The identification and verification of optimal reintroduction sites for the Southern Ground Hornbill *Bucorvus leadbeateri* in the Musina area of the Limpopo Province, South Africa

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PREFACE

The research reported in this dissertation was conducted from February 2010 to November 2011 in the School of Environmental Sciences and Development, North-West University, Potchefstroom Campus, Potchefstroom, South Africa. The first part of the research was purely literary research which was conducted during 2010, and the remainder of the research period was focused on field research in the selected study area.

The research conducted in this dissertation represents original work undertaken by the author and has not previously been submitted for degree purposes to any university. Where use has been made of the work of other researchers, it is duly acknowledged in the text.

The reference style used in this dissertation is according to the specifications given by the Harvard method subscribed to by the International Standards Organisation and the HSRC.

Any opinions, findings, and conclusions or recommendations expressed in this dissertation are those of the author and therefore the North-West University, Potchefstroom Campus, does not accept any liability thereto.

SUMMARY

The Southern Ground Hornbill (SGH) (*Bucorvus leadbeateri*) has recently been listed globally by the IUCN Red list as Endangered or Critically Endangered. In South Africa, the declining population of the SGH has led it to be listed nationally as Vulnerable and falls under the “Protected Species” legislation. Research into the habitat preferences and identification of suitable reintroduction areas have been few since the initiation of reintroduction attempts, therefore resulting in mixed outcomes of previously-reintroduced SGH. The aim of this study was to identify and verify optimal reintroduction sites for the SGH, in the Musina area in the Limpopo Province. Five main objectives were determined, namely: to identify optimal reintroduction areas; to develop a habitat profile of the designated area; to determine the availability of prey items; to determine the availability of large trees needed for nesting and roosting; to evaluate pre-release sites by involving a number of stakeholders. Three study sites were selected on the farm Greyghost Safaris (Ludwigslust), each made up of a different plant community. Sampling was carried out a total of four times during the year: one sampling bout in each season. A niche-based modelling technique was used to describe the suitability of a particular habitat (“ecological space”) then used to project it onto another geographical space. Floristic and faunal surveys were conducted to determine the species composition of prey items and composition and frequency of the herbaceous and woody layer. High-resolution, natural-colour aerial imagery was used in order to determine the availability of trees for nesting and roosting. Pre-release site evaluations and stakeholder engagements were conducted by means of interviews with landowners on and around the study sites. The Limpopo River Valley and across to the KNP on the eastern border of the Limpopo Province, is suitable re-introduction sites for the SGH. This study site provided a good opportunity to explore what an optimal site for reintroduction should resemble.

Keywords: Southern Ground Hornbill; habitat profile; prey abundance; vegetation structure; plant community; conservation; reintroduction; habitat viability assessment

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CHAPTER 1

INTRODUCTION AND LITERATURE REVIEW

CHAPTER 1: INTRODUCTION

1.1 CONTEXT AND MOTIVATION FOR STUDY

This chapter gives a brief overview of the following topics: description of the Southern Ground Hornbill (*Bucorvus leadbeateri*, Vigors, 1825) (SGH), its current distribution, basic biological information, current conservation status, reasons for decline, previous reintroduction attempts, and the objectives as well as importance of this study.

1.1.1 Description of the Southern Ground Hornbill

The SGH is the largest hornbill (Bucerotiformes) in the world. There are approximately 54 hornbill species that are grouped together in the order *Bucerotiformes*. Two of these, namely the Southern and Northern (Abyssinian) Ground Hornbill (NGH), differ from most other hornbills and are grouped in their own family, *Bucorvidae* (Kemp, 1995:94).

The adult male SGH is approximately 100 cm in body length and has an all black plumage with white primary feathers. It has a large, black bill with a low casque at the ridge on the base of the bill. Around its eyes and throat, it has bare red facial skin with an inflatable red throat pouch below its bill. Its eyes are yellow, and it has black legs and feet. The adult female is similar in appearance but is slightly smaller and has violet-blue patches on the throat, sometimes extending down the side of the neck (Fig. 1.1). The NGH differs from the SGH by having predominantly blue facial skin, a cowl-like casque and a yellow patch at the base of upper mandible. It also has a slightly different call to the SGH (Kemp, 1995).

Figure 1.1: Left shows a female with red facial skin with a blue patches under throat; top right shows juvenile bird being fed (right) by adult male; bottom right shows male with all-red facial skin.

The immature SGH differs from adult birds by having a more sooty-brown colouration with black flecks in the white primaries. The bill of the immature bird is also greyer in colour and is not as large as the adult bird's (Fig. 1.1). Its eyes are grey with pale grey-brown facial skin. Once the bird has reached a sub-adult stage, which can be from the age of three years, it will start to gain adult colouration around its face and neck (Kemp,1995).

The SGH makes a deep four-note booming call, or *hoo hoo hoo-hoo*, followed by three bodily contractions, the last one producing the double note. Males and females often call in a duet and mostly at dawn and dusk. The sound of the call carries over large distances of up to 5 km and is presumably used to advertise their territories (Kemp, 1995).

1.1.2 Current distribution of the SGH

The SGH is distributed throughout Rwanda, Burundi, southern Kenya, Zaire, Tanzania, Angola, Zambia, Malawi, Namibia, Botswana, Zimbabwe, Mozambique and South Africa (Kemp, 1995). In South Africa (Fig. 1.2), the SGH can be found in the north-western and northern parts of the Limpopo Province (e.g. Limpopo River Valley), in the Kruger National Park and its surrounding game reserves in the Limpopo and Mpumalanga Provinces, where the majority of the population occur, down into the northern parts of KwaZulu-Natal, into its midlands areas and all the way down into the Eastern Cape.

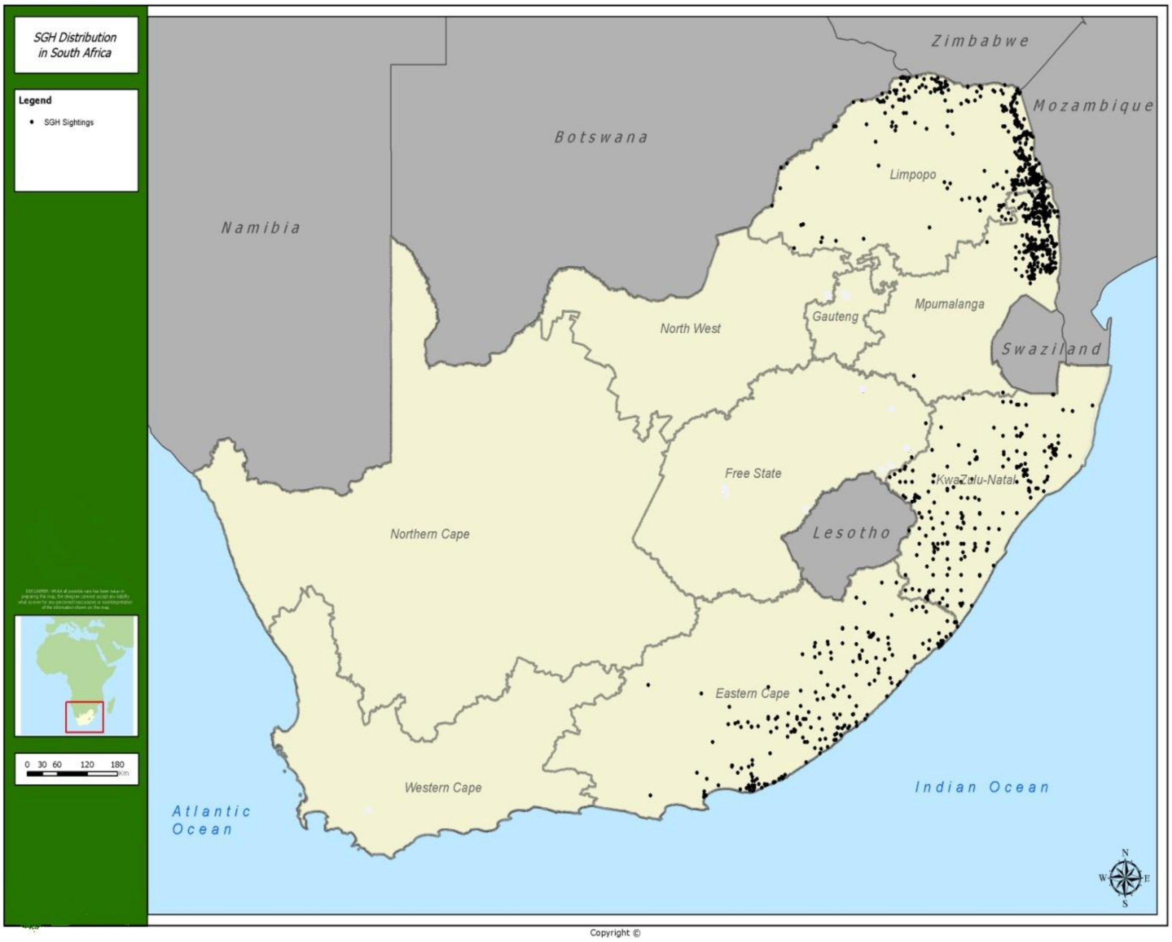


Figure 1.2: Current distribution of the Southern Ground Hornbill in South Africa (Cilliers, 2011).

1.1.3 Biology of the SGH

1.1.3.1 Social and feeding behaviour

A SGH group territory can stretch up to a distance of 100 km^2 per group from estimations made in the Kruger National Park (KNP) (Kemp & Kemp, 1980), Eastern Cape (Vernon,

1984) and KwaZulu-Natal (Knight, 1990) but can reach up to 200 km^2 in semi-arid areas outside of protected areas (Theron, 2011). A group primarily consists of numbers ranging between three and five birds with one alpha breeding pair. The remainder of the group will then consist of a combination of male and female juveniles and adult male helpers (Kemp, 1980). Social interactions between the birds include cooperative hunting, play, cooperative breeding, allo-feeding and allo-preening (Kemp & Kemp, 1980).

According to Kemp (1995), foraging takes place during the day, with birds walking an average distance of 11 km. Walking is preferred (up to 70% of the day) unless unsuitable habitat has to be crossed (Kemp, 1995). The diet of the hornbill, being primarily carnivorous (Kemp, 1987; Kemp, 1988; Msimanga, 2004), consists of anything it can overpower, including snakes, tortoises, rabbits, rodents, lizards, smaller birds and invertebrates (Kemp & Kemp, 1978). The groups forage in areas with low plant growth densities, such as open grasslands in KZN (Knight, 1990), and do so by capturing prey in the low vegetation or by digging in the ground with their large bills (Kemp, 1995).

1.1.3.2 Nesting and breeding behaviour

According to Jones (1969), nest-spacing between groups usually ranges from 4.0-8.9 km, the latter being in lesser dense areas. In more dense vegetation, as is found in the KwaZulu-Natal reserves and farmland, nest-spacing was found to have averaged a distance of up to 10 km. Hornbill groups usually remain sedentary within their territories throughout the year as long as there is adequate food and trees available for nesting and roosting (Kemp, 1980; Kemp, 1988).

Breeding behaviour of the SGH is primarily cooperative breeding (Du Plessis, Siegfried & Armstrong, 1995), as mentioned above, with one monogamous pair per group and several helpers (Ranger, 1931). Breeding takes place at the start of the rainy season from September to November, usually following within 1-2 weeks after the first heavy rainfall (Kemp & Kemp, 1991) Late rainfall for example in May, will result in a missed breeding endeavour. Nest sites consist of large tree cavities of at least 40 cm diameter in the KNP (Kemp & Begg, 1996).

The SGH's preferred nesting sites in the KNP, due to its large size, include cavities with a median internal diameter of 40 cm in a tree (96%) or on a rock face (4%) (Kemp & Begg, 1996). Popular nesting trees for the SGH include: *Comretum imberbe*, *Ficus sycomorus*, *Diospyros mespiliformis*, *Sclerocarya birrea* and *Adansonia digitata* (Kemp, 1995). The availability of suitable nesting sites are a primary factor limiting the SGH population in the KNP (Kemp, 1995). Once a nest has been selected, the female will spend approximately five hours a day in the cavity, preparing the inside of the nest. Helpers will help to bring in dried leaves as well as food items for the female (Kemp & Kemp, 1980). The alpha male will encourage the female towards the nest by giving a high-pitched call and by depositing food items for the female outside the nest cavity (Ranger, 1931).

Once the female is ready to lay her eggs, she will lay a clutch of one to three eggs, each a few days apart, and incubate them for 42 days (Kemp, 1976) followed by an 86 day nestling period (Kemp & Kemp, 1991). If a second chick is hatched, it will usually die of starvation within a week due to parental neglect as well as sibling competition (Kemp & Kemp, 2007). Once the first egg has hatched, it takes another 86 days before the fledgling will be old enough to leave the nest. Feeding during this time is assisted by the other members of the group. The chick will remain a juvenile for five to six years before it reaches sexual maturity, and even then it might not be ready to breed (Kemp, 1976).

It has been estimated that in South Africa, the SGH will start to breed for the first time only after nine years (Kemp, 1995). Females, after having obtained their full facial colouring, tend to leave the group in search of a new group or to start a group themselves. Because of their slow reproductive rate, Kemp (2000b) suggested that by harvesting the second-hatched chicks and rearing them in captivity, the chicks can be used as a resource that could be used to manage the conservation of the species. Attempts of this sort have been taking place in the Kruger National Park (KNP) since 1969 (Kemp, 2000b).

1.1.3.3 Habitat requirements of the Southern Ground Hornbill

A suitable habitat site is an important aspect to be considered before reintroducing ground hornbills back into the wild. The need to clearly understand habitat utilisation incurred by the SGH lies in the aspiration of contributing to the overall fitness and the survival of the individual (Block & Brennan, 1993). Once this is understood, conservationists can gain knowledge of the factors that are limiting and affect the size and selection of territories.

SGH are prone to choose the savannah biome as their nesting and foraging territories, which, according to Tainton (1999), is characterised by seasonal rainfall and dry winters. SGH's can also be found in some woodland and grassland (Kemp & Webster, 2007; Wilfred, 2007; Engelbrecht *et al*, 2007). The savannah biome has the richest abundance of bird species, but only 8.5% is protected (Rutherford & Westfall, 1994), hence the emphasis on the cooperation from landowners to maintain ecological integrity (Theron, 2011). Alongside the SGH, competing for prey, the savannah and grassland biomes includes many other terrestrial carnivorous bird species, such as cranes (now *Anthropoides paradiseus*), herons (*Ardea melanocephala*), storks (*Leptoptilos crumeniferus*), *Otis* bustards and the Secretarybird (*Sagittarius serpentarius*) (Kemp & Kemp, 1978).

1.1.4 Conservation status and reasons for decline

1.1.4.1 Conservation status

According to the South African Red Data Book (Kemp, 2000), the species has been listed as Vulnerable. However, more recent studies have determined that with a 66% decline in range over the last 115 years, the species may require re-classification as Endangered or Critically Endangered (Kemp & Webster, 2008). An IUCN global status review of the birds has precipitated a change from Least Concern to Vulnerable by BirdLife International due to the increase in knowledge of the existing threats posed to the SGH (BirdLife International, 2010). This has caused some concern regarding the decline in population numbers and distribution of the SGH (Kemp, 1980; Vernon & Herremans, 1997; Cyrus & Robson, 1980).

