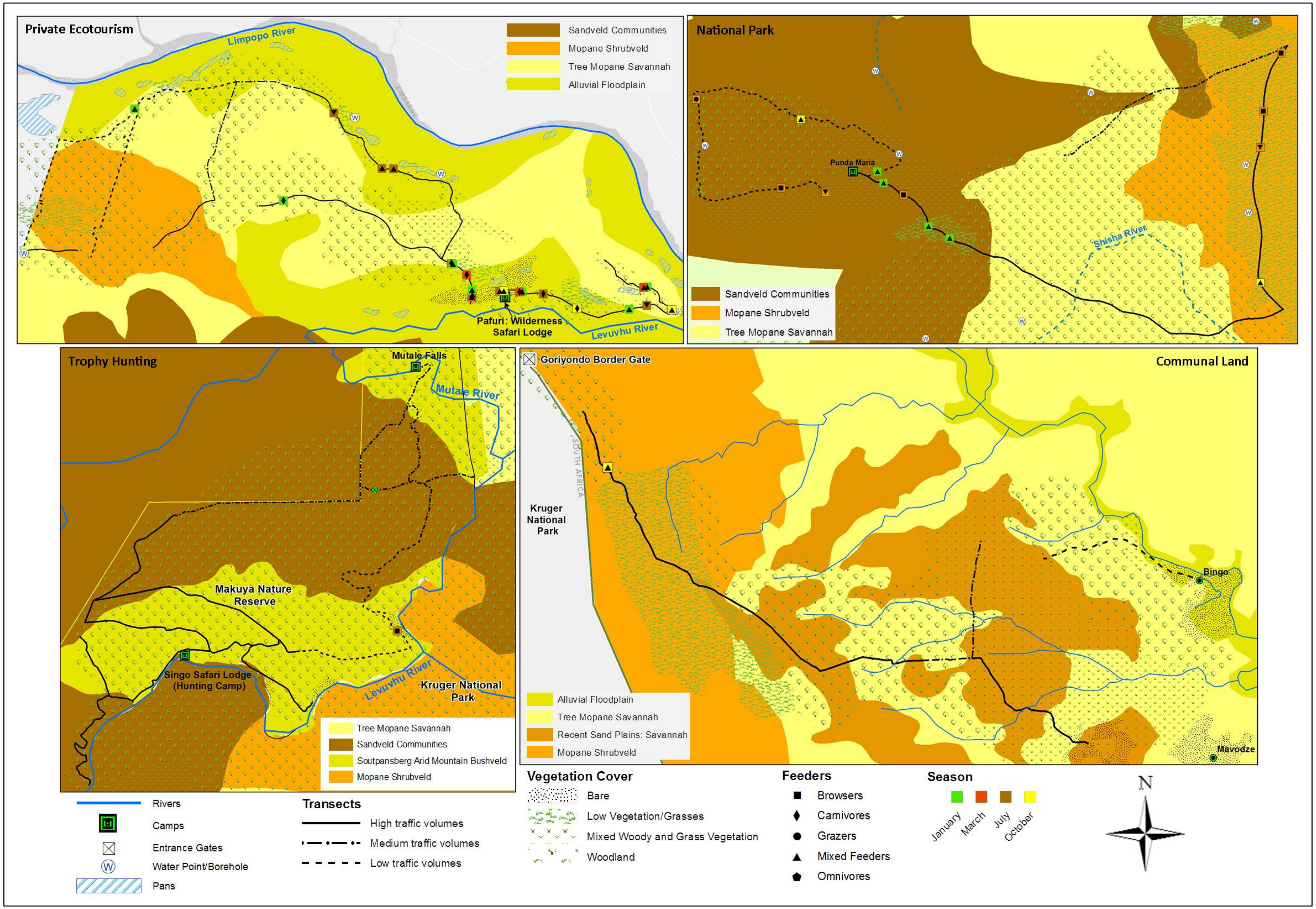

Figure 5.41: Cluster 4 summary maps showing the distribution of sightings across the four study areas