During the 1960's and 1970's, the SGH population in South Africa was much larger; however, over the last 20-30 years, the population numbers declined rapidly (Theron, 2011). Conservation strategies in South Africa have been ongoing over a period of 15-20 years, including education and awareness campaigns among children, farmers and the general public. A number of different activities have been taking place, such as harvesting and hand rearing of second-hatched chicks, captive breeding, reintroduction programmes, as well as the erection of artificial nests

1.1.4.2 Reasons for decline in population numbers

The main reasons for their decline have been attributed to a number of human-induced threats such as the removal of large trees needed for nesting and roosting, habitat alteration and destruction, direct and indirect poisoning, persecution, increase in human population (Kemp, 2000; Engelbrecht *et al*, 2007; Morrison *et al*, 2007) and the illegal trade in live specimens and traditional practices (Derwent & Mander, 1997; Kemp, 2000).

Along with human-induced causes, there are numerous biological factors that play a role in the decline of population numbers as can be seen from exploring their slow reproductive rate as a result of slow sexual maturity and their large territories. Furthermore, the ideal habitat site for a SGH requires numerous factors in order for it to breed regularly (Vernon, 1984). The birds' natural breeding cavities for nesting are usually limited, so breeding site selection usually takes a lot of time, hence contributing to the slow reproductive rate (Kemp & Kemp, 1991).

1.1.5 Previous Southern Ground Hornbill reintroduction attempts

A SGH Working Group was established in 2003 and has compiled a Species National Recovery Plan (SNRP) in 2011 which includes strategies, relevant fieldwork techniques, application of research activities and investigations into the threats to the species and its habitat. Reintroduction is considered to be a viable option that needs further and more intense research attention.

Previous attempts to reintroduce hand-reared SGHs back into the wild have had mixed results. The first number of attempts to reintroduce hand-reared SGH chicks took place between 1999 and 2002 at Mabula Game Reserve (see Mabula website for more information [http://www.ground-hornbill.org.za]). More recent reintroductions attempts have taken place since then, still exhibiting varied results with different natural- and human-induced causes for failure and success. These reintroduction projects proved to be highly labour intensive as reintroduced groups need individual experience and training as juveniles for their survival in the wild. Constant guarding against predators and supplementary feeding is usually carried out by a shepherd after the release. The use of shepherds has proved successful in the sense that the young birds are led along a specific route for a two-day period, with them finally able to walk the same route staying within the boundaries for up to two years. The shepherding unfortunately also meant that the birds became habituated to humans which could cause potential problems for the birds in future. In order for reintroductions to be successful, the elimination of possible poisoning, excessive human contact, feasible causes of injury and inadequate housing are to be attended to (Kemp *et al*, 2007).

A series of releases subsequently followed in the Limpopo, Eastern Cape and North West Provinces between 2003 and 2009. One group of hand-reared birds from Mabula was released in the Marakele National Park and flew back to Mabula within three months. Many of the released juvenile birds found it difficult to adapt to their new environments, especially near human settlements, and preferred the company of humans to their wild counterparts. In other cases, the members of the group were lost due to poisoning or human error or died because of Newcastle's disease. An ongoing programme to harvest redundant, second-hatched SGH chicks from the KNP and surrounding Associated Private Nature Reserves (APNR) in the Limpopo and Mpumalanga Province is currently undertaken by the Mabula Ground Hornbill Action Group, and attempts to further develop and perfect a reintroduction protocol for SGHs are underway.

1.1.6 Aim and objectives of the study

The aim of this study was to identify and verify optimal reintroduction sites for the SGH, specifically in the Musina area in the Limpopo Province. Five main objectives were set out to be determined, namely: 1) to identify optimal reintroduction areas, 2) to develop a habitat profile of the designated area, 3) to determine the availability of prey items, 4) to determine the availability of large trees needed for nesting and roosting and 5) to evaluate pre-release sites by involving a number of stakeholders.

1.1.7 Importance of the study

The identification of optimal reintroduction sites is of utmost importance, due to the fact that SGH reintroduction projects are an expensive and time-consuming process that requires a lot of manpower and resources. It will contribute to the conservation of the SGH in South Africa by aiming to eliminate problems regarding the four basic prerequisites for feasible SGH reintroductions, namely basic environmental variables, the availability of food and the availability of trees for nesting and roosting, as well as the attitudes of relevant stakeholders regarding SGH reintroduction.

The survival of the SGH is of vital importance as it plays an important role in the functioning of the ecosystem. Being one of the so-called 'Big 6' birds in South Africa, the SGH is of great economic importance in the eco-tourism industry and is also a flagship species for the savannah biome and, therefore, acts as an important indicator species (Engelbrecht *et al*, 2007; Wilfred, 2007). With the ever increasing human population and subsequent increasing number of disturbed natural habitat, it is important to be able to identify areas which are suited for the SGH and to be able to distinguish between different habitat types and different niches during different seasons. The preferred habitat type during different seasons and the types of habitat that allow for the greatest prey abundance are also of great significance. This study can be a first step towards providing a platform for future reference when in the process of reintroducing the SGH back into the wild, whether it be in protected areas or not.

CHAPTER 2

STUDY SITE, MATERIALS AND METHODS

CHAPTER 2: STUDY SITE, MATERIALS AND METHODS

This chapter gives a brief description of the study site and the methods and materials used.

2.1 DESCRIPTION OF STUDY SITE

2.1.1 Location

The study was conducted between January and November 2011 on the game farm Greyghost Safaris, approximately 30 km west of Mucina at 22º 17.77’ S latitude and 29º 47.05’ E, south of the road to Mapungubwe National Park (Fig. 2.1). The farm is approximately 2000 ha in size.

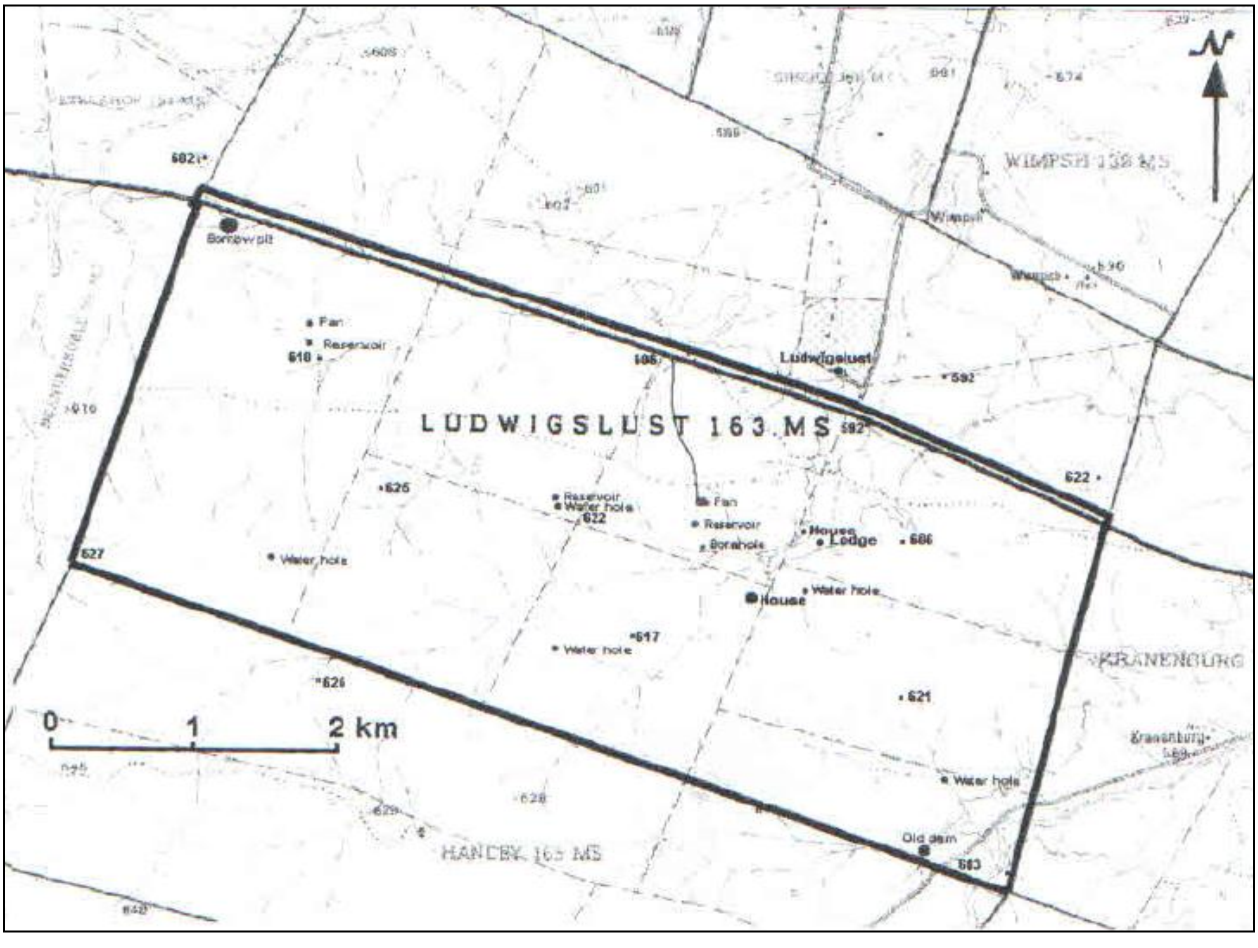


Figure 2.1: Topocadastral map of Greyghost Safaris on the Farm Ludwigslust 22º 17.77’ S latitude and 29º 47.05’ E longitude (Van Rooyen, 2008)

2.1.2 Climate

2.1.2.1 Rainfall

According to Van Rooyen (2008), the mean annual rainfall in the area is 348 mm (min = 155 mm and max = 539 mm) according to readings from 12 stations in and around Musina. However, looking at the rainfall specifically for Greyghost Safaris from 2008 to 2011 (table 2.1), it is clear that in 2010-2011, the highest rainfall compared to the other years occurred. The months October to February are predominantly the rainy season (wet), with the driest months occurring from May to September. The rainy season can deliver up to 83% of the annual rainfall.

Table 2.1: Rainfall readings for Greyghost Safaris from the year 2008-2011.

Season	**2008/2009**	**2009/2010**	**2010/2011**	**2011/2012**
October	0	40.75	15	30.5
November	60.25	130.75	60	
December	168.5	25.5	85.5	
January	199	30	355.5	
February	31.5	25.5	0	
March	9.5	0	10	
Total	**468.75**	**252.50**	**526**	**30.5**

2.1.2.2 Temperature

At the station Macauville (22º 16' S; 29º 54' E), an annual mean temperature for a 29-year period was recorded as 22.5ºC, with an extreme maximum of 43.5ºC and an extreme minimum of -3.8ºC. A mean daily maximum temperature for the area was recorded as 33.5ºC during January and 24.9ºC during July. The mean minimum daily temperature during January is 21.3ºC and 6.9ºC during July. Frost may occur from June to August. The area's highest relative percentage air humidity occurs from February to July, resulting in dew precipitation in the mornings. During December, January and February the area has the highest cloud cover, while the least cover occurs during July, August and September.

2.1.3 Geology

According to Van Rooyen (2008), the geology of the farm consists of predominantly sedimentary coarse-grained sand of the Quaternary System (Qs) and different types of gneiss (granite). However, on the surface of the ground in the central-western part of the farm, quartzite and calc-silicate can be found. That specific area is comprised mainly of metaanorthosite metagabbro of the Messina suite. In the south-western corner of the farm, one can find a small section comprising of dark to light-grey or pink porphyroblastic biotite gneiss (Alldays gneiss). Within the north-eastern corner, leucocratic quartzo-feldspatic gneiss and metapelite of the Malala Drift Group of the Beit Bridge Complex can be found. Porphyroblastic gneiss (Bulai gneiss) in the form of rocky outcrops can be seen on the south-eastern corner.

2.1.4 Vegetation

According to Acocks (1953) and Low and Rebelo (1996), Greyghost Safaris is located in an area of Mopane Veld and Mopani Bushveld. More recent studies, however, conducted by Mucina and Rutherford (2006) described the area as being dominantly Musina Mopani Bushveld, with a small section of Limpopo Ridge Bushveld in the south-eastern corner of the farm (Fig. 2.2).

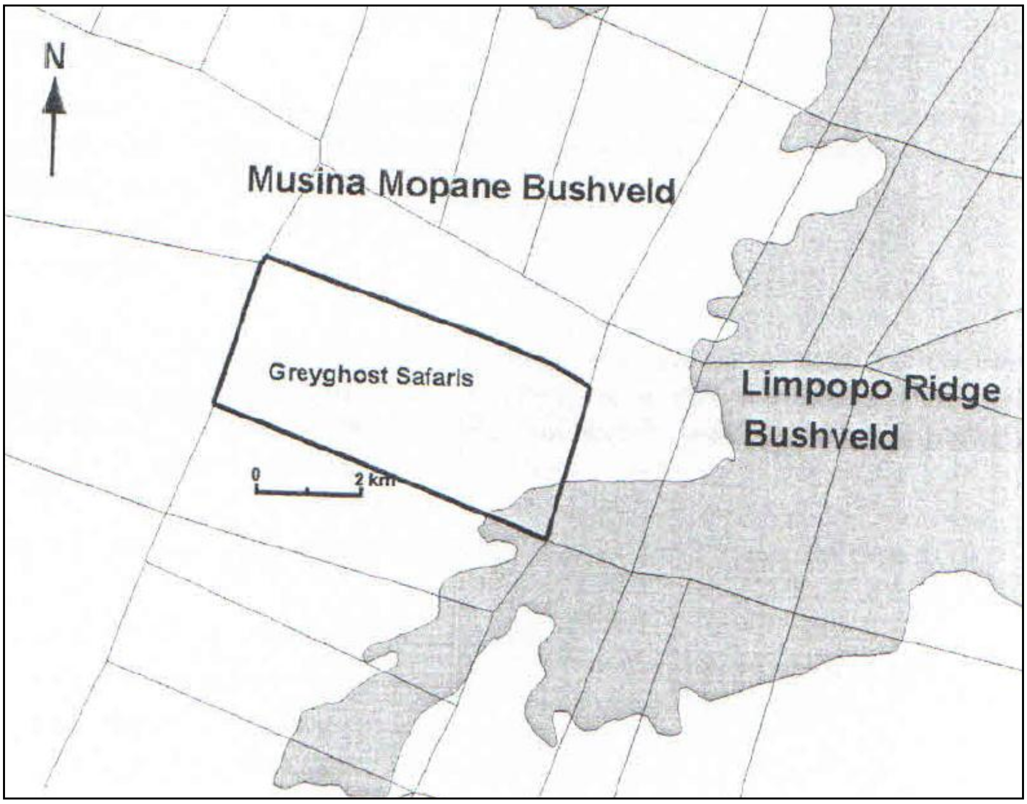


Figure 2.2: Musina Mopani Bushveld and Limpopo Ridge Bushveld forming the main vegetation types for Greyghost Safaris (Mucina & Rutherford, 2006).