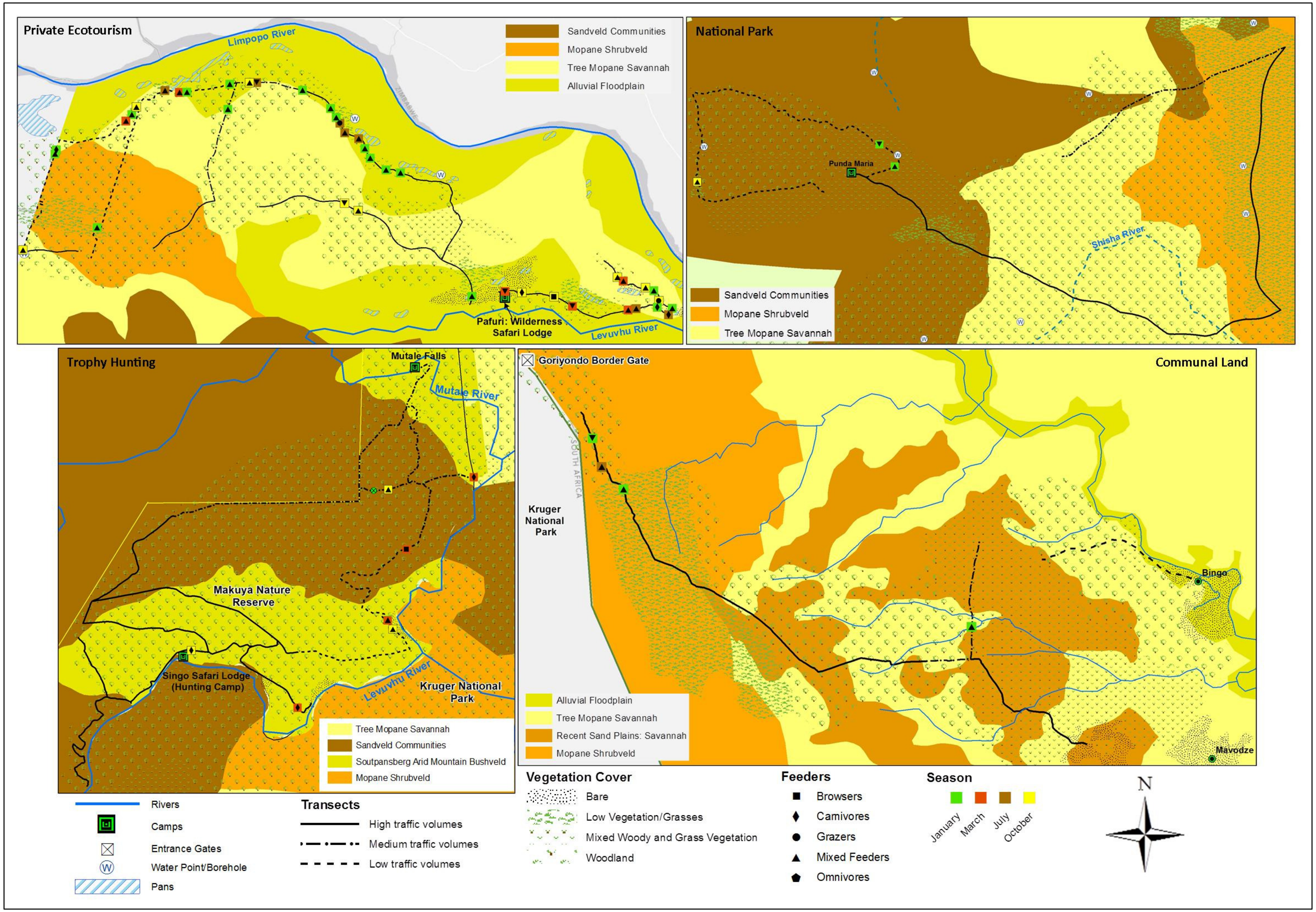

Figure 5.42: Cluster 5 summary maps showing the distribution of sightings across the four study areas

CHAPTER 6: DISCUSSION

Although the four conservation land use areas investigated in this study form part of one transfrontier conservation area, each one differs considerably in past and current management practices. This study aimed to determine whether these differences in management practices had implications on the distribution of mammals across the study area and their response behaviour towards game viewing vehicles. This study investigated the spatial variance of mammal sightings (frequency and diversity) and their response behaviour between the various conservation land use areas, as well as the spatial variance within each conservation land use area. In addition, this study was carried out over the various seasons, in order to take into account the impacts of influencing variables such as climate, breeding season, hunting season, etc.