2.1.4.1 Musina Mopane Bushveld

According to Mucina & Rutherford (2006), characteristics of the Musina Mopane Bushveld include undulating and uneven plains with a number of scattered hills with altitudes reaching up to approximately 600 m. Situated near the Beit Bridge Complex, Greyghost Safari's geology consists mainly of gneisses and metasediments, rocks having undergone metamorphism and intense deformation. This then leads to the various types of soil which can be found, ranging from deep red/brown clays to freely-drained sandy soils as well as shallow Glenrosa and Mispah soils often formed as a result of rock weathering and clay alleviation (Rossouw & Van der Waals, 2010).

Trees commonly found in the area include the Mopane (*Colosphospermum mopane*), baobab (*Adansonia digitata*), knobthorn (*Acacia nigrensis*), red bushwillow (*Combretum apiculatum*), slender three-hook thorn (*Acacia senegal* var. *leiorhachis*) and velvet corkwood (*Commiphora mollis*).

Some of the more conspicuous small trees and shrubs include the white raisin (*Grewia bicolor*), Lowveld cluster leaf (*Terminalia prunioides*), stink shepherds tree (*Boscia foetida* subsp. *rehmanniana*) and velvet raisin (*Grewia flava*). Grass species commonly found include bushveld signal grass (*Urochloa mosambicensis*), grey sour grass (*Enneapogon cenchroides*), false signal grass (*Brachiaria deflexa*), three-awn (*Aristida sp.*), sand quick (*Schmidtia pappophroides*) and silky bushman grass (*Stipagrostis uniplumis*).

2.1.4.2 Limpopo Ridge Bushveld (Mucina & Rutherford, 2006)

Making up the south-eastern corner of the farm, the Limpopo Ridge Bushveld is characterised as having more irregular hills and ridges which reach up to altitudes of between 300 to 1000 m. The area consists of poorly developed ground resulting in a moderate savannah vegetation structure. The soils found here are more calcareous gravel and calc-silicate soils, which provide perfect growing environments for the white syringa (*Kirkia acuminata*) and the baobab (*Adansonia digitata*). Thriving in the calcareous gravel, the shrub *Catophractes alexandri* is dominant. Near the Mapungubwe National Park, more sandstone of the Clarens Formation can be seen.

The vegetation structure found here is primarily in a frost-free area. Primary species of trees found include the before-mentioned baobab, marula (*Sclerocaya birrea*), mopane

(*Colophospermum mopane*), tall common corkwood (*Commiphora glandulosa*), Lowveld cluster-leaf (*Terminalia prunoides*), shepherd's tree (*Boscia albitrunca*) and various fig species (*Ficus spp.*).

2.1.5 Plant Communities (Van Rooyen, 2008)

Within these vegetation structures on Greyghost Safari are 11 identified plant communities, namely (Fig. 2.3):

1. Umbrella thorn-bushveld signal grass old fields
2. White syringa-red bushwillow bushveld
3. Red bushwillow bushveld
4. White syringa-mopane-Lowveld cluster-leaf bushveld
5. White syringa-velvet corkwood bushveld
6. Mopane-Lowveld cluster-leaf dense bushveld
7. Mopane-slender three-hook thorn low dense bushveld
8. Apple-leaf-umbrella thorn drainage lines
9. Rocky outcrops
10. Disturbed areas
11. Mopane erosion patches

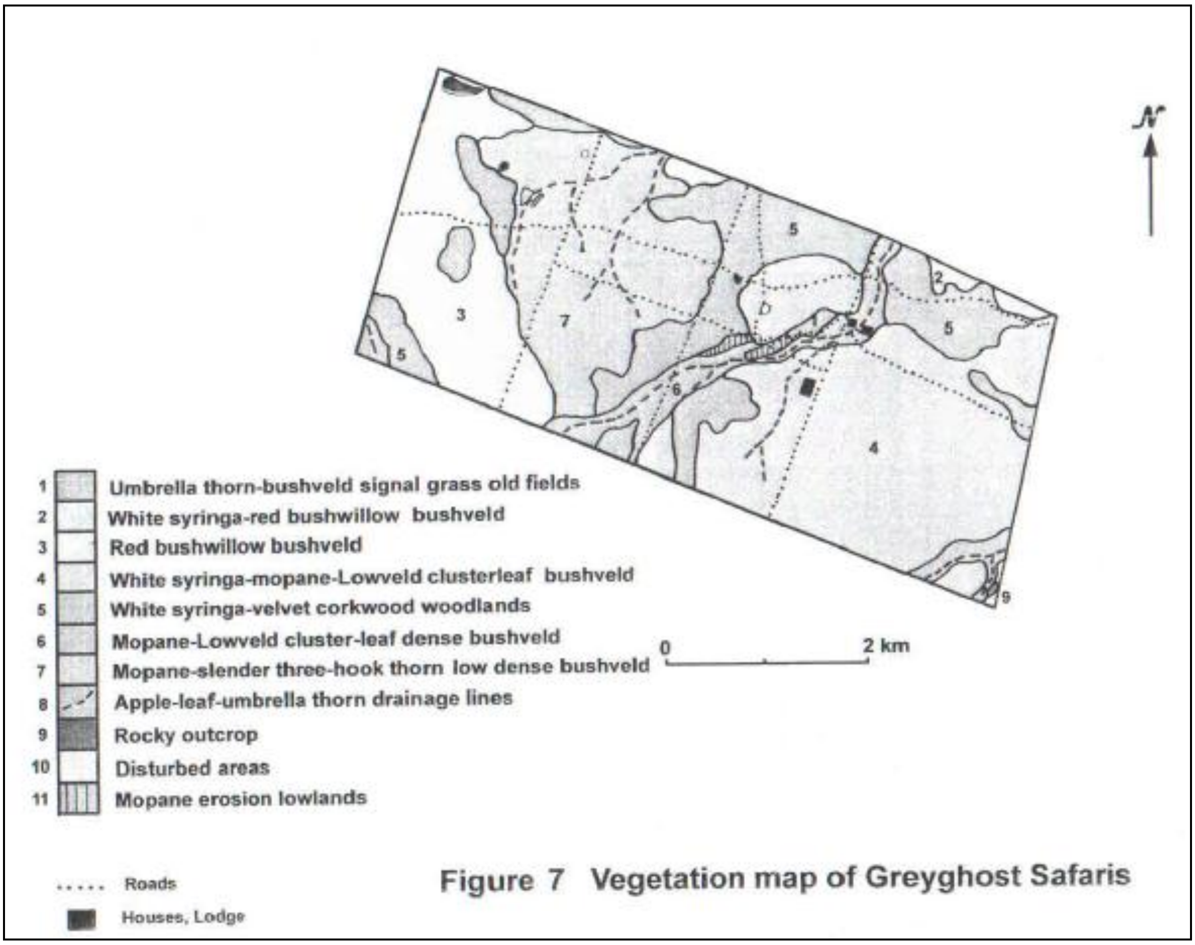


Figure 7 Vegetation map of Greyghost Safaris

Figure 2.3: Different plant communities found on Greyghost Safaris (Van Rooyen, 2008).

Three plant communities were selected for the study, namely white syringa-mopane-lowveld cluster-leaf bushveld (4), mopane-slender three-hook thorn low dense bushveld (7) and umbrella thorn-bushveld signal grass old fields (1) and will, therefore, be discussed in more detail. These sites were selected based on where the SGHs have frequently been observed by the landowners and the farm labourers during the year 2010. The afore-going sites will be referred to as site A, B and C respectively.

2.1.5.1 Site A: White syringa-mopane-Lowveld cluster-leaf bushveld (4) (Van Rooyen, 2008) (*Kirkia acuminata-Colophospermum mopane-Terminalia prunoides* bushveld)

Most of the western part of the farm is found to be comprised of the white syringa-mopane-lowveld cluster leaf bushveld, covering an area of approximately 706 ha. This part of the farm is relatively flat with occasional slopes of 3º with surface rocks covering 20% of the area. The soils are more deep red loamy to deep yellow-red to sandy clay-loam soils which are formed as a result of the gneiss.

Diagnostic tall trees that are associated with this plant community include baobab, white syringa, velvet corkwood, false marula and the slender three-hook thorn. Other trees commonly found are the Lowveld cluster-leaf, blue thorn (*Acacia erubescens*), mopane (*Colophospermum mopane*), umbrella thorn (*Acacia tortilis*), shepherd's tree (*Boscia albitrunca*), common star chestnut (*Sterculia rogersii*) and the common corkwood (*Commiphora glandulosa*).

Characteristic shrubs in this community include raisin bushes, glossy-leaved corkwood (*Commiphora schimperi*) and sickle bush (*Dichrostachys cinerea*). The average cover of shrubs is approximately 12%. The grass layer, on the other hand, covers on average 52% of the area and includes species such as the grey sour grass (*Enneapogon cenchroides*), false signal grass (*Brachiaria deflexa*), silky bushman grass (*Stipagrostis uniplumis*), Lehman's love grass (*Eragrostis lehmanniana*), annual three-awn (*Arristida adscensionis*), carrotseed grass (*Trachus berteronius*) and flaccid finger grass (*Digitaria velutina*). Less commonly found are the Natal red top (*Melenis repens*), bushveld signal grass (*Urochloa mosambicensis*), blue buffalo grass (*Cenchrus ciliaris*) and large-seeded three-awn (*Aristida rhiniochloa*).

The most commonly found forbs in this plant community, covering 12% of the area, include *Euphorbia neopolycnemoides*, *Amaranthus praetermissus*, *Dicoma tomentosa*, *Geigeria acaulis*, *Ptycholobium contortum*, *Pavonia burchellii*, *Crotalaria sphaerocarpa*, *Vigna frutenscens*, *Hermannia modesta*, *Achyranthus aspera*, *Hibiscus sidiformis*, *Hermannia, boraginiflora*, *Tephrosia purpurea*, *Monsonia senegalensisAcalyphya indica*, *Kyphocarpa angustifolia, Evolvulus aslinoides* and *Solanum kwebense.*

<u>*2.1.5.2 Site B: Mopane-slender three-hook thorn low dense bushveld*</u> (7) (Van Rooyen, 2008) (*Colophospermum mopane-Acacia Senegal* var. *Leiorhachis* dense bushveld)

Towards the north-west corner of the farm is a slightly more hilly area with a rocky low dense surface. This area makes up approximately 412 ha and is characterised by calcrete gravel and rocks. These rocks make up approximately 40% of the 412 ha. The slightly hilly surface slopes up to about 3º. Due to the high lime content in the soil, the majority of the soils found here are more whitish shallow loam soils.

This type of plant community can be classified by taking note of the most diagnostic species, namely the eight-day grass (*Enneapogon desvauxii*), blue bushman grass (*Stipagrostis hirtiglumma*), *Lantana rugosa, Tribulus zeyheri, Cleome augustiflora* and *Commicarpus pentadrus*.

The main tall tree species (>6 m) are the knobthorn, the shepherd's tree and the slender three-hook thorn. The mean canopy cover is 2% with a tree occurrence density of approximately 4 individuals/ha. The average tree density (<6 m) is 112 individuals per ha and covers 13% of the area. Trees such as the tall trees mentioned above together with the mopane, umbrella thorn, Lowveld cluster-leaf and the red bushwillow make up this community. There are numerous shrubs found here, making up 18% of the area, namely stink shepherd's tree, white raisin, sickle bush, blue sourplum (*Ximenia Americana*), white-berry bush (*Flueggia virosa*) and the knobbly creeper (*Combretum mossambicense*). The density of the shrubs makes up more of the area than do the trees, with a mean density of between 704 individuals/ha to 1110 individuals/ha.

Because of the high density rock cover in the area, the grass layer is relatively low, covering on average 41%. Characteristic species of this plant community include grey sour grass, Lehman's love grass, blue buffalo grass and carrotseed grass.

Common forbs found in this plant community include *Hermbstaedtia odorata, Corchorus asplenifolius, Phyllanthus angolensis, Kohautia caespitose, Acalypha indica, Monechma divaricatum* and *Chascanum pinnatifidum*.

2.1.5.3 Site C: Umbrella thorn-bushveld signal grass old fields (1) (Van Rooyen, 2008)

(*Acacia tortilis-Urochloa mosambicensis* old fields)

This type of plant community consists of old ploughed fields set in the deep red sandy-clay-loam soils of the gneissic plains. A number of vegetation species found here characterise this type of plant community, namely *Solanum incanum, Alternanthera pungens* and the common crowfoot (*Dactyloctenium aegyptium*). This area has been found to have a lack of tall trees (between 3 and 600> m) but, instead, has a 3% cover of shrubs, including the mopane and the umbrella thorn. As a result of previous cultivation practices and heavy grazing, grass cover is only approximately 15% in this area. Common grass species found, however, include the common crowfoot, spreading three-awn (*Aristida congesta* subsp. *barbicollis*), false signal grass, annual three-awn, grey sour grass, carrotseed grass, Lehmans love grass and the bushveld signal grass. Forbs such as *Althernanthera pungens, Solanum incanum, Geigeria acaulis, Waltheria indica, Indigofera vicioides, Limeum sulcatum* and *Heliotropium steudneri* cover approximately 8% of the basal cover.

2.2 METHODS AND MATERIALS

2.2.1 Selection of optimal reintroduction sites

One of the primary determinants for reintroduction success is habitat quality/suitability (Moorhouse *et al*, 2009; Tavecchia *et al*, 2009; Michel *et al*, 2010; Hebblewhite *et al*, 2011). However, these habitats (specific sites) first need to be identified and later verified. One option is to use a niche-based modelling technique that describes the suitability of a particular habitat ("ecological space") in terms of its environmental attributes and then to project this onto another geographical space (Phillips *et al*, 2006). Maxent 3.3.3e was used which is obtainable from http://www.cs.princeton.edu/~schapire/maxent. Maxent is a niche-based model as it represents an approximation of a species' environmental niche in the examined environment. It uses a predictive modelling approach that allows for the estimation of the target distribution of a species based on environmental conditions at sites where the species is known to occur (Phillips *et al*, 2004, 2006).

A species' fundamental niche is all those factors and conditions that enable it to survive, while its realized niche is that subset of the fundamental niche which in reality it occupies (Hutchinson 1957). This realized niche will often be smaller that the fundamental niche due to external influences such as human activities and geographic barriers.

If assumed that occurrence localities, as discussed above, were extracted from source habitat (habitat which meets the requirements of the species to survive), the environmental conditions at these localities should be made up of samples of the realised niche (Phillips *et al*, 2006). A niche-based model will then represent an approximation of the species' realised niche within the environmental variables being studied (Phillips *et al*, 2006). The origins of Maxent lie in statistical mechanics and are based on the maximum entropy principle discussed by E.T. Jaynes (Jaynes 1957; Phillips *et al*, 2006). It uses machine learning techniques to find maximum entropy distribution and, thus, habitat suitability (Phillips *et al*, 2004, 2006).

For this reason, it was decided to follow a four-step process to identify optimal reintroduction sites in the Limpopo area. Figure 2.4 depicts the basic process that was followed.