6.1 Spatial Variation

Throughout the study period, the mammal diversity and frequency of mammal sightings were the highest in the private ecotourism concession, followed by the national park, and then the trophy hunting reserve and communal land. The behavioural responses displayed by the five study mammals also varied considerably between the four conservation land use areas, with the lowest IRI's and least number of flight responses occurring in the national park, followed by the private ecotourism concession, and conversely, a higher average IRI and a greater occurrence of flight responses occurring in the trophy hunting reserve and communal land. This is in line with what was hypothesized for this study, indicating that the two conservation land use areas primarily used for photographic tourism had the least negative impacts on mammals and their response behaviour when compared to the two conservation land use areas that contain hunting, poaching and human wildlife conflict. This is also in line with findings from previous studies that compared un-hunted protected areas with hunting areas. Similar to the findings by Bahrend and Lubeck (1968), a greater frequency of mammal sightings was observed and shorter average flight distances occurred in the study areas where no hunting took place (private ecotourism concession and national park), than in the trophy hunting reserve. Further to this, the study compared these aforementioned conservation land use areas to communal land, which has not been as widely covered in previous literature due to a focus on the impacts of hunting. As hypothesized, the communal land showed similar trends to that of the trophy hunting reserve, with less frequent mammal sightings and more anxious response behaviour displayed by the five study mammals.

Within each study area, spatial variance was also evident with regards to both mammal sightings and their response behaviour. This could be attributed to three key influencing factors. The availability of resources, such as vegetation and particularly water resources, played a critical role in the distribution of mammals within each study area, with the majority of mammals occurring in close proximity to rivers or water holes/pans, and within a particular vegetation type. In the case of the communal land, mammals only occurred in areas where there was denser vegetation as a result of being further away from the villages, where the land was not disturbed by overgrazing and deforestation. The second influencing factor that differed across each conservation land use area, particularly in the private ecotourism concession, national park and communal land, was the level of human disturbance. Transects with higher traffic volumes were characterised by a higher frequency of mammal sightings, a lower average IRI and fewer flight responses. This suggests that habituation transpires with the repeated occurrence of benign human disturbances, such as passing tourist vehicles. Although the lower traffic volumes in the national park, in the western section, also yielded slightly higher IRI's with more flight responses, it was initially anticipated that in this case habituation would be more prominent in these areas than along the main roads with high traffic volumes. This is because, as discussed in **Section 5.1.1**, the main roads with high traffic volumes are commonly used as a thoroughfare rather than for game viewing, resulting in guests driving at higher speeds with less concern for the surrounding wildlife. It was thus hypothesized that mammals would react more anxiously along these transects than those that are primarily used by overnight guests. Seemingly, mammals have not been negatively impacted by the road users in this area and have become habituated to such disturbances. While Green and Giese (2004) acknowledge that frequent, non-threatening exposure to a stimulus can result in apparent habituation, there may still be long term effects that are not as obvious. Longer term studies on community structure would need to be carried out in order to determine the negative impacts on mammals. From an ecotourism point of view, the areas frequented by tourist vehicles yielded better viewing opportunities of mammals than those less frequented by tourists. The trophy hunting reserve did not show any obvious spatial behavioural response patterns, with higher average IRI's and flight responses occurring throughout the study area. This may be as a result of lower traffic volumes across the entire conservation land use area, as well as the widespread impact of hunting. The third factor to be considered, particularly within the private ecotourism concession and trophy hunting reserve, was the terrain and gradient of the land, as well as the vegetation structure, with steeper rocky slopes resulting in fewer mammal sightings and more anxious response behaviour. This may firstly affect the visibility of the area, resulting in mammals being less aware of the approaching vehicle and increasing the chance of surprising them. Secondly, this sort of terrain may cause mammals to feel more vulnerable with less opportunity to escape, resulting in a more anxious response. Not many studies have been conducted on the effects of terrain on the response behaviour of wildlife; however, Green and Giese (2004) concede that habitat features do affect responses. For example, a study on water birds in Thailand demonstrated how flight distances were greater in open water where they were more exposed, than in reed beds or amongst other vegetation (Green and Giese, 2004). According to Taylor and Knight (2003b), the response behaviour of animals is significantly influenced by the encounter distance, which is the distance at which a human/vehicle becomes visible to an animal. These three influencing factors are not mutually exclusive and work together, along with a number of other environmental factors which influence where mammals occur and how they respond to human presence.