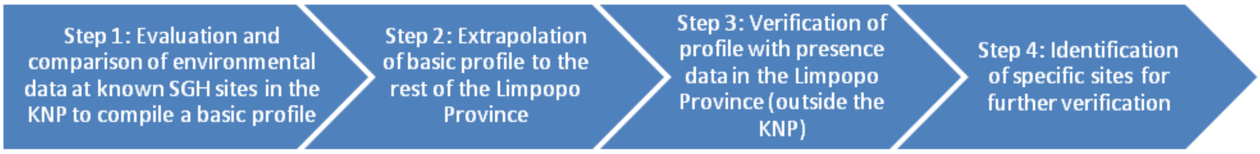


Figure 2.4: Illustration of the four-step process for identifying optimal reintroduction sites in the Limpopo Province.

Step 1: Geographic Information Science (GISc) in combination with the Maximum Entropy (MAXENT) algorithm in the "openModeller" software application was first used to evaluate and compare various environmental datasets at all available SGH sighting points within the Kruger National Park with a view to compiling a basic profile. The following environmental variables from three different classes, namely climate, topography and habitat, were used:

- Average maximum temperature (tmax)
- Average minimum temperature (tmin)
- Average rainfall (rain)
- Elevation (dem)
- Slope (slope)
- Vegetation (veg)
- Annual Natural Diversified Vegetation Index (ndvi)
- MODIS tree cover (tree)
- Soil types (soil)

All datasets were re-sampled to a cell size of 1000 meters and projected on the Albert Equal Area Projected Coordinate system after which they were converted to ASCII Grids. Land cover was not used as some of the occurrence records were older than the available national land-cover dataset and would not be suitable for modelling purposes (Phillips *et al*, 2006).

Step 2: This profile was then extrapolated to the rest of the Limpopo Province to identify specific sites with a similar profile as the sites in the Kruger National Park.

Step 3: These results were then compared to a control set of sighting data for the Limpopo Province to determine the accuracy of the projection.

Step 4: Finally, the results were then transferred from "openModeller" to ArcInfo for mapping purposes.

2.2.2 Methods to determine habitat profile (floristic survey)

In order to create a habitat profile, the ground cover and species composition was determined with regard to forbs and grasses and the woody composition. These parameters were sampled four times per year in order to determine any changes. During each survey, a 4 x 50 m cross transect was used to record the frequency (point to tuft distance), ecosystem integrity (at each 1 m interval the presence of erosion, rock, litter or bare patches are recorded) and woody vegetation (Sutherland, 2000:42). Measurements and samples were taken at 1 m intervals starting 10 m from the centre point so as to eliminate the possibility of oversampling. The frequency and basal cover of the herbaceous layer was recorded by identifying the herbaceous species that is closest to the point (descending point method) (Sutherland, 2000) and calculating the number of hits of herbaceous species (Fig. 2.5).

For the woody component, the species name of the tree is given, accompanied by the frequency of hits during the four months that sampling was done and the size of the tree. The sizes of the trees were categorized into four classes as follows: small (up to 5 m), medium-sized (5-15 m), large (15-30 m), and very large, (more than 30 m).

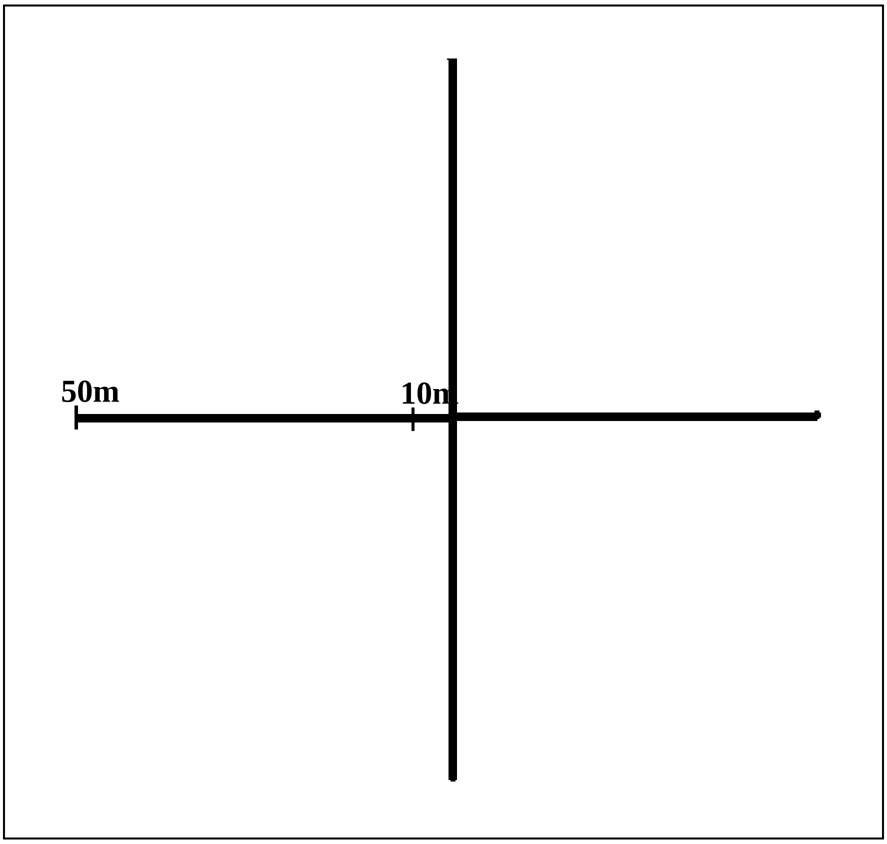


Figure 2.5: Diagram illustrating 4 x 50 m cross transect with measurements and samples taken at 1 m intervals starting 10 m from the centre point.

2.2.3 Methods to determine availability of prey items (faunal survey)

2.2.3.1 Methods to identify and quantify (frequency and volume) of prey items

A nested cross-array method (Perner & Schueler, 2004: 467-477) was used to survey invertebrate prey. A total of 13 pitfall traps – one in the centre, at 5 m, 15 m and 35 m – were used at each site (Fig. 2.6). The traps were constructed from 15 cm-long drainpipes, with a diameter of 20 cm, with a plastic cup inside it that is lowered into the ground and levelled with the surface. The cups were filled up to approximately 2 cm with non-hazardous propylene glycol. The invertebrate sampling was done for four consecutive days four times during the year 2011. Two 200 m sweep-net surveys were conducted per day at each site to capture low-flying invertebrates found in the grasses and forbs. All captured invertebrates were preserved in containers containing 70% alcohol. Invertebrates were sorted and identified up to order level as far as possible and classified into size classes so as to measure the volume using the volumetric water-displacement method (Magnusson, 2003).

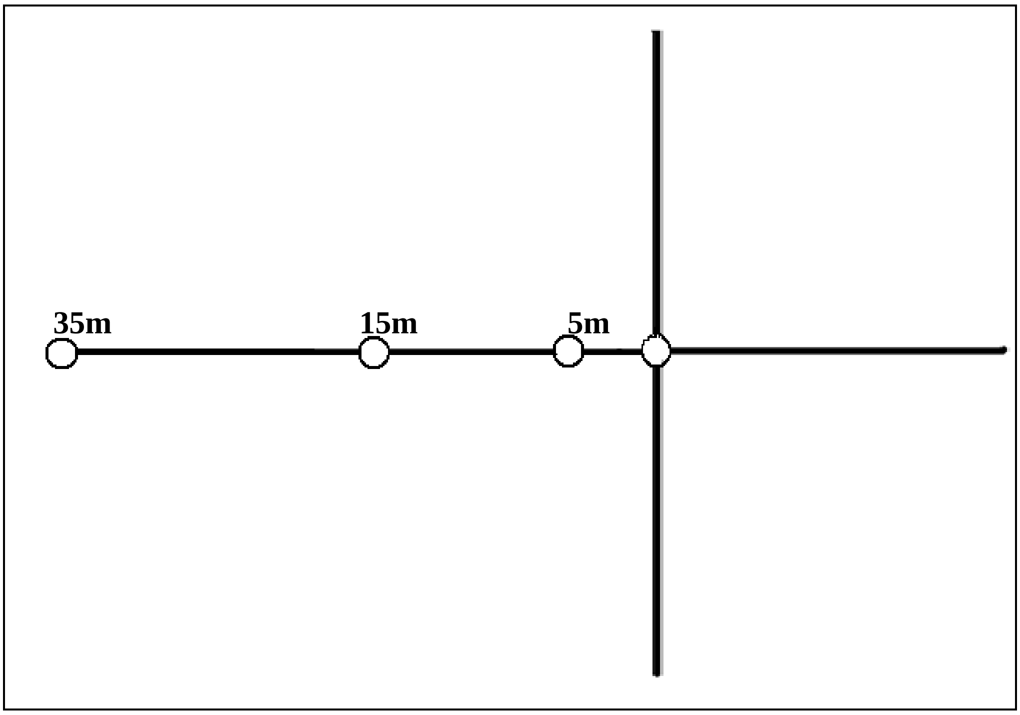


Figure 2.6: Diagram illustrating the 4 x 50 m cross-transect and the spacing between each pitfall trap.

The statistical methods used to analyse all the data for the vegetation and the prey items, a non-parametrical test was carried out using the statistical package Friedman ANOVA (Field, 2009).

2.2.4 Methods to determine the availability of trees for nesting and roosting (presence and spacing/ density and distribution of suitable trees)

High-resolution, natural-colour aerial imagery was used in order to determine the availability of trees for nesting and roosting. Firstly, 50 large baobab trees in and around the area were plotted using a GPS and then read into ArcMap 10. Twelve of the points were held back so as to be used for testing purposes. The remaining points were used to identify large trees on aerial photographs of the farm used for the study by means of an Image Analysis tool in ArcMap 10. Once the trees were identified on the aerial photographs, all other aspects were identified with the same Image Analysis tool in ArcMap 10, such as dams, small bushes and roads. Once all this information was extracted, all the large trees were extracted specifically, with the use of Interactive Supervised Classification. Included here were all the surface areas larger than 100 m^2 which were derived from the sizes of the trees plotted with the GPS. In order to test the effectiveness of the results, the remaining 12 plots held back at the commencement of the process were used. Ten out of the 12 points were revealed, thus indicating that there is an 83.3% certainty that the results are satisfactory.

2.2.5 Pre-release site evaluations/ stakeholder engagement

Ten interviews were conducted with local landowners in the area by means of a semi-structured questionnaire in order to determine the attitudes of local landowners regarding the reintroduction of SGHs on their farms or in the surrounding area. Interviews are useful to gather data in a person's own, verbalised words. The benefits of using interviews as a data gathering method are that it permits immediate follow-up questions that can be used for clarifications and can, thus, be regarded as a flexible mode of data collection that not only contributes to the trustworthiness of the data but the general credibility of the study. An example of the questionnaire can be found in the Appendix 2.

CHAPTER 3

RESULTS

CHAPTER 3: RESULTS

This chapter gives a brief overview of the results for the identification of the optimal reintroduction sites, habitat profile, availability of prey items, availability of trees for nesting and roosting, and the evaluations of the pre-release sites and stakeholder engagement.

3.1 OPTIMAL REINTRODUCTION SITES

As illustrated by the map in Figure 3.1, the areas in bright red to orange are areas more suited for SGH according to the biophysical aspects of its required habitat (results of Step 2). As can be seen from the map, high priority areas can be found all the way from south of Thabazimbi, stretching across to Ellisras (Lephalale), and all the way past Alldays along the Limpopo River Valley, north of the Soutpansberg. The area on the north-eastern and eastern border of the Limpopo and into the KNP also appear to be suitable. Other areas which are also suitable are south of Louis Trichardt, to the east of Tzaneen, stretching all the way to the western border of the KNP. Except for smaller pockets around Roedtan, Marble Hall and Groblersdal, the central parts of the province appears to be less suitable for re-introduction.

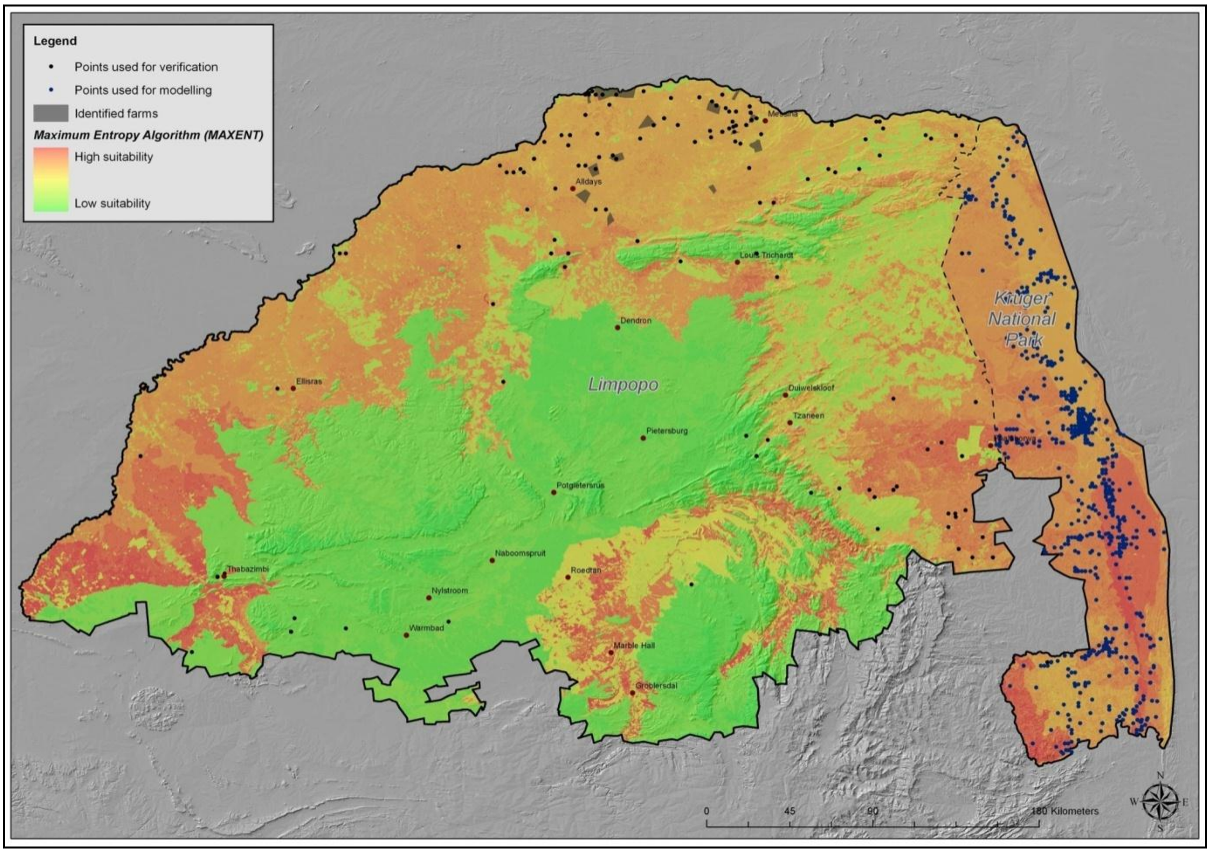
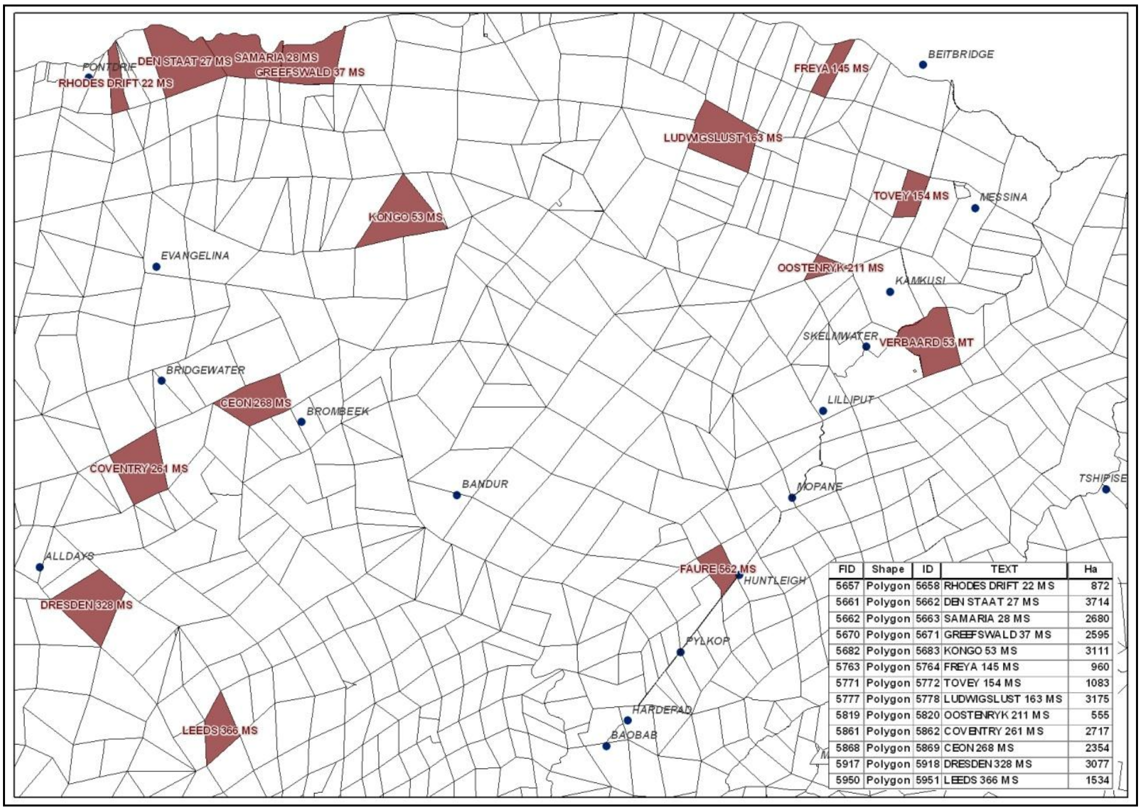