6.2 Seasonal Variation

There was a similar seasonal pattern evident among the various conservation land use areas and it was clear that seasonal variation of climate had both direct impacts on mammal sightings and indirect impacts. Exceptionally high temperatures (>35°C) seemed to negatively impact the sighting potential of mammals, as they remained inactive and out of sight for large portions of the day. Higher rainfall during the wet season also seemed to negatively impact on the frequency of mammal sightings as a result of mammals not being required to remain as close to water sources. Conversely, mammal sightings increased across all conservation land use areas over the dry season, most likely as a result of mammals remaining in close proximity to water sources. Indirectly, seasonal changes in climate impacted on the vegetation cover, thus affecting the visibility potential of each study area and the forage availability. An increase in mammal presence around water sources may also be due to better forage availability around these areas compared to elsewhere. On the other hand, the general increase in sightings over the dry season in less favourable areas such as steeper slopes and in the trophy hunting reserve may be as a result of some mammals travelling further and changing their forage preferences when nothing else is available. Smit *et al*. (2007b) demonstrated in a study on elephant resource utilization that male elephants travelled further away from water resources and had a higher tolerance for low quality food during the dry season, and thus had a far larger home range than female herds that remained close to water and abundant tree cover. Furthermore, even though zebra are primarily grazers, they are known to browse and may occur on steeper slopes than usual during the dry season when resources are limited (Emmett, 2012).

Considering that hunting in the trophy hunting reserve takes place during the dry season, from April to October, it was hypothesized that the number of mammal sightings and the response behaviour of the five study mammals would vary seasonally as well. To this end, it was anticipated that the frequency of mammal sightings would be the lowest over the dry season; however, mammal sightings generally increased over this period and were the lowest during March, just before the hunting season commenced. Similarly, the five study mammals did not display more anxious response behaviour over the dry season, also displaying more flight responses during March. The challenge for this study was the difficulty to establish the intensity of hunting that took place over the period of the study, as no hunting quotas were released publicly after the community tried to stop hunting in the reserve in 2010. From what was apparent through questions asked, very low numbers of game were hunted in 2011, potentially explaining why no evident seasonal pattern transpired as was anticipated. In addition, more mammals may cross the Levuvhu River from the Kruger National Park during the dry season when the river is easier to cross and, as mentioned, some mammals such as male elephant may move across in search of food when little else is available. This would not only result in more mammals being present in the hunting reserve over the dry season, but may also result in less anxious response behaviour due to them having no prior encounter to hunting.

6.3 Cluster Analysis

Cluster analysis has been widely used by strategy researchers, and has been acknowledged for its capability in dealing with the environment and management (Ketchen and Shook, 1996). This is primarily due to its ability to deal with multidimensionality, by grouping elements such that the statistical variance among elements grouped together is minimized, while between-group variance is maximized (Ketchen and Shook, 1996). Yongming *et al*. (2006) state that Principal Component Analysis and cluster analysis are the most common multivariate statistical methods used in environmental studies. It has also been useful for ecoregion classification, due to its ability to group points with similar ecological conditions, even when the points are widely separated in space. This is because K-means clustering is entirely independent of geographic location (Kumar *et al*., 2011). Other uses of K-means cluster analysis in environmental studies have included animal movement studies (linking landscape heterogeneity and animal movements), and linking animal behaviour to processes, such as dispersal, population dynamics and habitat selection (Moorter *et al*., 2010). In order to examine how human management practices impacted the mammal sightings and response behaviour in the four conservation land use areas, all influencing variables mentioned need to be taken into account. The role of the cluster algorithms was to group the observations with similar characteristics using this multivariate information. K-means cluster analysis was carried out on both the mammal sightings data and the response behaviour data in order to distinguish the main influencing variables that played a role in the outcome of this study.

What was evident from both the mammal sightings and response behaviour clustering, was that the conservation land use area and vegetation type were the top two influencing variables in the way the data were grouped. This demonstrates how both human management practices and resource availability impact the distribution of mammals as well as their response behaviour towards human disturbances. Seasonal variance also played an important role in determining the distribution of mammals in each conservation land use area, primarily determining the proximity of mammals to water sources and forage availability. According to the response behaviour clustering, the IRI’s and IRD’s were also two important variables that affected the groupings of the observations, showing variance both between the conservation land use areas, and within each conservation land use area. Once again, this can be attributed to the level of human disturbance and the habitat available, as well as the terrain. Finally, the mammal sightings data were grouped according to each species, with water dependent species such as impala remaining closer to water sources and browsers being more common in the woodland areas. The response behaviour also varied slightly with each species type, with species such as buffalo naturally reacting more anxiously to the approaching vehicle than the other four study mammals. The clustering thus highlighted the dominant influencing variables that work together, influencing the distribution of mammals across the landscape as well as the way they respond to human presence. These were conservation land use, vegetation, season and species.

6.4 Management Implications

According to the findings from this study, the type of conservation land use and associated management practices evidently impact the sighting potential and sighting quality of mammals, as a result of it influencing the distribution of mammals and their response behaviour towards human presence. This has implications for the management of a park that integrates a variety of conservation land uses but primarily derives its income from photo-tourism, as tourists seek a high sighting frequency with mammals reacting calmly to a vehicle for the opportunity of close encounters with these mammals. For this study, the photographic tourism in the private ecotourism concession and the national park did not show to have any short term negative implications on the five study mammals, based on their response behaviour. The areas within these two land uses that had the most exposure to human presence also showed the most habituated behaviour. Although the sighting potential of mammals and their response behaviour in the trophy hunting reserve was not as conducive for photographic tourism, this negative impact was limited to within this reserve and did not seem to extend to the national park. Further to this, the terrain of the hunting reserve was not conducive to the general public and most of the reserve was only accessible to vehicles with high clearance. A coal mine operating on the perimeter and some exploration taking place on the reserve also negatively affects the potential for this reserve to serve as a base for photographic tourism. Such an area may then work best for hunting with very low off-takes, where there is potential for money to be generated in an area that is not as suitable for photographic tourism, as suggested by Lindsay *et al*. (2007). Although very small scale trophy hunting on the perimeter of a protected area, such as KNP, may be financially viable while not affecting ecotourism within the protected area, integrating trophy hunting and photographic tourism in the same area would not be recommended, due to conflicting leisure interests. Small scale trophy hunting may thus be a viable option for buffer zones around protected areas. As suggested by Robinson and Jamal (2009), trophy hunting has the potential to be an income generator for local people. These findings are in line with the rationale of Barnes *et al*. (2002), suggesting that successful conservancies/protected areas can include several different economic and conservation purposes, with non-consumptive tourism dominating, followed by hunting and other less significant activities.

On the other hand, the goal behind the GLTP is to integrate the Limpopo National Park with the Kruger National Park as one conservation area that supports photographic tourism. In order for wildlife to move into this area, the excessive resource use by the surrounding communities needs to be managed so that the vegetation can recover in order to support this wildlife. In addition, a very similar response behaviour was evident in this study area to that of the trophy hunting reserve, indicating that the activities carried out in this land use area are not necessarily conducive for integrating photographic tourism. Reducing the human/wildlife conflict in the communal land and increasing the number of tourist vehicles in the area would be key to habituating the mammals to human presence, thus increasing the potential for integrating this land use area for photographic tourism.

Another aspect to consider with regards to managing a multi-use conservation area, is the time it takes for mammals to recover from certain disturbances, and this is also species specific. It was evident in the private ecotourism concession, which had a history of poaching and hunting, that elephant (particularly female herds) were still recovering from this unstable past. As discussed by Kiley-Worthington (2011), social learning in elephants results in elephants passing certain behaviours on from one generation to the next. This means that the effects of past hunting/poaching could still be apparent in the way in which elephant currently respond to human presence. There were also no evident seasonal changes in mammal sightings or their response behaviour in the trophy hunting reserve, even though hunting took place seasonally, indicating that it may take longer for mammals to recover from such disturbances and change the way they respond to human presence. However, this is difficult to determine as firstly, it is unclear what the hunting off-takes were in 2011, and secondly, not all mammals in the hunting reserve were necessarily impacted by hunting as they may have recently moved in from the KNP. Furthermore, recovery times to disturbances such as hunting are not widely covered in literature.

6.5 Limitations

Although the four conservation land use areas are integrated as one conservation area, each one is managed separately by different organizations. Thus, accessibility to data and information about how each conservation land use area was managed was not consistent, with the private ecotourism concession and national park being very transparent about management practices and providing necessary data such as weather data. In contrast, no data were available for the trophy hunting reserve and management did not provide any information about hunting quotas for the year during which this study took place. Similarly, limited data were available for the communal land and it was difficult to get an idea of the level of human wildlife conflict in the area, apart from previous studies and interviews. Climate and vegetation data were thus extrapolated from the national park data for the trophy hunting reserve and communal land at the closest localities to these two study areas.