Figure 3.1: Map illustrating the areas that are from least to most probable areas of optimal habitat for the SGH in the Limpopo Province



FID	Shape	ID	TEXT	Ha
5657	Polygon	5658	RHODES DRIFT 22 MS	872
5661	Polygon	5662	DEN STAAT 27 MS	3714
5662	Polygon	5663	SAMARIA 28 MS	2680
5670	Polygon	5671	GREEFSWALD 37 MS	2595
5682	Polygon	5683	KONGO 53 MS	3111
5763	Polygon	5764	FREYA 145 MS	960
5771	Polygon	5772	TOVEY 154 MS	1083
5777	Polygon	5778	LUDWIGSLUST 163 MS	3175
5819	Polygon	5820	OOSTENRYK 211 MS	555
5861	Polygon	5862	COVENTRY 261 MS	2717
5868	Polygon	5869	CEON 268 MS	2354
5917	Polygon	5918	DRESDEN 328 MS	3077
5950	Polygon	5951	LEEDS 366 MS	1534

Figure 3.2: Map of farmland areas in the Musina, Pondrif and Alldays vicinity. The farms in red are those that were identified as optimal sites.

According to the map, 14 farms were identified as meeting the optimal habitat requirements for the SGH (Figure 3.2, results of step 4), namely Denstaat, Verbaard 53 MT, Samaria, Greefswald, Kongo, Ceon, Coventry, Dresden, Leeds, Frey, Tovey, Oostenryk, Verbaard, Faure and, finally, Ludwigslust. As mentioned before, Greyghost Safaris forms part of the larger Ludwigslust. All these farms occur in the Pontdrif, Alldays and Musina region. This was subsequently verified by recent reported SGH sightings on some of the farms.

3.2 HABITAT PROFILE

3.2.1 Species composition

(Appendix 1)

3.2.2.1 Site A

A total number of 13 species, including grass and forbs, were recorded at site A (see Table 3.1).

Table 3.1: Species list of forbs and grasses for Site A

Aristida adscensionis
Cenchrus ciliaris
Endostemon tereticaulis
Eragrostis lehmanniana
Evolvulus alsinoides
Geigeria acaulis
Geigeria burkei
Heliotropium nelsonii
Hermannia modesta
Ocimum americanum
Panicum deustum
Waltheria indica
Xyrophyta humulis

Table 3.2: Basic descriptive statistics for forbs and grasses for Site A (STATISTICA 10)

Variable	**Mean**	**Median**	**Minimum**	**Maximum**	**Standard deviation**
January	6.1	6.000000	0	33	9.0
April	8.3	4.000000	0	40	14.4
August	9.2	1.000000	0	66	18.9
October	5.5	0.000000	0	32	9.4

in January, the average number of hits was 6.1 with a minimum number of 0 and a maximum number of 33 out of the maximum possible number of hits of 200 calculated from the 4 x 50 m cross-transect. The standard deviation for January is 9.0. In April, the average number of hits was 8.3 with a minimum number of 0 and maximum number of 40 (standard deviation = 14.4). In August, the highest average hits were obtained with 9.2 hits and a minimum of 0 and maximum of 66 (standard deviation = 18.9). October had the lowest number of hits with 5.5 and a minimum of 0 and a maximum of 32 (standard deviation = 9.4).

The woody component of Site A consists of six different tree species (Table 3.3).

Table 3.3: Species list, frequency, and size of the woody structure for Site A: small (up to 5 m), medium-sized (5-15 m), large (15-30 m) and very large (more than 30 m).

Species	**Frequency**	**Height (Class)**
Acacia senegal	5	Medium
Colophospermum mopane	27	Medium-large
Combretum apiculatum	9	Small-medium
Grewia bicolour	19	Small
Grewia flava	4	Small
Kirkia acuminate	6	Medium

As depicted by Table 3.3, there was a total count of five *Acacia senegal* (medium) species at Site A. *Colophospermum mopane* (medium-large) had a total count of 27 trees, *Combretum apiculatum* (small-medium), 9 trees, *Grewia bicolor* (small), 19 trees, *grewia flava* (small), four trees and *Kirkia acuminate* (medium), six trees. The dominant specie found at Site A is *Colophospermum mopane.*

3.2.2.2 Site B

A total number of 25 species including grass and other forbs were recorded at site B (see Table 3.4).

Table 3.4: Species list of forbs and grasses for Site B

Aristida adscensionis
Cenchrus ciliaris
Corchorus asplenifolius
Endostemon tereticaulis
Eragrostis lehmanniana
Heliotropium nelsonii
Hermbstaedtia fleckii
Hermannia modesta
Hermbstaedtia odorata
Indigofera ingrate
Indigofera trita
Indigofera vicioides
Microcharis galpinii
Monechma divaricatum
Ocimum americanum
Panicum deustum
Phylanthus angolensis
Seddera capensis

Sida chrysantha
Stipagrostis uniplumis
Syncolostemon canescens
Tephrosia semiglabra
Tragus berteronianus
Tragus racemosus
Waltheria indica

Table 3.5: Basic descriptive statistics for forbs and grasses for Site B (STATISTICA 10)

Variable	**Mean**	**Median**	**Minimum**	**Maximum**	**Standard deviation**
January	4.9	1	0	32	7.9
April	3.8	0	0	19	6.2
August	3.7	0	0	21	6.7
October	2.5	0	0	22	6.1

As can be seen from the basic descriptive statistics calculated for Site B (Table 3.5), it is clear that in January, the highest average number of hits was obtained with a number of 4.9 and a minimum number of 0 and a maximum number of 32 (standard deviation = 7.9). In April, the average number of hits was an average of 3.8, with a minimum number of 0 and maximum number of 19 (standard deviation = 6.2). In August, an average of 3.7 hits was obtained with a minimum of 0 and maximum of 21 (standard deviation = 6.7). October, once again, had the lowest number of hits with an average of 2.5, minimum= 0 and a maximum=22 (standard deviation = 6.1).

The woody component of Site B consists of nine different tree species (Table 3.6). The species name of the tree is given, accompanied by the frequency of hits during the four months that sampling was done, the height of the tree and the width of the canopy structure.

Table 3.6: Species list, frequency and size of the woody structure for Site B: small (up to 5 m), medium-sized (5-15 m), large (15-30 m) and very large (more than 30 m).

Species	**Frequency**	**Height (Class)**
Acacia nigrensis	9	Large
Acacia senegal	14	Small-medium
Acacia tortilus	10	Medium-large
Colophospermum mopane	38	Medium-large

Dichrostachys cinerea	6	Small-medium
Dombeya rotundifolia	1	Small-medium
Grewia bicolour	46	Small
Grewia flava	26	Small
Terminalia prunoides	17	Small-medium

As depicted by Table 3.6, there was a total count of nine *Acacia nigrensis* (large), 14 counts of *A. senegal* (small-medium), 10 counts of *A. tortilus* (medium-large), 38 counts of *Colophospermum mopane* (medium-large), six counts *Dichrostachys cinerea* (small-medium), one count of *Dombeya rotundifolia* (small-medium), 46 counts of *Grewia bicolor* (small) , 26 counts of *Grewia flava* (small), and 17 counts of *Terminalia prunoides* (small-medium). The dominant specie found at Site B is *Grewia bicolor*.

3.2.2.3. Site C

A total number of 13 species including grass and other forbs species were recorded at site C (see Table 3.7).

Table 3.7: Species list of forbs and grasses for Site C

Acanthosperma hispidum
Alternantha pungens
Aristida adscensionis
Boerhavia erecta
Brachiaria deflexa
Endostemon tereticaulis
Eragrostis lehmanniana
Geigeria acaulis
Panicum deustum
Tragus berteronianus
Tribulus terrestris
Uruchloa pancoides
Waltheria indica

Table 3.8: Basic descriptive statistics for forbs and grasses for Site C (STATISTICA 10)

Variable	**Mean**	**Median**	**Minimum**	**Maximum**	**Standard deviation**
January	7.1	5	0	22	8.0
April	8.7	0	0	52	15.8
August	5.7	0	0	46	13.0

October	2	0	0	13	4.2

As can be seen from the basic descriptive statistics calculated for Site C (Table 3.8), it is clear that in January, the average number of hits was calculated as 7.1 with a minimum number of 0 and a maximum number of 22 (standard deviation = 8.0). In April, the highest average number of hits was calculated as 8.7, with a minimum number of 0 and maximum number of 46 (standard deviation = 15.8). In August, an average of 5.7 hits was obtained with a minimum of 0 and maximum of 46 (standard deviation = 13.0). October, once again, had the lowest number of hits with an average of 2 hits, minimum= 0 and a maximum=13 (standard deviation = 4.2).

The woody component of Site C consists of five different tree species. This can be seen in Table 3.9. The species name of the tree is given, accompanied by the frequency of hits during the four months that sampling was done, the height of the tree and the width of the canopy structure.

Table 3.9: Species list, frequency and size of the woody structure for Site C: small (up to 5 m), medium-sized (5-15 m), large (15-30 m) and very large (more than 30 m).

Species	**Frequency**	**Height (Class)**
Acacia tortilus	2	Medium-large
Colophospermum mopane	7	Medium-large
Combretum apiculatum	2	Small-medium
Grewia bicolour	4	Small
Terminalia prunoides	2	Small-medium

As depicted by Table 3.9, there was a total count of two *A.tortilus* (medium-large), seven counts of *Colophospermum mopane* (medium-large), two counts of *Combretum apiculatum* (small-medium), 4 counts of *Grewia bicolor* (small), and two counts of *Terminalia prunoides* (small-medium). The dominant tree species for Site C is *Colophospermum mopane.*

3.2.2 Change in ground cover

3.2.2.1 Site A

In Table 3.10, below, the mean change in ground cover is given for Site A; the highest occurring in August. Following August, April had the second highest mean change in ground cover with a mean value of 8.3. January and October followed after with the values of 6.5 and 5.5, respectively. According to the p-value, which is bigger than 0.1 (0.49039) there is no statistical significance for the differences between the four months regarding change in ground cover for Site A.

Table 3.10: Friedman ANOVA analysis for determining the average change in ground cover for Site A (p = 0.49039).

Variable	Mean	Standard deviation
January	6.5	9.0
April	8.3	14.4
August	9.2	18.8
October	5.5	9.4

3.2.2.2 Site B

In Table 3.11, below, the average change in ground cover is given for Site B for each month. The highest average change in ground cover occurred in January, with a mean value of 4.9. Following January, April had the second highest change in ground cover with a value of 3.8. August has the third highest change in ground cover with a value of 3.7. The least average change in ground cover occurred in October with a value of 2.5. According to the p-value, which is bigger than 0.1 (0.20797) there is no statistical significance for the differences between the four months regarding change in ground cover for Site B.

Table 3.11: Friedman ANOVA analysis for determining the average change in ground cover for Site B (p = 0.20797).

Variable	Mean	Standard deviation
January	4.9	7.9
April	3.8	6.2
August	3.7	6.7
October	2.5	6.1

3.2.2.3 Site C

In Table 3.12, below, the average change in ground cover is given for Site C for each month. The highest average change in ground cover occurred during April, with a value of 8.7. Following April, January had the second highest average change in ground cover with a value of 8.7. August has the highest average change in ground cover with a value of 5.7. The least change in ground cover occurred in October with a value of 2.0. According to the p-value, which is smaller than 0.1 (0.06456) there is a statistical significance for the differences between the four months regarding change in ground cover for Site C.

Table 3.12: Friedman ANOVA analysis for determining the average change in ground cover for Site C ($p = 0.06456$).

Variable	Mean	Standard deviation
January	7.2	8.0
April	8.7	15.8
August	5.7	13.0
October	2.0	4.2

3.3 AVAILABILITY OF PREY ITEMS

3.3.1 Species composition

3.3.1.1. Site A

Below is a Table (3.13) which portrays the species composition and number of species caught in both the pitfall and sweepnet traps during all four months at Site A. Species were identified up to order level as far as possible. One can see that in January, the dominant prey species available was Coleoptera with a number of 38 insects. In April and August, the same can be found with a number of 38 and 29 Coleoptera insects respectively. In October, the order Hemiptera was found to be the dominant order of insects.