The data collection for this study involved measuring elements of behaviour for the five study mammals from a moving vehicle. This was firstly challenging as mammals were not always in clear view of sight due to terrain or vegetation, and so measuring the exact distance at which the mammal took flight often involved measuring the distance to the nearest land mark where the mammal was before taking flight. Secondly, recognising the response behaviour of the mammals as they became aware of the approaching vehicle involved a level of subjectivity as it meant interpreting the animal's stance, position of ears etc., at various distances. Furthermore, measuring initial responses with the use of an index, as was carried out in this study, and recording the associated initial response distance has never been used before in other studies. A pilot study was therefore undertaken as a trial, in addition to the four study periods, to test these methods and make necessary changes where certain objectives were not practical. It was clear from the beginning that, due to subjectivity of the data collection, it was paramount that the same two observers measure the flight distances, IRI's and IRD's throughout the study to ensure consistency of data collection and recording.

With regards to analysing the data, the quantity of data obtained for each land use area differed substantially, making it difficult to draw comparisons of the response behaviour between the various study areas. This challenge was evident in the kriging results, as the limited data for the trophy hunting reserve and communal land resulted in maps with little detail, compared to that for the private ecotourism area and national park. Considering that kriging is most useful for obtaining trends in the data by averaging out the data over space, it was primarily used in this study to compare key response behaviour trends between the four land use areas, as well as to compare response behaviour trends in different zones of each study area. K-means cluster analysis was performed in addition to the kriging in order to permit the inclusion of multiple variables into the analysis.

CHAPTER 7: CONCLUSION

Management of ecosystems in KNP aims to maintain biodiversity while providing human benefits in a manner which detracts as little as possible from the wilderness qualities (Rogers and O'Keeffe, 2003). The findings from this study indicated no negative short term impacts of photographic ecotourism on the behaviour of the five study mammals, and the areas with the highest traffic volumes were also the areas with the highest frequency of mammal sightings. Further studies on the behavioural responses of other key mammal species need to be carried out as certain species may be more sensitive to such human disturbances. Makuya Nature Reserve was chosen to represent trophy hunting in this study as it was located alongside both the private ecotourism concession and the national park. Being in such close proximity firstly made the study areas more comparable, based on natural resources, and also allowed this study to determine whether the trophy hunting had negative impacts on the wildlife viewing potential of the private ecotourism concession and national park. This study suggests that integrating small scale trophy hunting on the periphery of protected areas, in zones not conducive for photographic tourism, may provide income generating potential for surrounding communities, improving the livelihoods of local people and limiting the negative impacts on the protected area, by containing it to buffer zones. However, this study represents one type of hunting management model that was not well measured or managed, and so it is recommended to conduct further research on how well other hunting management models integrate with photographic tourism. It is thus recommended that future studies have a clearer idea of the occurrence and intensity of previous hunting, and that a study be carried over a longer period, as this is still a gap in current knowledge. The findings from this study also indicate that there may be potential for the integration of communal lands with photographic tourism, however, the resource use by communities needs to be better managed, and management strategies such as corridors, need to be implemented in order to protect communities from the damaging effects of wildlife, and in turn protect the wildlife by avoiding human wildlife conflict. This would need to be followed by a recovery period before ecotourism could be successfully used as an income earner. In terms of methodologies, previous studies on response behaviour primarily involved measuring the flight responses of mammals. This study showed that, in addition to the flight responses, measuring the initial responses of mammals, using the initial response index, is a useful tool to assess their behaviour towards human presence, especially in areas where mammals are habituated to human presence and do not take flight with approaching vehicles.

Although some human activities may be considered as “biodiversity friendly”, supporting biodiversity conservation while also supporting rural livelihoods, other human activities are harmful to wildlife and natural resources (Chazdon *et al*., 2009). It is thus recommended for the management of multi-use conservation areas, such as the GLTP, to have a clear understanding of the biodiversity patterns, both within the protected area as well as the various surrounding land use zones, and understand how the biodiversity patterns are affected by the various human practices (Chazdon *et al*., 2009). Through adaptive management, this multifunctional landscape needs to be managed at the landscape level, rather than managing each land use area as a separate entity (Gardner *et al*., 2009). This study has shown that there is great potential for supporting biodiversity conservation within human modified landscapes. With ever growing human populations across the world, it is critical to find effective ways to manage and integrate various land uses with protected areas.

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