Table 3.13: Species composition and frequency of prey obtained from both pitfall and sweepnet traps for each month at Site A.

Order	**January**	**April**	**August**	**October**
Blattodea	0	0	0	2
Centipede	0	0	1	0
Coleoptera	38	38	29	17
Dermaptera	0	0	0	0
Diptera	1	2	1	1
Gastropoda	0	0	0	0
Hemiptera	2	2	0	59
Hymenoptera	2	4	5	16
Isoptera	0	0	0	0
Larvae	0	1	0	0
Lepidoptera	2	6	0	2
Mantodea	0	2	0	0

Millipede	0	0	0	12
Neuroptera	0	0	0	0
Orthoptera	17	6	0	1
Phasmatodea	4	0	0	0
Scorpiones	0	1	0	1
Solifugae	0	1	1	4
Araneae	7	7	3	5
Thysanoptera	0	0	0	0
Thysanura	0	0	0	0

In Table 3.14, the descriptive statistics are given for the species compositions which were sampled in both the pitfall and the sweepnet traps during the four months for Site A. It is clear from referring to the Table that October had the highest average species composition with a number of 5.7 insects (min = 0; max = 59; standard deviation = 13.3). Second to October is January with an average of 3.5 species (min = 0; max = 38; standard deviation = 8.8). April has the second lowest average species composition with a value of 3.3 species (min = 0; max = 38; standard deviation = 8.3). The month with the least number of species was August with a number of 1.9 insects (min = 0; max = 29; standard deviation = 6.3).

Table 3.14: Descriptive statistics for the species composition sampled in both the pitfalls and sweepnet traps for Site A

Variable	Mean	Median	Minimum	Maximum	Standard deviation
January	3.5	0	0	38	8.8
April	3.3	1	0	38	8.3
August	1.9	0	0	29	6.3
October	5.7	1	0	59	13.3

In Table 3.15, the average change in species composition for Site A for each month is depicted. The highest average change in species composition occurred in October, with a value of 5.7. Following October, January has the second highest average change in species composition with a value of 3.5. The second lowest change in species composition falls in the month of April with a value of 3.3. The least average change in species composition falls in August with a value of 1.9. According to the p-value, which is smaller than 0.1 (0.06656) there is a statistical significance for the differences between the four months regarding species composition for Site A.

Table 3.15: Friedman ANOVA analysis for determining the change in species composition for Site A (p = 0.06656).

Variable	Mean	Standard deviation
January	3.5	8.8
April	3.3	8.3
August	1.9	6.3
October	5.7	13.3

3.3.1.2. Site B

Below is a Table (3.16) which portrays the species composition and number of species caught in both the pitfall and sweepnet traps during all four months at Site B. Species were identified up to order level as far as possible. One can see that in January, the dominant prey species available was Orthoptera with a number of 43 insects. In April, the dominant order is Coleoptera with a number of 112 insects. The same applies for August with Coleoptera being the dominant order with a number of 54. In October, the order Hemiptera was found to be the dominant order of insects.

Table 3.16: Species composition and frequency of prey obtained from both pitfall and sweepnet traps for each month at Site B

Order	**January**	**April**	**August**	**October**
Centipede	0	0	1	3
Coleoptera	6	112	54	5
Dermaptera	0	0	0	0
Diptera	2	1	0	0
Gastropoda	0	0	0	0
Hemiptera	9	2	0	14
Hymenoptera	15	11	1	4
Isoptera	0	0	0	0
Larvae	15	0	0	0
Lepidoptera	3	5	0	0
Mantodea	5	0	0	1
Millipede	1	0	0	3
Neuroptera	0	0	0	0
Orthoptera	43	4	3	2
Phasmatodea	11	0	0	0
Scorpiones	0	0	0	2
Solifugae	0	0	0	0

Araneae	9	3	4	2
Thysanoptera	0	0	0	0
Thysanura	0	0	0	0

In Table 3.17, the descriptive statistics are given for the species compositions which were sampled in both the pitfall and the sweepnet traps during the four months for Site B. It is clear from referring to the Table that April had the highest average species composition with a number of 6.6 insects (min = 0; max = 112; standard deviation = 24.3). Second to April is January with an average of 5.7 species (min = 0; max = 43; standard deviation = 10). August has the second lowest average species composition with a value of 3 species (min = 0; max = 54; standard deviation = 11.7). The month with the least number of species was October with a number of 1.7 insects (min = 0; max = 14; standard deviation = 3.2).

Table 3.17: Descriptive statistics for the species composition sampled in both the pitfalls and sweepnet traps for Site B

Variable	Mean	Median	Minimum	Maximum	Standard deviation
January	5.7	1	0	43	10.0
April	6.6	0	0	112	24.3
August	3.0	0	0	54	11.7
October	1.7	0	0	14	3.2

In Table 3.18, the average change in species composition for Site B for each month is depicted. The highest average change occurred in April, with a value of 6.6. Following April, January has the second highest change in species composition with a value of 5.7. The second lowest change in species composition occurred in the month of August with a value of 3.0. The least average change in species composition occurred in October with a value of 1.7. According to the p-value, which is smaller than 0.1 (0.06656) there is a statistical significance for the differences between the four months regarding species composition for Site B.

Table 3.18: Friedman ANOVA analysis for determining the change in species composition for Site B (p = 0.03725).

Variable	Mean	Standard deviation
January	5.7	10.0

April	6.6	24.3
August	3.0	11.7
October	1.7	3.2

3.3.1.3. Site C

Below is a Table (3.19) which portrays the species composition and number of species caught in both the pitfall and sweepnet traps during all four months at Site C. One can see in January, the dominant prey species available was Orthoptera with a number of 55 insects. In April, the dominant order is Coleoptera with a number of 52 insects. The same applies to August with Coleoptera being the dominant order with a number of 30. In October, the order Hemiptera was found to be the dominant order of insects.

Table 3.19: Species composition and frequency of prey obtained from both pitfall and sweepnet traps for each month at Site C

Order	**January**	**April**	**August**	**October**
Blattodea	0	0	1	0
Centipede	0	0	0	0
Coleoptera	20	52	30	11
Dermaptera	0	0	0	0
Diptera	4	1	5	0
Gastropoda	1	0	0	0
Hemiptera	3	1	0	46
Hymenoptera	1	6	1	10
Isoptera	0	0	0	0
Larvae	1	0	0	1
Lepidoptera	0	8	0	0
Mantodea	0	0	0	0
Millipede	4	0	0	2
Neuroptera	1	0	0	0
Orthoptera	55	25	1	0
Phasmatodea	0	0	0	0
Scorpiones	0	0	0	1
Solifugae	0	0	1	0
Araneae	14	1	4	3
Thysanoptera	1	0	0	0
Thysanura	0	0	0	0

In Table 3.20, the descriptive statistics are given for the species compositions which were sampled in both the pitfall and the sweepnet traps during the four months for Site B. It is clear from referring to the Table that April had the highest average species composition with a number of 6.6 insects (min = 0; max = 112; standard deviation = 24.3). Second to April is January with an average of 5.7 species (min = 0; max = 43; standard deviation = 10). August has the second lowest average species composition with a value of 3 species (min = 0; max = 54; standard deviation = 11.7). The month with the least number of species was October with a number of 1.7 insects (min = 0; max = 14; standard deviation = 3.2).

Table 3.20: Descriptive statistics for the species composition sampled in both the pitfalls and sweepnet traps for Site C

Variable	Mean	Median	Minimum	Maximum	Standard deviation
January	5	1	0	55	12.5
April	4	0	0	52	11.6
August	2	0	0	30	6.5
October	4	0	0	46	10.2

In Table 3.21, the average change in species composition for Site C for each month is depicted. The highest average change in species composition occurred in January, with a value of 4. Following January, April and October has the second highest change in species composition with values of 4. The least average change in species composition occurred in August with a value of 2. According to the p-value, which is bigger than 0.1 (0.27361) there is no statistical significance for the differences between the four months regarding species composition for Site C.

Table 3.21: Friedman ANOVA analysis for determining the change in species composition for Site C (p = 0.27361).

Variable	Mean	Standard deviation
January	5	12.5
April	4	11.6
August	2	6.5
October	4	10.2

3.3.1.4 Combination of all three sites A, B and C

In Table 3.22, grouped descriptive statistics are given for the species compositions which were sampled in both the pitfall and the sweepnet traps during the four months for Site A, B and C. It is clear from referring to the Table that January had the highest average species composition with a number of 4.7 (min = 0; max = 55; standard deviation = 10.4). Second to January is April with an average of 4.6 species (min = 0; max = 112; standard deviation = 16.1). October has the second lowest average species composition with a value of 3.7 species (min = 0; max = 59; standard deviation = 9.8). The month with the least number of species was August with a number of 2.3 insects (min = 0; max = 54; standard deviation = 8.5).

Table 3.22: Grouped descriptive statistics for the species composition sampled in both the pitfalls and sweepnet traps for Site A, B and C

Variable	Mean	Median	Minimum	Maximum	Standard deviation
January	4.7	0	0	55	10.4
April	4.6	0	0	112	16.1
August	2.3	0	0	54	8.5
October	3.7	0	0	59	9.8

Below is an illustration (Fig. 3.3) of what is portrayed in Table 3.22. The change in the quantity of prey items is depicted against the different months for each site A, B and C.

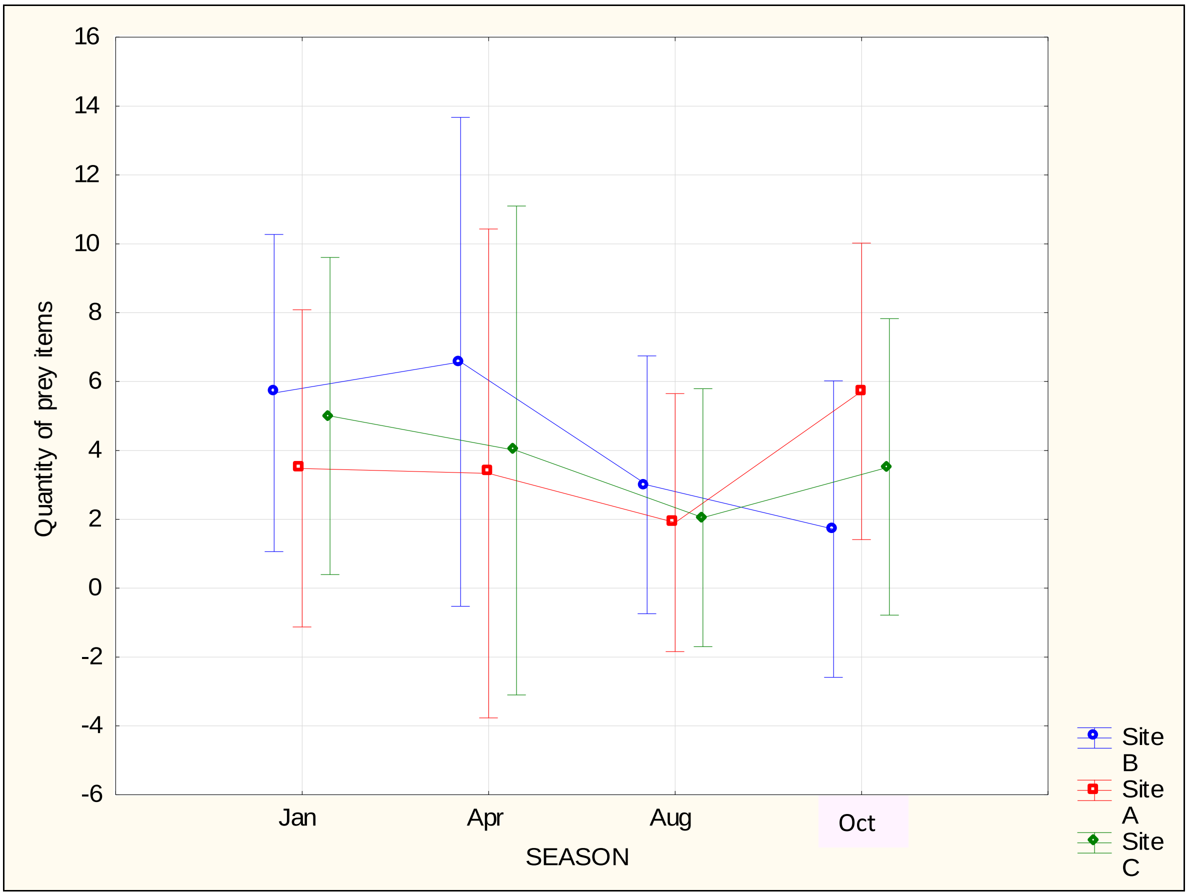


Figure 3.3 Illustration of the change in the quantity of prey items depicted against the different months for each site A, B and C.

In Table 3.23, the average change in species composition for Sites A, B and C for each month is depicted. The highest average change in species composition occurred in January, with a value of 4.7. Following January, April had the second highest change in species composition with a value of 4.6. The second least average change in species composition occurred in October with a value of 3.7. The least average change in species composition occurred in October. According to the p-value, which is smaller than 0.1 (0.06456) there is a statistical significance for the differences between the four months regarding species composition for all the sites grouped together.

Table 3.23: Grouped analysis (Site A, B and C) (Friedman ANOVA) for the determination of the average change in species composition (p = 0.01950)

Variable	Mean	Standard deviation
January	4.7	10.4
April	4.6	16.1

August	2.3	8.5
October	3.7	9.8

In Table 3.24, the results of the change in species composition with regard to each site for January is given. With a p-value of 0.4982 (bigger than 0.1), there is no statistical significant difference between the sites in January.

Table 3.24: Independent grouping (Kruskal-Wallis test) results using multiple comparisons for January ($p = 0.4982$)

January	**A**	**B**	**C**
A		0.8	1.0
B	0.8		1.0
C	1.0	1.0	

In Table 3.25, the results of the change in species composition with regard to each site for April is given. With a p-value of 0.5021 (bigger than 0.1), there is no statistical significant difference between the sites in April.

Table 3.25: Independent grouping (Kruskal-Wallis test) results using multiple comparisons for April ($p = 0.5021$)

April	**A**	**B**	**C**
A		1.0	1.0
B	1.0		1.0
C	1.0	1.0	

In Table 3.26, the results of the change in species composition with regard to each site for August is given. With a p-value of 0.8335 (bigger than 0.1), there is no statistical significant difference between the sites in August.

Table 3.26: Independent grouping (Kruskal-Wallis test) results using multiple comparisons for August ($p = 0.8335$)

August	**A**	**B**	**C**
A		1.0	1.0

B	1.0		1.0
C	1.0	1.0	

In Table 3.27, the results of the change in species composition with regard to each site for October is given. With a p-value of 0.4476 (bigger than 0.1), there is no statistical significant difference between the sites in October.

Table 3.27: Independent grouping (Kruskal-Wallis test) results using multiple comparisons for August (p = 0.4476)

<u>October</u>	**A**	**B**	**C**
A		1.0	0.8
B	1.0		1.0
C	0.8	1.0	

3.3.2 Quantification (frequency and volume) of prey items

Table 3.28: Combined data reflecting the number of invertebrates from all three sites and the volume which was obtained from the invertebrates

	Pitfalls		**Sweepnets**		
Month	**Invertebrate numbers**	**Invertebrate volume (ml)**	**Invertebrate numbers**	**Invertebrate volume (ml)**	**Mean individual invertebrate volume**
January	378	14.8	454	6.8	0.03
April	241	10.9	40	5.9	0.06
August	140	13	6	0.6	0.09
October	232	97.3	7	0.5	0.41
TOTAL	**991**	**136**	**507**	**13.8**	**0.1**

3.4 AVAILABILITY OF TREES FOR NESTING AND ROOSTING

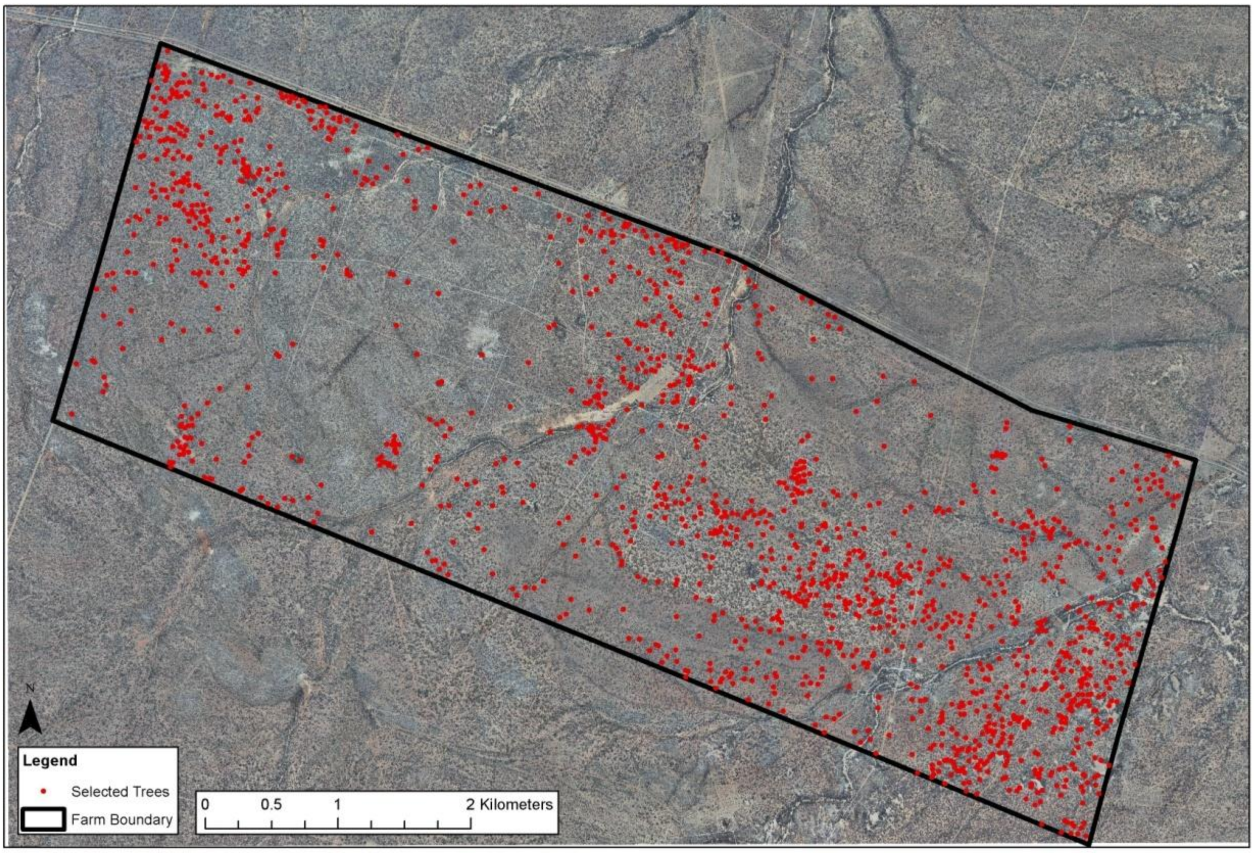


Figure 3.4: Map illustrating the availability of large trees on the farm Greyghost Safaris.

The results show that there are relatively a large number of large enough trees on the farm which could be suitable for nesting and roosting regarding size preference for nesting. However, a calculation of the number of trees shows less than one (0.605) tree per hectare. Suitable trees on the farm appear to occur in clusters on the eastern and western side of the farm.

3.5 PRE-RELEASE SITE EVALUATION/STAKEHOLDER ENGAGEMENT

A series of interviews were conducted with the local landowners regarding SGH's and the landowners' attitudes towards and opinions regarding potential reintroductions either on their farm or in the surrounding area.

3.5.1 Demographic information of stakeholders

Ten interviews were conducted using a purposeful sampling strategy with landowners in and around the study site. One of the interviewees was not a landowner as such but a reserve manager. Out of the ten interviewees, nine were male and one female. Their ages ranged from 30 years to 55 years with all the interviewees being Caucasian. Seventy percent of the farmers interviewed have been living on their farms for more than 10 years, some attaining a stay of between 20 and 30 years. Only one interviewee had been living in the area for less than a year. The type of farming activities taking place on these farms is primarily wildlife and hunting; however, four out of the 10 landowners have stock and practise arable farming activities, too. Sizes of the farms ranged between 330 and 9300 ha. These farms had various numbers of people working or living there, ranging between five and 500 people.

3.5.2 Attitudes regarding the SGH

All the interviewees claimed that they felt positive towards having SGHs on their farms and said that they would be glad if the birds were seen more frequently. Two of the interviewees, however, stated that even though they are for having the birds on their farms, they are concerned about the tortoises that act as prey for the SGH, since introducing the birds may result in a decline in their numbers.

3.5.3 Sightings of the SGH on farm or in area

Nine out of ten interviewees had seen the birds in or around their farms before. Three of the interviewees stated that they see the birds as often as once every week, either on their farm or on the roadside just outside of Musina. The same group seen by these observers consisted of two females and one male. One interviewee claimed that the birds are seen by him at least once a month, and another farmer claimed he sees the birds at least three times per month. Two interviewees claimed that the birds were sighted seasonally, especially during March or April. Other farmers claimed that they have not seen the birds for at least two years, whereas one farmer even claimed that he has not seen the birds for over eight years.

3.5.4 Willingness to reintroduce SGH onto farm

The question regarding whether or not the farmers are positive to have SGHs reintroduced onto their farm had an all-round positive response. Everyone was keen, if approached in the future, to allow reintroduced birds onto their farms. There was one concern from one farmer, however, and that was that there is a lot of activity taking place on some parts of his farm which could cause some disturbance and may cause the birds to fly off.

3.5.5 Presence of nest on farm

There was one farmer in particular who claimed that the birds were seen at least once a week on his land for a number of years. This could give rise to the possibility of there being a breeding pair, and even a nest, on this particular farm although the farmer was not aware of a nest. Fifty percent of the interviewees claimed that they are not aware of any nests on their farms, and 40% declared they have artificial nests erected although all were unoccupied at the time.

3.5.6 Dynamics regarding other stakeholders in the area

All the farmers stated that the relationships between the farmers are all positive and that there are no underlying issues as such which may create problems if the SGHs were to be reintroduced into the area.

3.5.7 Reasons for decline according to stakeholders

The main reasons for decline in SGH population numbers, according to the interviewees, are developments, agricultural activities, habitat alteration and degradation, poisoning (indirect), poaching and the birds' slow reproductive rates. Two of the interviewees stated that they had no idea why the decline is occurring, and one interviewee stated that the population numbers are not declining but are still the same as many years ago.

3.5.8 Sufficient farm size for reintroductions

In order to reintroduce SGHs into an area, one must be sure that there is a large enough area for them to forage and to claim as their territory. SGHs, as mentioned in chapter 1, require an area ranging between 100 and 200 km^2. When asked whether or not their farm will be suitable with regard to size for reintroducing the birds, six farmers claimed that their farms were sufficient in size. The remaining four interviewees who had not such a large area available claimed that their neighbours will gladly cooperate in allowing the birds to move about freely from one area to the next.

3.5.9 Active conservation officer

Five out of the ten interviewees were aware of the local fauna and flora conservation officer in Musina. The landowners of the area have incorporated their own group, called the Wildlife Study Group, which meets once a month outside hunting season. Here they discuss problems or aspects regarding wildlife and the conservation thereof.

3.5.10 Local vet in the area

According to the interviewees, there is a local veterinarian in Musina who deals mostly with domestic animals. When in need of a wildlife specialist, vets from Louis Trichardt and Bela-Bela and Lephalale (Ellisras) are called upon and transported to the farms. This, they say, is very costly to the farmers, thus the vets are only called upon when absolutely necessary. Every farmer was keen on taking an injured SGH to the veterinarian to be revived, if they ever come across one. During one interview, it came to the fore that one farmer had actually found an injured bird approximately two years ago and had tried to bring it back to good health; however, due to the severity of its injuries, the bird unfortunately did not survive.

3.5.11 Predators in the area

According to all the farmers, they all seem to have the same predator species on the farms, namely leopards, hyenas (brown and spotted), caracal, serval, African wildcat and occasional cheetah.

3.5.12 Problems regarding window-breaking

None of the interviewed farmers have had problems with SGHs breaking windows, although two farmers claimed that they have indeed heard of such incidents on neighbouring farms and near Lephalale.

CHAPTER 4

Discussion

CHAPTER 4: DISCUSSION

The aim of this study was to identify and verify optimal reintroduction sites for the Southern Ground Hornbill (SGH) in the Musina area of the Limpopo Province. To achieve this, five main objectives were identified, namely to: 1) identify optimal reintroduction areas, 2) develop a habitat profile, 3) determine the availability of prey items, 4) determine the availability of large trees, and 5) evaluate pre-release sites by involving a number of stakeholders. This study can be viewed as the foundation for similar work in other parts of the SGH's range.

4.1 OPTIMAL REINTRODUCTION SITES

It is clear that the Limpopo River Valley, north of the Soutpansberg and stretching across to the KNP on the eastern border of the Limpopo Province, is a potentially suitable re-introduction area for the SGH. Other areas in the central parts of the province seem to be less suitable, probably because of low minimum temperature which has an effect on the availability of prey items. Greyghost Safaris, the farm that was used as the primary study site which forms part of the larger farm called Ludwigslust, is one of the farms in the Limpopo River Valley and, therefore, a good representative of the larger area west of Musina. The SGH is also regularly observed on the farm in the habitats that were chosen for further analysis. Furthermore, the area has a high density of large baobabs and other large tree species and further meets the SGH's habitat requirements regarding vegetation, climate and prey abundance which makes it a very suitable area for re-introduction and a good study site.

4.2 HABITAT PROFILE

4.2.1 Forbs and grasses

In terms of the composition of forbs and grass species, Site A and Site C, had the same number of forbs and grass species, while Site B had the highest species composition. According to Van Rooyen's (2008) description of the different plant communities for the specific sites, Site A should have the highest species composition (52% grass cover and 12% forbs), while Site B should have a lower species composition (41% grass cover) than Site A as the area has a high rock density which should affect the percentage ground cover. Site C, on the other hand, should have the least percentage ground cover as it is an area of old ploughed fields lacking in tall trees. The area has previously been exposed to heavy grazing, and Site C has certain forbs species which are in high abundance, such as *Alternanthera pungens* and *Tribulus terrestris*. A possible reason for these phenomena could be the high rainfall on the farm which occurred during 2010 and 2011 relative to the years 2008 and 2009 (Table 2.1) which could have affected the average plant growth for the area at the different sites. The reason for Site A having a much lower species composition compared to Site B could be ascribed to poor land-use management, such as overgrazing. The presence of larger tree species at Site A could also have an adverse affect on the grass cover, compromising the composition, spatial distribution and productivity of grasses in the savannah (Scholes & Archer, 1997).

By referring to the descriptive analysis of the forbs and grass species composition for all the sites during the four different months (Tables 3.2, 3.5 and 3.8), it is clear that for Site A, the highest composition of species was collected during August. This can be due to the presence of a higher abundance of annual grasses and forbs which are adapted to survive throughout the winter months. At Site B, the highest composition of species was recorded during January. This could be a result of the high rainfall that occurred during January 2011 (Table 2.1). At Site C, the highest composition of species recorded was during April. April is usually a colder month, although Site C, having a disturbed soil and vegetation structure due to the previous use of the land, has a high abundance of vegetation which is commonly found on disturbed area, such as the before-mentioned *Alternanthera pungens*. Due to the lack of trees, this could also mean that compared to the other three sites, Site C would have the highest percentage ground cover during this month as the forbs and grasses composition cannot be adversely affected by trees and their roots, as could have been the case at the other sites. Although April is low in rainfall and temperatures relative to the other months of the year, Site C is still capable of providing enough food sources for the SGH. October provided the least number of species composition for all three sites. October is known to be one of the hottest and driest months as it is post-winter and precedes the rainfall season which usually runs from November to March (Van Rooyen, 2008). As a result, plant species composition is low.

4.2.2 Woody structure

Together with having the highest species composition of forbs and grasses, Site B had the highest tree species composition, compared to the other two sites, with nine different species

(Table 3.6). Site A followed with six main tree species (Table 3.3) and Site C with five species (Table 3.9). Most of the species found at all three sites are classified as small (up to 5 m) or medium (5-15 m) (Van Wyk & Van Wyk, 2007). This is not ideal for SGH nesting or roosting as they require larger trees, falling in the classes of large (15-30 m) to very large (more than 30 m). Trees which fall more in this size range include *Combretum imberbe*, *Ficus sycomorus*, *Diospyros mespiliformis*, *Sclerocarya birrea* and *Adansonia digitata*, which all are preferred by the SGH for nesting in the KNP (Kemp, 1995).

For all three Sites A (Table 3.3), B (Table 3.6) and C (Table 3.9), the dominant tree species recorded was *Colophospermum mopane*. The main reason for this is the fact that the sites all fall under the Musina Mopane Bushveld vegetation type (Fig. 2.2) (Mucina & Rutherford, 2006), so the chances of mopane being the dominantly found tree species along the transects are high, as the farm has large areas of dense mopane bushveld. Mopane can usually be found growing in deep red/brown clays to freely-drained sandy soils, as well as shallow Glenrosa and Mispah soils often formed as a result of rock weathering and clay alleviation (Rossouw & Van der Waals, 2010; Walker *et al*, 1978).

When comparing the species composition of all three sites with each other for the woody structure, it is clear that Site A and Site B have more in common with regard to tree species (two commonly-shared species, namely *Acacia senegal* and *Grewia flava*) than Site A with Site C. Site C has more in common with Site B, however, with two species occurring at both Sites (*Acacia tortilis* and *Terminalia prunioides*). Site C only has one species in common with Site A; that being *Combretum apiculatum*. Sites A and B both have species not occurring at any of the other sites (Site B *Acacia nigrescens*, *Dichrostachys cinerea* and *Dombeya rotundifolia*; Site A *Kirkia acuminata*).

According to the description of the different plant communities in which the three sites are classified (Fig. 2.3), *Kirkia acuminata* is common for Site A's specific plant community, together with the raisin bushes (*Grewia flava* and *G. bicolor*). The remaining characteristic trees and bushes of the plant community in which Site A is classified were not recorded. This could be due to the method of sampling which was used. The cross-transect of 200 m recordings does not provide 100% effectiveness for identifying all the tree species that are found in the area but, instead, only along the narrow transect lines.

For Site B, a greater similarity was found between the vegetation species composition identified during sampling and the description of the plant community (Fig. 2.3) according to Van Rooyen (2008). Seven of the species listed in the plant community description for Site B were amongst the nine species sampled through the cross-transect (Table 3.6). The classification of Site B's plant community as "mopane-slender three-hook thorn low dense bushveld" is, therefore, considered to be best-suited.

Acacia tortilus and *Colophospermum mopane* were recorded at Site C (Table 3.9), coinciding with the description of the plant community in which this site is classified (Fig. 2.3). According to the plant community description, "umbrella thorn-bushveld signal grass old fields" (Van Rooyen, 2008), the area does not consist of tree species but, instead, has a 3% cover of shrubs. This is due to the fact that the area was previously used for arable farming; consequently, any large tree species were possibly removed and the area heavily grazed.

4.2.3 Change in ground cover

In terms of the results for the change in ground cover per month for each site, Site A had the highest average change in ground cover occurring in August (Table 3.10). For Site B (Table 3.11), the highest average change in ground cover occurred during January, and for Site C (Table 3.12), the highest average change in ground cover occurred during April. The reason for the high change in ground cover at Site A during August could be due to the fact that during this month, Site A had the highest forbs and grass species composition compared to the other three months consequently more species commonly subject to the changing of the seasons occur at this site. Site B obtained the highest change in ground cover in January, and this could be due to the high species composition for Site B compared the other two sites. Since January falls in the rainy season, more species available on Site B are subject to change as a result of the changing of the seasons. October, being one of the driest and hottest months, is the month with the lowest change in ground cover for all three sites. The difference between Sites A and B with C, regarding the change in ground cover, is that Site C's results do have statistical significance for the difference between the months (p-value smaller than 0.1), while the other two did not. This could be due to the fact that Site C did not have a big species composition to begin with.

4.3 AVAILABILITY OF PREY ITEMS

The site with the highest prey species composition is Site A (3.13) with a total of 16 orders. Site C had a total of 15 different prey orders (Table 3.13), while Site B (Table 3.16) had the lowest composition of prey. The dominant prey order for all three sites is Coleoptera. However, when comparing the dominant prey order for each site between the different months, it is clear that Site B and Site C are more similar as they both have the same dominant orders for each month (January = Orthoptera, April = Coleoptera, August = Coleoptera and October = Hemiptera).

The only difference between Sites B and C and Site A is the dominant species in January (Site A = Coleoptera). At Site A, a member of the order Squamata was captured and released during April. This was unfortunately the only species of this order which was captured in the traps. It is clear that at Site C, the order Anura was recorded to appear during the month of October. The first rains of the season occurred during sampling in October (30.5 mm) and thus gave rise to the reappearance of amphibians. During October, at all three sites, the highest appearance of the order Scorpiones occurred. The size and abundance of millipedes were also much higher than during the previous months. Large millipedes tend to appear after the rainfall. This, too, is the reason why SGH would be able to survive in this area, even during the hotter, drier periods of the year, as each month has its own provision of prey items in its own form. The open grass field at Site C provided a large number of low-flying insects such as grasshoppers, butterflies and moths, especially during the rainy season. The SGH has been known to prefer open areas such as this for foraging as they have clear visibility for potential threats. Furthermore, because of their primarily walking nature, they prefer the openness as it is easier to forage with less density of bushes and trees.

During the rainy season, Site C was more prone to have stagnant water puddles after high rainfall. This gave rise to the presence of amphibians. Frogs provide high protein content for the SGH to prey upon. These water puddles together with the frogs can be an attraction for other potential prey species of the SGH, such as snakes, rodents, other insects and even species of smaller birds. The soft ground also allows for digging in search of food, especially during dry months.

With regard to the highest average prey species composition, Site A (Table 3.14) differs from Site B (Table 3.17) and C (Table 3.20) by having the highest species composition during

October. As the temperature becomes hotter, prey such as the mentioned scorpions, amphibians, reptiles and possible rodents appear due to the increase of insect abundance after August. October is near the start of the rainy season, which could give the SGH the opportunity to move back to this area in instances where they may have migrated to other areas during August. For Sites B and C, the month with the highest average species composition occurs in April. For Sites B and C, the least average species composition occurs in October, compared to August for Site A.

The highest average change in prey species composition, when it comes to change in species composition between the different months for Site A (Table 3.15), October has the highest change, compared to Site B (Table 3.18) which had the highest average change in April. Site C (Table 3.21) had the highest change in composition during January. For Sites A and C, the least average change in species composition occurred during August, compared to October for Site B. August was the month which could have the highest adverse effect on the feeding habits of the SGH. This would mean that the SGH groups are more likely to migrate to other areas; hence their large territory sizes outside protected areas. Foraging in cultivated fields or flying across to be closer to the Limpopo River is a possibility.

When comparing the different months regarding species composition for the three sites combined (Table 3.22), January has the highest average change in species composition for all three. This could be due to the high rainfall which had occurred during January (Table 2.1). Second is April, and third is October. The month with the least species composition is August. There is no significant statistical difference between the sites for each month separately (p-value bigger than 0.1). October has a higher species composition compared to August due to the fact that October is a warmer month and 30.5 mm rainfall was recorded during that month which could have initiated the return of prey species. Regarding the change in species composition for all three sites combined between the different months (Table 3.23), January showed the highest change, second is April, third is October and the lowest average change occurred during August.

The volumes of the prey which were measured for each month (Table 3.28) for the pitfall and sweepnet traps had appealing results. When combining the results for the sweepnet and the pitfall traps, it is clear that January had the highest number of prey which was collected; however, it did not offer the most volume. This indicates that the birds, during the summer months, will forage more and consume a higher number of smaller prey items, except when referring to larger prey such as rodents and tortoises and snakes which should be in greater abundance during this time. The SGHs are more likely then to travel longer distances in search of prey. January also had the highest composition of forbs and grasses at Site B. This is an indication that just because there is a higher number of insects offered during that month, it does not necessarily mean that the volume of food available whilst foraging will provide the sufficient amount of food to meet the SGH's feeding requirements. Surprisingly, October gave the highest volume of food items, although it was third when comparing the number of prey species caught. The large volume came from the large size of the insects as well as the large scorpions which were collected from the traps. As mentioned before, October also had the presence of amphibians which were collected in the traps. October, as it seems, would be the month which would provide the most sufficient volume of food within a smaller area. This is advantageous to the SGH as they would not need to walk long distance to forage during the drier months. This could also prepare them for the next breeding season which should occur as soon as the first big rains have occurred as of from the start of November. They could then spend more of their energy in preparing the nest for the female. August provided the least number of insects, and the least volume. This is partly due to the fact that during winter, less prey is available. April had the second highest number of species although it came third when comparing the volume it provided.

4.4 AVAILABILITY OF TREES FOR NESTING AND ROOSTING

As seen on the map in Figure 3.4, it is clear that a large number of large trees are available on Greyghost Safaris, although calculations have determined that there is less than one tree per hectare, which could mean that the quantity of the large trees is not as important as the availability of trees with suitable nest cavities.

4.5 PRE-RELEASE SITE EVALUATION/STAKEHOLDER ENGAGEMENT

Finally, the reaction from the local landowners in the Musina area was mainly positive with regard to the SGH being a local resident on their farms. The majority of the farms (60%) belonging to the farmers interviewed are wildlife farms ranging between 330 and 9300 ha. The general perception of the farmers of reintroducing SGHs into the area, if ever decided, is positive. Veterinary assistance is available in the area, as well as a local Fauna and Flora officer. The farmers have also established their own Wild Study Group which deals with everyday aspects regarding wildlife management. Conservation of wildlife species is a concern amongst the majority of the farmers. As was identified by means of the interviews, it is clear that there is an existing population of SGH (group of three) which is spotted regularly. The most sightings and voice calling of the group occur on the farm neighbouring Greyghost Safaris. This could be a sign that they have a nest in the vicinity and also that the habitat is preferred by the birds. Forty percent of the farmers claimed that they had artificial nests erected on their farms, although they have never been utilised by SGH.

All the landowners claimed to have the same species predators which may influence reintroduction site selection, namely leopards, brown and spotted hyena, jackal, caracal and the occasional cheetah.

A concern for reintroducing SGH into an area is the act of breaking windows. SGH are highly territorial (Kemp, 1995), and will thus attack anything that resembles an imposter, even though it is simply the bird's own reflection. Of the landowners interviewed, none had ever had a problem with window-breaking although it has been heard of elsewhere. This causes concern for the health of the SGH as they may be injured in the process of breaking the windows, and it affects the farmers financially.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

This study site provided a good opportunity to explore what an optimal site for reintroduction should resemble. Site A, with the highest composition of prey items for all four months combined, suggests that this type of plant community represents the most ideal habitat, including food variety and availability. As this area is considered to be woody in the sense of small bushes and trees (second to Site B), small mammals such as rodents are prone to habituate the area. Squirrels and other tree-living species are more abundant, as well as other smaller birds which make their nests in the branches of the trees. The presence of these species may likely attract other prey for the SGH such as snakes which are after the birds and their eggs, as well as small rodents.

Even though the presence of large trees in the sampling area were few, this does not indicate that there is no possible solution for the birds to make their nests, as artificial nests could be implemented and further research into the architecture and positioning of the nest-box can be undertaken. It is recommended that this type of habitat is further mapped and explored to identify similar areas.

The results obtained from the study are not 100% effective when compared to the actual sightings and observations of prey abundance and tree abundance. An aspect to consider when measuring the effectiveness of the study, with regard to the model used to determine the niche preference in the current study area, is the fact that most of the previous studies done on the habitat of the species were conducted in the KNP; that which the selected study site does not represent entirely. Thus, extrapolating environmental data from the KNP to the Limpopo River Valley ecosystem is not entirely a suitable method to determine niche or habitat preference in the current study area.

The cross-transect can provide a vague indication of the actual vegetation species abundance. Decisions should not be based wholly on this study or on studies resembling this one but, instead, should include actual observations and should be conducted on a larger area, possibly over a longer time period. The effectiveness of the large tree abundance can be questioned as only baobabs were identified; along the water courses other large Fig tree species could also be suitable for nesting. Also, ground-truthing needs to be done so as to identify trees with large enough cavities in them which will make it suitable for nesting.

The prey abundance results are not 100% effective either, as the pitfalls could have been deterred by external factors such as rainfall, the area selected, time of sampling and length of sampling, amongst others. The pitfall traps were there simply to give an indication as to what species are in the area which could be a possible food source for the SGH, although the majority of the prey captured in the traps was small-sized insects which only contribute slightly to the diet of the SGH. There are other sampling methods which could be implemented for a more detailed analysis. The scale of the sampling, relative to the size of the SGH territory also acted as a potential problem in the effectiveness of the results. As a solution to this problem, it is recommended to carry out similar studies but on larger scale. It is recommended by Sutherland (2000) to use long thin quadrats instead of the square, cross quadrants that were used in the study. Thin long quadrats can contain 18% more species than if using a square quadrat.

As was noted by the variation in prey abundance and vegetation during the different seasons, seasonal and breeding behaviour as well as seasonal requirements should be considered before reintroducing the birds. It is important not to ignore the vegetation composition in future modelling of SGH-habitat relationships as it could be a good indicator of food availability in reintroduced SGH populations. Habitat quality may also be assessed better within an interacting ecosystem and as a functional-resource-based concept of habitat (Michel *et al*, 2010). The distribution of resources and suitable habitats across the available landscape could influence the survival and reproduction of reintroduced bird populations.

With regard to the stakeholder interviews, it was not feasible to interview members of the local subsistence farmers as the area selected did not include any of the above mentioned farmer type; hence the limited data on the perception of farmers regarding the species. Future studies should include a larger area thus including other members of the surrounding communities as they also play an important role in the survival of the species.

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APPENDIX 1

Woody component

Scientific name	English name
Acacia nigrensis	Knob thorn
Acacia senegal	Slender three-hook thorn
Acacia tortilus	Umbrella thorn
Colophospermum mopane	Mopane
Combretum apiculatum	Red bushwillow
Dichrostachys cinerea	Sickle bush
Dombeya rotundifolia	Common wild pear
Grewia bicolor	White raisin
Grewia flava	Velvet raisin
Kirkia acuminata	White syringe
Terminalia prunoides	Lowveld cluster-leaf

Grasses and forbs

Scientific name	English name
Aristida adscensionis	Annual three-awn
Acanthospermum hispidum	Upright starbur
Alternantha pungens	Khakiweed/ Paperthorn
Boerhavia erecta	Erect spiderling
Brachiaria deflexa	False signal grass
Cenchrus ciliaris	Buffalo grass
Corchorus asplenifolius	Wild jute
Endostemon tereticaulis	Small purple keepsakes
Eragrostis lehmanniana	Lehmann's love grass
Evolvulus alsinoides	Blue haze
Geigeria acaulis	Rosulate geigeria
Geigeria burkei	(Afr. = knoppiesvermeerbos)
Heliotropium nelsonii	Common string of stars
Hermbstaedtia fleckii	(Afr. = katstert)
Hermbstaedtia odorata	Cat's tail
Hermannia modesta	Fairy lights
Indigofera ingrata	Unknown

Indigofera vicioides	Unknown
Microcharis galpinii	Grassy false indigo
Monechma divaricatum	Wild lucerne
Ocimum americanum	Wild basil
Panicum deustum	Broad-leaved panicum
Phylanthus angolensis	Unknown
Seddera capensis	Small white seddera
Sida chrysantha	Golden sida
Stipagrostis uniplumis	Silky bushman grass
Syncolostemon canescens	White-tipped hemizygia
Tephrosia semiglabra	Unknown
Tragus berteronianus	Carrot-seed grass
Tragus racemosus	Large carrot-seed grass
Tribulus terrestris	Devil's thorn
Uruchloa pancoides	Garden signal grass
Waltheria indica	Unknown
Xyrophyta humulis	Unknown

APPENDIX 2

Example of questionnaire:

1. Name

2. Age

3. Gender

4. Race

5. Farm name

6. Farm size

7. Type of farming activities

8. Number of people living on farm

9. How long have you lived on this farm?

10. How do you feel about ground hornbills?

11. How often do you see hornbills on your farm/other areas?

12. What are your views on having hornbills reintroduced onto your farm?

13. Are you aware of any nests on your farm?

14. What are the dynamics around the area regarding farmers' relationships or any other issues?

15. What do you think are the main reasons for their decline in the area?

16. Hornbills need a territory size of about 100-200km^{2}. Would your farm be big enough, or which of your neighbours would you recommend who will be willing to cooperate?

17. Do you know the local conservation officer in your area?

18. Do you have a local vet in your area and would you ever be willing to take a wounded bird to the vet?

19. What kind of predators do you have on your farm?

20. What will be your reaction towards window breaking?